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APPENDIX A
NPDES PERMIT

Issuance Date:	January 19, 2018
Effective Date:	March 1, 2018
Expiration Date:	February 28, 2023

National Pollutant Discharge Elimination System Waste Discharge Permit No. WA0023701

State of Washington
DEPARTMENT OF ECOLOGY
Northwest Regional Office
3190 160th Avenue SE
Bellevue, WA 98008-5452

In compliance with the provisions of
The State of Washington Water Pollution Control Law
Chapter 90.48 Revised Code of Washington
and
The Federal Water Pollution Control Act
(The Clean Water Act)
Title 33 United States Code, Section 1342 et seq.

KITSAP COUNTY PUBLIC WORKS
614 Division Street, MS-27
Port Orchard, WA 98366

is authorized to discharge in accordance with the Special and General Conditions that follow.

Plant Location:	Receiving Water:
Manchester Wastewater Treatment Plant 8020 East Caraway Road Manchester, WA 98353 Kitsap County	Rich Passage, Puget Sound Treatment Type: Conventional Activated Sludge – Secondary Treatment System

Rachel McCrea
Water Quality Section Manager
Northwest Regional Office
Washington State Department of Ecology

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Summary of Permit Report Submittals

Refer to the Special and General Conditions of this permit for additional submittal requirements.

Permit Section	Submittal	Frequency	First Submittal Date
S3.A	Discharge Monitoring Report (DMR)	Monthly	April 15, 2018
S3.A	Discharge Monitoring Report (DMR)	Quarterly	July 15, 2018
S3.A	Discharge Monitoring Report (DMR)	Annual	January 15, 2019
S3.F	Reporting Permit Violations	As necessary	
S4.B	Plans for Maintaining Adequate Capacity	As necessary	
S4.D	Notification of New or Altered Sources	As necessary	
S4.E	Infiltration and Inflow Evaluation	1/permit cycle	May 31, 2022
S5.F	Bypass Notification	As necessary	
S5.G	Operations and Maintenance Manual Submittal	1/permit cycle	June 30, 2021
S6.E	Industrial User Survey Submittal	1/permit cycle	June 30, 2022
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S9	Application for Permit Renewal	1/permit cycle	August 31, 2022
G1	Notice of Change in Authorization	As necessary	
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Special Conditions

S1. Discharge limits

S1.A. Effluent limits

All discharges and activities authorized by this permit must comply with the terms and conditions of this permit. The discharge of any of the following pollutants more frequently than, or at a level in excess of, that identified and authorized by this permit violates the terms and conditions of this permit.

Beginning on the effective date of this permit, the Permittee may discharge treated domestic wastewater to the Rich Passage, Puget Sound at the permitted location subject to compliance with the following limits:

Effluent Limits: Outfall 001 Latitude: 47.557778° Longitude: -122.538333°		
Parameter	**Average Monthly [a]**	**Average Weekly [b]**
Biochemical Oxygen Demand (5-day) (BOD_5)	30 milligrams/liter (mg/L) 115 pounds/day (lbs/day) 85% removal of influent BOD_5	45 mg/L 173 lbs/day
Total Suspended Solids (TSS)	30 mg/L 115 lbs/day 85% removal of influent TSS	45 mg/L 173 lbs/day
Parameter	**Daily Minimum**	**Daily Maximum**
pH	6.0 standard units	9.0 standard units
Parameter	**Monthly Geometric Mean**	**Weekly Geometric Mean**
Fecal Coliform Bacteria [c]	200/100 milliliter (mL)	400/100 mL

a	Average monthly effluent limit means the highest allowable average of daily discharges over a calendar month. To calculate the discharge value to compare to the limit, you add the value of each daily discharge measured during a calendar month and divide this sum by the total number of daily discharges measured. See footnote c for fecal coliform calculations.
b	Average weekly discharge limit means the highest allowable average of daily discharges over a calendar week, calculated as the sum of all daily discharges measured during a calendar week divided by the number of daily discharges' measured during that week. See footnote c for fecal coliform calculations.
c	Ecology provides directions to calculate the monthly and the weekly geometric mean in publication No. 04-10-020, Information Manual for Treatment Plant Operators available at: https://fortress.wa.gov/ecy/publications/SummaryPages/0410020.html

S1.B. Mixing zone authorization

Mixing zone for Outfall 001

The following paragraphs define the maximum boundaries of the mixing zones:

Chronic mixing zone

The mixing zone is a circle with radius of 235 feet measured from the center of the discharge port. The mixing zone extends from the bottom to the top of the water column. The concentration of pollutants at the edge of the chronic zone must meet chronic aquatic life criteria and human health criteria.

Acute mixing zone

The acute mixing zone is a circle with radius of 23.5 feet measured from the center of the discharge port. The mixing zone extends from the bottom to the top of the water column. The concentration of pollutants at the edge of the acute zone must meet acute aquatic life criteria.

Available Dilution (dilution factor)	
Acute Aquatic Life Criteria	45
Chronic Aquatic Life Criteria	305
Human Health Criteria - Carcinogen	305
Human Health Criteria - Non-carcinogen	305

S2. Monitoring requirements

S2.A. Monitoring schedule

The Permittee must monitor in accordance with the following schedule and the requirements specified in Appendix A.

Parameter	Units & Speciation	Minimum Sampling Frequency	Sample Type
(1) Wastewater influent			
Wastewater Influent means the raw sewage flow from the collection system into the treatment facility. Sample the wastewater entering the headworks of the treatment plant excluding any side-stream returns from inside the plant.			
Biochemical Oxygen Demand (BOD_5)	mg/L	2/week	24-hr composite [b]
BOD_5	lbs/day [a]	2/week	Calculated
Total Suspended Solids (TSS)	mg/L	2/week	24-hr composite
TSS	lbs/day	2/week	Calculated
(2) Final wastewater effluent			
Final Wastewater Effluent means wastewater exiting the last treatment process or operation. Typically, this is after or at the exit from the chlorine contact chamber or other disinfection process. The Permittee may take effluent samples for the BOD_5 analysis before or after the disinfection process. If taken after, the Permittee must dechlorinate and reseed the sample.			
Flow	MGD	Continuous [c]	Metered/recorded
BOD_5 [d]	mg/L	2/week	24-hr composite
BOD_5	lbs/day	2/week	Calculated
BOD_5	% removal [e]	1/month	Calculated
TSS	mg/L	2/week	24-hr composite
TSS	lbs/day	2/week	Calculated
TSS	% removal	1/month	Calculated
pH [f]	Standard Units	1/Day	Grab [g]
Fecal Coliform [h]	# /100 mL	2/week	Grab
Temperature [i]	Degrees centigrade (°C)	2/week (Jul.-Sep.)	Grab
(3) Effluent characterization – final wastewater effluent			
Total Ammonia	mg/L as N	Quarterly [j]	24-hr composite
Nitrate plus Nitrite Nitrogen	mg/L as N	Quarterly	24-hr composite
Total Kjeldahl Nitrogen (TKN)	mg/L as N	Quarterly	24-hr composite

Parameter	Units & Speciation	Minimum Sampling Frequency	Sample Type
Total Phosphorus	mg/L as P	Quarterly	24-hr composite
Soluble Reactive Phosphorus	mg/L as P	Quarterly	24-hr composite
(4) Permit renewal application requirements – final wastewater effluent			
The Permittee must record and report the wastewater treatment plant flow discharged on the day it collects the sample for priority pollutant testing with the discharge monitoring report.			
Dissolved Oxygen	mg/L	1/year	Grab
Oil and Grease	mg/L	1/year	Grab
Total Dissolved Solids	mg/L	1/year	24-hr composite
Total Hardness	mg/L	1/year	24-hr composite

a	Calculated means figured concurrently with the respective sample, using the following formula: Concentration (in mg/L) X Flow (in MGD) X Conversion Factor (8.34) = lbs/day
b	24-hour composite means a series of individual samples collected over a 24-hour period into a single container, and analyzed as one sample.
c	Continuous means uninterrupted except for brief lengths of time for calibration, power failure, or unanticipated equipment repair or maintenance. The Permittee must sample daily when continuous monitoring is not possible.
d	Take effluent samples for the BOD_5 analysis before or after the disinfection process. If taken after, dechlorinate and reseed the sample.
e	$\% \text{ removal} = \frac{\text{Influent concentration (mg/L)} - \text{Effluent concentration (mg/L)}}{\text{Influent concentration (mg/L)}} \times 100$ Calculate the percent (%) removal of BOD_5 and TSS using the above equation.
f	The Permittee must report the instantaneous maximum and minimum pH daily. Do not average pH values.
g	Grab means an individual sample collected over a fifteen (15) minute, or less, period.
h	Report a numerical value for fecal coliforms following the procedures in Ecology's *Information Manual for Wastewater Treatment Plant Operators*, Publication Number 04-10-020 available at: https://fortress.wa.gov/ecy/publications/SummaryPages/0410020.html. Do not report a result as too numerous to count (TNTC).
i	Temperature grab sampling must occur when the effluent is at or near its daily maximum temperature, which usually occurs in the late afternoon.
j	Quarterly sampling periods are January through March, April through June, July through September, and October through December.

S2.B. Sampling and analytical procedures

Samples and measurements taken to meet the requirements of this permit must represent the volume and nature of the monitored parameters. The Permittee must conduct representative sampling of any unusual discharge or discharge condition, including bypasses, upsets, and maintenance-related conditions that may affect effluent quality.

Sampling and analytical methods used to meet the monitoring requirements specified in this permit must conform to the latest revision of the *Guidelines Establishing Test Procedures for the Analysis of Pollutants* contained in 40 CFR Part 136 (or as applicable in 40 CFR subchapters N [Parts 400–471] or O [Parts 501-503]) unless otherwise specified in this permit. Ecology may only specify alternative methods for parameters without permit limits and for those parameters without an EPA approved test method in 40 CFR Part 136.

S2.C. Flow measurement, field measurement, and continuous monitoring devices

The Permittee must:

1. Select and use appropriate flow measurement, field measurement, and continuous monitoring devices and methods consistent with accepted scientific practices.
2. Install, calibrate, and maintain these devices to ensure the accuracy of the measurements is consistent with the accepted industry standard, the manufacturer's recommendation, and approved O&M manual procedures for the device and the wastestream.
3. Calibrate continuous monitoring instruments weekly unless it can demonstrate a longer period is sufficient based on monitoring records. The Permittee:
   a. May calibrate apparatus for continuous monitoring of dissolved oxygen by air calibration.
   b. Must calibrate continuous pH measurement instruments using a grab sample analyzed in the lab with a pH meter calibrated with standard buffers and analyzed within 15 minutes of sampling.
   c. Must calibrate continuous chlorine measurement instruments using a grab sample analyzed in the laboratory within 15 minutes of sampling.
4. Use field measurement devices as directed by the manufacturer and do not use reagents beyond their expiration dates.
5. Calibrate flow-monitoring devices at a minimum frequency of at least one calibration per year.
6. Maintain calibration records for at least three years.

S2.D. Laboratory accreditation

The Permittee must ensure that all monitoring data required by Ecology for permit specified parameters is prepared by a laboratory registered or accredited under the provisions of chapter 173-50 WAC, *Accreditation of Environmental Laboratories*. Flow, temperature, settleable solids, conductivity, pH, and internal process control parameters are exempt from this requirement. The Permittee must obtain accreditation for conductivity and pH if it must receive accreditation or registration for other parameters.

S2.E. Request for reduction in monitoring

The Permittee may request a reduction of the sampling frequency after twelve (12) months of monitoring. Ecology will review each request and at its discretion grant the request when it reissues the permit or by a permit modification.

The Permittee must:

1. Provide a written request.
2. Clearly state the parameters for which it is requesting reduced monitoring.
3. Clearly state the justification for the reduction.

S3. Reporting and recording requirements

The Permittee must monitor and report in accordance with the following conditions. Falsification of information submitted to Ecology is a violation of the terms and conditions of this permit.

S3.A. Discharge monitoring reports

The first monitoring period begins on the effective date of the permit (unless otherwise specified). The Permittee must:

1. Summarize, report, and submit monitoring data obtained during each monitoring period on the electronic discharge monitoring report (DMR) form provided by Ecology within the Water Quality Permitting Portal. Include data for each of the parameters tabulated in Special Condition S2 and as required by the form. Report a value for each day sampling occurred (unless specifically exempted in the permit) and for the summary values (when applicable) included on the electronic form.
2. Ensure that DMRs are electronically submitted no later than the dates specified below, unless otherwise specified in this permit.
3. The Permittee must also submit an electronic copy of the laboratory report as an attachment using WQWebDMR. The contract laboratory reports must also include information on the chain of custody, QA/QC results, and documentation of accreditation for the parameter.
4. Submit DMRs for parameters with the monitoring frequencies specified in S2 (monthly, quarterly, annual, etc.) at the reporting schedule identified below. The Permittee must:
   a. Submit **monthly DMRs** by the 15^{th} day of the following month. The first submittal is April 15, 2018.
   b. Submit **quarterly DMRs**, unless otherwise specified in the permit, by the 15^{th} day of the month following the monitoring period. Quarterly sampling periods are January through March, April through June, July through September, and October through December. The first four quarterly submittals are due by July 15, 2018; October 15, 2018; January 15, 2019; and April 15, 2019.
   c. Submit **annual DMRs**, unless otherwise specified in the permit, by January 15 for the previous calendar year. The annual sampling period is the calendar year. The first submittal is January 15, 2019.
5. Enter the “No Discharge” reporting code for an entire DMR, for a specific monitoring point, or for a specific parameter as appropriate, if the Permittee did not discharge wastewater or a specific pollutant during a given monitoring period.
6. Report single analytical values below detection as “less than the detection level (DL)” by entering < followed by the numeric value of the detection level (e.g. < 2.0) on the DMR. If the method used did not meet the minimum DL and quantitation level (QL) identified in the permit, report the actual QL and DL in the comments or in the location provided.

7. Report single analytical values between the detection level (DL) and the quantitation level (QL) by entering the estimated value, the code for estimated value/below quantitation limit (j) and any additional information in the comments. Submit a copy of the laboratory report as an attachment using WQWebDMR.
8. **Not** report zero for bacteria monitoring. Report as required by the laboratory method.
9. Calculate and report an arithmetic average value for each day for bacteria if multiple samples were taken in one day.
10. Calculate the geometric mean values for bacteria (unless otherwise specified in the permit) using:
    a. The reported numeric value for all bacteria samples measured above the detection value except when it took multiple samples in one day. If the Permittee takes multiple samples in one day it must use the arithmetic average for the day in the geometric mean calculation.
    b. The detection value for those samples measured below detection.
11. Report the test method used for analysis in the comments if the laboratory used an alternative method not specified in the permit and as allowed in Appendix A.
12. Calculate average values and calculated total values (unless otherwise specified in the permit) using:
    a. The reported numeric value for all parameters measured between the detection value and the quantitation value for the sample analysis.
    b. One-half the detection value (for values reported below detection) if the lab detected the parameter in another sample from the same monitoring point for the reporting period.
    c. Zero (for values reported below detection) if the lab did not detect the parameter in another sample for the reporting period.

S3.B. Permit submittals and schedules

The Permittee must use the Water Quality Permitting Portal – Permit Submittals application (unless otherwise specified in the permit) to submit all other written permit-required reports by the date specified in the permit.

When another permit condition requires submittal of a paper (hard-copy) report, the Permittee must ensure that it is postmarked or received by Ecology no later than the dates specified by this permit. Send these paper reports to Ecology at:

Water Quality Permit Coordinator
Department of Ecology
Northwest Regional Office
3190 160th Avenue SE
Bellevue, WA 98008-5452

S3.C. Records retention

The Permittee must retain records of all monitoring information for a minimum of three (3) years. Such information must include all calibration and maintenance records and all original recordings for continuous monitoring instrumentation, copies of all reports required by this permit, and records of all data used to complete the application for this permit. The Permittee must extend this period of retention during the course of any unresolved litigation regarding the discharge of pollutants by the Permittee or when requested by Ecology.

S3.D. Recording of results

For each measurement or sample taken, the Permittee must record the following information:

1. The date, exact place, method, and time of sampling or measurement.
2. The individual who performed the sampling or measurement.
3. The dates the analyses were performed.
4. The individual who performed the analyses.
5. The analytical techniques or methods used.
6. The results of all analyses.

S3.E. Additional monitoring by the Permittee

If the Permittee monitors any pollutant more frequently than required by Special Condition S2 of this permit, then the Permittee must include the results of such monitoring in the calculation and reporting of the data submitted in the Permittee's DMR unless otherwise specified by Special Condition S2.

S3.F. Reporting permit violations

The Permittee must take the following actions when it violates or is unable to comply with any permit condition:

1. Immediately take action to stop, contain, and cleanup unauthorized discharges or otherwise stop the noncompliance and correct the problem.
2. If applicable, immediately repeat sampling and analysis. Submit the results of any repeat sampling to Ecology within thirty (30) days of sampling.

a. Immediate reporting

The Permittee must immediately report to Ecology and the Department of Health, Shellfish Program, and the Kitsap Public Health District (at the numbers listed below), all:

- Failures of the disinfection system.
- Collection system overflows.
- Plant bypasses discharging to marine surface waters.
- Any other failures of the sewage system (pipe breaks, etc.)

Ecology's Northwest Regional Office	425-649-7000
Department of Health, Shellfish Program	360-236-3330 (business hours) 360-789-8962 (after business hours)
Kitsap Public Health District	360-728-2235 (call 24/7, after business hours press 9)

Additionally, for any sanitary sewer overflow (SSO) that discharges to a municipal separate storm sewer system (MS4), the Permittee must notify the appropriate MS4 owner or operator.

b. Twenty-four-hour reporting

The Permittee must report the following occurrences of noncompliance by telephone, to Ecology at the telephone numbers listed above, within 24 hours from the time the Permittee becomes aware of any of the following circumstances:

- Any noncompliance that may endanger health or the environment, unless previously reported under immediate reporting requirements.
- Any unanticipated bypass that causes an exceedance of an effluent limit in the permit (See Part S5.F, "Bypass Procedures").
- Any upset that causes an exceedance of an effluent limit in the permit (See G.15, "Upset").
- Any violation of a maximum daily or instantaneous maximum discharge limit for any of the pollutants in Section S1.A of this permit.
- Any overflow prior to the treatment works, whether or not such overflow endangers health or the environment or exceeds any effluent limit in the permit.

c. Report within five days

The Permittee must also submit a written report within five days of the time that the Permittee becomes aware of any reportable event under subparts a or b, above. The report must contain:

- A description of the noncompliance and its cause.
- The period of noncompliance, including exact dates and times.
- The estimated time the Permittee expects the noncompliance to continue if not yet corrected.
- Steps taken or planned to reduce, eliminate, and prevent recurrence of the noncompliance.
- If the noncompliance involves an overflow prior to the treatment works, an estimate of the quantity (in gallons) of untreated overflow.

d. Waiver of written reports

Ecology may waive the written report required in subpart c, above, on a case-by-case basis upon request if the Permittee has submitted a timely oral report.

e. All other permit violation reporting

The Permittee must report all permit violations, which do not require immediate or within 24 hours reporting, when it submits monitoring reports for S3.A ("Reporting"). The reports must contain the information listed in subpart c, above. Compliance with these requirements does not relieve the Permittee from responsibility to maintain continuous compliance with the terms and conditions of this permit or the resulting liability for failure to comply.

S3.G. Other reporting

a. Spills of oil or hazardous materials

The Permittee must report a spill of oil or hazardous materials in accordance with the requirements of RCW 90.56.280 and chapter 173-303-145. You can obtain further instructions at the following website:

https://ecology.wa.gov/About-us/Get-involved/Report-an-environmental-issue/Report-a-spill

b. Failure to submit relevant or correct facts

Where the Permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application, or in any report to Ecology, it must submit such facts or information promptly.

S3.H. Maintaining a copy of this permit

The Permittee must keep a copy of this permit at the facility and make it available upon request to Ecology inspectors.

S4. Facility loading

S4.A. Design criteria

The flows or waste loads for the permitted facility must not exceed the following design criteria:

Maximum Month Design Flow (MMDF)	0.46	MGD
BOD_5 Influent Loading for Maximum Month	832	lbs/day
TSS Influent Loading for Maximum Month	832	lbs/day

S4.B. Plans for maintaining adequate capacity

a. Conditions triggering plan submittal

The Permittee must submit a plan and a schedule for continuing to maintain capacity to Ecology when:

- The actual flow or waste load reaches 85 percent of any one of the design criteria in S4.A for three consecutive months.
- The projected plant flow or loading would reach design capacity within five years.

b. Plan and schedule content

The plan and schedule must identify the actions necessary to maintain adequate capacity for the expected population growth and to meet the limits and requirements of the permit. The Permittee must consider the following topics and actions in its plan.

- Analysis of the present design and proposed process modifications.
- Reduction or elimination of excessive infiltration and inflow of uncontaminated ground and surface water into the sewer system.
- Limits on future sewer extensions or connections or additional waste loads.
- Modification or expansion of facilities.
- Reduction of industrial or commercial flows or waste loads.

Engineering documents associated with the plan must meet the requirements of WAC 173-240-060, "Engineering Report," and be approved by Ecology prior to any construction.

S4.C. Duty to mitigate

The Permittee must take all reasonable steps to minimize or prevent any discharge or sludge use or disposal in violation of this permit that has a reasonable likelihood of adversely affecting human health or the environment.

S4.D. Notification of new or altered sources

1. The Permittee must submit written notice to Ecology whenever any new discharge or a substantial change in volume or character of an existing discharge into the wastewater treatment plant is proposed which:
   a. Would interfere with the operation of, or exceed the design capacity of, any portion of the wastewater treatment plant.
   b. Is not part of an approved general sewer plan or approved plans and specifications.
   c. Is subject to pretreatment standards under 40 CFR Part 403 and Section 307(b) of the Clean Water Act.
2. This notice must include an evaluation of the wastewater treatment plant’s ability to adequately transport and treat the added flow and/or waste load, the quality and volume of effluent to be discharged to the treatment plant, and the anticipated impact on the Permittee’s effluent [40 CFR 122.42(b)].

S4.E. Infiltration and inflow evaluation

1. The Permittee must conduct an infiltration and inflow evaluation. Refer to the U.S. EPA publication, I/I Analysis and Project Certification, available as Publication No. 97-03 at: https://fortress.wa.gov/ecy/publications/SummaryPages/9703.html

2. The Permittee may use monitoring records to assess measurable infiltration and inflow.

3. The Permittee must prepare a report summarizing any measurable infiltration and inflow. If infiltration and inflow have increased by more than 15 percent from that found in the previous report based on equivalent rainfall, the report must contain a plan and a schedule to locate the sources of infiltration and inflow and to correct the problem.

4. The Permittee must submit a report summarizing the results of the evaluation and any recommendations for corrective actions by May 31, 2022.

S5. Operation and maintenance

The Permittee must at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances), which are installed to achieve compliance with the terms and conditions of this permit. Proper operation and maintenance also includes keeping a daily operation logbook (paper or electronic), adequate laboratory controls, and appropriate quality assurance procedures. This provision of the permit requires the Permittee to operate backup or auxiliary facilities or similar systems only when the operation is necessary to achieve compliance with the conditions of this permit.

S5.A. Certified operator

This permitted facility must be operated by an operator certified by the state of Washington for at least a Class II plant. This operator must be in responsible charge of the day-to-day operation of the wastewater treatment plant. An operator certified for at least a Class I plant must be in charge during all regularly scheduled shifts. The Permittee must notify Ecology when the operator in charge at the facility changes. It must provide the new operator's name and certification level and provide the name of the operator leaving the facility.

S5.B. Operation and maintenance program

The Permittee must:

1. Institute an adequate operation and maintenance program for the entire sewage system.

2. Keep maintenance records on all major electrical and mechanical components of the treatment plant, as well as the sewage system and pumping stations. Such records must clearly specify the frequency and type of maintenance recommended by the manufacturer and must show the frequency and type of maintenance performed.

3. Make maintenance records available for inspection at all times.

S5.C. Short-term reduction

The Permittee must schedule any facility maintenance, which might require interruption of wastewater treatment and degrade effluent quality, during non-critical water quality periods and carry this maintenance out according to the approved O&M manual or as otherwise approved by Ecology.

If a Permittee contemplates a reduction in the level of treatment that would cause a violation of permit discharge limits on a short-term basis for any reason, and such reduction cannot be avoided, the Permittee must:

1. Give written notification to Ecology, if possible, thirty (30) days prior to such activities.
2. Detail the reasons for, length of time of, and the potential effects of the reduced level of treatment.

This notification does not relieve the Permittee of its obligations under this permit.

S5.D. Electrical power failure

The Permittee must ensure that adequate safeguards prevent the discharge of untreated wastes or wastes not treated in accordance with the requirements of this permit during electrical power failure at the treatment plant and/or sewage lift stations. Adequate safeguards include, but are not limited to, alternate power sources, standby generator(s), or retention of inadequately treated wastes.

The Permittee must maintain Reliability Class II (EPA 430-99-74-001) at the wastewater treatment plant. Reliability Class II requires a backup power source sufficient to operate all vital components and critical lighting and ventilation during peak wastewater flow conditions. Vital components used to support the secondary processes (i.e., mechanical aerators or aeration basin air compressors) need not be operable to full levels of treatment, but must be sufficient to maintain the biota.

S5.E. Prevent connection of inflow

The Permittee must strictly enforce its sewer ordinances and not allow the connection of inflow (roof drains, foundation drains, etc.) to the sanitary sewer system.

S5.F. Bypass procedures

A bypass is the intentional diversion of waste streams from any portion of a treatment facility. This permit prohibits all bypasses except when the bypass is for essential maintenance, as authorized in special condition S5.F.1, or is approved by Ecology as an anticipated bypass following the procedures in S5.F.2.

1. Bypass for essential maintenance without the potential to cause violation of permit limits or conditions.

   This permit allows bypasses for essential maintenance of the treatment system when necessary to ensure efficient operation of the system. The Permittee may bypass the treatment system for essential maintenance only if doing so does not cause violations of effluent limits. The Permittee is not required to notify Ecology when bypassing for essential maintenance. However the Permittee must comply with the monitoring requirements specified in special condition S2.B.

2. Anticipated bypasses for non-essential maintenance

   Ecology may approve an anticipated bypass under the conditions listed below. This permit prohibits any anticipated bypass that is not approved through the following process.

   a. If a bypass is for non-essential maintenance, the Permittee must notify Ecology, if possible, at least ten (10) days before the planned date of bypass. The notice must contain:

      - A description of the bypass and the reason the bypass is necessary.
      - An analysis of all known alternatives which would eliminate, reduce, or mitigate the potential impacts from the proposed bypass.
      - A cost-effectiveness analysis of alternatives.
      - The minimum and maximum duration of bypass under each alternative.
      - A recommendation as to the preferred alternative for conducting the bypass.
      - The projected date of bypass initiation.
      - A statement of compliance with SEPA.
      - A request for modification of water quality standards as provided for in WAC 173-201A-410, if an exceedance of any water quality standard is anticipated.
      - Details of the steps taken or planned to reduce, eliminate, and prevent recurrence of the bypass.

   b. For probable construction bypasses, the Permittee must notify Ecology of the need to bypass as early in the planning process as possible. The Permittee must consider the analysis required above during the project planning and design process. The project-specific engineering report as well as the plans and specifications must include details of probable construction bypasses to the extent practical. In cases where the Permittee determines the probable need to bypass early, the Permittee must continue to analyze conditions up to and including the construction period in an effort to minimize or eliminate the bypass.

   c. Ecology will determine if the Permittee has met the conditions of special condition S5.F.2 a and b and consider the following prior to issuing a determination letter, an administrative order, or a permit modification as appropriate for an anticipated bypass:

      - If the Permittee planned and scheduled the bypass to minimize adverse effects on the public and the environment.
      - If the bypass is unavoidable to prevent loss of life, personal injury, or severe property damage. “Severe property damage” means substantial physical damage to property, damage to the treatment facilities which would cause them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of a bypass.

- If feasible alternatives to the bypass exist, such as:
  - The use of auxiliary treatment facilities.
  - Retention of untreated wastes.
  - Stopping production.
  - Maintenance during normal periods of equipment downtime, but not if the Permittee should have installed adequate backup equipment in the exercise of reasonable engineering judgment to prevent a bypass which occurred during normal periods of equipment downtime or preventative maintenance.
  - Transport of untreated wastes to another treatment facility.

S5.G. Operations and maintenance (O&M) manual

a. O&M manual submittal and requirements

The Permittee must:

- Update the Operations and Maintenance (O&M) Manual that meets the requirements of 173-240-080 WAC and submit it to Ecology for approval by June 30, 2021.
- Submit to Ecology for review and approval substantial changes or updates to the O&M Manual whenever it incorporates them into the manual. The Permittee must submit a paper copy or an electronic copy via VPN access.
- Keep the approved O&M Manual at the permitted facility.
- Follow the instructions and procedures of this manual.

b. O&M manual components

In addition to the requirements of WAC 173-240-080(1) through (5), the O&M Manual must be consistent with the guidance in Table G1-3 in the *Criteria for Sewage Works Design* (Orange Book), 2008. The O&M Manual must include:

- Emergency procedures for cleanup in the event of wastewater system upset or failure.
- A review of system components which if failed could pollute surface water or could impact human health. Provide a procedure for a routine schedule of checking the function of these components.
- Wastewater system maintenance procedures that contribute to the generation of process wastewater.
- Reporting protocols for submitting reports to Ecology to comply with the reporting requirements in the discharge permit.
- Any directions to maintenance staff when cleaning or maintaining other equipment or performing other tasks which are necessary to protect the operation of the wastewater system (for example, defining maximum allowable discharge rate for draining a tank, blocking all floor drains before beginning the overhaul of a stationary engine).

- The treatment plant process control monitoring schedule.
- Minimum staffing adequate to operate and maintain the treatment processes and carry out compliance monitoring required by the permit.

S6. Pretreatment

S6.A. General requirements

The Permittee must work with Ecology to ensure that all commercial and industrial users of the publicly owned treatment works (POTW) comply with the pretreatment regulations in 40 CFR Part 403 and any additional regulations that the Environmental Protection Agency (U.S. EPA) may promulgate under Section 307(b) (pretreatment) and 308 (reporting) of the Federal Clean Water Act.

S6.B. Duty to enforce discharge prohibitions

1. Under federal regulations (40 CFR 403.5(a) and (b)), the Permittee must not authorize or knowingly allow the discharge of any pollutants into its POTW which may be reasonably expected to cause pass through or interference, or which otherwise violate general or specific discharge prohibitions contained in 40 CFR Part 403.5 or WAC 173-216-060.
2. The Permittee must not authorize or knowingly allow the introduction of any of the following into their treatment works:

   a. Pollutants which create a fire or explosion hazard in the POTW (including, but not limited to waste streams with a closed cup flashpoint of less than 140 degrees Fahrenheit or 60 degrees Centigrade using the test methods specified in 40 CFR 261.21).

   b. Pollutants which will cause corrosive structural damage to the POTW, but in no case discharges with pH lower than 5.0, or greater than 11.0 standard units, unless the works are specifically designed to accommodate such discharges.

   c. Solid or viscous pollutants in amounts that could cause obstruction to the flow in sewers or otherwise interfere with the operation of the POTW.

   d. Any pollutant, including oxygen-demanding pollutants, (BOD_5, etc.) released in a discharge at a flow rate and/or pollutant concentration which will cause interference with the POTW.

   e. Petroleum oil, non-biodegradable cutting oil, or products of mineral origin in amounts that will cause interference or pass through.

   f. Pollutants which result in the presence of toxic gases, vapors, or fumes within the POTW in a quantity which may cause acute worker health and safety problems.

   g. Heat in amounts that will inhibit biological activity in the POTW resulting in interference but in no case heat in such quantities such that the temperature at the POTW headworks exceeds 40 degrees Centigrade (104 degrees Fahrenheit) unless Ecology, upon request of the Permittee, approves, in writing, alternate temperature limits.

h. Any trucked or hauled pollutants, except at discharge points designated by the Permittee.

i. Wastewaters prohibited to be discharged to the POTW by the Dangerous Waste Regulations (chapter 173-303 WAC), unless authorized under the Domestic Sewage Exclusion (WAC 173-303-071).

3. The Permittee must also not allow the following discharges to the POTW unless approved in writing by Ecology:

   a. Noncontact cooling water in significant volumes.

   b. Stormwater and other direct inflow sources.

   c. Wastewaters significantly affecting system hydraulic loading, which do not require treatment, or would not be afforded a significant degree of treatment by the system.

4. The Permittee must notify Ecology if any industrial user violates the prohibitions listed in this section (S6.B), and initiate enforcement action to promptly curtail any such discharge.

S6.C. Wastewater discharge permit required

The Permittee must:

1. Establish a process for authorizing non-domestic wastewater discharges that ensures all SIUs in all tributary areas meet the applicable state waste discharge permit (SWDP) requirements in accordance with chapter 90.48 RCW and chapter 173-216 WAC.

2. Immediately notify Ecology of any proposed discharge of wastewater from a source, which may be a significant industrial user (SIU) [see fact sheet definitions or refer to 40 CFR 403.3(v)(i)(ii)].

3. Require all SIUs to obtain a SWDP from Ecology prior to accepting their non-domestic wastewater, or require proof that Ecology has determined they do not require a permit.

4. Require the documentation as described in S6.C.3 at the earliest practicable date as a condition of continuing to accept non-domestic wastewater discharges from a previously undiscovered, currently discharging and unpermitted SIU.

5. Require sources of non-domestic wastewater, which do not qualify as SIUs but merit a degree of oversight, to apply for a SWDP and provide it a copy of the application and any Ecology responses.

6. Keep all records documenting that its users have met the requirements of S6.C.

S6.D. Identification and reporting of existing, new, and proposed industrial users

1. The Permittee must take continuous, routine measures to identify all existing, new, and proposed SIUs and potential significant industrial users (PSIUs) discharging or proposing to discharge to the Permittee's sewer system (see **Appendix C** of the fact sheet for definitions).

2. Within 30 days of becoming aware of an unpermitted existing, new, or proposed industrial user who may be a significant industrial user (SIU), the Permittee must notify such user by registered mail that, if classified as an SIU, they must apply to Ecology and obtain a State Waste Discharge Permit. The Permittee must send a copy of this notification letter to Ecology within this same 30-day period.
3. The Permittee must also notify all Potential SIUs (PSIUs), as they are identified, that if their classification should change to an SIU, they must apply to Ecology for a State Waste Discharge Permit within 30 days of such change.

S6.E. Industrial user survey

The Permittee must complete an industrial user survey listing all SIUs and PSIUs discharging to the POTW. The Permittee must submit the survey to Ecology by June 30, 2022. At a minimum, the Permittee must develop the list of SIUs and PSIUs by means of a telephone book search, a water utility billing records search, and a physical reconnaissance of the service area. Information on PSIUs must include, at a minimum, the business name, telephone number, address, description of the industrial process(s), and the known wastewater volumes and characteristics.

S7. Solid wastes

S7.A. Solid waste handling

The Permittee must handle and dispose of all solid waste material in such a manner as to prevent its entry into state ground or surface water.

S7.B. Leachate

The Permittee must not allow leachate from its solid waste material to enter state waters without providing all known, available, and reasonable methods of treatment, nor allow such leachate to cause violations of the State Surface Water Quality Standards, Chapter 173-201A WAC, or the State Ground Water Quality Standards, Chapter 173-200 WAC. The Permittee must apply for a permit or permit modification as may be required for such discharges to state ground or surface waters.

S8. Outfall evaluation

The Permittee must inspect, once per permit cycle, the submerged portion of the outfall line and diffuser to document its integrity and continued function. If conditions allow for a photographic verification, the Permittee must include such verification in the report. By January 31, 2021, the Permittee must submit the inspection report to Ecology through the Water Quality Permitting Portal – Permit Submittals application. The Permittee must submit hard-copies of any video files to Ecology as required by Permit Condition S3.B. The Portal does not support submittal of video files.

The inspector must at a minimum:

- Assess the physical condition of the outfall pipe, diffuser, and associated couplings.
- Determine the extent of sediment accumulation in the vicinity of the diffuser.

- Ensure diffuser ports are free of obstructions and are allowing uniform flow.
- Confirm physical location (latitude/longitude) and depth (at MLLW) of the diffuser section of the outfall.
- Assess physical condition of the submarine line.
- Assess physical condition of anchors used to secure the submarine line.

S9. Application for permit renewal or modification for facility changes

The Permittee must submit an application for renewal of this permit by August 31, 2022. The Permittee must submit a paper copy and an electronic copy (preferably as a PDF).

The Permittee must also submit a new application or addendum at least one hundred eighty (180) days prior to commencement of discharges, resulting from the activities listed below, which may result in permit violations. These activities include any facility expansions, production increases, or other planned changes, such as process modifications, in the permitted facility.

General Conditions

G1. Signatory requirements

1. All applications submitted to Ecology must be signed and certified.
   a. In the case of corporations, by a responsible corporate officer. For the purpose of this section, a responsible corporate officer means:
      - A president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy or decision making functions for the corporation, or
      - The manager of one or more manufacturing, production, or operating facilities, provided, the manager is authorized to make management decisions which govern the operation of the regulated facility including having the explicit or implicit duty of making major capital investment recommendations, and initiating and directing other comprehensive measures to assure long-term environmental compliance with environmental laws and regulations; the manager can ensure that the necessary systems are established or actions taken to gather complete and accurate information for permit application requirements; and where authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures.

   b. In the case of a partnership, by a general partner.
   c. In the case of sole proprietorship, by the proprietor.
   d. In the case of a municipal, state, or other public facility, by either a principal executive officer or ranking elected official.

   Applications for permits for domestic wastewater facilities that are either owned or operated by, or under contract to, a public entity shall be submitted by the public entity.

2. All reports required by this permit and other information requested by Ecology must be signed by a person described above or by a duly authorized representative of that person. A person is a duly authorized representative only if:
   a. The authorization is made in writing by a person described above and submitted to Ecology.
   b. The authorization specifies either an individual or a position having responsibility for the overall operation of the regulated facility, such as the position of plant manager, superintendent, position of equivalent responsibility, or an individual or position having overall responsibility for environmental matters. (A duly authorized representative may thus be either a named individual or any individual occupying a named position.)

3. Changes to authorization. If an authorization under paragraph G1.2, above, is no longer accurate because a different individual or position has responsibility for the

overall operation of the facility, a new authorization satisfying the requirements of paragraph G1.2, above, must be submitted to Ecology prior to or together with any reports, information, or applications to be signed by an authorized representative.

4. Certification. Any person signing a document under this section must make the following certification:

   "I certify under penalty of law, that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

G2. Right of inspection and entry

The Permittee must allow an authorized representative of Ecology, upon the presentation of credentials and such other documents as may be required by law:

1. To enter upon the premises where a discharge is located or where any records must be kept under the terms and conditions of this permit.
2. To have access to and copy, at reasonable times and at reasonable cost, any records required to be kept under the terms and conditions of this permit.
3. To inspect, at reasonable times, any facilities, equipment (including monitoring and control equipment), practices, methods, or operations regulated or required under this permit.
4. To sample or monitor, at reasonable times, any substances or parameters at any location for purposes of assuring permit compliance or as otherwise authorized by the Clean Water Act.

G3. Permit actions

This permit may be modified, revoked and reissued, or terminated either at the request of any interested person (including the Permittee) or upon Ecology's initiative. However, the permit may only be modified, revoked and reissued, or terminated for the reasons specified in 40 CFR 122.62, 40 CFR 122.64 or WAC 173-220-150 according to the procedures of 40 CFR 124.5.

1. The following are causes for terminating this permit during its term, or for denying a permit renewal application:
   a. Violation of any permit term or condition.
   b. Obtaining a permit by misrepresentation or failure to disclose all relevant facts.
   c. A material change in quantity or type of waste disposal.

   d. A determination that the permitted activity endangers human health or the environment, or contributes to water quality standards violations and can only be regulated to acceptable levels by permit modification or termination.
   e. A change in any condition that requires either a temporary or permanent reduction, or elimination of any discharge or sludge use or disposal practice controlled by the permit.
   f. Nonpayment of fees assessed pursuant to RCW 90.48.465.
   g. Failure or refusal of the Permittee to allow entry as required in RCW 90.48.090.

2. The following are causes for modification but not revocation and reissuance except when the Permittee requests or agrees:
   a. A material change in the condition of the waters of the state.
   b. New information not available at the time of permit issuance that would have justified the application of different permit conditions.
   c. Material and substantial alterations or additions to the permitted facility or activities which occurred after this permit issuance.
   d. Promulgation of new or amended standards or regulations having a direct bearing upon permit conditions, or requiring permit revision.
   e. The Permittee has requested a modification based on other rationale meeting the criteria of 40 CFR Part 122.62.
   f. Ecology has determined that good cause exists for modification of a compliance schedule, and the modification will not violate statutory deadlines.
   g. Incorporation of an approved local pretreatment program into a municipality's permit.

3. The following are causes for modification or alternatively revocation and reissuance:
   a. When cause exists for termination for reasons listed in 1.a through 1.g of this section, and Ecology determines that modification or revocation and reissuance is appropriate.
   b. When Ecology has received notification of a proposed transfer of the permit. A permit may also be modified to reflect a transfer after the effective date of an automatic transfer (General Condition G7) but will not be revoked and reissued after the effective date of the transfer except upon the request of the new Permittee.

G4. Reporting planned changes

The Permittee must, as soon as possible, but no later than one hundred eighty (180) days prior to the proposed changes, give notice to Ecology of planned physical alterations or additions to the permitted facility, production increases, or process modification which will result in:

1. The permitted facility being determined to be a new source pursuant to 40 CFR 122.29(b).
2. A significant change in the nature or an increase in quantity of pollutants discharged.
3. A significant change in the Permittee's sludge use or disposal practices. Following such notice, and the submittal of a new application or supplement to the existing application, along with required engineering plans and reports, this permit may be modified, or revoked and reissued pursuant to 40 CFR 122.62(a) to specify and limit any pollutants not previously limited. Until such modification is effective, any new or increased discharge in excess of permit limits or not specifically authorized by this permit constitutes a violation.

G5. Plan review required

Prior to constructing or modifying any wastewater control facilities, an engineering report and detailed plans and specifications must be submitted to Ecology for approval in accordance with chapter 173-240 WAC. Engineering reports, plans, and specifications must be submitted at least one hundred eighty (180) days prior to the planned start of construction unless a shorter time is approved by Ecology. Facilities must be constructed and operated in accordance with the approved plans.

G6. Compliance with other laws and statutes

Nothing in this permit excuses the Permittee from compliance with any applicable federal, state, or local statutes, ordinances, or regulations.

G7. Transfer of this permit

In the event of any change in control or ownership of facilities from which the authorized discharge emanate, the Permittee must notify the succeeding owner or controller of the existence of this permit by letter, a copy of which must be forwarded to Ecology.

1. Transfers by Modification

   Except as provided in paragraph (2) below, this permit may be transferred by the Permittee to a new owner or operator only if this permit has been modified or revoked and reissued under 40 CFR 122.62(b)(2), or a minor modification made under 40 CFR 122.63(d), to identify the new Permittee and incorporate such other requirements as may be necessary under the Clean Water Act.

2. Automatic Transfers

   This permit may be automatically transferred to a new Permittee if:

   a. The Permittee notifies Ecology at least thirty (30) days in advance of the proposed transfer date.
   b. The notice includes a written agreement between the existing and new Permittees containing a specific date transfer of permit responsibility, coverage, and liability between them.

c. Ecology does not notify the existing Permittee and the proposed new Permittee of its intent to modify or revoke and reissue this permit. A modification under this subparagraph may also be minor modification under 40 CFR 122.63. If this notice is not received, the transfer is effective on the date specified in the written agreement.

G8. Reduced production for compliance

The Permittee, in order to maintain compliance with its permit, must control production and/or all discharges upon reduction, loss, failure, or bypass of the treatment facility until the facility is restored or an alternative method of treatment is provided. This requirement applies in the situation where, among other things, the primary source of power of the treatment facility is reduced, lost, or fails.

G9. Removed substances

Collected screenings, grit, solids, sludges, filter backwash, or other pollutants removed in the course of treatment or control of wastewaters must not be resuspended or reintroduced to the final effluent stream for discharge to state waters.

G10. Duty to provide information

The Permittee must submit to Ecology, within a reasonable time, all information which Ecology may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit or to determine compliance with this permit. The Permittee must also submit to Ecology upon request, copies of records required to be kept by this permit.

G11. Other requirements of 40 CFR

All other requirements of 40 CFR 122.41 and 122.42 are incorporated in this permit by reference.

G12. Additional monitoring

Ecology may establish specific monitoring requirements in addition to those contained in this permit by administrative order or permit modification.

G13. Payment of fees

The Permittee must submit payment of fees associated with this permit as assessed by Ecology.

G14. Penalties for violating permit conditions

Any person who is found guilty of willfully violating the terms and conditions of this permit is deemed guilty of a crime, and upon conviction thereof shall be punished by a fine of up to ten thousand dollars ($10,000) and costs of prosecution, or by imprisonment in the discretion of the court. Each day upon which a willful violation occurs may be deemed a separate and additional violation.

Any person who violates the terms and conditions of a waste discharge permit may incur, in addition to any other penalty as provided by law, a civil penalty in the amount of up to ten thousand dollars ($10,000) for every such violation. Each and every such violation is a separate and distinct offense, and in case of a continuing violation, every day's continuance is deemed to be a separate and distinct violation.

G15. Upset

Definition – “Upset” means an exceptional incident in which there is unintentional and temporary noncompliance with technology-based permit effluent limits because of factors beyond the reasonable control of the Permittee. An upset does not include noncompliance to the extent caused by operational error, improperly designed treatment facilities, inadequate treatment facilities, lack of preventive maintenance, or careless or improper operation.

An upset constitutes an affirmative defense to an action brought for noncompliance with such technology-based permit effluent limits if the requirements of the following paragraph are met.

A Permittee who wishes to establish the affirmative defense of upset must demonstrate, through properly signed, contemporaneous operating logs, or other relevant evidence that:

1. An upset occurred and that the Permittee can identify the cause(s) of the upset.
2. The permitted facility was being properly operated at the time of the upset.
3. The Permittee submitted notice of the upset as required in Special Condition S3.F.
4. The Permittee complied with any remedial measures required under S3.F of this permit.

In any enforcement action the Permittee seeking to establish the occurrence of an upset has the burden of proof.

G16. Property rights

This permit does not convey any property rights of any sort, or any exclusive privilege.

G17. Duty to comply

The Permittee must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the Clean Water Act and is grounds for enforcement action; for permit termination, revocation and reissuance, or modification; or denial of a permit renewal application.

G18. Toxic pollutants

The Permittee must comply with effluent standards or prohibitions established under Section 307(a) of the Clean Water Act for toxic pollutants within the time provided in the regulations that establish those standards or prohibitions, even if this permit has not yet been modified to incorporate the requirement.

G19. Penalties for tampering

The Clean Water Act provides that any person who falsifies, tampers with, or knowingly renders inaccurate any monitoring device or method required to be maintained under this permit shall, upon conviction, be punished by a fine of not more than $10,000 per violation, or by imprisonment for not more than two (2) years per violation, or by both. If a conviction of a person is for a violation committed after a first conviction of such person under this condition, punishment shall be a fine of not more than $20,000 per day of violation, or by imprisonment of not more than four (4) years, or by both.

G20. Compliance schedules

Reports of compliance or noncompliance with, or any progress reports on, interim and final requirements contained in any compliance schedule of this permit must be submitted no later than fourteen (14) days following each schedule date.

G21. Service agreement review

The Permittee must submit to Ecology any proposed service agreements and proposed revisions or updates to existing agreements for the operation of any wastewater treatment facility covered by this permit. The review is to ensure consistency with chapters 90.46 and 90.48 RCW as required by RCW 70.150.040(9). In the event that Ecology does not comment within a thirty-day (30) period, the Permittee may assume consistency and proceed with the service agreement or the revised/updated service agreement.

Appendix A

LIST OF POLLUTANTS WITH ANALYTICAL METHODS, DETECTION LIMITS AND QUANTITATION LEVELS

The Permittee must use the specified analytical methods, detection limits (DLs) and quantitation levels (QLs) in the following table for permit and application required monitoring unless:

- Another permit condition specifies other methods, detection levels, or quantitation levels.
- The method used produces measurable results in the sample and EPA has listed it as an EPA-approved method in 40 CFR Part 136.

If the Permittee uses an alternative method, not specified in the permit and as allowed above, it must report the test method, DL, and QL on the discharge monitoring report or in the required report.

If the Permittee is unable to obtain the required DL and QL in its effluent due to matrix effects, the Permittee must submit a matrix-specific detection limit (MDL) and a quantitation limit (QL) to Ecology with appropriate laboratory documentation.

Ecology added this appendix to the permit in order to reduce the number of analytical "non-detects" in permit-required monitoring and to measure effluent concentrations near or below criteria values where possible at a reasonable cost.

CONVENTIONAL POLLUTANTS

Pollutant	CAS Number (if available)	Recommended Analytical Protocol	Detection (DL)[1] *µg/L unless specified*	Quantitation Level (QL)[2] *µg/L unless specified*
Biochemical Oxygen Demand		SM5210-B		2 mg/L
Fecal Coliform		SM 9221E,9222	N/A	Specified in method - sample aliquot dependent
Oil and Grease (HEM) (Hexane Extractable Material)		1664 A or B	1,400	5,000
pH		SM4500-H^+ B	N/A	N/A
Total Suspended Solids		SM2540-D		5 mg/L

NONCONVENTIONAL POLLUTANTS

Pollutant & CAS No. (if available)	CAS Number (if available)	Recommended Analytical Protocol	Detection (DL)[1] µg/L unless specified	Quantitation Level (QL)[2] µg/L unless specified
Ammonia, Total (as N)		SM4500-NH3-B and C/D/E/G/H		20
Chlorine, Total Residual		SM4500 Cl G		50.0
Dissolved oxygen		SM4500-OC/OG		0.2 mg/L
Flow		Calibrated device		
Hardness, Total		SM2340B		200 as CaCO3
Nitrate + Nitrite Nitrogen (as N)		SM4500-NO3- E/F/H		100
Nitrogen, Total Kjeldahl (as N)		SM4500-N_{org}B/C and SM4500NH_3-B/C/D/EF/G/H		300
Phosphorus, Total (as P)		SM 4500 PB followed by SM4500-PE/PF	3	10

NONCONVENTIONAL POLLUTANTS

Pollutant & CAS No. (if available)	CAS Number (if available)	Recommended Analytical Protocol	Detection (DL)[1] µg/L unless specified	Quantitation Level (QL)[2] µg/L unless specified
Soluble Reactive Phosphorus (as P)		SM4500-P E/F/G	3	10
Temperature (max. 7-day avg.)		Analog recorder or use micro-recording devices known as thermistors		0.2º C
Total dissolved solids		SM2540 C		20 mg/L

1. Detection level (DL) or detection limit means the minimum concentration of an analyte (substance) that can be measured and reported with a 99% confidence that the analyte concentration is greater than zero as determined by the procedure given in 40 CFR part 136, Appendix B.

2. Quantitation Level (QL) also known as Minimum Level of Quantitation (ML) – The lowest level at which the entire analytical system must give a recognizable signal and acceptable calibration point for the analyte. It is equivalent to the concentration of the lowest calibration standard, assuming that the lab has used all method-specified sample weights, volumes, and cleanup procedures. The QL is calculated by multiplying the MDL by 3.18 and rounding the result to the number nearest to (1, 2, or 5) x 10^n, where n is an integer (64 FR 30417).
   ALSO GIVEN AS:
   The smallest detectable concentration of analyte greater than the Detection Limit (DL) where the accuracy (precision & bias) achieves the objectives of the intended purpose. (Report of the Federal Advisory Committee on Detection and Quantitation Approaches and Uses in Clean Water Act Programs Submitted to the US Environmental Protection Agency, December 2007).

Fact Sheet for NPDES Permit WA0023701

Manchester Wastewater Treatment Plant

Effective Date: March 1, 2018

Purpose of this fact sheet

This fact sheet explains and documents the decisions the Department of Ecology (Ecology) made in drafting the proposed National Pollutant Discharge Elimination System (NPDES) permit for Kitsap County Manchester Wastewater Treatment Plant (WWTP).

This fact sheet complies with Section 173-220-060 of the Washington Administrative Code (WAC), which requires Ecology to prepare a draft permit and accompanying fact sheet for public evaluation before issuing an NPDES permit.

Ecology makes the draft permit and fact sheet available for public review and comment at least thirty (30) days before issuing the final permit. Copies of the fact sheet and draft permit for Manchester WWTP, NPDES permit WA0023701, were available for public review and comment from December 11, 2017 until January 10, 2018. For more details on preparing and filing comments about these documents, please see *Appendix A - Public Involvement Information.*

Kitsap County reviewed the draft permit and fact sheet for factual accuracy. Ecology corrected any errors or omissions regarding the facility's location, history, wastewater discharges, or receiving water prior to publishing this draft fact sheet for public notice.

After the public comment period closes, Ecology summarized substantive comments and provide responses to them. Ecology included the summary and responses to comments in this fact sheet as *Appendix E - Response to Comments*, and publish it when issuing the final NPDES permit. Ecology generally does not revise the rest of the fact sheet. The full document becomes part of the legal history contained in the facility's permit file.

Summary

Kitsap County owns and operates the Manchester WWTP located in the City of Manchester. The treatment system at the facility utilizes a conventional activated sludge process for the secondary treatment of wastewater. The secondary treated and disinfected effluent from the plant discharges to Rich Passage - Puget Sound.

Ecology issued the previous permit for this facility on February 12, 2013. The proposed permit contains the same effluent limits for 5-day Biochemical Oxygen Demand (BOD_5), Total Suspended Solids (TSS), Fecal Coliform Bacteria, and pH as the previous permit.

Table of Contents

I. Introduction

The Federal Clean Water Act (FCWA, 1972, and later amendments in 1977, 1981, and 1987) established water quality goals for the navigable (surface) waters of the United States. One mechanism for achieving the goals of the Clean Water Act is the National Pollutant Discharge Elimination System (NPDES), administered by the federal Environmental Protection Agency (EPA). The EPA authorized the state of Washington to manage the NPDES permit program in our state. Our state legislature accepted the delegation and assigned the power and duty for conducting NPDES permitting and enforcement to Ecology. The Legislature defined Ecology's authority and obligations for the wastewater discharge permit program in 90.48 RCW (Revised Code of Washington).

The following regulations apply to domestic wastewater NPDES permits:

- Procedures Ecology follows for issuing NPDES permits (chapter 173-220 WAC).
- Technical criteria for discharges from municipal wastewater treatment facilities (chapter 173-221 WAC).
- Water quality criteria for surface waters (chapter 173-201A WAC).
- Water quality criteria for groundwaters (chapter 173-200 WAC).
- Whole effluent toxicity testing and limits (chapter 173-205 WAC).
- Sediment management standards (chapter 173-204 WAC).
- Submission of plans and reports for construction of wastewater facilities (chapter 173-240 WAC).

These rules require any treatment facility owner/operator to obtain an NPDES permit before discharging wastewater to state waters. They also help define the basis for limits on each discharge and for requirements imposed by the permit.

Under the NPDES permit program and in response to a complete and accepted permit application, Ecology must prepare a draft permit and accompanying fact sheet, and make them available for public review before final issuance. Ecology must also publish an announcement (public notice) telling people where they can read the draft permit, and where to send their comments, during a period of thirty days (WAC 173-220-050). (See *Appendix A - Public Involvement Information* for more detail about the public notice and comment procedures). After the public comment period ends, Ecology may make changes to the draft NPDES permit in response to comment(s). Ecology will summarize the responses to comments and any changes to the permit in *Appendix E*.

II. Background Information

Table 1. General Facility Information

Facility Information	
Applicant	Kitsap County Public Works 12351 Brownsville Highway NE Poulsbo, WA 98370
Facility Name and Address	Manchester WWTP 8020 East Caraway Road Manchester, WA 98353
Contact at Facility	Patrick Kongslie Utility Operations Supervisor Phone: 360-337-5768
Responsible Official	Stella Vakarcs Senior Program Manager – Sewer Utility Kitsap County Public Works 12351 Brownsville Highway NE Poulsbo, WA 98370 Phone: 360-337-7197
Type of Treatment	Activated Sludge
Facility Location (NAD83/WGS84 reference datum)	Latitude: 47.558889° Longitude: -122.545277°
Discharge Waterbody Name and Location (NAD83/WGS84 reference datum)	Rich Passage, Puget Sound Outfall 001: Latitude: 47.557778° Longitude: -122.538333°

Permit Status	
Issuance Date of Previous Permit	February 25, 2008
Application for Permit Renewal Submittal Date	August 28, 2017
Date of Ecology Acceptance of Application	September 8, 2017

Inspection Status	
Date of Last Non-sampling Inspection Date	October 3, 2017

Figure 1. Facility Location Map

A. Facility description

History

The facility was built in 1991 as a 0.23 MGD sequencing batch reactor system, and in 1998 was expanded and converted to a 0.46 MGD conventional activated sludge system.

Collection system status

Domestic sewage from residential and light commercial activities is the primary source of wastewater collected at the facility. Additionally, the facility treats domestic wastewater from the Manchester State Park, wastewater from the Environmental Protection Agency (EPA)/Ecology Accreditation laboratory, and sewage from the Manchester Naval Fuel Depot. The latter consists of domestic sewage from on-shore facilities and gray water from ships that dock at the Naval Fuel Depot. Non-domestic wastewater from the Ecology/EPA laboratory is pretreated for pH adjustment prior to discharge into the Kitsap County sewage pump station. The laboratory waste stream is collected into separate mixing tanks equipped with mechanical mixer, pH meter, and metering pump to add either sodium hydroxide or sulfuric acid to the mixing tanks. The average volume of laboratory wastes generated is approximately 1,132 gallons per day per the 2017 Industrial User Survey.

The collection system consists of PVC, asbestos cement, concrete and ductile iron pipes, all with rubber-gasketed joints. The majority of the collection system is gravity. There are six pump stations in the service area. Five pump stations have the capability to be hooked up to a trailer-mounted portable generator and one pump station has a 45-Kilowatt onsite generator. The permittee has pump station improvement projects (Pump Stations No. 45, No. 46, and No. 47) under construction which will be completed in 2018. In addition, the permittee has proposed a new pump station project (Pump Station No. 74) in the Yukon Harbor area and plans to begin construction in 2018.

The last infiltration and inflow (I&I) analysis was conducted in 2010 and indicated non-excessive I&I. However, in more recent years, the County has observed higher infiltration flows during wet weather months when groundwater level is higher. A further evaluation would help to better assess the extent of the infiltration observed during the previous permit cycle (see permit Condition S4.E).

Treatment processes

The treatment process at this facility consists of a conventional activated sludge secondary treatment system. The liquid treatment system includes influent pumping, a rotary fine screen and a manual bypass bar screen, a grit removal system, two aeration basins, two secondary clarifiers, a two-bank ultraviolet (UV) disinfection system. The facility is equipped with a 350-Kilowatt generator that can operate the entire plant in emergencies. The facility does not accept septage. Appendix D shows the treatment process schematic.

You can find basic information describing wastewater treatment processes included in a booklet at the Water Environment Federation website at:
http://www.wef.org/resources/for-the-public/public-information/

Solid wastes/Residual solids

The treatment facilities remove solids during the treatment of the wastewater at the headworks (grit and screenings), and at the secondary clarifiers, in addition to incidental solids (rags, scum, and other debris) removed as part of the routine maintenance of the equipment. Sludge removed from the secondary clarifiers is thickened by a gravity belt thickener and thickened sludge is stored in the sludge storage tanks. The thickened sludge is transported to the Kitsap County's Central Kitsap Wastewater Treatment Plant for further treatment by anaerobic digestion. The liquid from the thickening process flows by gravity back to the wetwell at the Influent Pump Station. The Kitsap County drains grit, rags, and screenings and disposes of this solid waste at the local landfill. This facility has met the solid waste requirements for screening, as required by WAC 173-308-205, by a rotary fine screen (1/4 inch) at the headworks.

Discharge outfall

The treated and disinfected effluent flows into Rich Passage, Puget Sound, through an outfall 001 which includes a diffuser consisting of a 12-inch diameter cast iron pipe and a vertical riser with a 12” x 6” reducer. The outfall discharge is 35 feet below mean lower low water (MLLW) and approximately 600 feet from the shoreline.

Staff

In accordance with WAC 173-230-140, this is a Class II plant. A Class II operator must be in responsible charge of the plant, and the operator in charge of each shift must be certified at a level of Class I or higher. Staff include certified operators (Group IV, Group II, and Group I). This facility is attended daily. On holidays and off-hours there is always someone on call. Staff at the Central Kitsap WWTP can provide operation assistance as needed.

B. Description of the receiving water

Manchester WWTP discharges to Rich Passage, Puget Sound. There are no other nearby point source outfalls.

The ambient background data used for this permit includes the following from two of Ecology’s long-term monitoring stations (1) PSB003 (Puget Sound Main basin –West Point) and (2) EAP001 (East passage – SW of Three Tree Point) (https://fortress.wa.gov/ecy/eap/marinewq/mwdataset.asp). Ecology does not have a water quality monitoring station in the immediate vicinity of this facility’s outfall. The two monitoring stations selected for ambient background data for this facility are Ecology’s long-term monitoring stations closest to the facility’s outfall and in the open waters of Puget Sound, where ambient conditions are similar to the ambient environment in the vicinity of this facility’s outfall.

Table 2. Ambient Background Data

Parameter		Value Used
Temperature (highest annual 1-DADMax)		15.0^{o} C
Temperature (90th percentile)		13.5^{o} C
pH	maximum	8.7 standard units
	minimum	6.7 standard units
Fecal Coliform	dry weather	1/100 mL
	wet weather	1/100 mL
Salinity (90th percentile)		30.0 psu

C. Wastewater influent characterization

The Kitsap County reported the concentration of influent pollutants in discharge monitoring reports. The tabulated data represents the quality of the wastewater influent from March 2013 to September 2017. The influent wastewater is characterized as follows:

Table 3. Wastewater Influent Characterization

Parameter	Units	Monthly Average Value	Maximum Day Value
BOD_5	mg/L	245	1,172*
BOD_5	lbs/day	375	1,632*
TSS	mg/L	250	2,130*
TSS	lbs/day	381	2,966*

* High loadings occurred one day only due to construction activities in the collection system.

D. Wastewater effluent characterization

The Kitsap County reported the concentration of pollutants in the discharge in the permit application and in discharge monitoring reports. The tabulated data represents the quality of the wastewater effluent discharged from March 2013 to September 2017. The wastewater effluent is characterized as follows:

Table 4. Wastewater Effluent Characterization

Parameter	Units	Monthly Average Value	Weekly Average Value
BOD_5	mg/L	5.2	6.5
BOD_5	lbs/day	8	12
TSS	mg/L	6	7.6
TSS	lbs/day	10	14

Parameter	Units	Maximum Monthly Geometric Mean	Maximum Weekly Geometric Mean
Fecal Coliforms	#/100 mL	46	202

Parameter	Units	Minimum Value	Maximum Value
pH	Standard units	6.5	8.7

Parameter	Units	Monthly Average Value	Maximum Day Value
Flow	MGD	0.2	0.7

Parameter	Units	Average Value	Maximum Daily Value
Temperature (Summer)	°C	20.8	22.3

Parameter	Units	Average Value	Maximum Daily Value
Ammonia	mg/L as N	2.72	16.4
Nitrate+Nitrite Nitrogen	mg/L as N	4.12	7.62
TKN	mg/L as N	4.64	12.5

Parameter	Units	Average Value	Maximum Daily Value
Dissolved Oxygen	mg/L	7.6	11.3
Oil and Grease	mg/L	5	5
TDS	mg/L	482	541
Total Phosphorus	mg/L as P	2.87	6.48

E. Summary of compliance with previous permit issued February 12, 2013

The previous permit placed effluent limits on BOD_5, TSS, fecal coliform, and pH.

The Manchester WWTP has complied with the effluent limits and permit conditions throughout the duration of the permit issued on February 12, 2013. Ecology assessed compliance based on its review of the facility's information in the Ecology Permitting and Reporting Information System (PARIS), discharge monitoring reports (DMRs) and on inspections. The facility received Ecology's Outstanding Treatment Plant Performance Awards from 1995 to 2016.

The permittee meets compliance with report submittal requirements over the permit term.

Table 5. Permit Submittals

Submittal Name	Due Date	Received Date
Industrial User Survey	August 28, 2017	August 18, 2017
Application for Permit Renewal	August 28, 2017	August 25, 2017

F. State environmental policy act (SEPA) compliance

State law exempts the issuance, reissuance or modification of any wastewater discharge permit from the SEPA process as long as the permit contains conditions that are no less stringent than federal and state rules and regulations (RCW 43.21C.0383). The exemption applies only to existing discharges, not to new discharges.

III. Proposed Permit Limits

Federal and state regulations require that effluent limits in an NPDES permit must be either technology- or water quality-based.

- Technology-based limits are based upon the treatment methods available to treat specific pollutants. Technology-based limits are set by the EPA and published as a regulation, or Ecology develops the limit on a case-by-case basis (40 CFR 125.3, and chapter 173-220 WAC).
- Water quality-based limits are calculated so that the effluent will comply with the Surface Water Quality Standards (chapter 173-201A WAC), Ground Water Standards (chapter 173-200 WAC), Sediment Quality Standards (chapter 173-204 WAC), or the National Toxics Rule (40 CFR 131.36).
- Ecology must apply the most stringent of these limits to each parameter of concern. These limits are described below.

The limits in this permit reflect information received in the application and from supporting reports (engineering, hydrogeology, etc.). Ecology evaluated the permit application and determined the limits needed to comply with the rules adopted by the state of Washington. Ecology does not develop effluent limits for all reported pollutants. Some pollutants are not treatable at the concentrations reported, are not controllable at the source, are not listed in regulation, and do not have a reasonable potential to cause a water quality violation.

Ecology does not usually develop limits for pollutants not reported in the permit application but may be present in the discharge. The permit does not authorize discharge of the non-reported pollutants. During the five-year permit term, the facility's effluent discharge conditions may change from those conditions reported in the permit application. The facility must notify Ecology if significant changes occur in any constituent [40 CFR 122.42(a)]. Until Ecology modifies the permit to reflect additional discharge of pollutants, a permitted facility could be violating its permit.

A. Design criteria

Under WAC 173-220-150 (1)(g), flows and waste loadings must not exceed approved design criteria. Ecology approved design criteria for this facility in *Manchester Wastewater Facilities Plan Addendum and Engineering Report, CH2M Hill, December 1996.* The table below includes design criteria from the referenced report.

Table 6. Design Criteria for Manchester WWTP

Parameter	Design Quantity
Maximum Month Design Flow (MMDF)	0.46 MGD
BOD_5 Loading for Maximum Month	832 lbs/day
TSS Loading for Maximum Month	832 lbs/day

B. Technology-based effluent limits

Federal and state regulations define technology-based effluent limits for domestic wastewater treatment plants. These effluent limits are given in 40 CFR Part 133 (federal) and in chapter 173-221 WAC (state). These regulations are performance standards that constitute all known, available, and reasonable methods of prevention, control, and treatment (AKART) for domestic wastewater.

The table below identifies technology-based limits for pH, fecal coliform, BOD_5, and TSS, as listed in chapter 173-221 WAC. Section III.F of this fact sheet describes the potential for water quality-based limits.

Table 7. Technology-based Limits

Parameter	Average Monthly Limit	Average Weekly Limit
BOD_5 (concentration)	30 mg/L	45 mg/L
	In addition, the BOD_5 effluent concentration must not exceed fifteen percent (15%) of the average influent concentration.	
TSS (concentration)	30 mg/L	45 mg/L
	In addition, the TSS effluent concentration must not exceed fifteen percent (15%) of the average influent concentration.	

Parameter	Monthly Geometric Mean Limit	Weekly Geometric Mean Limit
Fecal Coliform Bacteria	200 organisms/100 mL	400 organisms/100 mL

Parameter	Daily Minimum	Daily Maximum
pH	6.0 standard units	9.0 standard units

Technology-based mass limits are based on WAC 173-220-130(3)(b) and 173-221-030(11)(b). Ecology calculated the monthly and weekly average mass limits for BOD_5 and TSS as follows:

Mass Limit = CL x DF x CF

where:

CL = Technology-based concentration limits listed in the above table

DF = Maximum Monthly Average Design Flow (0.46 MGD)

CF = Conversion factor of 8.34

Table 8. Technology-based Mass Limits

Parameter	Concentration Limit (mg/L)	Mass Limit (lbs/day)
BOD_5 and TSS Monthly Average	30	115
BOD_5 and TSS Weekly Average	45	173

C. Surface water quality-based effluent limits

The Washington State surface water quality standards (chapter 173-201A WAC) are designed to protect existing water quality and preserve the beneficial uses of Washington's surface waters. Waste discharge permits must include conditions that ensure the discharge will meet the surface water quality standards (WAC 173-201A-510). Water quality-based effluent limits may be based on an individual waste load allocation or on a waste load allocation developed during a basin wide total maximum daily load study (TMDL).

Numerical criteria for the protection of aquatic life and recreation

Numerical water quality criteria are listed in the water quality standards for surface waters (chapter 173-201A WAC). They specify the maximum levels of pollutants allowed in receiving water to protect aquatic life and recreation in and on the water. Ecology uses numerical criteria along with chemical and physical data for the wastewater and receiving water to derive the effluent limits in the discharge permit. When surface water quality-based limits are more stringent or potentially more stringent than technology-based limits, the discharge must meet the water quality-based limits.

Numerical criteria for the protection of human health

In 1992, U.S. EPA published 91 numeric water quality criteria for the protection of human health that are applicable to dischargers in Washington State in its National Toxics Rule (40 CFR (EPA, 1992). Ecology submitted a standards revision for 192 new human health criteria for 97 pollutants to EPA on August 1, 2016. In accordance with requirements of CWA section 303(c)(2)(B), EPA finalized 144 new and revised Washington specific human health criteria for priority pollutants, to apply to waters under Washington’s jurisdiction. EPA approved 45 human health criteria as submitted by Washington. The EPA took no action on Ecology submitted criteria for arsenic, dioxin, and thallium. The existing criteria for these three pollutants as adopted in the National Toxics Rule (40 CFR 131.36) remain in effect.

These newly adopted criteria, located in WAC 173-201A-240, are designed to protect humans from exposure to pollutants linked to cancer and other diseases, based on consuming fish and shellfish and drinking contaminated surface waters. The water quality standards also include radionuclide criteria to protect humans from the effects of radioactive substances.

Narrative criteria

Narrative water quality criteria (e.g., WAC 173-201A-240(1); 2006) limit the toxic, radioactive, or other deleterious material concentrations that the facility may discharge to levels below those which have the potential to:

- Adversely affect designated water uses.
- Cause acute or chronic toxicity to biota.
- Impair aesthetic values.
- Adversely affect human health.

Narrative criteria protect the specific designated uses of all fresh waters (WAC 173-201A-200, 2006) and of all marine waters (WAC 173-201A-210, 2006) in the state of Washington.

Antidegradation

Description -- The purpose of Washington's Antidegradation Policy (WAC 173-201A-300-330; 2006) is to:

- Restore and maintain the highest possible quality of the surface waters of Washington.
- Describe situations under which water quality may be lowered from its current condition.
- Apply to human activities that are likely to have an impact on the water quality of surface water.
- Ensure that all human activities likely to contribute to a lowering of water quality, at a minimum, apply all known, available, and reasonable methods of prevention, control, and treatment (AKART).
- Apply three tiers of protection (described below) for surface waters of the state.

Tier I ensures existing and designated uses are maintained and protected and applies to all waters and all sources of pollutions. Tier II ensures that waters of a higher quality than the criteria assigned are not degraded unless such lowering of water quality is necessary and in the overriding public interest. Tier II applies only to a specific list of polluting activities. Tier III prevents the degradation of waters formally listed as "outstanding resource waters," and applies to all sources of pollution.

A facility must prepare a Tier II analysis when all three of the following conditions are met:

- The facility is planning a new or expanded action.
- Ecology regulates or authorizes the action.
- The action has the potential to cause measurable degradation to existing water quality at the edge of a chronic mixing zone.

Facility Specific Requirements -- This facility must meet Tier I requirements.

- Dischargers must maintain and protect existing and designated uses. Ecology must not allow any degradation that will interfere with, or become injurious to, existing or designated uses, except as provided for in chapter 173-201A WAC.

- For waters that do not meet assigned criteria, or protect existing or designated uses, Ecology will take appropriate and definitive steps to bring the water quality back into compliance with the water quality standards.
- Whenever the natural conditions of a water body are of a lower quality than the assigned criteria, the natural conditions constitute the water quality criteria. Where water quality criteria are not met because of natural conditions, human actions are not allowed to further lower the water quality, except where explicitly allowed in chapter 173-201A WAC.

Ecology's analysis described in this section of the fact sheet demonstrates that the proposed permit conditions will protect existing and designated uses of the receiving water.

Mixing zones

A mixing zone is the defined area in the receiving water surrounding the discharge port(s), where wastewater mixes with receiving water. Within mixing zones the pollutant concentrations may exceed water quality numeric standards, so long as the discharge doesn't interfere with designated uses of the receiving water body (for example, recreation, water supply, and aquatic life and wildlife habitat, etc.) The pollutant concentrations outside of the mixing zones must meet water quality numeric standards.

State and federal rules allow mixing zones because the concentrations and effects of most pollutants diminish rapidly after discharge, due to dilution. Ecology defines mixing zone sizes to limit the amount of time any exposure to the end-of-pipe discharge could harm water quality, plants, or fish.

The state's water quality standards allow Ecology to authorize mixing zones for the facility's permitted wastewater discharges only if those discharges already receive all known, available, and reasonable methods of prevention, control, and treatment (AKART). Mixing zones typically require compliance with water quality criteria within a specified distance from the point of discharge and must not use more than 25% of the available width of the water body for dilution [WAC 173-201A-400 (7)(a)(ii-iii) or WAC 173-201A-400(7)(b)(ii-iii)].

Ecology uses modeling to estimate the amount of mixing within the mixing zone. Through modeling Ecology determines the potential for violating the water quality standards at the edge of the mixing zone and derives any necessary effluent limits. Steady-state models are the most frequently used tools for conducting mixing zone analyses. Ecology chooses values for each effluent and for receiving water variables that correspond to the time period when the most critical condition is likely to occur (see Ecology's *Permit Writer's Manual*). Each critical condition parameter, by itself, has a low probability of occurrence and the resulting dilution factor is conservative. The term "reasonable worst-case" applies to these values.

The mixing zone analysis produces a numerical value called a dilution factor (DF). A dilution factor represents the amount of mixing of effluent and receiving water that occurs at the boundary of the mixing zone. For example, a dilution factor of 4 means the effluent is 25% and the receiving water is 75% of the total volume of water at the boundary of the mixing zone. Ecology uses dilution factors with the water quality criteria to calculate reasonable potentials and effluent limits. Water quality standards include both aquatic life-based criteria and human health-based criteria. The former are applied at both the acute and chronic mixing zone boundaries; the latter are applied only at the chronic boundary. The concentration of pollutants at the boundaries of any of these mixing zones may not exceed the numerical criteria for that zone.

Most aquatic life *acute* criteria are based on the assumption that organisms are not exposed to that concentration for more than one hour and more often than one exposure in three years. Most aquatic life *chronic* criteria are based on the assumption that organisms are not exposed to that concentration for more than four consecutive days and more often than once in three years.

The two types of human health-based water quality criteria distinguish between those pollutants linked to non-cancer effects (non-carcinogenic) and those linked to cancer effects (carcinogenic). The human health-based water quality criteria incorporate several exposure and risk assumptions. These assumptions include:

- A 70-year lifetime of daily exposures.
- An ingestion rate for fish or shellfish measured in kg/day.
- An ingestion rate of two and four tenths (2.4) liters/day for drinking water (increased from two liters/day in the 2016 Water Quality Standards update).
- A one-in-one-million cancer risk for carcinogenic chemicals.

This permit authorizes a small acute mixing zone, surrounded by a chronic mixing zone around the point of discharge (WAC 173-201A-400). The water quality standards impose certain conditions before allowing the discharger a mixing zone:

1. **Ecology must specify both the allowed size and location in a permit.**

   The proposed permit specifies the size and location of the allowed mixing zone (as specified below).

2. **The facility must fully apply "all known, available, and reasonable methods of prevention, control and treatment" (AKART) to its discharge.**

   Ecology has determined that the treatment provided at Manchester WWTP meets the requirements of AKART (see "Technology-based Limits").

3. **Ecology must consider critical discharge conditions.**

   Surface water quality-based limits are derived for the water body's critical condition (the receiving water and waste discharge condition with the highest potential for adverse impact on the aquatic biota, human health, and existing or designated waterbody uses). The critical discharge condition is often pollutant-specific or waterbody-specific.

   Critical discharge conditions are those conditions that result in reduced dilution or increased effect of the pollutant. Factors affecting dilution include the depth of water, the density stratification in the water column, the currents, and the rate of discharge. Density stratification is determined by the salinity and temperature of the receiving water. Temperatures are warmer in the surface waters in summer. Therefore, density stratification is generally greatest during the summer months. Density stratification affects how far up in the water column a freshwater plume may rise. The rate of mixing is greatest when an effluent is rising. The effluent stops rising when the mixed effluent is the same density as the surrounding water. After the effluent stops rising, the rate of mixing is much more gradual. Water depth can affect dilution when a plume might rise to the surface when there is little or no stratification. Ecology uses the water depth at mean lower low water (MLLW) for marine waters. Ecology's *Permit Writer's Manual* describes additional guidance on criteria/design conditions for determining dilution factors. The manual can be obtained from Ecology's website at:

   https://fortress.wa.gov/ecy/publications/summarypages/92109.html

The critical conditions used to model the discharge are shown in the table below. These are taken from the dilution modeling study results presented in the *Manchester Wastewater Facilities Plan Addendum and Engineering Report,* CH2M Hill, December 1996. This report was approved by Ecology on February 27, 1997.

Table 9. Critical Conditions Used to Model the Discharge

Critical Condition	Value
Water depth at MLLW	35 feet
Maximum average monthly effluent flow for chronic and human health non-carcinogen	0.46 MGD
Maximum daily flow for acute mixing zone	0.99 MGD
1 DAD MAX effluent temperature	21°C

4. Supporting information must clearly indicate the mixing zone would not:

- Have a reasonable potential to cause the loss of sensitive or important habitat.
- Substantially interfere with the existing or characteristic uses.
- Result in damage to the ecosystem.
- Adversely affect public health.

Ecology established Washington State water quality criteria for toxic chemicals using EPA criteria. EPA developed the criteria using toxicity tests with numerous organisms and set the criteria to generally protect the species tested and to fully protect all commercially and recreationally important species.

EPA sets acute criteria for toxic chemicals assuming organisms are exposed to the pollutant at the criteria concentration for one hour. They set chronic standards assuming organisms are exposed to the pollutant at the criteria concentration for four days. Dilution modeling under critical conditions generally shows that both acute and chronic criteria concentrations are reached within minutes of discharge.

The discharge plume does not impact drifting and non-strong swimming organisms because they cannot stay in the plume close to the outfall long enough to be affected. Strong swimming fish could maintain a position within the plume, but they can also avoid the discharge by swimming away. Mixing zones generally do not affect benthic organisms (bottom dwellers) because the buoyant plume rises in the water column. Ecology has additionally determined that the effluent will not exceed 33 degrees C for more than two seconds after discharge; and that the temperature of the water will not create lethal conditions or blockages to fish migration.

Ecology evaluates the cumulative toxicity of an effluent by testing the discharge with whole effluent toxicity (WET) testing.

Ecology reviewed the above information, the specific information on the characteristics of the discharge, the receiving water characteristics, and the discharge location. Based on this review, Ecology concluded that the discharge does not have a reasonable potential to cause the loss of sensitive or important habitat, substantially interfere with existing or characteristics uses, result in damage to the ecosystem, or adversely affect public health if the permit limits are met.

5. **The discharge/receiving water mixture must not exceed water quality criteria outside the boundary of a mixing zone.**

   Ecology conducted a reasonable potential analysis, using procedures established by the EPA and by Ecology, for each pollutant and concluded the discharge/receiving water mixture will not violate water quality criteria outside the boundary of the mixing zone if permit limits are met.

6. **The size of the mixing zone and the concentrations of the pollutants must be minimized.**

   At any given time, the effluent plume uses only a portion of the acute and chronic mixing zone, which minimizes the volume of water involved in mixing. Because tidal currents change direction, the plume orientation within the mixing zone changes. The plume mixes as it rises through the water column therefore much of the receiving water volume at lower depths in the mixing zone is not mixed with discharge. Similarly, because the discharge may stop rising at some depth due to density stratification, waters above that depth will not mix with the discharge. Ecology determined it is impractical to specify in the permit the actual, much more limited volume in which the dilution occurs as the plume rises and moves with the current.

   Ecology minimizes the size of mixing zones by requiring dischargers to install diffusers when they are appropriate to the discharge and the specific receiving waterbody. When a diffuser is installed, the discharge is more completely mixed with the receiving water in a shorter time. Ecology also minimizes the size of the mixing zone (in the form of the dilution factor) using design criteria with a low probability of occurrence. For example, Ecology uses the expected 95th percentile pollutant concentration, the 90th percentile background concentration, the centerline dilution factor, and the lowest flow occurring once in every ten years to perform the reasonable potential analysis.

   Because of the above reasons, Ecology has effectively minimized the size of the mixing zone authorized in the proposed permit.

7. **Maximum size of mixing zone.**

   The authorized mixing zone does not exceed the maximum size restriction.

8. **Acute mixing zone.**

   - **The discharge/receiving water mixture must comply with acute criteria as near to the point of discharge as practicably attainable.**

     Ecology determined the acute criteria will be met at 10% of the distance of the chronic mixing zone.

   - **The pollutant concentration, duration, and frequency of exposure to the discharge will not create a barrier to migration or translocation of indigenous organisms to a degree that has the potential to cause damage to the ecosystem.**

     As described above, the toxicity of any pollutant depends upon the exposure, the pollutant concentration, and the time the organism is exposed to that concentration. Authorizing a limited acute mixing zone for this discharge assures that it will not create a barrier to migration. The effluent from this discharge will rise as it enters the receiving water, assuring that the rising effluent will not cause translocation of indigenous organisms near the point of discharge (below the rising effluent).

- **Comply with size restrictions.**

  The mixing zone authorized for this discharge complies with the size restrictions published in chapter 173-201A WAC.

9. Overlap of mixing zones.

This mixing zone does not overlap another mixing zone.

D. Designated uses and surface water quality criteria

Applicable designated uses and surface water quality criteria are defined in chapter 173-201A WAC. In addition, the U.S. EPA set human health criteria for toxic pollutants (EPA 1992). The tables included below summarize the criteria applicable to the receiving water's designated uses.

- Aquatic life uses are designated using the following general categories. All indigenous fish and non-fish aquatic species must be protected in waters of the state.

  a. Extraordinary quality salmonid and other fish migration, rearing, and spawning; clam, oyster, and mussel rearing and spawning; crustaceans and other shellfish (crabs, shrimp, crayfish, scallops, etc.) rearing and spawning.

  b. Excellent quality salmonid and other fish migration, rearing, and spawning; clam, oyster, and mussel rearing and spawning; crustaceans and other shellfish (crabs, shrimp, crayfish, scallops, etc.) rearing and spawning.

  c. Good quality salmonid migration and rearing; other fish migration, rearing, and spawning; clam, oyster, and mussel rearing and spawning; crustaceans and other shellfish (crabs, shrimp, crayfish, scallops, etc.) rearing and spawning.

  d. Fair quality salmonid and other fish migration.

The *Aquatic Life Uses* and the associated criteria for this receiving water are identified below.

Table 10. Marine Aquatic Life Uses and Associated Criteria

Extraordinary Quality	
Temperature Criteria – Highest 1D MAX	13°C (55.4°F)
Dissolved Oxygen Criteria – Lowest 1-Day Minimum	7.0 mg/L
Turbidity Criteria	• 5 NTU over background when the background is 50 NTU or less; or • A 10 percent increase in turbidity when the background turbidity is more than 50 NTU.
pH Criteria	pH must be within the range of 7.0 to 8.5 with a human-caused variation within the above range of less than 0.2 units.

- To protect shellfish harvesting, fecal coliform organism levels must not exceed a geometric mean value of 14 colonies/100 mL, and not have more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 43 colonies/100 mL.
- The *recreational use* is primary contact recreation.

The recreational uses for this receiving water are identified below.

Table 11. Recreational Uses

Recreational Use	Criteria
Primary Contact Recreation	Fecal coliform organism levels must not exceed a geometric mean value of 14 colonies/100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 43 colonies /100 mL.

- The *miscellaneous marine water uses* are wildlife habitat, harvesting, commerce and navigation, boating, and aesthetics.

E. Water quality impairments

Puget Sound (Central) in the vicinity of the Manchester WWTP outfall is listed in the EPA approved 2012 303(d) list as an impaired waterbody for dissolved oxygen (D.O.) under Category 5. The listing remarks state that "this listing is determined to be category 5 based on a minimum of three excursions from all data considered and at least ten percent of samples collected in a given year that do not meet the criterion. This listing was reviewed by Department of Ecology Environmental Assessment Program staff, who concluded that these excursions cannot be attributed solely to natural conditions. Further study and model evaluation will resolve the relative influence of human activity."

Ecology is not currently conducting a dissolved oxygen Total Maximum Daily Load (TMDL) analysis for this area. Instead, Ecology is focusing on the South Puget Sound Dissolved Oxygen study. Ecology completed a report, "South Puget Sound Dissolved Oxygen Study – Water Quality Model Calibration and Scenarios" (March 2014). In addition, Ecology in collaboration with Pacific Northwest National Laboratory completed a report, "Puget Sound and the Straits Dissolved Oxygen Assessment - Impacts of Current and Future Human Nitrogen Sources and Climate Change through 2070" (March 2014). More work is needed to improve the computer prediction models over the next few years to better understand dissolved oxygen deficits in Puget Sound.

F. Evaluation of surface water quality-based effluent limits for narrative criteria

Ecology must consider the narrative criteria described in WAC 173-201A-160 when it determines permit limits and conditions. Narrative water quality criteria limit the toxic, radioactive, or other deleterious material concentrations that the facility may discharge which have the potential to adversely affect designated uses, cause acute or chronic toxicity to biota, impair aesthetic values, or adversely affect human health.

Ecology considers narrative criteria when it evaluates the characteristics of the wastewater and when it implements all known, available, and reasonable methods of treatment and prevention (AKART) as described above in the technology-based limits section. When Ecology determines if a facility is meeting AKART it considers the pollutants in the wastewater and the adequacy of the treatment to prevent the violation of narrative criteria.

In addition, Ecology considers the toxicity of the wastewater discharge by requiring whole effluent toxicity (WET) testing when there is a reasonable potential for the discharge to contain toxics. Ecology's analysis of the need for WET testing for this discharge is described later in the fact sheet.

G. Evaluation of surface water quality-based effluent limits for numeric criteria

Pollutants in an effluent may affect the aquatic environment near the point of discharge (near-field) or at a considerable distance from the point of discharge (far-field). Toxic pollutants, for example, are near-field pollutants; their adverse effects diminish rapidly with mixing in the receiving water. Conversely, a pollutant such as biochemical oxygen demand (BOD_5) is a far-field pollutant whose adverse effect occurs away from the discharge even after dilution has occurred. Thus, the method of calculating surface water quality-based effluent limits varies with the point at which the pollutant has its maximum effect.

With technology-based controls (AKART), predicted pollutant concentrations in the discharge exceed water quality criteria. Ecology therefore authorizes a mixing zone in accordance with the geometric configuration, flow restriction, and other restrictions imposed on mixing zones by chapter 173-201A WAC.

The diffuser at Outfall 001 consists of a 12-inch diameter cast iron pipe and a vertical riser with a 12” x 6” reducer. The discharge depth is 35 feet below mean lower low water (MLLW). Ecology obtained this information from *Manchester Wastewater Facilities Plan Addendum and Engineering Report*, CH2M Hill, December 1996.

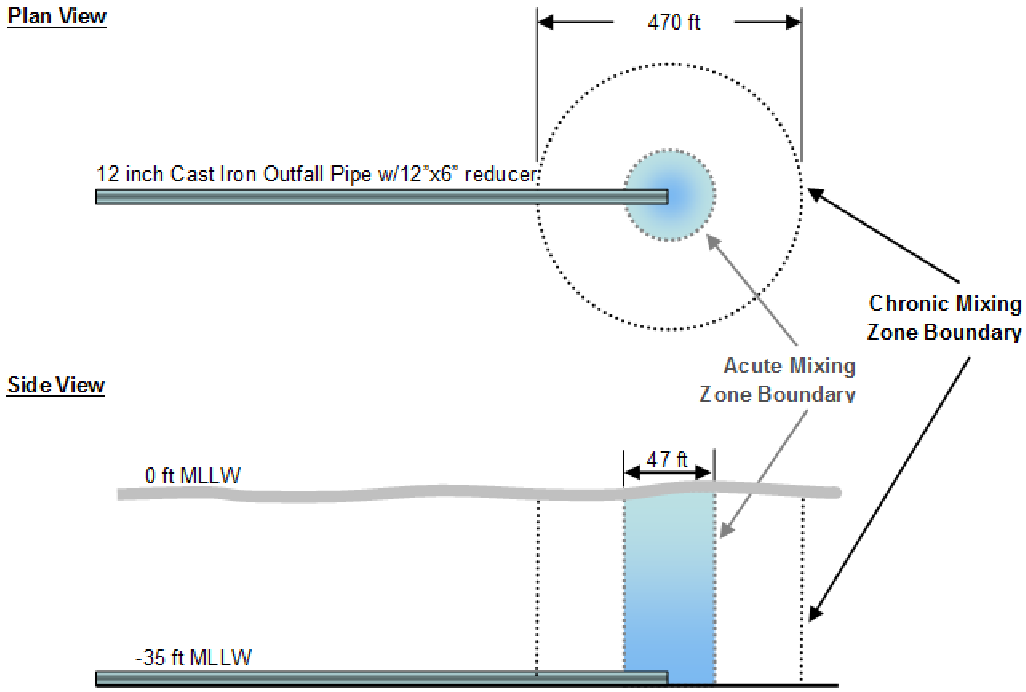
Chronic Mixing Zone--WAC 173-201A-400(7)(b) specifies that mixing zones must not extend in any horizontal direction from the discharge ports for a distance greater than 200 feet plus the depth of water over the discharge ports and may not occupy more than 25% of the width of the water body as measured during MLLW.

The chronic mixing zone for Outfall 001 extends 235 feet in any direction from the discharge port. The mixing zone extends from the top of the discharge ports to the water surface.

Acute Mixing Zone -- WAC 173-201A-400(8)(b) specifies that in estuarine waters a zone where acute criteria may be exceeded must not extend beyond 10% of the distance established for the chronic zone. The acute mixing zone for Outfall 001 extends 23.5 feet in any direction from any discharge port.

Figure below shows the dimensions of the acute and chronic mixing zones for this facility’s discharge.

Figure 2. Outfall Mixing Zone Depiction



The facility's engineering report for the plant expansion, *Manchester Wastewater Facilities Plan Addendum and Engineering Report*, CH2M Hill, December 1996, includes the EPA PLUMES model and the dye tracer study used to calculate the dilution factors that occur within these zones at the critical condition. Ecology approved this report on February 27, 1997. The dilution factors are listed below.

Table 12. Dilution Factors (DF)

Criteria	Acute	Chronic
Aquatic Life	45	305
Human Health, Carcinogen		305
Human Health, Non-carcinogen		305

Ecology determined the impacts of dissolved oxygen deficiency, nutrients, pH, fecal coliform, ammonia, and temperature as described below, using the dilution factors in the above table. The derivation of surface water quality-based limits also takes into account the variability of pollutant concentrations in both the effluent and the receiving water.

Dissolved Oxygen -- BOD_5 and Ammonia Effects -- Natural decomposition of organic material in wastewater effluent impacts dissolved oxygen in the receiving water at distances far outside of the regulated mixing zone. The 5-day Biochemical Oxygen Demand (BOD_5) of an effluent sample indicates the amount of biodegradable material in the wastewater and estimates the magnitude of oxygen consumption the wastewater will generate in the receiving water. The amount of ammonia-based nitrogen in the wastewater also provides an indication of oxygen demand potential in the receiving water.

With technology-based limits, this discharge results in a small amount of biochemical oxygen demand (BOD_5) relative to the large amount of dilution in the receiving water at critical conditions. Technology-based limits will ensure that dissolved oxygen criteria are met in the receiving water.

pH -- Compliance with the technology-based limits of 6.0 to 9.0 will assure compliance with the water quality standards of surface waters because of the high buffering capacity of marine water.

Fecal Coliform -- Ecology modeled the numbers of fecal coliform by simple mixing analysis using the technology-based limit of 400 organisms per 100 ml and a dilution factor of 45.

Under critical conditions, modeling predicts no violation of the water quality criterion for fecal coliform. Therefore, the proposed permit includes the technology-based effluent limit for fecal coliform bacteria.

Turbidity -- Ecology evaluated the impact of turbidity based on the range of total suspended solids in the effluent and turbidity of the receiving water. Ecology expects no violations of the turbidity criteria outside the designated mixing zone provided the facility meets its technology-based total suspended solids permit limits.

Toxic Pollutants -- Federal regulations (40 CFR 122.44) require Ecology to place limits in NPDES permits on toxic chemicals in an effluent whenever there is a reasonable potential for those chemicals to exceed the surface water quality criteria. Ecology does not exempt facilities with technology-based effluent limits from meeting the surface water quality standards.

The following toxic pollutant is present in the discharge: ammonia. Ecology conducted a reasonable potential analysis (See Appendix D) on this parameter to determine whether it would require effluent limits in this permit.

Ammonia's toxicity depends on that portion which is available in the unionized form. The amount of unionized ammonia depends on the temperature, pH, and salinity of the receiving marine water. To evaluate ammonia toxicity, Ecology used the available receiving water information for ambient station in section II.B (Description of the receiving water) and Ecology spreadsheet tools.

No valid ambient background data were available for ammonia. Ecology used zero for background. Ecology determined that ammonia poses no reasonable potential to exceed the water quality criteria at the critical condition using procedures given in EPA, 1991 (*Appendix D*) and as described above. Ecology's determination assumes that this facility meets the other effluent limits of this permit.

Temperature -- The state temperature standards [WAC 173-201A-200-210 and 600-612] include multiple elements:

- Annual summer maximum threshold criteria (June 15 to September 15).
- Supplemental spawning and rearing season criteria (September 15 to June 15).

- Incremental warming restrictions.
- Protections against acute effects.

Ecology evaluates each criterion independently to determine reasonable potential and derive permit limits.

- Annual summer maximum and supplementary spawning/rearing criteria

  Each water body has an annual maximum temperature criterion [WAC 173-201A-200(1)(c), 210(1)(c), and Table 602]. These threshold criteria (e.g., 12, 16, 17.5, 20°C) protect specific categories of aquatic life by controlling the effect of human actions on summer temperatures.

  Some waters have an additional threshold criterion to protect the spawning and incubation of salmonids (9°C for char and 13°C for salmon and trout) [WAC 173-201A-602, Table 602]. These criteria apply during specific date-windows.

  The threshold criteria apply at the edge of the chronic mixing zone. Criteria for most fresh waters are expressed as the highest 7-Day average of daily maximum temperature (7-DADMax). The 7-DADMax temperature is the arithmetic average of seven consecutive measures of daily maximum temperatures. Criteria for marine waters and some fresh waters are expressed as the highest 1-Day annual maximum temperature (1-DMax).

- Incremental warming criteria

  The water quality standards limit the amount of warming human sources can cause under specific situations [WAC 173-201A-200(1)(c)(i)-(ii), 210(1)(c)(i)-(ii)]. The incremental warming criteria apply at the edge of the chronic mixing zone.

  At locations and times when background temperatures are cooler than the assigned threshold criterion, point sources are permitted to warm the water by only a defined increment. These increments are permitted only to the extent doing so does not cause temperatures to exceed either the annual maximum or supplemental spawning criteria.

  At locations and times when a threshold criterion is being exceeded due to natural conditions, all human sources, considered cumulatively, must not warm the water more than 0.3°C above the naturally warm condition.

  When Ecology has not yet completed a TMDL, our policy allows each point source to warm water at the edge of the chronic mixing zone by 0.3°C. This is true regardless of the background temperature and even if doing so would cause the temperature at the edge of a standard mixing zone to exceed the numeric threshold criteria. Allowing a 0.3°C warming for each point source is reasonable and protective where the dilution factor is based on 25% or less of the critical flow. This is because the fully mixed effect on temperature will only be a fraction of the 0.3°C cumulative allowance (0.075°C or less) for all human sources combined.

- Protections for temperature acute effects

  Instantaneous lethality to passing fish: The upper 99th percentile daily maximum effluent temperature must not exceed 33°C, unless a dilution analysis indicates ambient temperatures will not exceed 33°C two seconds after discharge.

General lethality and migration blockage: Measurable (0.3°C) increases in temperature at the edge of a chronic mixing zone are not allowed when the receiving water temperature exceeds either a 1DMax of 23°C or a 7DADMax of 22°C.

Lethality to incubating fish: Human actions must not cause a measurable (0.3°C) warming above 17.5°C at locations where eggs are incubating.

Reasonable Potential Analysis

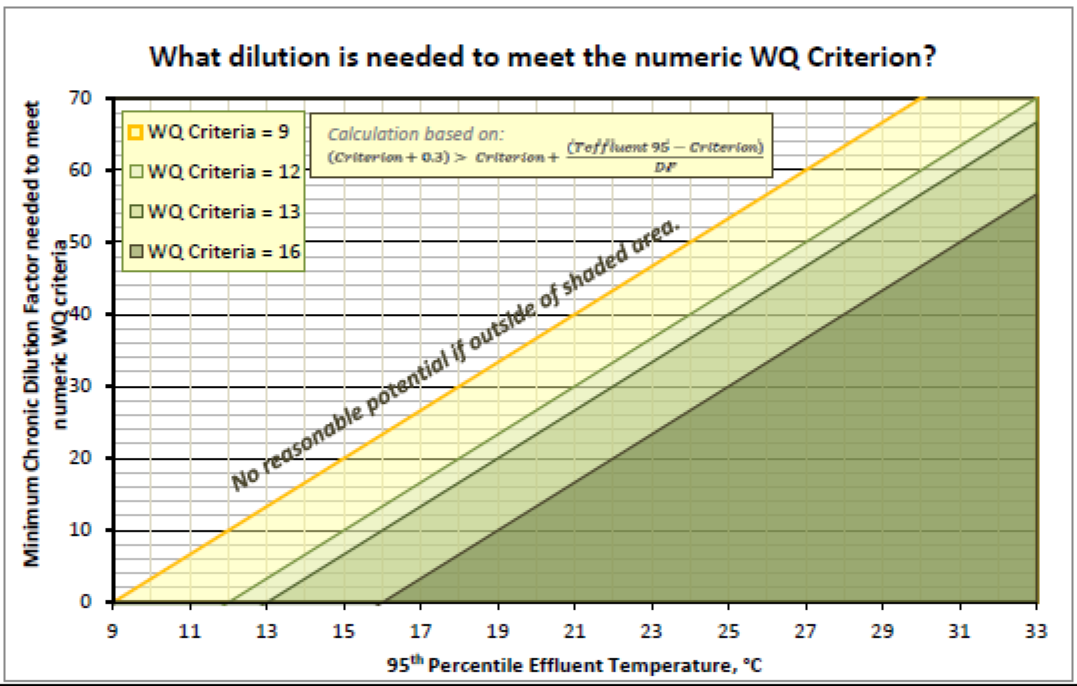
Annual summer maximum and incremental warming criteria: Ecology calculated the reasonable potential for the discharge to exceed the annual summer maximum and the incremental warming criteria at the edge of the chronic mixing zone during critical condition. No reasonable potential exists to exceed the temperature criterion where:

(Criterion + 0.3) > [Criterion + (Teffluent95 – Criterion)/DF].

(13 + 0.3) > (13 + (22.1 – 13)/305) => 13.3 > 13.0

The figure below graphically portrays the above equation and shows the conditions when a permit limit will apply.

Figure 3. Dilution Necessary to Meet Criteria at Edge of Mixing Zone



The chronic dilution available far exceeds the minimum needed to meet the numeric WQ criterion for temperature, consequently the incremental temperature increase for this discharge is within the allowable amount. Therefore, the proposed permit does not include a temperature limit. The permit requires additional monitoring of effluent temperatures. Ecology will reevaluate the reasonable potential during the next permit renewal.

H. Human health

Washington's water quality standards include numeric human health-based criteria that Ecology must consider when writing NPDES permits. Ecology determined the applicant's discharge is unlikely to contain chemicals regulated to protect human health, based on existing effluent data or knowledge of discharges to the wastewater treatment system. Ecology will reevaluate this discharge for impacts to human health at the next permit reissuance.

I. Sediment quality

The aquatic sediment standards (chapter 173-204 WAC) protect aquatic biota and human health. Under these standards Ecology may require a facility to evaluate the potential for its discharge to cause a violation of sediment standards (WAC 173-204-400). You can obtain additional information about sediments at the Aquatic Lands Cleanup Unit website.

https://ecology.wa.gov/Spills-Cleanup/Contamination-cleanup/Sediment-cleanups

Through a review of the discharger characteristics and of the effluent characteristics, Ecology determined that this discharge has no reasonable potential to violate the sediment management standards. Therefore, the proposed permit does not require sediment monitoring in the vicinity of the discharge outfall.

J. Whole effluent toxicity

The water quality standards for surface waters forbid discharge of effluent that has the potential to cause toxic effects in the receiving waters. Many toxic pollutants cannot be measured by commonly available detection methods. However, laboratory tests can measure toxicity directly by exposing living organisms to the wastewater and measuring their responses. These tests measure the aggregate toxicity of the whole effluent, so this approach is called whole effluent toxicity (WET) testing. Some WET tests measure acute toxicity and other WET tests measure chronic toxicity.

Using the screening criteria in chapter 173-205-040 WAC, Ecology determined that toxic effects caused by unidentified pollutants in the effluent are unlikely. Therefore, this permit does not require WET testing. Ecology may require WET testing in the future if it receives information indicating that toxicity may be present in this effluent.

K. Groundwater quality limits

The groundwater quality standards (chapter 173-200 WAC) protect beneficial uses of groundwater. Permits issued by Ecology must not allow violations of those standards (WAC 173-200-100).

The Manchester WWTP does not discharge wastewater to the ground. No permit limits are required to protect groundwater.

L. Comparison of effluent limits with the previous permit issued on February 12, 2013

Table 13. Comparison of Previous and Proposed Effluent Limits

		Previous Effluent Limits: Outfall No. 001		Proposed Effluent Limits: Outfall No. 001	
Parameter	**Basis of Limit**	**Average Monthly**	**Average Weekly**	**Average Monthly**	**Average Weekly**
BOD_5	Technology	30 mg/L 115 lbs/day 85% removal	45 mg/L 173 lbs/day	No Change	No Change
TSS	Technology	30 mg/L 115 lbs/day 85% removal	45 mg/L 173 lbs/day	No Change	No Change

Parameter		Monthly Geometric Mean Limit	Weekly Geometric Mean Limit	Monthly Geometric Mean Limit	Weekly Geometric Mean Limit
Fecal Coliform Bacteria	Technology	200/100 mL	400/100 mL	No Change	No Change

Parameter		Limit	Limit
pH	Technology	6.0-9.0	No Change

IV. Monitoring Requirements

Ecology requires monitoring, recording, and reporting (WAC 173-220-210 and 40 CFR 122.41) to verify that the treatment process is functioning correctly and that the discharge complies with the permit's effluent limits.

If a facility uses a contract laboratory to monitor wastewater, it must ensure that the laboratory uses the methods and meets or exceeds the method detection levels required by the permit. The permit describes when facilities may use alternative methods. It also describes what to do in certain situations when the laboratory encounters matrix effects. When a facility uses an alternative method as allowed by the permit, it must report the test method, detection level (DL), and quantitation level (QL) on the discharge monitoring report or in the required report.

A. Wastewater monitoring

The monitoring schedule is detailed in the proposed permit under Special Condition S.2. Specified monitoring frequencies take into account the quantity and variability of the discharge, the treatment method, past compliance, significance of pollutants, and cost of monitoring. The required monitoring frequency is consistent with agency guidance given in the current version of Ecology's *Permit Writer's Manual* (Publication Number 92-109) for an activated sludge treatment plant with less than 2 MGD average design flow.

Ecology has included some additional monitoring of nutrients in the proposed permit to establish a baseline for this discharger. It will use this data in the future as it develops TMDLs for dissolved oxygen and establishes WLAs for nutrients.

Monitoring of sludge quantity and quality is necessary to determine the appropriate uses of the sludge. Biosolids monitoring is required by the current state and local solid waste management program and also by EPA under 40 CFR 503.

B. Lab accreditation

Ecology requires that facilities must use a laboratory registered or accredited under the provisions of chapter 173-50 WAC, Accreditation of Environmental Laboratories, to prepare all monitoring data (with the exception of certain parameters). Kitsap County uses the laboratory at its Central Kitsap WWTP for monitoring of parameters required at the Manchester WWTP. Ecology accredited the laboratory at the Central Kitsap WWTP for various parameters including the following parameters that are required to be monitored at the Manchester WWTP:

Table 14. Accredited Parameters

General Chemistry				
Parameter Name	**Analyte Code**	**Method Description**	**NELAC Code**	**Matrix ***
Ammonia as N	1515	EPA 350.1	10063204	N
BOD	1530	SM 5210 B	20027401	N
Kjeldahl nitrogen - total	1795	EPA 351.2	10065006	N
Nitrate-nitrite	1820	EPA 353.2	10067206	N
Oxygen, dissolved (DO)	1880	SM 4500-O G	20025405	N
pH	1900	SM 4500-H	20022406	N
Phosphorus, total	1910	EPA 365.1	10069600	N
TSS	1960	SM 2540 D	20004802	N

Microbiology				
Parameter Name	**Analyte Code**	**Method Description**	**NELAC Code**	**Matrix ***
Fecal coliform-count	2530	SM 9222 D	20209603	N
* Matrix key: N = non-potable water				

V. Other Permit Conditions

A. Reporting and record keeping

Ecology based Special Condition S3 on its authority to specify any appropriate reporting and record keeping requirements to prevent and control waste discharges (WAC 173-220-210).

B. Prevention of facility overloading

Overloading of the treatment plant is a violation of the terms and conditions of the permit. To prevent this from occurring, RCW 90.48.110 and WAC 173-220-150 require Kitsap County to:

- Take the actions detailed in proposed permit Special Condition S.4.
- Design and construct expansions or modifications before the treatment plant reaches existing capacity.
- Report and correct conditions that could result in new or increased discharges of pollutants.

Special Condition S.4 restricts the amount of flow.

If a municipality intends to apply for Ecology-administered funding for the design or construction of a facility project, the planning documents must meet the requirements of WAC 173-98. The municipality should contact Ecology's regional office as early as practical before planning a project that may include Ecology-administered funding.

C. Operation and maintenance

The proposed permit contains Special Condition S.5 as authorized under RCW 90.48.110, WAC 173-220-150, chapter 173-230 WAC, and WAC 173-240-080. Ecology included it to ensure proper operation and regular maintenance of equipment, and to ensure that the permittee takes adequate safeguards so that it uses constructed facilities to their optimum potential in terms of pollutant capture and treatment.

The last infiltration and inflow (I&I) analysis was conducted using the wastewater facility monitoring data from 2008 to 2010 and indicated non-excessive I&I. However, in more recent years, the County has observed higher infiltration flows during wet weather months when the groundwater level is higher. It needs a further evaluation to better assess the extent of infiltration observed during the previous permit cycle. Therefore, the proposed permit requires the permittee to conduct an I&I evaluation and submit a report summarizing the results of the evaluation to characterize the collection system for the presence of leaks by providing the following information:

- Volume of the annual average and peak daily flow under worst conditions (inflow or infiltration) attributed to leaks.
- Location of each individual leaks.
- Size of each leak and/or volume of excess flow contributed by a run of sewer.
- Whether exfiltration occurs in the system's force mains and/or inverted siphons.
- Recommendations for corrective actions.

Three good references to aid in these tasks include:

- American Society of Civil Engineers and Water Environment Federation Manual of Practice FD-6, *Existing Sewer Evaluation and Rehabilitation,* (Third Edition, 2009).
- U.S. Environmental Protection Agency, *Handbook for Sewer System Infrastructure Analysis and Rehabilitation*, EPA/625/6-91/030, (1991).
- Washington State Department of Transportation, *Standard Specifications for Road, Bridge, and Municipal Construction*, (2016).

D. Pretreatment

Duty to enforce discharge prohibitions

This provision prohibits the publicly owned treatment works (POTW) from authorizing or permitting an industrial discharger to discharge certain types of waste into the sanitary sewer.

- The first section of the pretreatment requirements prohibits the POTW from accepting pollutants which causes “pass-through” or “interference”. This general prohibition is from 40 CFR §403.5(a). **Appendix C** of this fact sheet defines these terms.
- The second section reinforces a number of specific state and federal pretreatment prohibitions found in WAC 173-216-060 and 40 CFR §403.5(b). These reinforce that the POTW may not accept certain wastes, which:
  a. Are prohibited due to dangerous waste rules.
  b. Are explosive or flammable.
  c. Have too high or low of a pH (too corrosive, acidic or basic).
  d. May cause a blockage such as grease, sand, rocks, or viscous materials.
  e. Are hot enough to cause a problem.
  f. Are of sufficient strength or volume to interfere with treatment.
  g. Contain too much petroleum-based oils, mineral oil, or cutting fluid.
  h. Create noxious or toxic gases at any point.

40 CFR Part 403 contains the regulatory basis for these prohibitions, with the exception of the pH provisions which are based on WAC 173-216-060.

- The third section of pretreatment conditions reflects state prohibitions on the POTW accepting certain types of discharges unless the discharge has received prior written authorization from Ecology. These discharges include:
  a. Cooling water in significant volumes.
  b. Stormwater and other direct inflow sources.
  c. Wastewaters significantly affecting system hydraulic loading, which do not require treatment.

Federal and state pretreatment program requirements

Ecology administers the Pretreatment Program under the terms of the addendum to the “Memorandum of Understanding between Washington Department of Ecology and the United States Environmental Protection Agency, Region 10” (1986) and 40 CFR, part 403. Under this delegation of authority, Ecology issues wastewater discharge permits for significant industrial users (SIUs) discharging to POTWs which have not been delegated authority to issue wastewater discharge permits. Ecology must approve, condition, or deny new discharges or a significant increase in the discharge for existing significant industrial users (SIUs) [40 CFR 403.8 (f)(1)(i) and(iii)].

Industrial dischargers must obtain a permit from Ecology before discharging waste to the Manchester WWTP [WAC 173-216-110(5)]. Industries discharging wastewater that is similar in character to domestic wastewater do not require a permit.

Routine identification and reporting of industrial users

The permit requires non-delegated POTWs to take “continuous, routine measures to identify all existing, new, and proposed significant industrial users (SIUs) and potential significant industrial users (PSIUs)” discharging to their sewer system. Examples of such routine measures include regular review of water and sewer billing records, business license and building permit applications, advertisements, and personal reconnaissance. System maintenance personnel should be trained on what to look for so they can identify and report new industrial dischargers in the course of performing their jobs. The POTW may not allow SIUs to discharge prior to receiving a permit, and must notify all industrial dischargers (significant or not) in writing of their responsibility to apply for a State Waste Discharge Permit. The POTW must send a copy of this notification to Ecology.

Requirements for performing an industrial user survey

This POTW has the potential to serve significant industrial or commercial users and must conduct an industrial user (IU) survey. The purpose of the IU Survey is to identify all facilities that may be subject to pretreatment standards or requirements so that Ecology can take appropriate measures to control these discharges. The POTW should identify each such user, and require them to apply for a permit before allowing their discharge to the POTW to commence. For SIUs, the POTW must require they actually are issued a permit prior to accepting their discharge. The steps the POTW must document in their IU Survey submittal include:

1. The POTW must develop a master list of businesses that may be subject to pretreatment standards and requirements and show their disposition. This list must be based on several sources of information including business licenses, and water and sewer billing records.
2. The POTW must canvas all the potential sources, having them either complete a survey form or ruling them out by confirming they only generate domestic wastewater.
3. The POTW must develop a list of the SIUs and potential SIUs in all areas served by the POTW. The list must contain sufficient information on each to allow Ecology to decide which discharges merit further controls such as a state waste discharge permit.

Ecology describes the information needed in IU Survey submittals to allow Ecology to make permitting decision in the manual “Performing an Industrial User Survey”. Properly completing an Industrial User Survey helps Ecology control discharges that may otherwise harm the POTW including its collection system, processes, and receiving waters. Where surveys are incomplete, Ecology may take such enforcement as appropriate and/or require the POTW to develop a fully delegated pretreatment program.

The proposed permit requires the permittee to conduct an industrial user survey to determine the extent of compliance of all industrial users of the sanitary sewer and wastewater treatment facility with federal pretreatment regulations [40 CFR Part 403 and Sections 307(b) and 308 of the Clean Water Act)], with state regulations (chapter 90.48 RCW and chapter 173-216 WAC), and with local ordinances.

E. Solid wastes

To prevent water quality problems the facility is required in permit Special Condition S7 to store and handle all residual solids (grit, screenings, scum, sludge, and other solid waste) in accordance with the requirements of RCW 90.48.080 and state water quality standards.

The final use and disposal of sewage sludge from this facility is regulated by U.S. EPA under 40 CFR 503, and by Ecology under chapter 70.95J RCW, chapter 173-308 WAC “Biosolids Management,” and chapter 173-350 WAC “Solid Waste Handling Standards.” The disposal of other solid waste is under the jurisdiction of the Kitsap Public Health District.

Requirements for monitoring sewage sludge and record keeping are included in this permit. Ecology will use this information, required under 40 CFR 503, to develop or update local limits.

F. Outfall evaluation

The proposed permit requires the permittee to conduct an outfall inspection for the Manchester WWTP and submit a report detailing the findings of that inspection (Special Condition S.8). The inspection must evaluate the physical condition of the discharge pipe and diffusers, and evaluate the extent of sediment accumulations in the vicinity of the outfall.

G. General conditions

Ecology bases the standardized General Conditions on state and federal law and regulations. They are included in all individual domestic wastewater NPDES permits issued by Ecology.

VI. Permit Issuance Procedures

A. Permit modifications

Ecology may modify this permit to impose numerical limits, if necessary, to comply with water quality standards for surface waters, with sediment quality standards, or with water quality standards for groundwaters, based on new information from sources such as inspections, effluent monitoring, outfall studies, and effluent mixing studies.

Ecology may also modify this permit to comply with new or amended state or federal regulations.

B. Proposed permit issuance

This proposed permit meets all statutory requirements for Ecology to authorize a wastewater discharge. The permit includes limits and conditions to protect human health and aquatic life, and the beneficial uses of waters of the state of Washington. Ecology proposes to issue this permit for a term of 5 years.

VII. References for Text and Appendices

CH2M Hill (December, 1996). “Manchester Wastewater Facilities Plan Addendum and Engineering Report”.

Environmental Protection Agency (EPA)

1992. National Toxics Rule. Federal Register, V. 57, No. 246, Tuesday, December 22, 1992.

1991. *Technical Support Document for Water Quality-based Toxics Control*. EPA/505/2-90-001.

1988. *Technical Guidance on Supplementary Stream Design Conditions for Steady State Modeling*. USEPA Office of Water, Washington, D.C.

1985. *Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Ground Water*. EPA/600/6-85/002a.

1983. *Water Quality Standards Handbook*. USEPA Office of Water, Washington, D.C.

Tsivoglou, E.C., and J.R. Wallace.

1972. *Characterization of Stream Reaeration Capacity*. EPA-R3-72-012. (Cited in EPA 1985 op.cit.)

Washington State Department of Ecology.

January 2015. *Permit Writer's Manual*. Publication Number 92-109 (https://fortress.wa.gov/ecy/publications/summarypages/92109.html)

September 2011. *Water Quality Program Guidance Manual – Supplemental Guidance on Implementing Tier II Antidegradation*. Publication Number 11-10-073 (https://fortress.wa.gov/ecy/publications/summarypages/1110073.html)

October 2010 (revised). *Water Quality Program Guidance Manual – Procedures to Implement the State's Temperature Standards through NPDES Permits*. Publication Number 06-10-100 (https://fortress.wa.gov/ecy/publications/summarypages/0610100.html)

Laws and Regulations (https://ecology.wa.gov/Regulations-Permits)

Permit and Wastewater Related Information (https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Water-quality-permits-guidance)

Water Pollution Control Federation.

1976. *Chlorination of Wastewater*.

Wright, R.M., and A.J. McDonnell.

1979. *In-stream Deoxygenation Rate Prediction*. Journal Environmental Engineering Division, ASCE. 105(EE2). (Cited in EPA 1985 op.cit.)

Appendix A -- Public Involvement Information

Ecology proposes to reissue a permit to Kitsap County for its Manchester WWTP. The permit includes wastewater discharge limits and other conditions. This fact sheet describes the facility and Ecology's reasons for requiring permit conditions.

Ecology placed a Public Notice of Draft on December 11, 2017, in the *Kitsap Sun* to inform the public and to invite comment on the proposed draft National Pollutant Discharge Elimination System permit and fact sheet.

The notice:

- Told where copies of the draft permit and fact sheet were available for public evaluation (a local public library, the closest regional or field office, posted on our website).
- Offered to provide the documents in an alternate format to accommodate special needs.
- Asked people to tell us how well the proposed permit would protect the receiving water.
- Invited people to suggest fairer conditions, limits, and requirements for the permit.
- Invited comments on Ecology's determination of compliance with antidegradation rules.
- Urged people to submit their comments, in writing, before the end of the comment period.
- Told how to request a public hearing about the proposed NPDES permit.
- Explained the next step(s) in the permitting process.

Ecology has published a document entitled *Frequently Asked Questions about Effective Public Commenting,* which is available on our website at

https://fortress.wa.gov/ecy/publications/SummaryPages/0307023.html

You may obtain further information from Ecology by telephone, 425-649-7201, or by writing to the address listed below.

Water Quality Permit Coordinator
Department of Ecology
Northwest Regional Office
3190 160th Avenue SE
Bellevue, WA 98008-5452

The primary author of this permit and fact sheet is Kevin Leung.

Appendix B -- Your Right to Appeal

You have a right to appeal this permit to the Pollution Control Hearing Board (PCHB) within 30 days of the date of receipt of the final permit. The appeal process is governed by chapter 43.21B RCW and chapter 371-08 WAC. "Date of receipt" is defined in RCW 43.21B.001(2) (see glossary).

To appeal you must do the following within 30 days of the date of receipt of this permit:

- File your appeal and a copy of this permit with the PCHB (see addresses below). Filing means actual receipt by the PCHB during regular business hours.
- Serve a copy of your appeal and this permit on Ecology in paper form - by mail or in person. (See addresses below.) E-mail is not accepted.

You must also comply with other applicable requirements in chapter 43.21B RCW and chapter 371-08 WAC.

ADDRESS AND LOCATION INFORMATION

Street Addresses	Mailing Addresses
Department of Ecology Attn: Appeals Processing Desk 300 Desmond Drive SE Lacey, WA 98503	**Department of Ecology** Attn: Appeals Processing Desk PO Box 47608 Olympia, WA 98504-7608
Pollution Control Hearings Board 1111 Israel RD SW, STE 301 Tumwater, WA 98501	**Pollution Control Hearings Board** PO Box 40903 Olympia, WA 98504-0903

Appendix C -- Glossary

1-DMax or 1-day maximum temperature -- The highest water temperature reached on any given day. This measure can be obtained using calibrated maximum/minimum thermometers or continuous monitoring probes having sampling intervals of thirty minutes or less.

7-DADMax or 7-day average of the daily maximum temperatures -- The arithmetic average of seven consecutive measures of daily maximum temperatures. The 7-DADMax for any individual day is calculated by averaging that day's daily maximum temperature with the daily maximum temperatures of the three days prior and the three days after that date.

Acute toxicity -- The lethal effect of a compound on an organism that occurs in a short time period, usually 48 to 96 hours.

AKART -- The acronym for “all known, available, and reasonable methods of prevention, control and treatment.” AKART is a technology-based approach to limiting pollutants from wastewater discharges, which requires an engineering judgment and an economic judgment. AKART must be applied to all wastes and contaminants prior to entry into waters of the state in accordance with RCW 90.48.010 and 520, WAC 173-200-030(2)(c)(ii), and WAC 173-216-110(1)(a).

Alternate point of compliance -- An alternative location in the groundwater from the point of compliance where compliance with the groundwater standards is measured. It may be established in the groundwater at locations some distance from the discharge source, up to, but not exceeding the property boundary and is determined on a site specific basis following an AKART analysis. An “early warning value” must be used when an alternate point is established. An alternate point of compliance must be determined and approved in accordance with WAC 173-200-060(2).

Ambient water quality -- The existing environmental condition of the water in a receiving water body.

Ammonia -- Ammonia is produced by the breakdown of nitrogenous materials in wastewater. Ammonia is toxic to aquatic organisms, exerts an oxygen demand, and contributes to eutrophication. It also increases the amount of chlorine needed to disinfect wastewater.

Annual average design flow (AADF) -- The average of the daily flow volumes anticipated to occur over a calendar year.

Average monthly (intermittent) discharge limit -- The average of the measured values obtained over a calendar month’s time taking into account zero discharge days.

Average monthly discharge limit -- The average of the measured values obtained over a calendar month’s time.

Background water quality -- The concentrations of chemical, physical, biological or radiological constituents or other characteristics in or of groundwater at a particular point in time upgradient of an activity that has not been affected by that activity [WAC 173-200-020(3)]. Background water quality for any parameter is statistically defined as the 95% upper tolerance interval with a 95% confidence based on at least eight hydraulically upgradient water quality samples. The eight samples are collected over a period of at least one year, with no more than one sample collected during any month in a single calendar year.

Best management practices (BMPs) -- Schedules of activities, prohibitions of practices, maintenance procedures, and other physical, structural and/or managerial practices to prevent or reduce the pollution of waters of the state. BMPs include treatment systems, operating procedures, and practices to control: plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage. BMPs may be further categorized as operational, source control, erosion and sediment control, and treatment BMPs.

BOD5 -- Determining the five-day Biochemical Oxygen Demand of an effluent is an indirect way of measuring the quantity of organic material present in an effluent that is utilized by bacteria. The BOD5 is used in modeling to measure the reduction of dissolved oxygen in receiving waters after effluent is discharged. Stress caused by reduced dissolved oxygen levels makes organisms less competitive and less able to sustain their species in the aquatic environment. Although BOD_5 is not a specific compound, it is defined as a conventional pollutant under the federal Clean Water Act.

Bypass -- The intentional diversion of waste streams from any portion of a treatment facility.

Categorical pretreatment standards -- National pretreatment standards specifying quantities or concentrations of pollutants or pollutant properties, which may be discharged to a POTW by existing or new industrial users in specific industrial subcategories.

Chlorine -- A chemical used to disinfect wastewaters of pathogens harmful to human health. It is also extremely toxic to aquatic life.

Chronic toxicity -- The effect of a compound on an organism over a relatively long time, often 1/10 of an organism's lifespan or more. Chronic toxicity can measure survival, reproduction or growth rates, or other parameters to measure the toxic effects of a compound or combination of compounds.

Clean water act (CWA) -- The federal Water Pollution Control Act enacted by Public Law 92-500, as amended by Public Laws 95-217, 95-576, 96-483, 97-117; USC 1251 et seq.

Compliance inspection-without sampling -- A site visit for the purpose of determining the compliance of a facility with the terms and conditions of its permit or with applicable statutes and regulations.

Compliance inspection-with sampling -- A site visit for the purpose of determining the compliance of a facility with the terms and conditions of its permit or with applicable statutes and regulations. In addition it includes as a minimum, sampling and analysis for all parameters with limits in the permit to ascertain compliance with those limits; and, for municipal facilities, sampling of influent to ascertain compliance with the 85 percent removal requirement. Ecology may conduct additional sampling.

Composite sample -- A mixture of grab samples collected at the same sampling point at different times, formed either by continuous sampling or by mixing discrete samples. May be "time-composite" (collected at constant time intervals) or "flow-proportional" (collected either as a constant sample volume at time intervals proportional to stream flow, or collected by increasing the volume of each aliquot as the flow increased while maintaining a constant time interval between the aliquots).

Construction activity -- Clearing, grading, excavation, and any other activity, which disturbs the surface of the land. Such activities may include road building; construction of residential houses, office buildings, or industrial buildings; and demolition activity.

Continuous monitoring -- Uninterrupted, unless otherwise noted in the permit.

Critical condition -- The time during which the combination of receiving water and waste discharge conditions have the highest potential for causing toxicity in the receiving water environment. This situation usually occurs when the flow within a water body is low, thus, its ability to dilute effluent is reduced.

Date of receipt -- This is defined in RCW 43.21B.001(2) as five business days after the date of mailing; or the date of actual receipt, when the actual receipt date can be proven by a preponderance of the evidence. The recipient's sworn affidavit or declaration indicating the date of receipt, which is unchallenged by the agency, constitutes sufficient evidence of actual receipt. The date of actual receipt, however, may not exceed forty-five days from the date of mailing.

Detection limit -- The minimum concentration of a substance that can be measured and reported with 99 percent confidence that the pollutant concentration is above zero and is determined from analysis of a sample in a given matrix containing the pollutant.

Dilution factor (DF) -- A measure of the amount of mixing of effluent and receiving water that occurs at the boundary of the mixing zone. Expressed as the inverse of the percent effluent fraction, for example, a dilution factor of 10 means the effluent comprises 10% by volume and the receiving water 90%.

Distribution uniformity -- The uniformity of infiltration (or application in the case of sprinkle or trickle irrigation) throughout the field expressed as a percent relating to the average depth infiltrated in the lowest one-quarter of the area to the average depth of water infiltrated.

Early warning value -- The concentration of a pollutant set in accordance with WAC 173-200-070 that is a percentage of an enforcement limit. It may be established in the effluent, groundwater, surface water, the vadose zone or within the treatment process. This value acts as a trigger to detect and respond to increasing contaminant concentrations prior to the degradation of a beneficial use.

Enforcement limit -- The concentration assigned to a contaminant in the groundwater at the point of compliance for the purpose of regulation, [WAC 173-200-020(11)]. This limit assures that a groundwater criterion will not be exceeded and that background water quality will be protected.

Engineering report -- A document that thoroughly examines the engineering and administrative aspects of a particular domestic or industrial wastewater facility. The report must contain the appropriate information required in WAC 173-240-060 or 173-240-130.

Fecal coliform bacteria -- Fecal coliform bacteria are used as indicators of pathogenic bacteria in the effluent that are harmful to humans. Pathogenic bacteria in wastewater discharges are controlled by disinfecting the wastewater. The presence of high numbers of fecal coliform bacteria in a water body can indicate the recent release of untreated wastewater and/or the presence of animal feces.

Grab sample -- A single sample or measurement taken at a specific time or over as short a period of time as is feasible.

Groundwater -- Water in a saturated zone or stratum beneath the surface of land or below a surface water body.

Industrial user -- A discharger of wastewater to the sanitary sewer that is not sanitary wastewater or is not equivalent to sanitary wastewater in character.

Industrial wastewater -- Water or liquid-carried waste from industrial or commercial processes, as distinct from domestic wastewater. These wastes may result from any process or activity of industry, manufacture, trade or business; from the development of any natural resource; or from animal operations such as feed lots, poultry houses, or dairies. The term includes contaminated stormwater and, also, leachate from solid waste facilities.

Interference -- A discharge which, alone or in conjunction with a discharge or discharges from other sources, both:

- Inhibits or disrupts the POTW, its treatment processes or operations, or its sludge processes, use or disposal; and

- Therefore is a cause of a violation of any requirement of the POTW's NPDES permit (including an increase in the magnitude or duration of a violation) or of the prevention of sewage sludge use or disposal in compliance with the following statutory provisions and regulations or permits issued thereunder (or more stringent State or local regulations): Section 405 of the Clean Water Act, the Solid Waste Disposal Act (SWDA) (including title II, more commonly referred to as the Resource Conservation and Recovery Act (RCRA), and including State regulations contained in any State sludge management plan prepared pursuant to subtitle D of the SWDA), sludge regulations appearing in 40 CFR Part 507, the Clean Air Act, the Toxic Substances Control Act, and the Marine Protection, Research and Sanctuaries Act.

Local limits -- Specific prohibitions or limits on pollutants or pollutant parameters developed by a POTW.

Major facility -- A facility discharging to surface water with an EPA rating score of > 80 points based on such factors as flow volume, toxic pollutant potential, and public health impact.

Maximum daily discharge limit -- The highest allowable daily discharge of a pollutant measured during a calendar day or any 24-hour period that reasonably represents the calendar day for purposes of sampling. The daily discharge is calculated as the average measurement of the pollutant over the day.

Maximum day design flow (MDDF) -- The largest volume of flow anticipated to occur during a one-day period, expressed as a daily average.

Maximum month design flow (MMDF) -- The largest volume of flow anticipated to occur during a continuous 30-day period, expressed as a daily average.

Maximum week design flow (MWDF) -- The largest volume of flow anticipated to occur during a continuous 7-day period, expressed as a daily average.

Method detection level (MDL) -- See Detection Limit.

Minor facility -- A facility discharging to surface water with an EPA rating score of < 80 points based on such factors as flow volume, toxic pollutant potential, and public health impact.

Mixing zone -- An area that surrounds an effluent discharge within which water quality criteria may be exceeded. The permit specifies the area of the authorized mixing zone that Ecology defines following procedures outlined in state regulations (chapter 173-201A WAC).

National pollutant discharge elimination system (NPDES) -- The NPDES (Section 402 of the Clean Water Act) is the federal wastewater permitting system for discharges to navigable waters of the United States. Many states, including the state of Washington, have been delegated the authority to issue these permits. NPDES permits issued by Washington State permit writers are joint NPDES/State permits issued under both state and federal laws.

pH -- The pH of a liquid measures its acidity or alkalinity. It is the negative logarithm of the hydrogen ion concentration. A pH of 7 is defined as neutral and large variations above or below this value are considered harmful to most aquatic life.

Pass-through -- A discharge which exits the POTW into waters of the State in quantities or concentrations which, alone or in conjunction with a discharge or discharges from other sources, is a cause of a violation of any requirement of the POTW's NPDES permit (including an increase in the magnitude or duration of a violation), or which is a cause of a violation of State water quality standards.

Peak hour design flow (PHDF) -- The largest volume of flow anticipated to occur during a one-hour period, expressed as a daily or hourly average.

Peak instantaneous design flow (PIDF) -- The maximum anticipated instantaneous flow.

Point of compliance -- The location in the groundwater where the enforcement limit must not be exceeded and a facility must comply with the Ground Water Quality Standards. Ecology determines this limit on a site-specific basis. Ecology locates the point of compliance in the groundwater as near and directly downgradient from the pollutant source as technically, hydrogeologically, and geographically feasible, unless it approves an alternative point of compliance.

Potential significant industrial user (PSIU) --A potential significant industrial user is defined as an Industrial User that does not meet the criteria for a Significant Industrial User, but which discharges wastewater meeting one or more of the following criteria:

a. Exceeds 0.5 % of treatment plant design capacity criteria and discharges <25,000 gallons per day; or

b. Is a member of a group of similar industrial users which, taken together, have the potential to cause pass through or interference at the POTW (e.g. facilities which develop photographic film or paper, and car washes).

Ecology may determine that a discharger initially classified as a potential significant industrial user should be managed as a significant industrial user.

Quantitation level (QL) -- Also known as Minimum Level of Quantitation (ML) – The lowest level at which the entire analytical system must give a recognizable signal and acceptable calibration point for the analyte. It is equivalent to the concentration of the lowest calibration standard, assuming that the lab has used all method-specified sample weights, volumes, and

cleanup procedures. The QL is calculated by multiplying the MDL by 3.18 and rounding the result to the number nearest to (1, 2, or 5) x 10^n, where n is an integer (64 FR 30417).
ALSO GIVEN AS:
The smallest detectable concentration of analyte greater than the Detection Limit (DL) where the accuracy (precision & bias) achieves the objectives of the intended purpose. (Report of the Federal Advisory Committee on Detection and Quantitation Approaches and Uses in Clean Water Act Programs Submitted to the US Environmental Protection Agency, December 2007).

Reasonable potential -- A reasonable potential to cause a water quality violation, or loss of sensitive and/or important habitat.

Responsible corporate officer -- A president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy- or decision-making functions for the corporation, or the manager of one or more manufacturing, production, or operating facilities employing more than 250 persons or have gross annual sales or expenditures exceeding $25 million (in second quarter 1980 dollars), if authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures (40 CFR 122.22).

Sample Maximum -- No sample may exceed this value.

Significant industrial user (SIU) --

1) All industrial users subject to Categorical Pretreatment Standards under 40 CFR 403.6 and 40 CFR Chapter I, Subchapter N; and

2) Any other industrial user that: discharges an average of 25,000 gallons per day or more of process wastewater to the POTW (excluding sanitary, noncontact cooling, and boiler blow-down wastewater); contributes a process wastestream that makes up 5 percent or more of the average dry weather hydraulic or organic capacity of the POTW treatment plant; or is designated as such by the Control Authority* on the basis that the industrial user has a reasonable potential for adversely affecting the POTW's operation or for violating any pretreatment standard or requirement [in accordance with 40 CFR 403.8(f)(6)].

   Upon finding that the industrial user meeting the criteria in paragraph 2, above, has no reasonable potential for adversely affecting the POTW's operation or for violating any pretreatment standard or requirement, the Control Authority* may at any time, on its own initiative or in response to a petition received from an industrial user or POTW, and in accordance with 40 CFR 403.8(f)(6), determine that such industrial user is not a significant industrial user.

   *The term "Control Authority" refers to the Washington State Department of Ecology in the case of non-delegated POTWs or to the POTW in the case of delegated POTWs.

Slug discharge -- Any discharge of a non-routine, episodic nature, including but not limited to an accidental spill or a non-customary batch discharge to the POTW. This may include any pollutant released at a flow rate that may cause interference or pass through with the POTW or in any way violate the permit conditions or the POTW’s regulations and local limits.

Soil scientist -- An individual who is registered as a Certified or Registered Professional Soil Scientist or as a Certified Professional Soil Specialist by the American Registry of Certified Professionals in Agronomy, Crops, and Soils or by the National Society of Consulting Scientists or who has the credentials for membership. Minimum requirements for eligibility are: possession of a baccalaureate, masters, or doctorate degree from a U.S. or Canadian institution with a minimum of 30 semester hours or 45 quarter hours professional core courses in agronomy, crops or soils, and have 5, 3, or 1 year(s), respectively, of professional experience working in the area of agronomy, crops, or soils.

Solid waste -- All putrescible and non-putrescible solid and semisolid wastes including, but not limited to, garbage, rubbish, ashes, industrial wastes, swill, sewage sludge, demolition and construction wastes, abandoned vehicles or parts thereof, contaminated soils and contaminated dredged material, and recyclable materials.

Soluble BOD_5 -- Determining the soluble fraction of Biochemical Oxygen Demand of an effluent is an indirect way of measuring the quantity of soluble organic material present in an effluent that is utilized by bacteria. Although the soluble BOD_5 test is not specifically described in Standard Methods, filtering the raw sample through at least a 1.2 um filter prior to running the standard BOD_5 test is sufficient to remove the particulate organic fraction.

State waters -- Lakes, rivers, ponds, streams, inland waters, underground waters, salt waters, and all other surface waters and watercourses within the jurisdiction of the state of Washington.

Stormwater -- That portion of precipitation that does not naturally percolate into the ground or evaporate, but flows via overland flow, interflow, pipes, and other features of a stormwater drainage system into a defined surface water body, or a constructed infiltration facility.

Technology-based effluent limit -- A permit limit based on the ability of a treatment method to reduce the pollutant.

Total coliform bacteria -- A microbiological test, which detects and enumerates the total coliform group of bacteria in water samples.

Total dissolved solids -- That portion of total solids in water or wastewater that passes through a specific filter.

Total maximum daily load (TMDL) -- A determination of the amount of pollutant that a water body can receive and still meet water quality standards.

Total suspended solids (TSS) -- Total suspended solids is the particulate material in an effluent. Large quantities of TSS discharged to a receiving water may result in solids accumulation. Apart from any toxic effects attributable to substances leached out by water, suspended solids may kill fish, shellfish, and other aquatic organisms by causing abrasive injuries and by clogging the gills and respiratory passages of various aquatic fauna. Indirectly, suspended solids can screen out light and can promote and maintain the development of noxious conditions through oxygen depletion.

Upset -- An exceptional incident in which there is unintentional and temporary noncompliance with technology-based permit effluent limits because of factors beyond the reasonable control of the Permittee. An upset does not include noncompliance to the extent caused by operational error, improperly designed treatment facilities, lack of preventative maintenance, or careless or improper operation.

Water quality-based effluent limit -- A limit imposed on the concentration of an effluent parameter to prevent the concentration of that parameter from exceeding its water quality criterion after discharge into receiving waters.

Appendix D -- Technical Calculations

Several of the Excel® spreadsheet tools used to evaluate a discharger's ability to meet Washington State water quality standards can be found in the PermitCalc workbook on Ecology's webpage at:
https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Water-quality-permits-guidance

Simple Mixing:

Ecology uses simple mixing calculations to assess the impacts of certain conservative pollutants, such as the expected increase in fecal coliform bacteria at the edge of the chronic mixing zone boundary. Simple mixing uses a mass balance approach to proportionally distribute a pollutant load from a discharge into the authorized mixing zone. The approach assumes no decay or generation of the pollutant of concern within the mixing zone. The predicted concentration at the edge of a mixing zone (C_{mz}) is based on the following calculation:

$$C_{mz} = Ca + \frac{(Ce - Ca)}{DF}$$

where: Ce = Effluent Concentration
Ca = Ambient Concentration
DF = Dilution Factor

Reasonable Potential Analysis:

The spreadsheets Input 2 – Reasonable Potential, and LimitCalc in Ecology's PermitCalc Workbook determine reasonable potential (to violate the aquatic life and human health water quality standards) and calculate effluent limits. The process and formulas for determining reasonable potential and effluent limits in these spreadsheets are taken directly from the *Technical Support Document for Water Quality-based Toxics Control*, (EPA 505/2-90-001). The adjustment for autocorrelation is from EPA (1996a), and EPA (1996b).

Calculation of Water Quality-Based Effluent Limits:

Water quality-based effluent limits are calculated by the two-value wasteload allocation process as described on page 100 of the TSD (EPA, 1991) and shown below.

1. Calculate the acute wasteload allocation WLA_a by multiplying the acute criteria by the acute dilution factor and subtracting the background factor. Calculate the chronic wasteload allocation (WLA_c) by multiplying the chronic criteria by the chronic dilution factor and subtracting the background factor.

$$WLA_a = (\text{acute criteria} \times DF_a) - [(\text{background conc.} \times (DF_a - 1)]$$

$$WLA_c = (\text{chronic criteria} \times DF_c) - [(\text{background conc.} \times (DF_c - 1)]$$

where: DF_a = Acute Dilution Factor
DF_c = Chronic Dilution Factor

2. Calculate the long term averages (LTA_a and LTA_c) which will comply with the wasteload allocations WLA_a and WLA_c.

$$LTA_a = WLA_a \times e^{[0.5\sigma^2 - z\sigma]}$$

where: $\sigma^2 = \ln[CV^2 + 1]$

$z = 2.326$

CV = coefficient of variation = std. dev/mean

$$LTA_c = WLA_c \times e^{[0.5\sigma^2 - z\sigma]}$$

where: $\sigma^2 = \ln[(CV^2 \div 4) + 1]$

$z = 2.326$

3. Use the smallest LTA of the LTA_a or LTA_c to calculate the maximum daily effluent limit and the monthly average effluent limit.

MDL = Maximum Daily Limit

$$MDL = LTA x\, e^{(Z\sigma - 0.5\sigma^2)}$$

where: $\sigma^2 = \ln[CV^2 + 1]$

$z = 2.326$ (99th percentile occurrence)

LTA = Limiting long term average

AML = Average Monthly Limit

$$AML = LTA x\, e^{(Z\sigma_n - 0.5\sigma_n^2)}$$

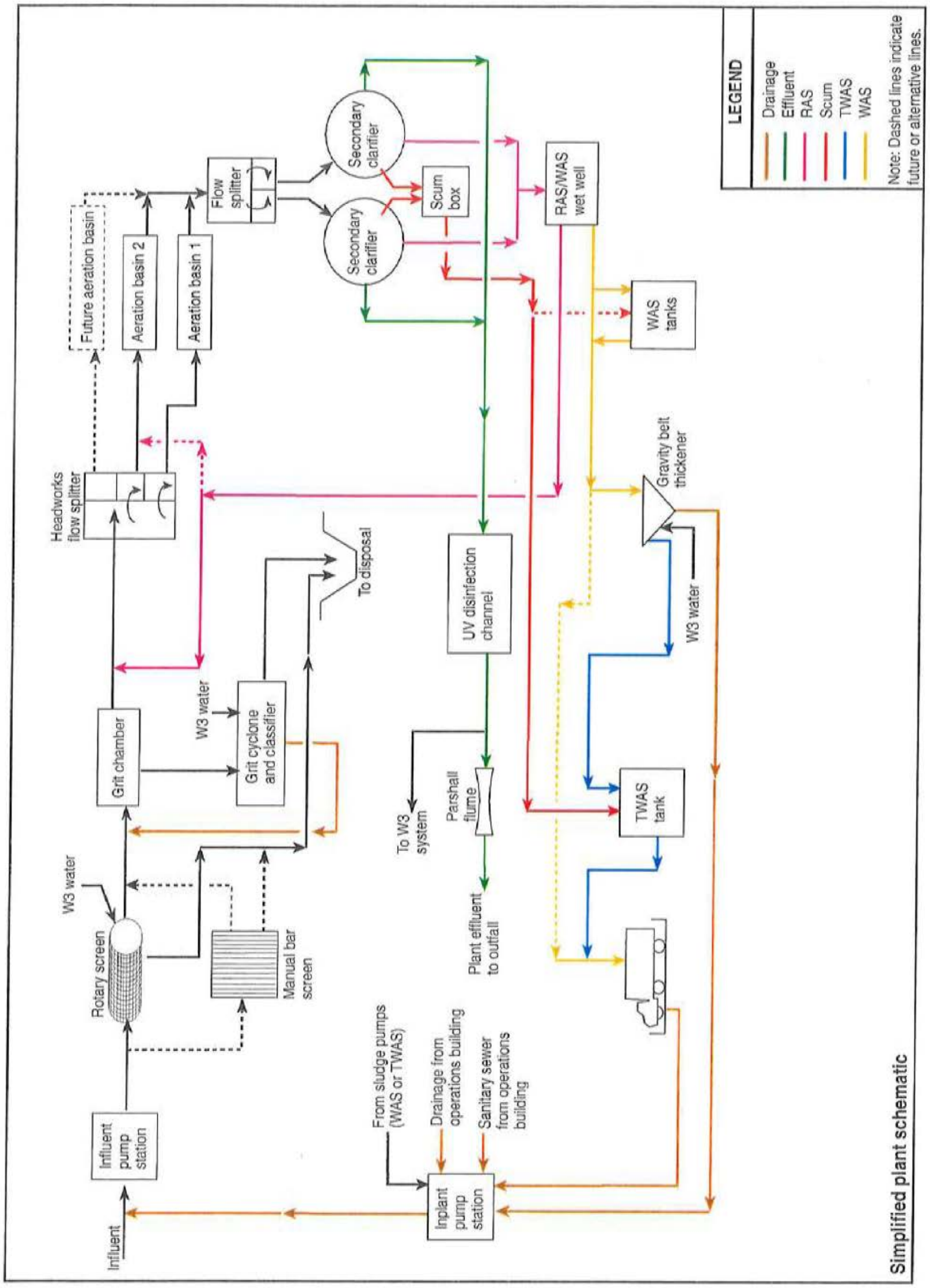
where: $\sigma^2 = \ln[(CV^2 \div n) + 1]$

n = number of samples/month

$z = 1.645$ (95^{th} % occurrence probability)

LTA = Limiting long term average

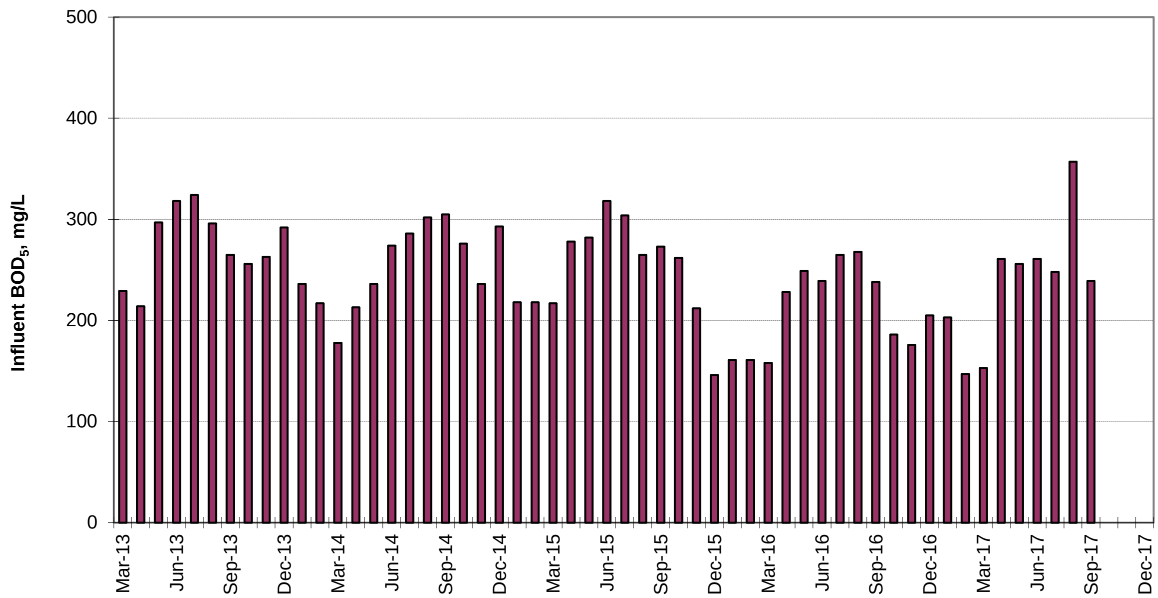
Manchester WWTP - Process Flow Diagram

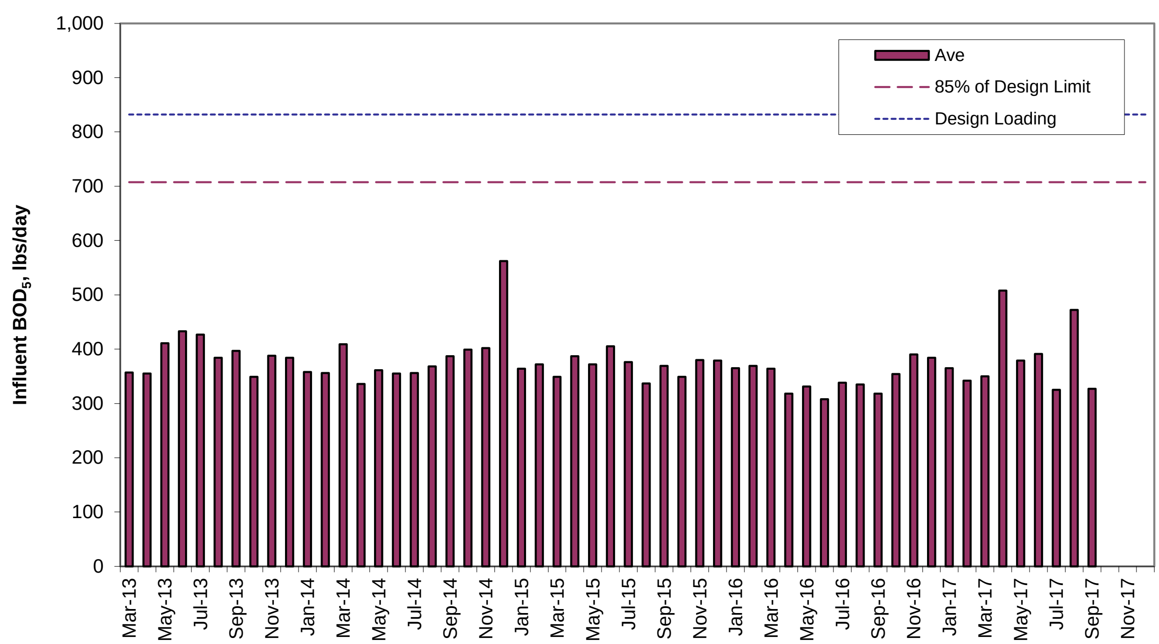


Manchester WWTP Data (2013-2017)

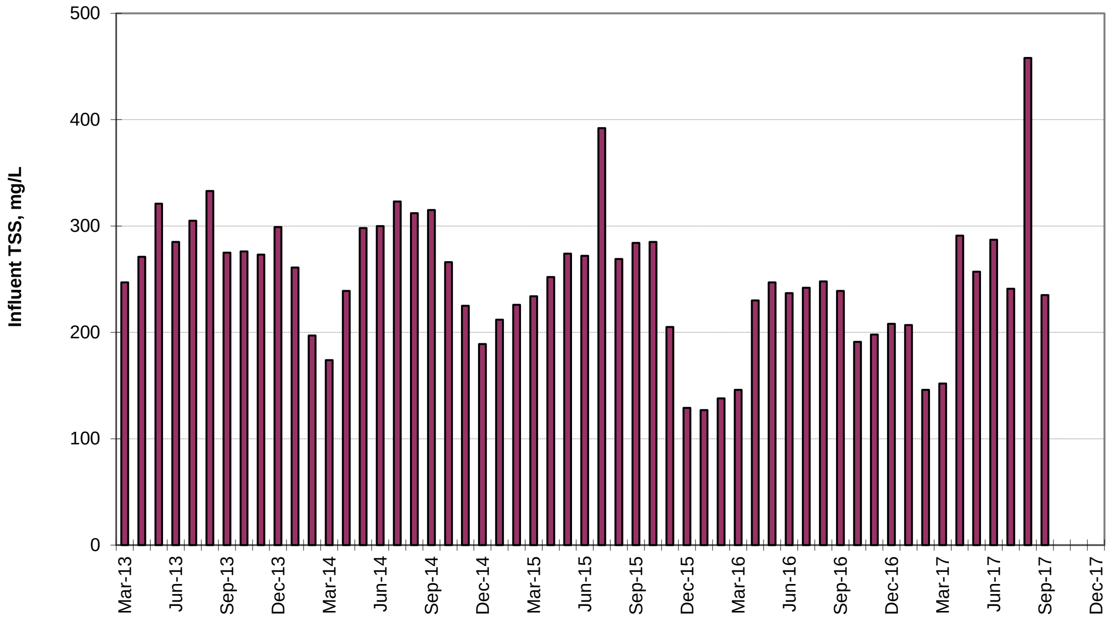
	Influent								Effluent																				
Date	BOD5, mg/L Ave	BOD5, mg/L Max	BOD5, ppd Ave	BOD5, ppd Max	TSS, mg/L Ave	TSS, mg/L Max	TSS, ppd Ave	TSS, ppd Max	Flow, MGD Ave	Flow, MGD Max Day	BOD5, mg/L Mnthly Ave	BOD5, mg/L Wkly Ave	BOD5, ppd Mnthly Ave	BOD5, ppd Wkly Ave	BOD5, % Removal Ave	TSS, mg/L Mnthly Ave	TSS, mg/L Wkly Ave	TSS, ppd Mnthly Ave	TSS, ppd Wkly Ave	TSS, % Removal Ave	Fecal Coliform, #/100 mL GEM	Fecal Coliform, #/100 mL GM7	PH Min	PH Max	Temperature, C Ave	Temperature, C Max	Ammonia-N mg/L Ave	NO3+NO2-N, mg/L Ave	TKN-N mg/L Ave
Mar-13	229	261	357	438	247	332	387	557	0.19	0.24	5.9	7.7	9.2	11.8	97	5.6	6.9	8.7	10.6	98	2	3	6.9	7.0					
Apr-13	214	279	355	428	271	411	449	630	0.19	0.33	4.0	5.1	7.0	8.5	98	5.0	5.5	8.6	11.9	98	2	8	6.8	7.0			2.1	5.6	3.5
May-13	297	337	411	511	321	496	440	605	0.16	0.21	5.7	8.2	8.1	12.8	98	4.6	5.5	6.4	7.6	99	1	2	6.9	7.0					
Jun-13	318	449	433	622	285	349	388	495	0.16	0.19	5.1	6.5	7.0	8.7	98	4.2	4.9	5.8	7.3	99	2	5	6.9	7.0					
Jul-13	324	430	427	541	305	338	404	506	0.15	0.18	7.4	7.9	9.7	10.2	98	8.2	9.5	10.8	12.2	97	3	8	6.9	7.1	20.0	21.0	2.3	4.2	4.7
Aug-13	296	329	384	441	333	433	434	548	0.15	0.18	4.4	6.1	5.7	7.5	99	4.4	5.8	5.7	7.3	99	1	2	6.9	7.0	21.0	21.0			
Sep-13	265	333	397	487	275	322	412	528	0.17	0.29	4.8	5.4	7.4	8.2	98	5.0	5.9	7.7	8.0	98	3	5	6.6	7.0	20.0	21.0			
Oct-13	256	286	349	413	276	357	376	474	0.16	0.21	3.7	4.0	5.1	8.2	99	4.2	4.7	5.7	7.6	99	3	6	6.7	7.0			1.5	6.9	3.2
Nov-13	263	302	388	460	273	369	403	528	0.18	0.28	4.3	4.6	6.4	7.5	98	5.1	5.9	7.5	9.1	98	3	15	6.8	6.9					
Dec-13	292	362	384	510	299	439	395	619	0.16	0.18	4.2	4.7	5.6	6.4	99	4.3	4.8	5.6	6.5	99	10	31	6.8	7.1					
Jan-14	236	291	358	424	261	358	396	590	0.19	0.36	4.3	4.6	6.5	8.1	98	5.4	6.1	8.3	9.3	98	6	34	6.7	7.1			1.5	4.4	3.7
Feb-14	217	309	356	407	197	306	325	403	0.22	0.42	3.5	4.3	6.1	8.1	98	4.4	5.2	7.8	10.5	98	1	2	6.5	7.2					
Mar-14	178	328	409	638	174	223	400	569	0.28	0.57	3.9	5.3	9.5	16.7	98	3.8	6.0	10.0	19.3	98	5	7	6.7	7.0					
Apr-14	213	251	336	430	239	319	378	548	0.18	0.21	2.5	3.8	4.0	5.8	99	3.6	5.5	5.8	8.2	99	3	9	6.8	7.2			1.6	6.0	2.7
May-14	236	291	361	500	298	405	467	760	0.17	0.30	4.1	5.2	6.4	9.6	98	4.7	5.0	7.4	11.1	98	2	4	6.8	7.1					
Jun-14	274	306	355	404	300	410	387	469	0.15	0.18	6.4	7.3	8.4	9.6	98	7.6	10.8	10.1	14.5	97	4	23	6.9	7.1					
Jul-14	286	333	356	455	323	385	402	487	0.15	0.18	4.2	5.8	5.1	7.2	99	3.9	5.0	4.9	5.8	99	2	7	6.9	7.1	20.8	21.4	2.6	4.1	4.7
Aug-14	302	335	368	413	312	368	380	448	0.15	0.17	6.6	8.0	8.0	10.0	98	7.7	8.6	9.4	10.7	98	2	5	6.8	7.0	21.3	21.8			
Sep-14	305	350	387	468	315	416	401	557	0.15	0.18	5.2	6.0	6.6	8.0	98	5.2	6.7	6.8	8.9	98	3	17	6.8	7.0	20.3	20.9			
Oct-14	276	338	399	472	266	369	384	478	0.17	0.27	7.6	9.4	10.8	12.2	97	8.6	12.6	11.8	16.3	97	2	8	6.8	7.0			1.3	6.7	3.6
Nov-14	236	300	402	467	225	273	388	532	0.21	0.47	4.2	5.2	7.2	8.2	98	4.3	4.7	7.6	7.6	98	3	24	6.7	7.0					
Dec-14	293	930	562	1630	189	249	380	616	0.25	0.41	4.0	4.8	8.0	11.3	98	4.6	6.2	9.7	15.9	98	2	4	6.6	8.7					
Jan-15	218	309	364	490	212	238	353	390	0.20	0.40	2.9	3.5	4.9	6.1	99	3.6	4.6	6.1	8.4	98	1	1	6.7	6.9			1.3	6.2	3.4
Feb-15	218	272	372	413	226	282	394	495	0.21	0.40	3.6	3.9	6.4	7.7	98	4.4	4.6	8.2	10.4	98	1	2	6.7	6.9					
Mar-15	217	298	349	454	234	352	379	583	0.20	0.52	3.2	3.5	5.3	5.7	98	4.0	5.2	6.7	7.6	98	21	60	6.7	6.9					
Apr-15	278	342	387	465	252	372	352	500	0.16	0.19	4.8	5.6	6.8	7.8	98	6.3	8.2	8.8	11.4	98	7	26	6.8	7.0			1.6	5.3	3.8
May-15	282	318	372	460	274	328	360	432	0.15	0.19	5.1	6.0	6.8	7.8	98	5.9	6.7	7.9	8.8	98	1	2	6.9	7.0					
Jun-15	318	389	405	547	272	346	346	487	0.15	0.18	6.4	7.6	8.2	9.9	98	6.2	7.7	7.8	9.9	98	2	10	6.9	7.0					
Jul-15	304	328	376	448	392	553	481	650	0.15	0.18	5.3	6.1	6.6	7.7	98	5.7	6.3	7.1	8.0	99	1	3	6.9	7.0	21.0	21.0	1.8	3.5	4.3
Aug-15	265	299	337	400	269	356	341	410	0.15	0.18	3.9	4.8	5.0	6.0	99	5.8	6.6	7.4	8.2	98	2	6	6.9	7.0	21.6	21.9			
Sep-15	273	313	369	434	284	330	384	470	0.15	0.18	3.7	4.4	5.0	6.3	99	5.9	7.1	8.0	9.9	98	1	4	6.9	7.1	20.4	21.2			
Oct-15	262	286	349	391	285	310	381	446	0.16	0.24	2.9	3.8	3.8	4.9	99	4.4	5.3	5.9	6.8	98	2	7	6.7	7.0			1.1	3.4	3.3
Nov-15	212	300	380	480	205	265	363	418	0.22	0.45	2.8	2.9	5.4	7.5	99	5.3	6.0	10.1	15.8	97	3	11	6.7	7.0					
Dec-15	146	204	379	418	129	160	340	418	0.32	0.68	5.8	7.0	16.4	25.4	96	8.9	10.6	25.4	41.8	93	5	16	6.6	7.8					
Jan-16	161	260	365	438	127	197	299	430	0.30	0.71	6.5	9.2	20.5	42.8	94	10.1	14.1	31.3	64.8	90	1	2	6.6	6.9			0.8	4.9	3.2
Feb-16	161	203	369	422	138	170	316	353	0.27	0.34	5.6	6.4	13.1	16.8	97	7.1	7.6	16.6	20.4	95	6	169	6.7	6.9					
Mar-16	158	266	364	586	146	216	338	460	0.30	0.49	4.8	5.8	12.3	16.6	96	6.6	9.0	17.9	27.3	95	2	11	6.6	6.9					
Apr-16	228	258	318	411	230	269	321	383	0.16	0.19	4.4	6.1	6.2	8.8	98	4.6	6.7	6.3	9.4	98	2	22	6.9	7.0			2.4	1.6	4.8
May-16	249	278	331	381	247	292	328	401	0.15	0.23	8.0	9.2	10.6	12.6	97	10.7	12.4	14.3	17.0	96	4	12	6.8	7.1					
Jun-16	239	258	308	369	237	283	307	347	0.15	0.20	7.8	11.2	10.1	15.0	97	10.5	14.1	13.7	19.0	96	6	32	6.9	7.1					
Jul-16	265	341	338	436	242	300	310	408	0.15	0.18	6.0	7.3	7.6	10.1	98	6.6	7.8	8.5	10.7	97	5	8	6.7	7.1	20.7	21.1	2.6	3.1	5.3
Aug-16	268	379	335	496	248	333	310	428	0.15	0.17	6.2	11.3	8.1	15.9	97	5.4	8.1	7.0	11.2	98	6	57	6.8	7.4	20.9	22.1			
Sep-16	238	276	318	381	239	280	319	394	0.16	0.18	5.4	5.8	7.1	8.1	98	6.5	6.9	8.7	9.3	97	5	8	6.7	7.1	19.9	21.3			
Oct-16	186	249	354	504	191	270	361	436	0.22	0.34	7.3	7.8	15.2	21.0	96	8.8	11.7	18.8	32.7	95	7	10	6.8	7.0			8.0	1.1	8.2
Nov-16	176	199	390	559	198	229	444	628	0.28	0.49	7.4	8.2	17.8	22.6	96	7.7	8.9	18.8	26.2	96	14	97	6.9	7.1					
Dec-16	205	255	384	587	208	295	393	679	0.23	0.33	5.6	7.5	10.7	15.5	97	5.9	7.4	11.3	15.4	97	8	16	6.9	7.0					
Jan-17	203	251	365	442	207	276	375	469	0.23	0.60	4.5	4.9	8.6	11.2	98	4.9	5.6	9.5	14.4	97	3	47	6.8	7.6			5.6	1.4	6.9
Feb-17	147	247	342	466	146	264	346	522	0.30	0.63	4.0	5.8	11.3	21.8	97	4.1	5.0	11.6	19.4	97	9	15	6.7	7.0					
Mar-17	153	211	350	458	152	246	348	643	0.29	0.42	3.6	3.9	8.3	8.9	98	4.0	4.9	9.1	10.4	97	5	12	6.8	7.0					
Apr-17	261	491	508	941	291	508	563	973	0.23	0.33	6.7	10.7	13.1	20.1	97	5.7	8.1	11.0	15.2	98	12	62	6.9	7.1			8.3	1.0	9.6
May-17	256	322	379	450	257	400	379	576	0.18	0.21	6.4	7.7	9.5	11.2	98	6.0	7.0	8.8	10.1	98	6	74	6.9	7.1					
Jun-17	261	341	391	494	287	430	426	623	0.17	0.28	5.9	7.4	9.0	11.5	98	8.9	14.0	13.8	22.7	97	5	56	6.9	7.1					
Jul-17	248	314	325	378	241	366	316	440	0.16	0.19	5.9	6.6	7.8	8.7	98	6.0	6.7	8.0	8.8	97	45	84	6.9	7.1	19.8	20.6	3.6	3.0	5.5
Aug-17	357	1172	472	1632	458	2130	611	2966	0.16	0.27	10.7	18.0	14.1	23.2	96	13.1	25.4	17.0	32.8	94	46	202	6.7	7.2	20.8	21.6			
Sep-17	239	272	327	391	235	321	319	399	0.16	0.18	4.5	5.3	6.1	7.1	98	6.1	7.6	8.4	10.2	97	29	71	6.7	7.2	20.2	21.2			
AVE:	245	331	375	512	250	362	381	556	0.2	0.3	5.2	6.5	8	12	98	6.0	7.6	10	14	97	6	26	6.8	7.1	20.6	21.3	2.8	4.0	4.7
MIN:	146	199	308	369	127	160	299	347	0.1	0.2	2.5	2.9	4	5	94	3.6	4.6	5	6	90	1	1	6.5	6.9	19.8	20.6	0.8	1.0	2.7
MAX:	357	1172	562	1632	458	2130	611	2966	0.3	0.7	10.7	18.0	21	43	99	13.1	25.4	31	65	99	46	202	6.9	8.7	21.6	22.1	8.3	6.9	9.6

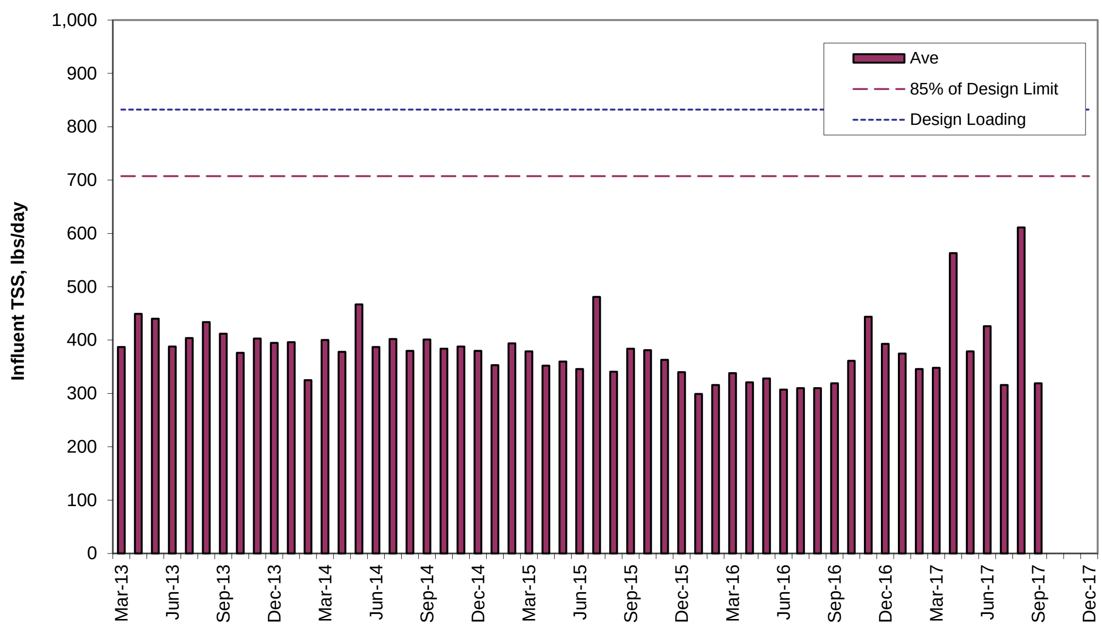
Manchester WWTP Influent – BOD_5



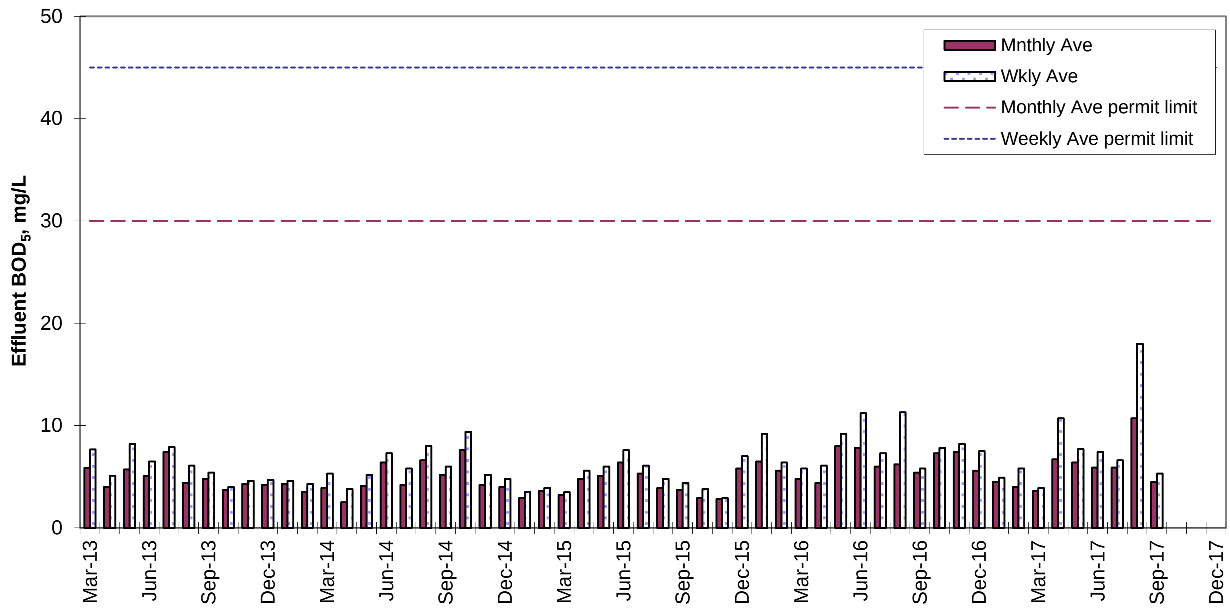


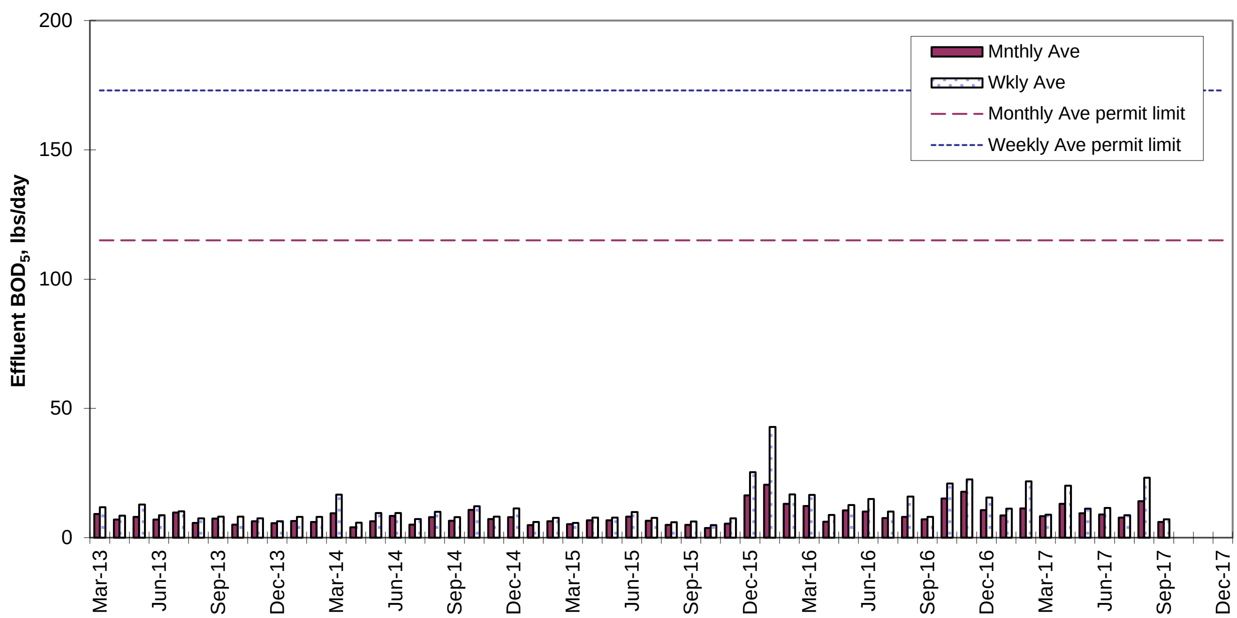
Manchester WWTP Influent - TSS



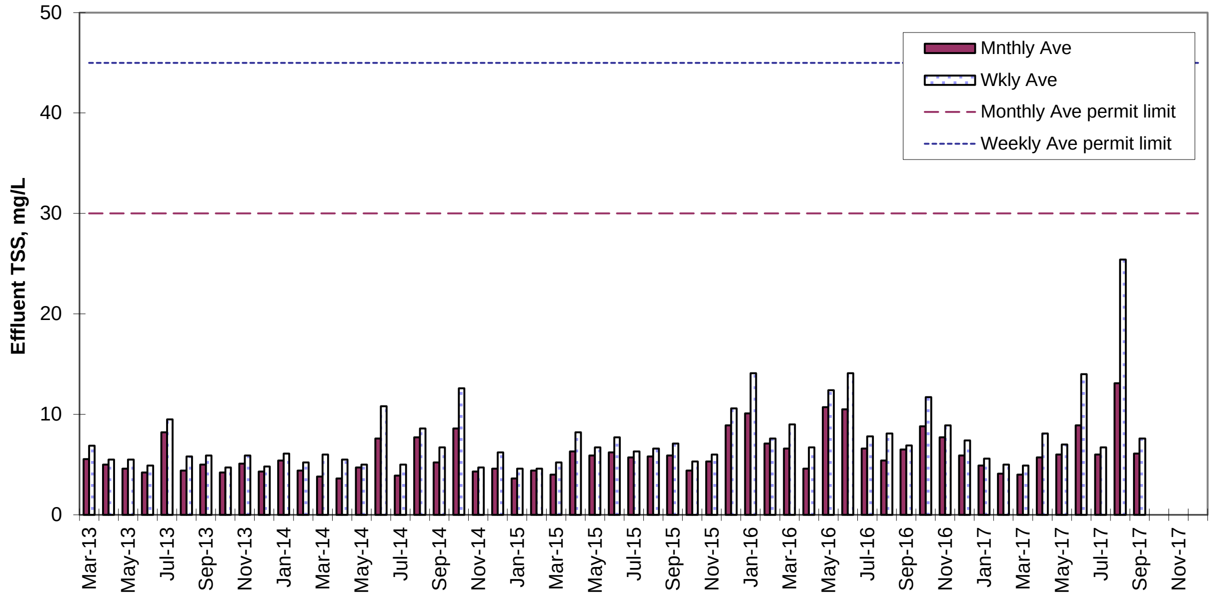


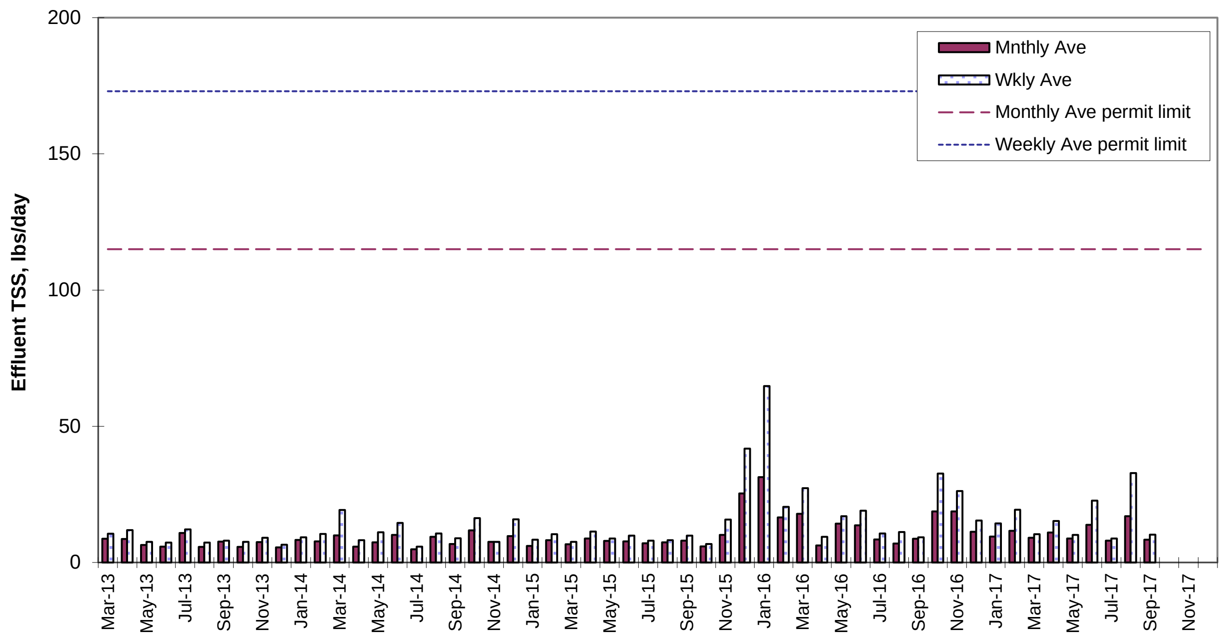
Manchester WWTP Effluent – BOD_5



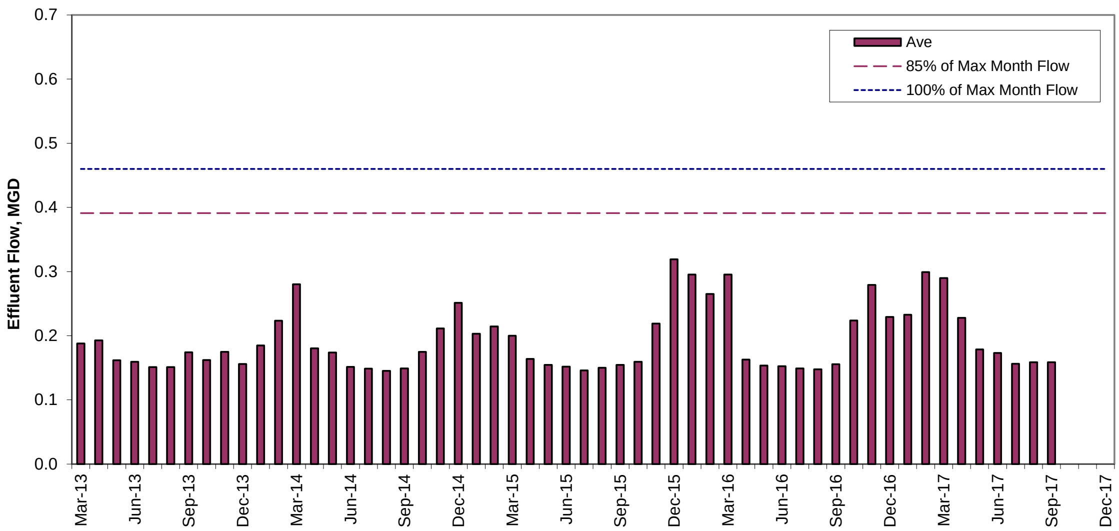


Manchester WWTP Effluent - TSS

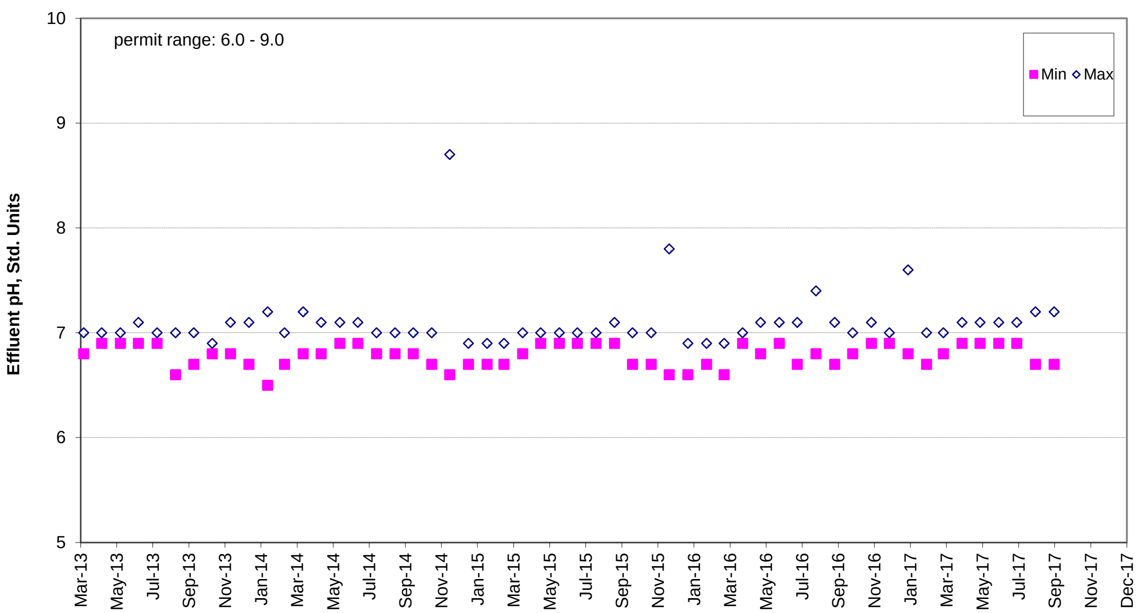




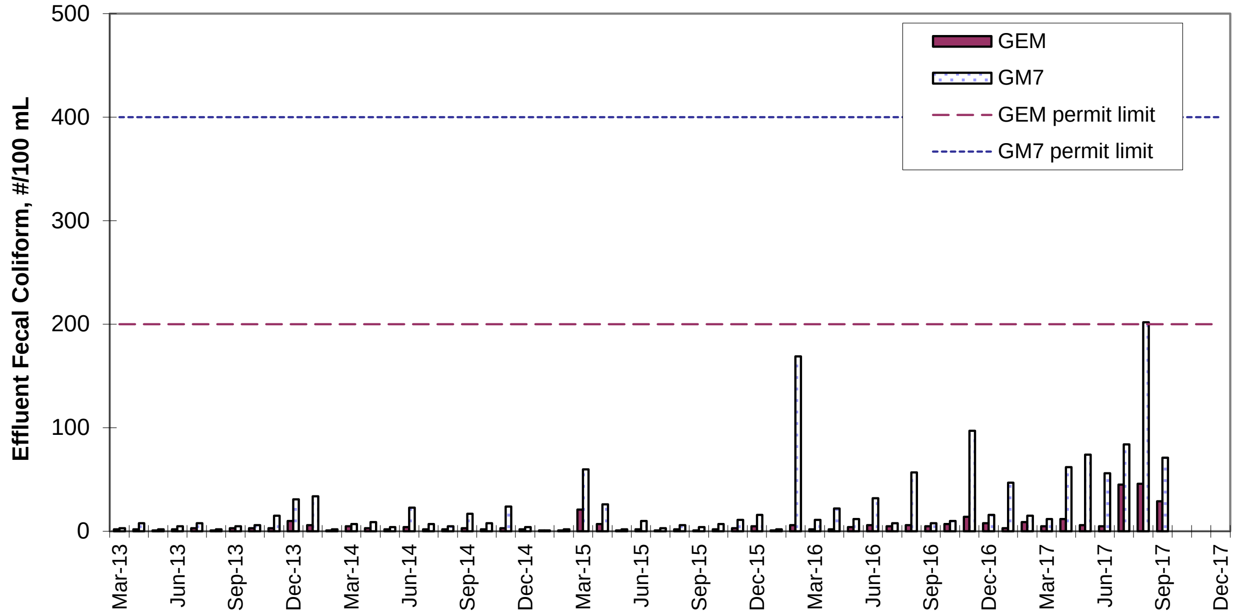
Manchester WWTP Effluent – Flow



Manchester WWTP Effluent - pH



Manchester WWTP Effluent – Fecal Coliform



Reasonable Potential Calculations

Reasonable Potential Calculation

Facility	Manchester WWTP
Water Body Type	Marine

Dilution Factors:	Acute	Chronic
Aquatic Life	45.0	305.0
Human Health Carcinogenic		305.0
Human Health Non-Carcinogenic		305.0

Pollutant, CAS No. & NPDES Application Ref. No.			AMMONIA, Criteria as Total NH3										
Effluent Data	# of Samples (n)		104										
	Coeff of Variation (Cv)		1.4	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Effluent Concentration, ug/L (Max. or 95th Percentile)		16,400										
	Calculated 50th percentile Effluent Conc. (when n>10)												
Receiving Water Data	90th Percentile Conc., ug/L		0										
	Geo Mean, ug/L												
Water Quality Criteria	Aquatic Life Criteria, ug/L	Acute	2,040										
		Chronic	306										
	WQ Criteria for Protection of Human Health, ug/L		-										
	Metal Criteria Translator, decimal	Acute	-										
		Chronic	-										
	Carcinogen?		N										

Aquatic Life Reasonable Potential

Effluent percentile value			0.950
s	$s^2=\ln(CV^2+1)$		1.042
Pn	$Pn=(1\text{-confidence level})^{1/n}$		0.972
Multiplier			1.00
Max concentration (ug/L) at edge of...		Acute	364
		Chronic	54
Reasonable Potential? Limit Required?			**NO**

Calculations for Fecal Coliform

Calculation of Fecal Coliform at Chronic Mixing Zone

INPUT	
Chronic Dilution Factor	305.0
Receiving Water Fecal Coliform, #/100 ml	1
Effluent Fecal Coliform - worst case, #/100 ml	400
Surface Water Criteria, #/100 ml	*14*
OUTPUT	
Fecal Coliform at Mixing Zone Boundary, #/100 ml	**2**
Difference between mixed and ambient, #/100 ml	1

Conclusion: At design flow, the discharge has no reasonable potential to violate water quality standards for fecal coliform.

Calculations for Ammonia

Marine Un-ionized Ammonia Criteria Calculation

Calculation of seawater fraction of un-ionized ammonia from Hampson (1977). Un-ionized ammonia criteria for salt water are from EPA 440/5-88-004. Revised 19-Oct-

INPUT	
1. Receiving Water Temperature, deg C (90th percentile):	13.5
2. Receiving Water pH, (90th percentile):	8.7
3. Receiving Water Salinity, g/kg (10th percentile):	30.0
4. Pressure, atm (EPA criteria assumes 1 atm):	1.0
5. Unionized ammonia criteria (mg un-ionized NH_3 per liter) from EPA 440/5-88-004:	
Acute:	0.233
Chronic:	0.035
OUTPUT	
Using mixed temp and pH at mixing zone boundaries?	No
1. Molal Ionic Strength (not valid if >0.85):	0.616
2. pKa8 at 25 deg C (Whitfield model "B"):	9.317
3. Percent of Total Ammonia Present as Unionized:	9.4%
4. Total Ammonia Criteria (mg/L as NH_3):	
Acute:	2.48
Chronic:	0.37
RESULTS	
Total Ammonia Criteria (mg/L as N)	
Acute:	**2.04**
Chronic:	**0.31**

Calculations for Temperature

Marine Temperature Reasonable Potential and Limit Calculation

Based on WAC 173-201A-200(1)(c)(i)--(ii) and Water Quality Program Guidance. All Data inputs must meet WQ guidelines. The Water Quality temperature guidance document may be found at: http://www.ecy.wa.gov/biblio/0610100.html

INPUT	Summer
1. Chronic Dilution Factor at Mixing Zone Boundary	305.0
2. Annual max 1DADMax Ambient Temperature (Background 90th percentile)	13.5 °C
3. 1DADMax Effluent Temperature (95th percentile)	22.3 °C
4. Aquatic Life Temperature WQ Criterion	13.0 °C
OUTPUT	
5. Temperature at Chronic Mixing Zone Boundary:	13.53 °C
6. Incremental Temperature Increase or decrease:	0.03 °C
7. Incremental Temperature Increase 12/(T-2) if T≤ crit:	---
8. Maximum Allowable Temperature at Mixing Zone Boundary:	13.80 °C
A. If ambient temp is warmer than WQ criterion	
9. Does temp fall within this warmer temp range?	YES
10. Temp increase allowed at mixing zone boundary, if required:	NO LIMIT
B. If ambient temp is cooler than WQ criterion but within 12/(T_{amb}-2) and within 0.3 °C of the criterion	
11. Does temp fall within this incremental temp. range?	---
12. Temp increase allowed at mixing zone boundary, if required:	---
C. If ambient temp is cooler than (WQ criterion-0.3) but within 12/(T_{amb}-2) of the criterion	
13. Does temp fall within this Incremental temp. range?	---
14. Temp increase allowed at mixing zone boundary, if required:	---
D. If ambient temp is cooler than (WQ criterion - 12/(T_{amb}-2))	
15. Does temp fall within this Incremental temp. range?	---
16. Temp increase allowed at mixing zone boundary, if required:	---
RESULTS	
17. Do any of the above cells show a temp increase?	**NO**
18. Temperature Limit if Required?	**NO LIMIT**

Appendix E -- Response to Comments

Draft NPDES Permit (Entity Review)

Comment 1:

NPDES Permit WA0023701, Section 5.G. Operations and maintenance (O&M) manual, a. O&M manual submittal and requirements – Please add provisions for electronic review of O&M manual as our manual resides on the County's SharePoint site and cannot be printed (see CKTP's Permit).

Response:

Per County's request, Ecology has added electronic O&M Manual submittal via VPN access.

Public Review 30-Day Comment Period:

During the public comment period, no comments were received.

consor

APPENDIX B
INDUSTRIAL USER SURVEY

KITSAP COUNTY DEPARTMENT OF PUBLIC WORKS
614 DIVISION STREET (MS-26), PORT ORCHARD, WA 98366-4699 | KITSAP1: 360.337.5777 | KITSAPGOV.COM

MANCHESTER WASTEWATER TREATMENT PLANT

INDUSTRIAL USER SURVEY

FOR THE

DEPARTMENT OF ECOLOGY

Prepared by:

KITSAP COUNTY'S SEWER UTILITY
12351 Brownsville Hwy NE
Poulsbo, WA 98370
(360) 337-7197

August 8, 2017

Table of Contents:

SECTION 1

MANCHESTER INDUSTRIAL USER SURVEY

KITSAP COUNTY CODE:

Chapter 13.12.160 Prohibited Discharges

SECTION 1 – KITSAP COUNTY CODE:

Chapter 13.12.160 Prohibited Discharges

Except as provided in Section 13.12.170, no discharger shall discharge or cause to be discharged into a public sewer, place or cause to be placed where they are likely to run, leak or escape into a public sewer, any of the following:

(1) Any solid or viscous substances which may obstruct or interfere with the capacity or operation of the sewer such as but not limited to ashes, cinders, sand, earth, rubbish, mud, straw, shavings, metal, glass, rags, feathers, tar, plastic or wood;

(2) Any liquids, solids, or gases, which because of their nature or quantity are, or may be, sufficient, either alone or by interaction with other substances, to cause fire or explosion or be injurious in any other way to the wastewater collection and treatment system. At no time shall two successive readings on an explosion hazard meter, at the point of discharge into the system (or at any point in the system), be more than five percent nor any single reading over ten percent of the lower explosive limit (LEL) of the meter. Prohibited materials include but are not limited to: gasoline, kerosene, naphtha, benzene, toluene, xylene, ethers, alcohols, ketones, aldehydes, peroxides, chlorates, perchlorates, bromates, carbides, hydrides and sulfides, and any other substances that the county, the state, the EPA, or the fire department has notified the user is a fire hazard or a hazard to the system;

(3) Any matter having a temperature greater than forty degrees Celsius, or will inhibit biological activity at the wastewater treatment plant;

(4) Sewage containing suspended solids in excess of three hundred fifty milligrams per liter;

(5) Wastewater containing fats, oils or grease in excess of one hundred parts per million (mg/L);

(6) Wastewater with B.O.D. greater than three hundred milligrams per liter;

(7) Wastewater with pH lower than 6.0 or higher that 9.0, or having any corrosive property capable of causing damage to structures, equipment or personnel;

(8) Garbage that has not been properly shredded;

(9) Wastewater containing toxic substances in sufficient quantity to injure or interfere with any wastewater treatment process, constitute a hazard to humans or the environment, create any hazard in the receiving waters of a wastewater treatment plant, or exceed the limitation set forth in the pretreatment standards;

(10) Any noxious or malodorous matter capable of creating a public nuisance or hazard to life, or sufficient to prevent entry into the sewers for their maintenance and repair;

(11) Any unpolluted water including but not limited to; waters from irrigation, water main flushing, cooling processes, industrial processes creating no substantial water contamination, storm drains, surface runoff, roof runoff, subsurface drainage, swimming pools, ponds or reservoirs;

(12) Any matter which is radioactive to any degree above that which normally prevails in the county;

(13) Any substance that may cause the wastewater treatment plant's effluent or treatment residues, biosolids or scums to be unsuitable for reclamation and reuse or to interfere with the reclamation process. (In no case shall a substance discharged to the wastewater treatment plant cause the treatment plant to be in noncompliance with biosolid use or disposal criteria, guidelines, or regulations developed under Sections 405 and 503 of the Clean Water Act, any criteria, guidelines or regulations affecting biosolids use or disposal developed pursuant to the Solid Waste Disposal Act, the Clean Air Act, the Toxic Substance Control Act, or state standards applicable to the biosolids management method being used.);

(14) Any substance that will cause the wastewater treatment plant to violate its NPDES and/or other disposal system permits;

(15) Any slugload, which shall mean any pollutant, including oxygen-demanding pollutants (B.O.D., etc.), released in a single extraordinary discharge episode of such volume or strength as to cause interference to the treatment plant. In no case shall a slugload contain concentrations or qualities of pollutants that exceed for any period longer than fifteen minutes more than five times the average twenty-four-hour concentration, quantities or flow during normal operation;

(16) Wastewater containing substances not amenable to treatment or reduction by the sewage treatment process employed, or are amenable to treatment only to such a degree that the sewage treatment plant effluent cannot meet the requirements of other agencies having jurisdiction over discharge to the receiving waters;

(17) National Categorical Pretreatment Standards. National categorical pretreatment standards, as promulgated by the EPA pursuant to the Clean Water Act and as adopted, shall be enforceable by this chapter and shall be met by all dischargers of the regulated industrial categories;

(18) State Requirements. State requirements and limitations on dischargers to the wastewater system shall be met by all dischargers which are subject to standards in any instance in which they are more stringent than federal requirements and limitations or those in this or any other applicable ordinance;

(19) Any discharge that exceeds the following daily maximum pollutant limits:

Arsenic	0.15 mg/L
Cadmium	0.10 mg/L
Chromium	1.0 mg/L
Copper	0.75 mg/L
Lead	0.25 mg/L
Mercury(1)	0.010 mg/L
Molybdenum	2.0 mg/L
Nickel	0.60 mg/L
Selenium	0.80 mg/L
Silver(1)	0.50 mg/L
Zinc	2.0 mg/L
Cyanide	0.75 mg/L
Ammonia	50.0 mg/L

Notes: (1) Businesses that follow Best Management Practices (BMPs) for their industry can petition Public Works Wastewater for higher limits. This will be limited to businesses contributing less than 1% of the total flow to the Publicly Owned Treatment Works (POTW).

(Ord. 300 (2003), 2003: Ord. 55-I (1996) § 1 (part), 1996: Ord. 55 (1974) § 16, 1974)

SECTION 2

MANCHESTER INDUSTRIAL USER SURVEY

INFORMATION USED FOR MASTER LIST

Kitsap County's Description of Source Information

Information used for Master List

August 8, 2017

Department of Ecology
Northwest Regional Office
3190 160th Ave SE
Bellevue, WA 98008-5452

Sources of information: As recommended by the "Guidance Manual for Performing an Industrial User Survey," Kitsap County compiled a master list using billing records, specifically water use. The manual recommended surveying businesses over 25,000 gallons per/day or businesses contributing a process wastestream of 5% or more of the average dry weather hydraulic or organic capacity of the Manchester Treatment Plant. This criteria eliminated every businesses from our survey pool. Kitsap County decided to set the standard at 1,000 cubic feet per/month, which put 6 businesses into Manchester's Industrial User Survey.

Along with using water consumption rates, the business accounts were evaluated for potential industrial dischargers based on their production. After this assessment there were no new businesses added to Manchester's list based on their production criteria.

If you have any questions or concerns, please contact me at 360-337-5768.

Thank You,

Patrick Kongslie

Patrick Kongslie
Utility Operations Supervisor
Kitsap County Public Works-Sewer Utility Division

CC: Stella Vakarcs, Kitsap County Senior Program Manager

SECTION 3

MANCHESTER INDUSTRIAL USER SURVEY

COPY OF QUESTIONNAIRE

Blank Copy of Survey Form

WASTEWATER DIVISION
INDUSTRIAL USER SURVEY FOR NON-RESIDENTIAL ESTABLISHMENTS

INTRUCTIONS: Please type or print information clearly with pen. Attach additional sheets as needed. Please complete a survey for each facility that discharges to the Kitsap County sanitary sewer system. Additional information and copies of this form are available from Patrick Kongslie, Kitsap County's Utility Operations Supervisor @ 12351 Brownsville Hwy NE Poulsbo, WA 98370. (360) 337-7197.

1. Company Name:______________________________ Survey # ________

2. Mailing Address:____

3. Facility Address:____

4. Telephone Number:______________________________________

5. Name and Title of contact person:____________________________

6. Products produced or service provided: __________________________

7. Provide a brief narrative of the manufacturing, production, or service activities at your facility:____

8. You use approximately ________ gallons of water per day.

9. How much of your daily water use goes into the wastewater sewer system?________________

10. Do you discharge any wastewater other than domestic waste (restrooms, showers, ect.)? ( ) Yes ( ) No

11. If yes, what kinds of non-domestic waste do you discharge? ________________

____

____

12. Will water be used for product manufacture, wash down, or floor cleaning in production areas? ( ) Yes ( ) No

13. Do you have floor drains in your process / work area? ( ) Yes ( ) No

14. Do you discharge oil, grease, or animal / vegetable fats to the sewer system? ( ) Yes ( ) No

15. Do you have a grease trap or oil / water separator on any discharge line to the sewer system? ( ) Yes ( ) No

16. If yes, which do you have? ( ) grease trap ( ) oil / water ( ) both

17. How often do you have it cleaned? ________________________________

18. Do you store toxic / hazardous / dangerous materials at your facility? ( ) Yes ( ) No

19. If yes, what are these materials?________________________________

____

20. Do you qualify as a Hazardous Waste Small Quantity Generator?
( ) Yes ( ) No

21. Are you aware of Kitsap County's Small Quantity Generator (SQG) Program?
( ) Yes ( ) No

22. Do you have a plan to prevent accidental spills? ( ) Yes ( ) No

For more information on the SQG Program call the Solid Waste Division at (360) 337- 5777. For technical assistance with hazardous waste contact the Bremerton – Kitsap County Health District at (360) 692-3611.

The information collected during this survey is used to fulfill the requirements for Kitsap County's Wastewater Treatment Plants National Pollutant Discharge Elimination System (NPDES) Permit through the Department of Ecology.

Print name and title: ______________________________

Sign and date: ______________________________

I understand by signing this I hereby certify the above statement is true to the best of my knowledge and ability. I understand that this is a legal document and will be used to determine our Industrial User Status with the Department of Ecology.

SECTION 4

MANCHESTER INDUSTRIAL USER SURVEY

FORM 1

Master List of Industries Surveyed

KITSAP COUNTY
18 57
WASHINGTON

Account no	Occupant code	Active(Y/N)	Name	Street	City	zip	TYPE	Cubic Ft/Month
320110	0	Y	MANCHESTER ELEMENTARY SCHOOL	1901 CALIFORNIA AVE	PORT ORCHARD	98366	CO	4220
320120	1	Y	DONALD SHARMAN M.D.	2256 COLCHESTER DR E	MANCHESTER	98353	CO	125
320200	0	Y	MANCHESTER WATER DISTRICT	2081 SPRING AVE E	MANCHESTER	98353	CO	FLAT BILL
320210	3	Y	STURDI HOLDINGS LLC	2288 COLCHESTER DR E	MANCHESTER	98353	CO	364
320230	0	Y	COMMANDING OFFICER(C/320)	MANCHESTER FUEL DEPO	MANCHESTER	98353	CO	FLAT BILL
320250	0	Y	MANCHESTER COMMUNITY CHURCH	7450 E CHESTER	MANCHESTER	98353	CO	197
320270	0	Y	E P A/USEPA RTP-FINANCE CENTER	7411 BEACH DR E	MANCHESTER	98353	CO	4603
320302	1	Y	MANCHESTER REALTY	9000 MAIN ST	MANCHESTER	98353	CO	261
320370	0	Y	MANCHESTER STATE PARK	7767 E HILLDALE RD	MANCHESTER	98353	CO	3747
320400	1	Y	RICHARD VAN ENGERS Sturdi Products	2280 COLCHESTER DR E	MANCHESTER	98353	CO	8
320410	0	Y	FRIENDS OF MANCHESTER LIBRARY	MAIN ST	MANCHESTER	98353	CO	423
321971	1	Y	PORT OF MANCHESTER	8115 E MAIN ST	MANCHESTER	98353	CO	142
336000	0	Y	MANCHESTER COMMUNITY CHURCH	7450 E CHESTER (SCHOOL)	MANCHESTER	98353	CO	1240
336590	0	Y	U S POSTAL SERVICE	2325 COLCHESTER DR E	MANCHESTER	98353	CO	167
337543	0	Y	NOAA NW FISHERIES SCIENCE CTR	7305 BEACH DR E	PORT ORCHARD	98366	CO	FLAT BILL
337659	0	Y	E P A/USEPA RTP-FINANCE CENTER	7411 BEACH DR E	MANCHESTER	98383	CO	340
337660	0	Y	E P A/USEPA RTP-FINANCE CENTER	7411 BEACH DR E	MANCHESTER	98353	CO	324
337661	0	Y	E P A/USEPA RTP-FINANCE CENTER	7411 BEACH DR E	MANCHESTER	98353	CO	324
337662	0	Y	E P A/USEPA RTP-FINANCE CENTER	7411 BEACH DR E	MANCHESTER	98353	CO	646
337743	0	Y	MARILYN OIEN	2350 COLCHESTER DR E	MANCHESTER	98353	CO	65
337744	0	Y	ANCHORS AT MANCHESTER HOA	8079 E MAIN ST	PORT ORCHARD	98366	CO	3857
337745	0	Y	ANCHORS AT MANCHESTER HOA	8185 E DANIELS LP	PORT ORHCARD	98366	CO	785
320081	1	Y	FAMILY INN AT MANCHESTER	2386 COLCHESTER DR E	PORT ORCHARD	98366	CR	1863
320131	1	Y	MARILYN OIEN - manchester pub	2326 COLCHESTER DR E	MANCHESTER	98353	CR	1231

SECTION 5

MANCHESTER INDUSTRIAL USER SURVEY

FORM 2

List of Industries Eliminated from Survey

FORM 2 - ELIMINATED INDUSTRIAL DISCHARGERS

Survey #	Active(Y/N)	Name	Street	City	Survey Status
1	Y	MANCHESTER ELEMENTARY SCHOOL	1901 CALIFORNIA AVE	PORT ORCHARD	ELIMINATED
2	Y	E P A/USEPA RTP-FINANCE CENTER	7411 BEACH DR E	MANCHESTER	POTENTIAL
3	Y	MANCHESTER STATE PARK	7767 E HILLDALE RD	MANCHESTER	ELIMINATED
4	Y	MANCHESTER COMMUNITY CHURCH	7450 E CHESTER (SCHOOL)	MANCHESTER	ELIMINATED
5	Y	FAMILY INN AT MANCHESTER	2386 COLCHESTER DR E	PORT ORCHARD	ELIMINATED
6	Y	MARILYN OIEN - manchester pub	2326 COLCHESTER DR E	MANCHESTER	ELIMINATED

SECTION 6

MANCHESTER INDUSTRIAL USER SURVEY

FORM 3

List of MIUs and SIUs

KITSAP COUNTY DEPARTMENT OF PUBLIC WORKS
614 DIVISION STREET (MS-26), PORT ORCHARD, WA 98366-4699 | KITSAP1: 360.337.5777 | KITSAPGOV.COM

Form 3 – Manchester Industrial User Survey

August 8, 2017

Department of Ecology
Northwest Regional Office
3190 160th Ave SE
Bellevue, WA 98008-5452

Priority A Facilities: There are no Priority A Facilities in the Manchester service area.

Priority B Facilities: After conduction Manchester's Industrial User Survey and looking through the results there is only one potential industrial user identified, which is EPA/USEPA RRP – Finance Center. EPA/USEPA RRP – Finance Center's signed Industrial User Survey shows that they discharge domestic waste as well as analytical waste streams from their environmental analytical laboratory. This leads Kitsap County to consider EPA/USEPA RRP – Finance Center as a potential industrial discharger. The other businesses surveyed confirmed compliance with Kitsap County's Prohibited Discharge Standards, and therefor have been eliminated from further survey efforts.

If you have any questions or concerns, please contact me at 360-337-5768.

Thank You,

Patrick Kongslie

Patrick Kongslie
Utility Operations Supervisor
Kitsap County Public Works-Sewer Utility Division

CC: Stella Vakarcs, Kitsap County Senior Program Manager

SECTION 7

MANCHESTER INDUSTRIAL USER SURVEY

COPY OF SIGNED SURVEY

Signed Surveys of Potential and Significant Industrial Users

KITSAP COUNTY DEPARTMENT OF PUBLIC WORKS
614 DIVISION STREET (MS-26), PORT ORCHARD, WA 98366-4699 | KITSAP1: 360.337.5777 | KITSAPGOV.COM

WASTEWATER DIVISION
INDUSTRIAL USER SURVEY FOR NON-RESIDENTIAL ESTABLISHMENTS

INTRUCTIONS: Please type or print information clearly with pen. Attach additional sheets as needed. Please complete a survey for each facility that discharges to the Kitsap County sanitary sewer system. Additional information and copies of this form are available from Patrick Kongslie, Kitsap County's Utility Operations Supervisor @ 12351 Brownsville Hwy NE Poulsbo, WA 98370. (360) 337-7197.

1. Company Name: EPA/USEPA RRP-Finance Center Survey # 2
2. Mailing Address: 7411 BEACH DRIVE E
   PORT ORCHARD, WA 98366
3. Facility Address: SAME
4. Telephone Number: 360-871-8714
5. Name and Title of contact person: TONY MORRIS
   EC OFFICER
6. Products produced or service provided: ENVIRONMENTAL
   ANALYTICAL LABORATORY
7. Provide a brief narrative of the manufacturing, production, or service activities at your facility: ANALYTICAL SERVICES FOR
   U.S.E.P.A. REGION 10 + WASHINGTON STATE
   DEPT. OF ECOLOGY

8. You use approximately 1,132 gallons of water per day.

9. How much of your daily water use goes into the wastewater sewer system? ~ 100%

10. Do you discharge any wastewater other than domestic waste (restrooms, showers, ect.)? (X) Yes ( ) No

11. If yes, what kinds of non-domestic waste do you discharge?
ANALYTICAL LABORATOY WASTE STREAMS

12. Will water be used for product manufacture, wash down, or floor cleaning in production areas? ( ) Yes (X) No

13. Do you have floor drains in your process / work area? ( ) Yes (X) No

14. Do you discharge oil, grease, or animal / vegetable fats to the sewer system? ( ) Yes (X) No

15. Do you have a grease trap or oil / water separator on any discharge line to the sewer system? ( ) Yes (X) No

16. If yes, which do you have? ( ) grease trap ( ) oil / water ( ) both

17. How often do you have it cleaned?

18. Do you store toxic / hazardous / dangerous materials at your facility? (X) Yes ( ) No

19. If yes, what are these materials? LABORATORY SOLVENTS, REAGENTS, DIESEL FUELS IN TANKS. UPS LEAD-ACID BATTERIES.

20. Do you qualify as a Hazardous Waste Small Quantity Generator?
(X) Yes ( ) No

21. Are you aware of Kitsap County's Small Quantity Generator (SQG) Program?
(X) Yes ( ) No

22. Do you have a plan to prevent accidental spills? (✓) Yes ( ) No

For more information on the SQG Program call the Solid Waste Division at (360) 337- 5777. For technical assistance with hazardous waste contact the Bremerton – Kitsap County Health District at (360) 692-3611.

The information collected during this survey is used to fulfill the requirements for Kitsap County's Wastewater Treatment Plants National Pollutant Discharge Elimination System (NPDES) Permit through the Department of Ecology.

Print name and title: TONY MORRIS, EC OFFICER

Sign and date: Tony Morris 7-25-12

I understand by signing this I hereby certify the above statement is true to the best of my knowledge and ability. I understand that this is a legal document and will be used to determine our Industrial User Status with the Department of Ecology.

APPENDIX C

KITSAP COUNTY PIPELINE OCI

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
H17-3017-H17-3016	606436	6/11/2019	Roots	80.00	Light	ROOTS AI 164 FT
J17-4036-H17-3085	606417	6/5/2019	Roots	80.00	Light	ROOTS IN MANHOLE H17=3085 DOWNSTREAM SIDE IN THE SAND COLLAR
H16-2014-H16-2013	606483	6/20/2019	Inflow and Infiltration	60.00	Running or Trickling	
M15-1006-M15-1005	607751	10/21/2020	Roots	80.00	Light	ROOTS IN THE SAND COLLAR OF M/H M15-1005
L17-1023-L17-1022	607903	1/12/2021	Roots	80.00	Light	ROOTS IN THE SAND COLLAR OF L17-1023
L17-1023-L17-1022	607903	1/12/2021	Inflow and Infiltration	60.00	Running or Trickling	
L17-1023-L17-1022	607903	1/12/2021	Cracks or Fractures	40.00	Severe Cracking	
L17-1023-L17-1022	607903	1/12/2021	Break or Failure	0.00	Collapse	
L17-1023-L17-1022	607903	1/12/2021	Lining or Repair Failure	80.00	Minor	
H16-2059-H16-2111	606521	6/27/2019	Roots	50.00	Medium	ROOTS IN THE MANHOLE H16-2111
G16-3015-G16-3014	606236	1/16/2019	Roots	80.00	Light	ROOTS IN THE SAND COLLAR IN MH 3014
G16-3015-G16-3014	606236	1/16/2019	Worn Surface	60.00	Moderate	
B28-4043-B28-4041	607312	7/2/2020	Roots	50.00	Medium	ENTIRE MANHOLE IS COVERED IN ROOTS
H15-2046-H15-2042	606888	12/10/2019	Belly or Sag	80.00	Minor (<10%)	
B28-4039-B28-4038	607335	7/8/2020	Roots	30.00	Heavy	ROOTS IN THE SIDE SERVICE AT 43 AND 84 FEET
H17-3065-H17-3064	606406	6/5/2019	Cracks or Fractures	80.00	Minor Cracking	
L17-1053-L17-1052	606603	7/22/2019	Inflow and Infiltration	60.00	Running or Trickling	
L17-1053-L17-1052	606603	7/22/2019	Roots	80.00	Light	Wall of L17-1052
L17-1053-L17-1052	606603	7/22/2019	Worn Surface	80.00	Minor	
L17-1053-L17-1052	606603	7/22/2019	Belly or Sag	40.00	Severe (>30%)	
L17-1053-L17-1052	606603	7/22/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
D23-2123-D23-2122	604815	8/23/2017	Inflow and Infiltration	90.00	Stain, Possible I&I	
D23-2123-D23-2122	604815	8/23/2017	Obstruction or Intrusion	80.00	Minor	
D23-2123-D23-2122	604815	8/23/2017	Cracks or Fractures	80.00	Minor Cracking	
J20-3057-J20-3056	607728	10/19/2020	Roots	80.00	Light	ROOTS IN THE JOINT AT 116.8

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
H17-3019-H17-3018	606390	5/30/2019	Roots	50.00	Medium	ROOTS AT 216 AND 375 FT FROM UPPER M/H
H17-3019-H17-3018	606390	5/30/2019	Cracks or Fractures	80.00	Minor Cracking	
G15-3019-G15-3040	606015	1/8/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
G16-4101-G16-4100	606796	10/1/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
G16-2002-G16-2001	606553	7/8/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
L17-1034-L17-1033	607898	1/12/2021	Inflow and Infiltration	40.00	Gushing or Spurting	
M18-4026-M18-4025	607869	1/4/2021	Roots	30.00	Heavy	HEAVY ROOTS IN MANHOLE M18-4027
L17-1047-L17-1043	606607	7/22/2019	Inflow and Infiltration	60.00	Running or Trickling	
L17-1047-L17-1043	606607	7/22/2019	Worn Surface	80.00	Minor	
L17-1047-L17-1043	606607	7/22/2019	Belly or Sag	40.00	Severe (>30%)	
L17-1047-L17-1043	606607	7/22/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J20-3060-J20-3059	607725	10/19/2020	Roots	80.00	Light	ROOTS IN MANHOLE J20-3060
A28-3015-A28-3014	607381	7/16/2020	Roots	30.00	Heavy	ROOTS IN THE UPPER MANHOLE COVERING THE BOTTOM
G16-2030-G16-2029	606306	1/16/2019	Roots	80.00	Light	246" VERY SMALL
G16-4059-G16-4057	606737	9/11/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
H16-2061-H16-2058	606515	6/26/2019	Belly or Sag	40.00	Severe (>30%)	
H15-4034-H15-4003	606120	2/7/2019	Roots	80.00	Light	Roots in the sand collar
J17-2009-J17-2008	607516	8/19/2020	Belly or Sag	80.00	Minor (<10%)	
L17-1049-L17-1047	606606	7/22/2019	Inflow and Infiltration	60.00	Running or Trickling	
L17-1049-L17-1047	606606	7/22/2019	Worn Surface	80.00	Minor	
L17-1049-L17-1047	606606	7/22/2019	Belly or Sag	40.00	Severe (>30%)	
L17-1049-L17-1047	606606	7/22/2019	Cracks or Fractures	80.00	Minor Cracking	
L17-1049-L17-1047	606606	7/22/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
G16-4003-G16-4005	606802	10/2/2019	Belly or Sag	80.00	Minor (<10%)	
H17-3038-H17-3037	606463	6/13/2019	Break or Failure	15.00	Hole Void Visible	
J16-1007-J16-1006	607041	2/10/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
G16-1014-G16-1013	605822	8/29/2018	Belly or Sag	80.00	Minor (<10%)	
G16-1014-G16-1013	605822	8/29/2018	Break or Failure	0.00	Collapse	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
G16-3084-G16-3078	606276	1/16/2019	Roots	30.00	Heavy	ROOTS IN THE MANHOLE EVERYWHERE ALL 3 SAND COLLARS AND STRETCHING DOWN THE PIE
G16-4088-G16-4084	606771	9/17/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
B28-4018-B28-4017	607334	7/8/2020	Inflow and Infiltration	90.00	Stain, Possible I&I	
B28-4046-B28-4039	607300	6/24/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
J19-2012-J19-2011	607941	2/2/2021	Belly or Sag	80.00	Minor (<10%)	
M16-1034-M16-1033	605599	7/2/2018	Inflow and Infiltration	60.00	Running or Trickling	
H16-4046-H16-4016	606381	1/16/2019	Inflow and Infiltration	90.00	Stain, Possible I&I	
J16-1094-J16-1095	607036	2/10/2020	Belly or Sag	80.00	Minor (<10%)	
L17-1064-L17-1063	607962	2/4/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
L17-1050-L17-1049	606605	7/23/2019	Inflow and Infiltration	60.00	Running or Trickling	
L17-1050-L17-1049	606605	7/23/2019	Worn Surface	80.00	Minor	
L17-1050-L17-1049	606605	7/23/2019	Belly or Sag	40.00	Severe (>30%)	
L17-1050-L17-1049	606605	7/23/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
M18-4009-M18-4008	607845	12/21/2020	Belly or Sag	80.00	Minor (<10%)	
B28-1006-B28-1005	607262	6/1/2020	Inflow and Infiltration	40.00	Gushing or Spurting	
J16-2005-J16-2003	605897	9/25/2018	Belly or Sag	60.00	Moderate (10 to 30%)	
B28-4054-B28-4053	607247	5/28/2020	Roots	50.00	Medium	ROOTS IN MANHOLE B28-4054 ALL OVER AND IN THE SAND COLLAR
L17-1024-L17-1023	607901	1/12/2021	Roots	80.00	Light	ROOTBALL IN THE BOTTOM OF MANHOLE L17-1023
J11-3040-J11-3039	605985	12/20/2018	Inflow and Infiltration	80.00	Weeping or Dripping	
J11-3040-J11-3039	605985	12/20/2018	Break or Failure	30.00	Hole Soil Visible	
J11-3040-J11-3039	605985	12/20/2018	Cracks or Fractures	80.00	Minor Cracking	
H16-2053-H16-2052	606505	6/25/2019	Obstruction or Intrusion	0.00	Severe or Impassable	
L18-3051-L18-3050	607783	10/27/2020	Belly or Sag	80.00	Minor (<10%)	
J16-1014-J16-1013	607024	2/6/2020	Belly or Sag	40.00	Severe (>30%)	
J16-1071-J16-1070	607048	2/11/2020	Obstruction or Intrusion	0.00	Severe or Impassable	
G21-2007-G21-2006	605428	6/18/2018	Belly or Sag	80.00	Minor (<10%)	
G16-2024-G16-2020	606293	1/16/2019	Roots	80.00	Light	ROOTS IN THE LOWER MANHOLE IN THE SANDCOLLAR G16-2020

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
L17-1041-L17-1092	607919	1/21/2021	Roots	50.00	Medium	ROOTS IN THE JOINTS AND SAND COLLARS LINE IS ONLY 10 FEET LONG
G16-3036-G16-3035	606180	2/26/2019	Worn Surface	40.00	Severe	
L16-2003-L16-2002	605511	7/2/2018	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
H16-3034-H16-3033	606923	1/3/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
J16-3006-J16-3002	605878	10/19/2018	Belly or Sag	80.00	Minor (<10%)	
A28-2032-A28-2031	607161	3/5/2020	Roots	80.00	Light	ROOTS IN THE MANHOLE A28-2031
L17-1065-L17-1064	607961	2/4/2021	Roots	0.00	Blockage	SIDE SERVICE BLOCKED AT 334.4 FROM THE GROCERY STORE
L17-1065-L17-1064	607961	2/4/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
L17-1065-L17-1064	607961	2/4/2021	Obstruction or Intrusion	0.00	Severe or Impassable	
B28-4024-B28-4021	607239	5/21/2020	Belly or Sag	80.00	Minor (<10%)	
L18-4011-L18-4010	606232	4/3/2019	Roots	80.00	Light	First 4 ft the at 230 ft
L18-4011-L18-4010	606232	4/3/2019	Worn Surface	80.00	Minor	
L18-4011-L18-4010	606232	4/3/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
L18-4011-L18-4010	606232	4/3/2019	Cracks or Fractures	80.00	Minor Cracking	
L18-4011-L18-4010	606232	4/3/2019	Break or Failure	15.00	Hole Void Visible	
L18-4011-L18-4010	606232	4/3/2019	Lining or Repair Failure	80.00	Minor	
L18-4011-L18-4010	606232	4/3/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J16-1002-J16-1001	607053	2/11/2020	Roots	50.00	Medium	ROOTS IN MANHOLE J16-1001
G16-2047C-G16-2004	606323	1/16/2019	Roots	50.00	Medium	ROOTS AT THE CLEANOUT CONNECTION
D23-2108-D23-2107	606129	2/14/2019	Inflow and Infiltration	80.00	Weeping or Dripping	
H16-3040-H16-3038	606916	1/3/2020	Belly or Sag	80.00	Minor (<10%)	
G16-4084-G16-4083	606774	9/17/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
L17-1096-L17-1054	606601	7/22/2019	Inflow and Infiltration	60.00	Running or Trickling	
L17-1096-L17-1054	606601	7/22/2019	Worn Surface	80.00	Minor	
L17-1096-L17-1054	606601	7/22/2019	Belly or Sag	40.00	Severe (>30%)	
L17-1096-L17-1054	606601	7/22/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J17-2018-J17-2009	607509	8/19/2020	Obstruction or Intrusion	80.00	Minor	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
J17-2018-J17-2009	607509	8/19/2020	Belly or Sag	80.00	Minor (<10%)	
J16-1012-J16-1094	607027	2/6/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
G16-3024-G16-3023	606200	2/28/2019	Roots	50.00	Medium	Roots in the side service connection about 97 ft
J19-3110-J19-3109	607995	3/1/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
H16-3009-H15-2004	604860	8/21/2017	Maintenance Condition	70.00	Heavy	
G16-4038-G16-4037	606744	9/11/2019	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-3021C-G16-3020	606382	1/16/2019	Roots	0.00	Blockage	ROOTS IN LATERAL AND MAIN AT 100 FT BLOCKAGE END CLEAOUT IS FULL OF ROOTS ALSO
L17-1027-L17-1026	607912	1/21/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
L17-1027-L17-1026	607912	1/21/2021	Obstruction or Intrusion	0.00	Severe or Impassable	
L17-1027-L17-1026	607912	1/21/2021	Break or Failure	15.00	Hole Void Visible	
L17-1027-L17-1026	607912	1/21/2021	Lining or Repair Failure	80.00	Minor	
H16-1054-H16-1017	606363	1/16/2019	Roots	80.00	Light	ROOTS IN THE MANHOLE AND HANGING INTO THE SEWER MAIN
G16-3020-G16-3019	606226	1/16/2019	Roots	30.00	Heavy	ROOTS FROM 65 TO 109 FEET ALMOST BLOCKING NEEDS CUT AND TREATMENT VERY SOON
G16-3020-G16-3019	606226	1/16/2019	Cracks or Fractures	60.00	Moderate Cracking	
L17-1038-L17-1003	606609	7/23/2019	Inflow and Infiltration	60.00	Running or Trickling	
L17-1038-L17-1003	606609	7/23/2019	Worn Surface	80.00	Minor	
L17-1038-L17-1003	606609	7/23/2019	Belly or Sag	40.00	Severe (>30%)	
L17-1038-L17-1003	606609	7/23/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
G16-4077-G16-4076	606672	8/7/2019	Belly or Sag	80.00	Minor (<10%)	
G15-3013-G15-3012	606062	1/24/2019	Roots	30.00	Heavy	Roots in drop m/h G15-3012
G21-2029-G21-2028	605371	5/10/2018	Inflow and Infiltration	80.00	Weeping or Dripping	
L18-3011-L18-3010	607764	10/22/2020	Roots	50.00	Medium	ROOTS IN THE MANHOLE L18-3010
H16-2016-H16-2015	606494	6/24/2019	Break or Failure	15.00	Hole Void Visible	
H16-4050-H16-4049	606217	3/28/2019	Cracks or Fractures	40.00	Severe Cracking	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
G16-3010-G16-3073	606279	1/16/2019	Roots	50.00	Medium	ROOTS IN THE SHELF OF MANHOLE G16-3073
H16-4002-H16-4001	606287	1/16/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
L17-1003-L17-1002	606610	7/23/2019	Inflow and Infiltration	60.00	Running or Trickling	
L17-1003-L17-1002	606610	7/23/2019	Worn Surface	80.00	Minor	
L17-1003-L17-1002	606610	7/23/2019	Belly or Sag	40.00	Severe (>30%)	
L17-1003-L17-1002	606610	7/23/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J16-2006-J16-2005	605898	9/25/2018	Belly or Sag	80.00	Minor (<10%)	
H16-2088-H16-2087	607113	2/24/2020	Roots	80.00	Light	ROOTS IN MANHOLE H16-2087
J16-1047-J16-1046	606617	7/29/2019	Roots	80.00	Light	ONE LARGE ROOT AT 22.5 FT
H16-3011-H16-3010	606944	1/7/2020	Obstruction or Intrusion	0.00	Severe or Impassable	
H16-3011-H16-3010	606944	1/7/2020	Belly or Sag	80.00	Minor (<10%)	
H16-3011-H16-3010	606944	1/7/2020	Lining or Repair Failure	60.00	Moderate	
H16-3011-H16-3010	606944	1/7/2020	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
L18-4038-L18-4036	607956	2/3/2021	Belly or Sag	80.00	Minor (<10%)	
H15-2002-H15-2001	607107	2/20/2020	Roots	50.00	Medium	Roots in the manhole needs treatment manhole 2001
A28-3029-A28-3018	607331	7/8/2020	Roots	80.00	Light	71FT FROM TOP MANHOLE
H16-2003-H16-2004	606424	6/10/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
H16-2003-H16-2004	606424	6/10/2019	Cracks or Fractures	80.00	Minor Cracking	
G16-3030-G16-3029	606195	2/28/2019	Roots	80.00	Light	Roots all along the pipe treat whole line
G16-3030-G16-3029	606195	2/28/2019	Cracks or Fractures	80.00	Minor Cracking	
H17-4046-H17-4045	606820	10/9/2019	Inflow and Infiltration	90.00	Stain, Possible I&I	
H17-4046-H17-4045	606820	10/9/2019	Obstruction or Intrusion	60.00	Moderate	
H16-1033-H16-1026	606137	2/20/2019	Roots	80.00	Light	
H16-1033-H16-1026	606137	2/20/2019	Cracks or Fractures	80.00	Minor Cracking	
B28-4019-B28-4018	607333	7/8/2020	Inflow and Infiltration	90.00	Stain, Possible I&I	
B28-4019-B28-4018	607333	7/8/2020	Obstruction or Intrusion	60.00	Moderate	
B28-4019-B28-4018	607333	7/8/2020	Cracks or Fractures	60.00	Moderate Cracking	
B28-4019-B28-4018	607333	7/8/2020	Lining or Repair Failure	80.00	Minor	
B28-4019-B28-4018	607333	7/8/2020	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
B28-4013-B28-4012	607360	7/15/2020	Lining or Repair Failure	60.00	Moderate	
L17-1069-L17-1068	607773	10/26/2020	Roots	50.00	Medium	ROOTS 5 FT FROM THE TOP OF THE RUN JUST INSIDE THE M/H ROOTS IN THE SIDE SERVICE AT THE LATERAL 88FT
G16-3073-G16-3078	606280	1/16/2019	Roots	50.00	Medium	ROOTS IN MANHOLE G16-3078
L15-2010-L15-2009	607698	10/12/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
G15-3012-G15-3050	606070	1/30/2019	Roots	30.00	Heavy	Roots in both M/Hs upper and lower
H17-3078-H17-3077	606403	6/5/2019	Cracks or Fractures	80.00	Minor Cracking	
G15-2026-G15-2025	606259	4/17/2019	Belly or Sag	80.00	Minor (<10%)	
G15-3010-G15-3009	606073	1/30/2019	Belly or Sag	80.00	Minor (<10%)	
G16-4006-G16-4005	606786	9/30/2019	Belly or Sag	80.00	Minor (<10%)	
G16-4006-G16-4005	606786	9/30/2019	Break or Failure	15.00	Hole Void Visible	
H16-1015-H16-1044	606374	1/16/2019	Roots	80.00	Light	ROOTS IN M/H H16-1044
H15-2023-H15-2032	606964	1/8/2020	Inflow and Infiltration	60.00	Running or Trickling	
H15-2023-H15-2032	606964	1/8/2020	Cracks or Fractures	80.00	Minor Cracking	
L18-4036-L18-4037	607958	2/3/2021	Inflow and Infiltration	60.00	Running or Trickling	
M18-4012-M18-4011	607844	12/21/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
H17-3085-H17-3012	606419	6/6/2019	Roots	80.00	Light	ROOT IN MANHOLE H17-3-85 ON THE SHELF
G16-4074-G16-4075	606725	8/19/2019	Belly or Sag	80.00	Minor (<10%)	
H17-3039-H17-3037	606469	6/13/2019	Cracks or Fractures	60.00	Moderate Cracking	
H17-3039-H17-3037	606469	6/13/2019	Break or Failure	15.00	Hole Void Visible	
J16-4021-J16-4022	607130	2/26/2020	Inflow and Infiltration	80.00	Weeping or Dripping	
J16-4021-J16-4022	607130	2/26/2020	Obstruction or Intrusion	60.00	Moderate	
J16-4021-J16-4022	607130	2/26/2020	Worn Surface	60.00	Moderate	
J16-4021-J16-4022	607130	2/26/2020	Lining or Repair Failure	60.00	Moderate	
H16-1038-H16-1037	606379	1/16/2019	Belly or Sag	80.00	Minor (<10%)	
G16-3075-G16-3074	606272	1/16/2019	Worn Surface	60.00	Moderate	
G16-3075-G16-3074	606272	1/16/2019	Cracks or Fractures	60.00	Moderate Cracking	
G16-3075-G16-3074	606272	1/16/2019	Break or Failure	15.00	Hole Void Visible	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
G16-3013-G16-3012	606237	1/16/2019	Roots	80.00	Light	ROOTS AT 200 FT AND IN LOWER MH 3012
G16-3013-G16-3012	606237	1/16/2019	Worn Surface	60.00	Moderate	
G16-4069-G16-4066	606674	8/7/2019	Belly or Sag	80.00	Minor (<10%)	
L18-3031-L18-3029	607810	12/10/2020	Belly or Sag	80.00	Minor (<10%)	
J11-3061-J11-3060	607467	8/11/2020	Worn Surface	60.00	Moderate	
J11-3061-J11-3060	607467	8/11/2020	Cracks or Fractures	60.00	Moderate Cracking	
J11-3061-J11-3060	607467	8/11/2020	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
A28-3004-A28-3002	607168	3/9/2020	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J16-4012-J16-4011	606625	7/29/2019	Roots	50.00	Medium	ROOTS RIGHT OUTSIDE THE MANHOLE
G15-3003-G15-3002	606056	1/24/2019	Roots	0.00	Blockage	Roots in sand collar
G16-2027-G16-2011	606304	1/16/2019	Roots	50.00	Medium	ROOTS AT 197
H15-2001-LS-34	607108	2/20/2020	Roots	50.00	Medium	Roots in manhole 2001
H17-3040-H17-3039	606468	6/13/2019	Cracks or Fractures	80.00	Minor Cracking	
H16-2073-H16-2115	606500	6/25/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
J16-4033-J16-4032	606970	1/9/2020	Inflow and Infiltration	60.00	Running or Trickling	
G16-3042-G16-3041	606224	1/16/2019	Roots	50.00	Medium	ROOTS IN THE SIDE SERVICE CONNECTION AT 17 FEET FROM UPPER MANHOLE
K18-3108-L18-4036	607957	2/3/2021	Belly or Sag	80.00	Minor (<10%)	
L14-3014-L14-3001	607705	10/13/2020	Roots	50.00	Medium	ROOTS IN MANHOLE L14-3001
J20-3063C-J20-3061	607723	10/19/2020	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
M17-4007-M17-4006	605453	6/26/2018	Belly or Sag	80.00	Minor (<10%)	
J16-4018-J16-4017	606622	7/29/2019	Roots	80.00	Light	ROOTS IN LATERAL AT REPAIR 260.7 FT
J11-4017-J11-4010	606979	1/10/2020	Roots	50.00	Medium	ROOTS AT 159 IN A SIDE SERVICE CONNECTION NOT BLOCKING
J11-4017-J11-4010	606979	1/10/2020	Worn Surface	40.00	Severe	
J11-4017-J11-4010	606979	1/10/2020	Break or Failure	15.00	Hole Void Visible	
J11-4017-J11-4010	606979	1/10/2020	Lining or Repair Failure	40.00	Severe	
G21-2014-G21-2002	605379	5/10/2018	Belly or Sag	80.00	Minor (<10%)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
D23-2085-D23-2083	606418	6/6/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
J16-2007-J16-2006	605899	9/25/2018	Belly or Sag	60.00	Moderate (10 to 30%)	
G21-2028-G21-2026	605373	5/10/2018	Belly or Sag	80.00	Minor (<10%)	
G21-2028-G21-2026	605373	5/10/2018	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
H16-1030-H16-1029	606136	2/19/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
H16-4049-H16-4047	606218	3/28/2019	Roots	50.00	Medium	H16-4047 Roots at section joint/ wall.
H16-2110-H16-2071	606531	6/27/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J11-3049-J11-3108	604831	8/24/2017	Maintenance Condition	90.00	Light	
J11-3049-J11-3108	604831	8/24/2017	Inflow and Infiltration	80.00	Weeping or Dripping	
J11-3049-J11-3108	604831	8/24/2017	Worn Surface	80.00	Minor	
J11-3049-J11-3108	604831	8/24/2017	Cracks or Fractures	80.00	Minor Cracking	
J11-3049-J11-3108	604831	8/24/2017	Lining or Repair Failure	80.00	Minor	
H16-3033-H16-3032	606924	1/3/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
H17-3031-H17-3030	606475	6/20/2019	Cracks or Fractures	80.00	Minor Cracking	
H17-3031-H17-3030	606475	6/20/2019	Break or Failure	30.00	Hole Soil Visible	
H16-3078-H16-3063	607005	1/21/2020	Worn Surface	40.00	Severe	
H16-3078-H16-3063	607005	1/21/2020	Cracks or Fractures	40.00	Severe Cracking	
H16-3078-H16-3063	607005	1/21/2020	Break or Failure	0.00	Collapse	
L18-4051-L18-4050	607967	2/5/2021	Inflow and Infiltration	60.00	Running or Trickling	
L18-4051-L18-4050	607967	2/5/2021	Cracks or Fractures	80.00	Minor Cracking	
L14-3005-LS-14	607924	1/27/2021	Lining or Repair Failure	40.00	Severe	
L14-3005-LS-14	607924	1/27/2021	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
J16-1077-J16-1033	606907	12/26/2019	Belly or Sag	80.00	Minor (<10%)	
G16-2021-G16-2020	606297	1/16/2019	Roots	50.00	Medium	ROOTS IN MANHOLE 2021 SAND COLLAR
M16-1033-M16-1032	605598	7/2/2018	Inflow and Infiltration	60.00	Running or Trickling	
G16-1057-G16-1013	606249	4/17/2019	Roots	50.00	Medium	At sand collar of G16-1013. Root cut this date.
H17-1026-H17-1021	607555	8/28/2020	Roots	50.00	Medium	ROOTBALL IN M/H H17-1027
G15-3014-G15-3051	606048	1/23/2019	Inflow and Infiltration	80.00	Weeping or Dripping	
J18-2010-J18-2009	606593	5/13/2019	Roots	50.00	Medium	J18-2009 SAND COLLAR, SHELF & WALL

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
L17-1092-L17-1076	607918	1/21/2021	Roots	80.00	Light	ROOTS IN THE SAND COLLAR OF L1`7-1092
J16-1072-J16-1071	607044	2/11/2020	Roots	50.00	Medium	ROOTS AT 136 FT IN A JOINT
M18-4051-M18-4040	607854	12/22/2020	Belly or Sag	80.00	Minor (<10%)	
L18-4023-L18-4022	607768	10/22/2020	Belly or Sag	80.00	Minor (<10%)	
G16-3014-G16-3013	606238	1/16/2019	Roots	80.00	Light	ROOTS IN THE LOWER SAND COLLAR
G16-3014-G16-3013	606238	1/16/2019	Worn Surface	60.00	Moderate	
L14-CAP-L14-3015	607703	10/13/2020	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
J16-1025-J16-1022	607016	1/24/2020	Roots	50.00	Medium	ROOTS IN SAND COLLAR OF M'H J16-1022
H17-1007-H17-1006	607437	7/30/2020	Roots	80.00	Light	ROOTS AT SAND COLLAR @ IN FLOW H17-1007
H16-1062-H16-1033	606134	2/19/2019	Roots	50.00	Medium	Roots at 49 and 73 ft from the upper manhole
H16-1062-H16-1033	606134	2/19/2019	Cracks or Fractures	80.00	Minor Cracking	
G21-2016-G21-2014	605426	5/10/2018	Inflow and Infiltration	80.00	Weeping or Dripping	
G21-2016-G21-2014	605426	5/10/2018	Worn Surface	80.00	Minor	
G21-2016-G21-2014	605426	5/10/2018	Belly or Sag	60.00	Moderate (10 to 30%)	
G21-2016-G21-2014	605426	5/10/2018	Cracks or Fractures	80.00	Minor Cracking	
G16-4106-G16-4105	606675	8/8/2019	Worn Surface	60.00	Moderate	
G16-4106-G16-4105	606675	8/8/2019	Belly or Sag	80.00	Minor (<10%)	
G16-4027-G16-4026	606781	9/30/2019	Break or Failure	15.00	Hole Void Visible	
G16-2007-G16-2006	606318	1/16/2019	Belly or Sag	80.00	Minor (<10%)	
L17-1036-L17-1035	607890	1/11/2021	Break or Failure	30.00	Hole Soil Visible	
H15-4040-H15-4037	606115	2/7/2019	Belly or Sag	80.00	Minor (<10%)	
H16-2048-H16-2047	606543	6/28/2019	Roots	30.00	Heavy	ROOTS IN BOTH SAND COLLARS OF H16-2048
L18-3016-L18-3015	607814	12/10/2020	Roots	50.00	Medium	ROOTS IN THE LATERAL AND ALSO THE JOINT AT 110.2 FT
J11-3108-J11-3048	604832	8/24/2017	Maintenance Condition	90.00	Light	
J11-3108-J11-3048	604832	8/24/2017	Inflow and Infiltration	80.00	Weeping or Dripping	
J11-3108-J11-3048	604832	8/24/2017	Worn Surface	80.00	Minor	
J11-3108-J11-3048	604832	8/24/2017	Cracks or Fractures	80.00	Minor Cracking	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
J20-3061-J20-3060	607724	10/19/2020	Roots	80.00	Light	ROOTS IN THE SAND COLLAR OF J20-3060
G16-1050-G16-1046	605800	9/13/2018	Belly or Sag	80.00	Minor (<10%)	
H16-2049-H16-2048	606542	6/28/2019	Roots	30.00	Heavy	ROOTS IN MANHOLE H16-2048 BOTH SAND COLLARS
H16-4012-H16-4011	606855	11/13/2019	Roots	50.00	Medium	ROOTS IN MANHOLE OR POSSIBLY SANDCOLLAR IN MH H16-4011
J19-3112-J19-3111	607993	3/1/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
L18-3017-L18-3016	607813	12/10/2020	Roots	80.00	Light	ROOTS IN THE SAND COLLAR OF L18-3016
F16-2021-F16-2020	605729	8/21/2018	Obstruction or Intrusion	60.00	Moderate	
F16-2021-F16-2020	605729	8/21/2018	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
L18-4048-L18-4047	607972	2/5/2021	Roots	50.00	Medium	ROOTS IN MANHOLE L18-4047
H15-4041-H15-4040	606114	2/7/2019	Belly or Sag	80.00	Minor (<10%)	
H17-2011-H17-2010	606588	7/10/2019	Obstruction or Intrusion	60.00	Moderate	
G15-3009-G15-3008	606074	1/30/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
B28-1026-B28-1025	607149	3/4/2020	Inflow and Infiltration	90.00	Stain, Possible I&I	
D23-2091-D23-2090	604828	8/24/2017	Worn Surface	80.00	Minor	
D23-2091-D23-2090	604828	8/24/2017	Belly or Sag	80.00	Minor (<10%)	
D23-2091-D23-2090	604828	8/24/2017	Lining or Repair Failure	80.00	Minor	
H17-4042-LS-35	606836	10/21/2019	Inflow and Infiltration	60.00	Running or Trickling	
H16-2081-H16-2080	606547	6/28/2019	Inflow and Infiltration	80.00	Weeping or Dripping	
H16-2007-H16-2008	606537	6/28/2019	Roots	50.00	Medium	ROOTS AT 106 AND 227 ALSO AT M/H 22008 IN THE CLEAN OUT
H16-2007-H16-2008	606537	6/28/2019	Cracks or Fractures	80.00	Minor Cracking	
H17-1016-H17-1014	607384	7/22/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
B28-4027-B28-4024	607238	5/21/2020	Belly or Sag	80.00	Minor (<10%)	
L18-3010-L18-3009	607763	10/22/2020	Roots	50.00	Medium	ROOTS IN THE MANHOLE L18-3009

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
M15-1001-L15-2007	607693	10/12/2020	Roots	50.00	Medium	ROOTS IN THE JOINTS CONNECTIONS AT 128 AND 153 ALSO ROOTS IN THE LATERS AT 83 AND 36
M15-1001-L15-2007	607693	10/12/2020	Cracks or Fractures	60.00	Moderate Cracking	
M15-1001-L15-2007	607693	10/12/2020	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
H16-2093C-H16-2017	606533	6/27/2019	Inflow and Infiltration	80.00	Weeping or Dripping	
H16-2093C-H16-2017	606533	6/27/2019	Break or Failure	15.00	Hole Void Visible	
M15-1010-M15-1006	607750	10/21/2020	Roots	50.00	Medium	ROOTS IN JOINT AT 143
G16-1034-G16-1033	605806	9/17/2018	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J17-2031-J17-2030	607530	8/24/2020	Break or Failure	30.00	Hole Soil Visible	
B28-4060-B28-4090	607228	5/20/2020	Roots	80.00	Light	ROOTS IN THE SAND COLLAR OF B28-4060
B28-4035-B28-4034	607298	6/24/2020	Roots	50.00	Medium	AT 195 FT CARRIES ON FOR 13 FEET
B28-4035-B28-4034	607298	6/24/2020	Cracks or Fractures	60.00	Moderate Cracking	
B28-4035-B28-4034	607298	6/24/2020	Lining or Repair Failure	60.00	Moderate	
G16-4026-G16-4018	606752	9/12/2019	Cracks or Fractures	80.00	Minor Cracking	
G16-4026-G16-4018	606752	9/12/2019	Break or Failure	30.00	Hole Soil Visible	
M17-1015-M17-1014	607824	12/14/2020	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
G21-2019-G21-2018	605376	5/10/2018	Inflow and Infiltration	90.00	Stain, Possible I&I	
G21-2019-G21-2018	605376	5/10/2018	Belly or Sag	80.00	Minor (<10%)	
J16-2008-J16-2011	606050	1/24/2019	Roots	50.00	Medium	
L18-4045-L18-4038	607955	2/3/2021	Belly or Sag	80.00	Minor (<10%)	
H16-4004-H16-4003	606216	3/27/2019	Inflow and Infiltration	80.00	Weeping or Dripping	
A28-3041-A28-3040	607315	7/2/2020	Roots	30.00	Heavy	ROOTS IN SIDE SERVICE ABOUT 30 FT FROM THE MAIN. CONTACTED HOME OWNER AT 1183 PENNSYLVANIA AND RECOMMENDED HE GET A PLUMBER CLEAN OUTS ARE NOT EASILY ACCESSED
J19-2083-J19-2082	607945	2/2/2021	Roots	50.00	Medium	
H16-3010-H16-3009	606949	1/8/2020	Inflow and Infiltration	90.00	Stain, Possible I&I	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
H16-3010-H16-3009	606949	1/8/2020	Worn Surface	80.00	Minor	
H16-3010-H16-3009	606949	1/8/2020	Lining or Repair Failure	80.00	Minor	
G21-2033-G21-2007	605427	6/18/2018	Belly or Sag	80.00	Minor (<10%)	
G16-4009-G16-4007	606783	9/30/2019	Inflow and Infiltration	90.00	Stain, Possible I&I	
J16-1062-J16-1059	606583	7/9/2019	Roots	80.00	Light	ROOTS IN LATERAL JOINT 52.5FT
J16-1062-J16-1059	606583	7/9/2019	Break or Failure	15.00	Hole Void Visible	
L18-3014-L18-3021	607819	12/14/2020	Roots	80.00	Light	ROOTS IN THE CONNECTION 105'
G16-3076-G16-3075	606271	1/16/2019	Roots	80.00	Light	ROOTS STARTING TO APPEAR IN THE SAND COLLAR G16-3075
K10-1074-K10-1007	605411	6/4/2018	Obstruction or Intrusion	60.00	Moderate	
K10-1074-K10-1007	605411	6/4/2018	Lining or Repair Failure	60.00	Moderate	
K10-1074-K10-1007	605411	6/4/2018	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
L17-1062-L17-1058	607966	2/4/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
L17-1062-L17-1058	607966	2/4/2021	Belly or Sag	80.00	Minor (<10%)	
J11-3084-J11-3083	606281	4/22/2019	Worn Surface	60.00	Moderate	
J11-3084-J11-3083	606281	4/22/2019	Cracks or Fractures	60.00	Moderate Cracking	
J11-3084-J11-3083	606281	4/22/2019	Break or Failure	30.00	Hole Soil Visible	
J11-3084-J11-3083	606281	4/22/2019	Lining or Repair Failure	60.00	Moderate	
G21-2026-G21-2018	605374	5/10/2018	Obstruction or Intrusion	0.00	Severe or Impassable	
G21-2026-G21-2018	605374	5/10/2018	Belly or Sag	80.00	Minor (<10%)	
H16-1040-H16-1002	606570	7/8/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
H17-4054-H17-1043	607343	7/9/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
L18-4018-L17-1069	607793	10/30/2020	Roots	30.00	Heavy	HEAVY ROOTS BETWEEN 267 AND 318 WITH ROOTS IN THE DROP
H15-1068C-H15-1042	605851	10/4/2018	Obstruction or Intrusion	80.00	Minor	
H15-1040-H15-1037	605856	10/5/2018	Belly or Sag	60.00	Moderate (10 to 30%)	
G16-3029-G16-3028	606196	2/28/2019	Belly or Sag	40.00	Severe (>30%)	
G21-2021-G21-2020	605431	6/18/2018	Obstruction or Intrusion	60.00	Moderate	
H16-2084-H16-2083	607088	2/18/2020	Roots	80.00	Light	ROOTS AT 48FT FROM THE TOP END MANHOLE
H16-3017-H16-3016	606938	1/6/2020	Belly or Sag	60.00	Moderate (10 to 30%)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
H16-3017-H16-3016	606938	1/6/2020	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
B28-4020-B28-4011	607294	6/11/2020	Belly or Sag	80.00	Minor (<10%)	
G16-1010-G16-1072	606107	2/6/2019	Roots	80.00	Light	Roots in sand collar G16=1010
H16-1006-H16-1005	606045	1/22/2019	Obstruction or Intrusion	0.00	Severe or Impassable	
D23-2113-D23-2112	604818	8/23/2017	Inflow and Infiltration	90.00	Stain, Possible I&I	
D23-2113-D23-2112	604818	8/23/2017	Cracks or Fractures	80.00	Minor Cracking	
H16-1036-H16-1035	606138	2/20/2019	Roots	30.00	Heavy	Roots at 9' 182,227,238,294 from upper m/h
H16-1036-H16-1035	606138	2/20/2019	Cracks or Fractures	80.00	Minor Cracking	
H15-4004-H15-4003	606128	2/8/2019	Roots	50.00	Medium	Roots just inside at 7 feet
M18-4036-M18-4035	607872	1/6/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
K10-1023-K10-1020	606201	3/4/2019	Roots	30.00	Heavy	Roots at 10ft,21ft,45ft,48ft,50ft,105ft, 106ft, 130ft, 147ft
K10-1023-K10-1020	606201	3/4/2019	Cracks or Fractures	60.00	Moderate Cracking	
K10-1023-K10-1020	606201	3/4/2019	Break or Failure	15.00	Hole Void Visible	
H17-3003-H17-3002	606471	6/19/2019	Roots	50.00	Medium	ROOTS AT 105FT TO 110 FT
L17-1035-L17-4004	607892	1/11/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
J19-3114-J19-3107	608000	3/2/2021	Obstruction or Intrusion	0.00	Severe or Impassable	
H17-1009-H17-1008	607433	7/30/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
L17-1056-L17-1055	606599	7/23/2019	Inflow and Infiltration	60.00	Running or Trickling	
L17-1056-L17-1055	606599	7/23/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
L17-1056-L17-1055	606599	7/23/2019	Worn Surface	80.00	Minor	
L17-1056-L17-1055	606599	7/23/2019	Cracks or Fractures	80.00	Minor Cracking	
L17-1056-L17-1055	606599	7/23/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
G16-2029-G16-2011	606305	1/16/2019	Roots	30.00	Heavy	HEAVY ROOTS AT 230.5
H15-4017-H15-4016	604858	9/5/2017	Belly or Sag	80.00	Minor (<10%)	
H16-2020-H16-2018	606480	6/20/2019	Cracks or Fractures	80.00	Minor Cracking	
H16-2020-H16-2018	606480	6/20/2019	Break or Failure	15.00	Hole Void Visible	
H16-2017-H16-2016	606495	6/24/2019	Break or Failure	15.00	Hole Void Visible	
H16-2057-H16-2056	606502	6/25/2019	Roots	80.00	Light	ROOTS IN MANHOLE H16-2056
J19-2082-J19-2041	607944	2/2/2021	Roots	50.00	Medium	ROOTS IN MANHOLE J19-2082

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
M18-4002-M18-4001	607881	1/6/2021	Inflow and Infiltration	40.00	Gushing or Spurting	
G21-2039-G21-2001	605432	6/18/2018	Obstruction or Intrusion	0.00	Severe or Impassable	
L17-1068-L17-1067	607796	11/2/2020	Roots	30.00	Heavy	HEAVY ROOTS FROM 27FT TO 317FT
M15-1011-M15-1010	607748	10/21/2020	Roots	30.00	Heavy	ROOTS IN LATERAL AT 145FT
G16-3037-G16-3034	606192	2/28/2019	Roots	0.00	Blockage	Roots in side service 95 feet from m/h
G21-2024-G21-2023	605404	5/17/2018	Inflow and Infiltration	80.00	Weeping or Dripping	
J19-2079-J19-2012	607939	2/1/2021	Break or Failure	30.00	Hole Soil Visible	
J16-4013-J16-4012	606624	7/29/2019	Roots	50.00	Medium	ROOTS RIGHT OUTSIDE THE MANHOLE
G16-4055-G16-4054	606758	9/16/2019	Roots	50.00	Medium	ROOTS IN THE M/H G16-4053
G16-4055-G16-4054	606758	9/16/2019	Belly or Sag	80.00	Minor (<10%)	
G16-4021-G16-4019	606755	9/12/2019	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-4021-G16-4019	606755	9/12/2019	Cracks or Fractures	80.00	Minor Cracking	
L18-4011-L18-4012	606233	4/3/2019	Roots	80.00	Light	ROOTS AT 106 IN THE JOINT
L18-4011-L18-4012	606233	4/3/2019	Belly or Sag	80.00	Minor (<10%)	
G21-2034C-G21-2029	605372	5/10/2018	Inflow and Infiltration	80.00	Weeping or Dripping	
G21-2034C-G21-2029	605372	5/10/2018	Cracks or Fractures	80.00	Minor Cracking	
H16-2008-H16-2009	606486	6/20/2019	Inflow and Infiltration	60.00	Running or Trickling	
H16-2008-H16-2009	606486	6/20/2019	Cracks or Fractures	80.00	Minor Cracking	
G16-2006-G16-2005	606319	1/16/2019	Roots	50.00	Medium	ROOTS IN MANHOLE 2006 ON THE SHELF
J20-3004-J20-3003	607607	9/25/2020	Roots	50.00	Medium	ROOTS IN LATERAL CONNECTIONS AT 14FT, 108FT, 111FT
L16-2027-L16-2026	605524	7/2/2018	Obstruction or Intrusion	80.00	Minor	
G16-4037-G16-4036	606765	9/16/2019	Belly or Sag	80.00	Minor (<10%)	
M18-1006-M18-4057	607738	10/20/2020	Belly or Sag	80.00	Minor (<10%)	
J16-4024-J16-4038	607070	2/18/2020	Worn Surface	80.00	Minor	
J16-4024-J16-4038	607070	2/18/2020	Lining or Repair Failure	80.00	Minor	
G16-4065-G16-4060	606732	9/10/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
G16-3016-G16-3015	606231	1/16/2019	Roots	50.00	Medium	ROOTS IN VARIOUS PLACES WHERE PIPE HAS ERODED
G16-3016-G16-3015	606231	1/16/2019	Inflow and Infiltration	40.00	Gushing or Spurting	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
G16-3016-G16-3015	606231	1/16/2019	Worn Surface	40.00	Severe	
G16-3016-G16-3015	606231	1/16/2019	Cracks or Fractures	60.00	Moderate Cracking	
G16-3016-G16-3015	606231	1/16/2019	Break or Failure	15.00	Hole Void Visible	
G16-3016-G16-3015	606231	1/16/2019	Lining or Repair Failure	40.00	Severe	
H16-2070-H16-2069	606510	6/26/2019	Roots	0.00	Blockage	HEAVY ROOTS IN M/H H16-2070
H16-1002-H16-1019	606380	1/16/2019	Obstruction or Intrusion	0.00	Severe or Impassable	
G16-4029-G16-4028	606750	9/12/2019	Roots	80.00	Light	VERY SMALL BIT OF ROOTS AND THE END OF THE RUN81 FT FROM THE TOP END
G16-4029-G16-4028	606750	9/12/2019	Belly or Sag	80.00	Minor (<10%)	
H16-3064-H16-3063	606992	1/16/2020	Worn Surface	60.00	Moderate	
H16-3064-H16-3063	606992	1/16/2020	Obstruction or Intrusion	60.00	Moderate	
H16-3064-H16-3063	606992	1/16/2020	Cracks or Fractures	60.00	Moderate Cracking	
H16-3064-H16-3063	606992	1/16/2020	Break or Failure	0.00	Collapse	
G16-2023C-G16-2021	606295	1/16/2019	Roots	50.00	Medium	ROOTS IN THE CLEAN OUT 2023C
J17-2035-J17-2032	607480	8/17/2020	Roots	50.00	Medium	
H16-2071-H16-2070	606532	6/27/2019	Roots	30.00	Heavy	ROOTS IN THE MANHOLE H16-2070 HEAVY ROOTS
M15-1003-M15-1002	607754	10/21/2020	Roots	50.00	Medium	ROOTS IN THE SAND COLLAR OF M/HOLE M15-1002
G21-2027-G21-2026	605375	5/10/2018	Inflow and Infiltration	80.00	Weeping or Dripping	
J11-3038-J11-3037	606698	8/13/2019	Roots	30.00	Heavy	HEAVY ROOTS THROUGHOUT THE WHOLE MAIN, MOST LATERALS HAVE ROOTS IN THEM ALSO
J11-3038-J11-3037	606698	8/13/2019	Obstruction or Intrusion	60.00	Moderate	
J11-3038-J11-3037	606698	8/13/2019	Belly or Sag	80.00	Minor (<10%)	
J11-3038-J11-3037	606698	8/13/2019	Cracks or Fractures	80.00	Minor Cracking	
J11-3038-J11-3037	606698	8/13/2019	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
M15-1005-M15-1004	607752	10/21/2020	Roots	80.00	Light	ROOTS 1 FOOT FROM THE TOP OF THE PIPE

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
B28-1037-B28-1036	607272	6/2/2020	Roots	50.00	Medium	ROOTS IN MANHOLE B28-1036
J16-4001-LS-11	606637	7/31/2019	Worn Surface	80.00	Minor	
J16-4001-LS-11	606637	7/31/2019	Lining or Repair Failure	80.00	Minor	
H17-2013-H17-2012	606560	7/8/2019	Roots	50.00	Medium	ROOTS IN THE SAND COLLAR H17-2012
G16-4058-G16-4057	606764	9/16/2019	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
H16-2118C-H16-2117	606876	11/27/2019	Roots	50.00	Medium	ROOTS IN MH G16-2118C
J16-4036-J16-4035	606966	1/9/2020	Inflow and Infiltration	60.00	Running or Trickling	
H17-3033-H17-3032	606474	6/19/2019	Cracks or Fractures	60.00	Moderate Cracking	
H17-3033-H17-3032	606474	6/19/2019	Break or Failure	15.00	Hole Void Visible	
H17-3033-H17-3032	606474	6/19/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
H17-2012-H17-2011	606561	7/8/2019	Roots	50.00	Medium	ROOTS IN THE SIDE SERVICE 223FT
G16-3039-G16-3038	606222	1/16/2019	Belly or Sag	80.00	Minor (<10%)	
M18-4021-M18-4014	607864	1/4/2021	Belly or Sag	80.00	Minor (<10%)	
J19-2046-J19-2010	607937	2/1/2021	Roots	80.00	Light	ROOTS IN THE SAND COLLAR OF J19-2010
G16-2032-G16-2031	606303	1/16/2019	Roots	50.00	Medium	ROOTS AT 123 AND 136
G21-2009-G21-2008	605415	6/5/2018	Belly or Sag	80.00	Minor (<10%)	
G16-2018-G16-2017	606110	2/6/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
L18-4009-L18-4008	604848	8/28/2017	Inflow and Infiltration	90.00	Stain, Possible I&I	
L18-4009-L18-4008	604848	8/28/2017	Belly or Sag	60.00	Moderate (10 to 30%)	
L18-4009-L18-4008	604848	8/28/2017	Cracks or Fractures	40.00	Severe Cracking	
L18-4009-L18-4008	604848	8/28/2017	Lining or Repair Failure	80.00	Minor	
L18-4009-L18-4008	604848	8/28/2017	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
H16-3041-H16-3040	606915	1/3/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
J17-4030-J17-4029	607462	8/11/2020	Roots	80.00	Light	NECK, SECTION JOINT AND SAND COLLAR J17-4030.
G21-2023-G21-2020	605430	5/10/2018	Belly or Sag	80.00	Minor (<10%)	
J16-1081-H16-2110	606529	6/27/2019	Belly or Sag	40.00	Severe (>30%)	
G21-2020-G21-2019	605377	5/10/2018	Obstruction or Intrusion	0.00	Severe or Impassable	
G21-2020-G21-2019	605377	5/10/2018	Belly or Sag	80.00	Minor (<10%)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
G21-2017-G21-2016	605425	5/10/2018	Inflow and Infiltration	90.00	Stain, Possible I&I	
G21-2017-G21-2016	605425	5/10/2018	Obstruction or Intrusion	80.00	Minor	
G21-2017-G21-2016	605425	5/10/2018	Worn Surface	80.00	Minor	
G21-2017-G21-2016	605425	5/10/2018	Belly or Sag	60.00	Moderate (10 to 30%)	
G21-2017-G21-2016	605425	5/10/2018	Cracks or Fractures	80.00	Minor Cracking	
G21-2017-G21-2016	605425	5/10/2018	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
G15-3050-G15-3011	606071	1/30/2019	Roots	0.00	Blockage	Roots at 80 ft from the upper m/h
H16-2022-H16-2021	606489	6/24/2019	Obstruction or Intrusion	60.00	Moderate	
H16-2022-H16-2021	606489	6/24/2019	Break or Failure	15.00	Hole Void Visible	
H16-2022-H16-2021	606489	6/24/2019	Cracks or Fractures	80.00	Minor Cracking	
J16-1036-J16-1035	606909	12/26/2019	Lining or Repair Failure	80.00	Minor	
J16-1036-J16-1035	606909	12/26/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
L17-1088C-L17-1087	607886	1/8/2021	Roots	50.00	Medium	
L17-1088C-L17-1087	607886	1/8/2021	Inflow and Infiltration	60.00	Running or Trickling	
L17-1088C-L17-1087	607886	1/8/2021	Cracks or Fractures	80.00	Minor Cracking	
L17-1043-L17-1038	606608	7/23/2019	Inflow and Infiltration	60.00	Running or Trickling	
L17-1043-L17-1038	606608	7/23/2019	Worn Surface	80.00	Minor	
L17-1043-L17-1038	606608	7/23/2019	Belly or Sag	40.00	Severe (>30%)	
L17-1043-L17-1038	606608	7/23/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
H15-4037-H15-4036	606116	2/7/2019	Belly or Sag	80.00	Minor (<10%)	
G16-3061-G16-3062	606345	1/16/2019	Obstruction or Intrusion	80.00	Minor	
M15-1007-M15-1006	607749	10/21/2020	Roots	30.00	Heavy	ROOTS AT VARIOUS POINTS TREAT WHOLE LINE
M15-1007-M15-1006	607749	10/21/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
M15-1007-M15-1006	607749	10/21/2020	Cracks or Fractures	80.00	Minor Cracking	
L18-3041-L18-3040	607801	11/2/2020	Roots	80.00	Light	ROOTS AT LATERAL 144.6
B28-4026-B28-4025	607243	5/26/2020	Roots	0.00	Blockage	HEAVY ROOTS IN LATERAL AT 95.5 FEET T3
H21-4005-H21-4004	605395	5/16/2018	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
M15-1033-M15-1012	607746	10/21/2020	Roots	80.00	Light	ROOTS ON THE SHELF OF M/H M15-1012
J17-4006-J17-4005	607475	8/12/2020	Belly or Sag	60.00	Moderate (10 to 30%)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
J20-3076-J20-3075	607619	9/29/2020	Roots	50.00	Medium	ROOTS IN THE SAND COLLAR OF J20-3075
G21-2003-G21-2002	605424	6/6/2018	Inflow and Infiltration	80.00	Weeping or Dripping	
G21-2003-G21-2002	605424	6/6/2018	Worn Surface	80.00	Minor	
G16-3070-G16-3062	606325	1/16/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
L15-2012-L15-2011	607691	10/9/2020	Roots	50.00	Medium	ROOTS IN THE SANDCOLLAR AND SHELF OF 15-2011
H16-2111-H16-2058	606520	6/27/2019	Roots	50.00	Medium	ROOTS IN MANHOLE H16-2111
G16-4112-G16-4111	606789	9/30/2019	Roots	50.00	Medium	ROOTS AT 220 AND 240 FROM LOWER M/H
G16-4112-G16-4111	606789	9/30/2019	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-4112-G16-4111	606789	9/30/2019	Cracks or Fractures	80.00	Minor Cracking	
G16-4112-G16-4111	606789	9/30/2019	Lining or Repair Failure	60.00	Moderate	
G15-2023-G15-2015	606261	4/17/2019	Worn Surface	60.00	Moderate	
G16-4090-G16-4089	606670	8/7/2019	Belly or Sag	80.00	Minor (<10%)	
H15-4007-LS-33	606034	1/16/2019	Roots	0.00	Blockage	Rootball just inside the sand collar down stream
H15-4003-H15-4002	606119	2/7/2019	Roots	80.00	Light	Roots in the sand collar
H16-3063-H16-3062	607006	1/21/2020	Belly or Sag	80.00	Minor (<10%)	
L14-3001-L14-3002	607707	10/13/2020	Roots	50.00	Medium	ROOTS IN MANHOLE L14-3001
J17-4031-J17-4021	607471	8/12/2020	Inflow and Infiltration	90.00	Stain, Possible I&I	
L17-1026-L17-1022	607902	1/12/2021	Inflow and Infiltration	40.00	Gushing or Spurting	
M17-4008-M17-4007	605452	6/26/2018	Belly or Sag	60.00	Moderate (10 to 30%)	
H16-2092C-H16-2022	606488	6/24/2019	Roots	50.00	Medium	ROOTS AT 92.5 AND 142
H16-2092C-H16-2022	606488	6/24/2019	Cracks or Fractures	60.00	Moderate Cracking	
H16-2092C-H16-2022	606488	6/24/2019	Break or Failure	15.00	Hole Void Visible	
M18-4023-M18-4022	607861	12/23/2020	Belly or Sag	80.00	Minor (<10%)	
L17-1016-L17-1015	607908	1/14/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
L17-1016-L17-1015	607908	1/14/2021	Cracks or Fractures	80.00	Minor Cracking	
A28-3036-A28-3035	607309	6/30/2020	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
J16-1004-J16-1001	607051	2/11/2020	Roots	50.00	Medium	ROOTS IN THE SAND COLLAR J16-1001

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
G16-2033-G16-2032	606301	1/16/2019	Roots	30.00	Heavy	ROOTS IN A LATERAL AT 135 TREAT LINE FROM UPPER MANHOLE AT 115 TO 140
G16-3026-G16-3025	606197	2/28/2019	Roots	0.00	Blockage	Blockage in side service did a dye test and talked to the owner blockage at 200 ft
M15-1002-M15-1001	607755	10/21/2020	Roots	50.00	Medium	ROOTS IN THE DROP
J16-1058-J16-1056	606574	7/8/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
M18-4013-M18-4012	607843	12/21/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
H21-1004-H21-1003	605405	5/17/2018	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-2028-G16-2027	606312	1/16/2019	Roots	30.00	Heavy	ROOTS IN MANHOLE 2028
L17-1042C-L17-1041	607920	1/21/2021	Roots	50.00	Medium	ROOTS IN THE FIRST 50 FEET
L17-1042C-L17-1041	607920	1/21/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
L17-1042C-L17-1041	607920	1/21/2021	Cracks or Fractures	80.00	Minor Cracking	
L15-2016-L15-2015	607689	10/9/2020	Roots	50.00	Medium	ROOTS IN THE SHELF OF L15-2015
G16-2031-G16-2029	606300	1/16/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
H15-4035-H15-4034	606118	2/7/2019	Roots	80.00	Light	Roots in sand collars
H16-3028-H16-3027	606903	12/11/2019	Belly or Sag	80.00	Minor (<10%)	
L17-1092-L17-1038	606302	4/30/2019	Roots	50.00	Medium	ROOTS IN SEVERAL JOINTS 124 AND 329
L17-1092-L17-1038	606302	4/30/2019	Inflow and Infiltration	90.00	Stain, Possible I&I	
L17-1086-L17-1017	607889	1/11/2021	Roots	50.00	Medium	ROOTS IN JOINTS AND CRACKS MULTIPLE AREAS 82FT 98 FT AND 103 FT
L17-1086-L17-1017	607889	1/11/2021	Belly or Sag	80.00	Minor (<10%)	
L17-1086-L17-1017	607889	1/11/2021	Cracks or Fractures	80.00	Minor Cracking	
L17-1086-L17-1017	607889	1/11/2021	Lining or Repair Failure	80.00	Minor	
L17-1086-L17-1017	607889	1/11/2021	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
H15-2035-H15-2034	606901	12/11/2019	Belly or Sag	80.00	Minor (<10%)	
H16-2018-H16-2014	606482	6/20/2019	Lining or Repair Failure	60.00	Moderate	
K18-3014-LS-1-N	605948	12/3/2018	Belly or Sag	40.00	Severe (>30%)	
M18-4043-M18-4042	607850	12/22/2020	Belly or Sag	80.00	Minor (<10%)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
G16-3043-G16-3042	606223	1/16/2019	Roots	80.00	Light	ROOTS IN THE FIRST 3 FEET OF THE RUN FROM THE TOP MANHOLE
G16-3043-G16-3042	606223	1/16/2019	Cracks or Fractures	80.00	Minor Cracking	
H17-4057-H17-4056	607338	7/9/2020	Belly or Sag	80.00	Minor (<10%)	
G16-2035-G16-2019	606294	1/16/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
H17-4044-H17-4043	606822	10/9/2019	Inflow and Infiltration	80.00	Weeping or Dripping	
J16-4008-J16-4007	606631	7/30/2019	Roots	50.00	Medium	ROOTS AT 237
J16-4008-J16-4007	606631	7/30/2019	Cracks or Fractures	80.00	Minor Cracking	
G16-4057-G16-4055	606759	9/16/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
G16-4057-G16-4055	606759	9/16/2019	Cracks or Fractures	80.00	Minor Cracking	
H17-3036-H17-3034	606478	6/20/2019	Cracks or Fractures	60.00	Moderate Cracking	
H17-3036-H17-3034	606478	6/20/2019	Break or Failure	30.00	Hole Soil Visible	
M15-1004-M15-1003	607753	10/21/2020	Roots	50.00	Medium	ROOTS IN THE JOINT AT 114
G16-4098-G16-4002	606800	10/2/2019	Belly or Sag	80.00	Minor (<10%)	
G16-4012-G16-4011	606784	9/30/2019	Roots	80.00	Light	ROOTS IN MANHOLE G16-4012 COMING IN FROM THE RING AND ALSO IN THE SAND COLLAR
H17-1024-H17-1023	607438	7/30/2020	Inflow and Infiltration	90.00	Stain, Possible I&I	
L17-1087-L17-1086	607887	1/8/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
L17-1087-L17-1086	607887	1/8/2021	Belly or Sag	80.00	Minor (<10%)	
L17-1057-L17-1063	607963	2/4/2021	Roots	80.00	Light	LIGHT ROOTS IN THE TOP OF THE PIPE AT 125 FT
L17-1057-L17-1063	607963	2/4/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
L17-1057-L17-1063	607963	2/4/2021	Belly or Sag	80.00	Minor (<10%)	
G16-4089-G16-4088	606671	8/7/2019	Belly or Sag	80.00	Minor (<10%)	
G16-4107-G16-4106	606792	10/1/2019	Obstruction or Intrusion	60.00	Moderate	
J16-1017-J16-1016	607018	1/24/2020	Roots	50.00	Medium	ROOTS IN THE SAND COLLARS
G16-4102-G16-4100	606770	9/16/2019	Obstruction or Intrusion	0.00	Severe or Impassable	
G16-4102-G16-4100	606770	9/16/2019	Belly or Sag	80.00	Minor (<10%)	
G16-4102-G16-4100	606770	9/16/2019	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
J16-1085-J16-1012	607026	2/6/2020	Belly or Sag	40.00	Severe (>30%)	
G15-3015-G15-3016	605996	12/26/2018	Belly or Sag	80.00	Minor (<10%)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
J17-1015-J17-2048	607528	8/24/2020	Break or Failure	30.00	Hole Soil Visible	
G16-3017-G16-3016	606230	1/16/2019	Inflow and Infiltration	40.00	Gushing or Spurting	
K18-Cap-K18-3055	604836	8/28/2017	Inflow and Infiltration	90.00	Stain, Possible I&I	
G15-3016-G15-3017	605997	11/13/2018	Belly or Sag	80.00	Minor (<10%)	
L17-1089C-L17-1086	607888	1/11/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
K18-3033-L18-4045	607954	2/3/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
H15-4038-H15-4037	606125	2/8/2019	Roots	80.00	Light	Roots in side service connections at 7 feet from upper m/h
G16-4017-G16-4009	606782	9/30/2019	Inflow and Infiltration	90.00	Stain, Possible I&I	
H17-1023-H17-1022	607440	7/30/2020	Roots	80.00	Light	ROOTS SAND COLLAR H17-1022
G21-2025-G21-2024	605402	5/17/2018	Inflow and Infiltration	90.00	Stain, Possible I&I	
G21-2025-G21-2024	605402	5/17/2018	Cracks or Fractures	80.00	Minor Cracking	
L17-1017-L17-1016	607907	1/13/2021	Inflow and Infiltration	60.00	Running or Trickling	
J16-4002-J16-4001	606636	7/31/2019	Roots	80.00	Light	ROOTS AT 283 DOWN STREAM
L14-3015-L14-3014	607704	10/13/2020	Roots	50.00	Medium	ROOTS IN THE SAND COLLAR OF MANHOLE L14-3014
L18-4037-L18-4071	607959	2/3/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
L18-4037-L18-4071	607959	2/3/2021	Belly or Sag	80.00	Minor (<10%)	
K18-3016-K18-3106	606202	3/4/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
K18-3016-K18-3106	606202	3/4/2019	Lining or Repair Failure	80.00	Minor	
K18-3016-K18-3106	606202	3/4/2019	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
H16-2032-H16-2033	606871	11/19/2019	Belly or Sag	80.00	Minor (<10%)	
L17-1007-L17-1006	607922	1/22/2021	Belly or Sag	80.00	Minor (<10%)	
A28-2014-A28-2013	607193	3/17/2020	Roots	0.00	Blockage	ROOTS IN THE LATERAL WITH A BLOCKAGE AT 149FT. ALSO IN THE MANHOLE A28-2013
G16-3048-G16-3047	606678	8/12/2019	Obstruction or Intrusion	80.00	Minor	
G16-3048-G16-3047	606678	8/12/2019	Cracks or Fractures	80.00	Minor Cracking	
J16-2004-J16-2003	605900	9/25/2018	Belly or Sag	80.00	Minor (<10%)	
H17-1017-H17-1013	607389	7/22/2020	Inflow and Infiltration	90.00	Stain, Possible I&I	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
G16-4086-G16-4084	606748	9/12/2019	Belly or Sag	80.00	Minor (<10%)	
H16-2094C-H16-2012	606493	6/24/2019	Roots	80.00	Light	ROOTS IN LATERAL CONNECTION
H16-2094C-H16-2012	606493	6/24/2019	Cracks or Fractures	80.00	Minor Cracking	
A28-2026-A28-2010	607148	3/3/2020	Roots	50.00	Medium	ROOTS IN ALMOST EVERY JOINT, AT THE T3 AT 96 FT THERE IS A LARGE ROOT BALL BLOCKING THE CONNECTION
A28-2026-A28-2010	607148	3/3/2020	Cracks or Fractures	80.00	Minor Cracking	
H15-4036-H15-4035	606117	2/7/2019	Roots	80.00	Light	Roots in both sand collars
H16-2009-H16-2010	606485	6/20/2019	Inflow and Infiltration	60.00	Running or Trickling	
H16-2009-H16-2010	606485	6/20/2019	Cracks or Fractures	80.00	Minor Cracking	
H16-2086-H16-2083	607114	2/24/2020	Inflow and Infiltration	80.00	Weeping or Dripping	
H17-1008-H17-1007	607434	7/30/2020	Roots	80.00	Light	ROOTS AT SAND COLLAR IN FLOW H17--1007
H17-1008-H17-1007	607434	7/30/2020	Inflow and Infiltration	90.00	Stain, Possible I&I	
H17-1008-H17-1007	607434	7/30/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
H17-1003-H17-1002	607577	8/31/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
H17-4004-H17-4003	606808	10/3/2019	Roots	50.00	Medium	ROOTS IN M/H H17-4004 AT THE SAND COLLAR
H17-3037-H17-3030	606457	6/13/2019	Obstruction or Intrusion	0.00	Severe or Impassable	
G21-2012-H21-1003	605406	5/17/2018	Inflow and Infiltration	90.00	Stain, Possible I&I	
G21-2012-H21-1003	605406	5/17/2018	Obstruction or Intrusion	80.00	Minor	
G21-2012-H21-1003	605406	5/17/2018	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
L15-2008-L15-2009	607695	10/12/2020	Roots	80.00	Light	ROOTS AT THE LATERAL NOT BLOCKING
M18-4027-M18-4026	607870	1/4/2021	Roots	30.00	Heavy	HEAVY ROOTS IN MANHOLE M18-4027
B28-4022-B28-4021	607241	5/26/2020	Lining or Repair Failure	80.00	Minor	
J16-4022-J16-4023	607131	2/26/2020	Inflow and Infiltration	80.00	Weeping or Dripping	
J16-4022-J16-4023	607131	2/26/2020	Worn Surface	60.00	Moderate	
J16-4022-J16-4023	607131	2/26/2020	Lining or Repair Failure	60.00	Moderate	
L17-1098-L17-1065	607960	2/4/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
H16-3025-H16-3023	606930	1/6/2020	Belly or Sag	60.00	Moderate (10 to 30%)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
G16-4031-G16-4029	606749	9/12/2019	Belly or Sag	80.00	Minor (<10%)	
H16-3023-H16-3016	606935	1/6/2020	Inflow and Infiltration	90.00	Stain, Possible I&I	
H16-3023-H16-3016	606935	1/6/2020	Belly or Sag	80.00	Minor (<10%)	
J19-3109-J19-3108	607997	3/1/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
H16-2072-H16-2070	606509	6/26/2019	Roots	0.00	Blockage	ROOTS IN H16-2070 BLOCKING ENTANCE AND EXIT
J17-4021-J17-4020	607473	8/12/2020	Inflow and Infiltration	80.00	Weeping or Dripping	
J17-2025-J17-2024	607493	8/17/2020	Roots	80.00	Light	J17-2024 WALL
J16-1009-J16-1007	607040	2/10/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
H17-1013-H17-1012	607390	7/22/2020	Belly or Sag	80.00	Minor (<10%)	
H16-1021-H16-1020	606568	7/8/2019	Belly or Sag	40.00	Severe (>30%)	
H17-2008-H17-2009	606559	7/8/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
H17-2009-LS-37	606563	7/8/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
H17-1018-H17-1017	607386	7/22/2020	Cracks or Fractures	80.00	Minor Cracking	
L17-1055-L17-1096	606600	7/22/2019	Inflow and Infiltration	60.00	Running or Trickling	
L17-1055-L17-1096	606600	7/22/2019	Worn Surface	80.00	Minor	
L17-1055-L17-1096	606600	7/22/2019	Belly or Sag	60.00	Moderate (10 to 30%)	
L17-1055-L17-1096	606600	7/22/2019	Cracks or Fractures	80.00	Minor Cracking	
L17-1055-L17-1096	606600	7/22/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J17-2024-J17-2023	607483	8/17/2020	Inflow and Infiltration	90.00	Stain, Possible I&I	
L17-1052-L17-1050	606604	7/23/2019	Inflow and Infiltration	60.00	Running or Trickling	
L17-1052-L17-1050	606604	7/23/2019	Worn Surface	80.00	Minor	
L17-1052-L17-1050	606604	7/23/2019	Belly or Sag	40.00	Severe (>30%)	
L17-1052-L17-1050	606604	7/23/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
G21-2015-G21-2014	605495	7/2/2018	Inflow and Infiltration	80.00	Weeping or Dripping	
J16-4007-J16-4027	606653	8/5/2019	Roots	30.00	Heavy	RE TV AFTER ROOT CUT STILL NEEDS MORE CUTTING
G15-2011-G15-2010	606084	2/1/2019	Obstruction or Intrusion	80.00	Minor	
G15-3036-G15-3012	606069	1/30/2019	Roots	0.00	Blockage	Roots in M/H and sand collar
J16-1019-J16-1016	607014	1/24/2020	Roots	50.00	Medium	ROOTS IN THE SAND COLLAR OF M/H J16-1016
H16-2004-H16-2005	606421	6/6/2019	Roots	30.00	Heavy	ROOTS THROUGH OUT THE LINE

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
H16-2004-H16-2005	606421	6/6/2019	Belly or Sag	80.00	Minor (<10%)	
M18-4004-M18-4003	607871	1/5/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
G16-3069-G16-3068	606235	1/16/2019	Roots	30.00	Heavy	ROOTS AT EVERY SIDE SERVICE TREAT WHOLE PIPE
G16-3069-G16-3068	606235	1/16/2019	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-3069-G16-3068	606235	1/16/2019	Cracks or Fractures	80.00	Minor Cracking	
G16-3068-G16-3012	606234	1/16/2019	Roots	50.00	Medium	ROOTS IN UPPER AND LOWER MANHOLE
G16-3068-G16-3012	606234	1/16/2019	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-4100-G16-4099	606797	10/1/2019	Roots	50.00	Medium	ROOTS IN THE MANHOLE SECTION JOINTS OF G16-4099
H16-2098-H16-2078	607121	2/25/2020	Roots	50.00	Medium	ROOTS IN BOTH MANHOLE H16-2098 AND 2078
H16-2098-H16-2078	607121	2/25/2020	Belly or Sag	60.00	Moderate (10 to 30%)	
L17-4018C-L17-4004	607893	1/11/2021	Belly or Sag	80.00	Minor (<10%)	
L17-4018C-L17-4004	607893	1/11/2021	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
J16-4027-J16-4006	606654	8/5/2019	Roots	30.00	Heavy	ROOTS 34 FEET FROM THE TOP WILL CUT SIDE SERVICE 8/6/19
H17-2010-LS-37	606562	7/8/2019	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
G15-3008-G15-3007	606256	4/17/2019	Worn Surface	80.00	Minor	
L18-3049-L18-3003	607786	10/27/2020	Belly or Sag	80.00	Minor (<10%)	
J16-4005-J16-4004	606629	7/30/2019	Roots	50.00	Medium	ROOTS AT 35, 273, 275 AND 283 AND 289
J16-4005-J16-4004	606629	7/30/2019	Cracks or Fractures	80.00	Minor Cracking	
J16-4005-J16-4004	606629	7/30/2019	Break or Failure	15.00	Hole Void Visible	
L17-1033-L17-1032	607899	1/12/2021	Roots	80.00	Light	ROOTS JUST INSIDE THE SAND COLLAR OF MANHOLE L17-1032
G15-2020-G15-2019	606257	4/17/2019	Roots	80.00	Light	From top end, 100’
H16-2087-H16-2086	607115	2/24/2020	Inflow and Infiltration	80.00	Weeping or Dripping	
H17-3076-H16-2017	606534	6/27/2019	Inflow and Infiltration	80.00	Weeping or Dripping	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
H17-3076-H16-2017	606534	6/27/2019	Break or Failure	15.00	Hole Void Visible	
G16-2034-G16-2009	606309	1/16/2019	Roots	50.00	Medium	ROOTS IN THE MANHOLE SAND COLLAR AT G16-2034
H15-2003-H15-2032	607110	2/21/2020	Inflow and Infiltration	60.00	Running or Trickling	
H16-2012-H16-2011	606491	6/24/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
L17-1078-L17-1077	607916	1/21/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
L17-1054-L17-1053	606602	7/22/2019	Inflow and Infiltration	60.00	Running or Trickling	
L17-1054-L17-1053	606602	7/22/2019	Worn Surface	80.00	Minor	
L17-1054-L17-1053	606602	7/22/2019	Belly or Sag	40.00	Severe (>30%)	
L17-1054-L17-1053	606602	7/22/2019	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J16-1041-J16-1044	606612	7/29/2019	Roots	30.00	Heavy	ROOTS AT 1 FT 16 FT AND 73 FT
J16-1041-J16-1044	606612	7/29/2019	Cracks or Fractures	80.00	Minor Cracking	
J11-3039-J11-3037	605984	12/20/2018	Inflow and Infiltration	80.00	Weeping or Dripping	
J11-3039-J11-3037	605984	12/20/2018	Cracks or Fractures	80.00	Minor Cracking	
J20-3075-J20-3074	607620	9/29/2020	Roots	50.00	Medium	M/H J20-3074 IN THE SAND COLLAR
J16-1073C-J16-1072	607043	2/11/2020	Cracks or Fractures	80.00	Minor Cracking	
H17-1033-H17-1032	607399	7/27/2020	Belly or Sag	80.00	Minor (<10%)	
G15-3011-G15-3010	606072	1/30/2019	Roots	50.00	Medium	Roots the wall at G15-3011
J16-1055-J16-1054	606576	7/8/2019	Belly or Sag	80.00	Minor (<10%)	
L17-1015-L17-1081	607909	1/14/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
H17-1048-H17-1011	607393	7/23/2020	Inflow and Infiltration	90.00	Stain, Possible I&I	
H17-1048-H17-1011	607393	7/23/2020	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
H17-1012-H17-1011	607392	7/23/2020	Break or Failure	30.00	Hole Soil Visible	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
K18-4053-K18-4007	609006	2/3/2022	Roots	50.00	Medium	ROOTS IN STRUCTURE K18-4007
G21-2027-G21-2026	609874	11/8/2022	Cracks or Fractures	80.00	Minor Cracking	
G21-2027-G21-2026	609874	11/8/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
J20-2002-J20-2001	608801	11/15/2021	Roots	80.00	Light	IN STRUCTURE 2002 AROUND OUTFLOW PIPE
D10-2001-D10-1027	609741	10/4/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
L17-1017-L17-1016	607907	1/13/2021	Inflow and Infiltration	60.00	Running or Trickling	
D23-2046-D23-2042	608186	5/3/2021	Cracks or Fractures	80.00	Minor Cracking	
D23-2057-D23-2056	608134	4/12/2021	Belly or Sag	80.00	Minor (<10%)	
L18-4071-L17-1058	609532	7/17/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
D10-2057-D10-2056	609510	7/6/2022	Cracks or Fractures	80.00	Minor Cracking	
G16-4102-G16-4100	610145	1/18/2023	Obstruction or Intrusion	60.00	Moderate	
H15-4010-H15-4009	610595	8/3/2023	Break or Failure	15.00	Hole Void Visible	
L17-1026-L17-1022	607902	1/12/2021	Inflow and Infiltration	40.00	Gushing or Spurting	
D23-3049-D23-3032	608201	5/4/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
M18-4021-M18-4014	607864	1/4/2021	Belly or Sag	80.00	Minor (<10%)	
L17-1015-L17-1081	607909	1/14/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
J11-2026-J11-3032	608321	5/20/2021	Roots	50.00	Medium	ROOTS AT 15, 27, 29, 36, 45, 55
H16-4003-H16-4002	610359	4/4/2023	Belly or Sag	80.00	Minor (<10%)	
H17-3060-H17-3059	611089	12/28/2023	Roots	80.00	Light	H17-3059
J11-3099-J11-3051	608388	6/10/2021	Obstruction or Intrusion	80.00	Minor	
J11-3099-J11-3051	608388	6/10/2021	Cracks or Fractures	80.00	Minor Cracking	
D10-2054-D10-2053	609507	7/6/2022	Roots	80.00	Light	D10-2053
D10-2054-D10-2053	609507	7/6/2022	Inflow and Infiltration	60.00	Running or Trickling	
J11-3106-J11-3072	608426	7/1/2021	Obstruction or Intrusion	80.00	Minor	
J11-3106-J11-3072	608426	7/1/2021	Cracks or Fractures	80.00	Minor Cracking	
G15-3036-G15-3012	610466	5/8/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-4015-G16-4013	610128	1/17/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-2047C-G16-2004	610448	5/3/2023	Roots	50.00	Medium	
K18-3017-K18-3016	609323	4/27/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
L19-4009-L19-4008	610228	2/6/2023	Inflow and Infiltration	80.00	Weeping or Dripping	
L17-1035-L17-4004	607892	1/11/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
G15-3014-G15-3051	610256	3/8/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
J19-3109-J19-3108	607997	3/1/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-4058-G16-4057	610146	1/19/2023	Obstruction or Intrusion	80.00	Minor	
G16-4058-G16-4057	610146	1/19/2023	Cracks or Fractures	60.00	Moderate Cracking	
G15-2019-G15-2018	610393	4/12/2023	Inflow and Infiltration	60.00	Running or Trickling	
D10-2053-D10-2052	609501	6/30/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
D10-2053-D10-2052	609501	6/30/2022	Belly or Sag	80.00	Minor (<10%)	
J18-3040-J18-3038	608205	5/5/2021	Roots	50.00	Medium	ROOTS IN STRUCTURE 3038
L17-1010C-L17-1009	608758	10/22/2021	Cracks or Fractures	80.00	Minor Cracking	
D23-2078-D23-2077	608082	3/24/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
J11-3078-J11-3107	608403	6/22/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-3078-J11-3107	608403	6/22/2021	Roots	50.00	Medium	VARIOUS JOINTS THROUGHOUT MAINLINE.
J11-3078-J11-3107	608403	6/22/2021	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
J11-3078-J11-3107	608403	6/22/2021	Belly or Sag	80.00	Minor (<10%)	
J11-3056-J11-3055	608457	7/13/2021	Roots	80.00	Light	
J11-3068-J11-3067	608405	6/22/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
J11-3068-J11-3067	608405	6/22/2021	Break or Failure	30.00	Hole Soil Visible	
J11-3068-J11-3067	608405	6/22/2021	Worn Surface	80.00	Minor	
K18-3069-K18-3002	609352	5/4/2022	Obstruction or Intrusion	80.00	Minor	
F16-3018-F16-3041	610038	12/6/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
H17-3057-H17-3056	611072	12/27/2023	Cracks or Fractures	80.00	Minor Cracking	
H17-3057-H17-3056	611072	12/27/2023	Roots	80.00	Light	
H17-3057-H17-3056	611072	12/27/2023	Worn Surface	80.00	Minor	
H16-1062-H16-1033	610457	5/5/2023	Roots	50.00	Medium	ROOTS AT LATERALS
H16-1062-H16-1033	610457	5/5/2023	Cracks or Fractures	80.00	Minor Cracking	
D23-3032-D23-3031	608223	5/6/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
K19-1064-K19-1063	609243	4/13/2022	Roots	50.00	Medium	IN DOWNSTREAM STRUCTURE K19-1063
G16-3057-LS-31	610559	7/20/2023	Belly or Sag	80.00	Minor (<10%)	
G21-2024-G21-2023	609877	11/8/2022	Cracks or Fractures	80.00	Minor Cracking	
D11-4024-D11-4023	609696	9/12/2022	Belly or Sag	80.00	Minor (<10%)	
D11-4024-D11-4023	609696	9/12/2022	Roots	80.00	Light	D11-4024 ROOTS IN MH

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
E23-1006-E23-1005	608087	3/29/2021	Roots	50.00	Medium	SAND COLLAR AND WALL 0F E23-1005
K18-2011-K18-2008	609569	7/20/2022	Inflow and Infiltration	60.00	Running or Trickling	
L17-1078-L17-1077	607916	1/21/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
J11-3063-J11-3058	608525	8/3/2021	Roots	80.00	Light	ON ROOTS LIST
D23-1019-D23-1003	608166	4/27/2021	Roots	80.00	Light	
D23-1019-D23-1003	608166	4/27/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
J11-3071-J11-3070	608425	7/1/2021	Roots	80.00	Light	ROOTS AT JOINTS 120'-150', 172'-190', 201', 218'-222' JOINTS
J11-3071-J11-3070	608425	7/1/2021	Break or Failure	30.00	Hole Soil Visible	
J11-3071-J11-3070	608425	7/1/2021	Worn Surface	80.00	Minor	
H15-4036-H15-4035	610513	6/29/2023	Belly or Sag	80.00	Minor (<10%)	
J11-3050-J11-3048	608485	7/20/2021	Roots	80.00	Light	
D11-4061-D11-4060	609618	8/9/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
D23-1020-D23-1019	608156	4/20/2021	Roots	80.00	Light	
J16-4027-J16-4006	610933	12/1/2023	Cracks or Fractures	60.00	Moderate Cracking	
J16-4027-J16-4006	610933	12/1/2023	Roots	80.00	Light	ROOTS IN LATERAL AND JOINTS
J16-4027-J16-4006	610933	12/1/2023	Inflow and Infiltration	80.00	Weeping or Dripping	
J19-2012-J19-2011	607941	2/2/2021	Belly or Sag	80.00	Minor (<10%)	
H17-3052-H17-3051	611060	12/20/2023	Break or Failure	30.00	Hole Soil Visible	
H16-3110-H16-3109	610777	9/13/2023	Belly or Sag	80.00	Minor (<10%)	
K18-2027-K18-2025	608890	12/23/2021	Inflow and Infiltration	60.00	Running or Trickling	
D23-2018-D23-2017	608127	4/8/2021	Roots	50.00	Medium	ROOTS AT 23FT ,34 FT, 201FT, 220FT, 257FT 264FT
L17-1006-L17-1005	608725	10/18/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
L17-1006-L17-1005	608725	10/18/2021	Belly or Sag	80.00	Minor (<10%)	
H16-2004-H16-2005	611006	12/13/2023	Roots	50.00	Medium	ROOTS IN A COUPLE JOINTS AND LATERAL CONNECTIONS
D23-2093-D23-2090	608061	3/18/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
J11-4023-J11-4026	608465	7/19/2021	Belly or Sag	80.00	Minor (<10%)	
K18-2005-K18-2004	609354	5/4/2022	Roots	80.00	Light	K18-2004 ROOTS STARTING TO GROW IN MH

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
F16-3029-F16-3027	610018	12/1/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
K18-3058-K18-3057	608731	10/19/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
G15-3013-G15-3012	610258	3/8/2023	Roots	30.00	Heavy	DONWSTEAM MAN STRUCTURE
G21-2012-H21-1003	609880	11/8/2022	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
L17-1059-L17-1058	609433	6/13/2022	Inflow and Infiltration	40.00	Gushing or Spurting	
G16-1017-G16-1016	610435	4/27/2023	Roots	30.00	Heavy	
L18-4037-L18-4071	607959	2/3/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
L18-4037-L18-4071	607959	2/3/2021	Belly or Sag	80.00	Minor (<10%)	
H16-2021-H16-2010	611005	12/13/2023	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
H16-2021-H16-2010	611005	12/13/2023	Obstruction or Intrusion	80.00	Minor	
H16-2021-H16-2010	611005	12/13/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
H16-2021-H16-2010	611005	12/13/2023	Cracks or Fractures	40.00	Severe Cracking	
K20-4021-K19-1045	609376	5/24/2022	Roots	80.00	Light	K20-4016 ROOTS AT INFLOW SAND COLLAR
K19-1029-K19-1028	609062	2/15/2022	Roots	80.00	Light	
G16-4016-G16-4015	610117	1/11/2023	Inflow and Infiltration	60.00	Running or Trickling	
G16-4016-G16-4015	610117	1/11/2023	Break or Failure	30.00	Hole Soil Visible	
H17-3021-H17-3018	611067	12/26/2023	Roots	80.00	Light	
J11-3042-J11-3096	608446	7/8/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
J11-3042-J11-3096	608446	7/8/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
J11-3042-J11-3096	608446	7/8/2021	Roots	80.00	Light	
J11-3042-J11-3096	608446	7/8/2021	Cracks or Fractures	80.00	Minor Cracking	
J19-2009-J19-2008	609516	7/12/2022	Roots	80.00	Light	J19-2009-J19-2008 IN STRUCTURE....REQUIRE ROOTX
J20-2007-J20-2006	608792	11/15/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
J11-3073-J11-3106	608427	7/1/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-3073-J11-3106	608427	7/1/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
D10-2047-D10-2043	609505	7/6/2022	Roots	80.00	Light	D10-2047
G16-4112-G16-4111	610152	1/19/2023	Inflow and Infiltration	60.00	Running or Trickling	
G16-4112-G16-4111	610152	1/19/2023	Roots	50.00	Medium	roots sticking through patch
G16-4112-G16-4111	610152	1/19/2023	Lining or Repair Failure	60.00	Moderate	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
G16-4112-G16-4111	610152	1/19/2023	Cracks or Fractures	40.00	Severe Cracking	
M18-4027-M18-4026	607870	1/4/2021	Roots	30.00	Heavy	HEAVY ROOTS IN MANHOLE M18-4027
K18-2029-K18-2028	608867	12/20/2021	Belly or Sag	80.00	Minor (<10%)	
J19-2080C-J19-2056	608816	11/30/2021	Lining or Repair Failure	80.00	Minor	
K10-1075-K10-1030	608258	5/11/2021	Roots	80.00	Light	
H15-4001-H15-1016	610519	7/6/2023	Roots	30.00	Heavy	HEAVY ROOTS IN UPSTREAM STRUCTURE H15-4001
H15-4001-H15-1016	610519	7/6/2023	Belly or Sag	80.00	Minor (<10%)	
G21-2039-G21-2001	609904	11/14/2022	Obstruction or Intrusion	0.00	Severe or Impassable	
D23-2013-D23-2012	608179	5/3/2021	Roots	80.00	Light	LIGHT ROOTS AT 80' LAT...RECOMMENDING ROOT TREATMENT
D23-1017-D23-1016	608152	4/15/2021	Roots	50.00	Medium	ROOTS AT 27 FT FROM UPPER M/H
D11-1008-D11-1007	609675	9/1/2022	Roots	80.00	Light	@126" AT LATERAL CONNECTION, RECOMMEND FOAM....ADDED TO ROOT TREATMENT LIST 9-1-22
K10-1033-K10-1032	608253	5/11/2021	Cracks or Fractures	80.00	Minor Cracking	
D10-1034-D10-1033	609628	8/15/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
D11-4022-D11-4021	609698	9/12/2022	Obstruction or Intrusion	80.00	Minor	
G16-1050-G16-1046	610201	1/27/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
J18-3054-J18-3053	609367	5/23/2022	Roots	30.00	Heavy	J18-3053: ROOTS IN STRUCTURE JOINT
G16-3010-G16-3073	610275	3/13/2023	Roots	50.00	Medium	
D10-2002-D10-2001	609629	8/15/2022	Worn Surface	40.00	Severe	
L17-1087-L17-1086	607887	1/8/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
L17-1087-L17-1086	607887	1/8/2021	Belly or Sag	80.00	Minor (<10%)	
G16-4022-G16-4125	610110	1/9/2023	Cracks or Fractures	60.00	Moderate Cracking	
G16-4022-G16-4125	610110	1/9/2023	Inflow and Infiltration	60.00	Running or Trickling	
J11-4021-J11-4022	608467	7/19/2021	Belly or Sag	80.00	Minor (<10%)	
K19-4013-K19-4012	609038	2/9/2022	Roots	50.00	Medium	K19-4013- ROOTS IN SAND COLLAR JOINT
H16-3022-H16-3016	610839	9/28/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
H16-1034C-H16-1062	610455	5/5/2023	Roots	0.00	Blockage	
H16-1034C-H16-1062	610455	5/5/2023	Obstruction or Intrusion	0.00	Severe or Impassable	
H16-1034C-H16-1062	610455	5/5/2023	Inflow and Infiltration	80.00	Weeping or Dripping	
K18-4027-K18-4026	609319	4/27/2022	Break or Failure	15.00	Hole Void Visible	
J16-4007-J16-4027	610932	12/1/2023	Cracks or Fractures	80.00	Minor Cracking	
J11-3024-J11-3023	608332	5/26/2021	Roots	50.00	Medium	ROOTS IN LATERAL AT 22.6FT IN THE RIGHT OF WAY
J16-1040-J16-1041	610919	11/29/2023	Roots	80.00	Light	J16-1041 ROOTS IN MANHOLE
G21-2022-G21-2021	609893	11/10/2022	Roots	50.00	Medium	
J18-2080-J18-2087	609251	4/14/2022	Roots	30.00	Heavy	SEVERE ROOTS IN LATERAL AT 26 FEET UPSTREAM
L17-3009-L17-3008	609106	3/2/2022	Belly or Sag	80.00	Minor (<10%)	
L17-3009-L17-3008	609106	3/2/2022	Roots	80.00	Light	IN LATERAL JOINT
K18-3024-K18-3014	609360	5/6/2022	Cracks or Fractures	80.00	Minor Cracking	
K18-3024-K18-3014	609360	5/6/2022	Roots	80.00	Light	K18-3024 ROOTS THROUGH OUT. ROOTS GROWING THROUGH INFLOW SAND COLLAR
K18-4040-K18-4002	608906	1/4/2022	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
H16-1006-H16-1005	610282	3/16/2023	Obstruction or Intrusion	60.00	Moderate	
D23-2019-D23-2018	608126	4/8/2021	Roots	50.00	Medium	ROOTS AT 15 AND 51 FT FROM LOWER M/H
C11-2006-C11-2004	609604	8/2/2022	Belly or Sag	80.00	Minor (<10%)	
K19-1061-K19-1060	609247	4/13/2022	Belly or Sag	80.00	Minor (<10%)	
K18-4074-K18-4073	609351	5/4/2022	Cracks or Fractures	80.00	Minor Cracking	
J16-1017-J16-1016	610629	8/9/2023	Roots	80.00	Light	ROOTS IN DOWN STREAM MANHOLE J16-1016 AROUND THE END OF THE PIPE
J19-2083-J19-2082	607945	2/2/2021	Roots	50.00	Medium	
H17-3022-H17-3021	611068	12/26/2023	Belly or Sag	80.00	Minor (<10%)	
H17-3022-H17-3021	611068	12/26/2023	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
K19-1006-K19-1005	609121	3/9/2022	Roots	50.00	Medium	ROOTS IN UPSTREAM STRUCTURE K19-1006

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
G15-3038-G15-3037	610260	3/9/2023	Roots	80.00	Light	G15-3038- ROOTS IN STRUCTURE JOINT
J18-2047-J18-2046	608972	1/28/2022	Roots	80.00	Light	IN UPSTREAM STRUCTURE J18-2047
D23-2058-D23-2057	608133	4/12/2021	Inflow and Infiltration	60.00	Running or Trickling	
D23-2058-D23-2057	608133	4/12/2021	Roots	80.00	Light	
D23-2058-D23-2057	608133	4/12/2021	Cracks or Fractures	80.00	Minor Cracking	
M18-2014-M18-2013	610236	3/2/2023	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
M18-2014-M18-2013	610236	3/2/2023	Belly or Sag	80.00	Minor (<10%)	
H16-3023-H16-3016	610830	9/27/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
J11-3047C-J11-3045	608439	7/6/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J11-3047C-J11-3045	608439	7/6/2021	Belly or Sag	80.00	Minor (<10%)	
J11-3047C-J11-3045	608439	7/6/2021	Cracks or Fractures	80.00	Minor Cracking	
J19-3003-J19-3002	608551	8/16/2021	Roots	80.00	Light	WALL AND SAND COLLAR J19-3002
K18-4003-K18-3094	609542	7/18/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
M18-4004-M18-4003	607871	1/5/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
G16-3093-G16-3027	610426	4/26/2023	Cracks or Fractures	60.00	Moderate Cracking	
C11-3012-LS-47	609821	10/19/2022	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
C11-3012-LS-47	609821	10/19/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
H15-4008-H15-4007	610594	8/3/2023	Roots	50.00	Medium	H15-4007 ROOTS
C11-2014-C11-2013	609738	10/4/2022	Worn Surface	80.00	Minor	
C11-2014-C11-2013	609738	10/4/2022	Obstruction or Intrusion	80.00	Minor	
C11-2014-C11-2013	609738	10/4/2022	Belly or Sag	80.00	Minor (<10%)	
K10-1006-K10-1005	608340	5/27/2021	Belly or Sag	80.00	Minor (<10%)	
K10-1006-K10-1005	608340	5/27/2021	Inflow and Infiltration	60.00	Running or Trickling	
H16-2008-H16-2009	611010	12/13/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-1022-G16-1021	610489	5/30/2023	Belly or Sag	60.00	Moderate (10 to 30%)	
K18-2016-K18-2015	609342	5/3/2022	Inflow and Infiltration	60.00	Running or Trickling	
K18-3011-K18-3010	609537	7/18/2022	Obstruction or Intrusion	80.00	Minor	
K19-1026-K19-1025	609060	2/15/2022	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
J19-3040-J19-3039	608538	8/10/2021	Break or Failure	15.00	Hole Void Visible	
J19-3040-J19-3039	608538	8/10/2021	Obstruction or Intrusion	60.00	Moderate	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
K18-4059-K18-4058	609300	4/25/2022	Cracks or Fractures	80.00	Minor Cracking	
G18-4001-LS-9	608163	4/22/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
G18-4001-LS-9	608163	4/22/2021	Belly or Sag	80.00	Minor (<10%)	
K18-2037-K18-2036	609341	5/3/2022	Roots	80.00	Light	K18-2036 MINOR ROOT INTRUSION IN STRUCTURE NEAR TOP
H16-2017-H16-2016	611030	12/18/2023	Cracks or Fractures	80.00	Minor Cracking	
H16-2017-H16-2016	611030	12/18/2023	Break or Failure	30.00	Hole Soil Visible	
J11-2022-J11-2040	608533	8/5/2021	Cracks or Fractures	80.00	Minor Cracking	
H15-4011-H15-4010	610596	8/3/2023	Obstruction or Intrusion	0.00	Severe or Impassable	
J11-3062-J11-3103	608420	6/28/2021	Roots	50.00	Medium	ROOT CUT WHOLE LINE
J11-3053-J11-3051	608484	7/20/2021	Belly or Sag	80.00	Minor (<10%)	
J11-3082-J11-3105	608381	6/10/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
L17-1100-L17-1079	608759	10/22/2021	Inflow and Infiltration	60.00	Running or Trickling	
K18-4068-K18-4009	609349	5/4/2022	Cracks or Fractures	80.00	Minor Cracking	
D10-1026-D10-1025	609631	8/25/2022	Roots	80.00	Light	IN STRUCTURE D10-1025
H17-3076-H16-2017	611029	12/18/2023	Break or Failure	30.00	Hole Soil Visible	
H17-3076-H16-2017	611029	12/18/2023	Cracks or Fractures	60.00	Moderate Cracking	
H17-3076-H16-2017	611029	12/18/2023	Lining or Repair Failure	80.00	Minor	
K18-4090-K18-4010	608450	7/12/2021	Obstruction or Intrusion	80.00	Minor	
G16-3035-G16-3034	610414	4/21/2023	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
L17-1007-L17-1006	607922	1/22/2021	Belly or Sag	80.00	Minor (<10%)	
G16-3026-G16-3025	610418	4/24/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
J19-3051-J19-3050	609003	2/3/2022	Roots	80.00	Light	J19-3051 ROOTS IN STRUCTURE
J19-2046-J19-2010	607937	2/1/2021	Roots	80.00	Light	ROOTS IN THE SAND COLLAR OF J19-2010
K18-4041-K18-4082	608904	1/4/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
L17-1092-L17-1076	607918	1/21/2021	Roots	80.00	Light	ROOTS IN THE SAND COLLAR OF L1`7-1092
D23-1018-D23-1017	608151	4/15/2021	Roots	50.00	Medium	ROOTS IN JOINT 107 FROM LOWER M/H
K18-3033-L18-4045	607954	2/3/2021	Belly or Sag	60.00	Moderate (10 to 30%)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
J20-3027-J20-3024	608840	12/9/2021	Roots	50.00	Medium	ROOTS IN DOWNSTREAM MANHOLE STRUCTURE
G21-2023-G21-2020	608051	3/16/2021	Worn Surface	80.00	Minor	
J20-2004-J20-2003	608800	11/15/2021	Belly or Sag	80.00	Minor (<10%)	
H16-2016-H16-2015	611027	12/14/2023	Cracks or Fractures	80.00	Minor Cracking	
H16-2016-H16-2015	611027	12/14/2023	Break or Failure	30.00	Hole Soil Visible	
D23-2107-D23-2156	608031	3/10/2021	Inflow and Infiltration	60.00	Running or Trickling	
H16-2089-H16-2088	611023	12/14/2023	Roots	80.00	Light	H16-2088
C11-2013-C11-2008	609739	10/4/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
C11-2013-C11-2008	609739	10/4/2022	Cracks or Fractures	80.00	Minor Cracking	
K19-4008-K19-4007	609043	2/10/2022	Inflow and Infiltration	60.00	Running or Trickling	
L18-4008-L18-4007	609293	4/22/2022	Cracks or Fractures	80.00	Minor Cracking	
D23-2054-D23-2053	608139	4/12/2021	Obstruction or Intrusion	60.00	Moderate	
D23-2054-D23-2053	608139	4/12/2021	Roots	30.00	Heavy	CANNOT PROCEDE THROUGH ROOTS
J11-2028-J11-2027	608460	7/14/2021	Belly or Sag	40.00	Severe (>30%)	
K10-1016-K10-1006	608339	5/27/2021	Belly or Sag	80.00	Minor (<10%)	
K19-1056-K19-1055	608959	1/24/2022	Inflow and Infiltration	60.00	Running or Trickling	
J11-3084-J11-3083	608377	6/9/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-3084-J11-3083	608377	6/9/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J11-3094-J11-3014	608399	6/22/2021	Roots	80.00	Light	@ LATERAL PIPE 5'.
K18-3004-K18-3003	609357	5/5/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
L17-1064-L17-1063	607962	2/4/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
D10-2052-D10-2051	609482	6/22/2022	Inflow and Infiltration	60.00	Running or Trickling	
L17-1034-L17-1033	607898	1/12/2021	Inflow and Infiltration	40.00	Gushing or Spurting	
B26-2028-B26-2027	610889	11/20/2023	Roots	80.00	Light	ROOTS IN BOTH MANHOLES
B26-2028-B26-2027	610889	11/20/2023	Obstruction or Intrusion	60.00	Moderate	
D10-1001-D11-4055	609614	8/8/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
G16-2033-G16-2032	610394	4/12/2023	Roots	50.00	Medium	
G15-2008-G15-2002	610685	8/17/2023	Belly or Sag	80.00	Minor (<10%)	
J11-2024-J11-2023	608379	6/9/2021	Cracks or Fractures	80.00	Minor Cracking	
D23-2020-D23-2019	608116	4/6/2021	Roots	80.00	Light	ROOTS IN SIDE SERVEVICE AT 45.9 FEET
K19-1072-K19-1071	609417	6/7/2022	Belly or Sag	80.00	Minor (<10%)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
K19-1072-K19-1071	609417	6/7/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
B26-2034-B26-2033	610883	11/20/2023	Obstruction or Intrusion	80.00	Minor	
J18-3058-J18-3054	609368	5/23/2022	Roots	30.00	Heavy	J18-3054: ROOTS IN STRUCTURE
H15-4002-H15-4001	610518	7/6/2023	Roots	30.00	Heavy	ROOTS IN DOWNSTREAM STRUCTURE H15-4001
K10-1024-K10-1023	608272	5/13/2021	Roots	80.00	Light	AT LATERAL CONNECTIONS...109', 252.6'
K10-1024-K10-1023	608272	5/13/2021	Cracks or Fractures	80.00	Minor Cracking	
K10-1024-K10-1023	608272	5/13/2021	Break or Failure	30.00	Hole Soil Visible	
J11-3064-J11-3063	608384	6/10/2021	Worn Surface	80.00	Minor	
J11-3064-J11-3063	608384	6/10/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-2011-J11-2026	608320	5/20/2021	Roots	50.00	Medium	roots throughout the whole pipe
J11-3107-J11-3077	608477	7/20/2021	Roots	80.00	Light	SEE ROOTS LIST
J16-4028-H16-3042	610850	10/3/2023	Belly or Sag	80.00	Minor (<10%)	
K10-1053-K10-1005	608304	5/18/2021	Inflow and Infiltration	60.00	Running or Trickling	
K10-1053-K10-1005	608304	5/18/2021	Cracks or Fractures	80.00	Minor Cracking	
J16-4016C-J16-4015	610922	11/29/2023	Roots	80.00	Light	
J16-4016C-J16-4015	610922	11/29/2023	Cracks or Fractures	60.00	Moderate Cracking	
D23-2038-D23-2036	608189	5/4/2021	Cracks or Fractures	80.00	Minor Cracking	
D23-3038-D23-3037	608360	6/7/2021	Roots	50.00	Medium	D23-3038-D23-3037 ROOTS IN JOINT AT
K10-1041-J10-2005	608316	5/20/2021	Roots	50.00	Medium	ROOTS IN MANHOLE AND AT 12 FT
J11-3043-J11-3041	608437	7/6/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-3043-J11-3041	608437	7/6/2021	Obstruction or Intrusion	80.00	Minor	
G16-4036-G16-4033	610143	1/18/2023	Roots	50.00	Medium	
K18-3003-K18-3002	609356	5/5/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
K18-3003-K18-3002	609356	5/5/2022	Obstruction or Intrusion	80.00	Minor	
H16-2007-H16-2008	611009	12/13/2023	Roots	50.00	Medium	PRETTY HEAVY ROOTS IN THE DROP AT THE END OF THIS PIPE
H16-2007-H16-2008	611009	12/13/2023	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
D11-4057-D11-4056	609621	8/15/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
D11-4009-D11-4008	609728	9/29/2022	Break or Failure	30.00	Hole Soil Visible	
D11-4009-D11-4008	609728	9/29/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
D11-4009-D11-4008	609728	9/29/2022	Cracks or Fractures	60.00	Moderate Cracking	
K18-2012-K18-2011	609572	7/20/2022	Inflow and Infiltration	60.00	Running or Trickling	
L17-1058-L17-1056	609533	7/18/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
L17-1058-L17-1056	609533	7/18/2022	Belly or Sag	80.00	Minor (<10%)	
J16-4013-J16-4012	610921	11/29/2023	Cracks or Fractures	60.00	Moderate Cracking	
J16-4013-J16-4012	610921	11/29/2023	Roots	50.00	Medium	
H17-3072C-H17-3038	609059	2/14/2022	Obstruction or Intrusion	0.00	Severe or Impassable	
K18-1008-K18-1007	609593	7/27/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-4054-G16-4053	610150	1/19/2023	Roots	30.00	Heavy	G16-4053 HEAVY ROOTS IN MH
H16-3113-H16-3112	610760	9/11/2023	Belly or Sag	80.00	Minor (<10%)	
K18-3071-K18-3066	609099	3/1/2022	Obstruction or Intrusion	80.00	Minor	
H15-4016-H15-4013	610599	8/7/2023	Roots	50.00	Medium	IN STRUCTURE 4016, NEEDS ROOTX
G21-2014-G21-2002	609898	11/10/2022	Obstruction or Intrusion	60.00	Moderate	
G21-2014-G21-2002	609898	11/10/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
K19-4034C-K19-4030	609032	2/7/2022	Roots	80.00	Light	MINOR ROOT INTRUSION AT K19-4034C
G15-3042-G15-3014	610255	3/8/2023	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J16-1033-J16-1032	610618	8/8/2023	Roots	80.00	Light	ROOTS IN STRUCTURE/MANHOLE
K18-3016-K18-3106	609325	4/28/2022	Cracks or Fractures	60.00	Moderate Cracking	
K18-3016-K18-3106	609325	4/28/2022	Break or Failure	15.00	Hole Void Visible	
K18-3016-K18-3106	609325	4/28/2022	Belly or Sag	40.00	Severe (>30%)	
K18-3016-K18-3106	609325	4/28/2022	Worn Surface	60.00	Moderate	
K19-1008-K19-1007	609473	6/17/2022	Roots	30.00	Heavy	K19-1008 HEAVY ROOTS K19-1007 MEDIUM ROOTS
D10-1013-D10-1012	609699	9/13/2022	Belly or Sag	80.00	Minor (<10%)	
D10-1013-D10-1012	609699	9/13/2022	Inflow and Infiltration	60.00	Running or Trickling	
D23-2036-D23-2001	608190	5/4/2021	Cracks or Fractures	80.00	Minor Cracking	
H17-3037-H17-3030	611040	12/19/2023	Obstruction or Intrusion	0.00	Severe or Impassable	
H17-3037-H17-3030	611040	12/19/2023	Break or Failure	15.00	Hole Void Visible	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
H17-3037-H17-3030	611040	12/19/2023	Cracks or Fractures	60.00	Moderate Cracking	
H16-2023-H16-2021	611004	12/13/2023	Cracks or Fractures	60.00	Moderate Cracking	
H16-2023-H16-2021	611004	12/13/2023	Inflow and Infiltration	80.00	Weeping or Dripping	
CAP-K18-3094	609544	7/18/2022	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
L18-4060-L18-4001	608888	12/21/2021	Belly or Sag	80.00	Minor (<10%)	
J11-3045-J11-3043	608438	7/6/2021	Belly or Sag	80.00	Minor (<10%)	
J18-2015-K18-1020	609445	6/14/2022	Roots	50.00	Medium	K18-1020: ROOTS IN MH
J11-2017-J11-2014	608322	5/21/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
K18-4088-K18-4087	609301	4/25/2022	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
K18-4088-K18-4087	609301	4/25/2022	Belly or Sag	80.00	Minor (<10%)	
G21-2028-G21-2026	609872	11/7/2022	Belly or Sag	80.00	Minor (<10%)	
K20-4019-K20-4003	609374	5/24/2022	Roots	80.00	Light	K20-4019 ROOTS IN STRUCTURE
K19-1059-K19-1058	609244	4/13/2022	Roots	50.00	Medium	ROOTS IN UPSTREAM STRUCTURE K19-1059
K10-1021-K10-1019	608277	5/13/2021	Break or Failure	30.00	Hole Soil Visible	
K10-1021-K10-1019	608277	5/13/2021	Cracks or Fractures	60.00	Moderate Cracking	
G16-4111-G16-4107	610153	1/19/2023	Cracks or Fractures	80.00	Minor Cracking	
G16-3079-G16-3084	610308	3/23/2023	Roots	50.00	Medium	SIGNIFICANT ROOTS IN DOWNSTREAM STRUCTURE G16-3084
D10-2043-D10-2042	609506	7/6/2022	Belly or Sag	80.00	Minor (<10%)	
K18-1016-K18-1015	609450	6/15/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
L19-4012-L19-4011	609209	4/7/2022	Obstruction or Intrusion	60.00	Moderate	
E23-1007-E23-1006	608086	3/29/2021	Belly or Sag	80.00	Minor (<10%)	
E23-1007-E23-1006	608086	3/29/2021	Obstruction or Intrusion	60.00	Moderate	
J11-3016-J11-3015	608456	7/13/2021	Obstruction or Intrusion	80.00	Minor	
H16-2015-H16-2014	611026	12/14/2023	Cracks or Fractures	80.00	Minor Cracking	
H16-2015-H16-2014	611026	12/14/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
H16-2015-H16-2014	611026	12/14/2023	Roots	80.00	Light	H16-2014
K18-3012-K18-3011	609536	7/18/2022	Belly or Sag	40.00	Severe (>30%)	
J16-4009C-J16-4008	610929	12/1/2023	Cracks or Fractures	60.00	Moderate Cracking	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
J16-4009C-J16-4008	610929	12/1/2023	Roots	80.00	Light	IN JOINT AT MATERIAL CHANGE
K18-3057-K18-3056	608732	10/19/2021	Belly or Sag	80.00	Minor (<10%)	
K18-2003-K18-2002	609355	5/4/2022	Inflow and Infiltration	60.00	Running or Trickling	
K18-2003-K18-2002	609355	5/4/2022	Cracks or Fractures	80.00	Minor Cracking	
D11-4004-D11-4003	609737	10/4/2022	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
K18-3001-LS-1	609359	5/5/2022	Obstruction or Intrusion	0.00	Severe or Impassable	
K18-3001-LS-1	609359	5/5/2022	Inflow and Infiltration	60.00	Running or Trickling	
K18-3001-LS-1	609359	5/5/2022	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
J18-2088-J18-2008	608617	9/9/2021	Roots	50.00	Medium	J1802008 SECTION JOINT
J19-2068-K20-4012	608829	12/8/2021	Roots	50.00	Medium	ROOTS IN BOTH MANHOLE STRUCTURES
J18-2010-J18-2009	608615	9/9/2021	Roots	50.00	Medium	WALL AND SAND COLLAR OF J18-2009
J11-3072-J11-3069	608415	6/23/2021	Break or Failure	15.00	Hole Void Visible	
J11-3072-J11-3069	608415	6/23/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-3072-J11-3069	608415	6/23/2021	Belly or Sag	40.00	Severe (>30%)	
K18-3106-K18-3021	609396	6/6/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
K18-3106-K18-3021	609396	6/6/2022	Cracks or Fractures	40.00	Severe Cracking	
K18-3106-K18-3021	609396	6/6/2022	Worn Surface	60.00	Moderate	
K18-3106-K18-3021	609396	6/6/2022	Break or Failure	30.00	Hole Soil Visible	
K18-3106-K18-3021	609396	6/6/2022	Belly or Sag	40.00	Severe (>30%)	
K18-1012-K18-1011	609454	6/15/2022	Roots	80.00	Light	ROOTS IN STRUCTURE 1011
K10-1027-K10-1026	608270	5/12/2021	Cracks or Fractures	80.00	Minor Cracking	
K10-1027-K10-1026	608270	5/12/2021	Break or Failure	15.00	Hole Void Visible	
J20-2005-J20-2004	608799	11/15/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
H16-1036-H16-1035	610458	5/5/2023	Inflow and Infiltration	80.00	Weeping or Dripping	
H16-1036-H16-1035	610458	5/5/2023	Cracks or Fractures	40.00	Severe Cracking	
H16-1036-H16-1035	610458	5/5/2023	Roots	50.00	Medium	SOME ROOTS IN PIPE, SOME GROWING IN FROM LATERALS.
H16-1036-H16-1035	610458	5/5/2023	Break or Failure	15.00	Hole Void Visible	
G21-2029-G21-2028	609870	11/7/2022	Cracks or Fractures	80.00	Minor Cracking	
M18-4036-M18-4035	607872	1/6/2021	Belly or Sag	60.00	Moderate (10 to 30%)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
D23-2040-D23-2039	608180	5/3/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
D23-2040-D23-2039	608180	5/3/2021	Roots	80.00	Light	LIGHT ROOTS AT VARIOUS SPOTS @ LATS...RECOMMENDING ROOT TREATMENT
K10-1032-K10-1026	608254	5/11/2021	Cracks or Fractures	80.00	Minor Cracking	
L18-1050-L18-1049	610862	5/18/2022	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
L18-1050-L18-1049	610862	5/18/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
H16-2025-H16-2024	610996	12/12/2023	Inflow and Infiltration	40.00	Gushing or Spurting	
D24-3011-D24-3010	608013	3/5/2021	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
J11-4016-J11-4015	608401	6/22/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-4016-J11-4015	610745	9/7/2023	Roots	80.00	Light	
H16-4047-H16-4046	610313	3/23/2023	Roots	50.00	Medium	ROOTS IN UPSTREAM STRUCTURE H16-4047
F16-2021-F16-2020	610011	11/29/2022	Belly or Sag	80.00	Minor (<10%)	
L17-1029-L17-1028	608767	10/22/2021	Roots	30.00	Heavy	185.0
L17-1029-L17-1028	608767	10/22/2021	Cracks or Fractures	40.00	Severe Cracking	
D23-2072-D23-2071	608073	3/22/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
D23-2072-D23-2071	608073	3/22/2021	Lining or Repair Failure	80.00	Minor	
D10-2022-D10-2021	609588	7/26/2022	Roots	80.00	Light	light in structure D10-2021 ROOTX
J18-2004-J18-2003	608573	8/24/2021	Roots	50.00	Medium	J18-2004 ON WALLS
J18-2004-J18-2003	608573	8/24/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-4099-G16-4098	610154	1/25/2023	Roots	50.00	Medium	G16-4099
D23-2092-D23-2091	608058	3/18/2021	Obstruction or Intrusion	80.00	Minor	
K18-3070-K18-3023	609327	4/28/2022	Roots	80.00	Light	25' UP STREAM
K18-3070-K18-3023	609327	4/28/2022	Cracks or Fractures	60.00	Moderate Cracking	
K18-3018-K18-3017	609322	4/27/2022	Break or Failure	15.00	Hole Void Visible	
J11-2004-J11-2003	608495	7/21/2021	Worn Surface	60.00	Moderate	
J11-2004-J11-2003	608495	7/21/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
J11-2004-J11-2003	608495	7/21/2021	Lining or Repair Failure	80.00	Minor	
J18-2140-J18-2139	608582	8/25/2021	Roots	80.00	Light	WALL OF J18-2139
J11-4028-J11-4027T	608390	6/14/2021	Belly or Sag	60.00	Moderate (10 to 30%)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
J11-4028-J11-4027T	608390	6/14/2021	Obstruction or Intrusion	60.00	Moderate	
K18-4005-K18-4003	609266	4/18/2022	Inflow and Infiltration	60.00	Running or Trickling	
J11-2013C-J11-2012	608443	7/7/2021	Roots	80.00	Light	
J11-2013C-J11-2012	608443	7/7/2021	Cracks or Fractures	80.00	Minor Cracking	
K19-1004-K19-1087	608927	1/10/2022	Roots	80.00	Light	IN BOTH STRUCTURES
K18-2039-K18-2038	609335	5/2/2022	Cracks or Fractures	80.00	Minor Cracking	
J18-2016-J18-2087	609253	4/14/2022	Roots	80.00	Light	
H16-3033-H16-3032	610824	9/26/2023	Inflow and Infiltration	80.00	Weeping or Dripping	
J16-1047-J16-1046	610914	11/29/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-3038-G16-3037	610316	3/27/2023	Cracks or Fractures	80.00	Minor Cracking	
G15-2020-G15-2019	610392	4/12/2023	Roots	80.00	Light	
H15-2010-H15-2009	610853	10/3/2023	Roots	80.00	Light	H15-2009
G15-2013-G15-2012	610540	7/12/2023	Obstruction or Intrusion	0.00	Severe or Impassable	
H16-3034-H16-3033	610823	9/26/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
J18-2040-J18-2039	608595	8/26/2021	Roots	80.00	Light	J18-2040 FROM LIFTING HOLE OF CONE
J19-2087-J19-2034	609075	2/16/2022	Roots	50.00	Medium	J19-2034 IN STRUCTURE
G16-3039-G16-3038	610315	3/27/2023	Cracks or Fractures	80.00	Minor Cracking	
J20-3024-J20-3023	609047	2/10/2022	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J20-3024-J20-3023	609047	2/10/2022	Roots	50.00	Medium	J20-3024- ROOTS THROUGHOUT BOTTOM OF STRUCTURE
J16-1045-J16-4013	610918	11/29/2023	Roots	50.00	Medium	ROOTS IN PIPE CRACK ROOTS IN MYSTERY MANHOLE
J16-1045-J16-4013	610918	11/29/2023	Cracks or Fractures	60.00	Moderate Cracking	
J11-3096-J11-3041	608445	7/8/2021	Roots	80.00	Light	
J11-3096-J11-3041	608445	7/8/2021	Belly or Sag	80.00	Minor (<10%)	
J11-3018-J11-3014	608398	6/22/2021	Worn Surface	80.00	Minor	
J11-3018-J11-3014	608398	6/22/2021	Roots	80.00	Light	LIGHT ROOTS IN VARIOUS JOINTS...LOGGED IN ROOTS LIST FOR TREATMENT
J11-3018-J11-3014	608398	6/22/2021	Break or Failure	15.00	Hole Void Visible	
H17-3077-H17-3061	611083	12/27/2023	Roots	80.00	Light	H17-3061
J11-3037-J11-3036	608434	7/6/2021	Cracks or Fractures	80.00	Minor Cracking	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
J11-3037-J11-3036	608434	7/6/2021	Roots	50.00	Medium	AT VARIOUS JOINTS THROUGHOUT MAIN RUN....TRANSFERRED TO ROOTS LIST
J11-3037-J11-3036	608434	7/6/2021	Break or Failure	30.00	Hole Soil Visible	
D11-4001-D11-1002	609707	9/26/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
G16-3036-G16-3035	610413	4/21/2023	Break or Failure	30.00	Hole Soil Visible	
G16-3036-G16-3035	610413	4/21/2023	Cracks or Fractures	80.00	Minor Cracking	
G16-4109-G16-4108	610186	1/26/2023	Belly or Sag	80.00	Minor (<10%)	
J20-3035C-J20-3034	608831	12/8/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
H16-STUB-H16-1046	610481	5/15/2023	Belly or Sag	60.00	Moderate (10 to 30%)	
J11-3067-J11-3104	608430	7/1/2021	Belly or Sag	40.00	Severe (>30%)	
J20-3036-K20-4007	608813	11/22/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J19-2018-J19-2017	608918	1/6/2022	Roots	80.00	Light	IN J19-2017 STRUCTURE
G21-2036-G21-2028	609869	11/7/2022	Belly or Sag	80.00	Minor (<10%)	
D11-4058-D11-4057	609622	8/15/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
D11-4058-D11-4057	609622	8/15/2022	Roots	80.00	Light	D11-4058
J19-3050-J19-3049	609004	2/3/2022	Roots	80.00	Light	J19-3050 ROOTS IN STRUCTURE
K10-1030-K10-1029	608266	5/12/2021	Cracks or Fractures	80.00	Minor Cracking	
K10-1030-K10-1029	608266	5/12/2021	Break or Failure	15.00	Hole Void Visible	
K18-4054-K18-4053	609007	2/3/2022	Roots	80.00	Light	ROOTS IN STRUCTURE K18-4054
H17-3032-H17-3031	611050	12/19/2023	Break or Failure	15.00	Hole Void Visible	
H17-3032-H17-3031	611050	12/19/2023	Cracks or Fractures	60.00	Moderate Cracking	
K19-1055-K19-1002	608960	1/24/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
H17-3070-H17-3049	611054	12/19/2023	Cracks or Fractures	80.00	Minor Cracking	
G16-3071-G16-3070	610310	3/23/2023	Belly or Sag	80.00	Minor (<10%)	
G16-4088-G16-4084	610106	1/3/2023	Belly or Sag	60.00	Moderate (10 to 30%)	
J11-3111-J11-3110	608471	7/19/2021	Belly or Sag	80.00	Minor (<10%)	
K18-2009-K18-2008	609347	5/3/2022	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
H17-3028-H17-3027	611061	12/26/2023	Cracks or Fractures	80.00	Minor Cracking	
H15-1054-H15-1053	610574	8/1/2023	Cracks or Fractures	80.00	Minor Cracking	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
J11-2012-J11-2011	608319	5/20/2021	Roots	50.00	Medium	ROOTS IN ALMOST EVERY JOINT TREAT WHOLE LINE
J11-2012-J11-2011	608319	5/20/2021	Belly or Sag	80.00	Minor (<10%)	
J11-4015-J11-3078	608402	6/22/2021	Roots	80.00	Light	
J11-4015-J11-3078	608402	6/22/2021	Break or Failure	15.00	Hole Void Visible	
J11-4015-J11-3078	608402	6/22/2021	Worn Surface	80.00	Minor	
J11-4015-J11-3078	608402	6/22/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J11-4015-J11-3078	608402	6/22/2021	Belly or Sag	80.00	Minor (<10%)	
J11-4015-J11-3078	610744	9/7/2023	Roots	80.00	Light	
K19-1010-K19-1009	609471	6/17/2022	Break or Failure	15.00	Hole Void Visible	
K19-1010-K19-1009	609471	6/17/2022	Roots	80.00	Light	K19-1010 ROOTS IN MH
D11-1043-D11-4066	609667	9/1/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
J18-2048-J18-2047	608971	1/28/2022	Roots	50.00	Medium	IN DOWNSTREAM STRUCTURE J18-2047
B26-2029-B26-2028	610888	11/20/2023	Roots	80.00	Light	ROOTS IN INFLOW AND OUTFLOW OF BOTH MANHOLES
B26-2029-B26-2028	610888	11/20/2023	Inflow and Infiltration	60.00	Running or Trickling	
B26-2029-B26-2028	610888	11/20/2023	Obstruction or Intrusion	80.00	Minor	
C11-3003C-C11-3002	609825	10/19/2022	Cracks or Fractures	60.00	Moderate Cracking	
G16-1021-G16-1020	610452	5/3/2023	Roots	50.00	Medium	MAHOLE FULL OF ROOTS STARTING TO COME DOWN INTO CHANNLE
H17-3019-H17-3018	611070	12/26/2023	Roots	30.00	Heavy	IMPASSABLE BEFORE FLUSHING
H17-3031-H17-3030	611043	12/19/2023	Cracks or Fractures	60.00	Moderate Cracking	
H17-3031-H17-3030	611043	12/19/2023	Break or Failure	15.00	Hole Void Visible	
H17-3069-H17-3050	611052	12/19/2023	Cracks or Fractures	60.00	Moderate Cracking	
H17-3069-H17-3050	611052	12/19/2023	Break or Failure	30.00	Hole Soil Visible	
J11-4008-J11-4007	608375	6/8/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-4008-J11-4007	608375	6/8/2021	Roots	50.00	Medium	ROOTS IN ALMOST EVERY JOINT
J18-2023-J18-2022	609465	6/16/2022	Roots	80.00	Light	ROOTS IN LATERAL
G21-2016-G21-2014	609895	11/10/2022	Belly or Sag	80.00	Minor (<10%)	
G21-2016-G21-2014	609895	11/10/2022	Roots	80.00	Light	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
H21-4015-H21-4014	609921	11/16/2022	Lining or Repair Failure	80.00	Minor	
L17-1036-L17-1035	607890	1/11/2021	Break or Failure	30.00	Hole Soil Visible	
K19-1019-K19-1018	608922	1/10/2022	Roots	50.00	Medium	IN K19-1019 STRUCTURE
K19-1046-K19-1082	609400	6/6/2022	Lining or Repair Failure	80.00	Minor	
J16-4005-J16-4004	610936	12/1/2023	Cracks or Fractures	60.00	Moderate Cracking	
J16-4005-J16-4004	610936	12/1/2023	Roots	50.00	Medium	ROOTS THROUGHOUT
J16-4005-J16-4004	610936	12/1/2023	Break or Failure	15.00	Hole Void Visible	
L17-1027-L17-1026	607912	1/21/2021	Obstruction or Intrusion	0.00	Severe or Impassable	
L17-1027-L17-1026	607912	1/21/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
L17-1027-L17-1026	607912	1/21/2021	Break or Failure	15.00	Hole Void Visible	
L17-1027-L17-1026	607912	1/21/2021	Lining or Repair Failure	80.00	Minor	
D23-2070-D23-2069	608091	3/30/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
M18-3010-M18-2015	610238	3/2/2023	Belly or Sag	80.00	Minor (<10%)	
J20-2008-J20-2005	608798	11/15/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
J18-3107C-J18-3103	608659	9/27/2021	Obstruction or Intrusion	60.00	Moderate	
D23-2077-D23-2076	608083	3/24/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
J20-3025-J20-3024	608837	12/9/2021	Roots	50.00	Medium	ROOTS IN DOWNSTREAM MANHOLE STRUCTURE
G21-2019-G21-2018	609884	11/8/2022	Belly or Sag	80.00	Minor (<10%)	
K18-4031-K18-4030	609308	4/25/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
H15-1024-H15-1023	610353	4/3/2023	Roots	80.00	Light	H15-1023
J11-3075-J11-3074	608480	7/20/2021	Cracks or Fractures	80.00	Minor Cracking	
H16-1023-H16-1021	610473	5/11/2023	Inflow and Infiltration	80.00	Weeping or Dripping	
H16-1023-H16-1021	610473	5/11/2023	Belly or Sag	80.00	Minor (<10%)	
H16-1023-H16-1021	610473	5/11/2023	Obstruction or Intrusion	80.00	Minor	
D23-2082-D23-2081	608070	3/22/2021	Roots	80.00	Light	FOAMING SUGESTED @ 8'-15' FROM D23-2082
H16-1033-H16-1028	610369	4/5/2023	Cracks or Fractures	60.00	Moderate Cracking	
H16-1033-H16-1028	610369	4/5/2023	Roots	30.00	Heavy	BLOCKAGE CLEARED, STILL HEAVY ROOTS IN PIPE. HEAVY ROOTS IN SOME LATERALS
G16-1028-G16-1027	610488	5/30/2023	Belly or Sag	80.00	Minor (<10%)	
G15-3039-G15-3037	610261	3/9/2023	Roots	80.00	Light	G15-3039: ROOTS STARTING IN OUTFLOW SAND COLLAR

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
H16-2012-H16-2011	611002	12/13/2023	Obstruction or Intrusion	0.00	Severe or Impassable	
H16-2012-H16-2011	611002	12/13/2023	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
G16-1046-G16-1043	610202	1/27/2023	Belly or Sag	80.00	Minor (<10%)	
K18-3088-K18-3022	609330	4/28/2022	Cracks or Fractures	80.00	Minor Cracking	
K18-3027-K18-3026	609566	7/20/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
J11-3034-J11-3028	608380	6/9/2021	Worn Surface	60.00	Moderate	
J11-3034-J11-3028	608380	6/9/2021	Cracks or Fractures	80.00	Minor Cracking	
K19-4007-K19-4006	609044	2/10/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
K18-3002-K18-3001	609358	5/5/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
G16-4029-G16-4028	610116	1/11/2023	Roots	50.00	Medium	LATERAL JOINT NEAR DOWNSTREAM MH
G16-4029-G16-4028	610116	1/11/2023	Belly or Sag	80.00	Minor (<10%)	
J16-4002-J16-4001	610939	12/1/2023	Cracks or Fractures	60.00	Moderate Cracking	
J16-4002-J16-4001	610939	12/1/2023	Break or Failure	30.00	Hole Soil Visible	
J16-4002-J16-4001	610939	12/1/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
D23-2069-D23-2068	608092	3/30/2021	Cracks or Fractures	80.00	Minor Cracking	
J19-3110-J19-3109	607995	3/1/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
L17-1098-L17-1065	607960	2/4/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
H16-2042-H16-2041	610944	12/4/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
J11-2010-J11-2009	608489	7/21/2021	Break or Failure	15.00	Hole Void Visible	
J11-2010-J11-2009	608489	7/21/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
H17-3036-H17-3034	611042	12/19/2023	Break or Failure	15.00	Hole Void Visible	
H17-3036-H17-3034	611042	12/19/2023	Cracks or Fractures	60.00	Moderate Cracking	
L18-4038-L18-4036	607956	2/3/2021	Belly or Sag	80.00	Minor (<10%)	
J16-4001-LS-11	610941	12/4/2023	Cracks or Fractures	60.00	Moderate Cracking	
J16-4001-LS-11	610941	12/4/2023	Roots	80.00	Light	ROOTS INSIDE THE WETWELL
J16-4001-LS-11	610941	12/4/2023	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J11-4007-J11-4019	608376	6/8/2021	Break or Failure	15.00	Hole Void Visible	
J11-4007-J11-4019	608376	6/8/2021	Cracks or Fractures	80.00	Minor Cracking	
J19-3043-J19-3006	609023	2/7/2022	Belly or Sag	80.00	Minor (<10%)	
D11-4059-D11-4058	609620	8/15/2022	Roots	80.00	Light	D11-4058
D11-4059-D11-4058	609620	8/15/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
J11-3098-J11-3019	608393	6/17/2021	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
D11-4003-D11-4002	610288	3/21/2023	Obstruction or Intrusion	80.00	Minor	
J11-3038-J11-3037	608433	7/6/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-3038-J11-3037	608433	7/6/2021	Worn Surface	80.00	Minor	
J11-4025-J11-4024	608468	7/19/2021	Belly or Sag	80.00	Minor (<10%)	
J18-3017-J18-3016	608676	9/28/2021	Roots	50.00	Medium	ROOTS AT LATERAL CONNECTION POINT IN MAIN @81' NO BLOCKAGES
J11-4013-J11-4012	608408	6/23/2021	Roots	80.00	Light	
J11-4013-J11-4012	608408	6/23/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-4020-J11-4021	608475	7/20/2021	Belly or Sag	80.00	Minor (<10%)	
J18-3152C-J18-3150	608624	9/14/2021	Obstruction or Intrusion	60.00	Moderate	
D23-2071-D23-2049	608128	4/8/2021	Roots	50.00	Medium	D23-2071 ROOTS IN THE PIPE AT 233 FROM UPPER M/H
K20-4013-K20-4002	609373	5/24/2022	Roots	50.00	Medium	ROOTS IN BOTH MANHOLES
J19-2034-J19-2029	609077	2/17/2022	Roots	50.00	Medium	ROOTS IN UPSTREAM STRUCTURE J19-2034
K19-1005-K19-1004	609120	3/9/2022	Roots	80.00	Light	ROOTS IN DOWNSTREAM STRUCTURE K19-1004
K19-4002-K19-4001	609114	3/3/2022	Belly or Sag	80.00	Minor (<10%)	
K19-1021-K19-1020	609071	2/16/2022	Roots	80.00	Light	K19-1020- ROOTS IN STRUCTURE
J11-2029-J11-2028	608459	7/14/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
D23-2085-D23-2083	608067	3/22/2021	Inflow and Infiltration	60.00	Running or Trickling	
D23-2085-D23-2083	608067	3/22/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
K18-3042-K18-3035	608880	12/21/2021	Belly or Sag	80.00	Minor (<10%)	
K10-1008-K10-1074	608315	5/19/2021	Roots	30.00	Heavy	K10-1008-K10-1074 ROOTS THE THE TOP OF THE PIPE 3 FT IN, ROOTS AT 29FT, ROOTS AT 48 FT, 75 FT, 79 FT, 84 FT
D23-3041-D23-3040	608194	5/4/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
D10-1030-D10-1029	609625	8/15/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
D10-2048-D10-2047	609504	7/6/2022	Roots	80.00	Light	D10-2048 D10-2047
K10-1020-K10-1019	608274	5/13/2021	Break or Failure	15.00	Hole Void Visible	
K10-1020-K10-1019	608274	5/13/2021	Roots	50.00	Medium	AT 45'

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
G16-4053-G16-4036	610139	1/18/2023	Roots	30.00	Heavy	HEAVY ROOTS IN UPSTREAM MH G16-4053 NEAR BLOCKAGE IN CHANEL
D11-1028-C11-2002	609790	10/12/2022	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
D11-1028-C11-2002	609790	10/12/2022	Worn Surface	60.00	Moderate	
D11-1028-C11-2002	609790	10/12/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
H15-4037-H15-4036	610512	6/29/2023	Belly or Sag	60.00	Moderate (10 to 30%)	
H16-1031-H16-1030	610389	4/10/2023	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
J11-3095-J11-3036	608455	7/13/2021	Roots	50.00	Medium	MANY MANY JOINTS
J19-2004-J19-2003	608610	8/30/2021	Worn Surface	80.00	Minor	
J11-3104-J11-3066	608440	7/6/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
L17-1086-L17-1017	607889	1/11/2021	Lining or Repair Failure	80.00	Minor	
L17-1086-L17-1017	607889	1/11/2021	Roots	50.00	Medium	ROOTS IN JOINTS AND CRACKS MULTIPLE AREAS 82FT 98 FT AND 103 FT
L17-1086-L17-1017	607889	1/11/2021	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
L17-1086-L17-1017	607889	1/11/2021	Cracks or Fractures	80.00	Minor Cracking	
L17-1086-L17-1017	607889	1/11/2021	Belly or Sag	80.00	Minor (<10%)	
J19-3004-J19-3003	608545	8/12/2021	Roots	80.00	Light	D9 @ 210 SIDESEWER
K18-4086-K18-4039	609303	4/25/2022	Roots	80.00	Light	K18-4039 ROOTS IN STRUCTURE
K18-4086-K18-4039	609303	4/25/2022	Cracks or Fractures	60.00	Moderate Cracking	
K19-4021-K19-1010	609474	6/17/2022	Obstruction or Intrusion	0.00	Severe or Impassable	
E23-1012-E23-1011	608098	3/31/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
G16-3012-G16-3011	610279	3/13/2023	Roots	30.00	Heavy	STRUCTURE
J11-3CAP-J11-3071	608424	7/1/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
H15-4034-H15-4003	610515	6/29/2023	Belly or Sag	80.00	Minor (<10%)	
B26-2030-B26-2029	610887	11/20/2023	Roots	80.00	Light	B26-2029- ROOTS ABOVE INFLOW
B26-2030-B26-2029	610887	11/20/2023	Obstruction or Intrusion	80.00	Minor	
J16-4014-J16-4013	610920	11/29/2023	Break or Failure	30.00	Hole Soil Visible	
J16-4014-J16-4013	610920	11/29/2023	Cracks or Fractures	60.00	Moderate Cracking	
K19-1062-K19-1061	609246	4/13/2022	Roots	80.00	Light	IN UPSTREAM STRUCTURE K19-1062

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
L18-4004-K18-3032	609292	4/22/2022	Belly or Sag	80.00	Minor (<10%)	
L18-4004-K18-3032	609292	4/22/2022	Inflow and Infiltration	60.00	Running or Trickling	
L18-4004-K18-3032	609292	4/22/2022	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
G21-2015-G21-2014	609897	11/10/2022	Obstruction or Intrusion	60.00	Moderate	
G21-2015-G21-2014	609897	11/10/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
K18-4056-K18-4054	609094	3/1/2022	Roots	80.00	Light	IN K18-4054 STRUCTURE
J16-1011-J16-1010	610705	8/22/2023	Belly or Sag	80.00	Minor (<10%)	
G15-3012-G15-3050	610465	3/8/2023	Roots	30.00	Heavy	ROOTS IN BOTH MANHOLES, SEVERE IN G15-3012.
K18-3094-K18-3005	609545	7/18/2022	Break or Failure	15.00	Hole Void Visible	
K18-3094-K18-3005	609545	7/18/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
K20-4006-K20-4005	608807	11/17/2021	Roots	80.00	Light	ROOTS IN DOWNSTREAM MANHOLE STRUCTURE
L17-1011-L17-1009	608729	10/18/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
L17-1011-L17-1009	608729	10/18/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
D10-2049-D10-2048	609481	6/22/2022	Roots	80.00	Light	D10-2048
D10-2049-D10-2048	609481	6/22/2022	Belly or Sag	80.00	Minor (<10%)	
K18-3108-L18-4036	607957	2/3/2021	Belly or Sag	80.00	Minor (<10%)	
F16-4002-F16-4006	609987	11/28/2022	Roots	80.00	Light	IN UPSTREAM SAND COLLAR
G16-4026-G16-4018	610120	1/11/2023	Cracks or Fractures	60.00	Moderate Cracking	
G16-4026-G16-4018	610120	1/11/2023	Roots	80.00	Light	ROOTS IN LATERAL
D23-2034-D23-2033	608117	4/7/2021	Roots	50.00	Medium	ROOTS AT 133FT FROM BOTTOM M/H
J11-3049-J11-3108	608391	6/17/2021	Roots	80.00	Light	ROOTS IN JOINTS 130'-140'
J11-3049-J11-3108	608391	6/17/2021	Cracks or Fractures	80.00	Minor Cracking	
G21-2009-G21-2008	609889	11/9/2022	Belly or Sag	80.00	Minor (<10%)	
G16-4063-G16-4061	610094	12/28/2022	Obstruction or Intrusion	80.00	Minor	
L17-1042C-L17-1041	607920	1/21/2021	Cracks or Fractures	80.00	Minor Cracking	
L17-1042C-L17-1041	607920	1/21/2021	Roots	50.00	Medium	ROOTS IN THE FIRST 50 FEET
L17-1042C-L17-1041	607920	1/21/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
L18-4006-L18-4005	608892	12/23/2021	Belly or Sag	80.00	Minor (<10%)	
L17-1060-L17-1059	609432	6/13/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
H16-2093C-H16-2017	611028	12/18/2023	Lining or Repair Failure	80.00	Minor	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
H16-2093C-H16-2017	611028	12/18/2023	Cracks or Fractures	60.00	Moderate Cracking	
H16-2093C-H16-2017	611028	12/18/2023	Break or Failure	15.00	Hole Void Visible	
D23-2068-D23-2067	608093	3/30/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
H16-3104-H16-3094	610792	9/18/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
J18-3057-J18-3056	609362	5/6/2022	Roots	50.00	Medium	J18-3057 ROOTS IN MANHOLE
G16-4005-LS-8	609053	2/11/2022	Roots	50.00	Medium	ROOTS IN JOINT AT 62 FEET
G16-4005-LS-8	610157	1/25/2023	Roots	80.00	Light	
G16-4005-LS-8	610157	1/25/2023	Obstruction or Intrusion	60.00	Moderate	
K18-1032-K18-1025	609273	4/19/2022	Obstruction or Intrusion	60.00	Moderate	
K18-1032-K18-1025	609273	4/19/2022	Cracks or Fractures	40.00	Severe Cracking	
K18-1032-K18-1025	609273	4/19/2022	Break or Failure	30.00	Hole Soil Visible	
K18-2013-K18-2012	609573	7/20/2022	Inflow and Infiltration	60.00	Running or Trickling	
K18-3048-K18-3049	609529	7/17/2022	Inflow and Infiltration	40.00	Gushing or Spurting	
D23-3034-D23-3033	608222	5/6/2021	Inflow and Infiltration	60.00	Running or Trickling	
H16-2009-H16-2010	611011	12/13/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
D23-2090-D23-2085	608066	3/22/2021	Obstruction or Intrusion	80.00	Minor	
D23-2090-D23-2085	608066	3/22/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
L17-1004-L17-1003	608726	10/18/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
G16-4003-G16-4005	609052	2/11/2022	Roots	80.00	Light	ROOTS BEGINNING TO FORM IN 2 LATERALS
K10-1023-K10-1020	608273	5/13/2021	Roots	80.00	Light	LIGHT ROOTS @112.3'
K10-1023-K10-1020	608273	5/13/2021	Cracks or Fractures	60.00	Moderate Cracking	
K18-2007-K18-2006	609571	7/20/2022	Inflow and Infiltration	60.00	Running or Trickling	
K18-3089-K18-3026	609105	3/1/2022	Roots	80.00	Light	IN K18-3089 SAND COLLAR JOINT
K18-3089-K18-3026	609105	3/1/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
J11-3103-J11-3061	608419	6/28/2021	Roots	50.00	Medium	
J16-1032-J16-1031	610615	8/8/2023	Roots	80.00	Light	ROOTS IN STRUCTURE/MANHOLE J16-1032
L17-1009-L17-1005	608727	10/18/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
L17-1009-L17-1005	608727	10/18/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
H16-4004-H16-4003	610347	3/29/2023	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
L18-4036-L18-4037	607958	2/3/2021	Inflow and Infiltration	60.00	Running or Trickling	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
B26-2035-B26-2034	610882	11/20/2023	Obstruction or Intrusion	80.00	Minor	
H16-2022-H16-2021	610994	12/12/2023	Inflow and Infiltration	60.00	Running or Trickling	
H16-2022-H16-2021	610994	12/12/2023	Cracks or Fractures	40.00	Severe Cracking	
H16-2022-H16-2021	610994	12/12/2023	Break or Failure	15.00	Hole Void Visible	
K19-1013-K19-1004	608926	1/10/2022	Roots	80.00	Light	IN K19-1004 STRUCTURE
J11-3040-J11-3039	608431	7/1/2021	Cracks or Fractures	80.00	Minor Cracking	
D11-1009-D11-1008	609734	10/4/2022	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
D11-1009-D11-1008	609734	10/4/2022	Belly or Sag	80.00	Minor (<10%)	
J16-1058-J16-1056	610902	11/28/2023	Belly or Sag	80.00	Minor (<10%)	
J11-3052-J11-3099	608387	6/10/2021	Roots	80.00	Light	
G15-2010-G15-2009	610546	7/12/2023	Obstruction or Intrusion	0.00	Severe or Impassable	
J11-4017-J11-4010	608412	6/23/2021	Cracks or Fractures	80.00	Minor Cracking	
G15-3056-G15-3003	610522	7/10/2023	Obstruction or Intrusion	60.00	Moderate	
D23-2118-D23-2117	608077	3/24/2021	Roots	80.00	Light	FINE ROOTS AT JOINT
D23-2001-D23-1002	608191	5/4/2021	Cracks or Fractures	80.00	Minor Cracking	
J18-3037-J18-3030	608265	5/12/2021	Roots	80.00	Light	ROOTS IN STRUCTURE J18-3037,
D11-4040-D11-4039	609518	7/14/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
H17-3042-H17-3041	611058	12/20/2023	Cracks or Fractures	80.00	Minor Cracking	
G15-3050-G15-3011	610263	3/8/2023	Roots	80.00	Light	ROOTS IN PIPE JOINT, NEEDS FOAMED
B26-2033-B26-2032	610884	11/20/2023	Obstruction or Intrusion	80.00	Minor	
L17-1024-L17-1023	607901	1/12/2021	Roots	80.00	Light	ROOTBALL IN THE BOTTOM OF MANHOLE L17-1023
D11-4023-D11-4022	609697	9/12/2022	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
L16-2024-L16-2022	609793	10/13/2022	Belly or Sag	80.00	Minor (<10%)	
J11-3088C-J11-3084	608444	7/7/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
J11-3088C-J11-3084	608444	7/7/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-3088C-J11-3084	608444	7/7/2021	Obstruction or Intrusion	80.00	Minor	
J16-1025-J16-1022	610624	8/9/2023	Roots	80.00	Light	ROOTS IN STRUCTURE/MANHOLE 1022
L14-3005-LS-14	607924	1/27/2021	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
L14-3005-LS-14	607924	1/27/2021	Lining or Repair Failure	40.00	Severe	
D10-1014-D10-1013	609700	9/13/2022	Obstruction or Intrusion	80.00	Minor	
D10-1014-D10-1013	609700	9/13/2022	Inflow and Infiltration	60.00	Running or Trickling	
J18-3014-J18-3013	608692	9/30/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
H15-4017-H15-4016	610601	8/7/2023	Roots	50.00	Medium	IN STRUCTURE 4016
D23-2044-D23-2043	608174	4/28/2021	Cracks or Fractures	80.00	Minor Cracking	
D23-2044-D23-2043	608174	4/28/2021	Roots	80.00	Light	REFER TO ROOTS LIST FOR FOOTAGES...LIGHT ROOTS AT VARIOUS SPOTS THROUGHOUT PIPE
D23-3040-D23-3038	608195	5/4/2021	Belly or Sag	80.00	Minor (<10%)	
H16-3016-H16-3013	610840	9/28/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
K10-1019-K10-1044	608275	5/13/2021	Cracks or Fractures	80.00	Minor Cracking	
K18-4006-K18-4005	609265	4/18/2022	Inflow and Infiltration	60.00	Running or Trickling	
E23-1005-E23-1004	608088	3/29/2021	Roots	50.00	Medium	E23-1004 @ SAND COLLAR
G16-4027-G16-4026	610119	1/11/2023	Cracks or Fractures	60.00	Moderate Cracking	
G16-4027-G16-4026	610119	1/11/2023	Roots	50.00	Medium	MINOR ROOTS THROUGHOUT
G16-4027-G16-4026	610119	1/11/2023	Obstruction or Intrusion	80.00	Minor	
D11-4035-D11-4034	609808	10/18/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
J11-3069-J11-3067	608429	7/1/2021	Belly or Sag	40.00	Severe (>30%)	
J11-3069-J11-3067	610185	1/26/2023	Break or Failure	30.00	Hole Soil Visible	
J11-3069-J11-3067	610185	1/26/2023	Belly or Sag	80.00	Minor (<10%)	
J11-3069-J11-3067	610185	1/26/2023	Inflow and Infiltration	60.00	Running or Trickling	
G21-2031-G21-2007	609887	11/9/2022	Belly or Sag	80.00	Minor (<10%)	
M17-1011-M18-4061	608974	1/28/2022	Inflow and Infiltration	60.00	Running or Trickling	
L17-1041-L17-1092	607919	1/21/2021	Roots	50.00	Medium	ROOTS IN THE JOINTS AND SAND COLLARS LINE IS ONLY 10 FEET LONG
H16-2118-H16-2117	610957	12/5/2023	Roots	80.00	Light	ROOTS IN UPSTREAM MH H16-2118C
K18-3023-K18-3086	609328	4/28/2022	Cracks or Fractures	60.00	Moderate Cracking	
K18-3023-K18-3086	609328	4/28/2022	Roots	50.00	Medium	
J20-2003-J20-2002	609050	2/10/2022	Obstruction or Intrusion	0.00	Severe or Impassable	
J20-2003-J20-2002	609050	2/10/2022	Cracks or Fractures	40.00	Severe Cracking	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
H16-2024-H16-2023	610997	12/12/2023	Worn Surface	80.00	Minor	
D23-2064-D23-2063	608096	3/30/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
J11-2005-J11-2004	608494	7/21/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
L16-2016-L16-2015	609801	10/13/2022	Roots	50.00	Medium	ROOTS IN UPSTREAM MH L16-2016
K19-1040-K19-1039	609409	6/7/2022	Roots	80.00	Light	K19-1039 ROOTS IN MANHOLE
D23-1022-D23-1021	608148	4/14/2021	Roots	0.00	Blockage	109 FROM UPPER MANHOLE CANNOT CONTINUE TOOTS TO HEAVY TO GET PAST
J11-2040-J11-2004	608534	8/5/2021	Cracks or Fractures	80.00	Minor Cracking	
K18-4075C-K18-4074	609350	5/4/2022	Roots	80.00	Light	ROOT INTRUSION STARTING IN CLEANOUT
K18-2040-K18-2036	609337	5/2/2022	Cracks or Fractures	80.00	Minor Cracking	
J18-2065-J18-2064	608648	9/23/2021	Roots	50.00	Medium	IN STRUCTURE J18-2064
J18-2065-J18-2064	608648	9/23/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
K19-1043-K19-1039	609406	6/6/2022	Roots	80.00	Light	IN STRUCTURE K19-1039
J11-3055-J11-3054	608422	6/28/2021	Roots	50.00	Medium	ROOTS THROUGH OUT LINE
L17-1005-L17-1004	608724	10/18/2021	Belly or Sag	80.00	Minor (<10%)	
L17-1005-L17-1004	608724	10/18/2021	Inflow and Infiltration	60.00	Running or Trickling	
K18-4039-K18-4038	609305	4/25/2022	Roots	80.00	Light	K18-4039: ROOTS IN STRUCTURE
K19-1009-K19-1008	609472	6/17/2022	Obstruction or Intrusion	80.00	Minor	
K19-1009-K19-1008	609472	6/17/2022	Roots	30.00	Heavy	K19-1008
H17-3061-H17-3060	611084	12/27/2023	Roots	80.00	Light	H17-3060
G16-1072-G16-1007	610632	8/10/2023	Belly or Sag	80.00	Minor (<10%)	
D23-2056-D23-2055	608142	4/12/2021	Belly or Sag	80.00	Minor (<10%)	
D23-2056-D23-2055	608142	4/12/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
L17-1089C-L17-1086	607888	1/11/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
J18-3055-J18-3054	609364	5/6/2022	Roots	50.00	Medium	J18-3054 ROOTS IN STRUCTURE
D23-1012-D23-1011	608149	4/15/2021	Roots	50.00	Medium	D23-1012-D23-1011 283 FROM LOWER M/H ROOTS IN THE JOINT
D11-4068-D11-4067	609716	9/27/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
K10-1028-K10-1027	608269	5/12/2021	Roots	80.00	Light	IN MAIN/LATERAL 60'-75'

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
K10-1028-K10-1027	608269	5/12/2021	Cracks or Fractures	80.00	Minor Cracking	
K18-2113-K18-2108	609232	4/11/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
K18-2113-K18-2108	609232	4/11/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
H15-1034-LS-69	610592	8/3/2023	Roots	80.00	Light	IN INSERT A TEE JOINT
G16-3009-G16-3008	610278	3/13/2023	Lining or Repair Failure	80.00	Minor	
M18-4026-M18-4025	607869	1/4/2021	Roots	30.00	Heavy	HEAVY ROOTS IN MANHOLE M18-4027
G16-3095-G16-3001	609868	11/7/2022	Belly or Sag	80.00	Minor (<10%)	
J19-2082-J19-2041	607944	2/2/2021	Roots	50.00	Medium	ROOTS IN MANHOLE J19-2082
J20-3021-K20-4007	609366	5/16/2022	Roots	30.00	Heavy	J20-3021: ROOTS IN STRUCTURE
K10-1052C-K10-1051	608282	5/17/2021	Roots	80.00	Light	SMALL ROOT IN THE LATERA CONNECTION AT 45 FT
H17-3074C-H17-3033	611048	12/19/2023	Cracks or Fractures	80.00	Minor Cracking	
G16-1039-G16-1038	610397	4/19/2023	Belly or Sag	80.00	Minor (<10%)	
E23-1008-E23-1003	608069	3/22/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
D23-1009-D23-1008	608158	4/21/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
G21-2033-G21-2007	609886	11/9/2022	Roots	30.00	Heavy	HEAVY ROOTS IN THE LATERAL AT THE TOP END OF PIPE
G16-3084-G16-3078	610409	4/20/2023	Roots	50.00	Medium	ROOTS IN UPSTREAM MH G16-3084
J16-1014-J16-1013	610692	8/21/2023	Belly or Sag	40.00	Severe (>30%)	
J19-3052-J19-3051	609001	2/2/2022	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
H16-1066-H16-1065	610463	5/8/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
H17-3033-H17-3032	611049	12/19/2023	Cracks or Fractures	80.00	Minor Cracking	
J18-3038-J18-3037	608207	5/5/2021	Roots	80.00	Light	IN STRUCTURE J18-3038 AND 3037 ROOT X
D23-2123-D23-2122	608025	3/9/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
J11-3032-J11-3031	608442	7/6/2021	Roots	80.00	Light	ON ROOTS LIST
K18-2020-K18-3041	608851	12/15/2021	Belly or Sag	80.00	Minor (<10%)	
G16-4006-G16-4005	610871	5/17/2022	Cracks or Fractures	60.00	Moderate Cracking	
G16-4006-G16-4005	610135	1/17/2023	Cracks or Fractures	60.00	Moderate Cracking	
M18-4002-M18-4001	607881	1/6/2021	Inflow and Infiltration	40.00	Gushing or Spurting	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
H15-4009-H15-4008	610593	8/3/2023	Cracks or Fractures	80.00	Minor Cracking	
D10-2027-D10-2016	609521	7/14/2022	Cracks or Fractures	80.00	Minor Cracking	
D10-2027-D10-2016	609521	7/14/2022	Belly or Sag	80.00	Minor (<10%)	
K19-1027-K19-1026	608901	12/23/2021	Roots	80.00	Light	IN UPSTREAM MH
L17-1061-L17-1060	609431	6/13/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
J19-2007-J19-2006	609477	6/17/2022	Roots	80.00	Light	J19-2007
J19-2007-J19-2006	609477	6/17/2022	Belly or Sag	80.00	Minor (<10%)	
H15-4012-H15-4007	610604	8/7/2023	Roots	50.00	Medium	IN STRUCTURE 4007
K19-1007-K19-1006	609122	3/9/2022	Roots	50.00	Medium	ROOTS IN DOWNSTREAM STRUCTURE K19-1006
D23-1002-D23-1001	608192	5/4/2021	Cracks or Fractures	80.00	Minor Cracking	
J18-2118-J18-2117	608567	8/18/2021	Roots	80.00	Light	WALL OF J18-2117
G16-4011-G16-4010	610131	1/17/2023	Roots	30.00	Heavy	G16-4011: ROOTS IN STRUCTURE CAUSING I&I
G16-4011-G16-4010	610131	1/17/2023	Inflow and Infiltration	80.00	Weeping or Dripping	
H16-1005-H16-1004	610283	3/16/2023	Inflow and Infiltration	60.00	Running or Trickling	
G15-3051-G15-3013	610257	3/8/2023	Roots	80.00	Light	COMING FROM BEHIND LADDER
D11-1011-D11-1008	609733	10/3/2022	Roots	80.00	Light	ROOTS IN LAST 15-20 FEET OF PIPE DOWNSTREAM
G16-1038-G16-1037	610398	4/19/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-1038-G16-1037	610398	4/19/2023	Belly or Sag	80.00	Minor (<10%)	
J19-2017-J19-2015	608847	12/9/2021	Roots	80.00	Light	IN STRUCTURE
J16-1076-J16-1075	610865	10/24/2023	Worn Surface	80.00	Minor	
J19-2079-J19-2012	607939	2/1/2021	Break or Failure	30.00	Hole Soil Visible	
K10-1022-K10-1020	608276	5/13/2021	Roots	50.00	Medium	@49.8' @170.9'
K10-1022-K10-1020	608276	5/13/2021	Cracks or Fractures	80.00	Minor Cracking	
J18-2035C-J18-2034	608593	8/26/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
H16-3011-H16-3010	610838	9/28/2023	Belly or Sag	40.00	Severe (>30%)	
H16-3011-H16-3010	610838	9/28/2023	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
K18-2046-K18-2045	609345	5/3/2022	Roots	80.00	Light	K18-2045: ROOTS IN STRUCTURE
D23-2119-D23-2118	608023	3/9/2021	Cracks or Fractures	40.00	Severe Cracking	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
D23-2119-D23-2118	608023	3/9/2021	Break or Failure	0.00	Collapse	
H17-3034-H17-3030	611041	12/19/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
H17-3034-H17-3030	611041	12/19/2023	Cracks or Fractures	80.00	Minor Cracking	
H17-3034-H17-3030	611041	12/19/2023	Break or Failure	30.00	Hole Soil Visible	
J11-2018-J11-2017	608463	7/14/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
J18-3039-J18-3038	608206	5/5/2021	Belly or Sag	80.00	Minor (<10%)	
J18-3099-J18-3098	608705	9/30/2021	Break or Failure	15.00	Hole Void Visible	
J18-3099-J18-3098	608705	9/30/2021	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
D11-4029-D11-4028	609641	8/29/2022	Cracks or Fractures	80.00	Minor Cracking	
D11-4029-D11-4028	609641	8/29/2022	Inflow and Infiltration	80.00	Weeping or Dripping	
J11-3017-J11-3015	608532	8/5/2021	Obstruction or Intrusion	80.00	Minor	
J11-3017-J11-3015	608532	8/5/2021	Cracks or Fractures	80.00	Minor Cracking	
K10-1070-K10-1022	608318	5/20/2021	Roots	80.00	Light	ROOTS AT 80.4 IN LATERAL
E23-1004-D23-2071	608089	3/30/2021	Worn Surface	60.00	Moderate	
E23-1004-D23-2071	608089	3/30/2021	Cracks or Fractures	60.00	Moderate Cracking	
J16-1075-J16-1074	610868	10/25/2023	Roots	80.00	Light	J16-1075 ROOTS STARTING IN STRUCTURE WALL
L16-2022-L16-2021	609795	10/13/2022	Belly or Sag	80.00	Minor (<10%)	
K19-1014-K19-1013	608925	1/10/2022	Roots	80.00	Light	IN K19-1013 STRUCTURE
G16-4055-G16-4054	610149	1/19/2023	Roots	80.00	Light	G16-4054: ROOTS IN MH
D11-1014-D11-1013	609776	10/11/2022	Roots	50.00	Medium	ROOTS IN UPSTREAM STRUCTURE D11-1014 AND LATERAL THAT TIES IN
D10-2042-LS-49	609597	7/14/2022	Belly or Sag	80.00	Minor (<10%)	
G16-3018-G16-3017	610528	7/11/2023	Worn Surface	80.00	Minor	
G16-3073-G16-3078	610276	3/13/2023	Inflow and Infiltration	80.00	Weeping or Dripping	
D23-2091-D23-2090	608059	3/18/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
K18-4022-K18-4021	609313	4/26/2022	Cracks or Fractures	80.00	Minor Cracking	
K19-1022-K19-1018	608921	1/10/2022	Roots	50.00	Medium	IN K19-1022 STRUCTURE AND ENTERING PIPE
D11-4034-D11-4024	609809	10/18/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
G21-2004-G21-2002	609894	11/10/2022	Belly or Sag	80.00	Minor (<10%)	
G21-2004-G21-2002	609894	11/10/2022	Cracks or Fractures	80.00	Minor Cracking	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
J18-2012-J18-2011	608556	8/16/2021	Roots	80.00	Light	J18-2011 WALL AND SAND COLLAR
D23-2076-D23-2075	608084	3/24/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
J11-4022-J11-4023	608466	7/19/2021	Belly or Sag	80.00	Minor (<10%)	
G16-4072-G16-4071	610060	12/8/2022	Inflow and Infiltration	60.00	Running or Trickling	
G16-4062-G16-4061	610092	12/28/2022	Cracks or Fractures	80.00	Minor Cracking	
G21-2026-G21-2018	609873	11/7/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
K18-3036-K18-3035	608881	12/21/2021	Belly or Sag	80.00	Minor (<10%)	
D23-2015-D23-2013	608159	4/21/2021	Cracks or Fractures	80.00	Minor Cracking	
D23-2118-D23-2152	608037	3/11/2021	Cracks or Fractures	80.00	Minor Cracking	
D23-2118-D23-2152	608037	3/11/2021	Roots	80.00	Light	LIGHT ROOTS AT LATERAL
K10-1035-K10-1034	608249	5/11/2021	Belly or Sag	80.00	Minor (<10%)	
J18-3030-J18-3029	608241	5/10/2021	Roots	80.00	Light	AT OUT FLOW OF J18-3030
J16-1004-J16-1001	610852	10/3/2023	Roots	50.00	Medium	ROOTS IN J16-1001
H16-2092C-H16-2022	610993	12/12/2023	Roots	80.00	Light	
H16-2092C-H16-2022	610993	12/12/2023	Break or Failure	30.00	Hole Soil Visible	
H16-2092C-H16-2022	610993	12/12/2023	Cracks or Fractures	60.00	Moderate Cracking	
J19-2008-J19-2004	608611	8/30/2021	Worn Surface	80.00	Minor	
J16-4003-J16-4002	610938	12/1/2023	Cracks or Fractures	80.00	Minor Cracking	
J16-4003-J16-4002	610938	12/1/2023	Roots	80.00	Light	
K19-1057-K19-1056	608958	1/24/2022	Inflow and Infiltration	60.00	Running or Trickling	
J11-4014-J11-4018	608407	6/23/2021	Cracks or Fractures	80.00	Minor Cracking	
K18-2035-K18-2011	609338	5/2/2022	Inflow and Infiltration	40.00	Gushing or Spurting	
H17-3038-H17-3037	611039	12/18/2023	Break or Failure	30.00	Hole Soil Visible	
H17-3038-H17-3037	611039	12/18/2023	Cracks or Fractures	60.00	Moderate Cracking	
J11-3015-J11-3094	608400	6/22/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-3015-J11-3094	608400	6/22/2021	Break or Failure	30.00	Hole Soil Visible	
B26-2048-B26-2047	610880	11/16/2023	Break or Failure	0.00	Collapse	
K18-3030-K18-3028	609564	7/19/2022	Inflow and Infiltration	60.00	Running or Trickling	
D23-2010-D23-2009	608218	5/6/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
J11-4009-J11-4008	608389	6/14/2021	Roots	50.00	Medium	ROOTS MAINLY TO 60 FT IN
J11-3059-J11-3101	608385	6/10/2021	Roots	80.00	Light	@ JOINTS @ 41', 55', 65'
G16-1047-G16-1046	610200	1/27/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
D23-2047-D23-2046	608177	4/28/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
D23-2047-D23-2046	608177	4/28/2021	Cracks or Fractures	80.00	Minor Cracking	
G21-2020-G21-2019	608052	3/16/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
G21-2020-G21-2019	609883	11/8/2022	Belly or Sag	80.00	Minor (<10%)	
G16-2035-G16-2019	610500	5/31/2023	Belly or Sag	60.00	Moderate (10 to 30%)	
K10-1039-K10-1033	608251	5/11/2021	Roots	50.00	Medium	
K10-1039-K10-1033	608251	5/11/2021	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
K10-1039-K10-1033	608251	5/11/2021	Cracks or Fractures	80.00	Minor Cracking	
K10-1039-K10-1033	608251	5/11/2021	Break or Failure	15.00	Hole Void Visible	
J18-2063-J18-2004	608650	9/23/2021	Obstruction or Intrusion	80.00	Minor	
J18-2063-J18-2004	608650	9/23/2021	Roots	50.00	Medium	J18-2004 IN STRUCTURE
J11-3100-J11-3053	608423	6/28/2021	Cracks or Fractures	80.00	Minor Cracking	
J16-4012-J16-4011	610934	12/1/2023	Cracks or Fractures	80.00	Minor Cracking	
K18-3067-K18-3008	608948	1/18/2022	Belly or Sag	80.00	Minor (<10%)	
G16-2031-G16-2029	610380	4/6/2023	Roots	80.00	Light	
K18-4017-K18-4016	608236	5/10/2021	Belly or Sag	80.00	Minor (<10%)	
L18-4045-L18-4038	607955	2/3/2021	Belly or Sag	80.00	Minor (<10%)	
G21-2034C-G21-2029	609871	11/7/2022	Roots	30.00	Heavy	HEAVY ROOTS AT END OF PIPE
G21-2034C-G21-2029	609871	11/7/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
H17-3040-H17-3039	611036	12/18/2023	Break or Failure	30.00	Hole Soil Visible	
H17-3040-H17-3039	611036	12/18/2023	Cracks or Fractures	80.00	Minor Cracking	
K18-3006-K18-3005	609096	3/1/2022	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
K18-2022-K18-2021	608849	12/15/2021	Belly or Sag	80.00	Minor (<10%)	
D23-2114-D23-2113	608026	3/10/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
L17-1013-L17-1012	608730	10/18/2021	Obstruction or Intrusion	60.00	Moderate	
K18-4048-K18-4047	608791	11/9/2021	Obstruction or Intrusion	60.00	Moderate	
H16-4001-H16-1018	610322	3/28/2023	Inflow and Infiltration	60.00	Running or Trickling	
J11-2016-J11-2015	608324	5/21/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
L18-4057-L18-4028	609197	3/30/2022	Worn Surface	80.00	Minor	
L18-4057-L18-4028	609197	3/30/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
K18-2044-K18-2043	609239	4/11/2022	Inflow and Infiltration	80.00	Weeping or Dripping	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
K18-1015-K18-1014	609451	6/15/2022	Roots	80.00	Light	K18-1014 ROOTS IN STRUCTURE
J11-3019-J11-3018	608394	6/17/2021	Roots	80.00	Light	ROOTS IN JOINTS FROM 35' TO 55'
J11-3019-J11-3018	608394	6/17/2021	Obstruction or Intrusion	60.00	Moderate	
J11-3019-J11-3018	608394	6/17/2021	Worn Surface	80.00	Minor	
J20-2001-J20-3055	608802	11/15/2021	Roots	80.00	Light	IN STRUCTURE 3055
G16-3015-G16-3014	610273	3/13/2023	Cracks or Fractures	40.00	Severe Cracking	
G16-3015-G16-3014	610273	3/13/2023	Roots	50.00	Medium	
L17-1033-L17-1032	607899	1/12/2021	Roots	80.00	Light	ROOTS JUST INSIDE THE SAND COLLAR OF MANHOLE L17-1032
L17-4018C-L17-4004	607893	1/11/2021	Belly or Sag	80.00	Minor (<10%)	
L17-4018C-L17-4004	607893	1/11/2021	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
L17-1065-L17-1064	607961	2/4/2021	Obstruction or Intrusion	0.00	Severe or Impassable	
L17-1065-L17-1064	607961	2/4/2021	Roots	0.00	Blockage	SIDE SERVICE BLOCKED AT 334.4 FROM THE GROCERY STORE
L17-1065-L17-1064	607961	2/4/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
L16-2017-L16-2016	609800	10/13/2022	Roots	30.00	Heavy	ROOTS IN DOWNSTREAM MH -L16-2016
J19-3114-J19-3107	608000	3/2/2021	Obstruction or Intrusion	0.00	Severe or Impassable	
J18-2019-J18-2018	609515	7/12/2022	Roots	80.00	Light	J18-2018 IN STRUCTURE....REQUEST ROOT X TREATMENT
D23-2051-D23-2050	608141	4/12/2021	Belly or Sag	80.00	Minor (<10%)	
L17-1016-L17-1015	607908	1/14/2021	Cracks or Fractures	80.00	Minor Cracking	
L17-1016-L17-1015	607908	1/14/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
L17-1057-L17-1063	607963	2/4/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
L17-1057-L17-1063	607963	2/4/2021	Roots	80.00	Light	LIGHT ROOTS IN THE TOP OF THE PIPE AT 125 FT
L17-1057-L17-1063	607963	2/4/2021	Belly or Sag	80.00	Minor (<10%)	
K20-4007-K20-4006	609365	5/16/2022	Roots	50.00	Medium	K20-4007: roots in structure
K10-1010-K10-1007	608346	5/27/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
K10-1010-K10-1007	608346	5/27/2021	Roots	80.00	Light	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
H16-3106-H16-3105	610790	9/18/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
J16-4011-J16-4006	610935	12/1/2023	Cracks or Fractures	60.00	Moderate Cracking	
D23-2012-D23-2009	608216	5/6/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-3081-J11-3066	608523	8/3/2021	Roots	80.00	Light	REFER ROOTS LIST
D23-2108-D23-2107	608030	3/10/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
D10-1032-D10-1031	609623	8/15/2022	Cracks or Fractures	80.00	Minor Cracking	
D11-4002-D11-4001	610302	3/22/2023	Obstruction or Intrusion	80.00	Minor	
J19-2006-J19-2005	609478	6/17/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
J11-4011-J11-4010	608409	6/23/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-4011-J11-4010	608409	6/23/2021	Belly or Sag	80.00	Minor (<10%)	
J11-4011-J11-4010	608409	6/23/2021	Break or Failure	30.00	Hole Soil Visible	
J11-4011-J11-4010	608409	6/23/2021	Worn Surface	80.00	Minor	
H16-3038-H16-3034	610822	9/26/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
K18-3049-LS-2	608753	10/20/2021	Inflow and Infiltration	40.00	Gushing or Spurting	
D23-3050-D23-3049	608200	5/4/2021	Belly or Sag	80.00	Minor (<10%)	
D23-3050-D23-3049	608200	5/4/2021	Obstruction or Intrusion	60.00	Moderate	
F16-4009-F16-4002	609986	11/28/2022	Roots	80.00	Light	IN DOWNSTREAM SAND COLLAR MH F16-4002
L17-1023-L17-1022	607903	1/12/2021	Break or Failure	0.00	Collapse	
L17-1023-L17-1022	607903	1/12/2021	Inflow and Infiltration	60.00	Running or Trickling	
L17-1023-L17-1022	607903	1/12/2021	Roots	80.00	Light	ROOTS IN THE SAND COLLAR OF L17-1023
L17-1023-L17-1022	607903	1/12/2021	Cracks or Fractures	40.00	Severe Cracking	
L17-1023-L17-1022	607903	1/12/2021	Lining or Repair Failure	80.00	Minor	
L18-4067-L18-4066	608896	12/23/2021	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
L18-4067-L18-4066	608896	12/23/2021	Obstruction or Intrusion	80.00	Minor	
K18-3028-K18-3027	609565	7/19/2022	Inflow and Infiltration	60.00	Running or Trickling	
K18-2025-K18-2024	608891	12/23/2021	Inflow and Infiltration	60.00	Running or Trickling	
G16-1013-G16-1019	610493	5/30/2023	Roots	80.00	Light	
J19-3112-J19-3111	607993	3/1/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
J11-2030-J11-2029	608458	7/14/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
K18-4047-K18-4046	608790	11/9/2021	Belly or Sag	80.00	Minor (<10%)	
G16-4101-G16-4100	610156	1/25/2023	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
D23-2087-D23-2086	608064	3/18/2021	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
K18-3099C-K18-3052	609320	4/27/2022	Joint Separation or Offset	60.00	Moderate (1 to 1.5 Pipe Thickness)	
K18-3099C-K18-3052	609320	4/27/2022	Belly or Sag	40.00	Severe (>30%)	
K18-3099C-K18-3052	609320	4/27/2022	Obstruction or Intrusion	0.00	Severe or Impassable	
J11-3044-J11-3043	608436	7/6/2021	Obstruction or Intrusion	80.00	Minor	
J11-3044-J11-3043	608436	7/6/2021	Break or Failure	15.00	Hole Void Visible	
J11-3044-J11-3043	608436	7/6/2021	Cracks or Fractures	80.00	Minor Cracking	
D23-1003-D23-1002	608172	4/27/2021	Roots	80.00	Light	
K10-1009-K10-1008	608313	5/19/2021	Roots	80.00	Light	K10-1009-K10-1008 ROOTS IN THE LATERAL 29 FT FROM THE UPPER M/H, 58 FT FROM UPPER M/H, 137 FROM UPPER M/H
K10-1009-K10-1008	609008	2/4/2022	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
K10-1009-K10-1008	609008	2/4/2022	Roots	50.00	Medium	SIDE SERVICE BLOCKED BY ROOTS AND POSSIBLY COLLAPSED
K19-4014-K19-4013	609029	2/7/2022	Roots	50.00	Medium	ROOT BUILD UP IN K19-4013
B26-2031-B26-2030	610886	11/20/2023	Obstruction or Intrusion	80.00	Minor	
H17-3050-H17-3049	611053	12/19/2023	Cracks or Fractures	60.00	Moderate Cracking	
H17-3050-H17-3049	611053	12/19/2023	Break or Failure	30.00	Hole Soil Visible	
D11-4026-D11-4025	609689	9/6/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
D11-4047-D11-4045	609684	9/6/2022	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
G21-2017-G21-2016	609891	11/9/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
K17-2011-LS-39	608742	10/19/2021	Worn Surface	80.00	Minor	
G21-2025-G21-2024	609876	11/8/2022	Cracks or Fractures	80.00	Minor Cracking	
K18-3035-K18-3031	608882	12/21/2021	Belly or Sag	80.00	Minor (<10%)	
L18-4080-L18-4079	609278	4/20/2022	Obstruction or Intrusion	80.00	Minor	
D10-1002-D10-1001	609613	8/8/2022	Belly or Sag	40.00	Severe (>30%)	
G21-2003-G21-2002	609903	11/14/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
G21-2003-G21-2002	609903	11/14/2022	Cracks or Fractures	80.00	Minor Cracking	
K18-2006-K18-2005	609353	5/4/2022	Inflow and Infiltration	60.00	Running or Trickling	
L18-4051-L18-4050	607967	2/5/2021	Inflow and Infiltration	60.00	Running or Trickling	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
L18-4051-L18-4050	607967	2/5/2021	Cracks or Fractures	80.00	Minor Cracking	
K10-1054-K10-1053	608303	5/18/2021	Cracks or Fractures	80.00	Minor Cracking	
K10-1054-K10-1053	608303	5/18/2021	Inflow and Infiltration	60.00	Running or Trickling	
G16-3070-G16-3062	610311	3/23/2023	Belly or Sag	80.00	Minor (<10%)	
G15-3037-G15-3036	610262	3/9/2023	Belly or Sag	80.00	Minor (<10%)	
D23-2011-D23-2010	608219	5/6/2021	Inflow and Infiltration	80.00	Weeping or Dripping	
K19-1020-K19-1019	609072	2/16/2022	Roots	80.00	Light	K19-1019- ROOTS IN STRUCTURE
K18-4001-K18-3003	609270	4/19/2022	Belly or Sag	60.00	Moderate (10 to 30%)	
K19-1038-K19-1037	609410	6/7/2022	Roots	80.00	Light	ROOTS IN LATERAL 49' DOWNSTREAM
J16-4015-J16-4014	610923	11/29/2023	Cracks or Fractures	80.00	Minor Cracking	
G16-4031-G16-4029	610115	1/11/2023	Belly or Sag	80.00	Minor (<10%)	
J11-3065-J11-3064	608383	6/10/2021	Worn Surface	80.00	Minor	
G16-1051-G16-1050	610197	1/27/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-1051-G16-1050	610197	1/27/2023	Obstruction or Intrusion	80.00	Minor	
J19-2086-J19-2008	608612	8/30/2021	Roots	80.00	Light	
K19-1037-K19-1036	609411	6/7/2022	Roots	80.00	Light	K19-1036 ROOTS ON LADDER RUNGS
G16-2037-G16-2018	610634	8/10/2023	Belly or Sag	80.00	Minor (<10%)	
J11-4012-J11-4011	608410	6/23/2021	Worn Surface	80.00	Minor	
J11-4012-J11-4011	608410	6/23/2021	Break or Failure	30.00	Hole Soil Visible	
J11-4012-J11-4011	608410	6/23/2021	Cracks or Fractures	80.00	Minor Cracking	
K18-2057-K18-2031	609257	4/18/2022	Belly or Sag	80.00	Minor (<10%)	
H16-2094C-H16-2012	611003	12/13/2023	Break or Failure	30.00	Hole Soil Visible	
H16-2094C-H16-2012	611003	12/13/2023	Roots	50.00	Medium	
H16-2094C-H16-2012	611003	12/13/2023	Cracks or Fractures	60.00	Moderate Cracking	
H17-3054-H17-3053	611075	12/27/2023	Break or Failure	30.00	Hole Soil Visible	
K18-4026-K18-4025	609312	4/26/2022	Cracks or Fractures	80.00	Minor Cracking	
J18-2006-J18-2005	608639	9/16/2021	Roots	80.00	Light	ROOTS IN J18-2005 APPLYING ROOT TREATMENT
K18-1018-K18-1017	609448	6/15/2022	Roots	80.00	Light	K18-1017 ROOTS IN STRUCTURE
J19-2019-J19-2018	608919	1/10/2022	Roots	80.00	Light	IN J19-2019 STRUCTURE

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
G16-4012-G16-4011	610132	1/17/2023	Roots	50.00	Medium	G16-4012 ROOTS IN MH CAUSING I&I
G16-4012-G16-4011	610132	1/17/2023	Inflow and Infiltration	60.00	Running or Trickling	
K10-1037-K10-1036	608245	5/11/2021	Joint Separation or Offset	80.00	Minor (< Pipe Wall Thickness)	
K10-1037-K10-1036	608245	5/11/2021	Belly or Sag	80.00	Minor (<10%)	
L17-1088C-L17-1087	607886	1/8/2021	Roots	50.00	Medium	
L17-1088C-L17-1087	607886	1/8/2021	Inflow and Infiltration	60.00	Running or Trickling	
L17-1088C-L17-1087	607886	1/8/2021	Cracks or Fractures	80.00	Minor Cracking	
L17-1088C-L17-1087	610746	9/7/2023	Break or Failure	30.00	Hole Soil Visible	
L17-1088C-L17-1087	610746	9/7/2023	Roots	0.00	Blockage	
K18-1009-K18-1008	609592	7/27/2022	Inflow and Infiltration	90.00	Stain, Possible I&I	
K18-4044-K18-4024	609309	4/25/2022	Obstruction or Intrusion	0.00	Severe or Impassable	
K18-4044-K18-4024	609309	4/25/2022	Cracks or Fractures	80.00	Minor Cracking	
J16-1027-J16-1025	610622	8/8/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
D23-2066-D23-2065	608094	3/30/2021	Roots	80.00	Light	ROOTS IN LATERAL @60.4
C11-3010-C11-3008	609711	9/27/2022	Belly or Sag	80.00	Minor (<10%)	
J11-3102-J11-3058	608416	6/28/2021	Belly or Sag	80.00	Minor (<10%)	
H15-1023-H15-1001	610356	4/3/2023	Cracks or Fractures	60.00	Moderate Cracking	
H16-1030-H16-1029	610390	4/10/2023	Joint Separation or Offset	40.00	Severe (> 1.5 Pipe Thickness)	
K18-4058-K18-4036	609295	4/22/2022	Cracks or Fractures	60.00	Moderate Cracking	
D23-2045-D23-2044	608173	4/27/2021	Roots	80.00	Light	IN D23-2045
L18-4048-L18-4047	607972	2/5/2021	Roots	50.00	Medium	ROOTS IN MANHOLE L18-4047
H16-4048-H16-4047	610312	3/23/2023	Roots	50.00	Medium	ROOTS IN DOWNSTREAM STRUCTURE H16-4047
H15-1001-G15-2011	610544	7/12/2023	Break or Failure	15.00	Hole Void Visible	
K18-2041-K18-2040	609339	5/2/2022	Roots	80.00	Light	K-18-2040: ROOT NEAR TOP OF STRUCTURE
J11-3089-J11-3095	608454	7/13/2021	Roots	80.00	Light	ON ROOTS LIST
L17-1062-L17-1058	607966	2/4/2021	Inflow and Infiltration	90.00	Stain, Possible I&I	
L17-1062-L17-1058	607966	2/4/2021	Belly or Sag	80.00	Minor (<10%)	
K19-1060-K19-1059	609248	4/13/2022	Roots	50.00	Medium	BOTH STRUCTURES K19-1060-K19-1059
H16-3041-H16-3040	610820	9/26/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
H16-3041-H16-3040	610820	9/26/2023	Belly or Sag	80.00	Minor (<10%)	

Pipe ID	Inspection ID	Inspection Date	Condition_Category	Index	Measured Value	Notes
J16-4008-J16-4007	610931	12/1/2023	Cracks or Fractures	80.00	Minor Cracking	
G16-3078-G16-3009	610277	3/13/2023	Inflow and Infiltration	60.00	Running or Trickling	
J19-2067-J19-2068	608828	12/8/2021	Roots	50.00	Medium	ROOTS IN DOWNSTREAM MANHOLE STRUCTURE
K18-3031-K18-3030	609563	7/19/2022	Inflow and Infiltration	60.00	Running or Trickling	
J11-4018-J11-4013	608406	6/23/2021	Roots	80.00	Light	
J11-3046-J11-3045	608435	7/6/2021	Roots	80.00	Light	ON ROOTS LIST
J11-3046-J11-3045	608435	7/6/2021	Cracks or Fractures	80.00	Minor Cracking	
J11-3046-J11-3045	608435	7/6/2021	Worn Surface	80.00	Minor	
J11-3046-J11-3045	608435	7/6/2021	Obstruction or Intrusion	80.00	Minor	
G16-4089-G16-4088	610086	12/15/2022	Belly or Sag	80.00	Minor (<10%)	
D23-2143-D23-2142	608367	6/7/2021	Belly or Sag	60.00	Moderate (10 to 30%)	
D23-2062-D23-2061	608193	5/4/2021	Worn Surface	80.00	Minor	
J11-3051-J11-3048	608528	8/3/2021	Worn Surface	80.00	Minor	
H16-4002-H16-4001	610360	4/4/2023	Belly or Sag	60.00	Moderate (10 to 30%)	
J18-3044-J18-3043	608204	5/5/2021	Roots	80.00	Light	J18-3043 STRUCTURE HAS LIGH ROOTS...RECOMMEND ROOT X TREATMENT
K18-3008-K18-3007	609426	6/8/2022	Cracks or Fractures	80.00	Minor Cracking	
K18-4067-K18-4066	608784	11/9/2021	Belly or Sag	80.00	Minor (<10%)	
K19-4022-K19-4025	609475	6/17/2022	Roots	80.00	Light	K19-4022
L17-1039-L17-1038	610348	3/30/2023	Belly or Sag	80.00	Minor (<10%)	
L17-1039-L17-1038	610348	3/30/2023	Obstruction or Intrusion	60.00	Moderate	
L17-1039-L17-1038	610348	3/30/2023	Lining or Repair Failure	40.00	Severe	
J16-4004-J16-4003	610937	12/1/2023	Roots	80.00	Light	
J16-4004-J16-4003	610937	12/1/2023	Break or Failure	15.00	Hole Void Visible	
G16-4087-G16-4086	610108	1/3/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-4013-G16-4010	610129	1/17/2023	Inflow and Infiltration	90.00	Stain, Possible I&I	
G16-2024-G16-2020	610383	4/7/2023	Belly or Sag	60.00	Moderate (10 to 30%)	

APPENDIX D
WWTP CONDITION ASSESSMENT

Kitsap County
Facilities Plan
Manchester WWTP Process Condition and Criticality Ranking

Process	Condition (1-5)	CoF (1-5)	Serviceability (1-4)	Condition* CoF	Overall Condition Score	Weighted CoF	Asset Health Score	Ranking
Civil	2.0	1.0	2.0	2.0	2.0	1	2.0	8
Influent Pumping	2.3	3.0		7.0	2.4	3	7.2	5
Equipment	2.0	3.0	2.0	6.0				
Instrumentation	2.0	2.0	2.0	4.0				
Structural	3.0	4.0	NA	12.0				
Piping	NA	NA	NA	NA				
Preliminary Treatment	2.4	2.6	2.0	6.3	2.4	3	7.2	5
Equipment	2.9	2.5	2.0	7.3				
Instrumentation	NA	NA	NA	NA				
Structural	2.0	2.7	NA	5.3				
Piping	NA	NA	NA	NA				
Biological Treatment	2.9	3.4	2.8	9.9	2.9	5	14.5	1
Equipment	3.8	3.0	2.8	11.3				
Instrumentation	NA	NA	NA	NA				
Structural	2.0	3.2	NA	6.4				
Piping	3.0	4.0	NA	12.0				
Effluent and UV	3.1	2.9	2.3	9.2	3.1	3	9.3	4
Equipment	3.3	3.3	2.7	11.1				
Instrumentation	3.0	3.5	2.0	10.5				
Structural	3.0	2.0	NA	6.0				
Piping	NA	NA	NA	NA				
Solids Treatment	2.0	3.0	2.4	6.2	2.0	3	6.0	7
Equipment	2.2	3.0	2.1	6.5				
Instrumentation	2.6	2.5	2.6	6.4				
Structural	1.7	3.7	NA	6.4				
Piping	1.7	3.0	NA	5.0				
Support Systems	3.4	1.6	2.8	5.4	3.2	3	9.6	3
Equipment	3.5	2.1	2.5	7.4				
Instrumentation	5.0	1.0	4.0	5.0				
Structural	2.3	2.0	2.0	4.7				
Piping	2.8	1.3	NA	3.4				
Power Distribution	2.5	3.1	1.2	8.0	2.6	5	13.0	2
Equipment	3.1	3.3	1.2	10.1				
Instrumentation	NA	NA	NA	NA				
Structural	2.0	3.0	NA	6.0				
Piping	NA	NA	NA	NA				

Manchester Wastewater Treatment Plant

Facility Name: Influent Pump Station

Location: Influent Pump Station

Unit Process: Influent Pumping

Description: Manchester WWTP has an influent pumping station wetwell that collects flow from the sanitary sewer system and boosts the flow through the plant.

EQUIPMENT

Equipment Name	Equipment Tag	Condition (1-5)	Criticality/CoF (1-5)	Serviceability (1-4)	Install Year	Location	Type	Manufacturer	Model	Motor HP	Capacity
Influent Pump	P-101	2	3	2	2015	Influent wetwell	Submersible sewage	Flygt	NP 3127 HT	10	641 gpm @40 ft TDH
Influent Pump	P-102	2	3	2	2015	Influent wetwell	Submersible sewage	Flygt	NP 3127 HT	10	641 gpm @40 ft TDH
Influent Pump	P-103	2	3	2	2015	Influent wetwell	Submersible sewage	Flygt	NP 3127 HT	10	641 gpm @40 ft TDH

INSTRUMENTATION

Influent Wetwell Ultrasonic Level	LE/LIT 100	2	2	2	1998	Influent wetwell	Ultrasonic	Milltronics	OCM III		
Influent Wetwell Floats	LSL/H/HH 100	2	2	2	1998	Influent wetwell	Level floats				

STRUCTURAL/FACILITIES

Influent wetwell	N/A	3	4	NA	1998	Influent wetwell					

PIPING

*Condition (1 = very good, 5 = very poor). CoF (1 = not critical, 5 = highly critical). Serviceability (1 = very good, 4 = very poor)

Manchester Wastewater Treatment Plant

Facility Name: Influent Pump Station

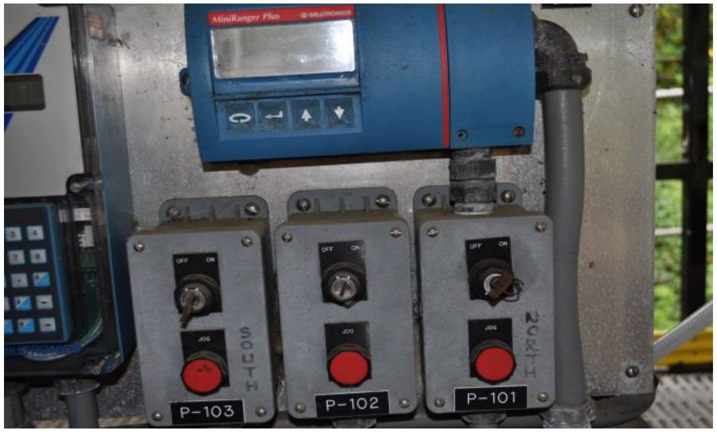
Location: Influent Pump Station

Unit Process: Influent Pumping

Photos:

Influent Pump Station

Influent Pump Station Controls



Notes:

Manchester Wastewater Treatment Plant

Facility Name: Headworks

Location: Headworks Building

Unit Process: Headworks

Description: The preliminary treatment processes at Manchester WWTP include a rotary screen with a bypass channel with a manual screen, a grit tank, grit cyclone and classifier, channel aeration basin and flow splitter. The preliminary treatment equipment is located in the Headworks building, which was constructed in 1998.

EQUIPMENT

Equipment Name	Equipment Tag	Condition (1-5)	Criticality/CoF (1-5)	Serviceability (1-4)	Install Year	Location	Type	Manufacturer	Model	Motor HP	Capacity
Mechanical Fine Screen	M-201	3	2	2	1998	Headworks upper level	Rotating drum screen	Lakeside	Raptor	2	2.1 MGD
Manual Screen	M-202	Not obs	2	2	1998	Headworks upper level	Bar Screen Rack 1 inch				2.1 MGD
Grit Chamber	M-210	3	2	2	1998	Headworks upper level	Vortex	Smith & Loveless	Pista Grit trap 2.5	0.75	2.1 MGD
Grit Pump	P-212	3	2	2	1998	Headworks lower level	Recessed impeller	WEMCO	C 3x3 Torque Flow Pump	5	220 gpm
Grit Cyclone	M-205	3	2	2	1998	Headworks upper level	Vortex	WEMCO	Whemclone 1000C		220 gpm
Grit Classifier	M-205	4	2	2	1998	Headworks upper level	Inclined Screw-type dewatering classifier	WEMCO	Hydrogritter12" F.FLARE	1	15 gpm
Screenings and Grit Hopper	N/A	2	2	1	1998	Headworks lower level	N/A	N/A	N/A		~ 1 CY
Influent Sampler	M-220	2	4	2	1998	Headworks upper level	Outdoor auto sampler	Campbell Scientific	BVS4300C		
Compressed Air System	M-230	Not obs	3	2	1998	Ops building garage/shop?	Reciprocating air compressor	Devilblis	PAPV-5051	5	17.5 scfm @ 175 psig
Channel Aeration Blower	B-211	3	3	3	1998	Headworks lower level	Positive Displacement	Dresser Roots	33-U-RAI	5	100 scfm @ 3.5 psig

INSTRUMENTATION

STRUCTURAL/FACILITIES

Influent Parshall Flume	M-221	2	2		1998	Headworks upper level					12-inch, 10.4 MGD
Headworks building	N/A	2	4		1998	Headworks					
Headworks Aeration Channel and Flow Splitter	N/A	2	2		1998	Headworks					

PIPING

*Condition (1 = very good, 5 = very poor). CoF (1 = not critical, 5 = highly critical). Serviceability (1 = very good, 4 = very poor)

Manchester Wastewater Treatment Plant

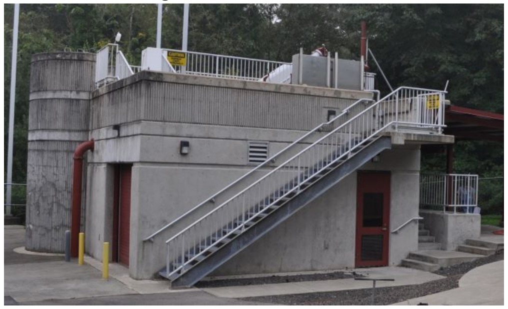
Facility Name: Headworks

Location: Headworks Building

Unit Process: Headworks

Photos:

Headworks building



M-201 Rotary Screen

M-210 Grit Chamber

Grit Trap Corrosion around motor

P-212 Grit Pump

M-205 Grit Cyclone and Classifier

Manchester Wastewater Treatment Plant

Facility Name: Headworks

Location: Headworks Building

Unit Process: Headworks

Photos:

Grit classifier

M-220 Influent Sampler

Grit and Screenings Bin

B-211 Channel Aeration Blower

Headworks Aeration Channel and Flow Splitter

Notes:

Did not observe manual screen or influent Parshall flume

Did not observe inside of aerated grit channel and flow splitter

Severe corrosion beginning on motor connection to grit chamber

Severe corrosion on grit classifier body

No level sensor at the Parshall flume. The flume is not used for influent flow measurement

Manchester Wastewater Treatment Plant

Facility Name: Secondary Treatment

Location: Aeration Basins, Blower Building and Secondary Clarifiers

Unit Process: Secondary Treatment

Description: Manchester WWTP has two parallel aeration basins, located NE of the headworks building. Blowers for the aeration basins are in the blower building west of the aeration basins. Two Secondary clarifiers are located west of the headworks building.

EQUIPMENT

Equipment Name	Equipment Tag	Condition (1-5)	Criticality/CoF (1-5)	Serviceability (1-4)	Install Year	Location	Type	Manufacturer	Model	Motor HP	Capacity
Aeration Blower	B-305	4	3	3	1991	Blower building	Constant speed PD	Roots Dresser	45 U RAI	15	250 scfm
Aeration Blower	B-306	4	3	3	1991	Blower building	Constant speed PD	Roots Dresser	45 U RAI	15	250 scfm
Aeration Blower	B-307	4	3	3	1991	Blower building	Constant speed PD	Roots Dresser	45 U RAI	15	250 scfm
Jet Aeration Pump No. 1	P-311	4	3	3	1991	Aeration basin	Submersible sewage	Hydromatic	S8L1500M6-8	15	
Jet Aeration Pump No. 2	P-312	4	3	3	1991	Aeration basin	Submersible sewage	Hydromatic	S8L1500M6-8	15	
Jet Aeration System No. 1	N/A	4	3	3	1991	Aeration basin	Jet aeration nozzles				
Jet Aeration System No. 2	N/A	4	3	3	1991	Aeration basin	Jet aeration nozzles				
Seconday Clarifier 1 - Drive	M-401	3	3	2	1998	Secondary clarifier	Center column	Eimco		1.0	
Seconday Clarifier 2 - Drive	M-402	3	3	2	1998	Secondary clarifier	Center column	Eimco		1.0	

INSTRUMENTATION

STRUCTURAL/FACILITIES

Blower Building					1991	Blower building					
Aeration Basin 1	T-301	2	3		1991	Aeration basin					16,840 ft^3
Aeration Basin 2	T-302	2	3		1991	Aeration basin					16,840 ft^3
ML flow Splitter	N/A	2	4		1991	Flow splitter/RAS PS					
Secondary Clarifier 1	N/A	2	3		1998	Secondary clarifier					35' dia. x 13' SWD
Secondary Clarifier 2	N/A	2	3		1998	Secondary clarifier					35' dia. x 13' SWD

PIPING

Aeration basin process piping	N/A	3	4		1991	in basin	ductile iron pipe				

*Condition (1 = very good, 5 = very poor). CoF (1 = not critical, 5 = highly critical). Serviceability (1 = very good, 4 = very poor)

Manchester Wastewater Treatment Plant

Facility Name: Secondary Treatment

Location: Aeration Basins, Blower Building and Secondary Clarifiers

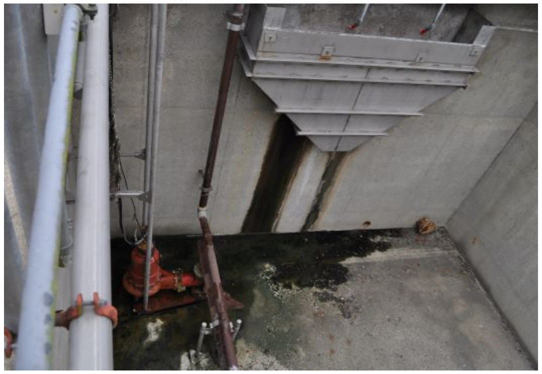
Unit Process: Secondary Treatment

Photos:

Aeration Basin

AB Jet system nozzles

AB Jet Aeration Pump and Effluent Weir



Aeration Basin Blower

FV-42-1 AB 1 effluent piping control valve

FV-42-2 AB 2 effluent piping control valve

Manchester Wastewater Treatment Plant

Facility Name: Secondary Treatment

Location: Aeration Basins, Blower Building and Secondary Clarifiers

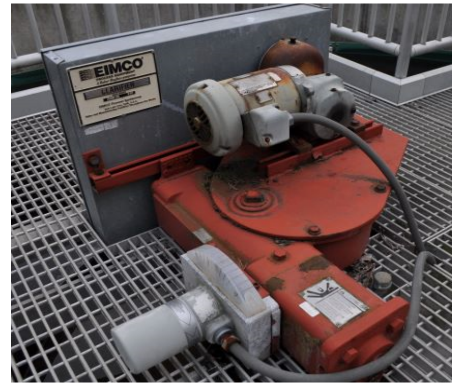
Unit Process: Secondary Treatment

Photos:

ML Splitter Box to Secondary Clarifiers

Secondary Clarifier

M-401 Secondary Clarifier Drive



M-402 Secondary Clarifier Drive

NOTES:

Only use one aeration blower at a time. Constant airflow 4 hours on and 2 hours off

Require use of both clarifiers in the winter with I&I

Secondary clarifier drives starting to show exterior corrosion

No DO probe in the aeration basins

Poor control of DO level in aeration basins via manual air flow control

AB SE control valves significantly corroded

Effluent piping control valves from 1991 are in poor condition

Manchester Wastewater Treatment Plant

Facility Name: UV Disinfection and Reclaimed Water

Location: UV and IPS Area

Unit Process: UV Disinfection

Description: Manchester WWTP treats secondary effluent using UV disinfection prior to the outfall, and meters effluent flow with a Parshall flume and ultrasonic level.

EQUIPMENT

Equipment Name	Equipment Tag	Condition (1-5)	Criticality/CoF (1-5)	Serviceability (1-4)	Install Year	Location	Type	Manufacturer	Model	Motor HP	Capacity
UV Bank 1	N/A	4	3	3	1998	UV channel in IPS_UV area	UV open channel horizontal lamps	Trojan	3000B		1.4 MGD
UV Bank 2	N/A	4	3	3	1998	UV channel in IPS_UV area	UV open channel horizontal lamps	Trojan	3000B		1.4 MGD
Effluent Sampler	M-510	2	4	2	1998	Effluent channel in IPS_UV area	Outdoor auto sampler	Campbell Scientific	BVS4300C		

INSTRUMENTATION

Parshall Flume Effluent Flow Transducer	FE/FIT 505	3	4	2	1998	Effluent channel in IPS_UV area	Ultrasonic	Milltronics	OCM III		
UV Channel Floats	LSL/H 504	3	3	2	1998	Effluent channel in IPS_UV area	Level floats				

STRUCTURAL/FACILITIES

Parshall Flume	M-505	3	2		1998	Effluent channel in IPS_UV area					6 inch, 2.5 MGD

PIPING

*Condition (1 = very good, 5 = very poor). CoF (1 = not critical, 5 = highly critical). Serviceability (1 = very good, 4 = very poor)

Manchester Wastewater Treatment Plant

Facility Name: UV Disinfection and Reclaimed Water

Location: UV and IPS Area

Unit Process: UV Disinfection

Photos:

UV Power Distribution Center

Trojan UV System

M-510 Effluent Sampler

M-505 Effluent Parshall Flume

FE 505- Effluent Flow Ultrasonic

Notes:

Manchester Wastewater Treatment Plant

Facility Name: Sludge Processing

Location: RAS/WAS Pump Station

Unit Process: Sludge Processing

Description: Sludge flows by gravity from the secondary clarifiers into the RAS/WAS wetwell. The wetwell is split in two sides with one RAS pump each; each pump is dedicated to one clarifier and cannot cross over. RAS is pumped to headworks after the parshall flume and prior to the aeration channel. RAS pumps also can separately pump WAS to the WAS basins.

EQUIPMENT

Equipment Name	Equipment Tag	Condition (1-5)	Criticality/CoF (1-5)	Serviceability (1-4)	Install Year	Location	Type	Manufacturer	Model	Motor HP	Capacity
RAS Pump	P-411	1	3	1	2020	RAS PS	Submersible sewage	Flygt	NX-3102 MT	5	275 gpm
RAS Pump	P-412	1	3	1	2020	RAS PS	Submersible sewage	Flygt	NX-3102 MT	5	275 gpm

INSTRUMENTATION

RAS Magmeter	FE/FIT 415	2	2	2	Approx 2009	RAS PS	Magnetic Flowmeter	KROHNE	IFC 090		
RAS Magmeter	?	2	2	2	Approx 2009	RAS PS	Magnetic Flowmeter	KROHNE	IFC 090		
RAS tank floats	LSL/LSH 406	2	3	2	1998	RAS PS	Level Floats				

STRUCTURAL/FACILITIES

RAS Wetwell	N/A	2	4		1998	RAS PS					

PIPING

RAS WAS pipe	N/A	2	3		1998	RAS PS	Ductile Iron pipe				

*Condition (1 = very good, 5 = very poor). CoF (1 = not critical, 5 = highly critical). Serviceability (1 = very good, 4 = very poor)

Photos:

RAS PS and ML Splitter Box Structure

RAS wetwell

RAS Magmeters

NOTES:

RAS Yard piping and buried valves should be inspected

Manchester Wastewater Treatment Plant

Facility Name: Sludge Processing

Location: Operations Building

Unit Process: Sludge Processing

Description: Manchester WWTP stores and thickens sludge for transport to Central Kitsap WWTP for further treatment. Solids handling equipment is in the Operations building. The Operations building is a multipurpose building with office and laboratory space, bathroom with shower and lockers, electrical room, and garage/shop.

EQUIPMENT

Equipment Name	Equipment Tag	Condition (1-5)	Criticality/CoF (1-5)	Serviceability (1-4)	Install Year	Location	Type	Manufacturer	Model	Motor HP	Capacity
Gravity Belt Thickener	M-615	2	4	2	1998	Ops building ground floor	Gravity belt thickener	Ashbrook	24383		200 gpm
Polymer System	M-800	2	2	2	1998	Ops building ground floor	Liquid polymer mix/activation	Stranco	Polyblend Model 1000.3		
Polymer metering pump	M-801	2	2	2		Ops building ground floor	Metering	MILTON-ROY	CD31-20PB		
Sludge Tank Blower	B-601	3	3	2	1998	Ops building lower level	Positive Displacement	Roots Dresser	45 U RAI	15	200 scfm @ 6.0 psig
Sludge Tank Blower	B-602	3	3	2	1998	Ops building lower level	Positive Displacement	Roots Dresser	45 U RAI	15	200 scfm @ 6.0 psig
Sludge Tank Blower	B-603	3	3	2	1998	Ops building lower level	Positive Displacement	Roots Dresser	45 U RAI	15	200 scfm @ 6.0 psig
Sludge Pump	P-611	2	3	2	1998	Ops building lower level	Progressive Cavity	Mono	Monoflo CE101MS1R2/A87Z	15	200 gpm
Sludge Pump	P-612	2	3	2	1998	Ops building lower level	Progressive Cavity	Mono	Monoflo CE101MS1R2/A87Z	15	200 gpm
Scum Pump	P-405	3	4	3	1998	Sludge ww by Sec.Cl.	Submersible slduge			2	100 gpm

*Condition (1 = very good, 5 = very poor). CoF (1 = not critical, 5 = highly critical). Serviceability (1 = very good, 4 = very poor)

Manchester Wastewater Treatment Plant

Facility Name: Sludge Processing

Location: Operations Building

Unit Process: Sludge Processing

INSTRUMENTATION

Equipment Name	Equipment Tag	Condition (1-5)	Criticality/CoF (1-5)	Serviceability (1-4)	Install Year	Location	Type	Manufacturer	Model	Motor HP	Capacity
Sludge to GBT Magmeter	FE/FIT 606	4	2	1	1998	Ops building ground floor	Magnetic flowmeter	Krohne	IFC 090		
Scum Tank float	LSL 405	2	2	2	1998	Sludge ww by Sec.Cl.	Level floats				
WAS Tank Level Transmitter	LIT 631	3	3	3	1998	Ops building lower level					
WAS Tank Level Transmitter	LIT 632	3	3	3	1998	Ops building lower level					
TWAS Tank Level Transmitter	LIT 605	3	4	3	1998	Ops building lower level					
WAS tanks LEL monitor	AE 633	5 - in op	2	3	1998	Ops building lower level	Combustible gas detector				
WAS tanks LEL monitor	AE 634	5 - in op	2	3	1998	Ops building lower level	Combustible gas detector				
TWAS tank LEL monitor	AE 604	5 - in op	2	3	1998	Ops building lower level	Combustible gas detector				

STRUCTURAL/FACILITIES

Operations Building		2	4		1998	Ops building					
Scum Wetwell		1	3		1998	By Secondary clarifier					
TWAS Tank	T-605	2	4		1998	Ops building					14,000 gallons
WAS Tank	T-631	2	3		1998	Ops building					20,000 gallons
WAS Tank	T-632	2	3		1998	Ops building					20,000 gallons
Truck loading		1	5		1998	Truck loading N of AB					

PIPING

Sludge pipe	N/A	2	3		1998	Ops building lower level	Ductile Iron pipe				
Sludge tank air pipe	N/A	1	3		1998	Ops building lower level	SST pipe				

*Condition (1 = very good, 5 = very poor). CoF (1 = not critical, 5 = highly critical). Serviceability (1 = very good, 4 = very poor)

Manchester Wastewater Treatment Plant

Facility Name: Sludge Processing

Location: Operations Building

Unit Process: Sludge Processing

Photos:

Operations Building

M-615 Gravity Belt Thickener

Polymer system for GBT

FE 606 Sludge to GBT Magmeter

B-601-603 Sludge Tank Blowers

P-611 Sludge Pump

Manchester Wastewater Treatment Plant

Facility Name: Sludge Processing

Location: Operations Building

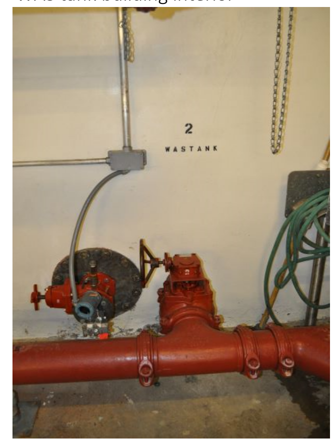
Unit Process: Sludge Processing

Photos:

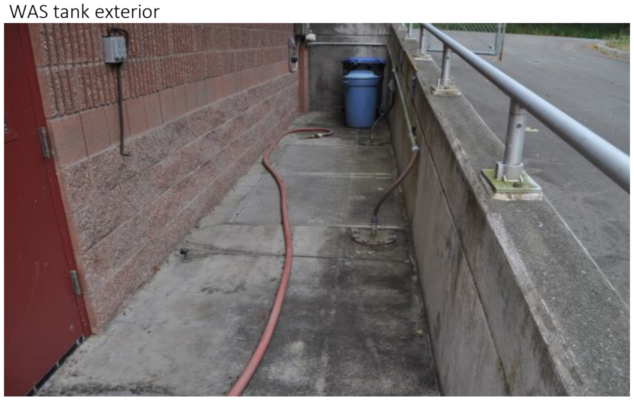
Scum Pump Wetwell

Scum wetwell interior and scum pump P-405

WAS tank building interior

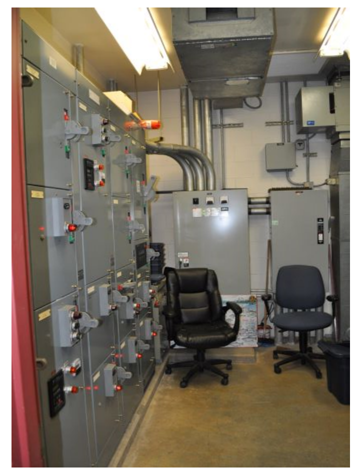


WAS tank exterior



Truck Filling Station

Control Room



NOTES:

Corrosion on GBT replaceable plows

Corrosion on GBT feed magmeter and piping

Corrosion on scum pump piping, submersible pump not observed

5 - 5.5% solids from GBT

Two sludge tank blowers on all the time

WAS tanks are filled and emptied one at a time to avoid septic conditions

Manchester Wastewater Treatment Plant

Facility Name: Hypochlorite room

Location: Headworks Building

Unit Process: Sodium hypochlorite

Description: Manchester WWTP has bulk sodium hypochlorite storage for odor control.

EQUIPMENT

Equipment Name	Equipment Tag	Condition (1-5)	Criticality/CoF (1-5)	Serviceability (1-4)	Install Year	Location	Type	Manufacturer	Model	Motor HP	Capacity
NaOCl Feed Pump (and piping)	P-811	5	2	4	1998	Hypo Room					

INSTRUMENTATION

STRUCTURAL/FACILITIES

Sodium Hydrochlorite Tank	T-810	2	1	3	1998	Hypo Room		POLY PROCESS CO.	500 GAL XLPE		500 gallons
Hypochlorite room		3	1		1998	Hypo Room					

PIPING

Hypo piping		3	1		1998	Hypo Room	PVC chemical piping				

*Condition (1 = very good, 5 = very poor). CoF (1 = not critical, 5 = highly critical). Serviceability (1 = very good, 4 = very poor)

Manchester Wastewater Treatment Plant

Facility Name: Hypochlorite room

Location: Headworks Building

Unit Process: Sodium hypochlorite

Photos:

T-810 Sodium

Hypochlorite fan and pump

Hypochlorite piping

Notes:

Evaluate piping and appurtenances - especially pulsation dampeners
There is no ultrasonic or tank level safety mechanism for tank overflow especially during bulk delivery
Confirm HVAC operation in room
Emergency eye shower is needed in this room

Manchester Wastewater Treatment Plant

Facility Name: Odor Control

Location: Headworks Building

Unit Process: Odor Control

Description: The milti-stage chemical scrubber treats foul air drawn from the headworks channels, grit/screenings dumpster room, dewatering GBT room, WAS and TWAS storage tanks.

EQUIPMENT

Equipment Name	Equipment Tag	Condition (1-5)	Criticality/CoF (1-5)	Serviceability (1-4)	Install Year	Location	Type	Manufacturer	Model	Motor HP	Capacity
Multi-stage scrubber vessel		3	1	2	1998	Outside of headworks		RJ ENVIROMENTAL	LO/PRO ODOR CONTROL SYSTEM		
Recirculation Pump No. 1	P-701	4	1	3	1998	Outside of headworks				5	
Recirculation Pump No. 2	P-702	4	1	3	1998	Outside of headworks				5	
Odor Control Fan	B-705	4	1	2	1998	Outside of headworks		NEW YORK BLOWER CO.	18"/2497RPM	10	
Odor Control Blowdown Pump	P-175	4	2	3	1998	Outside of headworks		VANTON Pump		3	

INSTRUMENTATION

Scrubber Vessel pH/ORP	AIT 706/710/711	5	1	4		Outside of headworks					

STRUCTURAL/FACILITIES

PIPING

Scrubbant recirc pipe		3	1		1998	Odor control unit	PVC pipe with insulation				
Odor ductwork		2	1		1998	Odor control unit	FRP ductwork				

*Condition (1 = very good, 5 = very poor). CoF (1 = not critical, 5 = highly critical). Serviceability (1 = very good, 4 = very poor)

Manchester Wastewater Treatment Plant

Facility Name: Odor Control

Location: Headworks Building

Unit Process: Odor Control

Photos:

Odor Control System

Odor Control Fan

Scrubber pH/ORP not in use

P-701 Recirculation Pump

P-702 Recirculation Pump

P-175 Odor Control Blowdown Pump

Notes:

Scrubber Vessel instrumentation pH/ORP instrumentation is not in use

No caustic is used. Hypochlorite is added in batches via the chemical dosing pump

Manchester Wastewater Treatment Plant

Facility Name: Plant Water, W2 and W3 systems

Location: In Plant PS, Operations Building

Unit Process: Plant water

Description: Manchester WWTP has an In-plant wetwell to handle plant and process drainage. W2 and W3 systems support plant operations and process water needs.

EQUIPMENT

Equipment Name	Equipment Tag	Condition (1-5)	Criticality/CoF (1-5)	Serviceability (1-4)	Install Year	Location	Type	Manufacturer	Model	Motor HP	Capacity
W2 Pump No. 1	P-931	2	3	1	1998	Ops building LL	Vertical Centrifugal inline	Grundfos	CR 16-40	15	50 gpm @ 100 psig
W2 Pump No. 2	P-932	2	3	1	1998	Ops building LL	Vertical Centrifugal inline	Grundfos	CR 16-40	15	50 gpm @ 100 psig
W3 Pump - Ops Bldg	P-901	4	3	2	1998	Ops building LL	Horizontal centrifugal	Paco Pump		15	70 gpm @ 100 psig
W3 Pump - Ops Bldg	P-902	3	3	2	1998	Ops building LL	Horizontal centrifugal	Peerless	TH32 2 STAGE	15	70 gpm @ 100 psig
Automatic Strainer	M-905	4	1	4	1998	Ops building LL		SP Kinney	A 3"		200 gpm
Inplant Pump	P-921	Not obs	3	3	1998	In Plant PS wetwell	Submersible	Myers	VH(X) 50 M6-43	5	
Inplant Pump	P-922	Not obs	3	3	1998	In Plant PS wetwell	Submersible	Myers	VH(X) 50 M6-44	5	

INSTRUMENTATION

W3 Flowmeter	FE 906	5 - in op	1			Ops building LL		Sparling	3" Sono64316		

STRUCTURAL/FACILITIES

Hydropneumatic Tank	T-935	2	2	1	1998	Ops building LL					
In plant Wetwell	N/A	Not obs	4	NA	1998	In Plant PS					

PIPING

W3 piping		3	2		1998	Ops building LL	ductile iron pipe				

*Condition (1 = very good, 5 = very poor). CoF (1 = not critical, 5 = highly critical). Serviceability (1 = very good, 4 = very poor)

Manchester Wastewater Treatment Plant

Facility Name: Plant Water, W2 and W3 systems

Location: In Plant PS, Operations Building

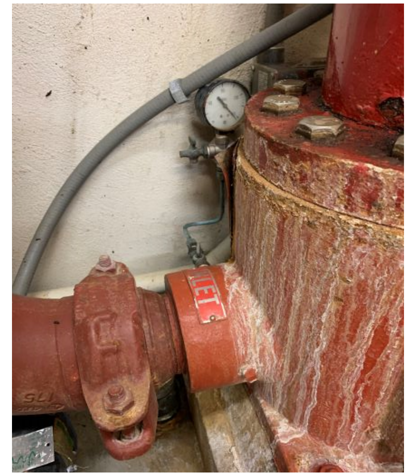
Unit Process: Plant water

Photos:

W2 System

W3 System

W3 Automatic Strainer corrosion



Notes:

W3 Strainer showing significant leaking and corrosion, also some corrosion on valves and piping. Per plant staff, strainer is not in use

P-901 is the blue pump to the left and P-902 is the black pump to the right

In plant wetwell not opened. Per plant staff, the inplant pumps need to be replaced soon

Manchester Wastewater Treatment Plant

Facility Name: Other Facilities

Location: Site

Unit Process: Generator

Description: Extra facilities include a generator building and a diesel tank that supports the backup generator outside of the generator building.

EQUIPMENT

Equipment Name	Equipment Tag	Condition (1-5)	Criticality/CoF (1-5)	Serviceability (1-4)	Install Year	Location	Type	Manufacturer	Model	Motor HP	Capacity
Puget Sound Energey Utility Transformer and Meter (Service)		3	5		1998	Outside, south of operation building	underground primary power source, padmount transformer				300 KVA
Diesel Tank		3	5	2	1998	Outside generator building					unknown
Generator		3	3	1	1998	Generator Building		Cummins	350DFCC 89384P		350 kW
Service Entrance Equipment		3	3	1	Estimate 1997	Operations Building		Siemens	MXD63B800		
Automatic/Manual Transfer Switch		3	4	3	1997	Operations Building		Asco	940 F940380097XC		
Generator Service Fused Disconnect		3	4	1	Estimate 1997	Operations Building		Siemens	F-356		
MCC	MCC-01	3	4	1	Estimate 1998	Operations Building		Allen-Bradley	Centerline Bulletin 2100		
Switchboard/Panelboard	DPP-01	3	4	1	10/1/1997	Operations Building		Siemens	SEF42ML250CTS		
Switchboard/Panelboard	DPP-02	3	4	1	10/1/1997	Headworks Building		Siemens	SEF42FX225CTS		
Switchboard/Panelboard	DPP-03	3	4	1	10/1/1997	Blower Building		Siemens	SEF30FX225CTS		
Switchboard/Panelboard	DPL-01	3	4	1	10/1/1997	Operations Building		Siemens	S1C42QH225CTS		
Switchboard/Panelboard	DPL-02	3	4	1	10/1/1997	Headworks Building		Siemens	S1C42BL100CTS		
Switchboard/Panelboard	PB	4	4	1	8/1/1991	Blower Building		Westinghouse	PRL1		
Panel PB Main Circuit Breaker		3	4	1	Estimate 1997	Operations Building		Siemens			
Transformer	XFMR-01	3	4	1	Estimate 1997	Service Building		Siemens	3F3Y045		45 KVA
Transformer	XFMR-02	3	4	1	Estimate 1997	Headworks Building		Siemens	3F3Y030		30 KVA
Transformer	XFMR-03	3	4	1	Estimate 1997	Blower Building		Siemens	3F3Y112		112.5 KVA

Manchester Wastewater Treatment Plant

Facility Name: Other Facilities

Location: Site

Unit Process: Generator

Control Panel	PCP-Plant Main PLC Pnl	2	4	1	Estimate 1997. PLC upgraded in 2018.	Operations Building		Elcon	PLC Brand/Model: Allen-Bradley CompactLogix L33ER		
Control Panel	LP-205 Grit Collection Pnl	4	2	1	Estimate 1997	Headworks Area					
Control Panel	LP-225-Influent Pump Stn Control Pnl	2	4	1	Estimate 1997. PLC upgraded in 2018.	Headworks Building		Elcon	PLC Brand/Model: Allen-Bradley CompactLogix 1769 I/O		
Control Panel	SBR Remote I/O Panel	2	4	1	2018	Blower Building		Elcon	PLC Brand/Model: Allen-Bradley CompactLogix 1769 I/O		
Control Panel	JetTech-SBR Control Pnl (Modified)	4	4	1	Estimate 1991	Blower Building		Integrated Controls, Inc.			
Control Panel	SBR Motor Powel Pnl	4	4	1	Estimate 1991	Blower Building		Integrated Controls, Inc.			
Control Panel	SBR Valve Power Pnl (No longer in-use)				Estimate 1991	Blower Building		Integrated Controls, Inc.			
Control Panel	LP-TLP Truck Loading Pnl	3	2	1	Estimate 1997	Sludge Loading Area		Elcon			
Control Panel	LP-TCP Truck Loading Pnl	3	4	1	Estimate 1997	Process Building					
Control Panel	Gravity Belt Panel	3	4	3	Estimate 2005	Process Building		Ashbrook Corp.			
Control Panel	FP-201 Rotary Screen Pnl	4	4	3	Estimate 1997	Headworks Area		Lakeside Industries	PLC Brand/Model: GE Fanuc Micro 90		
Control Panel	FP-700 Odor Ctrl System	5	1	1	Estimate 1997	Odor Control Area		RJ Environmental			
Control Panel	FP-715 Odor Ctrl Blowdown Sump Pnl	3	1	1	Jan-98	Odor Control Area		Vanton Pump&Equipment Corp			
Control Panel	FP-905 Auto Strainer Pnl	3	1	1	Estimate 1997	Operations Bldg (lower level)		Klockner Moeller			
Control Panel	FP-915 Sump Pump Pnl	4	4	1	Estimate 1997	Operations Bldg (lower level)		International Control Systems			

Manchester Wastewater Treatment Plant

Facility Name: Other Facilities

Location: Site

Unit Process: Generator

Control Panel	FP-930 W-2M Control Pnl	3	2	1	Estimate 1997	Operations Bldg (lower level)		International Control Systems				
Motor Starter	Influent Pump VFD Panels	3	3	1	1997	Headworks Building		Systems Interface				
Motor Starter	Sludge VFD Panel	3	2	1	1997	Inside Control Panel		Systems Interface				
Control Panel	FP-500 UV System Panel	4	4	1	Estimate 1997	Effluent Area		Trojan Technologies Inc.				
Control J-BOX	TJB-WP1-Influent Terminal Box	4	2	1	Estimate 1997	Influent Pump Station Area						
Lighting - Exterior		1	1	1		Process Areas						
Lighting - Interior		1	1	1		Bldg Interiors						

INSTRUMENTATION

STRUCTURAL/FACILITIES

Generator building		2	3	2	1998	Generator Building						

*Condition (1 = very good, 5 = very poor). CoF (1 = not critical, 5 = highly critical). Serviceability (1 = very good, 4 = very poor)

Manchester Wastewater Treatment Plant

Facility Name: Other Facilities

Location: Site

Unit Process: Generator

Photos:

Generator building (background) and blower building (foreground)

Generator

Diesel Tank

Notes:

APPENDIX E
RED FLAG FINDINGS AND MITIGATION RECOMMENDATIONS

Technical Memorandum

Date:	October 20, 2020
Project:	Facility Plan and Sewer Plan Update
To:	Barbara Zaroff, PE, PMP Christopher Sheridan Kitsap County, WA
From:	Miaomiao Zhang, PE, PMP (Murraysmith) John Koch, PE (HDR) Tom Perry, PE (Murraysmith) Peter Cunningham, PE (Murraysmith) Erika Schuyler, PE, PMP (Murraysmith)
Re:	Condition Assessment Red Flag Findings and Mitigation Recommendations

Introduction

The Murraysmith and HDR team conducted a 4-day condition assessment field visit at Kitsap County's (County) four wastewater treatment plants and over forty selected pump stations from 9/14/2020 to 9/17/2020. This memorandum documents the "red flag" issues observed during the visits and provides the Engineer's opinion on the consequence of failure and potential solutions. The "red flag" issues are ones that pose health and safety risks or could result in imminent failure. The red flag issues were identified through discussions with plant staff and field verification. Although this list of "red flag" issues is intended to be as complete as possible, there is always a risk that other unknown issues exist due to the nature of wastewater treatment plants and pump stations. A detailed engineering analysis has not been performed and some of the solutions may warrant further study prior to implementation.

Central Kitsap Treatment Plant (CKTP)

Red Flag 1 – Digester 2 Seal Failure

Issue: Approximately two linear feet of annular seal on the east side of Digester 2 has failed (Figure 1). The top sealant is missing. At least one foot deep of the fill material under the sealant is also missing resulting in a void space. The exposed digester cover skirt does not appear to be coated and is severely corroded.

Consequence of failure: Biogas and sludge may leak through the space, resulting in the loss of the digester. If failure occurs, the plant will have to meet solids retention time requirements from EPA Part 503 with only one digester online. Leaking biogas poses health and safety risks due to its toxicity and explosive potential, and are also corrosive to the concrete and metal components of the digester structure.

Potential solution: The temporary solution is to repair the seal per the cover manufacturer's standard and the Detail E/G4 of 1991 digester cover replacement drawings. Routine inspection of the digester seals is recommended. Long term solution for a reliable digestion operation will be evaluated as part of the Facility Plan update.

Figure 1 – CKTP Digester 2 Seal Failure

Red Flag 2 – Leaking Digester PRVs

Issue: The pressure relief valves (PRVs) on both digesters are leaking. Strong biogas odor and the sound of biogas leaking from the PRVs were observed at both digester PRVs. The PRV on Digester 2 appears to have more significant leakage than Digester 1.

Consequence of failure: Leaking digester PRVs reduce biogas storage and pose health and safety risk due to biogas toxicity and explosive potential. The leaking digester PRVs also contribute to the corrosion of digester structure and odors at the plant.

Potential solution: Contact Varec field service staff to service and repair the PRVs. The isolation valves and flame arrestors should also be inspected and serviced, as needed.

Red Flag 3 – Aged In-Plant Pump Station

Issue: The in-plant pump station is in poor condition, with one of the pumps failed, coating on the concrete inside of the wetwell falling off, and the pipes severely corroded (Figure 2). There is no bypass route to allow the pump station to be taken offline for maintenance. Currently a mobile diesel pump is used as a backup.

Consequence of failure: If the in-plant pump station is down, there are limited options to get the plant sanitary sewage and the recycle streams back to the process.

Potential solution: The short-term solution is to maintain the diesel pump and replace the broken pump with a larger unit. The long-term solution may be to replace the in-plant pump station with sufficient capacity to handle the in-plant flows, provide odor control and overflow to other process basins for redundancy.

Figure 2 – CKTP In-Plant Pump Station

Red Flag 4 – Failing Aeration Diffusers

Issue: The Aerostrip diffusers in multiple zones have failed in the last couple of years. The diffusers have long lead times and are difficult to procure in emergency situations.

Consequence of failure: Broken diffusers significantly reduce the oxygen transfer efficiency, making it impossible to control the aeration air. Large quantity of failed diffusers will result in the loss of the aeration basin.

Potential solution: The short-term solution is to repair and replace the diffusers to the best ability of the plant staff and have a significant number of spare diffusers on hand. A long-term solution may be to replace the diffusers with an industry proven type acceptable to plant staff.

Red Flag 5 – Leaking Roof Penetrations over Boilers

Issue: It appears the roof penetrations over the two boiler stacks are leaking. The ducting, piping, valves, and panels under the boilers show significant signs of corrosion (Figure 3).

Consequence of failure: The boilers were installed in 1977 and may be nearing the end of their useful life. Corrosion and water getting into the conduit or panels could result in the failure of the boilers.

Potential solution: Repair the leaking roof. Clean or replace the components.

Figure 3 – Rusty Boiler Components due to the Leaking Roof Penetrations

Red Flag 6 – Insufficient Ventilation in Headworks Electrical Room

Issue: Ventilation in the headworks electrical room can't keep the room temperature down in summer; during the site visit, it was 77 degrees F when the thermostat was set at 72 degrees F. Strong hydrogen sulfide smells and some corrosion near the conduit grounding were noticed.

Consequence of failure: Excessive heat and a corrosive environment will cause eventual failure of the controls and VFDs.

Potential solution: Inspect the ventilation currently provided to the room. Add additional cooling, if needed. Install a Purafil positive pressurization unit to keep the room pressurized with air free of corrosive gas.

Red Flag 7 – Insufficient Ventilation and Heating in the Lab and Admin Building

Issue: The ventilation system in the lab and administration building is from the original construction in 1977. Issues observed include:

- The east lab has a positive pressure. The west lab, which was converted from the training and lunchroom approximately 15 years ago, has a negative pressure when the fume hood exhaust is on. Fugitive gas has been noted in the administration room during lab analyses. Based on a review of 1977 design drawings, no ventilation was provided to the training and lunchroom (now the west lab) or the administration room. The east lab was designed to have approximately 1,000 cfm of exhaust air and higher supply airflow, resulting in positive pressure. Lack of ventilation in the west lab and positive pressure in the east lab do not meet the laboratory standards, while lack of ventilation in the administration room exposes the staff to the risk of hazardous gases from the lab.
- The air handling fan for the entire building (installed in 1977) is missing approximately half of its blades, resulting in reduced capacity.
- The heating provided by the heat water loop from the boiler cannot keep up with the heating demand in the space. The lab must use the wall mounted air conditioner to supplement the heating.

Consequence of failure: Lack of ventilation in all lab spaces and positive pressure in the east lab will violate the NFPA 45 Standard on Fire Protection for Laboratories using Chemicals, posing the potential health and safety risk to the staff working in the lab or near the lab.

Potential solution: Contract a HVAC testing and balancing company to inspect and balance the existing HVAC system, and replace the equipment as needed. Install the ventilation system in the west lab and the administration room.

Other Treatment Plants

Red Flag 1 – Operator Safety in Hypochlorite Room at Manchester Treatment Plant (MTP)

Issue: Strong and pungent chlorine odor was noticed inside the hypochlorite room. Although there is a supply fan and exhaust fan in the room, it is not certain if they work. There is no emergency shower/eyewash in the room (Figure 4).

Consequence of failure: High concentration of chlorine fumes will pose a health risk to the operator with exposure. No shower/eyewash in the room and keeping the door always closed violates building code and OSHA requirements.

Potential solution: Clean up chemical residual that causes chlorine fumes, especially from the secondary containment sump. Check and ensure sufficient ventilation. Install a shower or eyewash and a gas chlorine sensor in the room.

Figure 4 – MTP Sodium Hypochlorite Storage Room

Red Flag 2 – Operator Safety and Classification of Headworks Room at Suquamish Treatment Plant (STP)

Issue: The screening channel, the odor control scrubber, and the WAS rotary drum thickener are all in the same room (Figure 5). The screening channel cover plates were open. Strong hydrogen sulfide odor was observed during the visit. The room is Class 1 Division 1 or Class 1 Division 2 depending on ventilation provided. The room does not currently meet all the NFPA 820 requirements, i.e. combustible gas (LEL) detection is missing, explosion proof panels have bolts missing, and most motors are not explosion proof.

Consequence of failure: Flammable gas migrating from headworks channel could cause fire or explosion if ventilation is insufficient or shut down.

Potential solution: Install LEL alarm. Tighten and replace the missing bolts at the enclosures. Keep the screening channel cover plate on and make sure the airspace under the cover is kept under negative pressure so that no foul air escape into the room. Inspect the odor control fan to make sure the room is always ventilated at 12 air changes per hour.

Figure 5 – STP Headworks Room

Pump Stations

Red Flag 1 – Broken Conduits at PS-30

Issue: Broken conduits to the panel are within the classified area of the wet well hatch.

Consequence of failure: Gas intrusion to the classified area pose health and safety risk due to explosive potential.

Potential solution: Fix the conduits and move the panel further away from the wet well hatch.

Red Flag 2 – Broken Pump Shaft at PS-24

Issue: One pump shaft was broken.

Consequence of failure: Loss of pump could result in pump station not being able to convey influent flows that could possibly result in a spill.

Potential solution: The County O&M staff are aware of the issue and working on fixing it.

consor

APPENDIX F
SEWER UTILITY SCADA MASTER PLAN TECHNICAL MEMORANDUM

TM-1: Existing System Overview

FINAL

Sewer Utility SCADA Master Plan

Kitsap County Public Works
Sewer Utility Division

November 2, 2020

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Kitsap County Public Works, Sewer Utility Division
Sewer Utility SCADA Master Plan

TM-1: Existing System Overview

November 2, 2020

Prepared by:

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(425) 450-6240

I hereby certify that the technical memorandum was prepared under my direct supervision and that I am a duly registered Engineer under the laws of the State of Washington.

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Abbreviations

µm	micron(s)
AAA	authentication, authorization, and accounting
AES	Advanced Encryption Standard
ANSI	American National Standards Institute
AOI	Add-on Instruction
BNR	biological nutrient removal
Branom	Branom Instrument Co.
CIA	Confidentiality, Integrity, and Availability
CIP	capital improvement program
CKTP	Central Kitsap Treatment Plant
CMMS	computerized maintenance management system
County	Kitsap County
CTU	central telemetry unit
DHS	U.S. Department of Homeland Security
DO	dissolved oxygen
EMS	energy management system
eO&M	electronic operation and maintenance
FCC	Federal Communications Commission
ft^3	cubic foot/feet
FVNR	full-voltage non-reversing
GbE	gigabit(s) Ethernet
GBT	gravity belt thickener
GE	General Electric
GHz	gigahertz
gpm	gallon(s) per minute
H_2S	hydrogen sulfide
HDR	HDR Engineering, Inc.
HIP	Host Identity Protocol
HMI	human-machine interface
HOA	Hand-Off-Auto
hp	horsepower
HVAC	heating, ventilation, and air conditioning
Hz	hertz
I&C	instrumentation and controls
ICS	industrial control system
IEEE	Institute of Electrical and Electronics Engineers
IGMP	Internet Group Management Protocol
in	inch(es)
I/O	input/output
IP	Internet Protocol
IR	infrared
ISA	International Society of Automation
IT	Information Technology
kB	kilobyte(s)
kbps	kilobit(s) per second
kHz	kilohertz
KPI	key performance indicator
KPUD	Kitsap Public Utility District
kW	kilowatt(s)
KWWTP	Kingston Wastewater Treatment Plant
LAN	local area network
LEL	lower explosive limit

LIMS	laboratory information management system
LTE	Long-Term Evolution
M2M	machine-to-machine
mA	milliampere(s)
MB	megabyte(s)
Mbps	megabit(s) per second
MCC	motor control center
MFA	multi-factor authentication
mgd	million gallons per day
MHz	megahertz
MTU	master telemetry unit
MWWTP	Manchester Wastewater Treatment Plant
N/A	not applicable
NAT	Network Address Translation
NEC	National Electrical Code
NIC	network interface card
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
OIT	operator interface terminal
O&M	operation and maintenance
OM1	Optical Multi-mode 1
OM3	Optical Multi-mode 3
OOP	object-oriented programming
OS2	Optical Single-mode 2
OSI	Open Systems Interconnection
OT	Operational Technology
PC	personal computer
P&ID	piping and instrumentation diagram
PID	proportional-integral-derivative
PLC	programmable logic controller
PNL	panel
PS	pump station
PSTN	public switched telephone network
QCC	Quality Controls Corporation
QoS	Quality of Service
RACS	Raptor Acceptance Control System
RAS	return activated sludge
RDT	rotary-drum thickener
RFB	Remote Frame Buffer
RIO	remote input/output
RS	Recommended Standard
RTU	remote telemetry unit
RVSS	reduced-voltage soft starter
SBR	sequencing batch reactor
SCADA	supervisory control and data acquisition
Sewer Utility	Public Works Sewer Utility Division
SMS	Short Message Service
SNMP	Simple Network Management Protocol
SOP	standard operating procedure
SP1	Service Pack 1
SPB	solids processing building
SSID	Service Set Identifier
ST	straight-tip
SWGR	switchgear

SWWTP	Suquamish Wastewater Treatment Plant
TCC	total calculated capacity
TCP	Transmission Control Protocol
THD	total harmonic distortion
TM	technical memorandum
UDT	User-defined Data Type
UPS	uninterruptible power supply
USB	Universal Serial Bus
UTP	unshielded twisted pair
UV	ultraviolet
V	volt(s)
VAC	volt(s) alternating current
VDC	volt(s) direct current
VFD	variable-frequency drive
VHF	very high frequency
VLAN	virtual local area network
VM	virtual machine
VNC	Virtual Network Computing
VPN	virtual private network
W3	service water
WAN	wide-area network
WAS	waste activated sludge
WIMS	Water Information Management Solution
WWTP	wastewater treatment plant

1 Introduction

This Existing System Overview Technical Memorandum (TM)-1 describes the current condition, arrangement, life-cycle state, and identified areas of risk for the Kitsap County (County) Public Works Sewer Utility Division (Sewer Utility) supervisory control and data acquisition (SCADA) system components and associated wastewater treatment plant (WWTP) and pump station (PS) systems. The content of TM-1 is based on information that HDR Engineering, Inc. (HDR) obtained from the Sewer Utility and field data collected by HDR during various site assessment visits conducted in August 2020.

1.1 Technical Memorandum Organization

TM-1 is organized into nine sections and four appendices, as described below. In any subsection where a risk or deficiency is identified, a summary risk or deficiency description is presented at the end of that subsection, as shown below, so that these risks and deficiencies are easily visible and can be quickly located. Risks and deficiencies are compiled in Section 8 in Table 8-2.

> ✸ Identified risks and deficiencies are shown in condensed highlighted form like this throughout the report.

Section 1: Introduction summarizes TM organization, briefly describes each Sewer Utility wastewater facility included in the TM, and details the site assessment work performed in preparation of TM-1.

Section 2: Network Architecture describes the existing Operational Technology (OT) network architecture at the Sewer Utility WWTPs and pump stations. It includes an overview of the current network topologies and segmentation practices, major hardware and software elements, network management and system backup procedures, and cybersecurity measures currently implemented at the facilities.

Section 3: Industrial Control System Hardware describes the current industrial control system (ICS) hardware at Sewer Utility WWTPs and wastewater pump stations. It includes a description of the major hardware elements and a summary of the WWTP control room equipment.

Section 4: Industrial Control System Software describes the Sewer Utility's current ICS software, including an overview of the programmable logic controller (PLC) programming, human-machine interface (HMI), historian, and alarm notification software packages in use at the WWTPs and wastewater pump stations. It also describes the SCADA system functionality that has been implemented with this software.

Section 5: Industrial Control System Documentation summarizes documentation associated with the Sewer Utility's wastewater ICS. It describes the type of documents that the Sewer Utility has available along with a general description of how they are organized and maintained.

Section 6: Other Software Packages provides an overview of the non-ICS software packages at the Sewer Utility's WWTPs that bear a relationship to the Sewer Utility

SCADA system and the assets with which it interacts. It includes a description of the software tools and provides a general summary of their current uses at Sewer Utility facilities.

Section 7: Organizational Improvement Categories presents five organizational improvement categories that apply to utility control systems and how they will be applied within the Sewer Utility SCADA Master Plan to relate risks, deficiencies, and proposed improvements to facets of the Sewer Utility's organizational health.

Section 8: Risk and Deficiency Summary compiles the risks and deficiencies associated with the Sewer Utility's OT networks, SCADA system components, and associated infrastructure that were identified in previous sections of TM-1, correlating each of them to one or more of the organizational improvement categories.

Section 9: References lists the supporting source materials cited in TM-1.

Appendix A: Site Maps includes an overall site map showing the general locations of the Sewer Utility's WWTPs and pump stations. The appendix also includes a site map for each of the WWTPs, labeled with major buildings and process areas.

Appendix B: Network Architecture Diagrams includes various network architecture diagrams that are referenced throughout TM-1.

Appendix C: QCC Network Design Diagrams includes various network diagrams that Quality Controls Corporation (QCC) has developed to document implementation of telemetry and wide-area network (WAN) upgrades it is contracted to perform for the Sewer Utility. At the time of this writing, QCC's work is ongoing and the network documentation included in Appendix C may not reflect as-built conditions once QCC's work is complete.

Appendix D: WWTP PLC I/O Summary and PLC and Remote I/O Module Summary includes a summary of input/output (I/O) quantities and types by PLC and a summary of the installed modules at the various PLC and remote input/output (RIO) racks throughout each WWTP.

1.2 Site Descriptions

The following site descriptions provide a general summary of the Sewer Utility's 4 WWTPs and 12 pump stations included in HDR's site assessments. The Sewer Utility has a total of 62 pump stations that are currently in service with remote alarm monitoring. An overall site map showing the general locations of the Sewer Utility's WWTP and pump station facilities can be found in Appendix A.

1.2.1 Central Kitsap Treatment Plant

The Central Kitsap Treatment Plant (CKTP), located at 12351 Brownsville Highway NE in Poulsbo, Washington, is a regional facility serving the central area of Kitsap County. The facility, which was put into service in 1979, uses a conventional activated sludge secondary treatment process, ultraviolet (UV) disinfection, and sand filtration for tertiary treatment and reclaimed water. CKTP has a design flow of 6.0 million gallons per day (mgd) of average dry weather flow and has attended operations 17 hours per day, 7 days per week, with significantly reduced staff during evening operations. Appendix A provides a site plan with major buildings and process areas indicated.

1.2.2 Kingston Wastewater Treatment Plant

The Kingston Wastewater Treatment Plant (KWWTP), located at the end of a gravel road near 23055 S Kingston Road NE in Kingston, Washington, is an oxidation ditch type activated sludge facility with a mechanical fine screen and aerated grit chamber for preliminary treatment. Following the oxidation ditches, the liquid stream flows through secondary clarifiers for solids settling and then to UV disinfection before reaching the KWWTP outfall. Sludge removed from the secondary clarifiers is thickened by a gravity belt thickener (GBT) and stored for transport to CKTP for further treatment and disposal. KWWTP has a design flow of 0.292 mgd for the average day within the maximum month flow. The facility, which was first put into service in 2005, is currently manned 8 hours per day, 5 days per week. Appendix A provides a site plan with major buildings and process areas indicated.

1.2.3 Manchester Wastewater Treatment Plant

The Manchester Wastewater Treatment Plant (MWWTP), located at 8020 E Caraway Road in Port Orchard, Washington, is an activated sludge facility with a rotary screen and aerated grit chamber for preliminary treatment and aeration basins for biological treatment. Following the aeration basins, the liquid stream flows through secondary clarifiers for solids settling and then to UV disinfection before reaching the plant outfall. Sludge removed from the secondary clarifiers is thickened by a GBT and stored for transport to CKTP for further treatment and disposal. MWWTP has a design flow of 0.460 mgd for the average day within the maximum month flow. The original facility, which consisted of primary treatment only, was first put into service in 1969. The final phase of secondary treatment improvements was completed in 1998. MWWTP is currently manned 8 hours per day, 5 days per week. Appendix A provides a site plan with major buildings and process areas indicated.

1.2.4 Suquamish Wastewater Treatment Plant

The Suquamish Wastewater Treatment Plant (SWWTP), located on land belonging to the Suquamish Tribe at 18019 Division Avenue NE in Suquamish, Washington, is a sequencing batch reactor (SBR)-type activated sludge facility with a rotary bar screen and aerated grit chamber for preliminary treatment. Supernatant from the SBRs is decanted to an equalization tank and then flows to UV disinfection before reaching the plant outfall. Sludge removed from the SBRs is thickened by a rotary-drum thickener (RDT) and stored for transport to CKTP for further treatment and disposal. SWWTP has an average design flow of 0.4 mgd. The facility, which was first put into service in the 1970s, was upgraded in 1998 to accommodate increased flows and to convert SWWTP to an SBR-type activated sludge facility. SWWTP is currently manned 8 hours per day, 5 days per week. Appendix A provides a site plan with major buildings and process areas indicated.

1.2.5 Pump Stations

The Sewer Utility selected the wastewater pump stations listed in Table 1-1 for inclusion based on criticality; they serve as a representative sample for all of the Sewer Utility's wastewater conveyance system pump stations. The table presents the pump station numbers and descriptions along with their site address, number and type of pump, pump horsepower (hp), and type of pump motor controller (e.g., variable-frequency drive [VFD], reduced-voltage soft starter [RVSS], or full-voltage non-reversing [FVNR] starter). The pump station wet well total calculated capacities (TCCs) listed in Table 1-1 were obtained from Sewer Utility–provided documentation and were not verified by HDR. The County's Utilities group handles day-to-day operation and maintenance (O&M) of the pump stations. The Utilities staff visit the pump stations on a weekly basis to test pump station alarms and perform maintenance as needed.

Table 1-1. Sewer Utility pump station summary

Station	Pump station description	Site address	Pump qty.	Pump type	hp	Motor controller	TCC (ft^3)
PS-01	Levin Road	10015 Levin Rd. NW Silverdale, Washington	3	Submersible	160	VFD	3,334
PS-04	Pump station 4	9606 Frederickson Rd. NW Bremerton, Washington	3	Vertical non-clog centrifugal	75	VFD	5,636
PS-06	Parkwood East	457 NE Conifer Dr. Bremerton, Washington	3	Submersible	60	VFD	2,837
PS-07	Fairgrounds	1300 NE Fairgrounds Rd. Bremerton, Washington	3	Submersible	150	VFD	1,948
PS-12	Newberry Hill	8160 Chico Way NW Silverdale, Washington	2	Vertical non-clog centrifugal	10	FVNR	673
PS-17	Bangor	14690 Clear Creek Rd. NW Silverdale, Washington	3	Vertical non-clog centrifugal	40	VFD	1,920
PS-24	Brownsville Highway	14501 Brownsville Hwy. NE Poulsbo, Washington	3	Vertical non-clog centrifugal	250	VFD	4,111
PS-32	Riddell Road	1552 NE Riddell Rd. Bremerton, Washington	2	Vertical non-clog centrifugal	10	FVNR	874
PS-34	Central Valley	6240 Central Valley Rd. NE Bremerton, Washington	2	Submersible	60	FVNR	1,884
PS-41	Kingston waterfront	10809 NE West Kingston Rd. Kingston, Washington	2	Vertical non-clog centrifugal	15	FVNR	558
PS-67	Keyport	15378 Washington Ave. NE Keyport, Washington	3	Submersible	70	VFD	6,030
PS-71	Kingston (old plant)	26198 Dulay Rd. NE Kingston, Washington	2	Vertical non-clog centrifugal	75	RVSS w/ FVNR bypass	942

1.3 Site Assessment Protocol

The current Sewer Utility SCADA Master Plan effort (for which TM-1 is a deliverable) is part of a larger effort the Sewer Utility is currently undertaking to update its sewer and wastewater treatment facility plans. The site assessment work conducted under this first phase of the Sewer Utility SCADA Master Plan was focused on identifying the current condition, arrangement, life-cycle state, and areas of risk for the major SCADA infrastructure components and associated systems.

1.3.1 Existing Documentation

To the extent possible, existing documentation provided by the Sewer Utility was used in conjunction with fieldwork assessments to identify SCADA and associated system components and determine their arrangement, configuration, and potential risks and deficiencies. This documentation includes the following:

- Contract and record drawings
- Internet Protocol (IP) address lists
- O&M manuals
- Monthly lab reports
- Pump station holding time data

1.3.2 Field Surveys

Fieldwork for the site assessments consisted of site visits to all WWTP facilities and 12 pump stations, occurring over two rounds of site visits totaling 7 days in August 2020. HDR instrumentation and controls (I&C) engineer John Thomas and HDR I&C engineer-in-training Maddi Hutson performed the fieldwork. As part of the fieldwork, HDR obtained the following additional documentation to include in its assessment:

- Photo documentation of existing Sewer Utility infrastructure
- Screenshots of various software packages
- Wonderware Historian and General Electric (GE) EnerVista Viewpoint database exports
- PLC program files

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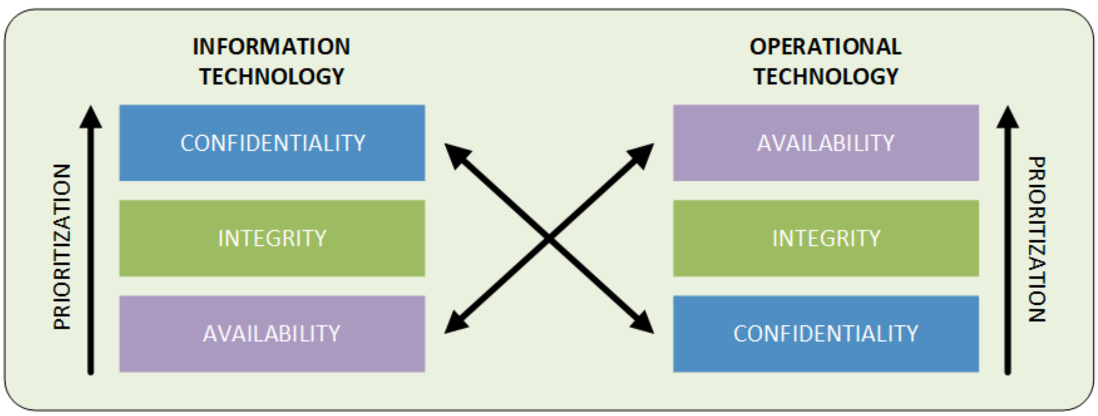
2 Network Architecture

This section describes the existing OT network architecture at the Sewer Utility WWTPs and pump stations. It includes an overview of the current network topologies and segmentation practices, major hardware and software elements, network management and system backup procedures, and cybersecurity measures currently implemented at the facilities.

2.1 Operational Technology versus Information Technology

Before discussing the Sewer Utility's OT networks, it is important that some of the differences between Information Technology (IT) and OT networks are understood. To facilitate the comparison, Figure 2-1 introduces an information security industry model known as the Confidentiality, Integrity, and Availability (CIA) Triad. The CIA Triad consists of three core components for the security of any communication network, and the figure depicts how these security components are prioritized in IT and OT networks.

Figure 2-1. CIA Triad for IT and OT networks



Many readers may be more familiar with IT networks because these are the standard home and office network environments. In IT networks, confidentiality, or the securing of sensitive and/or private information, is typically the highest priority. Preventing unauthorized access to trade secrets, employee/customer personally identifiable information, or credit card information is mission critical. Data integrity is also very important, and typically involves taking steps to back up critical files and databases to avoid loss of information and preventing unauthorized access that could lead to data corruption and/or manipulation. While availability is also important in IT networks, it is the lowest priority of the three security components. Outages to services, file systems, and databases typically result only in lost revenue or efficiency and planned outages for updates and maintenance can often be scheduled around business hours.

In OT networks, availability is the highest priority. OT networks involve equipment and processes that interact with the physical world. Disruption of OT network communication can jeopardize the safety of an organization's personnel and infrastructure, as well as the natural environment. Data integrity is equally important to both IT and OT networks, as they both rely on these data for day-to-day operation. Confidentiality, on the other hand, is much less of a priority in OT networks. Though organizations may prefer to keep SCADA and other OT network data private, their chief concerns are with maintaining the availability of the OT network resources and ensuring that the data being generated are of sufficient quality to provide insight and inform decisions.

Because IT and OT networks have different priorities, they require different approaches to security and architecture. The discussions and observations provided in Section 2 are based on the OT network priorities described above and tailored to the specific requirements of wastewater facilities as critical infrastructure.

2.2 WWTP Network Architecture Overview

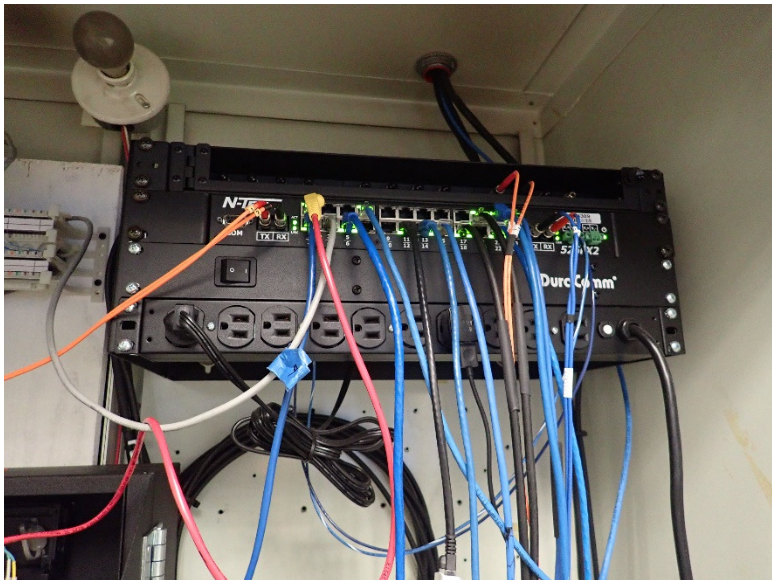
This subsection provides an overview of the network at each of the Sewer Utility WWTPs.

2.2.1 Central Kitsap Treatment Plant

The CKTP OT network is configured in an extended-star topology, as shown in the Central Kitsap Treatment Plant Physical Network Diagram in Appendix B, Figure B1. The network has no core or distribution switches and consists only of managed and unmanaged industrial access switches installed within control panels in the various buildings and process areas. These switches provide access to the CKTP OT network for the various IP-connected devices (IP nodes) near their respective locations.

The most critical switch within the OT network is an unmanaged access switch located within a network cabinet in the solids process building (SPB) control room (see Figure 2-2). This switch handles traffic between the CKTP SCADA nodes, historian server, and all CKTP PLCs. All data exchange that will eventually occur between CKTP and the other Sewer Utility WWTPs would also traverse this switch, given the current network topology. This switch is a single point of failure for the CKTP OT network.

Figure 2-2. Unmanaged switch (N-Tron 526FX2) in SPB control room network cabinet



Being unmanaged, this switch introduces additional risks to the OT network. Among other shortcomings, unmanaged switches provide no means of filtering broadcast and multicast packets and will propagate these packets to all connected nodes, creating the potential for flooding events that can take down the network. The Microsoft Windows operating system, which is running on all personal computers (PCs) connected to this switch, is notorious for generating a high volume of needless broadcast and multicast packets because of the large number of processes that are set to run by default within the operating system. Having managed switches handle network traffic to and from PCs and servers would, among other benefits, allow the Sewer Utility to filter undesirable packets and preserve OT network bandwidth for its intended use.

Though much of the CKTP OT network topology is typical of industrial networks that evolve organically throughout multiple capital improvement program (CIP) projects, the network arrangement in panel (PNL) 8580A within the SPB control room deserves attention. Several of the CKTP building access switches for the OT network are connected to one of two modular access switches located in PNL 8580A (see Figure 2-3). These modular switches are networked via a fiber-optic patch cable, but only one of these switches has a connection to a network switch that provides connectivity to the CKTP SCADA nodes, which are the endpoints for most of the traffic traversing these switches from the various PLCs throughout CKTP. This arrangement effectively forces traffic from one of the modular switches to traverse the other modular switch. All traffic from both modular switches is then consolidated onto one fiber-optic pair between one of the modular switches and the unmanaged switch (discussed above) that serves as the access switch for the SCADA PCs, historian server, and other ICS IP nodes within the SPB. This arrangement creates multiple single points of failure (e.g., the fiber patch cord, the switch ports at either end, the modular switch processor, etc.) for communications between the plant SCADA PCs and most of the PLCs at CKTP.

Figure 2-3. Modular access switches in PNL 8580A

2.2.2 Kingston Wastewater Treatment Plant

The KWWTP OT network is configured in an extended-star topology, as shown in the Kingston WWTP Physical Network Diagram in Appendix B, Figure B2. This relatively small network consists of industrial access switches installed within control panels in the operations building, process building, and headworks area. These switches provide access to the KWWTP OT network for the various IP nodes within these buildings and process areas.

2.2.3 Manchester Wastewater Treatment Plant

The MWWTP OT network is configured in an extended-star topology, as shown in the Manchester WWTP Physical Network Diagram in Appendix B, Figure B3. This relatively small network consists of industrial access switches installed within control panels in the operations building, blower building, and headworks building. These switches provide access to the MWWTP OT network for the few IP nodes within these buildings.

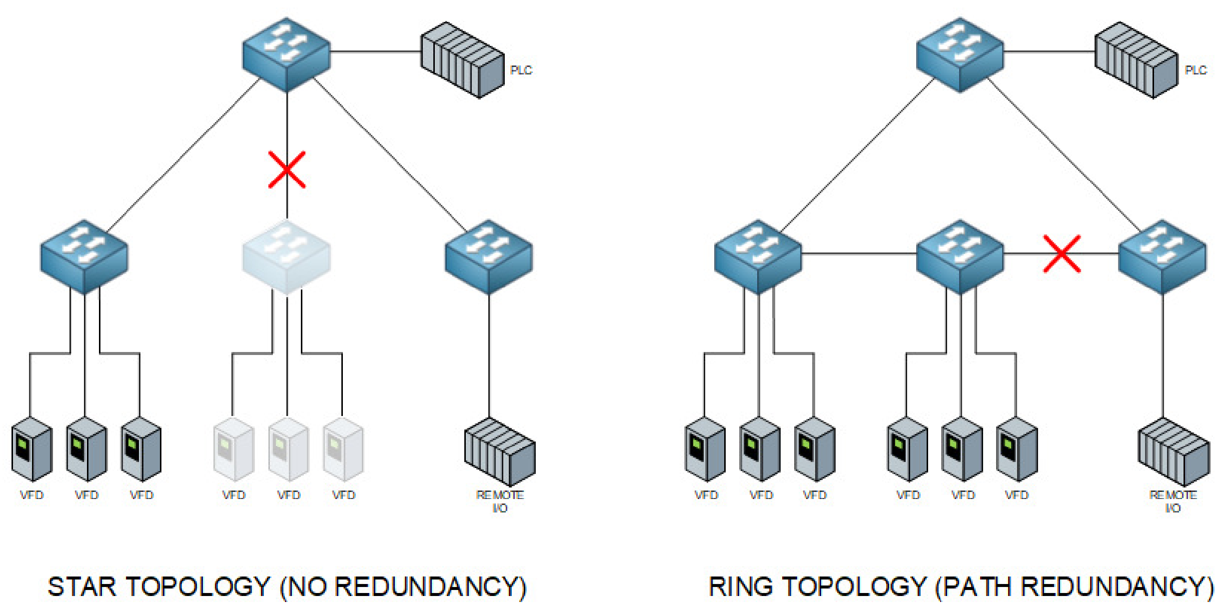
2.2.4 Suquamish Wastewater Treatment Plant

The SWWTP OT network is configured in an extended-star topology, as shown in the Suquamish WWTP Physical Network Diagram in Appendix B, Figure B4. This relatively small network consists of industrial access switches installed within control panels in the process building. These switches provide access to the SWWTP OT network for the few IP nodes within the building.

2.2.5 Resilience Considerations

As shown in the WWTP physical network diagrams in Appendix B, the Sewer Utility's WWTP OT networks have no N+1 redundancy. Without switch-level and/or cable path redundancy for connected devices, failure of an access switch would result in loss of communications for all connected IP nodes. Similarly, with all connections between access switches consisting of single copper and/or fiber-optic cable segments, the WWTP OT networks have no resilience against damage or disconnection of one of these cables or failure of one of the switch ports to which the cable connects on either side. Figure 2-4 illustrates how a single cable or switch port failure would impact devices on a non-redundant network topology versus a network topology with path redundancy. The screened back devices shown in the star topology portion of the figure are the devices that would lose communication under the depicted failure scenario. The ring topology, on the other hand, is tolerant of single path failures and preserves communications for all devices shown in the figure.

Figure 2-4. Consequences of cable path or switch port failure in star versus ring topology



Though non-resilient network topologies like the ones deployed at the Sewer Utility's WWTPs are common within the water/wastewater industry, a general best practice is for the OT network segments and components to adopt the same level of redundancy inherent in the plant processes that they serve, at a minimum. This practice prevents the OT network from inadvertently reducing or eliminating the actual redundancy of plant processes in the event of a single network component and/or cable failure.

Central Kitsap Treatment Plant

At CKTP, many of the plant processes consist of parallel trains and equipment systems designed to provide some degree of redundancy. The plant electrical distribution system has also been designed with redundancy in mind. Electrical loads for parallel and/or redundant processes have been split between "A" bus and "B" bus throughout the CKTP electrical distribution system so that loss of either the “A” or “B” bus may reduce process capacity but will not result in a total loss of the process. By configuring main-tie-main breakers, the Sewer Utility can also quickly re-establish utility power to CKTP loads in the event of a feeder fault or circuit breaker failure.

Given the inherent redundancy of the process design and the electrical distribution system serving the process electrical loads, there are instances where the resilience of the CKTP OT network could be improved so that the redundancy of the process is not undermined by a singular network component or cable failure. Even where the approach taken at CKTP to distribute process control among PLCs local to the processes themselves has significantly reduced the number of potential network failures that could impact a PLC’s ability to govern the process(es) it controls, improved OT network resilience could preserve Sewer Utility staff’s ability to monitor and control the various plant processes from SCADA and prevent gaps in historical data in the event of singular network component or cable failures.

Kingston, Manchester, and Suquamish Wastewater Treatment Plants

In the case of KWWTP, MWWTP, and SWWTP, many of the process trains have no redundancy. These WWTPs are also much smaller than CKTP and are more manageable for Sewer Utility operations staff to run manually in the event of an OT network outage. However, if OT network redundancy were to reflect process redundancy, the liquid stream at KWWTP branches into two parallel trains for the oxidation ditches and secondary clarifiers. The network components and cable segments that establish communications between the KWWTP PLC and RIO racks in the process building, where I/O associated with these processes are received, could be candidates for redundancy considerations. The liquid stream at MWWTP also splits into two parallel trains, but the plant has only one RIO rack dedicated to the liquid stream processes. An investment in OT network resilience at MWWTP without a more redundant control system design would not fully complement the redundancy of the process.

- Given the current network arrangement, the most critical network switch in the CKTP OT network is a single point of failure for the network.
- The access switch serving the CKTP SCADA PCs and historian server is an unmanaged switch, which propagates undesirable broadcast and multicast packets generated by the operating systems on those machines throughout the network.
- CKTP OT network arrangement in PNL 8580A has created multiple single points of failure for communication between plant SCADA nodes and all of the plant PLCs.
- CKTP OT network has no resilience because of a lack of access switch and cable path redundancy, and there are instances where lack of OT network redundancy may undermine process redundancy.

- Improving CKTP OT network resilience could prevent loss of SCADA monitoring and control functionality and continue logging of historical SCADA data in the event of singular network component or cable failure.
- KWWTP OT network has no resilience because of a lack of access switch and cable path redundancy, and this lack of OT network redundancy may undermine liquid stream process redundancy.

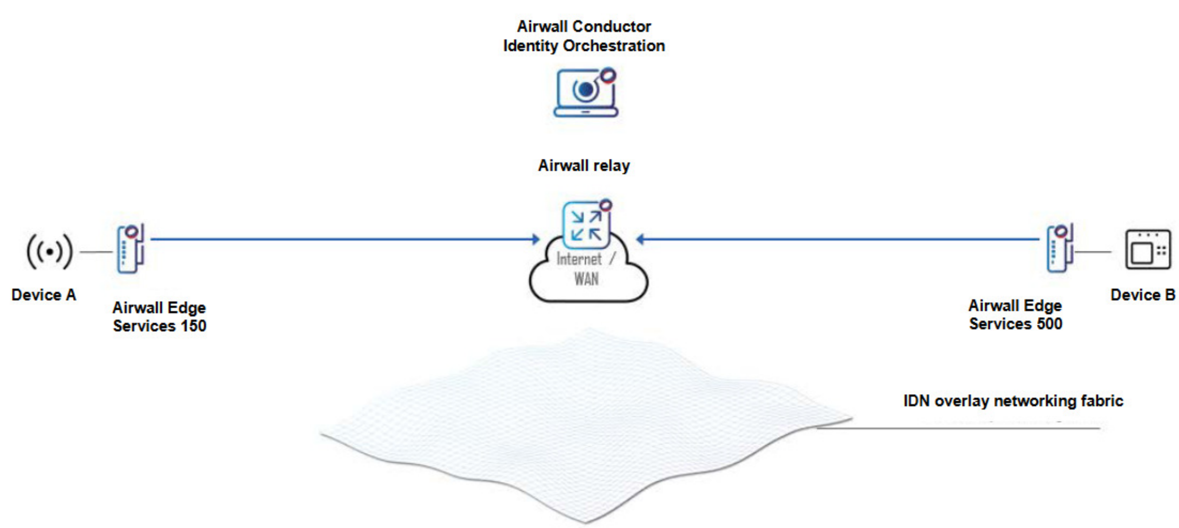
2.3 Wide-area Network Architecture Overview

This subsection provides an overview of the WANs that maintain communications between the WWTPs and pump stations.

2.3.1 WWTP WAN

In 2019 the Sewer Utility hired QCC to establish network connectivity between the OT networks at the remote WWTPs and the CKTP OT network. QCC implemented a solution from Tempered Networks that is founded on Host Identity Protocol (HIP) and proprietary software. The Tempered Networks Airwall system implemented for the Sewer Utility consists of hardware security appliances called HIPswitches that are installed at each WWTP, software agents installed on County laptops and tablets, a virtual security appliance called a HIPrelay that is hosted in a Microsoft Azure cloud instance, and the Tempered Networks Conductor software, which is also cloud-hosted. Figure 2-5 depicts a general overview of the core Tempered Networks Airwall system components. A high-level network diagram of the Tempered Networks Airwall system implemented for the Sewer Utility is depicted on QCC drawing N-00 in Appendix C.

Figure 2-5. Tempered Networks Airwall system general overview diagram



Source: Tempered Networks.

The Tempered Networks Airwall system is configured to deny all communications by default. Through the use of HIP and proprietary software, the technology is designed to “cloak” network devices behind Airwall edge services (e.g., HIPswitches, software agents, and server agents) so that they are not discoverable by untrusted external devices using network scans, ping requests, and other traditional enumeration methods. The technology also functions as an overlay to existing network switch and router hardware infrastructure and can effectively bypass active configurations at these hardware instances that might otherwise prevent communication between remote devices. This feature can simplify management of the WAN, greatly reduce commissioning efforts when implementing within existing networks, and allow for micro-segmentation (i.e., the practice of logically dividing the network into several small segments based on workload or intended communication groups) that would otherwise require a significant network configuration and management effort to establish and maintain.

The Tempered Networks Conductor provides a web-based user interface for network managers to add trusted devices to user-defined groups, each of which can have specific security policies and permissions defined. Once security policies and permissions are in place, devices belonging to a group may communicate over an encrypted data plane that spans between Airwall edge services. Because the data plane spans the public Internet and typically involves two devices belonging to separate private networks, the HIPrelay is required to overcome this double Network Address Translation (NAT) scenario and to provide secure routing between the Airwall edge services. The HIPrelay does not decrypt the packets sent over the data plane, so the encryption remains intact between endpoints. The Airwall edge services are responsible for enforcing the security policies defined in the Conductor using an authenticated key exchange. They also manage encryption and decryption of outgoing and incoming packets, respectively.

At the time of this writing, the WWTP WAN is used by QCC only to provide remote programming and configuration services and by County staff to provide periodic remote monitoring of CKTP SCADA alarm screens. Data exchange between the SCADA systems at remote WWTPs and CKTP has yet to be implemented. Currently, Sewer Utility staff do not have a central location where all WWTP SCADA systems can be monitored and controlled. Sewer Utility staff must call the on-duty operator at the remote WWTPs to obtain plant process operation status and near real-time process values.

2.3.2 Pump Station VHF Licensed Radio WAN

This subsection describes the existing configuration, historical performance, and planned modifications of the Sewer Utility’s very high frequency (VHF) licensed radio WAN for the wastewater pump stations.

Existing Configuration

Most of the Sewer Utility’s pump stations within the wastewater conveyance system communicate with a master telemetry unit (MTU) at CKTP via VHF licensed radio. The MTU polls the pump station in a set round-robin sequence where each station is polled one at a time until the last station in the sequence is polled, then the sequence starts over from the beginning of the sequence. High-level network diagrams depicting the VHF licensed radio WAN and the repeaters involved in some of the radio paths are shown in QCC drawings N-02, N-03, N-04, and N-05 in Appendix C. These QCC drawings also depict some of the planned work between the Sewer Utility and QCC to move additional pump stations onto the cellular network and to modify the radio paths of the Manchester area pump stations to communicate with MWWTP instead of CKTP.

The Sewer Utility has standardized on CalAmp Viper SC 100 (depicted in Figure 2-6) and SC+ 100 radios for the pump station VHF licensed radio WAN. The radios have been configured to communicate using a frequency of 173.3125 megahertz (MHz) and a 6.25-kilohertz (kHz) channel bandwidth. The County has an active license with the Federal Communications Commission (FCC) for this frequency, which is set to expire in July 2024.

Figure 2-6. CalAmp Viper SC 100 VHF radio

Source: CalAmp.

Some of the benefits of VHF include longer range and better penetration of trees and other foliage when compared to higher frequency ranges. Given that FCC restrictions on antenna mounting heights likely rule out line-of-sight radio paths for most, if not all, of the pump stations, VHF is likely to be more tolerant of the non-ideal radio paths within the Sewer Utility's licensed radio WAN than higher-frequency range alternatives. In theory, the licensed frequency should also eliminate noise resulting from competing signals produced by other entities operating within the same frequency range.

One of the significant limitations of VHF and lower frequency ranges, in general, is lower bandwidth. This means that the VHF radio paths within the Sewer Utility's licensed radio WAN take considerably longer than higher frequency alternatives to communicate the same amount of data. While the current volume of data exchange occurring over the Sewer Utility's licensed radio WAN is limited, the lower bandwidth contributes to longer polling cycle times (i.e., the time it takes for the MTU to complete one round of transmitting and receiving data to and from each pump station). Sewer Utility staff have indicated that it can take the MTU roughly 8 minutes to complete a polling cycle, which means that the CKTP SCADA system is receiving updates for pump station statuses and alarms only every 8 minutes or so, assuming that all communication attempts are successful. If communication attempts are unsuccessful, then updates for a given pump station may occur at intervals greater than 16 minutes. These delays in communication of pump station statuses and alarms have presented challenges to County staff in providing timely responses to critical pump station alarms and accurate calculations of accumulated equipment runtimes.

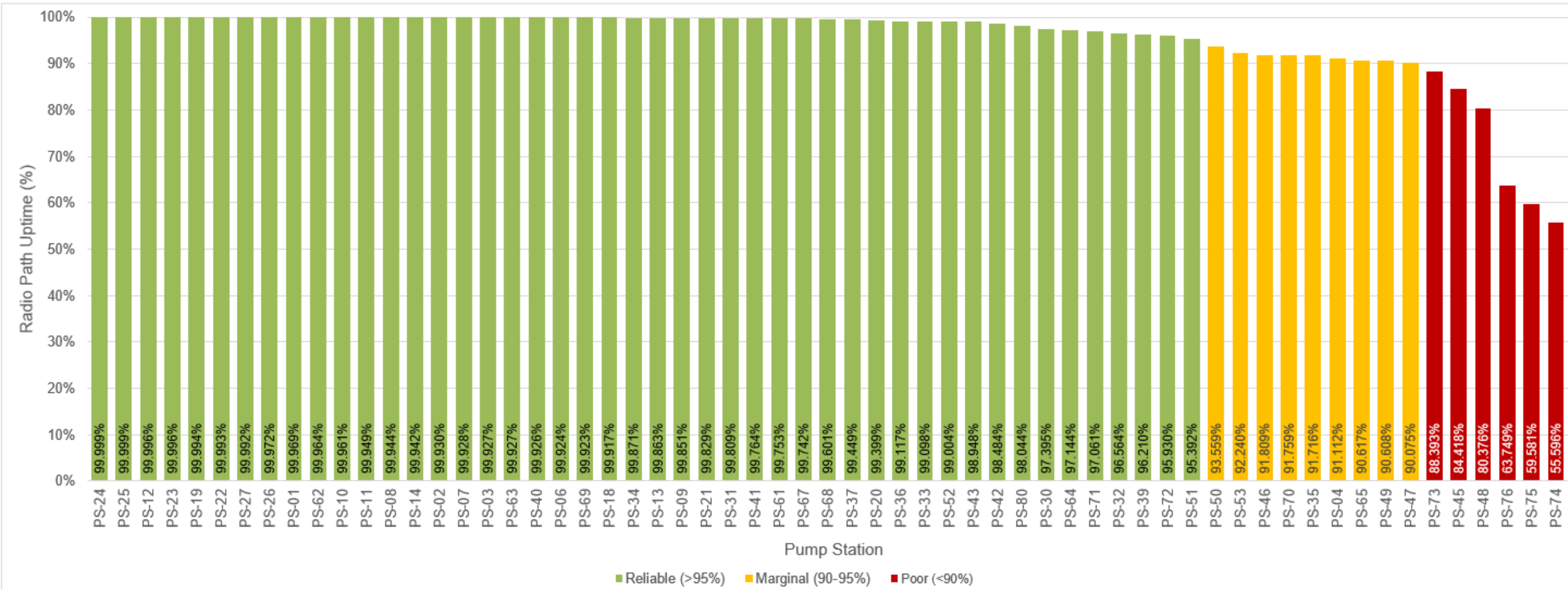
The Sewer Utility has expressed a desire to move toward more real-time monitoring and alarming for the pump stations. Furthermore, the recommendations that are anticipated to come from the ongoing Sewer Utility SCADA Master Plan will likely include increasing the amount of data exchanged between the pump stations and the CKTP SCADA system. Decreasing polling cycle times while supporting increased data exchange over the Sewer Utility's pump station WAN will likely not be achievable using VHF-based telemetry.

The Sewer Utility has also indicated that some pump stations experience poor communications on the VHF licensed radio WAN. The County considers improving the communications for these sites a high priority so that status and alarms are communicated more frequently and communication loss alarms have significance and are not a nuisance for staff.

Historical Performance

To better quantify the performance of the pump station VHF licensed radio WAN, HDR obtained 2 years' worth of communication data from the CKTP historian for the period between August 24, 2018, and August 24, 2020. During this period, the median polling cycle time was 8 minutes and 41 seconds, which aligns with information obtained from Sewer Utility staff. Uptime percentages were calculated for each pump station radio path based on the ratio of successful versus attempted data exchanges between the MTU and pump station PLCs. The radio path uptime percentages for each station are presented in Figure 2-7.

Figure 2-7. Pump station VHF licensed radio WAN radio path uptime percentages



Notes:

a. Radio path uptime calculations are based on historical data obtained between 8/24/2018 and 8/24/2020.

b. PS-17 has been on the cellular WAN for more than half of this period and is excluded from the figure.

As depicted in Figure 2-7, six of the pump stations were found to have poor communications. Two of these pump stations (PS-75 and PS-76) have already been added to the pump station cellular WAN described in the following subsection. PS-04 has also been added to the pump station cellular WAN. Based on discussions with Sewer Utility staff, the upgrade to cellular communications has greatly improved the reliability of communications with these pump stations.

The PLC that serves as the MTU for the VHF licensed radio WAN is programmed to generate a new value for a “watchdog” parameter for each pump station on every polling cycle. These “watchdog” parameter values, which are logged in the CKTP historian, were used to determine the timing of the polling cycles for Figure 2-7. The MTU PLC is also programmed to update a communication efficiency parameter for each pump station based on the outcome of the data exchange between the MTU PLC and the PLC at the pump station during each polling cycle. If the data exchange is successful, 0.1 is added to the communication efficiency parameter value (with the value restricted to an upper bound of 100.0), while 0.1 is subtracted from the communication efficiency parameter value when the data exchange fails. The pump station communication efficiency parameter values are displayed at the CKTP SCADA HMI and logged in the CKTP historian.

While these values are helpful for locating failed communication attempts when reviewing historical data, the values themselves do not accurately represent “communication efficiency” and may be misrepresenting the performance of the various radio paths to Sewer Utility staff. Consider a scenario where there are 20 successful and 20 unsuccessful data exchange attempts within a given period. At the end of this period, the communication efficiency parameter value may have returned to the same value it had at the beginning of the period. If that value was 75.0, for example, staff may be led to believe that 75.0 percent of data exchange attempts have been successful.

Planned Modifications

Historically, communications for Manchester area pump stations have been poor because of the surrounding terrain and dependence on multiple repeaters along the communication paths. Currently, these stations communicate with the CKTP MTU radio. QCC has installed an industrial VHF radio within the MWWTP operations building electrical room and an omnidirectional antenna near the southwest corner of the building. The radio was not connected to the MWWTP OT network during HDR’s site visit. The new radio and antenna are in preparation for modifying the VHF radio paths of the Manchester area pump stations to communicate with this new radio at MWWTP. QCC and the Sewer Utility are planning to have the MWWTP PLC handle data exchange for the Manchester area pump stations and to relay that data exchange to CKTP over the Tempered Networks WWTP WAN.

2.3.3 Pump Station Cellular WAN

The Sewer Utility has subscribed to Verizon Wireless’s Private Network service and contracted with QCC to implement a 4G Long-Term Evolution (LTE) cellular WAN for the Sewer Utility’s wastewater pump stations. A high-level network diagram depicting the cellular WAN is presented in QCC drawing N-01 in Appendix C. As shown in QCC’s network diagram, QCC has cut over four of the Sewer Utility's pump stations to use the new cellular WAN as a primary communications path and there are plans to cut over seven additional pump stations in the near future. The Sewer Utility is leaving the VHF licensed radio equipment in place at the pump stations that are added to the cellular WAN so that the pump stations can fail over to the VHF licensed radio WAN in the event of a prolonged cellular communications outage.

The Sewer Utility has standardized on Cradlepoint IBR600C Series cellular routers for the pump station cellular WAN (see Figure 2-8). These routers are equipped with a 1-gigabit Ethernet (GbE) local area network (LAN) port, support virtual private network (VPN) tunnels, and have 75-megabit per second (Mbps) throughput capability. The routers also have a rugged enclosure and an extended operating temperature range, making them suitable for installation within the industrial control panel environments found at the Sewer Utility's pump stations.

Figure 2-8. Cradlepoint IBR600C Series cellular router

Source: Cradlepoint.

The Sewer Utility's cellular WAN has a dedicated MTU PLC that manages data exchange between the pump stations and the CKTP SCADA system. A cursory review of the PLC's programming suggests that QCC and the Sewer Utility are implementing a report-by-exception telemetry scheme for the pump stations on the cellular WAN. Under this scheme, the pump stations initiate data exchange based on a change in status or process values with the MTU PLC programmed to poll any pump station that has not initiated data exchange within a set period. The report-by-exception scheme can significantly reduce the volume of data traversing the WAN, which also reduces the data usage charges on the Sewer Utility's monthly bill(s) from Verizon Wireless. The scheme can also reduce CKTP historian workload by filtering out static status and process values at the WAN periphery.

Unlike the VHF licensed radio WAN, the CKTP SCADA system does not appear to be accurately recording communication status data for the pump stations on the cellular WAN. Historical SCADA data reviewed by HDR showed static values for communication efficiency and "watchdog" parameters at the four pump stations communicating via the cellular WAN. Tracking parameters related to the quality of communications for pump stations on the cellular WAN is recommended so that the County has historical reference for communications at all sites.

Given the data throughput capabilities of the Sewer Utility's cellular routers, and 4G LTE cellular technology in general, the Sewer Utility's pump station cellular WAN provides a means of tightening the data gaps and eliminating the long polling cycle times that hinder the Sewer Utility's VHF licensed radio WAN. The cellular WAN should also be capable of supporting the increased data exchange anticipated from recommendations to come in subsequent phases of the Sewer Utility SCADA Master Plan. It should be noted that cellular reception may not be sufficient at every pump station to make the pump station's inclusion in the cellular WAN viable. In general, cellular signal strength surveys should be performed at pump stations to gauge the feasibility of cellular communications prior to implementation.

- Currently, Sewer Utility staff do not have a central location where all WWTP SCADA systems can be monitored and controlled.
- Pump stations on the VHF licensed radio WAN experience long delays in communication of pump station statuses and alarms, which have presented challenges to County staff in providing timely responses to critical pump station alarms and accurate calculations of accumulated equipment runtimes.
- The lower bandwidth inherent in VHF-based telemetry is ill-suited for increased data exchange between the pump stations and the CKTP SCADA system and would constrain the Sewer Utility's objective of near real-time monitoring and alarming for wastewater pump stations.
- Four of the six pump stations with historically poor VHF communications remain on the VHF licensed radio WAN. Planned modifications for the Manchester area pump stations may improve communications for those pump stations.
- The pump station communication efficiency parameter values displayed at the CKTP SCADA HMI and logged in the CKTP historian may be misrepresenting actual VHF licensed radio WAN radio path performance because of the calculations used in the MTU PLC programming.
- The CKTP SCADA system does not appear to be accurately recording communication status data for the pump stations on the cellular WAN.

2.4 Network Cabling

This subsection describes the network cabling installed at the Sewer Utility's WWTPs and wastewater pump stations.

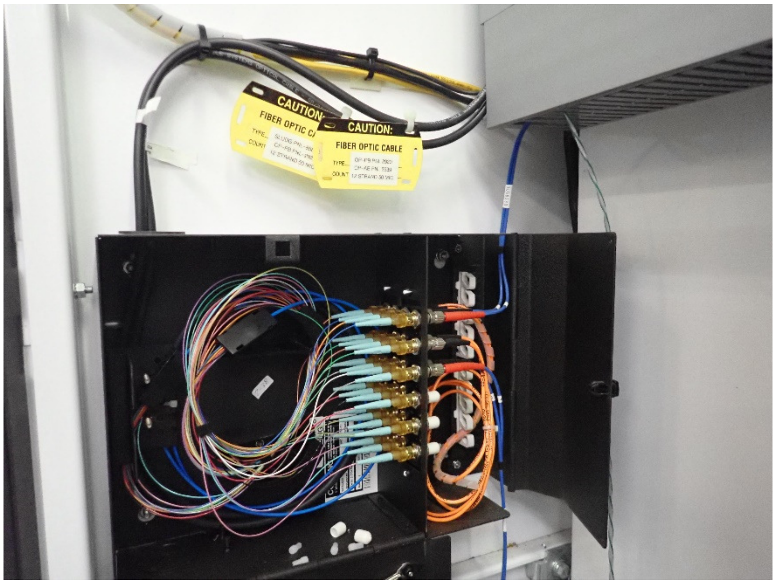
2.4.1 Central Kitsap Treatment Plant

Ethernet cabling within the CKTP OT network consists of multi-mode fiber-optic cables and a variety of copper Category cables. Among the fiber-optic cables, a mix of 62.5/125-micron (µm) (Optical Multi-mode 1 [OM1]) multi-mode fiber and laser-optimized, 50/125 µm (Optical Multi-mode 3 [OM3]) multi-mode fiber is installed at CKTP and the Sewer Utility has standardized on straight-tip (ST) connectors for fiber-optic cable terminations at fiber-optic patch panels. OM1 and OM3 fiber have a distance limitation of 275 meters and 550 meters, respectively, for 1 GbE throughput. GbE has replaced fast Ethernet (with a theoretical throughput of 100 Mbps) as the default base speed provided for modern PC and server network interface cards (NICs). Industrial automation manufacturers are following suit, and GbE network interfaces are becoming more common throughout the automation industry. As data volumes increase because of the proliferation of IP-based communications in industrial networks, it will become critical that fiber-optic networks can support GbE throughput, at a minimum, in the coming years.

Fortunately, the distances of the multi-mode fiber-optic cables observed at CKTP appear to be well below the GbE distance limitation thresholds. Assuming that the fiber-optic strands within these cables have not been damaged, the existing cables should support near-term modifications and upgrades to the OT network that affect their respective endpoints. However, it should be noted that OM1 fiber-optic cable has a distance limitation of 33 meters for 10 GbE throughput (the next higher Institute of Electrical and Electronics Engineers [IEEE] standard for Ethernet speed), so the existing OM1 cables will not support future 10 GbE network connections, if and when the CKTP OT network requires them.

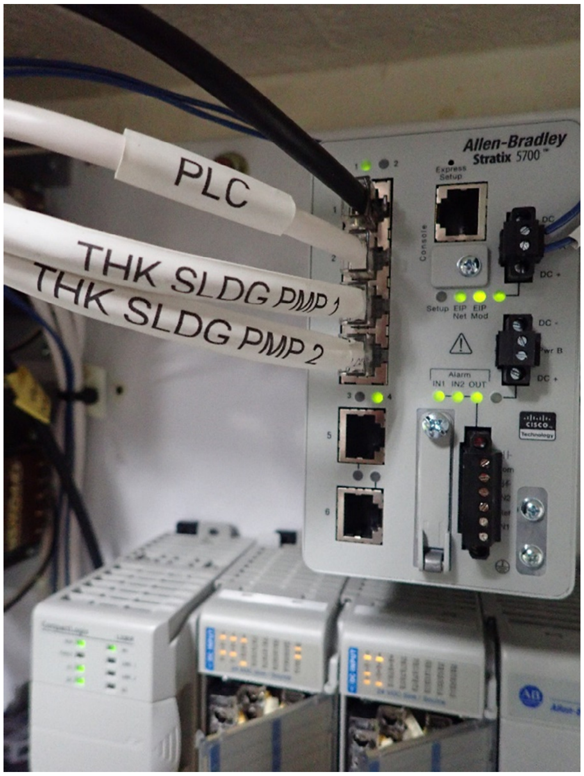
During its site visits, HDR noticed that an OM1 patch cord (the orange patch cord shown in Figure 2-9) was used to connect two OM3 cables at the fiber-optic patch panel within PNL 2920 in the power/blower building. Mixing OM1 and OM3 fiber-optic cables can result in severe losses at the connection points because of mismatches in the core sizes of the two fiber strands (50 µm versus 62.5 µm). This OM1 patch cable should be replaced with a suitable OM3 patch cable.

Figure 2-9. OM1 patch cord used to patch OM3 cables in PNL 2920



Most of the copper Ethernet cabling at CKTP is unshielded twisted pair (UTP) Category cable. There are instances where shielded, 600-volt (V)-rated Category 6 cable is used to connect IP nodes installed within motor control centers (MCCs) or other 480-volt alternating current (VAC)-rated equipment enclosures, but this best practice has not been adhered to in all cases. Figure 2-10 presents an example from PNL 6000 in the digester control building, where the control panel's network switch receives two UTP Category cables from VFDs located within an adjacent electrical enclosure. These cables are most likely rated for 300 V and installing them within an enclosure that houses electrical equipment powered from a higher voltage than the cables' insulation rating without proper separation is a National Electrical Code (NEC) violation. Shielding of copper Ethernet cables is important, when run in parallel with power cables or within power equipment enclosures, to mitigate outside interference (particularly from VFDs) that may impact data integrity and to prevent induced voltage on the cable's conductors that could damage sensitive electronics and create personnel and fire safety issues.

Figure 2-10. UTP cable received from 480 VAC VFD enclosure



2.4.2 Kingston Wastewater Treatment Plant

Ethernet cabling within KWWTP is exclusively copper cable. Shielded Category 6 cable is used for network connections between buildings and to connect IP nodes installed within MCCs. The remainder of the Ethernet cabling is UTP Category cable. Aside from the incoming fiber-optic Internet service from Kitsap Public Utility District (KPUD), described in Section 2.8 below, no fiber-optic cable is installed at KWWTP.

2.4.3 Manchester Wastewater Treatment Plant

Ethernet cabling within MWWTP is exclusively copper, UTP Category cable. Aside from the incoming fiber-optic Internet service from KPUD, described in Section 2.8 below, no fiber-optic cable is installed at MWWTP.

2.4.4 Suquamish Wastewater Treatment Plant

Ethernet cabling within SWWTP is exclusively copper cable. Shielded Category 5e cable is used for network connections between the three sludge pump VFDs and the network switch in CP-01. HDR did not confirm the insulation rating of these cables. Aside from the incoming fiber-optic Internet service from KPUD, described in Section 2.8 below, no fiber-optic cable is installed at SWWTP.

2.4.5 Pump Stations

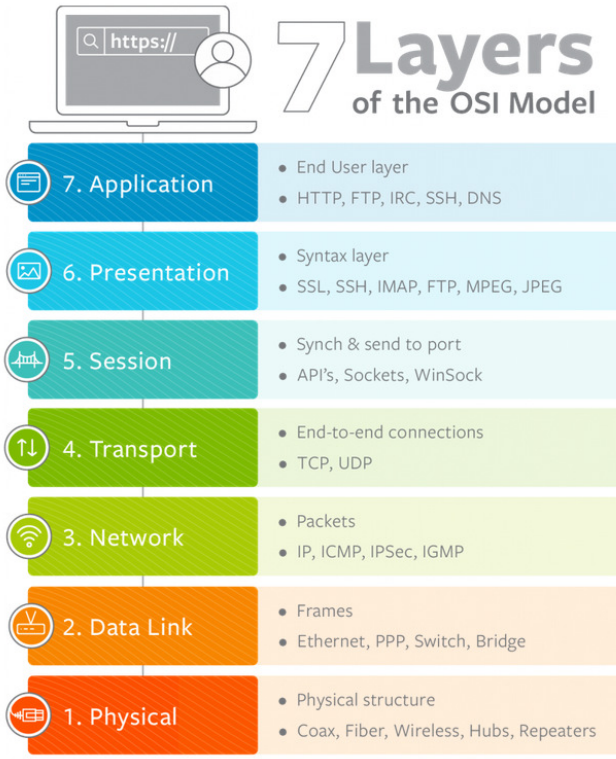
Ethernet cabling at the pump stations is limited and, where found, appears to be exclusively copper, UTP Category cable. HDR observed UTP Category cable connecting the VFDs for PS-67 pumps to the network switch in the station's control panel. HDR did not confirm the insulation rating of these cables. As previously mentioned, copper Ethernet cables routed near power cables and/or connecting IP nodes within 480 VAC equipment enclosures should be shielded and have a 600 V insulation rating. No fiber-optic cable appears to be installed at the pump stations visited by HDR.

- An OM1 fiber-optic patch cable has been used to patch two OM3 fiber-optic cables at the fiber-optic patch panel within PNL 2920 in the CKTP power/blower building. This patch cable should be replaced with a suitable OM3 patch cable.
- There are instances of UTP Category cables with insufficient voltage insulation ratings connecting IP nodes within 480 VAC equipment enclosures at CKTP and PS-67.

2.5 Network Switches

A variety of managed (Layer 2) and unmanaged network switches exist throughout the Sewer Utility OT networks. For reference, Layer 2 refers to a specific layer within the Open Systems Interconnection (OSI) Model (see Figure 2-11), which was developed to help establish order through the use of standard protocols in a wildly diverse technological marketplace. Unlike Layer 3 or multilayer switches, Layer 2 switches deal only with the Data Link and Physical layers and do not recognize IP addressing or other packet headers within the frames they traffic. In basic terms, this means that they are incapable of routing. However, their Layer 2 management functionality provides several benefits when compared to unmanaged switches, as discussed in the following paragraphs.

Figure 2-11. OSI Model summary



Source: BMC Software, Inc.

Most of the unmanaged switches are installed in vendor control panels, which is a fairly common practice because vendors often default to unmanaged switches to reduce costs and simplify integration of their systems with existing industrial networks. However, there are a few instances where unmanaged switches have been installed at more critical locations within the OT networks—an example of this being the unmanaged switch serving the CKTP SCADA PCs discussed in Section 2.2 above.

In addition to the filtering of broadcast and multicast packets mentioned previously, managed switches provide several other benefits, including the following:

- Means of segmenting the network to avoid exposing devices to traffic from other devices they were never intended to communicate with
- Monitoring of network traffic to help troubleshoot network upsets
- Implementation of more resilient network architectures like ring and redundant star topologies
- Prioritization of specific traffic over other network traffic when bandwidth capacity is reached
- The ability to disable unused ports
- Mitigation of several common network security risks

A list of unmanaged switches that are recommended for replacement with managed switches is included in Table 2-1.

Table 2-1. Unmanaged switches recommended for replacement

Facility	Location	Panel	Manufacturer	Model
CKTP	Administration and lab building network closet	N/A	N-Tron	112FX4
CKTP	SPB control room	Master station CTU	N-Tron	108TX
CKTP	SPB control room	Network cabinet	N-Tron	526FX2
CKTP	Trailer 103 I&C technician office	N/A	Netgear	ProSAFE GS105E
CKTP	Headworks electrical room	PNL 1050	N-Tron	526FX2

For most network switches within its OT networks, the Sewer Utility appears to have standardized on N-Tron (acquired by Red Lion in 2010) industrial DIN-rail-mountable switches. N-Tron 700 Series switches appear to be the most prevalent product line of the manufacturer's offerings found at Sewer Utility facilities, though there does not appear to be standardization on a specific model within that product line. An example of one of the switches within the 700 Series product line found at Sewer Utility facilities is depicted in Figure 2-12.

Figure 2-12. N-Tron 716TX industrial managed Ethernet switch

Source: Red Lion.

The N-Tron 700 Series switches are managed (Layer 2) switches that have rugged enclosures and support a broader operating temperature range than more conventional network switches designed for office, server room, or communications closet environments. Among the management features available with these switches are Quality of Service (QoS), Internet Group Management Protocol (IGMP) snooping (a critical feature for filtering undesirable multicast traffic, as discussed previously), per-port virtual local area network (VLAN) configuration, and support for Simple Network Management Protocol (SNMP) management and monitoring. All ports on these switches are 10/100BaseTX or 100BaseFX ports, so the existing IP nodes at Sewer Utility facilities with GbE NICs have their potential throughput effectively capped at the theoretical 100 Mbps limit inherent in the 700 Series switch ports. As data volumes increase with the anticipated proliferation of IP nodes within the Sewer Utility's OT networks in the coming years, the port speeds supported by these switches may become a limiting factor.

Another notable network switch product within the CKTP OT network is the N-Tron 7900 Series switches installed within PNL 8580A in the SPB control room (see Figure 2-13). Like the 700 Series switches, these network switches are managed (Layer 2), DIN-rail-mountable, have rugged enclosures, and support a relatively broad operating temperature range. The switches also benefit from the same management features included with 700 Series switches. Where the 7900 Series switches differ is in their modular design, which allows for customizable fiber-optic or copper switch port arrangements. The 7900 Series switches also feature two 1 GbE fiber-optic ports on the processor module.

Figure 2-13. N-Tron 7900 Series modular, industrial, managed Ethernet switch

Source: Red Lion.

As part of its condition assessment site work, HDR was able to obtain access to the web-browser-based management interface for several of these Ethernet switches using the manufacturer's default username and password. Because default usernames and passwords are easily discoverable on the Internet, information security industry standard practice for hardening network devices includes changing device login credentials to disable access via default username and password combinations. HDR recommends establishing new login credentials for theses switches and disabling access via the manufacturer's default username and password.

- Several unmanaged switches at CKTP are recommended for replacement with managed switches to mitigate risks to network stability and security.
- The Sewer Utility has not standardized on a specific managed switch, which can lead to stocking of additional spare switches to facilitate rapid switch replacement in the event of switch failure.
- All ports on most switches throughout the Sewer Utility OT networks are capping connected devices at the theoretical 100 Mbps limit inherent in the switch ports. As data volumes increase within the Sewer Utility's OT networks in the coming years, the port speeds supported by these switches may become a limiting factor.

✸ Several managed switches on Sewer Utility OT networks are accessible via manufacturer default username and password.

2.6 On-Premises Wireless Access to OT Networks

At CKTP, the Sewer Utility has implemented a wireless extension of the OT network using a 5-gigahertz (GHz) Wi-Fi base station and access points from Ubiquiti. The base station installed within the SPB control room (see Figure 2-14) has been configured for point to multi-point communications with two access points installed at trailer 103 and the operations facilities building at the north end of CKTP. This wireless application appears to be solely for the purpose of providing OT network connectivity for three SCADA PCs located in trailer 103 and the operations facilities building. HDR does not believe that the Sewer Utility is currently using the installed access points to provide Wi-Fi access to Sewer Utility staff mobile devices. The Ubiquiti base station and access points also do not appear to be broadcasting Service Set Identifiers (SSIDs), which increases the network's security by not advertising its existence to nearby Wi-Fi cable devices.

Figure 2-14. Ubiquiti Rocket Prism 5AC Gen 2 5 GHz access point

Source: Ubiquiti Networks.

Without OT network access via mobile devices while on-site, operators can access CKTP OT network IP nodes only via SCADA PCs and available ports at OT network access switches. Operators can also access SCADA HMI screens via HMI thick client panel PCs installed in the enclosure doors of control panels in the headworks building, power/blower building, aeration basin electrical building, reclaimed-water building, and waste activated sludge (WAS) thickening building. Though not implementing wireless access to the OT networks for mobile devices eliminates some common potential attack vectors that can be exploited by malicious actors, it also eliminates one method of implementing tablet-based workflows for Sewer Utility staff, which can improve workforce efficiency and increase staff engagement with ICS software.

Wireless access to the OT networks via Wi-Fi technology has not been implemented at KWWTP, MWWTP, or SWWTP. At these WWTPs, Sewer Utility staff must use the SCADA PC in the plant control room or physically connect to an available port at one of the OT network access switches to interact with IP nodes on the plant OT network.

> ✷ The Sewer Utility has not implemented on-site tablet-based workflows for Sewer Utility staff, which can improve workforce efficiency and increase staff engagement with ICS software.

2.7 Network Segmentation and Segregation

This subsection describes the network segmentation and segregation practices within the Sewer Utility OT networks.

2.7.1 Segmentation

This subsection describes the network segmentation practices within the Sewer Utility OT networks.

Central Kitsap Treatment Plant

The CKTP OT network is configured as a single /24 subnet allocated from the County's public IP address range. No further segmentation of the network was observed. Though the IP nodes within the CKTP OT network should not be directly reachable from the public Internet, having IP addresses that are routable from the public Internet is a significant security risk. Misconfiguration of a switch or security appliance or inadvertent connection of the OT network to an Internet-facing network like the CKTP business LAN could potentially expose devices on the OT network to the public Internet, making them reachable by anyone in the world with an Internet connection. Standard practice for securing ICS networks includes assigning ICS IP nodes private IP addresses, which are not routable from the public Internet.

The size of the CKTP OT subnet presents another concern in terms of future growth and development of the network. As a /24 subnet, the CKTP OT network is restricted to 254 usable IP addresses, which limits the number of IP-capable devices communicating on the network to 254. Though the Sewer Utility has yet to reach this number of connected devices, the number of devices on the CKTP OT network is expected to grow considerably in the coming years. The industrial automation industry has embraced IP-based communications, and demand for more robust data exchange between ICS devices and software platforms is driving a proliferation of IP devices in ICS networks. The Sewer Utility will require a larger pool of IP addresses to support this industry trend and benefit from the data that newer IP-based technologies can provide.

Suquamish Wastewater Treatment Plant

The SWWTP OT network is also configured as a single /24 subnet allocated from the County's public IP address range. No further segmentation of the network was observed. Though the IP nodes within the SWWTP OT network should not be directly reachable from the public Internet, the same security risk introduced by assigning public IP addresses to ICS devices that was discussed for the CKTP OT network also applies to the SWWTP OT network.

Because of the small size of SWWTP, the connected device limitation of a /24 subnet is not likely to constrain near-term potential growth of the plant's OT network. Because the current network is small in scale and all IP nodes on the network are part of the ICS, further segmentation of the OT network is not recommended at this time. Segmenting an already small network of closely related devices would introduce complexity and maintenance requirements that would likely outweigh any security or performance enhancements that could be achieved from separating the IP nodes into different broadcast domains.

Kingston and Manchester Wastewater Treatment Plants

The KWWTP and MWWTP OT networks are configured as single Class C networks using a private IP address range. No further segmentation of the networks was observed. The assignment of private IP addresses to devices within these OT networks adds a layer of security and is consistent with standard practice for securing ICS networks.

Because of the small size of KWWTP and MWWTP, the connected device limitation of a /24 subnet is not likely to constrain near-term potential growth of the plants' OT networks. Because the current networks are small in scale and all IP nodes on the networks are part of the ICS, further segmentation of the OT networks is not recommended at this time. Segmenting an already small network of closely related devices would introduce complexity and maintenance requirements that would likely outweigh any security or performance enhancements that could be achieved from separating the IP nodes into different broadcast domains.

Pump Station VHF Licensed Radio Network

Each pump station has been allocated a single /24 subnet using a private IP address range. At CKTP, a separate /24 subnet also using private IP addresses has been assigned for the devices involved in the pump station telemetry. This CKTP subnet is distinct from the subnet used for the remainder of the CKTP OT network. Finally, a separate /24 subnet has been assigned to the VHF licensed radio network, also using a private IP address range. All of these subnets share the same first two octets in their IP addresses, which was most likely done to simplify the subnet scheme and its documentation.

Under this subnet scheme, IP devices within the pump stations are assigned IP addresses from the station's subnet, while the external-facing interface on the VHF radios is assigned an IP address from the radio network subnet. Similarly, at CKTP, the MTU PLCs and dedicated interfaces at the SCADA PCs have been assigned IP addresses from CKTP's pump station telemetry subnet, while the external-facing interface on the CKTP VHF radio is assigned an IP address from the radio network subnet. The VHF radios have been configured to handle routing between the various subnets via entries made within the radio routing tables. In this way, the Sewer Utility can restrict communication between devices in different subnets to the devices that need to communicate only. Based on the few VHF radio configurations reviewed during HDR's site visits, HDR believes that the VHF radio routing tables have been configured to limit communication over the VHF licensed radio network to communication between the VHF radio MTU PLC at CKTP and each pump station remote telemetry unit (RTU). Communication between devices at different pump stations, for example, does not appear to be permitted given current routing table configurations.

Pump Station Cellular Network

The LAN interfaces of the cellular routers installed at Sewer Utility pump stations and CKTP are assigned IP addresses belonging to the same subnets used for the pump station VHF licensed radio network. The MTU PLC responsible for the cellular telemetry at CKTP has also been assigned an IP address within the CKTP pump station telemetry subnet. The actual cellular communications between the cellular routers occur over the Sewer Utility's cellular provider's network. The cellular carrier's management of this communication is discussed in more detail under Section 2.7.3 below.

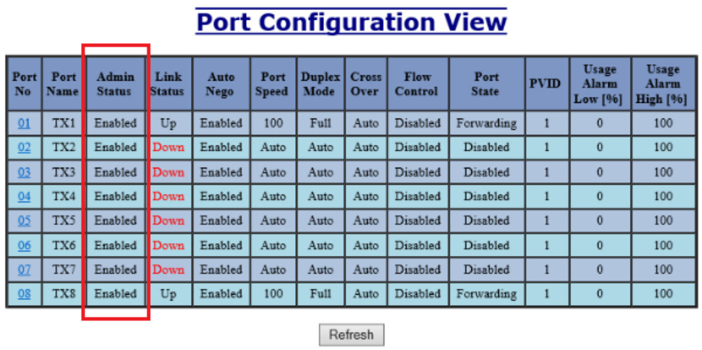
Tempered Networks WWTP WAN

The LAN interfaces of the Tempered Networks HIPswitches installed at Sewer Utility WWTPs are assigned IP addresses belonging to the same subnets used for the WWTP OT networks. The external-facing interfaces on the HIPswitches are assigned public IP addresses. All trusted devices situated behind the HIPswitches at the Sewer Utility WWTPs are part of the OT network for that WWTP and have been assigned IP addresses from the WWTP OT network subnets. As discussed in Section 2.3 above, the Sewer Utility's HIPrelay handles routing between devices within the various subnets.

2.7.2 Unused Access Ports

During its site visits, HDR performed a cursory review of the configurations for a selection of the managed network switches found within the Sewer Utility's WWTPs. All managed Ethernet switch ports reviewed are currently enabled and assigned to default VLAN 1. As an example, the port configuration screen for the managed switch in the MWWTP influent pump station control panel is shown in Figure 2-15. Under the Admin Status column (boxed in red), all ports are shown as enabled though only ports 1 and 8 are in use, as indicated by the adjacent Link Status column. Information security industry standard practice and National Institute of Standards and Technology (NIST) recommendations for ICSs include disabling unused ports as part of recommended network device hardening measures (NIST 2015). Though disabling unused ports is the primary means of securing unused switch ports, assigning unused switch ports to an unused VLAN (i.e., black hole VLAN) can provide an additional layer of security from inadvertent connection errors and unauthorized network access.

Figure 2-15. Example managed switch port configuration screen



Port Configuration View

Port No	Port Name	Admin Status	Link Status	Auto Nego	Port Speed	Duplex Mode	Cross Over	Flow Control	Port State	PVID	Usage Alarm Low [%]	Usage Alarm High [%]
01	TX1	Enabled	Up	Enabled	100	Full	Auto	Disabled	Forwarding	1	0	100
02	TX2	Enabled	Down	Enabled	Auto	Auto	Auto	Disabled	Disabled	1	0	100
03	TX3	Enabled	Down	Enabled	Auto	Auto	Auto	Disabled	Disabled	1	0	100
04	TX4	Enabled	Down	Enabled	Auto	Auto	Auto	Disabled	Disabled	1	0	100
05	TX5	Enabled	Down	Enabled	Auto	Auto	Auto	Disabled	Disabled	1	0	100
06	TX6	Enabled	Down	Enabled	Auto	Auto	Auto	Disabled	Disabled	1	0	100
07	TX7	Enabled	Down	Enabled	Auto	Auto	Auto	Disabled	Disabled	1	0	100
08	TX8	Enabled	Up	Enabled	100	Full	Auto	Disabled	Forwarding	1	0	100

Refresh

2.7.3 Segregation

This subsection describes the network segregation practices within the Sewer Utility OT networks.

Central Kitsap Treatment Plant

During its site visits, HDR observed that the unmanaged access switch serving the SPB SCADA PCs, CKTP historian, and other OT network devices is connected to a managed switch used by the CKTP business LAN. Both switches are located in the SPB control room network cabinet. Depending on how the business LAN switch is configured, the CKTP OT network may be exposed to PCs and other devices on the business LAN that have Internet access and can present a security risk to the OT network if given direct access. HDR did not review the configuration of this managed switch, but considers a direct connection between the business LAN and OT network a significant security risk for the OT network that should be remedied.

HDR also observed a cellular router connected to the same OT network unmanaged access switch in the SPB control room network cabinet (see Figure 2-16). Based on discussions with Sewer Utility I&C technicians, the purpose of this cellular router is unknown and the router is believed to have been left behind by an equipment vendor or past systems integrator. Sewer Utility staff do not recall having granted permission for the router to be installed on the OT network. The cellular router presents a significant risk to the CKTP OT network as it can serve as a backdoor into the network, bypassing security measures implemented by the CKTP HIPswitch and other security appliances that may be in place within KPUD's Carrier Ethernet network. The Sewer Utility also has no control over the security of the device or devices that may be connecting to the CKTP OT network via this cellular router, so any vulnerabilities inherent with those devices or any malware present on the devices could easily be shared with the Sewer Utility's network. After a discussion of the potential security risks presented by the cellular router, Sewer Utility staff powered down the device and disconnected it from the network.

Figure 2-16. TP-Link MR3040 cellular router connected to OT network unmanaged switch

Suquamish Wastewater Treatment Plant

During its site visits, HDR observed that the secure gateway used to provide Internet connectivity to a wireless access point on the SWWTP business LAN is also connected to a managed switch on the SWWTP OT network. This managed switch, located in CP-01, is “behind” the Tempered Networks HIPswitch in the SWWTP OT network architecture. HDR did not review the configuration of the secure gateway to determine the level of segregation between the two networks provided by the gateway’s firewall functionality. However, allowing connection from the public Internet to the OT network through the secure gateway would effectively bypass any security controls implemented via the Tempered Networks WAN. Eliminating an unnecessary external access method to the SWWTP OT network would reduce the network’s attack surface by eliminating a potential entry point, allowing the Sewer Utility and its contractors to focus on maintaining the security of a single data conduit between the SWWTP OT network and external permissioned devices.

Kingston and Manchester Wastewater Treatment Plants

HDR did not observe instances of the OT networks and business LANs sharing physical network devices at KWWTP or MWWTP, nor were multi-homed PCs observed. The KWWTP and MWWTP OT networks appear to be physically and logically separated from the plant business LANs, which is consistent with information security industry recommended practices for ICSs.

Pump Station Cellular Network

The Sewer Utility's cellular provider is Verizon Wireless and the Sewer Utility has subscribed to the Verizon Wireless Private Network service, which has been deployed as a zero-tunnel configuration for machine-to-machine (M2M) applications. This service provides the Sewer Utility with a private cellular WAN for devices within the Sewer Utility's IP pool. The cellular WAN is segregated from the public Internet and the rest of the cellular carrier's network. Though this approach effectively outsources much of the WAN security to Verizon Wireless and requires trust in the cellular carrier's ability to maintain the segregation it advertises, it does provide a low-maintenance, economical means of establishing communication between CKTP and the remote pump stations with significantly higher data throughput than the VHF licensed radio network can offer.

- Public IP addresses are assigned to IP nodes within the CKTP and SWWTP OT networks.
- The subnet assigned to the CKTP OT network effectively limits the network to 254 connected devices. The Sewer Utility will require a larger pool of IP addresses to support additional devices in the future and adapt to the proliferation of IP devices that is becoming the norm in the industrial automation industry.
- Unused network switch ports are enabled and assigned to active VLANs throughout the Sewer Utility's OT networks.
- There is a direct connection between CKTP business LAN and OT network switches in the SPB control room network cabinet. This direct connection between the business LAN and OT network presents a significant security risk for the OT network.
- A cellular router was found connected to the unmanaged OT network switch in the SPB control room network cabinet. The device could provide a backdoor into the CKTP OT network for external devices that the Sewer Utility has no control over, bypassing security measures in place for the network. Sewer Utility staff have since disconnected the cellular router from the network.
- There appear to be parallel entry points to the SWWTP OT network from external networks: one via the plant's Tempered Networks HIPswitch and one via a secure gateway used for the plant business LAN wireless access point.

2.8 Internet Service

This subsection describes the Internet service for the Sewer Utility's wastewater facilities.

2.8.1 Central Kitsap Treatment Plant

CKTP receives Internet service from KPUD via a fiber-optic connection to KPUD's Carrier Ethernet network. This connection consists of a single strand of single-mode (Optical Single-mode 2 [OS2]) fiber. To facilitate the Sewer Utility's connection to its network, KPUD has installed a fiber-optic patch panel and a Carrier Ethernet access switch within the administration and lab building communications room. The patch panel receives the incoming fiber-optic cable from KPUD's network, which is patched to KPUD's Cisco ME 3400E Series Carrier Ethernet access switch that serves as the point of demarcation between the KPUD and Sewer Utility networks. The KPUD Internet service connection serves ingress and egress traffic from both the CKTP business LAN and OT network.

2.8.2 Kingston Wastewater Treatment Plant

To establish network connectivity between the KWWTP OT network and the CKTP OT network, the Sewer Utility contracted with KPUD for the installation of fiber-optic cable to KWWTP. KWWTP now receives Internet service from KPUD over this fiber-optic connection, which consists of a single strand of single-mode (OS2) fiber. To facilitate the Sewer Utility's connection to its network, KPUD has installed a fiber-optic patch panel and a Carrier Ethernet access switch within the operations building electrical room (see Figure 2-17). The patch panel receives the incoming fiber-optic cable from KPUD's network, which is patched to KPUD's Cisco ME 3400E Series Carrier Ethernet access switch that serves as the point of demarcation between KPUD and Sewer Utility networks.

Figure 2-17. KWWTP operations building electrical room communications backboard

The Sewer Utility has implemented a separate Internet service for the KWWTP business LAN, which consists primarily of a PC located in the operations building control room. Internet access for the business LAN is achieved via a Peplink PEPWAVE MAX BR1 mini-cellular router. HDR did not review configuration or security settings for this device.

2.8.3 Manchester Wastewater Treatment Plant

To establish network connectivity between the MWWTP OT network and the CKTP OT network, the Sewer Utility contracted with KPUD for the installation of fiber-optic cable to MWWTP. MWWTP now receives Internet service from KPUD over this fiber-optic connection, which consists of a single strand of single-mode (OS2) fiber. To facilitate the Sewer Utility's connection to its network, KPUD has installed a fiber-optic patch panel and a Carrier Ethernet access switch within the operations building electrical room (see Figure 2-18). The patch panel receives the incoming fiber-optic cable from KPUD's network, which is patched to KPUD's Cisco ME 3400E Series Carrier Ethernet access switch that serves as the point of demarcation between KPUD and Sewer Utility networks.

Figure 2-18. MWWTP operations building electrical room communications backboard

The Sewer Utility has implemented a separate Internet service for the MWWTP business LAN, which consists primarily of a wireless access point and a laptop located in the operations building control room. Internet access for the business LAN is achieved via a Motorola SB5120 cable modem. HDR did not review configuration or security settings for this device.

2.8.4 Suquamish Wastewater Treatment Plant

SWWTP receives Internet service from KPUD via a fiber-optic connection to KPUD's Carrier Ethernet network. This connection consists of a single strand of single-mode (OS2) fiber. To facilitate the Sewer Utility's connection to its network, KPUD has installed a fiber-optic patch panel and a Carrier Ethernet access switch within the process building electrical room (see Figure 2-19). The patch panel receives the incoming fiber-optic cable from KPUD's network, which is patched to KPUD's ADVA FSP 150CC-GE114 Carrier Ethernet access switch that serves as the point of demarcation between KPUD and Sewer Utility networks. The KPUD Internet service connection serves ingress and egress traffic from both the SWWTP business LAN and OT network.

Figure 2-19. SWWTP process building electrical room communications backboard

2.9 Remote Access

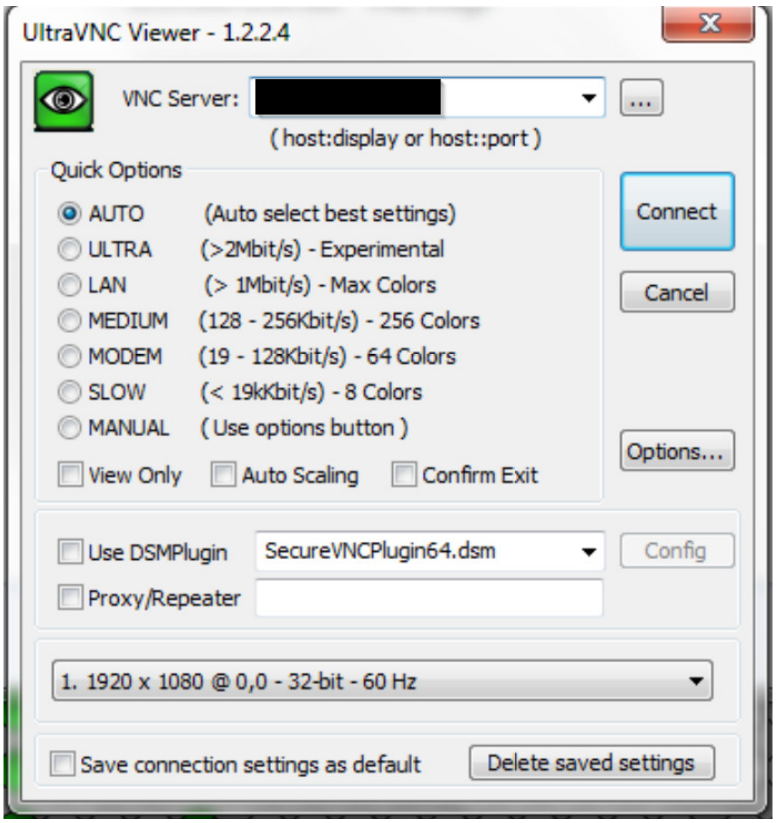
This subsection describes the remote access methods in place for the Sewer Utility's OT networks.

2.9.1 Central Kitsap Treatment Plant

The Sewer Utility has implemented remote access to the CKTP OT network for QCC, County Utilities group personnel, Sewer Utility I&C technicians, on-call operators, and the on-call supervisor. Currently, County Utilities group personnel and Sewer Utility on-call staff use County-issued tablets to access CKTP SCADA system alarm screens for review and acknowledgment of active alarms, the Utilities group personnel focusing on alarms pertaining to the pump stations. Sewer Utility I&C technicians use a County-issued laptop to access CKTP SCADA system screens for remote monitoring of the plant and to support troubleshooting efforts. QCC uses one of its programming laptops to access the CKTP OT network for online PLC programming modification, modifications to Wonderware screens and historian configuration, and other device configuration and maintenance services.

All remote access to the CKTP OT network occurs over the Tempered Networks WWTP WAN from trusted devices that have been added to the appropriate Airwall overlay network. Users on a trusted device initiate the remote access sessions by opening a Virtual Network Computing (VNC) application called UltraVNC Viewer on the trusted device and selecting the desired VNC Server over which to assume control (see screenshot in Figure 2-20). Typically, users select from one of the three SCADA PCs located in trailer 103 and the operations facilities building, but UltraVNC Server is installed on all SCADA PCs at CKTP so no measures are in place to prevent users from also taking control of those machines. After the user has selected a VNC Server, the user is then prompted for a common password shared by all users before remote control of the SCADA PC is granted. Once the VNC session is established, users must log onto Wonderware with their unique username and password to obtain the control and alarm acknowledgment permissions that have been established for them.

Figure 2-20. UltraVNC Viewer screenshot



VNC is founded on the Remote Frame Buffer (RFB) protocol, which is not a secure protocol. In the absence of encrypted tunnels, passwords exchanged over an unsecure network can be easily cracked by malicious actors. UltraVNC has an encryption plugin that strengthens the security of the application by providing encryption for the VNC sessions. HDR observed that this plugin has not been enabled for the UltraVNC Servers within the CKTP OT network (see the unchecked Use DSMPlugin box in Figure 2-20). Though the VNC sessions occurring over the Sewer Utility's Tempered Networks WWTP WAN benefit from the encryption inherent in the Tempered Networks Airwall system, enabling encryption of the VNC session itself within the UltraVNC application would provide another layer of security for the CKTP OT network.

However, the security risks inherent with VNC-based applications are rarely worth the benefit of the simplified approach to remote access that they offer. HDR recommends transitioning away from VNC sessions for remote access to the Sewer Utility's OT networks.

The practice of having one common password for all users to establish remote access sessions presents a security risk for the CKTP OT network. Common username and password scenarios do not allow for user authentication, authorization, or accounting (AAA). This means that the Sewer Utility has no means of positively identifying who is assuming remote control of a PC on the CKTP OT network. When users are not required to identify themselves (i.e., authentication), there is no means of limiting their permissions and access to network resources (i.e., authorization) or keeping track of their activity while on the network (i.e., accounting). Though the Sewer Utility requires user authentication for the CKTP Wonderware platform, remote users have full access to several other network resources once given control over a CKTP SCADA PC.

Though requiring unique username and password entry to establish remote access to the CKTP OT network would provide a significant boost to network security, this measure, alone, still leaves the CKTP OT network vulnerable to some common security risks like the loss or theft of tablets and laptops that are designated as trusted devices. Information security industry best practice is to require multi-factor authentication (MFA) prior to establishing a remote connection to ICS networks. For remote access applications, MFA requires the user to authenticate using two or more of the following:

- Something the user knows (e.g., a password)
- Something the user has (e.g., a mobile phone)
- Something the user is (e.g., retinal scan)

A common and effective MFA approach is the one taken by County Information Services for VPN connections to the County SharePoint site, which requires users to enter a unique username and password and then successfully enter a code they receive on their mobile phone via text message (i.e., something the user knows and something the user has).

2.9.2 Kingston, Manchester, and Suquamish Wastewater Treatment Plants

Sewer Utility staff do not currently access the KWWTP, MWWTP, and SWWTP OT networks remotely. However, the Tempered Networks Airwall system provides the necessary infrastructure for remote access to occur, as described previously for CKTP. Based on review of the Tempered Networks Conductor configuration, HDR believes that County and contractor tablets and laptops already have access to specific devices within the KWWTP, MWWTP, and SWWTP OT networks. The same security risks identified for remote access sessions to the CKTP OT networks also apply to the other WWTP OT networks.

2.9.3 Pump Stations

Aside from the remote ICS monitoring occurring via the VHF licensed radio and cellular WANs, Sewer Utility staff do not currently access the pump station OT networks remotely.

- UltraVNC encryption plugin is not enabled. Security of VNC sessions used to establish remote access to WWTP OT networks could be increased by enabling encryption at the VNC application layer.
- Because of inherent security risks with VNC-based applications, HDR recommends transitioning away from VNC sessions for remote access to the Sewer Utility's OT networks.
- Users accessing the WWTP OT networks remotely share a common password, which means that no AAA measures are in place for remote access to the WWTP OT networks.
- MFA for remote access sessions to the WWTP OT networks would provide additional security for the network in conjunction with the adoption of AAA measures.

2.10 Network Security Hardware and Software

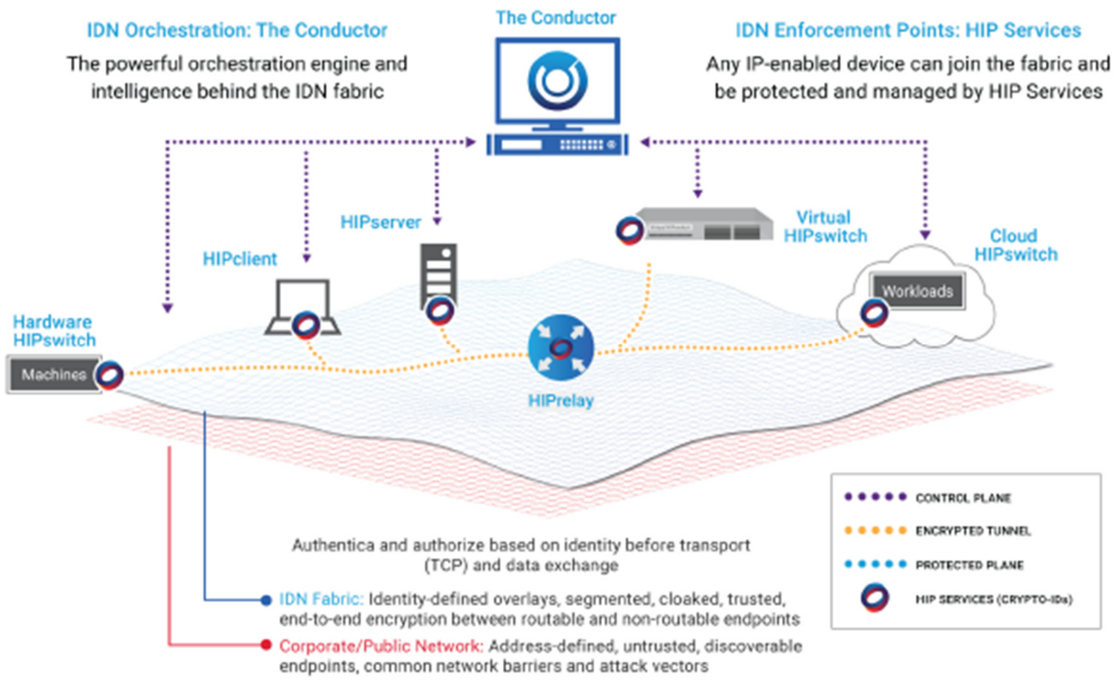
This subsection describes the network security hardware currently enforcing security controls for Sewer Utility OT network ingress and egress traffic.

2.10.1 Tempered Networks Conductor

The Tempered Networks Conductor is a cloud-hosted, web-based user interface for network managers to add trusted devices to user-defined groups, called overlay networks, within their Tempered Networks Airwall system deployment. Security policies and permissions for each overlay network can be defined so that any trusted device added to the overlay network inherits those policies and permissions. Security settings can also be configured at the device level, and permissions for specific devices can be enabled and disabled manually or via timed or scheduled sessions.

Modifications to security policies and settings are pushed out from the Conductor to the Airwall edge services over the Tempered Networks control plane, which is distinct from the encrypted data plane over which the overlay network data exchange occurs. Once modifications to security policies and settings are registered by the Airwall edge services, they will be retained by the HIPswitches, HIPrelays, and software and server agents within the Airwall system. In this way, the Airwall edge services are not reliant on the Conductor to implement security and the system can remain online, enforcing the most recently registered security policies and settings, even if the Conductor is taken offline. Figure 2-21 depicts the Conductor's role within the Airwall system and the separation of the control and data planes.

Figure 2-21. Tempered Networks Conductor diagram



Source: Tempered Networks.

Though the Tempered Networks Airwall system has many benefits, its simplicity and convenience come with some tradeoffs. The benefit of having one "pane of glass," the Conductor, to establish and manage communication between devices also presents a potential vulnerability in that the security of the communication links is consolidated into a single software platform. Inadvertent modifications to settings or inclusion of a device in the wrong overlay network could potentially expose the Sewer Utility's OT networks to considerable risk.

Because any user given access to the Sewer Utility's Conductor instance essentially holds the "keys to the kingdom," in terms of Sewer Utility OT network cybersecurity, it is essential that access to the Conductor be restricted to a minimum number of trained and trusted individuals. Authentication of these individuals should also be required to improve security and allow for meaningful accounting of which modifications are made by whom. Currently, the only two user accounts that are active for the Conductor are QCC and Local Administrator. In addition, no MFA measures are in place, so users are required to enter only one of these usernames and the corresponding password. Creating unique user accounts that are each attributable to a single individual and implementing MFA for access to the Conductor would significantly improve the security of the Sewer Utility's Conductor instance.

Currently, QCC and the Sewer Utility have established three overlay networks involving various devices on the Sewer Utility's OT networks. The Remote Support overlay network appears to be a work in progress and has no trusted devices or Airwall edge services assigned to it. The Kitsap Telemetry overlay network consists of all County-issued tablets and laptops, a QCC laptop, SCADA PCs and HIPswitches at all four of the Sewer Utility WWTPs, the PLCs at the remote WWTPs, the MTU PLC at CKTP, and various operator interface terminals (OITs) and HMIs at the four WWTPs.

A principle in the information security industry, referred to as Least Privilege, dictates that permissions for the various user groups on an ICS network should be tightly restricted to the access needs and monitoring and control functionality use cases required by the users to perform their work. While HDR did not review the security controls implemented at the Conductor for each trusted device in the Sewer Utility's overlay networks, it appears that Sewer Utility on-call staff may have access to some of the Sewer Utility WWTP PLCs, OITs, and HMIs from their tablets. There are not likely to be any desirable use cases for Sewer Utility on-call staff to access these devices from their tablets. Though on-call staff may be denied access via device settings made within the Conductor, a more secure approach would be to establish a separate overlay network for on-call staff that includes only the tablets and the limited number of SCADA PCs they are anticipated to interact with.

Similarly, a separate overlay network (e.g., the Remote Support overlay network) should be established for QCC so that third-party access to the Sewer Utility's OT network can be more tightly managed. This would allow the Sewer Utility to easily enable and disable QCC's access, add and remove Sewer Utility resources from the overlay network that QCC has access to on an as-needed basis, and maintain a clearer view of the Sewer Utility resources accessible to QCC at any given moment.

The third overlay network is called Kitsap IC. This overlay network consists of the County-issued I&C technician laptop, SCADA PCs at all four Sewer Utility WWTPs, the KWWTP PLC, the Wonderware thick-client HMI at the reclaimed-water building control panel, and the HIPswitches at all four Sewer Utility WWTPs. HDR believes that this overlay network was established to provide the Sewer Utility's I&C technicians with mobile and remote access to the Sewer Utility WWTP SCADA systems via VNC sessions. Unless there is a current need for Sewer Utility I&C technicians to access the KWWTP PLC or the Wonderware thick-client HMI at the reclaimed-water building remotely, to better adhere to the principle of Least Privilege, HDR recommends eliminating these devices from the Kitsap IC overlay network to reduce the scope of the overlay network to the I&C technician laptop and SCADA PCs only.

The current approach of allowing remote access to all SCADA PCs at CKTP may be convenient for QCC and County staff, but this approach also spreads the risks inherent in remote access to all of the SCADA PCs. As part of the Sewer Utility SCADA Master Plan effort, HDR recommends defining the specific use cases for remote access for each type of user so that appropriate security controls can be identified and implemented. For example, if Sewer Utility on-call staff require access only to Wonderware alarm screens, allowing them to assume remote control over a SCADA PC on the CKTP OT network provides them with many more permissions and a higher level of access than that use case would require. Limiting the number of OT network resources that are accessible remotely and segmenting these resources from the rest of the OT network would also improve the security of the Sewer Utility's OT networks.

While performing a cursory review of the Sewer Utility's Conductor configuration, HDR observed that all Airwall edge services have one of a variety of non-current firmware versions installed. Technology providers use firmware updates to fix bugs and patch vulnerabilities in their software and hardware offerings. Establishing routine patch management procedures to maintain current firmware versions for its Airwall edge services would help the Sewer Utility reduce the number of known vulnerabilities to which its OT networks are exposed.

2.10.2 Firewalls

At all four of the Sewer Utility's WWTPs, the Tempered Networks HIPswitch is deployed as the sole Sewer Utility–controlled security appliance at the OT network periphery. Though the HIPswitches do have internal stateful firewalls, they provide only a single layer of defense for critical Sewer Utility OT networks. And while Tempered Networks Airwall technology has yet to achieve widespread adoption in the marketplace and may benefit from a degree of "security by obscurity," as the technology gains market penetration it will likely receive more attention from threat actors.

Because no device or technology is immune to cybersecurity vulnerabilities, the U.S. Department of Homeland Security (DHS) and several other information security organizations recommend a Defense-in-Depth strategy for securing ICS networks (DHS 2016). This approach is based on implementing layers of security controls so that the security of the ICS does not depend on a single component or security control. For example, installing a Sewer Utility–managed firewall between the KPUD Internet service demarcation appliance and the Tempered Networks HIPswitch at each WWTP would add another layer of security for the Sewer Utility OT networks. This measure would reduce the Sewer Utility's exposure to zero-day and other vulnerabilities that may exist in the Tempered Networks Airwall system or the Sewer Utility's implementation of the Airwall technology.

2.10.3 Central Kitsap Treatment Plant

At CKTP, a Tempered Networks HIPswitch 100g (see Figure 2-22) is installed between the plant OT network and the point of demarcation with KPUD's network, through which CKTP receives access to the Internet as described in Section 2.8 above. The HIPswitch is an industrial edge gateway that monitors inbound and outbound network traffic and provides local enforcement of security policies and permissions that are configured via the Sewer Utility's cloud-hosted Tempered Networks Conductor software service. Tempered Networks indicates that this HIPswitch model is limited to 10 Mbps of data throughput. Given the intended application for SCADA-related data exchange between CKTP and the other WWTPs, this amount of throughput will likely be inadequate for the Sewer Utility's near-term needs.

Figure 2-22. Tempered Networks HIPswitch 100g

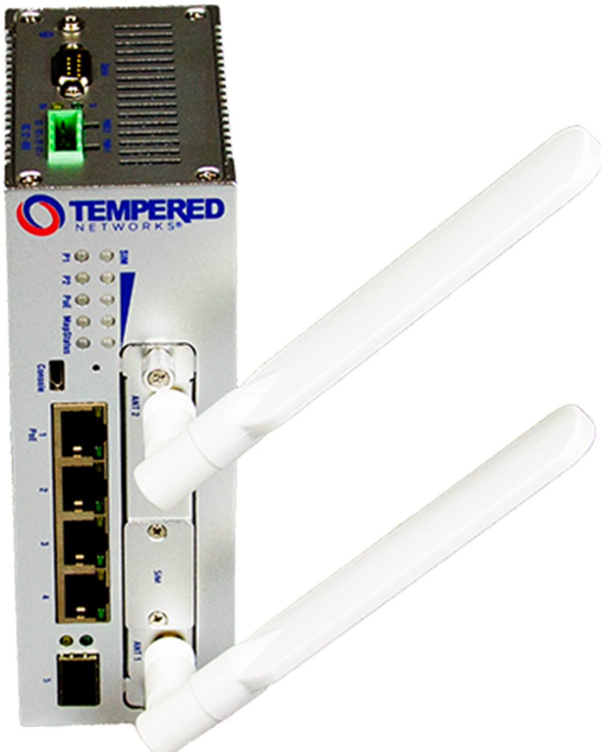
Source: Tempered Networks.

Figure 2-22 depicts a HIPswitch 100g with a cellular antennas used to provide failover to a secondary cellular network in the event of failure of the wired network. The HIPswitch at CKTP has no cellular antennas installed and the Sewer Utility has not configured the HIPswitch for failover to a secondary cellular network. While a non-redundant communication link between these WWTPs and CKTP is not a critical issue for remote monitoring purposes, if these communication links will be used for communication of plant alarms or remote control of the plants, establishing a secondary communication link would be worth considering. Provided that cellular reception is adequate at CKTP, the secondary cellular communications capability of the HIPswitch would be a suitable means of implementing this secondary communication link.

2.10.4 Kingston, Manchester, and Suquamish Wastewater Treatment Plants

At KWWTP, MWWTP, and SWWTP, a Tempered Networks HIPswitch 150e (see Figure 2-23) is installed between the plant OT network and the point of demarcation with KPUD's network, through which the WWTPs receive access to the Internet as described in Section 2.8 above. The HIPswitch is an industrial edge gateway that monitors inbound and outbound network traffic and provides local enforcement of security policies and permissions that are configured via the Sewer Utility's cloud-hosted Tempered Networks Conductor software service. The HIPswitch is capable of 75 Mbps of data throughput. Given the intended application for SCADA-related data exchange between KWWTP and CKTP, this amount of throughput is likely adequate for the Sewer Utility's near-term needs.

Figure 2-23. Tempered Networks HIPswitch 150e



Source: Tempered Networks.

Figure 2-23 depicts a HIPswitch 150e with an optional cellular expansion module that provides failover to a secondary cellular network in the event of failure of the wired network. This feature is not included in the HIPswitches deployed at KWWTP, MWWTP, and SWWTP. While a non-redundant communication link between these WWTPs and CKTP is not a critical issue for remote monitoring purposes, if these communication links are to be used for communication of plant alarms or remote control of the plants, establishing a secondary communication link would be worth considering. Provided that cellular reception is adequate at KWWTP, MWWTP, and SWWTP, the optional cellular expansion module for the HIPswitch would be a suitable means of implementing this secondary communication link.

2.10.5 Pump Stations

Because the Sewer Utility's wastewater pump stations have no Internet service, the exposure to cyber threats at the stations is greatly reduced. With no Internet access and limited IP infrastructure, the Sewer Utility has not deployed network security appliances at the pump stations. As discussed in Section 2.7 above, the security of the pump station cellular WAN is largely dependent on Verizon Wireless. HDR did not review the configuration of the pump station cellular routers, but hardening of the cellular routers could provide an additional layer of security.

The only means of securing the VHF licensed radio communications at the pump stations is via configuration of the radios themselves. HDR's review of the configurations for a selection of the VHF radios showed that Advanced Encryption Standard (AES) encryption has not been enabled. Encryption of the data streams between the pump stations and the MTU at CKTP is highly recommended to prevent eavesdropping and to mitigate potential security risks from malicious actors intruding on the radio network to modify radio configuration or otherwise disrupt communications. Enabling the VHF radios' inherent 128-bit AES encryption feature would provide a significant layer of security for a relatively minor configuration effort.

- The Sewer Utility's Tempered Networks Conductor instance has generic user accounts that do not allow for adequate user authentication or attributing of any security modifications made to a specific individual.
- No MFA measures are in place to secure access to the Sewer Utility's Tempered Networks Conductor instance.
- On-call staff, QCC, and I&C technicians all share access to the Tempered Networks Kitsap Telemetry overlay network. This may be allowing access to PLCs and other OT network resources that on-call staff do not require access to and complicates management of third-party access to the Sewer Utility's OT network.
- Devices are included in the Tempered Networks Kitsap IC overlay network that County staff may not need to access remotely. If remote access is not required for these devices, they should be removed from the overlay network as a security precaution.
- Multiple user types are allowed to assume remote control over SCADA PCs on the Sewer Utility's OT networks, which may be providing some users with more permissions and access to OT network resources than they require. Sewer Utility OT network remote access use cases need to be defined so that appropriate security controls can be identified and implemented.
- The Sewer Utility's Airwall edge services do not have current firmware versions installed.
- HIPswitches are providing a single layer of defense at the periphery of the Sewer Utility's OT networks, which does not adhere to Defense-in-Depth strategies recommended by DHS and other information security organizations.
- The HIPswitch 100g installed at CKTP appears to be limited to 5 Mbps of data throughput. Given the intended application for SCADA-related data exchange between CKTP and the other WWTPs, this amount of throughput will likely be inadequate for the Sewer Utility's near-term needs.
- Communication links between KWWTP, MWWTP, and SWWTP and CKTP have no redundancy.

- Pump station and CKTP MTU VHF radios have AES encryption disabled, which exposes the pump station VHF licensed radio WAN to eavesdropping and security risks.

2.11 Servers and Personal Computers

This subsection describes the servers and PCs deployed within the WWTP OT networks.

2.11.1 Central Kitsap Treatment Plant

CKTP has a variety of PCs and one tower server in the OT network inventory. A summary of the manufacturer, model, operating system, and release date for these machines is found in Table 2-2. Microsoft discontinued support for the Windows 7 operating system in January 2020, which means that security patches are no longer provided for the operating system on three of the CKTP SCADA PCs and the PC dedicated to the GE EnerVista Viewpoint power monitoring software platform. Windows 10 is the most current version of the Windows operating system for PCs and is currently supported by Microsoft. Microsoft has announced an extension of its support for Windows Server 2012 R2 through October 10, 2023.

Given the release dates for the various PCs, some of the PCs have most likely been in service for 5 to 7 years. Depending on the warranty period for the PCs, a general best practice is to replace business-grade PCs and servers, like the Dell PCs and server in the CKTP OT network inventory, every 3 to 5 years. Because the Sewer Utility plans to upgrade the Wonderware implementation at CKTP, HDR recommends that the replacement of the older PCs and server be aligned with the Wonderware upgrade to ensure that PCs and servers are selected to meet Wonderware's recommended hardware specifications. The replacement of these PCs would also resolve the lack of manufacturer support for the operating system running on these older PCs.

Table 2-2. CKTP OT network PC and server summary

PC name	Location	Manufacturer	Model	Operating system	PC release date
CKTPHISTORIAN	SPB control room	Dell	PowerEdge T130	Windows Server 2012 R2 Standard	2015
SCADA1	SPB ground floor	Dell	Precision T1700	Windows 7 Pro SP1	2013
SCADA2	SPB control room	Dell	Precision T1700	Windows 7 Pro SP1	2013
SCADA3	Administration and lab building office	Dell	Precision T1700	Windows 7 Pro SP1	2013
VIEWPOINTKITSAP	SPB control room	Dell	Inspiron 3647	Windows 7 Pro SP1	2014
N/A	Operations facilities building	Dell	Inspiron 3670	Windows 10 Pro	2019
N/A	I&C tech office	Dell	Inspiron 3670	Windows 10 Pro	2019

Table 2-2. CKTP OT network PC and server summary

PC name	Location	Manufacturer	Model	Operating system	PC release date
N/A	M&O supervisor office	Dell	Inspiron 3670	Windows 10 Pro	2019

The CKTP OT network has been set up as a workgroup. This implementation establishes all PCs and servers on the network as peers and requires that they remain in the same subnet to maintain the ability to share resources. It also requires that any user accounts that the Sewer Utility wishes to create for the PCs and servers be established on every PC and server in the workgroup, which can quickly become a burden for those maintaining the network as the number of PCs, servers, and users increases. Implementing a domain for the OT network, on the other hand, would allow the Sewer Utility to manage all user accounts and permissions on a single server and enable segmentation of the OT network to increase security and optimize network performance.

In terms of user access, the PCs that HDR observed have been configured to maintain the operating system user login sessions and do not automatically log out the user based on inactivity. Unlike the PCs, the historian server does log the user out on inactivity. For the PCs that HDR observed, a generic Operator username is used for the maintained login sessions on the PCs. While the practice of leaving the login sessions active is much more convenient for operators needing to occasionally glance at real-time process values or review and acknowledge alarms than if they were required to continually log in throughout their shift, it does prevent the Sewer Utility from implementing accounting measures that could attribute actions and events occurring on the network to specific individuals.

When it comes to managing user login sessions, there is a tradeoff between network security and workforce efficiency. Making the process of accessing ICS software too cumbersome can reduce operator engagement with the software, while leaving the machines running the software open to anyone can expose the organization to additional risks from unauthorized users and internal malicious actors. Whether to prioritize network security or user experience and efficiency is something each organization must decide for itself.

2.11.2 Kingston, Manchester, and Suquamish Wastewater Treatment Plants

The KWWTP and MWWTP SCADA PCs are Dell Optiplex 5050s running the Windows 10 Professional operating system. The SWWTP SCADA PC is a Dell XPS 8910 also running the Windows 10 Professional operating system. Windows 10 is the most current version of the Windows operating system and is currently supported by Microsoft. Given the 2017 release date for the KWWTP and MWWTP PCs, the machines have most likely been in service for less than 3 years. The SWWTP PC has a release date in 2016. Depending on the warranty period for the PCs, a general best practice is to replace business-grade PCs, like the Dell Optiplex 5050, every 3 to 5 years. Because the Sewer Utility plans to upgrade the Wonderware implementation at KWWTP, MWWTP, and

SWWTP, HDR recommends that the replacement of these PCs be aligned with the Wonderware upgrade to ensure that a PC is selected to meet Wonderware's recommended hardware specifications.

The username and password credentials used to log into the operating system on the SCADA PCs at these WWTPs are the same as those used for the CKTP SCADA PCs. The operating system login sessions are also persistent and the user is not logged out on inactivity. Because there is ordinarily only one operator at these WWTPs, attributing network activity to a specific individual becomes much easier and it is less likely for an unauthorized user to gain access to the PCs unnoticed.

No other servers, workstations, PCs, or tablets in use at KWWTP, MWWTP, and SWWTP are associated with the OT network.

- Some of the PCs on the CKTP OT network have likely been in service for 5 to 7 years and should be replaced as part of the Sewer Utility's planned Wonderware upgrade at CKTP.
- CKTP OT network has been set up as a workgroup. Implementing a domain for the OT network would allow the Sewer Utility to manage all user accounts and permissions on a single server and enable segmentation of the OT network to increase security and optimize network performance.
- Operating system login sessions are maintained on CKTP OT network PCs and a common username and password is shared by all users.
- KWWTP, MWWTP, and SWWTP SCADA have likely been in service for 3 to 4 years and should be replaced as part of the Sewer Utility's planned Wonderware upgrade at the WWTPs.

2.12 Network Infrastructure Physical Security, Environmental Conditions, and Power Supply

This subsection describes the physical security, environmental conditions, and power supply where the Sewer Utility OT network infrastructure is installed.

2.12.1 Physical Security

This subsection describes the physical security where the Sewer Utility OT network infrastructure is installed.

Central Kitsap Treatment Plant

CKTP is at least partially surrounded by a chain-link fence. HDR did not walk the CKTP perimeter to confirm that the fencing is continuous. The two gated entrances for vehicle entry are secured with padlocks. CKTP buildings are secured with keyed locks on man doors but, with the exception of the administration and lab building, the doors are not monitored with intrusion switches. Based on discussions with Sewer Utility staff, HDR believes that the administration and lab building doors are monitored by a third-party alarm system. HDR did not observe motion detectors or security cameras installed at CKTP.

Kingston Wastewater Treatment Plant

KWWTP is surrounded by a chain-link fence with three-line barbed wire. The one gated entrance for vehicle entry is secured with a padlock. KWWTP buildings are secured with keyed locks on man doors and intrusion switches on the operation building and process building doors generate an alarm via the SCADA system during hours when KWWTP is not attended. The operations building also has a motion detector that generates an alarm via the SCADA system after hours. No security cameras are installed at KWWTP.

Manchester Wastewater Treatment Plant

MWWTP is surrounded by a chain-link fence with three-line barbed wire. The two gated entrances for vehicle entry are secured with padlocks. MWWTP buildings are secured with keyed locks on man doors but the doors are not monitored with intrusion switches. A motion detector installed in the operations building control room generates an alarm via the SCADA system during hours when MWWTP is not attended. No security cameras are installed at MWWTP.

Suquamish Wastewater Treatment Plant

SWWTP is surrounded by a chain-link fence with three-line barbed wire. The one gated entrance for vehicle entry is secured with a padlock. SWWTP buildings are secured with keyed locks on man doors but the doors are not monitored with intrusion switches. No motion detectors or security cameras are installed at SWWTP.

WWTP Network Equipment Panels

The only enclosed network equipment racks, panels, or cabinets dedicated to OT network components found within the Sewer Utility’s facilities are the network cabinet and network panel (PNL 8580A) in the SPB control room. Both of these panels are left unlocked and are, therefore, dependent on the security of the building itself to prevent unauthorized access. Because Sewer Utility staff are not anticipated to require frequent access to these enclosures, establishing the practice of keeping the enclosures locked at all hours would help protect the OT network components from unauthorized access and inadvertent disruptions caused by untrained staff.

2.12.2 Environmental Conditions

Network components are installed at all four WWTPs outside of enclosures on communications backboards and/or open communication racks in electrical rooms. At CKTP, exposed plumbing passes next to OT network components (see Figure 2-24) in the administration and lab building electrical room. In addition to exposed water and air piping, the small room is shared by an air compressor and other mechanical equipment. Ideally, sensitive network components are kept away from mechanical equipment and plumbing, especially when those components are not housed within a protective enclosure. Rupture of a pipe or failure of the mechanical equipment in this electrical room could easily destroy the OT network and business LAN components therein.

Figure 2-24. Exposed plumbing next to network components in CKTP administration and lab building electrical room

At KWWTP, the KPUD Carrier Ethernet switch is installed low to the ground on a communications backboard (see Figure 2-17). The ongoing construction activities at KWWTP have generated a significant amount of dust, which can be seen collected on the floor in the figure. It appears that staff have covered the building entrance terminals for the plant telephone system in a plastic bag to protect the equipment from dust. However, the KPUD Carrier Ethernet access switch that serves as KWWTP's Internet service demarcation appliance has been left exposed to the dust. Significant and/or prolonged exposure to dust can cause unprotected network components without rugged enclosures to fail prematurely.

Most of the remaining network components at the Sewer Utility's facilities are installed within industrial control panels. Environmental conditions for the Sewer Utility's industrial control panels are discussed in Section 3.

2.12.3 Network Infrastructure Battery Backup Power

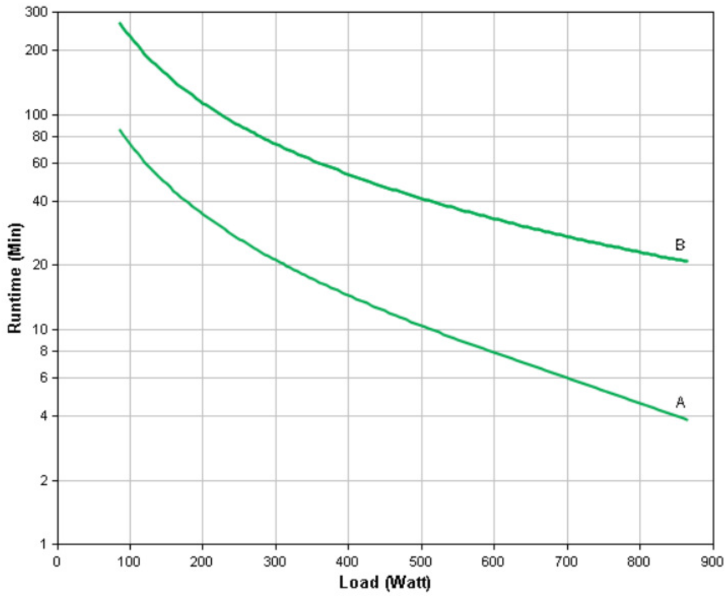
The SCADA PCs, CKTP historian server, and CKTP control room network cabinet have been provided with uninterruptible power supply (UPS) battery backup power to ride through brownouts and keep components powered until the plant or pump station transitions to standby generator power. These UPSs are line-interactive type, which provide an intermediate level of surge protection and noise filtering compared to other UPS technologies. The installed UPSs are not monitored by the facility SCADA system, so Sewer Utility staff have no indication of whether the SCADA PCs and servers and network equipment are on utility or battery power and do not receive notification of UPS low battery or fault conditions. Furthermore, the installed line-interactive UPSs have no remote monitoring capability in the form of relay contacts or Ethernet communications. Monitoring UPS health and status points at SCADA can alert Sewer Utility staff to issues that UPSs might be experiencing prior to a power outage event, which can avoid discovering these issues when the Sewer Utility is dependent on the UPSs to provide power to critical loads during emergency scenarios.

HDR observed that the KPUD-owned Carrier Ethernet access switches at KWWTP, MWWTP, and SWWTP are plugged into standard wall receptacles and are not receiving UPS power. Any brownouts experienced at these WWTPs have the potential to suspend communications occurring through these switches while the switches recover from the brownout, power up, and go through their boot cycle. Loss of power to these WWTPs also results in loss of communications until the WWTPs transition to generator power and the switches complete their boot cycle. Providing these switches with UPS power would eliminate unnecessary power-related communication losses and avoid delaying the communication of KWWTP, MWWTP, and SWWTP power-related alarms to CKTP.

A typical battery life for UPSs of the type found at Sewer Utility facilities is between 3 and 5 years, while the useful service life for the UPS itself typically ranges between 6 and 8 years. HDR did not review the Sewer Utility’s battery replacement practices or obtain installation dates for the various UPSs in the Sewer Utility’s inventory.

HDR also did not review or perform electrical load calculations for the Sewer Utility’s UPS inventory. The UPS size along with the total electrical load that a UPS will need to power during loss of utility power determine how long the UPS batteries can support the connected electrical loads. Figure 2-25 shows the battery runtime graph for the APC Back-UPS 1500 UPS, which the Sewer Utility has provided for its SCADA PCs and CKTP historian server and installed in several of its industrial control panels. As indicated in the figure, UPSs of this size are not intended to support loads for extended periods and are typically provided as a buffer to carry the loads through brownouts or until standby generators come online for blackout scenarios.

Figure 2-25. Battery runtime graph for APC Back-UPS 1500



Source: APC (Schneider Electric 2020).

Sewer Utility staff indicated that during a recent power outage in August 2020, the standby generator feeding the low-voltage switchgear (SWGR) in the SPB failed to come online because of improper controller settings at the switchgear. This resulted in loss of the Sewer Utility's SCADA PCs and historian shortly thereafter, which could be an indicator of an improperly sized or faulty UPS. If the Sewer Utility wishes to maintain power for OT network servers, PCs, and other critical loads during emergency scenarios where the standby generator(s) fail to come online in a matter of minutes after utility power is lost, a more robust UPS strategy will be required.

2.12.4 Power Supply Redundancy

HDR observed that, in general, the network switches within the Sewer Utility's OT networks accept a single power input. Where switches accept two power supply inputs, like the unmanaged switch in the CKTP SPB control room network cabinet, only one power supply input has been wired. There are also several network switches that are powered with 24 volts direct current (VDC) in enclosures that have no 24 VDC power supply redundancy. Specific enclosures with a lack of 24 VDC power supply redundancy are discussed in Section 3.3. Providing power supply redundancy for critical network switches would help prevent OT network outages because of single power supply failures.

- Physical security at the Sewer Utility WWTPs could be improved by introducing camera systems and providing monitoring and alarming of more of the building entrances during hours when the WWTPs are unattended.
- Network cabinet and network panel PNL-8580A are routinely left unlocked.

- Unprotected OT network components share space with exposed plumbing and mechanical equipment in the CTKP administration and lab building electrical room.
- Construction activity at KWWTP is generating a significant amount of dust in the space occupied by KWWTP's Internet service demarcation appliance.
- Status and alarms are not monitored for UPSs that provide power to SCADA PCs and servers and OT network equipment. The installed UPSs also have no remote monitoring capability.
- KPUD-owned Carrier Ethernet access switches that provide communication between KWWTP, MWWTP, and SWWTP and CKTP are not on UPS power.
- The Sewer Utility's current strategy of allocating small, dedicated UPSs for OT network PCs, servers, and other critical loads provides very limited battery backup times for this equipment, leaving the Sewer Utility reliant on the proper functioning of the standby generators to keep the equipment online during power outages.
- In general, the network switches within the Sewer Utility's OT network have no onboard power supply or external 24 VDC power supply redundancy.

2.13 Backup Procedures and Disaster Recovery

This subsection describes the Sewer Utility's current backup procedures and general disaster recovery preparedness for its OT network resources.

2.13.1 Backup Procedures

At CKTP, ICS software programming and configuration files for the Sewer Utility PLCs, HMIs, and OITs appear to be manually backed up on the CKTP historian server. The folder containing the CKTP PLC programming files that HDR observed contained several versions for many of the PLCs, making it difficult to ascertain which version was the most current in some cases. In terms of historical SCADA data, HDR does not believe that the Sewer Utility has procedures for backing up the CKTP historian data. Unless QCC or another contracted systems integrator obtains periodic backups of the historian data, failure of the CKTP historian server could result in loss of CKTP's historical SCADA data.

At KWWTP, MWWTP, and SWWTP, the WWTP's Wonderware configuration files are stored on an external hard drive resting on top of the SCADA PC (see Figure 2-26). The LGH files containing the WWTPs' historical SCADA data are also automatically saved on this external hard drive. HDR did not find copies of these LGH files at CKTP, and if there are copies they would have had to have been obtained manually. Given that the SCADA PCs and external hard drives reside in the same physical location, a catastrophic event at the location of the SCADA PC would likely result in loss of all available historical SCADA data for that WWTP. External hard drives also have a typical useful service life of 3 to 5 years, but are often overlooked in asset management programs and left in service until someone observes that data have been corrupted. Any off-site backups of the SCADA PC, ICS software configuration and programming files, and historical SCADA data that exist are likely to be held by the systems integrator(s) that last upgraded or worked on the KWWTP, MWWTP, and SWWTP ICS.

Figure 2-26. KWWTP SCADA PC with connected external hard drive

Other than what contracted systems integrators may have stored on their networks, HDR does not believe that the Sewer Utility has placed backups of ICS programming and configuration files or historical data in off-site or cloud storage. HDR also believes that backing up the OT network PCs and servers themselves is not a current Sewer Utility practice.

2.13.2 Disaster Recovery

All SCADA PCs and servers observed within the Sewer Utility OT networks are also running ICS software installed on the host operating system. Aside from one instance of Rockwell's Studio 5000 running on a virtual machine (VM) hosted on the SWWTP SCADA PC, HDR did not observe any ICS software running within a virtualized environment. There are several advantages to virtualization when compared with installing services directly on host operating systems. The greatest advantage, given the relatively small scale of the Sewer Utility's OT networks, is the ability to quickly recover from loss of the physical host machine. With hypervisor software, purpose-built VMs running SCADA system services like the HMI software and historian can be easily cloned and transferred to other physical machines. As long as regularly scheduled backups occur, virtualization would allow the Sewer Utility to quickly recover from disaster or server equipment failure and avoid having to manually reinstall and configure software, which would likely require contracting a systems integrator for support. Other advantages of virtualization include the following:

- Easier backup procedures
- Ability to dedicate VMs to specific services so that an issue with one service does not result in a single point of failure for the rest of the services
- Ability to test patches and software upgrades in a controlled environment
- Potentially some cost savings in server hardware and energy consumption due to fewer physical servers

> ✷ Backups of PLC programming project files could be better organized to improve version control.
>
> ✷ No automated or manual backup procedures appear to be in place for the historical SCADA data contained on the CKTP historian. Failure of the CKTP historian server could result in loss of CKTP's historical SCADA data.
>
> ✷ No automated or manual procedures are in place for establishing off-site backups of Sewer Utility WWTP SCADA data or ICS configuration and programming files.
>
> ✷ Historical SCADA data for KWWTP, MWWTP, and SWWTP may exist only on external hard drives connected to the SCADA PCs at the WWTPs. Failure of the external hard drive or a catastrophic event that impacts the SCADA PC and external hard drive may result in loss of the WWTP's historical SCADA data.
>
> ✷ No automated or manual backup procedures appear to be in place for backing up the Sewer Utility OT network PCs and servers.
>
> ✷ The Sewer Utility is not leveraging virtualization for the PCs and servers in its OT networks. Recovering from loss of one of these physical machines or a disaster would require significantly more time and effort than a scenario where the Sewer Utility's ICS software is installed in a virtualized environment.

2.14 Network Management

This subsection describes the Sewer Utility's network management practices for the WWTP OT networks.

2.14.1 Central Kitsap Treatment Plant

Aside from the Tempered Networks Conductor described previously, HDR does not believe that the Sewer Utility is currently using other software to monitor and manage the performance of the CKTP OT network. Many of the managed switches have web-based interfaces where basic switch configuration and status information may be obtained and firmware may be upgraded, but the Sewer Utility has no other means of observing the network. The Sewer Utility also does not have a syslog server or other central repository for collecting device logs and network event data. With no logging practices in place and no software tools to provide visibility into current and historical network status and performance, abnormal events within the CKTP OT network likely go undetected until they begin disrupting communications between devices. Without a baseline against which to compare current network activity, and with no software tools, it is also likely that Sewer Utility staff face significant challenges when attempting to troubleshoot network disruptions.

Aside from simplifying network maintenance and troubleshooting, monitoring and logging of network events and activity could also improve the Sewer Utility's ability to respond to a cybersecurity event. Early detection of unauthorized access to the CKTP OT network could allow the Sewer Utility to contain the threat before significant harm is done. Good logging practices can be helpful in determining how malicious actors gained access to the network so that exploited vulnerabilities can be mitigated. The information contained in network logs can also be crucial to helping federal authorities prosecute malicious actors.

Current configuration files for the Sewer Utility's VHF radios appear to be stored on the CKTP historian server. HDR was unable to locate configuration file backups for the managed switches and cellular routers within the Sewer Utility's OT networks. It is likely that QCC has current configuration files for some of these devices, but having more immediate access to the files would enable Sewer Utility staff to recover more quickly from a failure of one of these devices. Maintaining backup configuration files for the managed switches and cellular routers within the OT networks is recommended, if not already included in the Sewer Utility's network management practices.

2.14.2 Kingston, Manchester, and Suquamish Wastewater Treatment Plants

Because of the small scale of the KWWTP, MWWTP, and SWWTP OT networks, the Sewer Utility does not use software tools to manage and monitor the networks. Because the OT networks are isolated from the public Internet, Windows and other potentially disruptive software updates and hotfixes are prevented from happening automatically and must be performed manually. HDR does not believe that the Sewer Utility maintains backups of managed switch configuration files. Backups of these configuration files, if they exist, are most likely held by the system integrator that last worked on these devices.

> ✸ The Sewer Utility does not have software tools to monitor the CKTP OT network and manage its performance.

- The Sewer Utility does not have a syslog server or other central repository for collecting CKTP OT network device logs and network event data.
- The Sewer Utility does not maintain an organized system of easily accessible network device configuration file backups for managed switches and cellular routers within its OT networks.

2.15 Network Documentation and Tagging

This subsection describes the network documentation and tagging practices observed at Sewer Utility WWTPs and pump stations along with their level of completeness.

2.15.1 Network Architecture Diagrams

The Sewer Utility does not have a complete and accurate set of network architecture diagrams for the WWTPs. Several partial ICS network diagrams from a variety of past construction projects along with high-level block diagrams show general physical connections between ICS components available on the County's electronic operation and maintenance (eO&M) SharePoint site. Some of the network diagrams available are no longer current or do not provide a complete representation of the current network implementation in the areas or buildings covered by the diagrams.

2.15.2 Fiber-Optic Patch Panels and Fiber-Optic Cabling

The Sewer Utility has high-level block diagrams that document the fiber-optic cable runs between various buildings, but these diagrams do not indicate fiber count or the uses of the various fiber runs (e.g., whether the fiber is used for the business LAN or the OT network). Fiber-optic patch panels at CKTP do not have printed schedules noting destination of fiber pairs and Sewer Utility staff do not maintain detailed fiber-optic patch cable schedules that identify fiber connections between buildings along with individual fiber pair connections to end devices.

A fiber-optic cable and fiber-optic patch panel tagging system does not appear to be in practice at CKTP. Many of the fiber-optic patch panels observed and several of the fiber-optic cables entering fiber-optic patch panels at the various buildings and process areas are not labeled. Those cables that are labeled indicate the equipment tags of the control panels or equipment enclosures in which terminations are made at both ends of the cable. Without additional documentation, someone unfamiliar with CKTP must follow fiber patch cables and as-build the connections to identify end devices for each fiber pair.

2.15.3 Copper Ethernet Cabling

Documentation for IP network connections occurring via copper Ethernet cables consists of what was described in Section 2.15.1. Where Category cables connect PCs or other network hardware to network switches, there are very few cases where the cables are labeled at either end. Within control panel enclosures, there are some instances where cables are labeled at either end, but there are several cases where labels have not been applied or have fallen off. This lack of cable labeling makes documenting the installed network very difficult and can present challenges for network maintenance and troubleshooting efforts.

- Sewer Utility has high-level network block diagrams for the WWTPs, but does not maintain comprehensive network architecture diagrams.
- Sewer Utility does not maintain detailed fiber-optic patch panel schedules or have a consistently applied tagging system for fiber-optic patch panels and cables.
- Sewer Utility practices for tagging copper Ethernet cables at both ends could be improved.

2.16 Cybersecurity Incident Response Program

Though the County Information Services department may have protocols in place for the County, in general, the Sewer Utility does not have a formal cybersecurity incident response program for the OT networks it manages. These programs establish procedures to prepare for cybersecurity threats, identify when cybersecurity incidents occur, how to respond to the incidents, which individuals and agencies to contact, and how to adequately document any cybersecurity incidents and resolutions. Having a cybersecurity incident response program in place that is practiced and updated at regular intervals can greatly improve an organization's ability to respond effectively if and when an incident occurs. Effective responses can minimize the impact and duration of attacks and allow staff to collect valuable information that can help federal agencies identify and prosecute attackers.

- The Sewer Utility does not have a formal cybersecurity incident response program for the OT networks it manages.

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3 Industrial Control System Hardware

This section describes the current ICS hardware at Sewer Utility WWTPs and pump stations. It includes a description of the major hardware elements, along with their power supply and environmental conditions. The section also includes a summary of the WWTP control room equipment.

3.1 Programmable Logic Controllers

This subsection describes the major PLC hardware elements at Sewer Utility WWTPs and pump stations.

3.1.1 Controller Hardware

The Sewer Utility has standardized on Allen-Bradley PLCs throughout its wastewater infrastructure. Table 3-1 provides a list of PLCs installed at the WWTPs and pump stations visited by HDR during its site assessments. In addition to model and catalog number information, the table lists the manufacturer life-cycle status and installation year for each PLC.

Table 3-1. WWTP and pump station PLC summary

Facility	Panel tag	Panel description	Manufacturer	Model	Catalog number	Life-cycle status	Year installed
CKTP	PNL 1021	Influent screen 1 main control panel	Allen-Bradley	SLC 5/05	1747-L552	Active mature	2010
CKTP	PNL 1023	Influent screen 3 main control panel	Allen-Bradley	SLC 5/05	1747-L552	Active mature	2010
CKTP	PNL 1026	Screwpactor main control panel	Allen-Bradley	SLC 5/05	1747-L552	Active mature	2010
CKTP	PNL 1050	Headworks control panel	Allen-Bradley	SLC 5/05	1747-L552	Active mature	2010
CKTP	PNL 1111	Grit washer 1 control panel	Allen-Bradley	SLC 5/05	1747-L551	Active mature	2010
CKTP	PNL 1112	Grit washer 2 control panel	Allen-Bradley	SLC 5/05	1747-L551	Active mature	2010
CKTP	PNL 2920	Power/blower building control panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2014
CKTP	PNL 2939	Aeration basins electrical building control panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2014
CKTP	PNL 2990	Power/blower building I/O panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2014
CKTP	SCC 3100	UV system control center	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2018
CKTP	PNL 4012	RDT control panel	Allen-Bradley	CompactLogix 5370	1769-L30ER/A	Active	2014
CKTP	PNL 4050	Polymer blending system control panel	Allen-Bradley	CompactLogix L3x	1769-L32E	End of life	2014
CKTP	PNL 4080	Polymer feed system control panel	Allen-Bradley	CompactLogix L3x	1769-L32E	End of life	2014
CKTP	PNL 4905	WAS thickening building control panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2014
CKTP	N/A	RACS operator interface control panel	Allen-Bradley	MicroLogix 1100	1763-L16BWA	Active mature	2010
CKTP	PNL 5010	Raptor septage acceptance plant control panel	Allen-Bradley	MicroLogix 1100	1763-L16AWA	Active mature	2010
CKTP	PNL 6000	Digester building control panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2014
CKTP	PNL 7105	PLC 7105 I/O rack	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2014
CKTP	PNL 7110	Centrifuge 1 control panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2019
CKTP	PNL 7120	Centrifuge 2 control panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2019

Table 3-1. WWTP and pump station PLC summary

Facility	Panel tag	Panel description	Manufacturer	Model	Catalog number	Life-cycle status	Year installed
CKTP	PNL 7225	Dewatering polymer panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2019
CKTP	PNL 8200	Filter system control panel	Allen-Bradley	CompactLogix L3x	1769-L32E	End of life	2014
CKTP	PNL 8905	Reclaimed-water control panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2014
CKTP	PNL 9201	Digester gas treatment control panel	Allen-Bradley	CompactLogix L3x	1769-L32E	End of life	2014
CKTP	N/A	Master station CTU (radio)	Allen-Bradley	CompactLogix L3x	1769-L35E	End of life	2017
CKTP	N/A	Master station CTU (cell)	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2019
KWWTP	CP-200	Operations building control panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2020
KWWTP	FCP-201	Mechanical fine screen control panel	Allen-Bradley	MicroLogix 1400	1766-L32AWA	Active	2020
MWWTP	PCP	Plant control panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2018
PS-1	N/A	Main control panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2016
PS-1	N/A	Telemetry control panel	Allen-Bradley	MicroLogix 1400	1766-L32BXBA	Active	2016
PS-4	N/A	Main control panel	Allen-Bradley	MicroLogix 1500	1764-24BWA	Discontinued	2004
PS-4	N/A	Telemetry control panel	Allen-Bradley	MicroLogix 1400	1766-L32BXBA	Active	2017
PS-6	N/A	Main control panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2016
PS-6	N/A	Telemetry control panel	Allen-Bradley	MicroLogix 1400	1766-L32BXBA	Active	2016
PS-7	N/A	Main control panel	Allen-Bradley	MicroLogix 1500	1764-24AWA	Discontinued	2007
PS-7	N/A	Telemetry control panel	Allen-Bradley	MicroLogix 1400	1766-L32BXBA	Active	2017
PS-12	N/A	Telemetry control panel	Allen-Bradley	MicroLogix 1400	1766-L32BXBA	Active	2017
PS-17	N/A	Main control panel	Allen-Bradley	MicroLogix 1500	1764-24BWA	Discontinued	2004

Table 3-1. WWTP and pump station PLC summary

Facility	Panel tag	Panel description	Manufacturer	Model	Catalog number	Life-cycle status	Year installed
PS-17	N/A	Telemetry control panel	Allen-Bradley	MicroLogix 1400	1766-L32BXBA	Active	2017
PS-24	N/A	Main control panel	Allen-Bradley	SLC 5/03	1747-L532	Active mature	2000
PS-24	N/A	Telemetry control panel	Allen-Bradley	MicroLogix 1400	1766-L32BXBA	Active	2017
PS-32	N/A	Telemetry control panel	Allen-Bradley	MicroLogix 1400	1766-L32BXBA	Active	2017
PS-34	N/A	Telemetry control panel	Allen-Bradley	MicroLogix 1400	1766-L32BXBA	Active	2017
PS-41	N/A	Telemetry control panel	Allen-Bradley	MicroLogix 1400	1766-L32BXBA	Active	2017
PS-67	N/A	Main control panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2016
PS-67	N/A	Telemetry control panel	Allen-Bradley	MicroLogix 1400	1766-L32BXBA	Active	2017
PS-71	N/A	Main control panel	Allen-Bradley	SLC 5/05	1747-L552	Active mature	2004
PS-71	N/A	Telemetry control panel	Allen-Bradley	MicroLogix 1400	1766-L32BXBA	Active	2016
SWWTP	CP-01	Main control panel	Allen-Bradley	CompactLogix 5370	1769-L33ER/A	Active	2016
SWWTP	CP-15	RDT control panel	Allen-Bradley	CompactLogix 5370	1769-L30ER/A	Active	2016

Current PLC Standard for Process Control Applications

Though a variety of PLC models are installed throughout the WWTPs and pump stations, in recent years, the Sewer Utility has standardized on Allen-Bradley 1769-L33ER CompactLogix 5370 L3 controllers and Bulletin 1769 Compact I/O modules (see Figure 3-1) for WWTP and pump station industrial control panels. These controllers have 2 megabytes (MB) of user memory and two 10/100 Mbps EtherNet/IP communication ports that support ring network topologies. They also support up to 16 connected I/O modules and are capable of integrating up to 32 EtherNet/IP nodes via installed PLC programming logic. Given that the Sewer Utility has installed these PLCs to handle controls for pump stations, small WWTPs, and dedicated processes at the larger CKTP, HDR believes that the CompactLogix PLC is well-suited and right-sized for its current applications within the Sewer Utility's wastewater infrastructure. The next processor tier above the CompactLogix series in the Allen-Bradley product line is the ControlLogix series, which is better suited for larger and/or more centralized control applications or where process criticality demands a hot-standby redundancy solution.

Figure 3-1. Allen-Bradley CompactLogix PLC with 1769-L33ER controller and Bulletin 1769 Compact I/O modules

Source: Rockwell Automation.

Rockwell has released a newer generation of the CompactLogix controller line (CompactLogix 5380), which has options for greater controller user memory and supports 1 GbE EtherNet/IP communication and an increased number of EtherNet/IP nodes. However, the CompactLogix 5370 PLCs and the Bulletin 1769 Compact I/O modules are still in the active phase of the manufacturer's life cycle, which indicates that they are considered a current product offering and are fully supported by the manufacturer.

Current PLC Standard for Telemetry Applications

For the pump station RTU control panels, the Sewer Utility has standardized on Allen-Bradley 1766-L32BXBA MicroLogix 1400 controllers (see Figure 3-2). These compact controllers have 10 kilobytes (kB) of user memory, 32 onboard hardwired I/O points, one serial port that can be configured for a variety of serial-based protocols, and one 10/100 Mbps EtherNet/IP communication port for EtherNet/IP peer-to-peer messaging. These

PLCs are well-suited and right-sized for managing the telemetry controls for the Sewer Utility's wastewater pump stations.

Figure 3-2. Allen-Bradley 1766-L32BXBA MicroLogix 1400 PLC

Source: Rockwell Automation.

Discontinued PLCs

As shown in Table 3-1, the Sewer Utility has some PLCs in its inventory that have been discontinued by the manufacturer. According to information available on the Allen-Bradley website, MicroLogix 1500 PLCs are no longer manufactured or available for sale and the manufacturer is encouraging migration to MicroLogix 1400 or CompactLogix 5370 PLC platforms (Rockwell Automation 2020a). Replacement parts for these PLCs are anticipated to become increasingly difficult to procure in the coming years. The MicroLogix 1500 PLCs in the Sewer Utility's inventory have also been in service for roughly 13 to 16 years. Depending on the environmental conditions to which PLCs are subjected throughout their service life, the typical useful service life for PLCs is roughly 15 years. These discontinued PLCs are nearing the end of their useful service life and will soon be operating in their wear-out period.

End-of-Life Announcements and Active Mature Products

Table 3-1 also indicates that the Sewer Utility has five Allen-Bradley CompactLogix L3x PLCs in its inventory. The manufacturer has made an end-of-life announcement for these PLCs, warning that the components will no longer be manufactured or available for sale as of December 2020 (Rockwell Automation 2020b). Allen-Bradley is encouraging migration of these PLCs to the CompactLogix 5380 platform. In the meantime, a small window remains for the Sewer Utility to make last-time purchases of spare components for these PLCs, if there is interest in doing so.

The Sewer Utility also has several Allen-Bradley SLC 500 Series and MicroLogix 1100 PLCs installed throughout its WWTPs and pump stations. Both of these PLC platforms are in the active mature phase of the manufacturer's life cycle, which indicates that the products are still fully supported by the manufacturer but that migration to a newer PLC platform is encouraged (Rockwell Automation 2020c). Though an end-of-life announcement has yet to be released for these PLCs, the Sewer Utility may wish to consider near-term upgrades of the PS-24 and PS-71 PLCs because they have been in service for roughly 20 years and 16 years, respectively, and are nearing the end of their useful service life.

Miscellaneous Observations

During its site visits, HDR observed that the PLC controller battery alarm light was illuminated at the bar screen 1023 main control panel in the CKTP headworks electrical room (see Figure 3-3). This could indicate that the battery voltage has fallen below a threshold level, or the battery is missing or not connected. Because the PLC memory where the programming is stored is backed up by the PLC's internal battery, loss of power to this PLC could result in loss of the programming and a prolonged equipment outage to enable Sewer Utility staff to re-download programming to the controller.

Figure 3-3. CKTP bar screen 1023 main control panel PLC controller battery alarm light illuminated

Another observation is that the RIO control panel in the MWWTP blower building is installed above the old SBR control panel and is not readily accessible. Figure 3-4 shows this panel with its door open above the SBR control panel. Sewer Utility staff would need a ladder to perform modifications to the panel or troubleshoot its wiring.

Figure 3-4. MWWTP blower building RIO control panel installation

3.1.2 DeviceNet Networks

At CKTP, several of the MCCs have been furnished with a DeviceNet network connecting the various overload relays and VFDs within the MCC to a DeviceNet scanner module in the PLC rack within the industrial control panel that provides control for the building or process area. Figure 3-5 shows the DeviceNet scanners dedicated to MCC 2935 and MCC 2936 in the aeration basins 3 and 4 electrical building. These and most other DeviceNet MCCs at CKTP were commissioned in 2014 as part of the CKTP Resource Recovery project. The DeviceNet MCCs in the headworks building were commissioned in 2010 as part of the Headworks Upgrade project.

Figure 3-5. DeviceNet scanners in PNL 2939 PLC rack

DeviceNet technology, originally developed by Allen-Bradley, features a bus topology consisting of a common trunk line to which devices are connected via taps and dedicated drop lines. Device power and communication occur over the same physical cables used in this topology and terminating resistors are required at either end of the bus. The DeviceNet network data rate is configurable and selection of an appropriate data rate needs to take into consideration the overall trunk and drop line cable lengths and cable type used. With a maximum data rate of 500 kilobits per second (kbps), DeviceNet has become a dated technology that falls well below the bandwidths achievable with today's Ethernet-based technologies. Furthermore, with several design and implementation considerations and more components involved, the physical layer of DeviceNet networks is also relatively complex when compared to Ethernet networks. This complexity can often lead to maintenance and troubleshooting challenges for the end user. Sewer Utility staff have reported experiencing difficulties working with DeviceNet technology at CKTP. The challenges Sewer Utility staff are having with the maintenance and troubleshooting of the DeviceNet networks have the potential to increase downtime for equipment connected to the DeviceNet networks.

Like Ethernet, DeviceNet allows for an increased volume of data exchange between the ICS and networked devices that would not be possible via hardwired I/O alone. Currently, data derived from DeviceNet-connected devices represents a significant portion of the overall unique I/O points received from and sent to field devices by the CKTP ICS.

3.1.3 Hardwired Input/Output

When it comes to data exchange between the Sewer Utility's PLCs and process equipment and instrumentation, much of this control and monitoring is hardwired. For analog signals, the Sewer Utility has standardized on 4–20-milliampere (mA) current-based I/O. The Sewer Utility facilities have a mix of isolated and non-isolated analog I/O modules at the PLCs and RIO racks. Hardwired discrete I/O was observed to be a mix of 120 VAC and 24 VDC I/O, depending on the connected equipment. A summary of the

I/O modules types and quantities installed in the various PLC and RIO racks throughout the WWTPs is provided in Appendix D.

Though the Sewer Utility has succeeded in standardizing on one manufacturer for all PLCs in its inventory, there is some diversity when it comes to the I/O modules that systems integrators and/or consulting engineers have selected for Sewer Utility industrial control panels over the years. The Sewer Utility may be able to reduce its spare-parts inventory and enforce its preferences by standardizing on specific I/O modules for future projects. For example, for most analog signal applications, an industry best practice is to select isolated analog I/O modules to mitigate noise issues on analog signals and to prevent faults on one signal from impacting other inputs or outputs on the same I/O module. If the Sewer Utility wished to establish a preference for isolated analog I/O modules, this requirement could be introduced to Sewer Utility standards documentation and used to guide consulting engineers and systems integrators in the design and fabrication of future industrial control panels.

3.1.4 IP Network Input/Output

CKTP, KWWTP, and SWWTP all have a few Allen-Bradley VFDs that communicate with plant PLCs via EtherNet/IP. The overload relays for the new oxidation ditch mixers at KWWTP also communicate with the plant PLC via EtherNet/IP. At CKTP, power monitors installed within several of the MCCs and switchgear lineups communicate with GE controllers in the SWGR 2961 control stack via Modbus Transmission Control Protocol (TCP)/IP as part of the CKTP energy management system (EMS) described in Section 6 below. Aside from these cases, HDR observed relatively little IP network–based data exchange occurring between Sewer Utility PLCs and field equipment and instrumentation.

- The Allen-Bradley MicroLogix 1500 PLCs installed at PS-4, PS-7, and PS-17 have been discontinued by the manufacturer and are nearing the end of their useful service life.
- Allen-Bradley has made an end-of-life announcement for the CompactLogix L3x PLCs installed in various panels at CKTP. These PLCs will be discontinued by the manufacturer as of December 2020.
- The Allen-Bradley SLC 500 PLCs installed at PS-24 and PS-71 are in the active mature phase of the manufacturer’s product life cycle and are nearing the end of their useful service life.
- HDR observed that the PLC controller battery alarm light was illuminated at the bar screen 1023 main control panel in the CKTP headworks building electrical room.
- The MWWTP blower building RIO control panel is installed above another control panel in a location that is not easily accessible by Sewer Utility staff.

- Sewer Utility staff have difficulty maintaining MCC DeviceNet networks at CKTP, which has the potential to increase downtime for equipment connected to the DeviceNet networks.
- The Sewer Utility does not appear to have standardized on PLC platform I/O module types. I/O module standardization could help the Sewer Utility reduce spare-parts inventory and enforce its preferences.

3.2 Human-Machine Interfaces

This subsection describes the HMI hardware by which Sewer Utility staff interact with the ICS at the various Sewer Utility facilities.

3.2.1 Wonderware Thick Clients

The Sewer Utility has standardized on Wonderware InTouch 2014 R2 for the SCADA HMIs at its WWTPs. The software and its configuration and implementation are discussed in Section 4. In terms of HMI hardware, the Sewer Utility has installed a Wonderware InTouch runtime license on each control room operator SCADA PC for KWWTP, MWWTP, and SWWTP. Throughout CKTP, the Sewer Utility has installed several Wonderware InTouch thick clients. These thick clients consist of several SCADA PCs and industrial panel PCs (see Figure 3-6) installed in various buildings throughout CKTP, as depicted in the Central Kitsap Treatment Plant Physical Network Diagram included in Appendix B (Figure B1).

Figure 3-6. Headworks building electrical room Wonderware InTouch thick client

The Sewer Utility has standardized on National Electrical Manufacturers Association (NEMA) 4X, touchscreen hardware for its industrial panel PCs at CKTP. Table 3-2 provides a summary of manufacturer, model, size, and year of manufacture information for the industrial panel PCs installed throughout CKTP. Depending on the environmental conditions to which industrial panel PCs are subjected throughout their service life, the typical useful service life for industrial panel PCs is roughly 5 to 7 years. Based on this information, the CKTP industrial panel PCs are expected to have most of their useful service life remaining.

Table 3-2. CKTP industrial panel PC summary

Panel tag	Panel description	Manufacturer	Model	Size (in)	Year manufactured
PNL 1050	Headworks control panel	Arista	ARP-1715AP-108	15.0	2017
PNL 2920	Power/blower building control panel	Arista	ADM-1821AP	21.5	2019
PNL 2939	Aeration basin control panel	Arista	ADM-1821AP	21.5	2020
PNL 4905	WAS thickening building control panel	Arista	ADM-1821AP	21.5	2019
PNL 8905	Reclaimed-water control panel	Arista	ADM-1821AP	21.5	2019

The SCADA PCs used for the Wonderware InTouch thick clients at the Sewer Utility WWTPs are described in Section 2.

3.2.2 Control Panel Operator Interface Terminals

In addition to the WWTP Wonderware InTouch thick clients, several OITs are installed throughout the Sewer Utility's WWTPs and pump stations. These OITs are dedicated to the PLC within their respective industrial control panels and do not provide visibility into other systems within the Sewer Utility's ICS. Table 3-3 provides a summary of manufacturer, model, size, and year of manufacture information for the OITs installed throughout the Sewer Utility WWTPs and pump stations. The table also lists the current manufacturer life-cycle status for each of the OITs, where life-cycle status information is readily available from the manufacturer.

Table 3-3. WWTP and pump station OIT summary

Facility	Panel tag	Panel description	Manufacturer	Model	Size (in)	Life-cycle status	Year manufactured
CKTP	PNL 4012	RDT control panel	Maple Systems	HMI5070TH	7.0	Legacy	2013
CKTP	PNL 4050	Polymer blending control panel	Allen-Bradley	PanelView Plus 600	5.7	End of life	2013
CKTP	PNL 4080	Polymer feed control panel	Allen-Bradley	PanelView Plus 600	5.7	End of life	2013
CKTP	PNL 7110	Centrifuge 1 control panel	Allen-Bradley	PanelView Plus 7	15.0	Active	2018
CKTP	PNL 7120	Centrifuge 2 control panel	Allen-Bradley	PanelView Plus 7	15.0	Active	2018
CKTP	PNL 7225	Dewatering polymer panel	Allen-Bradley	PanelView Plus 700	6.5	End of life	2018
CKTP	PNL 8200	Filter system control panel	Siemens	SIMATIC MP 277	8.0	Phase out	2013
CKTP	PNL 9201	Digester gas treatment control panel	Pro-face	GP-4601T	12.1	Unknown	2013
CKTP	SCC 3100	UV system control panel	Allen-Bradley	PanelView Plus 7	15.0	Active	2018
CKTP	N/A	Master station CTU	Allen-Bradley	PanelView Plus 1000	10.4	End of life	2012
CKTP	N/A	RACS operator interface control panel	Maple Systems	HMI6060T	6.0	Legacy	2010
CKTP	N/A	SWGR 2961	VarTech Systems	VTPC150P	15.0	Unknown	2013
CKTP	N/A	SWGR 2961 control stack	VarTech Systems	VTPC150P	15.0	Unknown	2013
KWWTP	CP-300	Process building control panel	Allen-Bradley	PanelView 600	5.7	Discontinued	2004
KWWTP	N/A	Mechanical fine screen control panel	Allen-Bradley	PanelView 800	7.0	Active	2020
PS-01	N/A	Main control panel	Allen-Bradley	PanelView Plus 700	7.0	End of life	2016
PS-04	N/A	Main control panel	Allen-Bradley	PanelView Plus 700	7.0	Discontinued	2004
PS-06	N/A	Main control panel	Allen-Bradley	PanelView Plus 700	7.0	End of life	2016
PS-07	N/A	Main control panel	Allen-Bradley	PanelView Plus 1000	10.4	End of life	2014
PS-17	N/A	Main control panel	Allen-Bradley	PanelView Plus 700	7.0	Discontinued	2004
PS-24	N/A	Main control panel	Allen-Bradley	PanelView Plus 600	5.7	Discontinued	2000

Table 3-3. WWTP and pump station OIT summary

Facility	Panel tag	Panel description	Manufacturer	Model	Size (in)	Life-cycle status	Year manufactured
PS-67	N/A	Main control panel	Allen-Bradley	PanelView Plus 700	7.0	End of life	2015
PS-71	CP-100	Main control panel	Allen-Bradley	PanelView Plus 600	5.7	Discontinued	2004
SWWTP	CP-15	RDT control panel	Maple Systems	HMI5097XL	9.7	Active	2016

Unlike industrial panel PCs where SCADA software is installed on a base operating system, OITs run proprietary software developed by the OIT manufacturer that is distinct from the Sewer Utility's Wonderware InTouch software. The distinct software platforms require additional configuration and development effort to implement and maintain graphical content and functionality for these OITs.

Depending on the environmental conditions to which OITs are subjected throughout their service life, the typical useful service life for OITs is roughly 7 to 10 years. However, it is not uncommon for OITs that receive infrequent use to remain in service for significantly longer than this. As Table 3-3 suggests, a few OITs in the Sewer Utility's inventory are likely nearing the end of their useful service life, particularly at some of the Sewer Utility's pump stations and CP-300 at KWWTP.

During its site visit at KWWTP, HDR observed that a communication error was displayed at the CP-300 OIT, indicating it could not communicate with a specific IP address. This issue may be due to the ongoing construction effort at KWWTP and will likely be resolved as the ICS upgrade implementation at KWWTP is finalized. HDR also observed that the OIT at the master station central telemetry unit (CTU) control panel in the SPB control room at CKTP has been disconnected from the network switch in that panel and appeared to be powered down. This OIT may be permanently out of service. However, given its proximity to a SCADA PC with Wonderware InTouch screens dedicated to the various pump stations, replacement of this OIT may not provide much value to Sewer Utility staff.

- The OITs installed at PS-4, PS-17, PS-24, PS-71, and CP-300 at KWWTP are nearing the end of their useful service life.
- The CP-300 OIT at KWWTP was experiencing a communication error during HDR's site visit.
- The OIT at the master station CTU control panel in the SPB control room at CKTP appears to be out of service.

3.3 Power Supply and Environmental Conditions

This subsection describes the power supply measures provided for the industrial control panels containing ICS components, control panel National Fire Protection Association (NFPA) 70E considerations, and the environmental conditions to which these control panels are subjected.

3.3.1 ICS Battery Backup Power

Several of the industrial control panels containing OT network and ICS components within the Sewer Utility WWTPs and pump stations have a dedicated UPS installed within the panel enclosure that provides the control system, instrumentation, and network components with battery backup power to ride through brownouts and keep components powered until the WWTP or pump station transitions to standby generator power. In general, the UPSs installed at Sewer Utility facilities are line-interactive type. However, in most cases, the UPSs are not monitored by the facility SCADA system, so Sewer Utility staff have no indication of whether the control panels are on utility or battery power and do not receive notification of UPS low battery or fault conditions. Furthermore, many of the installed line-interactive UPSs have no remote monitoring capability in the form of relay contacts or Ethernet communications. Monitoring UPS health and status points at SCADA can alert Sewer Utility staff to issues that UPSs might be experiencing prior to a power outage event, which can avoid discovering these issues when the Sewer Utility is dependent on the UPSs to provide power to critical loads during emergency scenarios.

Industrial control panels containing OT network and ICS components without UPS or other form of battery backup power are listed in Table 3-4. The control system, instrumentation, and OT network components housed within or powered from these panels immediately lose power during loss of utility power and may drop offline during voltage dips and power fluctuations experienced at the plant. The components without UPS battery backup power also do not benefit from the surge protection and noise filtering that line-interactive or online, double-conversion UPSs provide. Note, PNL 1050, included in Table 3-4 below, does have a line-interactive UPS installed within its enclosure, but the UPS was found unplugged during HDR’s site visit. Note, also, that Table 3-4 is limited to Sewer Utility industrial control panels containing OT network components and/or major ICS components, like PLCs, and does not apply to all industrial control panels within the Sewer Utility’s infrastructure.

Table 3-4. Industrial control panels containing OT network and ICS components with no battery backup power

Facility	Location	Panel	Panel description
CKTP	Digester control building	PNL 6000	Digester control building control panel
CKTP	Headworks building	PNL 1026	Screwpactor main control panel
CKTP	Headworks building	PNL 1027	Grit washer 1 control panel
CKTP	Headworks building	PNL 1028	Grit washer 2 control panel
CKTP	Headworks building	PNL 1050	Headworks control panel
CKTP	Power/blower building	PNL 2920	Power/blower building control panel
CKTP	Power/blower building	PNL 2990	Power/blower building I/O panel
CKTP	SPB	PNL 7105	PLC 7105 I/O rack
CKTP	WAS thickening building	PNL 4050	Polymer blending control panel
CKTP	WAS thickening building	PNL 4080	Polymer feed control panel
KWWTP	Headworks area	N/A	Mechanical fine screen control panel
MWWTP	Blower building	SBR-CP	Blower building control panel
MWWTP	Headworks building	LP-225	Influent pump station control panel
MWWTP	Operations building	PCP	Plant control panel
PS-07	Pump station 7	N/A	PS-07 control panel
PS-17	Pump station 17	N/A	PS-17 control panel
PS-34	Pump station 34	N/A	PS-34 control panel

3.3.2 24 VDC Power Supplies

Providing UPS battery backup power is a means of establishing a degree of power source redundancy and fault tolerance for critical ICS and OT network components. However, many of these ICS and OT network components are powered from 24 VDC power supplies that are typically downstream from utility and UPS power sources within the industrial control panel electrical distribution. If there is no redundancy in the 24 VDC power supply, as well, the power supply redundancy and fault tolerance measures introduced by the UPS do not carry all the way through to the critical components.

During its site visits, HDR observed that several Sewer Utility industrial control panels containing OT network and ICS components do not have 24 VDC power supply redundancy. Industrial control panels containing OT network and ICS components without 24 VDC power supply redundancy are listed in Table 3-5. The 24 VDC control system, instrumentation, and OT network components housed within or powered from these panels immediately lose power upon failure of the control panel's 24 VDC power supply. Control panels that have 24 VDC UPS systems or 24 VDC battery power, like the telemetry control panels, are not included in the table. Failure of the single 24 VDC power supply in these control panels would still leave the OT network and ICS components with a buffer of backup battery power and would not result in an immediate loss of power for the 24 VDC–powered components.

Table 3-5. Industrial control panels containing OT network and ICS components without 24 VDC power supply redundancy

Facility	Location	Panel	Panel description
CKTP	Digester control building	PNL 6000	Digester control building control panel
CKTP	Digester gas conditioning facility	PNL 9201	Digester gas treatment control panel
CKTP	Headworks building	PNL 1021	Influent screen 1 west channel
CKTP	Headworks building	PNL 1023	Influent screen 3 east channel
CKTP	Headworks building	PNL 1026	Screwpactor main control panel
CKTP	Headworks building	PNL 1027	Grit washer 1 control panel
CKTP	Headworks building	PNL 1028	Grit washer 2 control panel
CKTP	Headworks building	PNL 1050	Headworks control panel
CKTP	Power/blower building	PNL 2990	Power/blower building I/O panel
CKTP	Reclaimed-water building	PNL 8200	Filter system control panel
CKTP	Septage receiving	N/A	RACS operator interface control panel
CKTP	Septage receiving	PNL 5010	Raptor septage acceptance plant control panel
CKTP	SPB	N/A	Master station CTU
CKTP	SPB	MCC 2984	MCC 2984 control section
CKTP	WAS thickening building	PNL 4012	RDT control panel
CKTP	WAS thickening building	PNL 4050	Polymer blending control panel
CKTP	WAS thickening building	PNL 4080	Polymer feed control panel

Table 3-5. Industrial control panels containing OT network and ICS components without 24 VDC power supply redundancy

Facility	Location	Panel	Panel description
KWWTP	Headworks area	N/A	Mechanical fine screen control panel
MWWTP	Blower building	SBR-CP	Blower building control panel
MWWTP	Headworks building	LP-225	Influent pump station control panel
MWWTP	Operations building	PCP	Plant control panel
PS-04	Pump station 4	N/A	PS-04 control panel
PS-07	Pump station 7	N/A	PS-07 control panel
PS-17	Pump station 17	N/A	PS-17 control panel
PS-24	Pump station 24	N/A	PS-24 control panel
PS-67	Pump station 67	N/A	PS-67 control panel
PS-71	Pump station 71	N/A	PS-71 control panel
SWWTP	Process building	CP-01	Main control panel
SWWTP	Process building	CP-15	RDT control panel

3.3.3 NFPA 70E Considerations

As discussed in Section 3.1, HDR observed a mix of 120 VAC and 24 VDC controls in the various Sewer Utility industrial control panels. In many cases, the power and control voltages were not readily apparent and required closer inspection of the components to identify. According to NFPA 70E: Standard for Electrical Safety in the Workplace, all voltages 50 V and greater are considered to present a shock hazard under most circumstances (NFPA 2021). To reduce or eliminate shock hazards for personnel, a common practice is to standardize on 24 VDC controls and power distribution, to the extent possible, within industrial control panels and for field instrumentation. Where 120 VAC power or controls are required to enter control panel enclosures (e.g., incoming 120 VAC power supply from a nearby panelboard), these circuits can be consolidated within a designated region of the control panel. The use of color-coded, covered wireways can also help alert staff to the presence of different voltages within control panel enclosures.

Though converting existing 120 VAC control system wiring to 24 VDC would be infeasible, the Sewer Utility may wish to consider standardizing on 24 VDC power and controls for industrial control panels introduced by future CIP projects.

3.3.4 Environmental Conditions

Several of the industrial control panels observed during HDR's site visits are installed in indoor, temperature-controlled environments with enclosures that prevent dust ingress. The control panels housing network and ICS components located in process areas or outdoors generally have NEMA 4X enclosures. Given the rugged design and extended operating temperature ranges of the industrial network and ICS components installed in these control panels, HDR did not observe severe environmental conditions that would significantly jeopardize the functionality of these components.

One notable exception to this observation is the CKTP digester control building control panel (PNL 6000), which is subjected to significant levels of hydrogen sulfide (H_2S) and high ambient temperatures. Evidence of this H_2S exposure can be seen in the blackening of the control panel's copper ground bar shown in Figure 3-7. H_2S is a corrosive gas, particularly to copper and silver, which are prevalent in network components, ICS hardware, and other sensitive electronics. Prolonged exposure to H_2S and high ambient temperatures can lead to premature failure of these components. County electricians have reported that H_2S corrosion has been a significant maintenance issue with control wiring at the MCC installed near this control panel in the digester control building. During HDR's site visit, the ambient temperature in the ground floor of the digester control building was easily above 90 degrees Fahrenheit. The digester control building also has a hazardous-area classification for which the PNL 6000 enclosure and many of its internal components are not rated, which is a NEC violation.

Figure 3-7. H_2S corrosion on digester control building control panel (PNL 6000) copper ground bar

Staff have also reported that microprocessor-based HVAC control panels installed to control temperatures within some of the CKTP electrical rooms are overly complicated and ultimately fail to adequately control the electrical room temperature. The HVAC control panels within the WAS thickening building and SPB electrical rooms are two examples of failed temperature control implementations. HDR also observed that the HVAC system for the headworks building electrical room was incapable of maintaining the temperature set point entered at the thermostat, resulting in an undesirably high ambient temperature in the electrical room (see Figure 3-8).

Figure 3-8. Headworks building electrical room thermostat

HDR observed a similar electrical room climate control issue at the MWWTP operations building. On the day of HDR's site visit to MWWTP, Sewer Utility staff had propped open the operations building electrical room door and temporarily placed a fan in the doorway to try to reduce the electrical room temperature (see Figure 3-9). During summer months, it is likely that the control system and network components within the room are regularly exposed to ambient temperatures above desirable ranges.

Figure 3-9. Temporary ventilation measure for MWWTP electrical room

- OT network and ICS components within the CKTP digester control building control panel (PNL 6000) are exposed to significant levels of H_2S and high ambient temperatures. Installation of this panel in an area with a hazardous-area classification is an NEC violation. County electricians also indicated that H_2S corrosion has been a significant maintenance issue for control wiring at the nearby MCC within the building.
- Status and alarms are not monitored for UPSs that provide power to ICS and instrumentation equipment. Many of the installed UPSs have no remote monitoring capability.
- Several control panels at Sewer Utility facilities do not have battery backup power.
- Several control panels at Sewer Utility facilities do not have 24 VDC power supply redundancy.
- A mix of 120 VAC and 24 VDC control and power circuits are installed within the Sewer Utility's industrial control panels and the voltages present are not always readily apparent without closer inspection of the components. To eliminate or reduce shock hazards for personnel, the Sewer Utility may wish to consider standardizing on 24 VDC power and controls and/or improved voltage segregation and identification for control panels introduced by future CIP projects.
- The Sewer Utility is having difficulty maintaining desirable ambient temperatures within the MWWTP electrical room and some of the CKTP electrical rooms.

3.4 Control Room

The Sewer Utility has stated that one of its near-term goals for the Sewer Utility SCADA system is to establish a central location where Sewer Utility staff can monitor and control all WWTPs and pump stations managed by the Sewer Utility. At CKTP, a control room on the second floor of the SPB provides office space for the CKTP Plant Operations Supervisor and other operations staff (see Figure 3-10). With exterior windows running nearly the entire length of two sides of the room and its position on the second floor of a centrally located building within CKTP, the control room provides a good vantage point from which to monitor plant activity. In addition to operations staff PCs and printers, the control room is equipped with a SCADA PC, the CKTP historian server, and the CKTP EMS PC. The network cabinet and network panel in the control room serve as the central hub for the CKTP OT network, and the master station CTU control panel housing the master PLCs for the Sewer Utility's wastewater pump station VHF licensed radio and cellular WANs is also installed within the room.

Figure 3-10. CKTP SPB control room

Given its location at CKTP and proximity to central connection points for the CKTP OT network and pump station WANs, the existing SPB control room is an obvious choice for a space in which to implement a control center for the Sewer Utility. The room is also an architecturally finished, climate-controlled space, which would provide suitable environmental conditions for PCs, workstations, displays, and other sensitive electronics introduced as part of the Sewer Utility control center implementation. Furthermore, the room's drop ceiling would simplify installation of new data communications cabling between future control center equipment.

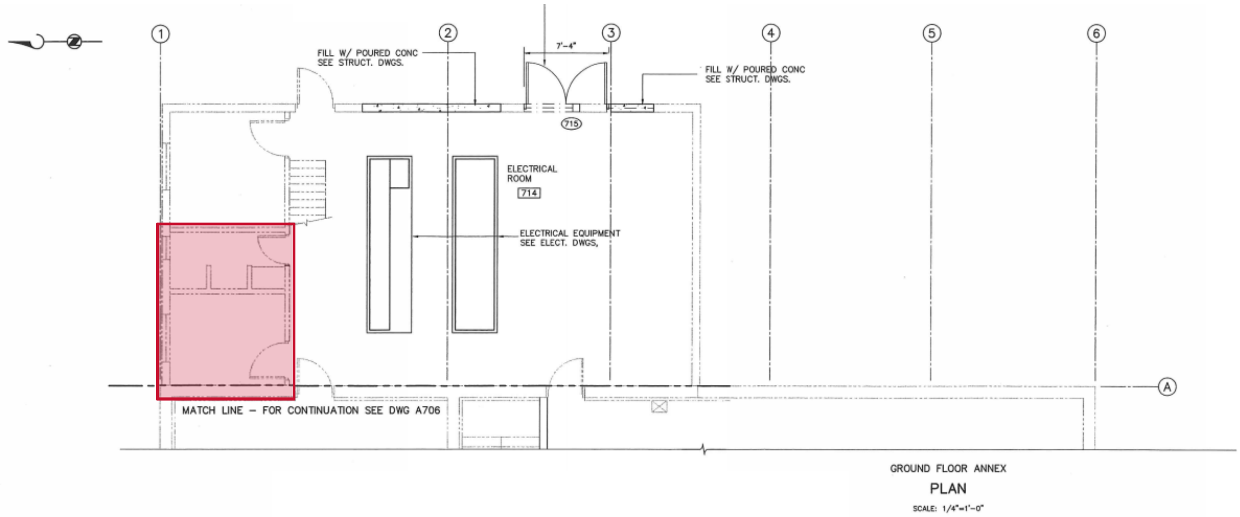
Though the control room has a SCADA PC, the PC is equipped with only two standard-size monitors (see Figure 3-11). This arrangement may be suitable for an individual, but is not an ideal solution for control center scenarios where multiple staff members need to engage with the SCADA screens and discuss current status, alarms, and/or events. The Sewer Utility would benefit from having large-format displays so that SCADA screens are discernible from a greater distance and could be referenced more easily during staff discussions. Having additional displays would also allow Sewer Utility staff to leave specific commonly used screens on display at all times to avoid having to constantly navigate back and forth between screens because only two monitors are available.

Figure 3-11. SPB control room SCADA PC monitors

Currently, Sewer Utility staff have no means of monitoring or controlling KWWTP, MWWTP, and SWWTP from the existing CKTP SCADA PCs. The Sewer Utility is working with QCC to establish data exchange between CKTP and the remote WWTPs, and this will be a critical step toward the future control center that the Sewer Utility wishes to implement. The Sewer Utility's ability to monitor its pump stations from CKTP is also significantly limited by the data refresh rate caused by the long polling cycle times discussed in Section 2. Because the information displayed on pump station SCADA screens is nowhere near real-time, Sewer Utility staff have indicated that they typically only make use of alarm information reported through the SCADA system for the pump stations.

Depending on spatial requirements and the quantity of servers and network appliances required by future CKTP ICS upgrades, the Sewer Utility may benefit from establishing a secure, dedicated space for ICS servers and critical network equipment. A potential candidate for such a space in the SPB would be a combination of the filing room and adjacent storage space in the ground floor of the SPB annex (proposed space shown enclosed in a red box in Figure 3-12). Though work would be required to properly prepare the space for use as a server room, this location would keep the ICS servers and critical network equipment in close proximity to the Sewer Utility control center and current incoming fiber-optic and copper cable network connections from other buildings at CKTP. Some of the work involved with converting this space into an appropriate server room environment would include combining the filing room and storage space; filling in existing windows; installing heating, ventilation, and air conditioning (HVAC) equipment to provide adequate cooling for the space; and providing new power and data communications circuits to the space.

Figure 3-12. SPB annex, ground floor: potential location for future server room



- The CKTP SPB control room has only two standard-size monitors where SCADA screens can be displayed. Having large-format displays would make it so that SCADA screens are discernible from a greater distance and could be referenced more easily during staff discussions. Additional monitors/displays would allow staff to leave commonly referenced screens on display at all times.
- Sewer Utility staff have no means of monitoring or controlling KWWTP, MWWTP, and SWWTP from the existing CKTP SCADA PCs.
- Sewer Utility staff do not have access to near real-time status and alarm information for wastewater pump stations at CKTP.
- The Sewer Utility may benefit from establishing a secure, dedicated space for ICS servers and critical network equipment.

3.5 Instrumentation

HDR site assessments did not include assessment of individual field instrumentation. However, HDR has included some general observations made during its site assessments and discussions with Sewer Utility staff that pertain to instrumentation and controls in the following paragraphs. The ideal time to perform a condition assessment survey of current instrumentation associated with a certain process or equipment is when that process or equipment is being evaluated for increased levels of automation and performance optimization. This way, the existing instruments are assessed based on identified future needs for the process or equipment to meet automation and performance optimization goals.

3.5.1 Instrumentation Calibration and Maintenance Program

Based on discussions with Sewer Utility I&C technicians, HDR believes that the Sewer Utility does not have a formal calibration and maintenance program for field instrumentation and associated control loops. Typically, I&C technicians are notified by maintenance or operations staff when instrumentation issues are encountered, at which time they investigate and troubleshoot. The Sewer Utility has hired Branom Instrument Co. (Branom) to perform field calibrations of select field instruments in the past, but does not have a service contract in place with Branom for scheduled routine calibration services.

Implementing regularly scheduled calibration and maintenance practices in accordance with manufacturer recommendations is critical to maintaining the accuracy, reliability, and repeatability of the I&C loops on which the Sewer Utility's process control and standard operating procedures (SOPs) depend. Furthermore, if the Sewer Utility wishes to pursue more data-centric operational strategies, the integrity of the historical data becomes increasingly important. Without a formal instrumentation calibration and maintenance program, instruments are often allowed to drift until inaccuracies become so great that they become noticeable to the staff who rely on the instruments to perform their work. This may result in long periods where the historian is logging inaccurate measurements. Regular calibration is especially important for instrument technologies that have a tendency to drift more significantly than others—technologies like analyzers (e.g., chlorine residual, dissolved oxygen [DO], turbidity, pH, and lower explosive limit [LEL]) and pressure instrumentation with diaphragm seals, for example.

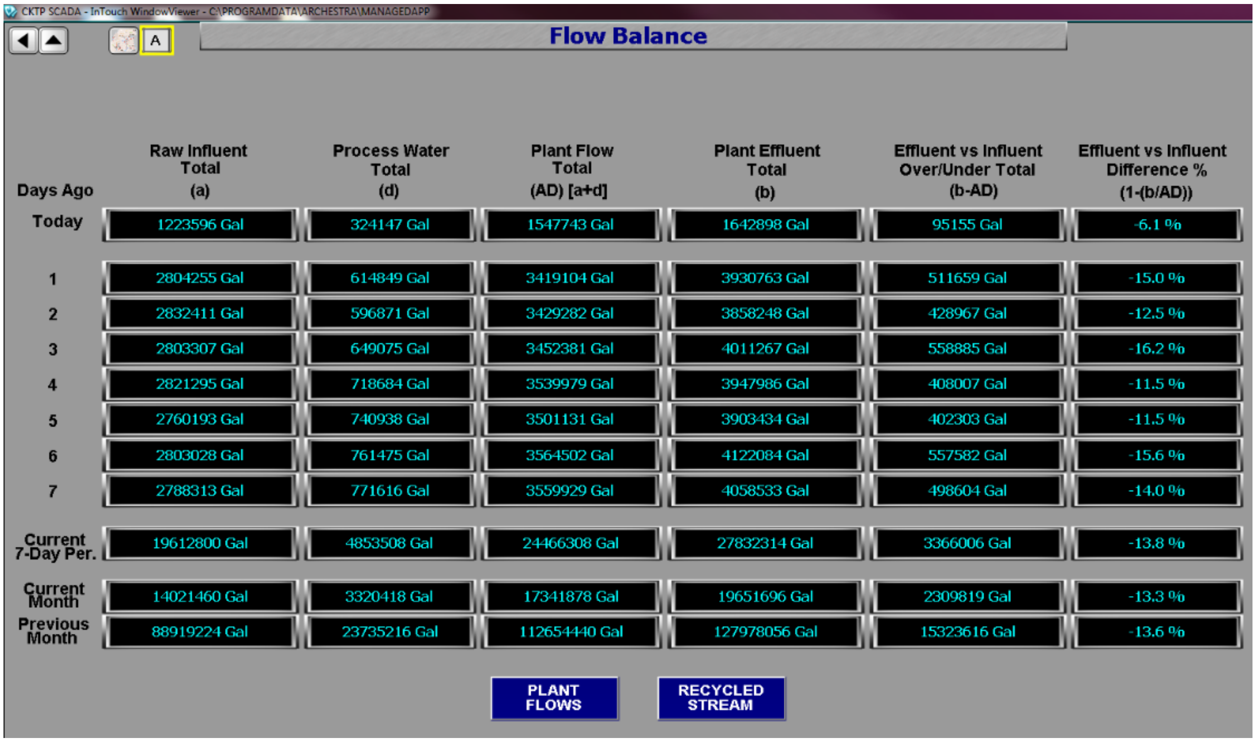
3.5.2 Central Kitsap Treatment Plant

This subsection describes HDR's general observations pertaining to field instrumentation and controls at CKTP.

Plant Effluent Flow Monitoring

The Sewer Utility has no means of direct measurement for CKTP effluent flow. Sewer Utility staff have installed various flow measurement technologies (including laser-based) at the effluent manhole where the effluent sampler draws its samples, but have been unsuccessful in establishing reliable flow readings. The effluent pipe connecting the discharge from the UV basins and tertiary treatment to the effluent manhole is buried deep and runs beneath the roadway, which has made more traditional flow measurement approaches, like installation of a magmeter, infeasible. Currently, CKTP's Trojan UV system calculates plant effluent flow by means of a level-based flow-over-weir calculation. However, these plant effluent flow calculations have typically been found to be anywhere from 6 to 16 percent higher than effluent flow values derived from an accounting of flow measurements recorded elsewhere within CKTP. This discrepancy can be seen in several historical values displayed on the CKTP Wonderware InTouch flow balance screen shown in Figure 3-13.

Figure 3-13. CKTP flow balance SCADA screen



Days Ago	Raw Influent Total (a)	Process Water Total (d)	Plant Flow Total (AD) [a+d]	Plant Effluent Total (b)	Effluent vs Influent Over/Under Total (b-AD)	Effluent vs Influent Difference % (1-(b/AD))
Today	1223596 Gal	324147 Gal	1547743 Gal	1642898 Gal	95155 Gal	-6.1 %
1	2804255 Gal	614849 Gal	3419104 Gal	3930763 Gal	511659 Gal	-15.0 %
2	2832411 Gal	596871 Gal	3429282 Gal	3858248 Gal	428967 Gal	-12.5 %
3	2803307 Gal	649075 Gal	3452381 Gal	4011267 Gal	558885 Gal	-16.2 %
4	2821295 Gal	718684 Gal	3539979 Gal	3947986 Gal	408007 Gal	-11.5 %
5	2760193 Gal	740938 Gal	3501131 Gal	3903434 Gal	402303 Gal	-11.5 %
6	2803028 Gal	761475 Gal	3564502 Gal	4122084 Gal	557582 Gal	-15.6 %
7	2788313 Gal	771616 Gal	3559929 Gal	4058533 Gal	498604 Gal	-14.0 %
Current 7-Day Per.	19612800 Gal	4853508 Gal	24466308 Gal	27832314 Gal	3366006 Gal	-13.8 %
Current Month	14021460 Gal	3320418 Gal	17341878 Gal	19651696 Gal	2309819 Gal	-13.3 %
Previous Month	88919224 Gal	23735216 Gal	112654440 Gal	127978056 Gal	15323616 Gal	-13.6 %

Biofilter Sprinkler Control

The SJE Rhombus biofilter sprinkler control panel (see Figure 3-14) for the headworks odor control biofilter is no longer in service. Sewer Utility staff currently water the headworks odor control biofilter via a hose connected to sprinklers positioned over the biofilter. Replacing and/or introducing instrumentation to maintain desirable moisture levels in the biofilter via automation could improve Sewer Utility workforce efficiency and the effectiveness of the biofilter.

Figure 3-14. Out-of-service headworks odor control biofilter sprinkler control panel

Headworks Odor Control LEL Measurement

During its site visit, HDR observed that the LEL transmitter for the headworks odor control fan ductwork is registering an infrared (IR) source fault (see Figure 3-15). This is preventing the sensor and transmitter from measuring the concentration of combustible gas in the odor control system.

Figure 3-15. CKTP headworks odor control fan ductwork LEL transmitter in fault

Biological Nutrient Removal Control

Sewer Utility staff have indicated that the control of the biological nutrient removal (BNR) process at CKTP is currently the most significant operational challenge and frustration at the plant. According to Sewer Utility staff, the aeration blowers are controlled off of pressure but aeration control valves are responding too quickly to DO measurements in the basins, which has caused the blowers to go into surge. Because automated controls have proved to be unstable, the aeration control valves are currently positioned manually and operators have to frequently adjust blower header pressure set points based on process demand. Murraysmith and HDR are scoped to address BNR optimization at CKTP as part of a separate task.

Aeration Basin 1 DO Monitoring

Unlike the other three CKTP aeration basins, aeration basin 1 has no DO probes installed. DO measurement is critical input to the feedback loop governing aeration control strategies. Without DO measurement, the Sewer Utility has had to infer DO values in aeration basin 1 from DO values measured in other basis. This is one of the deficiencies frustrating the Sewer Utility’s BNR efforts at CKTP.

Aeration Basin Ammonium and Nitrate Monitoring

Currently, aeration basin 4 is the only basin with ammonium and nitrate probes installed. Ammonium and nitrate values for aeration basins 1 through 3 are being derived from measurements read from the probes installed in aeration basin 4. Without probes to measure these values in aeration basins 1 through 3, the Sewer Utility has no means of monitoring the nitrogen removal occurring via the nitrification and denitrification process in these basins.

Reclaimed-Water Chlorine Residual and Turbidity Monitoring

During its site visits, HDR observed that the chlorine residual and turbidity analyzers associated with the reclaimed-water filtration system were both powered down (see Figure 3-16 and Figure 3-17). HDR did not confirm whether these instruments were still functional, but in their powered-down state no chlorine residual or turbidity measurement is occurring for the reclaimed-water filtration system.

Figure 3-16. CKTP reclaimed-water filtration system chlorine residual analyzer powered down

Figure 3-17. CKTP reclaimed-water filtration system turbidity analyzer powered down

Thickened Sludge Blending Tank Low-Level Interlock

Sewer Utility staff indicated that the low-level switch for the thickened sludge blending tank has failed. This switch provides low-level shutdown of the thickened sludge blending tank circulation pump and digester feed pumps via PLC software interlock. Sewer Utility staff have plans to eliminate this switch and to provide low-level shutdown of these pumps based on level measurement from the tank's pressure-based level transmitter. Until the proposed alternate controls are implemented, these pumps are likely operating with no low-level shutdown interlock.

Aerated Grit Tank 1 Stage 2 Airflow Monitoring

HDR observed that the thermal dispersion flowmeter installed on the aeration line to the aerated grit tank 1 stage 2 diffuser is measuring zero flow (see Figure 3-18), while the positions of manual valves on either side of the instrument suggest that flow should be occurring. Comparing the totalized flow on the flowmeter's display with the other three flowmeters on the grit tank aeration lines, it appears that this instrument has been measuring zero flow for a significant amount of time. HDR did not investigate the root cause of the zero flow reading, but the matter should be investigated to confirm that the grit tank is being properly aerated (e.g., a zero flow reading could be due to a plugged diffuser).

Figure 3-18. CKTP aerated grit tank 1 stage 2 flowmeter reading zero flow

Cogeneration System

According to Sewer Utility staff, the CKTP cogeneration system has been offline for roughly a year. The cogeneration system was installed only a little more than 4 years ago and the Sewer Utility has already had to pay to have local mechanics rebuild the engine. The engine has since failed again and would require substantial maintenance to repair. There have been several other maintenance issues with the cogeneration system and the digester gas conditioning system, and Sewer Utility staff have come to believe that the maintenance and material costs associated with keeping the infrastructure in operation would exceed any energy savings CKTP may receive from the cogeneration system.

Another operational challenge for the cogeneration system has been the limited digester level range that the Sewer Utility has to operate within. According to Sewer Utility staff, this level range is about 1 foot. This narrow operating level range has limited how much digester gas could be supplied to the cogeneration system, which resulted in the system running at well below its rated output when it was in operation, limiting the system's potential to deliver energy savings. Even if the digester operating level constraints were resolved, the Sewer Utility has indicated that the digesters may not produce enough gas for the cogeneration system to run continually at its rated output.

Because the cogeneration system has been effectively abandoned in place, HDR did not perform a site assessment of its ICS components.

3.5.3 Kingston Wastewater Treatment Plant

HDR did not make significant observations pertaining to instrumentation and controls at KWWTP. Because the new instrumentation and controls associated with ongoing construction activities at KWWTP have yet to be commissioned, HDR did not assess the conditions of this new infrastructure.

3.5.4 Manchester Wastewater Treatment Plant

This subsection describes HDR’s general observations pertaining to field instrumentation and controls at MWWTP.

Plant Influent Flow Monitoring

The Sewer Utility has no means of direct measurement for plant influent flow. Incoming flows are received in the influent pump station wet well and there is not a convenient on-site location for installing flow measurement equipment upstream from the wet well. Based on discussions with Sewer Utility staff, HDR believes that the Sewer Utility is deriving MWWTP influent flow from measurements of plant effluent and return activated sludge (RAS) flows. Plant influent flow is a critical parameter for laboratory measurements and plant process performance metrics. Therefore, direct measurement of plant influent flow would be preferable to derivation from other plant flows.

Headworks Odor Control and Associated Chemical System Instrumentation

HDR observed that some of the instrumentation related to the MWWTP headworks odor control system and its associated chemical system either is non-functional or has been removed. For example, the sodium hypochlorite storage tank appears to have no level measurement instrumentation. Though a level value for this tank is displayed at the plant SCADA screens, historical SCADA data reviewed by HDR show a constant zero value for this parameter. The odor control system control panel also appears to have a non-functional analyzer, an analyzer with an active warning, and another analyzer displaying a potentially inaccurate negative pH value (see Figure 3-19). Based on observations and discussions with Sewer Utility staff, HDR believes that the odor control system is no longer functioning per its original design.

Figure 3-19. MWWTP odor control system control panel instrumentation

Gravity Belt Thickener Flow Monitoring

During its site visit, HDR observed that the magmeter on the sludge line feeding the MWWTP GBT was severely corroded (see Figure 3-20). As the meter continues to deteriorate, failure of the instrument will become more likely.

Figure 3-20. Corroded magmeter on sludge line to MWWTP gravity belt thickener

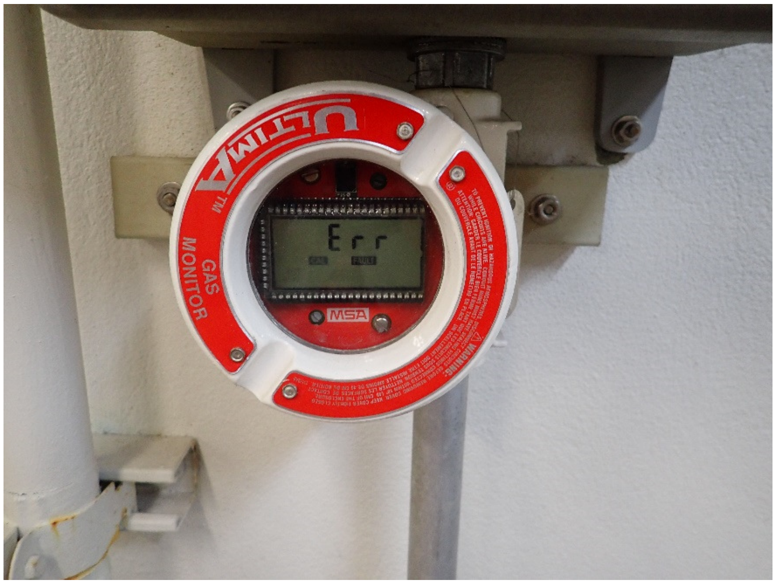
Aeration Basin Dissolved Oxygen Monitoring

The MWWTP aeration basins have no DO probes or other analytical instruments for monitoring the BNR process. Sewer Utility staff indicated that DO probes previously installed in the basins had presented maintenance challenges and were removed. Without DO measurement, control of the constant-speed aeration blowers has become more of a manual process.

LEL Monitoring

During its site visit, HDR observed that several of the MWWTP LEL gas monitors and transmitters were non-functional (see Figure 3-21 for an example). Non-functional LEL gas monitors were found in the operations building sludge pumping gallery, at the headworks odor control system, and at the WAS tank. Without functional gas monitoring equipment, the Sewer Utility is not measuring the concentration of combustible gas in these areas.

Figure 3-21. MWWTP sludge pumping gallery faulted LEL gas monitor



W3 Flow Monitoring

During its review of MWWTP HMI screens and historical SCADA data, HDR observed that a flow signal is not being received from the flow transmitter and totalizer on the MWWTP service water (W3) pump discharge piping (see Figure 3-22). HDR observed that the MWWTP W3 pumps HMI screen displayed zero flow while one of the W3 pumps was running. Historical data obtained for the last 2 years also show a constant zero value for W3 flow.

Figure 3-22. MWWTP W3 pump flow transmitter and totalizer

UV Disinfection Controls

Sewer Utility operations staff indicated that a recent fecal-coliform issue at MWWTP is believed to have been caused by a sensor within the Trojan UV system reporting false readings, which led to under-dosing of UV. After County electricians cleaned and serviced the sensor, the Trojan UV system performance has improved. However, operations staff still suspect there are some inaccuracies in the sensor readings and have reduced confidence in the equipment.

3.5.5 Suquamish Wastewater Treatment Plant

This subsection describes HDR's general observations pertaining to field instrumentation and controls at SWWTP.

Odor Control System

Based on nameplate information, HDR believes that the SWWTP odor control system has been in operation for at least 23 years. Sewer Utility operations staff indicated that they have had to resort to manual procedures like manually dosing the system with sodium hypochlorite to keep the equipment in operation. During its site visit, HDR observed that one of the analytical probes associated with the odor control system appears to have a splice in the probe's manufacturer cable (see Figure 3-23). Field splices are not a recommended practice for analog signals and this splice may be degrading the accuracy of the probe's measurement or disrupting the signal entirely.

Figure 3-23. SWWTP odor control system analytical probe with splice in manufacturer cable

Process Building Upper-Floor Process Room LEL Monitoring

During its site visit, HDR observed that the LEL gas monitor in the process building upper-floor process room is non-functional (see Figure 3-24). Without functional gas monitoring equipment, the Sewer Utility is not measuring the concentration of combustible gas in this area.

Figure 3-24. Non-functional LEL gas monitor in the SWWTP process building upper-floor process room

Plant Effluent Flow Control Valve Control

Sewer Utility staff have indicated that the SWWTP effluent flow control valve is unable to maintain its position when commanded to close. The valve tries to maintain a closed position but eventually begins opening. SWWTP has no bypass piping around this valve, so SWWTP would need to shut down in order for the control valve to be serviced or replaced.

Rotary-Drum Thickener Control

Sewer Utility operations staff indicated that the RDT operation is a highly manual process that requires operators to watch the sludge and manually modulate the spray bar, polymer dosing, and drum drainage to control sludge thickness. Because the sludge piping between the thickened sludge pump and the sludge storage tank is reported to be too small (3 or 4 inches), the thickened sludge pump, which is a progressing-cavity pump, shuts down on high pressure if the sludge is too thick. Operators must make sure that sludge thickness is below a certain threshold to avoid high pressures in the pump discharge piping. However, this workaround is reducing the efficacy of the RDT because the equipment is not dewatering sludge to the extent that it could.

Thickened Sludge Storage Tank Level Measurement

According to Sewer Utility operations staff, the level transmitter for the thickened sludge storage tank is reporting level measurements that do not align with actual tank levels. Operations staff indicated that it provides them with a ballpark estimate of tank level, but when low levels are reached during drawdown activities they have to resort to visual confirmation of tank levels to complete the drawdown. Based on record drawings from the SWWTP Thickening project under which the tank was installed, the tank level is measured by a pressure transmitter that was specified to be installed on a dedicated tank nozzle. HDR observed that the instrument was instead installed on the suction piping for the truck loadout pump within a few feet of the pump's inlet flange (see Figure 3-25). Installing the pressure-based level instrument on the suction piping for the progressing-cavity pump may be impacting stable and accurate level measurements when the pump is in operation.

Figure 3-25. SWWTP thickened sludge tank level transmitter on truck loadout pump suction piping

Sludge Storage Tank Level Measurement

The Sewer Utility is not monitoring sludge storage tank level. Operations staff report that they have tried multiple level measurement technologies, but all transmitters have failed. Operators have resorted to relying on a float switch installed on a string (see Figure 3-26) for high-level alarm indication and shutdown of sludge supply to the tank. To control tank level, operators use a flowmeter to gauge tank fill rate. However, this approach requires operators to be vigilant about when to stop flow to the tank because the remaining sludge in the tank sludge supply piping when the valve closes will continue to gravity-drain to the tank. The current approach to controlling sludge storage tank level introduces significant risk of operator error, has no backup level instrumentation, and relies on a level switch with a non-ideal installation.

Figure 3-26. SWWTP sludge storage tank high-level switch installation

Process Building Fire Alarm System

Sewer Utility staff indicated that the process building fire alarm dialer is no longer functional, so the fire alarm system was tied into SCADA for alarm callouts. However, the fire alarm panel (see Figure 3-27) itself has since failed so SWWTP is not currently monitoring or alarming for fires. Per NFPA 820 Table 6.2.2(a), Row 12, a fire alarm system is required due to the presence of dewatering equipment (e.g., the RDT) in the upper floor process area (NFPA 2020).

Figure 3-27. Failed fire alarm system panel at SWWTP process building

SBR Dissolved Oxygen Monitoring

The SWWTP SBRs have no DO probes or other analytical instruments for monitoring the BNR process. Sewer Utility staff indicated that DO probes previously installed in the SBRs had presented maintenance challenges and were removed. Without DO measurement, control of the constant-speed aeration blowers is based on operator-entered set points derived from institutional knowledge and not based on measured conditions within the SBRs.

Damaged RDT Spray Water Flow Switch

The thermal dispersion flow switch on the RDT spray water supply line has been damaged (see Figure 3-28). This may result in a shorter than expected useful service life for the switch.

Figure 3-28. Damaged flow switch on SWWTP RDT spray water supply line

3.5.6 Pump Stations

This subsection describes HDR's general observations pertaining to field instrumentation and controls at the wastewater pump stations.

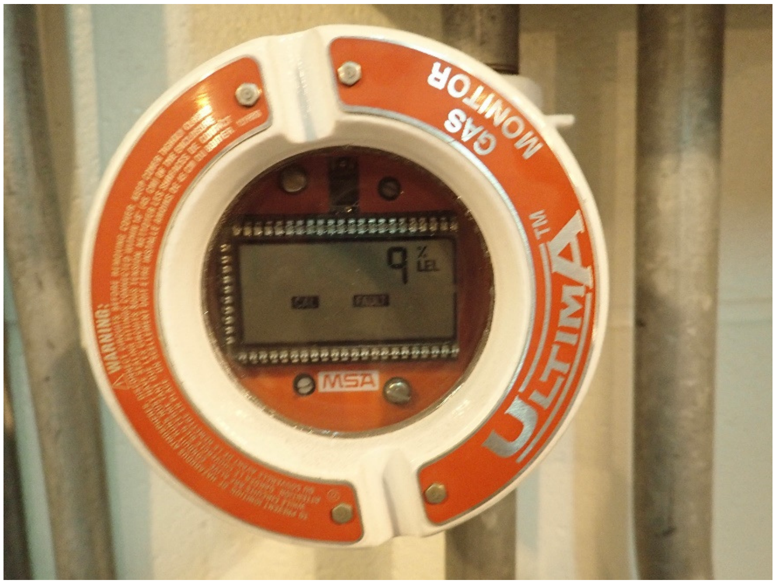
PS-24 Pumps Short Cycling

During HDR's site visit, one of PS-24's pumps turned on and off multiple times, running for about 30 seconds each time before turning off. Sewer Utility staff indicated that short cycling of the pumps is a common occurrence at this pump station. However, PS-24 can receive sudden high flows, so staff have been reluctant to tinker with the existing pump controls.

PS-24 Wet Well LEL Monitoring

During HDR's site visit, a CAL FAULT indication was observed at the wet well LEL gas monitor (see Figure 3-29). This typically indicates that the last calibration attempted was either incomplete or unsuccessful. The fault may be impairing the instrument's ability to accurately measure the concentration of combustible gas in the pump station wet well. Per NFPA 820 Table 4.2.2, Row 14, combustible gas detectors are required for wastewater pumping stations that are mechanically ventilated, which includes odor control, or that open into a building interior (NFPA 2020). Because the PS-24 wet well has an odor control system with mechanical ventilation, HDR believes that the NFPA 820 requirement for combustible gas detection at the station wet well applies to PS-24.

Figure 3-29. Faulted PS-24 wet well gas monitor



PS-24 Wet Well Level Measurement

During HDR's site visit, the ultrasonic level transducer measuring wet well level was observed to be coated with grime and dried scum (see Figure 3-30). The condition of the transducer may be degrading the accuracy of the level measurement.

Figure 3-30. PS-24 wet well ultrasonic level transducer coated with grime and dried scum

PS-34 Wet Well Level Control

PS-34 has no PLC and the pump station's wet well level appears to be controlled by a Precision Digital level indicator and controller that monitors the wet well's radar level transmitter. The remainder of PS-34's controls are hardwired. The pump station used to be controlled via a bubbler and its control panel (see Figure 3-31) includes several components associated with bubbler-based level control along with a handwritten note documenting procedures for reverting back to bubbler control in the event of radar level transmitter failure. Because of the age and condition of the control panel components, its undocumented modifications, and lack of PLC, PS-34 would be a good candidate for a control panel upgrade.

Figure 3-31. PS-34 control panel

PS-71 BIOXIDE Storage Tank Level Monitoring

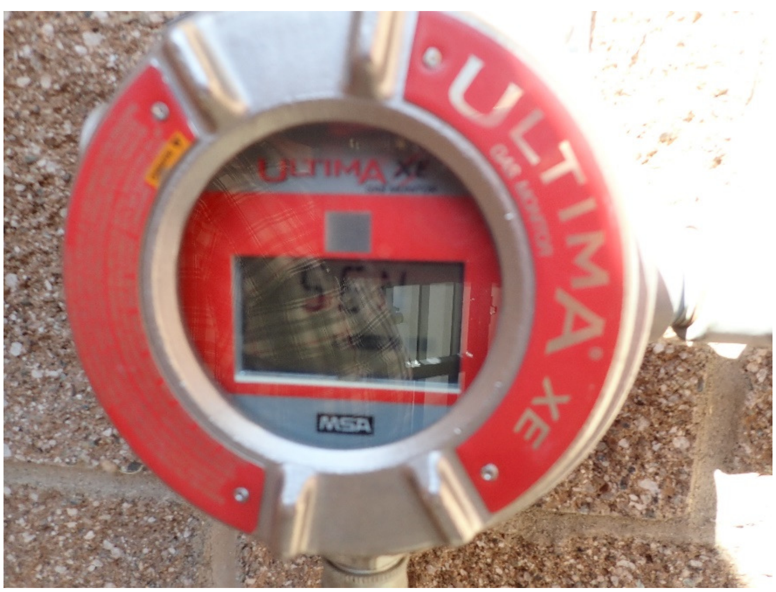
Sewer Utility staff indicated that the ultrasonic probe on the old sodium hypochlorite tank failed after 2 weeks because of exposure to the chemical. The tank has since been converted to a BIOXIDE storage tank, but the level instrument still remains hanging off of an old flange and is no longer connected to the tank (see Figure 3-32). The Sewer Utility is not currently monitoring BIOXIDE storage tank level.

Figure 3-32. Failed ultrasonic level probe disconnected from PS-71 BIOXIDE storage tank

PS-71 Wet Well LEL Monitoring

During its site visit, HDR observed that the LEL gas monitor for the PS-71 wet well is registering a fault and is not currently functioning (see Figure 3-33). Without functional gas monitoring equipment, the Sewer Utility is not measuring the concentration of combustible gas in the pump station wet well. Because the PS-71 wet well has an odor control system with mechanical ventilation, HDR believes that the NFPA 820 requirement for combustible gas detection at the station wet well applies to PS-71.

Figure 3-33. PS-71 wet well LEL monitor in alarm



- Based on discussions with Sewer Utility I&C technicians, HDR believes that the Sewer Utility does not have a formal calibration and maintenance program for field instrumentation and associated control loops.

- A condition assessment survey of existing instrumentation has yet to be performed. This effort would provide the most value if done on a process-by-process basis as part of process and equipment level-of-automation and performance optimization evaluations.

- The Sewer Utility has no means of direct measurement for CKTP effluent flow.

- Current CKTP effluent flow calculations provided by the Trojan UV system are resulting in higher flows than those derived from an accounting of other CKTP flow measurements.

- The CKTP headworks odor control biofilter sprinkler control panel is out of service and watering of the biofilter is now a manual process for Sewer Utility staff. Replacing and/or introducing instrumentation to maintain desirable moisture levels in the biofilter via automation could improve Sewer Utility workforce efficiency and the effectiveness of the biofilter.

- The LEL transmitter on the CKTP headworks odor control fan ductwork is registering an IR source fault and is not monitoring combustible-gas concentration in the odor control system.

- Automated control of the CKTP BNR process has proved to be unstable. Operators currently position the aeration control valves manually and have to frequently adjust blower header pressure set points based on process demand.

- Unlike the other three CKTP aeration basins, aeration basin 1 has no DO probes installed. This is one of the deficiencies frustrating the Sewer Utility's BNR efforts at CKTP.

- Only CKTP aeration basin 4 has ammonium and nitrate probes installed to monitor nitrogen removal occurring in the basin.

- The chlorine residual and turbidity analyzers associated with the CKTP reclaimed-water filtration system were found powered down during HDR's site visit.

- The low-level switch for the CKTP thickened sludge blending tank has failed and the tank's circulation pump and digester feed pumps are likely operating without a low-level shutdown interlock.

- HDR observed that the thermal dispersion flowmeter installed on the aeration line for the CKTP aerated grit tank 1 stage 2 diffuser is measuring zero flow, while the positions of manual valves on either side of the instrument suggest that flow should be occurring.

- The CKTP cogeneration system and digester gas conditioning system have been abandoned in place because of high material and maintenance costs and limited digester gas production.
- The Sewer Utility has no means of direct measurement for plant influent flow at MWWTP.
- Some of the instrumentation related to the MWWTP headworks odor control system and its associated chemical system either is non-functional or has been removed. Systems are no longer operating per their original design.
- The magmeter on the sludge line feeding the MWWTP GBT is severely corroded.
- The MWWTP aeration basins have no DO probes or other analytical instruments for monitoring the BNR process.
- Combustible-gas monitoring equipment at the MWWTP sludge pumping gallery, headworks odor control system, and WAS tank is non-functional.
- The MWWTP SCADA system is not receiving a flow signal from the flow transmitter and totalizer on the plant W3 pump discharge piping.
- Instrumentation within the MWWTP Trojan UV system has had recent issues and operations staff have reduced confidence in the system's UV dosing control.
- One of the analytical probes associated with the SWWTP odor control system appears to have a splice in the probe's manufacturer cable, which may be degrading the accuracy of the probe's measurement or disrupting the signal entirely.
- Combustible-gas monitoring equipment at the SWWTP process building upper-floor process room is non-functional.
- The SWWTP effluent flow control valve is unable to maintain its position when commanded to close. The valve tries to maintain a closed position but eventually begins opening. SWWTP has no bypass piping around this valve, so the plant would need to shut down in order for the control valve to be serviced or replaced.
- Operation of the SWWTP RDT is a highly manual process where operations staff have to target a reduced sludge thickness to avoid shutting down the thickened sludge pump on high discharge pressure because of reportedly undersized sludge discharge piping. This

workaround is reducing the efficacy of the RDT because the equipment is not dewatering sludge to the extent that it could.

- Sewer Utility staff indicated that the level transmitter for the SWWTP thickened sludge storage tank is reporting level measurements that do not align with actual tank levels.
- The SWWTP sludge storage tank level is not monitored. Operations staff have resorted to a manual method of controlling tank level that introduces significant risk of operator error and relies on a high-level switch with a non-ideal installation for alarming and shutdown of the sludge supply to the tank.
- The SWWTP process building fire alarm panel has failed so the plant is not currently monitoring or alarming for fires.
- The SWWTP SBRs have no DO probes or other analytical instruments for monitoring the BNR process.
- The thermal dispersion flow switch on the SWWTP RDT spray water supply line has been damaged. This may result in a shorter than expected useful service life for the switch.
- Short cycling of the pumps is a common occurrence at PS-24.
- Combustible-gas monitoring equipment at the PS-24 wet well is faulted.
- The ultrasonic level transducer measuring the PS-24 wet well level was observed to be coated with grime and dried scum. The condition of the transducer may be degrading the accuracy of the level measurement.
- PS-34 has no PLC and the pump station’s wet well level appears to be controlled by a level indicator and controller that monitors the wet well’s radar level transmitter. Because of the age and condition of the control panel components, its undocumented modifications, and lack of PLC, PS-34 would be a good candidate for a control panel upgrade.
- The Sewer Utility is not currently monitoring BIOXIDE storage tank level at PS-71.
- Combustible-gas monitoring equipment at the PS-71 wet well is non-functional.

4 Industrial Control System Software

This section describes the Sewer Utility's current ICS software, including an overview of the PLC programming, HMI, historian, and alarm notification software packages in use at the WWTPs and wastewater pump stations. It also describes the SCADA system functionality that has been implemented with this software.

4.1 PLC Programming Software

This subsection describes the PLC programming environments, firmware and software versions, and methods used in the development and maintenance of Sewer Utility PLCs.

4.1.1 Programming Environments

The various Allen-Bradley PLCs installed throughout the Sewer Utility's wastewater infrastructure are programmed via one of two separate Rockwell Automation software applications. Programming project files for the Allen-Bradley MicroLogix and SLC 500 series PLCs are developed with RSLogix 500, while programming files for the CompactLogix PLCs are developed within the Studio 5000 Logix Designer programming environment. Programming logic developed in the two programming environments is not interchangeable, which prevents standard programming templates or blocks developed in one environment from being used in the other. Because Rockwell Automation does not provide a single programming environment for all of its controllers, the consumer is left with the choice of standardizing on one controller that may be oversized for some applications or investing in additional effort to develop and maintain programming files in multiple programming environments. The Sewer Utility has opted for the latter scenario.

4.1.2 Firmware and Software Versions

Both RSLogix 500 and Studio 5000 Logix Designer are frequently updated by the manufacturer, along with firmware updates to the processors themselves, to fix bugs and mitigate security vulnerabilities. This has resulted in several versions of the firmware and software over the years. Keeping up with these firmware and software updates can be a challenge for any organization and it is not uncommon for firmware updates to yield unexpected results that require tweaks to programming files, which can result in unanticipated downtime. Another maintenance challenge is that the firmware and software versions need to be aligned, so programmers cannot simply install the most recent version of the programming environment and have the ability to work on programming files created in previous versions or make online revisions to programs downloaded to controllers running previous firmware versions.

Because of the manufacturer's approach to firmware and software versioning, many organizations adopt the practice of developing programming files with the latest software version available at the time the PLC is installed and avoiding firmware and software updates thereafter. Judging from the various software versions used to develop the Sewer Utility's PLC programming project files, it appears that the Sewer Utility has adopted this practice. For example, versions of Studio 5000 Logix Designer (and its predecessor RSLogix 5000) used for the development of Sewer Utility PLC programming project files reviewed by HDR range from versions 19.01.00 to 30.02.00. While avoiding firmware updates can provide some cost savings in terms of ICS maintenance and eliminates the chance of hiccups while controller firmware is updated, it leaves PLCs running without the advantages of current security patches and optimized controller features. Having a variety of firmware versions throughout the Sewer Utility's ICS also requires the Sewer Utility and contracted systems integrators to have several programming environment software versions installed on the machines used to work on the PLCs.

4.1.3 Programming Methods

With few exceptions, the Sewer Utility's PLCs are programmed using ladder logic. In general, the various systems integrators that have developed the Sewer Utility's programming project files have leveraged object-oriented programming (OOP) concepts to apply a degree of standardization to the programming project files and to make them more efficient and easier to maintain. For example, the Sewer Utility's programming project files that were developed in the Studio 5000 Logix Designer programming environment make extensive use of Add-on Instructions (AOIs) and User-defined Data Types (UDTs), which significantly reduces the amount of repetitive ladder logic rungs and manual tag creation.

Though OOP-based best practices appear to have been applied to several of the Sewer Utility's PLC programs, at least three systems integrators have independently applied these best practices over the years. This has resulted in an overall lack of standardization when it comes to organization, tag naming convention, annotation practices, and the AOIs and UDTs used throughout the Sewer Utility's PLC programming project files. Establishing PLC programming standards based on OOP principles would help the Sewer Utility implement a uniform approach to how its assets are managed within the ICS, which would simplify ICS programming maintenance and help guide future programming efforts by Sewer Utility staff and contracted systems integrators.

- Sewer Utility PLCs are running a variety of firmware versions.
- The Sewer Utility does not have PLC programming standards in place and its PLC programming project files reflect a variety of conventions and programming objects implemented by multiple systems integrators.

4.2 Human-Machine Interface Software

This subsection describes the Sewer Utility's HMI software as well as its configuration and implementation.

4.2.1 Wonderware InTouch

The Sewer Utility is currently standardized on Wonderware InTouch 2014 R2 Service Pack 1 (SP1) for CKTP and SWWTP. This software is currently in the mature support phase of the software developer's product life cycle. Mature support is the final phase in the product life cycle, during which limited support is offered and users are encouraged to upgrade licensing to current software versions. The Wonderware InTouch version at KWWTP and MWWTP has been recently upgraded to Wonderware InTouch 2017. This software is currently in the extended support phase of the software developer's product life cycle, but will soon reach the mature support phase in November 2020. Based on information provided by the Sewer Utility, HDR believes that the Wonderware InTouch licenses at CKTP are 60,000-tag licenses, while the licenses at the other WWTPSs are 3,000-tag licenses. Note, Wonderware has been rebranded as AVEVA as part of a recent reverse merger between Schneider Electric and AVEVA. However, this TM refers to the software as Wonderware, the name under which it has been marketed for several years.

The Sewer Utility's Wonderware InTouch software has been implemented in its standalone variant and not as part of a Wonderware System Platform deployment that incorporates Wonderware's ArchestrA Framework. Though this approach avoids much of the complexity introduced by the ArchestrA Framework, it provides none of the efficiencies and other benefits that come from a more centralized approach to managing ICS device data and SCADA visualizations. This lack of centralized management has resulted in non-standardized programming objects and visualizations at the various WWTPs. At CKTP, where there is more than one SCADA PC for the plant, the lack of a centralized server-client model for the HMIs has also presented some operational challenges such as alarm acknowledgments made at one HMI thick client not being registered by other HMI thick clients.

Based on discussions with the Sewer Utility and QCC, HDR believes that the Sewer Utility and QCC are planning to upgrade the Sewer Utility's Wonderware licensing at CKTP to a more current version. As part of the upgrade, QCC will implement an ArchestrA Framework–based Wonderware System Platform deployment consisting of redundant Wonderware Application Servers; an ArchestrA Galaxy Repository; two Wonderware InTouch runtime thick client PCs; and configuration of several Wonderware InTouch runtime thin clients for existing industrial panel PCs, SCADA PCs, and County-issued tablets. HDR's understanding is that the existing CKTP SCADA screens will be preserved as part of this upgrade and that modifications to the screens' graphics and functionality are not included in QCC's current scope of work.

4.2.2 Human-Machine Interface Screens

This subsection summarizes current Sewer Utility practices for HMI organization, color, overview screens, process screens, pump station screens, equipment pop-up screens, trend screens, and alarming.

Organization

The Sewer Utility WWTP HMI screens are generally arranged in a three-level hierarchy that begins with an overview screen (level 1) and provides more information and detail to operators as they progress through process-specific screens (level 2) to equipment-specific pop-up windows/screens and trend screens (level 3). The HMI screen composition differs depending on the WWTP, but all WWTPs have standardized on a top or bottom horizontal navigation banner with most of the screen dedicated to the screen-specific content. CKTP and SWWTP also include a bottom horizontal alarm summary banner on each screen, which is meant to display the most recent SCADA alarms.

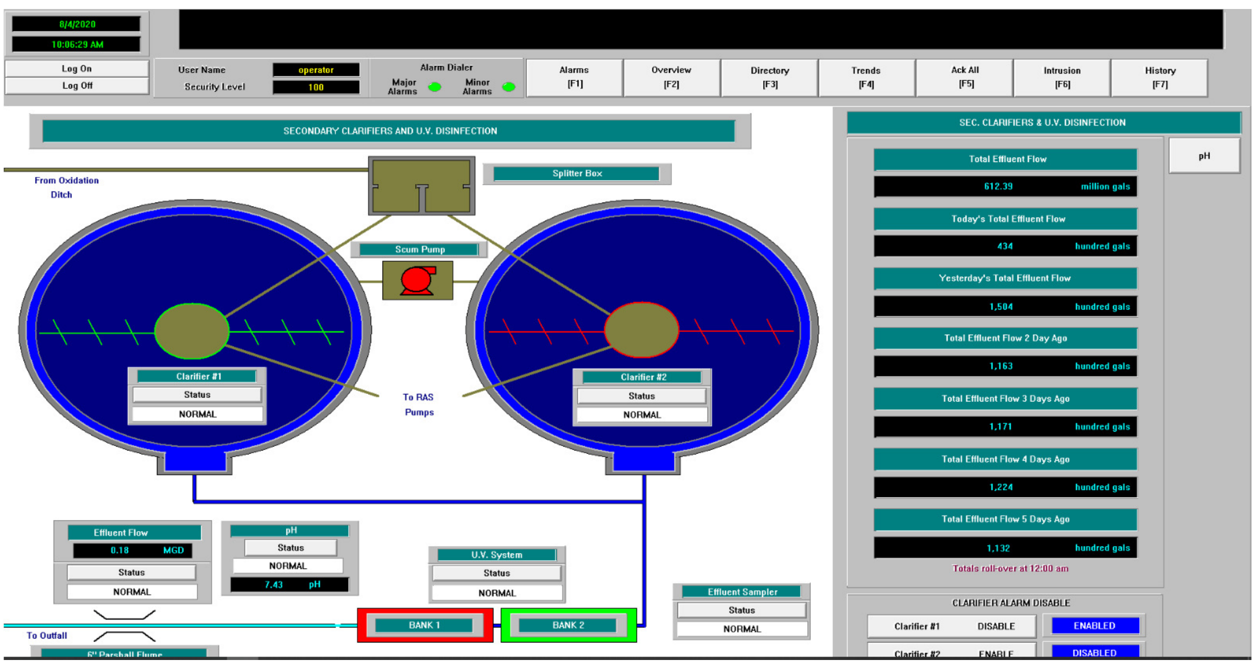
However, the alarm summary banner at SWWTP may be non-functional because it was displaying a single alarm from more than 4 months prior to HDR's site visit and did not include more current alarms found on the alarm summary screen. At CKTP, several plant flow values and select equipment operational statuses are also displayed in a vertical column at the right of each screen.

Operators can navigate through the WWTP HMI screens by means of the navigation banner, clickable screen content on the various screens, and, in some cases, by clicking on arrows that advance through the process screens. MWWTP and KWWTP also have a directory screen that allows operators to select the plant process or equipment group they would like to view.

Color

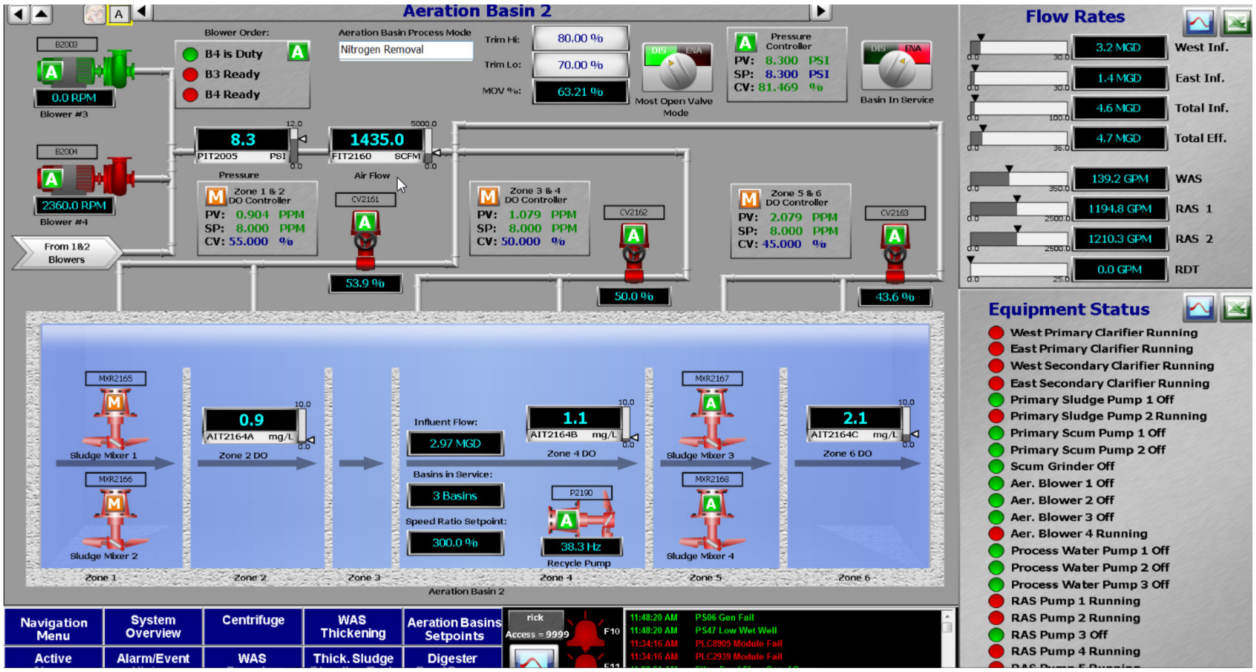
Throughout the HMI screens, color is often the sole means of differentiating important condition, status, or alarm state. For example, the secondary clarifiers and UV disinfection HMI screen at KWWTP shown in Figure 4-1 communicates clarifier, scum pump, and UV bank running status with color only. Because of the prevalence of color-detection deficiencies among the population, modern HMI graphics development best practices call for indication of condition, status, and alarm state to be accompanied by text and/or shapes.

Figure 4-1. KWWTP secondary clarifiers and UV disinfection HMI screen



Relying solely on color to communicate status, condition, and alarm state can also create confusion for operators (particularly recent hires) because institutional knowledge is required to decipher color significance. For example, an individual looking at the screen depicted in Figure 4-1 would have to know that red means "off" at KWWTP to understand that the scum pump shown on the screen is not running. The potential for confusion and operator error can increase significantly when "on/off" and "open/closed" color schemes are not consistently applied throughout an organization's infrastructure, as is the case with the Sewer Utility's HMI screens. At CKTP, for example, the on/off, open/closed color scheme appears to be reversed from the scheme adopted at KWWTP. As shown in the CKTP aeration basin 2 HMI screen depicted in Figure 4-2, running blowers, mixers, and pumps are shown in red. The color scheme inconsistency was also observed at the Sewer Utility's wastewater pump station OIT screens.

Figure 4-2. CKTP aeration basin 2 HMI screen

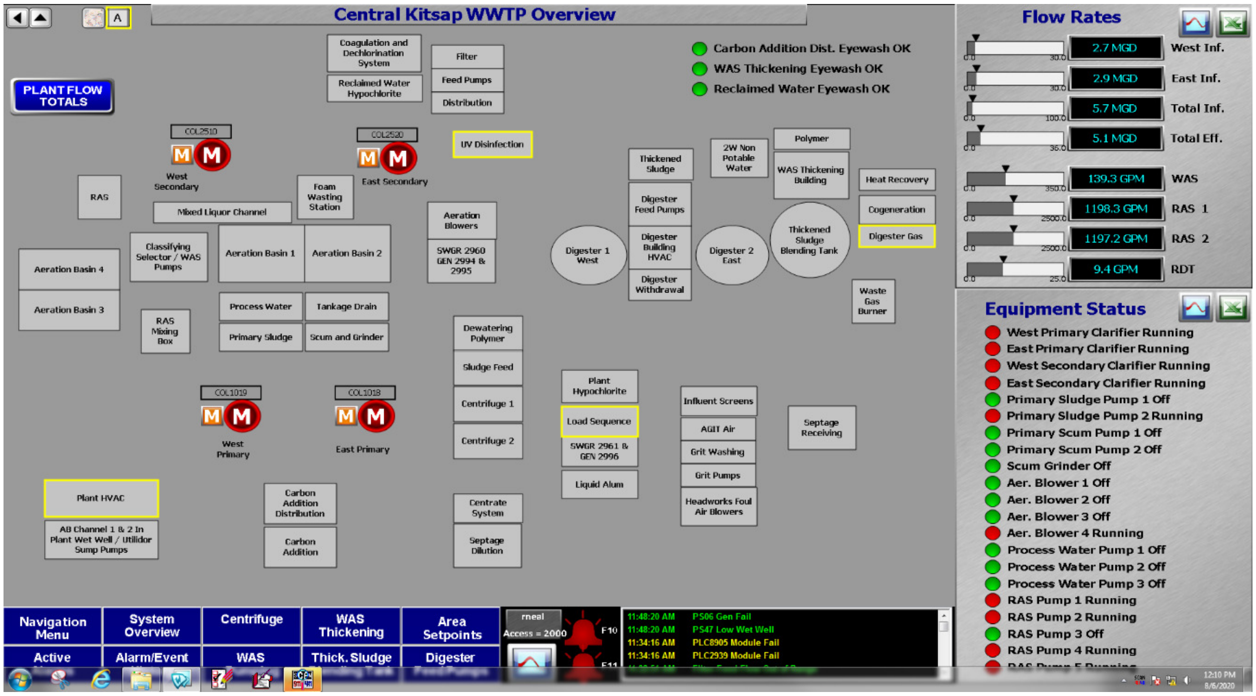


In many cases throughout the Sewer Utility's HMI screens, binary-type statuses like on and off are distinguished with equally vivid colors. Static portions of the CKTP and SWWTP HMI screens, like the piping and equipment graphics, are often displayed with colors that are brighter than the HMI screen background color. The background color for KWWTP and MWWTP HMI screens is white, which renders all other colors used to convey status, condition, or alarm state darker than the background. A general best practice is to show equipment that is running with a brighter color than the background and equipment that is off with a darker color than the background. Equipment and other elements that are not controlled via the ICS but are shown for other purposes would be shown filled with the same color as the background.

Overview Screens

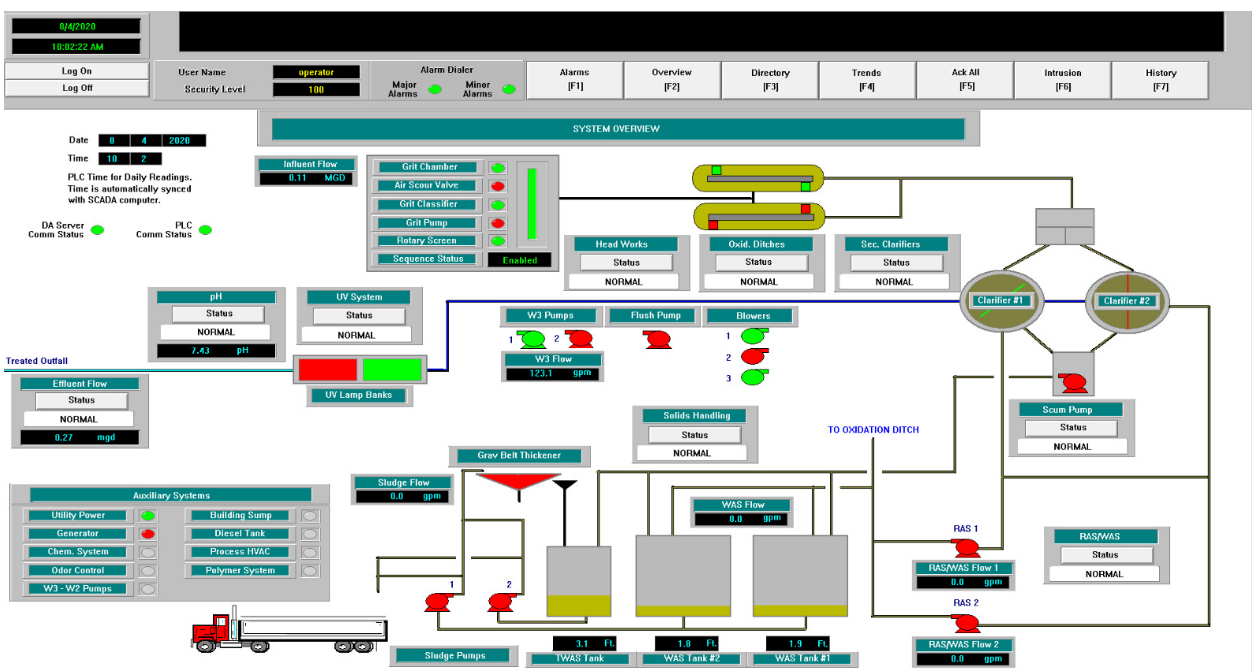
The CKTP overview HMI screen is displayed in Figure 4-3. Aside from displaying primary and secondary clarifier status and some emergency eyewash alarm status indications, the HMI screen functions more as a directory for operators to navigate to specific process screens than an overview of current CKTP operational status. It appears that process screens with active alarms and/or warnings are displayed with yellow outlines to draw operator attention. Beyond these elements and the plant flow and equipment status information displayed on all CKTP HMI screens, no additional information can be obtained from the screen.

Figure 4-3. CKTP overview HMI screen



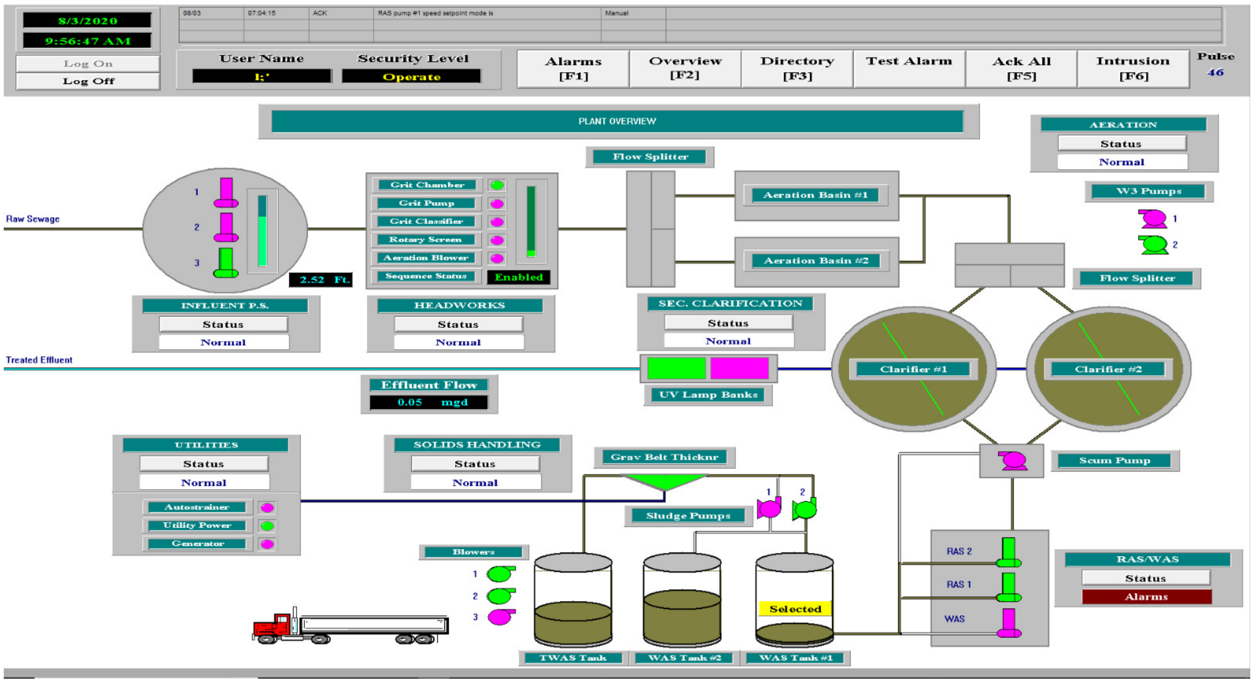
The KWWTP overview HMI screen is displayed in Figure 4-4. This screen provides a general process flow overview for KWWTP with running status for major plant equipment communicated by the plant's red and green color scheme. Several process parameters like level, flow, and pH are displayed on the overview screen along with current utility and generator power statuses.

Figure 4-4. KWWTP overview HMI screen



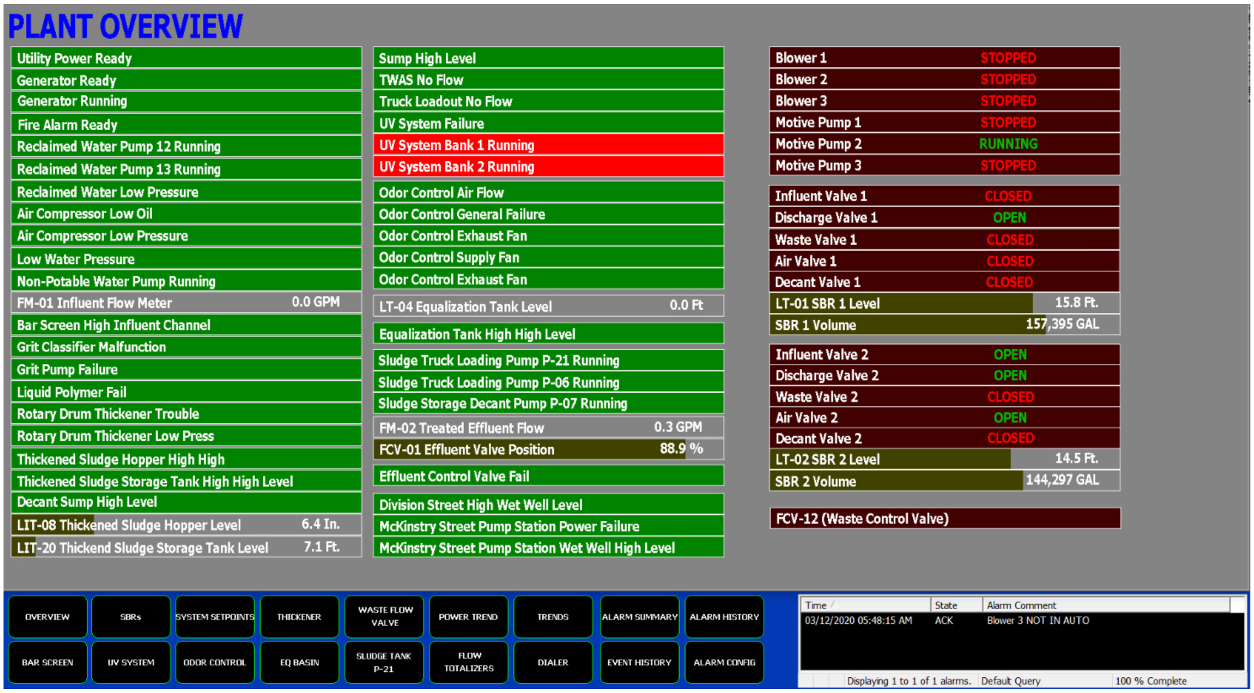
The MWWTP overview HMI screen is displayed in Figure 4-5. This screen provides a general process flow overview for MWWTP with running status for major plant equipment communicated by the plant's magenta and green color scheme. MWWTP influent pump station level and effluent flow values are displayed on the overview screen along with current utility and generator power statuses. Sludge tank levels are represented as proportional fill of their respective cylinders, but no level values are displayed.

Figure 4-5. MWWTP overview HMI screen



The SWWTP overview HMI screen is displayed in Figure 4-6. This screen provides no process flow overview and instead presents major equipment running status and SWWTP alarm information in table format using the plant's red and green color scheme. One confusing aspect of the overview screen is that the text associated with the equipment and alarm statuses does not appear to change along with the color. For example, the word "RUNNING" appears in both red and green cells. In addition to process-related on/off and alarm status information, several level and flow values for SWWTP processes are displayed on the overview screen along with current utility and generator power statuses.

Figure 4-6. SWWTP overview HMI screen



Despite the information displayed on the Sewer Utility's WWTP overview HMI screens, the screens do not provide much in the way of context that can aid situational awareness. For example, it would be difficult to relate the quantities of equipment in operation and displayed process values to percentage of plant/process operating capacity without the support of institutional knowledge. Normal operating ranges, target performance set points and ratios, and other key performance indicators (KPIs) are also absent. As currently configured, the overview screens rely on operator knowledge and experience to put the displayed process values in context and arrive at judgments related to current plant conditions.

Process Screens

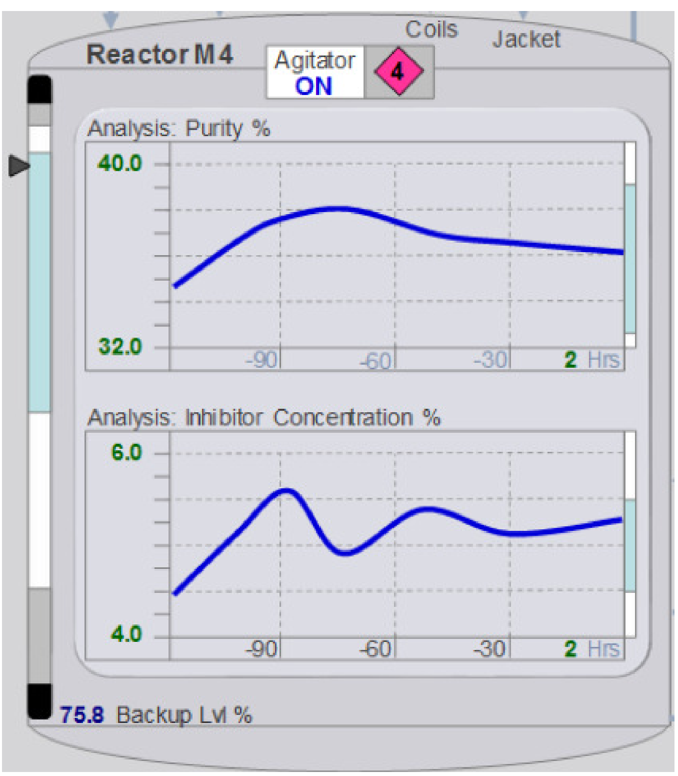
The various Sewer Utility process-specific HMI screens typically show a piping and instrumentation diagram (P&ID)-like, not-to-scale representation of the process with major equipment and vessels interconnected via pipelines with arrows showing flow direction. Process equipment and actuated valves are typically labeled with a descriptive name to help operators associate the graphics with the actual equipment, and, in some cases, the equipment tags are also included. Equipment running status and valve open/close position status are generally communicated via a green and red or green and magenta color scheme. Motor speed is also displayed, where applicable, though engineering units for speed vary between hertz (Hz) and percent speed depending on the equipment. Sewer Utility staff have indicated that there are cases throughout the WWTP HMI process screens where the wrong engineering units are being displayed for speed values (e.g., percent speed is displayed for values that represent hertz). Manual and auto status of equipment is also typically presented on the process screens.

In general, process parameters displayed on the HMI screens are shown with engineering units. Where HMI screens cover processes that include proportional-integral-derivative (PID) controllers, the screens provide some valuable context in terms of current process value versus target set point for the PID controller. However, HDR did not provide an in-depth comparison of PLC programming logic with HMI screens to determine the extent to which PID target set points are displayed alongside current process values.

As with the overview screens, the process screens lack some context that would provide greater insight into recent and present conditions. When levels are displayed, it is either just a value or a value with a bar or proportional fill that provides a visual gauge of how the current value relates to the capacity of the vessel. Though the bar and proportional fill gauges are an improvement over a simple value display, they could be further improved by including normal operating range, low- and high-level alarm set points, deadband, overflow, and/or equipment shutdown set point overlays. This type of information provides operators with obvious and immediate context when interpreting current level values. Adding sparklines to the level displays can expand on this context by showing the recent trending of the level signal, without operators having to leave the screen to open a separate trend screen.

Figure 4-7 depicts an example SCADA HMI graphics visualization that includes sparklines and vertical bars with normal operating ranges (light blue regions), low- and high-level alarm set points (borders of gray and black regions), and deadband (gray regions). The same approach could be applied to the various level, flow, pressure, temperature, and analytical measurements, which are currently displayed as values only or with limited context on the HMI screens.

Figure 4-7. Example HMI graphics content providing additional context and situational awareness

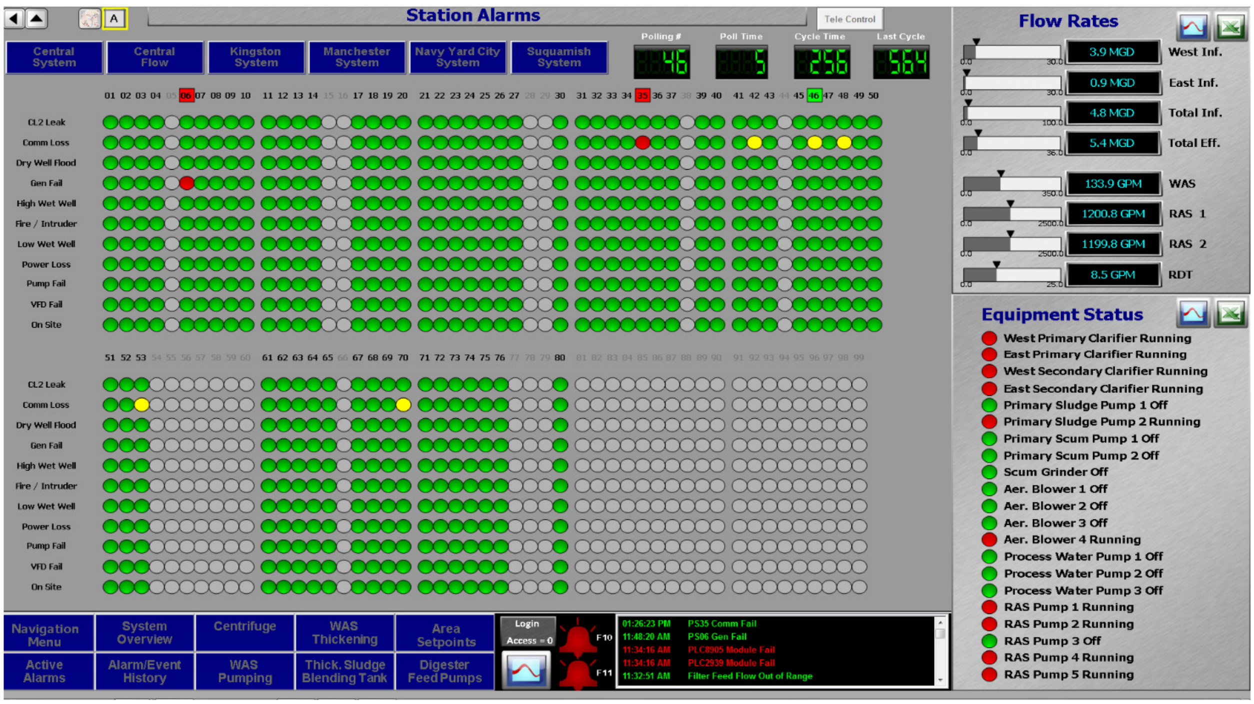


Source: PAS Global LLC.

Pump Station Screens

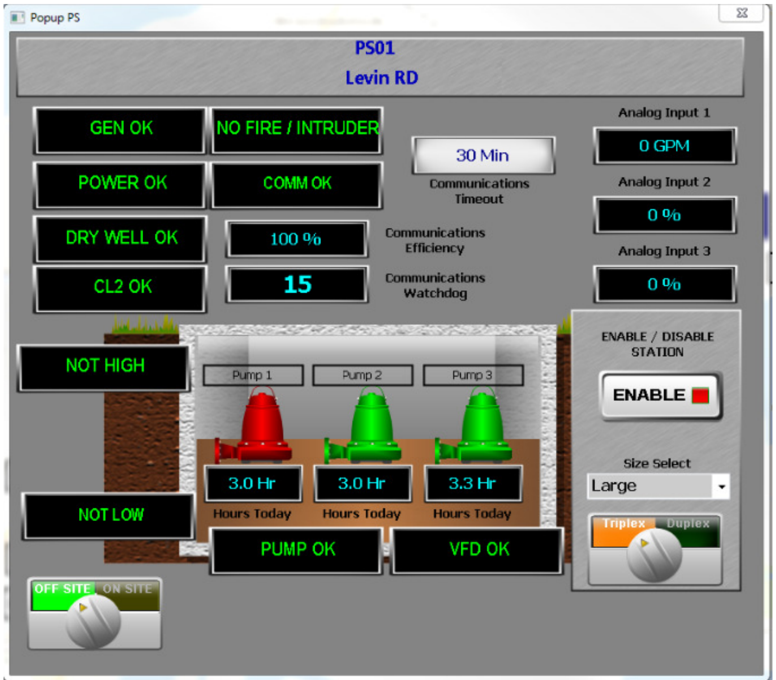
At CKTP, a pump station alarm screen displays the states of all monitored alarms for each pump station along with information pertaining to the current pump station being polled, the polling time, and current and previous polling cycle times (see Figure 4-8). As shown in the figure, the screen provides an intuitive overview of current alarm activity for the pump station that is conducive to quick assessment and location of pertinent information. Though the screen is effective at presenting alarm information, Sewer Utility staff have no means of remotely resetting pump station alarms from this or any other HMI screen at CKTP. The lack of remote alarm reset requires County staff to physically visit the pump stations to reset alarms.

Figure 4-8. Pump station alarm HMI screen



From a separate map HMI screen, operators can select individual pump stations by number, which brings up a pop-up screen dedicated to the pump station. An example pump station pop-up screen is shown in Figure 4-9. These pump station pop-up screens are derived from a common template, which has resulted in some fields and alarms being displayed for which data may not be available at the selected pump station.

Figure 4-9. Example pump station pop-up HMI screen



HDR also observed that there are issues with communication of analog parameters for some of the pump stations. Evidence of this can be seen in several of the pump station pop-up screens. For example, from the pump colors in Figure 4-9, it would appear that one of the station's pumps is running. However, the flow value is reading 0 gallons per minute (gpm). Historical data reviewed by HDR also indicate that constant, out-of-range values are being logged for several pump station analog parameters.

Even where communication of pump station analog parameters appears to be functional, the analog parameters included in the Sewer Utility's remote monitoring capabilities that HDR observed are limited to discharge flow. The Sewer Utility does not appear to be monitoring wet well level, force main pressure, pump speed, LEL, BIOXIDE/chemical storage tank level, power and energy parameters, or other analog parameters for the pump stations.

Equipment Pop-up Windows/Screens

While the HMI process screens typically communicate only equipment running status, manual/auto status, and speed (where applicable), in many cases operators can click on individual equipment to view an equipment-specific pop-up window or separate HMI screen. An example pop-up screen is depicted in Figure 4-10. These pop-up windows and screens provide additional information about the equipment that can include local Hand-Off-Auto (HOA) selector switch position, SCADA Manual-Off-Auto setting, ready status, accumulated runtime, and total starts or cycles. For equipment with DeviceNet or EtherNet/IP networked overload relays or VFDs, electrical parameters like voltage, current, power, and power factor are also displayed. Depending on login credentials, equipment start and stop control or open and close control, in the case of valves and gates, and SCADA manual and automatic control selection can be accessed through these pop-up windows/screens.

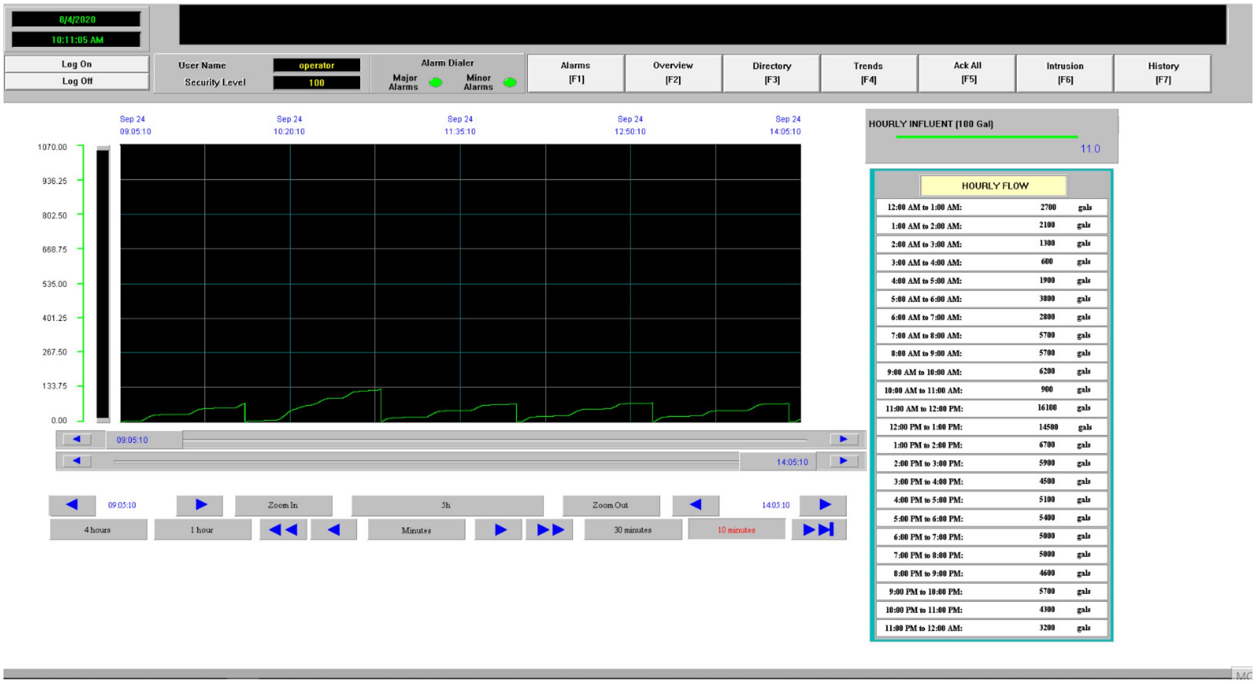
Figure 4-10. CKTP HRR pump 1 equipment pop-up window

As a troubleshooting tool, the equipment pop-up windows/screens reviewed by HDR could be further developed to provide additional value. Currently, they do not appear to be capable of providing information on active alarms or conditions external to the equipment that are inhibiting the equipment from running. Motor starts per last 1 hour and last 24 hours could also be valuable to operators and maintenance staff. With the data available from DeviceNet and EtherNet/IP networked overload relays and VFDs within the Sewer Utility's infrastructure, there are also opportunities to embed additional electrical, diagnostic, and performance data into the equipment pop-up windows/screens.

Trend Screens

The HMI trend screens reviewed by HDR consisted of preconfigured screens dedicated to specific process values (see Figure 4-11 for an example). Operators can interact with the trend screens to dynamically adjust the time axis and adjust vertical scroll bars to obtain process value information for specific time stamps. However, there appears to be no functionality for adding and removing plot lines or other means of customizing trend screens within the HMI environment. Furthermore, none of the trend screens observed indicated normal operation range, alarm set points, deadband ranges, interlock points, or other elements to improve situational awareness.

Figure 4-11. KWWTP hourly influent trend HMI screen



Alarm Screens

Historical alarm information is displayed on dedicated alarm summary or alarm history HMI screens at each WWTP. The Sewer Utility standard for these table-based alarm screens appears to include generation of a unique row with a time stamp for each change in alarm state, the sequence of which is typically as follows:

1. Alarm active and unacknowledged (displayed as UNACK_ALM)
2. Alarm active and acknowledged (displayed as ACK_ALM or ACK)
3. Alarm acknowledged and initiating state/value returned to normal (displayed as ACK_RTN)

Separate colors are used to distinguish the various alarm states, as shown in Figure 4-12, but the colors in use differ between the WWTPs. Although there is some variation in alarm table formatting between the WWTPs, along with the time stamp and alarm state information, each row typically includes the Wonderware tag associated with the alarm, a description of the alarm, and the username of the operator who acknowledged the alarm or “None” if the alarm is unacknowledged. At CKTP, there is also an active alarm HMI screen that shows a filtered list of all current active alarms, acknowledged and unacknowledged.

Figure 4-12. CKTP alarm history HMI screen

During HDR's site visit to SWWTP, Sewer Utility staff explained that the alarm summary and alarm history HMI screens at the plant SCADA PC do not automatically update. HDR confirmed that the user must right-click the screen and select "Refresh" for the screens to update with current alarm information. Requiring the operator to manually refresh alarm information runs counter to the intent of providing alarm screens as a means of alerting operators to new alarms.

When alarms first become active at CKTP, an audible notification is sounded at the SCADA PC in the SPB control room. There are two distinct audible notifications for plant-based and telemetry-based alarms. Both audible notifications continue to sound until the alarm is acknowledged. Unacknowledged alarms are also displayed as flashing text in the horizontal alarm banner at the bottom of the CKTP HMI screens. Upon alarm acknowledgement, the audible notification is silenced and the flashing alarm text in the horizontal alarm banner changes to green text until the alarm becomes inactive, at which point it is removed from the banner.

At CKTP, the volume of alarm activity appears to be considerable. During its site visits, HDR observed frequent alarm annunciations at the SCADA PC in the SPB control room with Sewer Utility staff having to repeatedly stop what they are doing to acknowledge the alarms. Much of this alarm activity is caused by recurrences of the same alarms, but it appears that Sewer Utility staff do not have a way of shelving alarms to filter out nuisance alarms or alarms associated with known issues or elements of the control system requiring maintenance. Providing select, suitably credentialed Sewer Utility staff with the ability to shelve alarms could significantly reduce unnecessary distractions for Sewer Utility staff and help prevent alarm fatigue.

One typical element that appears to be missing from the alarm information presented at the HMI screens is alarm priority or criticality. All alarms seem to be presented as equally important and there does not appear to be a means for operators to quickly sort or filter alarms by priority. Alarm priority information is crucial for operators to be able to focus their attention on the most urgent alarms. International Society of Automation (ISA)-18.2, an industry standard for alarm management (ANSI/ISA 2016), includes alarm priority as an attribute for all alarms and proposes sorting and filtering by alarm priority, along with an alarm priority color code for displaying alarms, as functional requirements of HMI design.

Based on site visit observations and discussions with Sewer Utility staff, HDR believes that the WWTP HMI systems have not been developed to include root-cause analysis and alarm suppression functionality to avoid alarm overload during process upsets. The HMI screens also do not include troubleshooting text prompts or decision tree aids, which could help operators navigate alarm conditions more efficiently.

Sewer Utility staff indicated that there was a recent Sewer Utility initiative to develop an alarm management program for the Sewer Utility with assistance from QCC, but this effort has been stalled by other priorities. Implementing an alarm management program based on the ISA-18.2 standard would improve the effectiveness of the Sewer Utility's HMI and alarm notification systems.

- The Sewer Utility's Wonderware InTouch software at its WWTPs is in, or will soon be entering, the mature support phase of the software developer's product life cycle, during which limited support is offered.
- Lack of centralized management for ICS device data and SCADA visualizations has resulted in non-standardized programming objects and visualizations at the Sewer Utility's WWTPs.
- At CKTP, alarm acknowledgments made at one HMI thick client are not being registered by other HMI thick clients.
- Horizontal alarm banner at the bottom of SWWTP HMI screens may be non-functional.
- Color is often the sole means of distinguishing among condition, status, and alarm state, putting operators with color blindness at a disadvantage.
- Red and green on/off, open/closed color schemes are not consistently applied throughout the Sewer Utility's HMI and OIT screens.
- Vivid colors are used for static HMI graphics elements as well as both on and off states, making it more difficult for operators to notice and focus on dynamic HMI screen elements that deserve more attention.
- HMI overview and process screens could be updated to include more contextual information to facilitate operator situational awareness.
- Sewer Utility staff have indicated that there are cases throughout the WWTP HMI process screens where the wrong engineering units are being displayed for equipment speed values.

- Sewer Utility staff have no means of remotely resetting pump station alarms from CKTP HMI screens. The lack of remote alarm reset requires County staff to physically visit the pump stations to reset alarms.
- HDR observed that there are issues with communication of analog parameters between several pump stations and CKTP. Several pump station pop-up HMI screens appear to constantly display zero values for analog parameters and historian data are also logging constant, out-of-range values for these pump station parameters.
- The Sewer Utility does not appear to have pump station remote monitoring capabilities for wet well level, force main pressure, pump speed, LEL, BIOXIDE/chemical storage tank level, power and energy parameters, or other analog parameters for the pump stations.
- Equipment pop-up windows/screens do not appear to have functionality to provide information on active alarms or conditions, not internal to the equipment, that are inhibiting the equipment from running.
- Equipment pop-up windows/screens could be developed to include additional electrical, diagnostic, and performance data as well as expanded motor start count information.
- Trend screens display current values against time only and do not provide meaningful situational awareness.
- Alarm summary and alarm history HMI screens at SWWTP are not automatically updated to display current alarm information.
- The CKTP Wonderware implementation is generating considerable alarm activity, much of which is caused by the same alarms.
- Sewer Utility staff do not appear to have a means of shelving nuisance alarms or alarms associated with known issues.
- Sewer Utility WWTP HMI screens do not appear to provide alarm priority information or allow for sorting and filtering of alarms by alarm priority.
- Root-cause analysis and alarm suppression functionality have not been developed for the Sewer Utility's WWTP HMI systems.
- HMI screens do not have troubleshooting text prompts or decision tree aids to help operators react to alarm conditions.

4.3 Historian

This subsection describes the Sewer Utility's historian software as well as its configuration and implementation.

4.3.1 Central Kitsap Treatment Plant

The Sewer Utility has Wonderware Historian 2014 R2 SP1 installed on a server in the SPB control room. This is the only historian for the Sewer Utility's wastewater infrastructure and the software is currently licensed for 5,000 tags. Wonderware Historian Client 2014 R2 SP1 software is installed on the historian server and the SCADA PC in the SPB control room. As with the 2014 R2 version of Wonderware InTouch, the 2014 R2 version of Wonderware Historian and Historian Client are also in the mature support phase of the software developer's product life cycle. Mature support is the final phase in the product life cycle, during which limited support is offered and users are encouraged to upgrade licensing to current software versions.

The CKTP historian logs SCADA data for CKTP and the Sewer Utility's pump stations. Of the Wonderware tags included in the historian's historical data, just over half of the tags are related to the pump stations.

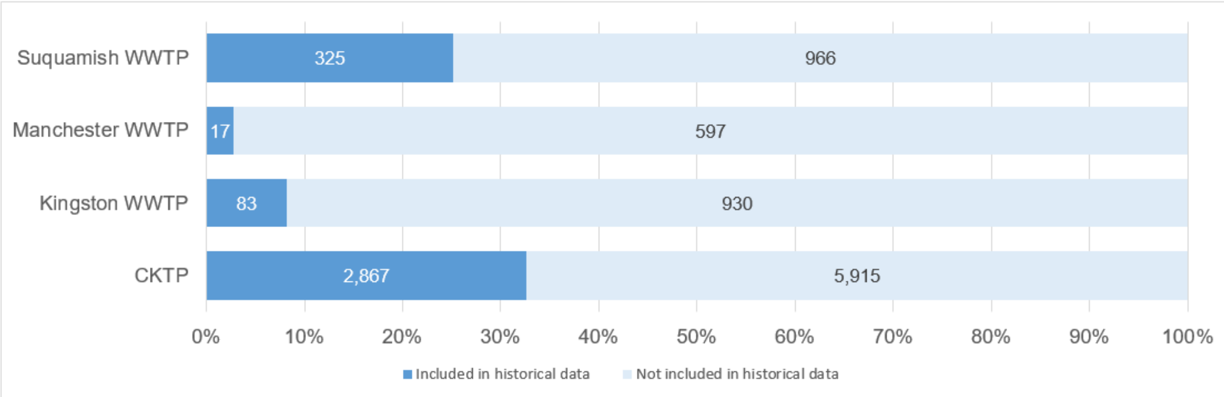
4.3.2 Kingston, Manchester, and Suquamish Wastewater Treatment Plants

No historian software is installed at KWWTP, MWWTP, and SWWTP. Instead, historical SCADA data are logged once per day as an LGH file on external hard drives by the Wonderware InTouch software at the WWTPs. The historical SCADA data for each WWTP are accessible only via each WWTP's SCADA PC and have not been imported to the Sewer Utility's historian at CKTP.

4.3.3 Historical SCADA Data

To better quantify the Sewer Utility's historical SCADA data collection practices, HDR obtained recent Wonderware tag database export files along with samples of historical data available from each of the WWTPs. Figure 4-13 compares the quantity of Wonderware I/O tags included in the Sewer Utility's historical data to the quantity of I/O tags for which no historical data are available at each WWTP. Not all tags within the Sewer Utility's Wonderware systems merit recording of their historical values, and HDR did not perform a tag-by-tag review to determine the number of tags with values that may be worth recording. However, as the figure indicates, the Sewer Utility has no historical data for the overwhelming majority of its SCADA tags. This indicates that the Sewer Utility is not capturing data for several processes and equipment.

Figure 4-13. Summary of available Wonderware tags included in historical data



Note: Tag counts reflect Wonderware I/O tags only and do not include other Wonderware tag types (e.g., memory tags).

Historical data are the foundation for process and equipment performance evaluation, predictive maintenance, process control optimization, and several other modern, data-centric technologies and infrastructure management practices. Identifying these and other specific use cases for data derived from its SCADA system would help the Sewer Utility assess which data are required to obtain the information it desires. After determining its historical data requirements, the Sewer Utility would then have to augment its data collection practices by recording historical data for more of the available Wonderware tags and, most likely, integrating new data sources into its Wonderware system.

4.3.4 Sewer Utility Use of Historical SCADA Data

Sewer Utility staff have indicated that accessing historical SCADA data is cumbersome. At CKTP, staff can use the Wonderware add-in for Excel to obtain historical data for selected tags based on a user-defined period and frequency. At the other WWTPs where there is no historian, staff must use a third-party software application called LGH File Inspector to obtain historical data from the LGH files stored on the plant's SCADA PC external hard drive. Though both of these methods are capable of serving historical data, they are time-consuming, are ill-suited for handling large queries, and present a barrier to ad hoc data exploration.

Currently, the Sewer Utility is not using data visualization tools to access and derive meaning from its historical SCADA data. HDR is also not aware of any dashboards that have been developed for the Sewer Utility to contextualize real-time or historical SCADA data. Data visualization tools could greatly improve the Sewer Utility's ability to leverage its historical SCADA data.

Given the cumbersome access and manipulation requirements and lack of data visualization tools, finding applications for historical SCADA data can be challenging. Unsurprisingly, Sewer Utility staff have reported that SCADA data are not being leveraged beyond data required for mandatory reporting. HDR believes that the SCADA data used for reporting are collected via a manual process involving Excel spreadsheets and that the Sewer Utility has not implemented automated reports for SCADA data at any of the WWTPs.

- The Sewer Utility's Wonderware Historian and Historian Client software at CKTP is in the mature support phase of the software developer's product life cycle, during which limited support is offered.
- The historical SCADA data for KWWTP, MWWTP, and SWWTP are accessible only via the SCADA PC at each WWTP and have not been imported to the Sewer Utility's historian at CKTP.
- The Sewer Utility has no historical data for the overwhelming majority of its SCADA tags, and the Sewer Utility is not capturing data for several processes and equipment.
- The Sewer Utility's means of accessing its historical SCADA data are time-consuming, are ill-suited for handling large queries, and present a barrier to ad hoc data exploration.
- SCADA data are not being leveraged beyond data required for mandatory reporting.
- The Sewer Utility has not implemented automated reports for SCADA data at any of the WWTPs.
- The Sewer Utility is not using data visualization tools to access and derive meaning from its historical SCADA data.

4.4 Alarm Notification Software

The Sewer Utility uses WIN-911 for its alarm notification software at all of its WWTPs. At KWWTP, MWWTP, and SWWTP, WIN-911 software is configured to send voice messages over the public switched telephone network (PSTN) via a Dialogic analog telephony card installed in the plant SCADA PC. These remote alarm notification voice messages are sent during hours when the WWTPs are unattended. Sewer Utility staff indicated that the software is configured to first dial operations staff at CKTP, then the on-call operator, followed by the on-call supervisor, advancing to the next number on the roster when acknowledgment has not been received within a set period. The software continues to cycle through the roster until the alarm is acknowledged.

Voice message call-out via PSTN is the only means of remote alarm notification for KWWTP, MWWTP, and SWWTP. There is no redundant alarm notification method, such as Short Message Service (SMS) text messages, at these WWTPs. Failure of the analog telephony card or disruption of telephone service to the WWTP would result in loss of remote alarm notification for the WWTP.

At CKTP, the WIN-911 software installed on the SCADA PCs in the SPB control room and management office has been configured to send both voice messages and SMS text messages simultaneously. Alarm notifications are typically sent out at all hours of the day, but can be enabled or disabled via the SCADA PC HMI screens. Voice messages are communicated over PSTN via Universal Serial Bus (USB) analog modems connected to the two SCADA PCs. SMS text messages are communicated via cellular modems connected to the SCADA PCs' Recommended Standard (RS)-232 serial interface. The redundant alarm notification methodology in place for CKTP and pump station alarms is consistent with industry best practices.

Sewer Utility staff indicated that individuals receiving alarm notification voice messages or SMS text messages are prompted to enter a code to acknowledge the alarm. However, if operators call in to the WIN-911 system to request a listing of active alarms, the system always reports that there are no active alarms. HDR did not investigate the issue to determine a root cause.

HDR did not review listings of WWTP and pump station alarms for which remote alarm notification is provided. Determination of which alarms to include in remote alarm notification should be included in the Sewer Utility's alarm management program initiative referenced previously.

- There is no redundant alarm notification method for KWWTP, MWWTP, and SWWTP. Failure of the SCADA PC's analog telephony card or disruption of telephone service to the WWTP would result in loss of remote alarm notification for the WWTP.
- Sewer Utility staff indicate that an unresolved issue with the Sewer Utility's WIN-911 implementation prevents operators from obtaining a listing of active alarms when calling in to the WIN-911 system.

5 Industrial Control System Documentation

This section summarizes documentation associated with the Sewer Utility's ICS. It describes the type of documents that the Sewer Utility has available along with a general description of how they are organized and maintained.

5.1 Piping and Instrumentation Diagrams

A collection of design and record drawings from past projects at its WWTPs and pump stations is hosted on the County's eO&M SharePoint site. Some P&IDs can be found throughout these documents, but the relevant record P&IDs for all WWTP or pump station processes are not maintained in consolidated P&ID drawing sets or located in one location. To navigate through the P&IDs between connected processes that were installed or modified under separate projects, the user must browse through different drawing sets.

HDR did not confirm how accurately record P&IDs reflect current conditions or the level of completion of the P&ID record documentation. However, a few general comments can be made. The most recent P&IDs found for MWWTP are from 1996 and observations made during HDR's site visit suggest that they are in need of updating. Based on the revisions to the MWWTP chemical system, abandonment of the WAS system, and revisions to the former SBRs, MWWTP will likely require an in-depth field survey to adequately document as-built conditions. Also, the available P&IDs for SWWTP are very limited. Aside from P&IDs developed for the plant's sludge thickening processes during the recent SWWTP Thickening project, no detailed P&IDs appear to be available for SWWTP.

- Record P&IDs are not maintained in consolidated drawing sets or located in one location.
- Record P&IDs for MWWTP are out of date.
- Aside from P&IDs recently developed for the SWWTP sludge thickening processes, no detailed P&IDs appear to be available for SWWTP.

5.2 Control Strategies

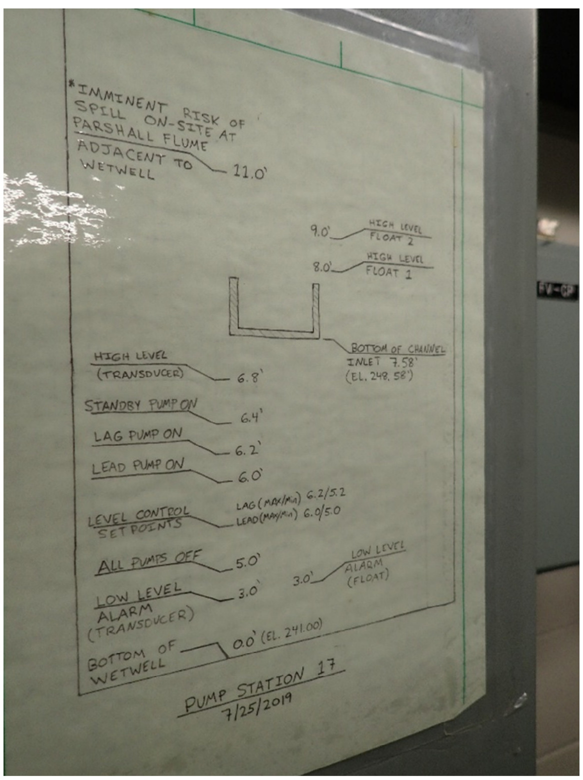
The County's eO&M SharePoint site includes narratives documenting general control descriptions for the major CKTP processes. However, the Sewer Utility has yet to add similar narratives for the processes at the other WWTPs or the wastewater pump stations. HDR understands that the County's eO&M SharePoint site is a work in progress and that the Sewer Utility is working on adding content for some of its wastewater infrastructure.

Aside from the CKTP narratives, the Sewer Utility does not maintain control strategies in electronic format that document how the WWTP and pump station processes and equipment are currently controlled locally and via SCADA. These documents are critical for understanding how WWTP and pump station processes are operating, and for evaluating their performance based on data obtained through SCADA. In the absence of record control strategy documentation, modifications to PLC programming, instrumentation, equipment configuration, and set points may go undocumented and can lead to disparities in understanding among management, operations, and other technical personnel over time. SOP documentation can also fall out of alignment with how equipment is being operated.

Sewer Utility staff indicated that operators currently log process control changes in log books kept at the WWTPs. Physical records do not provide an efficient means of reviewing past process control iterations and comparing previous settings with historical SCADA data. Also, if the log books were lost or damaged, the Sewer Utility would lose all information contained therein.

HDR observed that some of the Sewer Utility's pump stations have hand-drawn sketches taped to control panel enclosures that document the station's level set points for pump control and alarms (see Figure 5-1). HDR believes that these sketches are the most current documentation for pump control and level alarms at these stations.

Figure 5-1. PS-17 level set point documentation



- General control descriptions have yet to be added to the County's eO&M SharePoint site for the major processes at KWWTP, MWWTP, and SWWTP and wastewater pump stations.
- The Sewer Utility does not maintain as-implemented control strategies for its WWTPs and pump stations.

- ✸ The Sewer Utility is currently logging process control changes in physical operator log books and not in a more readily accessible, electronic format that can be backed up to prevent loss of information.
- ✸ PLC programming modifications may be occurring without documentation of changes made to process controls.

5.3 Control Panel Drawings and Loop Diagrams

Several sets of control panel drawings and loop diagrams can be found on the County's eO&M SharePoint site. The most useful of these drawings are the systems integrator shop drawings included in the O&M folders for the various WWTPs and pump stations. Though these shop drawings are not maintained in consolidated drawing sets, they are relatively easy to locate.

In general, documentation for recent control system additions and modifications appears to be fairly complete. One notable exception to this observation is the 2018 control system upgrade at MWWTP. Record drawings for this work were not available on the County's eO&M SharePoint site, and HDR had to request record drawings for this upgrade from QCC. Documentation for control system work executed on older projects is limited.

In addition to the electronic record drawing collection hosted on the County's eO&M SharePoint site, a hard-copy set of the control panel drawings and loop diagrams associated with a control panel can be found in most control panels.

- ✸ The County eO&M SharePoint site is missing record drawings from 2018 control system upgrade at MWWTP.

5.4 O&M Documentation

The Sewer Utility has documentation for several WWTP and pump station processes, equipment, and control system components available on its eO&M SharePoint site. Aside from control system drawings and documentation previously discussed in this section, HDR did not review this documentation in detail as part of its site assessment work.

5.5 ICS Standards and Governance Documentation

In its review of available documentation on the County's eO&M SharePoint site, HDR was unable to locate any ICS standards and governance documentation. Based on discussions with Sewer Utility staff, HDR believes that the Sewer Utility does not have formal documents to guide third-party design and implementation efforts. When an organization's standards are well-developed and documented, expectations for quality, work approach, and results are easily ascertainable from the standards documents. This helps an organization ensure that work is performed in a consistent and desirable manner throughout the ICS and establishes a basis for effectively managing the performance of internal and contracted staff.

In recent years, the Sewer Utility has been managing the quality of ICS implementation work at its facilities by restricting the pool of systems integrators eligible to perform the work to two local, trusted firms that are familiar with the Sewer Utility's infrastructure. Though cultivating a healthy relationship with one or two local competent systems integrators is highly recommended, it is important to take into consideration that systems integrators' workload can fluctuate and these trusted firms may not always be immediately available to perform work for the Sewer Utility. Good ICS standards documentation becomes especially important at times like these when an organization must entrust ICS work to contractors or systems integrators that may be less skilled and/or familiar with the Sewer Utility's infrastructure and preferences. ICS standards documentation can also communicate the Sewer Utility's requirements and preferences to consulting engineers so that their designs adequately capture these elements in the contract documents.

- The Sewer Utility does not have formal ICS standards documentation to guide third-party design and implementation efforts.

6 Other Software Packages

This section provides an overview of the non-ICS software packages at the Sewer Utility's WWTPs that bear a relationship to the Sewer Utility SCADA system and/or the assets with which it interacts. It includes a description of the software tools and provides a general summary of their current uses at Sewer Utility facilities.

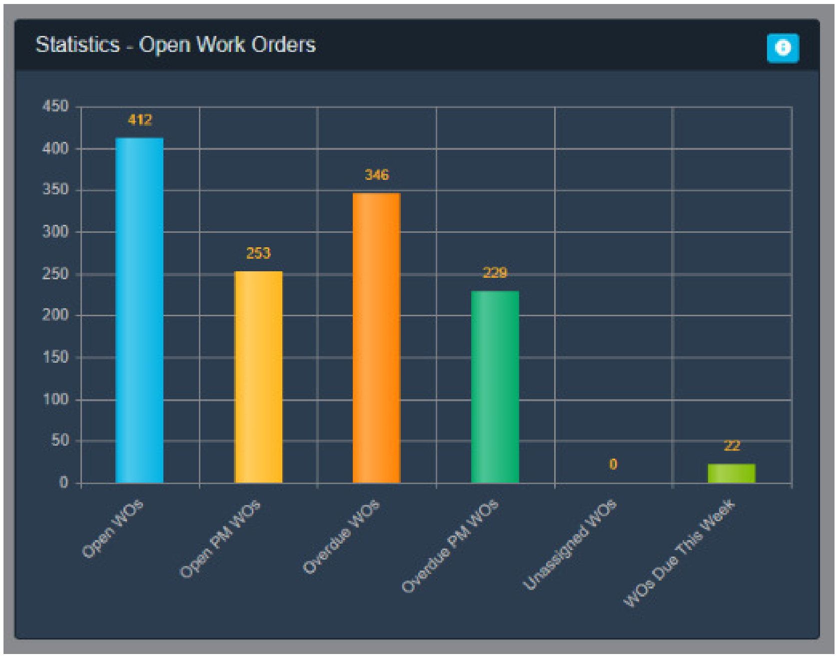
6.1 Computerized Maintenance Management System

The Sewer Utility has selected LLumin for its computerized maintenance management system (CMMS) software. LLumin software is a web browser–based application that provides management and tracking of assets, work orders, spare-parts inventory, and asset financials. The software can be extended with modular licensing to unlock additional functionality such as asset condition assessment tracking and integration with SCADA software platforms.

Sewer Utility staff are in the process of entering assets and their attributes into the LLumin database. Current focuses are adding critical assets and entering installation date and expected useful life data for assets that have already been added to the database. As part of the data entry process, the Sewer Utility is revising its asset tagging convention to establish a new tagging system that will be applied consistently throughout Sewer Utility infrastructure. At the time of HDR's site assessment visits, electrical, control, and instrumentation assets had yet to be entered for MWWTP and SWWTP. HDR also could not find any OT network equipment assets in the LLumin asset database.

The Sewer Utility is now using LLumin for scheduling and tracking reactive and preventive maintenance work orders for assets already entered into the database. Figure 6-1 shows a visualization summarizing open work orders in the LLumin system taken from a screenshot obtained by HDR during its site assessment visits. The Sewer Utility has not integrated the LLumin software with its SCADA system and CMMS and SCADA data remain siloed. Because no data exchange has been established, there are no SCADA-generated work orders based on accumulated runtime, alarms, or other events.

Figure 6-1. Open work orders visualization from LLumin home page



Sewer Utility staff indicated that the Sewer Utility has purchased the LLumin Data Collection and Condition Assessment module but that staff have yet to begin using its features. Among other things, the module will allow staff to log measurements, observations, photos, and other data via mobile devices during equipment inspections. The data collected during inspections can then be automatically compared with preset rules that trigger additional maintenance steps when field data fall outside of normal conditions. Currently, Sewer Utility O&M staff work from PCs and do not have tablets, which presents a barrier to incorporating this software tool into existing workflows.

- Data entry of WWTP and pump station assets and their attributes into the LLumin database has yet to be completed.
- The Sewer Utility's CMMS and SCADA data remain siloed and the Sewer Utility has not implemented automated work orders based on accumulated runtimes, alarms, and other events registered at the SCADA system.

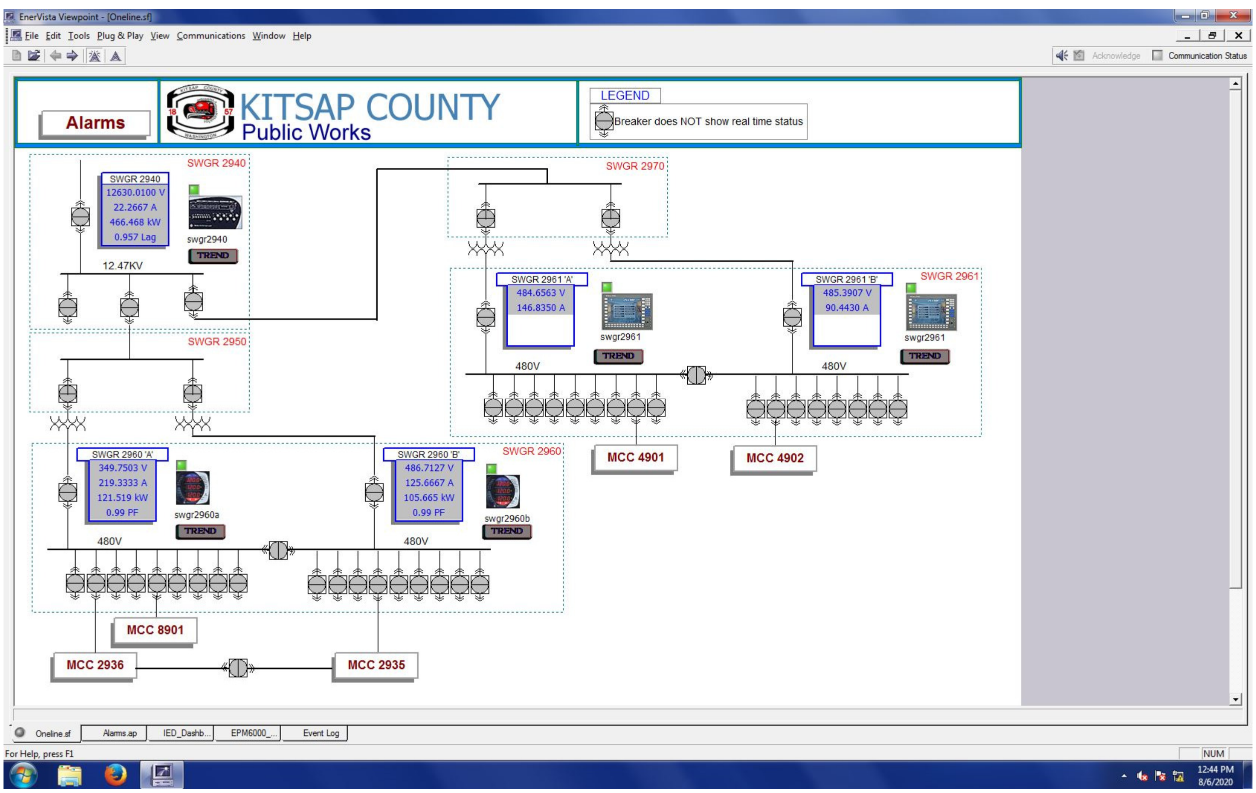
6.2 Energy Management System

At CKTP, an EMS was installed under the Resource Recovery project. This EMS consists of a dedicated EMS PC running GE's EnerVista Viewpoint software, GE Multilin EPM 6000 power monitors installed in several of the CKTP MCCs and switchgear SWGR-2960 (see Figure 6-2), a GE Multilin EPM 9650 power quality meter in CKTP's medium-voltage service entrance switchgear (SWGR-2940), and the GE Entellysis low-voltage switchgear (SWGR-2961) installed in the SPB. CKTP's EnerVista Viewpoint one-line diagram screen in Figure 6-3 depicts an overview of this EMS infrastructure.

Figure 6-2. GE EPM 6000 power monitor

Source: GE.

Figure 6-3. CKTP GE EnerVista Viewpoint one-line diagram screen



As Figure 6-3 indicates, CKTP's standby generators and large electrical loads, like the aeration blowers, have not been integrated into the EMS. Several of the CKTP MCCs and some of the power monitors installed at CKTP are also absent from the EMS. Power monitors have not been installed in the MCCs located in the digester control building (MCC 2), power/blower building (MCC 2971, MCC 2972, MCC 2973, and MCC 2974), headworks building (MCC 2975 and MCC 2976), or SPB (MCC 2981, MCC 2982, MCC 2983, and MCC 2984), so no power data are monitored by the EMS for these MCCs. The two power monitors located in the UV disinfection facility (JIT 3101 and JIT 3102) have also not been integrated into the EMS. Instead, the CKTP SCADA system monitors limited power data from the UV disinfection power monitors, of which it appears that only kilowatt (kW) values are recorded in the CKTP historian.

For the electrical distribution system buses that are included in the EMS, the EnerVista Viewpoint software has been configured to display real-time, minimum, maximum, and average values for several parameters, including phase current, line and phase voltage, power factor, real power, reactive power, apparent power, and total harmonic distortion (THD) (current and voltage). The software has also been configured to monitor several additional status and alarm parameters associated with the Entellysis low-voltage switchgear and its individual breakers. However, despite monitoring the requisite data, the various one-line diagram screens in the EnerVista Viewpoint software have not been configured to display breaker statuses for SWGR-2961. Because the EMS does not monitor breaker or switch statuses for any of the other electrical distribution system buses, the one-line diagram screens do not indicate those statuses either.

During its site visits, HDR observed that the Ethernet cable connecting the CKTP EMS PC to the network switch in the SPB control room network cabinet was not fully connected and the EnerVista Viewpoint software was not displaying real-time values. After Sewer Utility staff connected the PC to the switch, the software began displaying real-time values. However, HDR observed that the EnerVista Viewpoint software had never been set to record any of the real-time power data that it is monitoring. Unfortunately, it appears that the Sewer Utility has not generated any historical EMS data since the EMS was installed. HDR initiated the trending process within the software so that the EMS PC is now recording real-time data at a default of 1-minute intervals.

Even if historical EMS data were available, the CKTP EMS and SCADA system have not been integrated and their respective data sets remain separate. Furthermore, the Sewer Utility is not currently using power or energy data at the bus level (as monitored by the EMS) or load level (as monitored by SCADA via network VFDs and overload relays) to establish plant, process, or asset baselines or to evaluate process and equipment performance. Power and energy data are central to several KPIs used for individual equipment assets, plant processes, and WWTPs as a whole. If the Sewer Utility wishes to leverage energy-based KPIs to establish operational and/or maintenance goals and to then measure progress toward those goals, it will need to develop a strategy for collecting and managing the power and energy data that those KPIs require.

This strategy should also include the Sewer Utility’s other WWTPs and wastewater pump stations. Currently, the Sewer Utility does not have EMS software installed at KWWTP, MWWTP, or SWWTP. It also appears that the power monitors installed at the KWWTP and MWWTP MCCs are not networked to the WWTP PLCs or SCADA PCs. The CKTP EMS and SCADA system are also not monitoring power and energy data that may be available from power monitors and other electrical equipment at the Sewer Utility’s pump stations. Aside from Puget Sound Energy billing data and a few load-level power parameters recorded by the CKTP historian, HDR believes that the Sewer Utility has little to no historical power and energy data for its WWTP and wastewater pump station infrastructure.

- CKTP standby generators and large electrical loads (e.g., aeration blowers) have not been integrated into the CKTP EMS.
- Several MCCs at CKTP have no power monitor installed, which prevents them from being included in the CKTP EMS.
- Power monitors installed at the CKTP UV disinfection facility have not been integrated into the CKTP EMS.
- With the exception of SWGR-2961, the CKTP EMS is not monitoring switch and breaker statuses for the major electrical distribution system buses at CKTP.
- The CKTP EMS one-line diagram screens have not been configured to display current breaker statuses for SWGR-2961.
- It appears that the Sewer Utility has not generated any historical EMS data since the CKTP EMS was installed because the EMS software was never set to record any of the real-time power data that it monitors.
- The Sewer Utility is not currently using power or energy data at the bus level or load level to establish plant, process, or asset baselines or to evaluate process and equipment performance.
- Power monitors installed at the KWWTP and MWWTP MCCs are not networked to the WWTP PLCs or SCADA PCs.
- The CKTP EMS and SCADA system are not monitoring power and energy data that may be available from power monitors and other electrical equipment at the Sewer Utility's pump stations.
- Aside from Puget Sound Energy billing data and a few load-level power parameters recorded by the CKTP historian, HDR believes that the Sewer Utility has little to no historical power and energy data for its WWTP and wastewater pump station infrastructure.

6.3 Laboratory Information Management System

Currently, the Sewer Utility is recording laboratory data with Excel spreadsheets and HDR believes that much, if not all, of the associated data entry and processing is manual. Monthly lab reports for the Sewer Utility's four WWTPs are available on the County eO&M SharePoint site. If the laboratory data included in these monthly reports also reside in a Sewer Utility database, HDR is not aware of it. Without a database for laboratory data or laboratory information management system (LIMS) software, working with the Sewer Utility's historical laboratory data is likely to be labor-intensive. Because WWTP laboratory data factor into several plant and process KPIs, it is critical that these data be easily accessible to Sewer Utility staff and available to other Sewer Utility software platforms.

At the time of this writing, HDR believes that the Sewer Utility is negotiating contract terms and conditions with Hach for the installation and licensing of Hach Water Information Management Solution (WIMS) software, which would serve as the Sewer Utility's LIMS. The Sewer Utility has already purchased server and client hardware on which to install the software and Sewer Utility staff intend to add the machines to the WWTP OT networks. Based on review of Hach's scope of work, HDR believes that Hach WIMS client software will be installed on three PCs at CKTP and one PC each at KWWTP, MWWTP, and SWWTP. Hach LAB Cal software will also be installed on one of the three PCs at CKTP. The Hach WIMS server and database software will be installed on a server located at CKTP. The Sewer Utility also intends to purchase Hach WIMS SCADA Interface software for Wonderware InTouch to enable data exchange between the two software platforms.

- HDR believes that the Sewer Utility laboratory data are recorded in Excel spreadsheets and do not currently reside on a database, which makes working with the data labor-intensive.

6.4 Data Analytics and Visualization Software

The Sewer Utility is not currently using data analytics or visualization software to work with its CMMS, EMS, laboratory, SCADA, and other data sets outside of their respective software environments. Data analytics and visualization software tools are often highly customizable and can be used to combine data from multiple sources to derive insights that may be difficult or impossible to achieve within the constraints of separate, purpose-built software packages that were developed to serve specific data sets. Many of these tools are also designed with large data sets in mind and can handle manipulations of large blocks of historical data that may cause performance degradation if attempted within some of the Sewer Utility's other software platforms. If the Sewer Utility wishes to pursue a more data-centric approach to the operation and maintenance of its wastewater infrastructure, data analytics and visualization software will become an essential addition to the Sewer Utility's tool set.

- The Sewer Utility is not currently using data analytics or visualization software to derive insights from its CMMS, EMS, laboratory, SCADA, and other data sets outside of their respective software environments.

7 Organizational Improvement Categories

This section presents five organizational improvement categories that apply to utility control systems and how they will be applied within the Sewer Utility SCADA Master Plan to relate risks, deficiencies, and proposed improvements to facets of the Sewer Utility's organizational health.

7.1 Organizational Improvement Categories

Not all stakeholders involved with CIP investments in SCADA technologies or who interact with and/or rely on ICS infrastructure have the same degree of familiarity and experience with the associated hardware, software, and technical nuances. It can therefore be beneficial to correlate current risks and deficiencies, as well as proposed investments in specific technological improvements, with more widely understood facets of organizational health. These correlations can help provide context for identified shortcomings and vulnerabilities that may be rooted in technologies outside of some stakeholders' areas of expertise. They can also emphasize the organizational gains that are anticipated from a particular upgrade in a way that may be understood more readily than the technical description of the upgrade alone.

HDR presented five organizational improvement categories that apply to utility control systems during the Sewer Utility SCADA Master Plan kickoff meeting held on July 22, 2020. These organizational improvement categories, depicted in Figure 7-1, are described in the following subsections. The framework provided by these organizational improvement categories will be carried through the various Sewer Utility SCADA Master Plan TMs, contextualizing risks and deficiencies identified in TM-1, guiding development of objectives and technology selection, and relating proposed implementation plan projects to improvements in the Sewer Utility's organizational health.

Figure 7-1. Organizational improvement categories

7.1.1 Operational Optimization

This category covers deficiencies and improvements related to an organization's processes, control strategies, and procedures. Deficiencies that fall under this category might include labor-intensive data management practices, manual operation of equipment that could be automated, and unrefined control loops that result in unnecessary energy consumption (e.g., over-aeration). Operational optimization improvements may consist of equipment and instrumentation upgrades to WWTP processes, improved or increased automation, streamlined workflows, and other enhancements that lower operating costs and/or improve product quality (e.g., effluent, dewatered solids, etc.).

7.1.2 Infrastructure Stability and Modernization

This category focuses on the health and reliability of the organization's assets. Typical organizational efforts within this category include predicting and avoiding failure scenarios, replacing assets that are near the end of their useful lives, asset management initiatives, and ensuring the availability of manufacturer support for the organization's assets. Deficiencies that fall under this category might include failed instrumentation and reliance on discontinued products that are no longer supported by the manufacturer. Improvements in this category can include replacement of legacy hardware, software and firmware upgrades, and upgrading the organization's technology to obtain the benefits from enhanced functionality available in current market offerings.

7.1.3 Cybersecurity Risk Mitigation

According to DHS, critical infrastructure like wastewater facilities is facing increasing risks from cybersecurity threats. Where the technological barrier once limited the number of threat actors to individuals and organizations with intermediate to advanced skills and knowledge, several sophisticated tools have been developed and made accessible to anyone with an Internet connection. These tools have lowered the barrier to entry and increased the effectiveness of less skilled individuals, and, along with their proliferation, cyber-attacks on water and wastewater infrastructure are becoming more common.

The cybersecurity risk mitigation category is focused on improving the organization's cybersecurity posture. Deficiencies that fall under this category might include exposure of critical ICS infrastructure to the public Internet, poor password practices, and unpatched network appliances with known vulnerabilities. Improvements in this category can include modifications to network architecture, hardening of components, device configuration, and preparing for an effective response to a cybersecurity incident.

7.1.4 Critical System Resilience

Even when best practices are adopted, equipment and software can fail. Organizations can prepare for these failures by incorporating redundancy into ICS designs and establishing scripted procedures to guide staff response after failures occur. However, it is impossible for an organization to prepare for every failure scenario. Unexpected events happen and these events can disrupt ICS functionality.

The critical system resilience category is focused on identification and mitigation of potential failure scenarios before they happen as well as developing the organization's ability to recover from unplanned disruptions. Deficiencies that fall under this category might include critical ICS infrastructure without UPS battery backup power, poor data backup practices, and lack of redundancy in critical network infrastructure. Improvements in this category can include establishing redundancy for critical ICS components, revisions to network topologies, and implementing measures to protect against irrecoverable data loss.

7.1.5 Workforce Efficiency

The workforce efficiency category focuses on empowering an organization's staff and eliminating barriers to workforce performance. Many of the improvements related to this category have to do with providing staff with the information they need, when and where they need it, and introducing technologies that deepen insight and enable increased efficiency. Other enhancements in this category seek to capture institutional knowledge in the tools, documentation, and technologies used by an organization's staff to streamline knowledge transfer for new hires, accelerate the development of junior staff, and efficiently communicate organizational standards and expectations to contracted parties. Deficiencies that fall under this category might include cumbersome access to real-time and historical SCADA data, poor documentation practices, and ineffective HMI screen design that provides little situational awareness to operators.

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8 Risk and Deficiency Summary

Table 8-2 compiles the risks and deficiencies associated with the Sewer Utility's OT networks, SCADA system components, and associated infrastructure that were identified in previous sections of TM-1. The table includes subsection references to assist readers in locating the specific subsections where each risk and deficiency is described in more detail. The table also correlates each risk and deficiency to one or more of the organizational improvement categories introduced in Section 7. Applicable organizational improvement categories are denoted with one or more "✸" symbols in their respective columns.

To help communicate the significance of various risks and deficiencies, a ranking system has been applied based on the quantity of "✸" symbols shown for a given organizational improvement category. The ranking system is defined in Table 8-1. Risks and deficiencies from each TM-1 section are sorted in Table 8-2 so that the most significant risks and deficiencies from each section appear first.

Table 8-1. Risk and deficiency ranking system description

Ranking	Description
✸✸✸	**Major** risk or deficiency. Immediate corrective measures are recommended and/or major organizational health benefit(s) to be gained from related improvements.
✸✸	**Moderate** risk or deficiency. Near-term corrective measures are recommended and/or significant organizational health benefit(s) to be gained from related improvements.
✸	**Minor** risk or deficiency. Corrective measures are recommended, but likelihood and/or impact of failure/event may be low. Some organizational health benefit(s) to be gained from related improvements.

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
Network Architecture	2.7	There is a direct connection between CKTP business LAN and OT network switches in the SPB control room network cabinet. This direct connection between the business LAN and OT network presents a significant security risk for the OT network.			***		
Network Architecture	2.7	A cellular router was found connected to the unmanaged OT network switch in the SPB control room network cabinet. The device could provide a backdoor into the CKTP OT network for external devices that the Sewer Utility has no control over, bypassing security measures in place for the network. Sewer Utility staff have since disconnected the cellular router from the network.			***		
Network Architecture	2.13	No automated or manual backup procedures appear to be in place for the historical SCADA data contained on the CKTP historian. Failure of the CKTP historian server could result in loss of CKTP's historical SCADA data.				***	
Network Architecture	2.13	Historical SCADA data for KWWTP, MWWTP, and SWWTP may exist only on external hard drives connected to the SCADA PCs at the WWTPs. Failure of the external hard drive or a catastrophic event that impacts the SCADA PC and external hard drive may result in loss of the WWTP's historical SCADA data.				***	
Network Architecture	2.3	Pump stations on the VHF licensed radio WAN experience long delays in communication of pump station statuses and alarms, which have presented challenges to County staff in providing timely responses to critical pump station alarms and accurate calculations of accumulated equipment runtimes.	**				*
Network Architecture	2.2	Given the current network arrangement, the most critical network switch in the CKTP OT network is a single point of failure for the network.				**	

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
Network Architecture	2.2	CKTP OT network arrangement in PNL 8580A has created multiple single points of failure for communication between CKTP SCADA nodes and all of the plant PLCs.				✸✸	
Network Architecture	2.2	CKTP OT network has no resilience because of a lack of access switch and cable path redundancy, and there are instances where lack of OT network redundancy may undermine process redundancy.				✸✸	
Network Architecture	2.2	Improving CKTP OT network resilience could prevent loss of SCADA monitoring and control functionality and continue logging of historical SCADA data in the event of singular network component or cable failure.				✸✸	
Network Architecture	2.3	Currently, Sewer Utility staff do not have a central location where all WWTP SCADA systems can be monitored and controlled.					✸✸
Network Architecture	2.3	The lower bandwidth inherent in VHF-based telemetry is ill-suited for increased data exchange between the pump stations and the CKTP SCADA system and would constrain the Sewer Utility's objective of near real-time monitoring and alarming for wastewater pump stations.		✸✸			
Network Architecture	2.3	Four of the six pump stations with historically poor VHF communications remain on the VHF licensed radio WAN. Planned modifications for the Manchester area pump stations may improve communications for those pump stations.		✸✸			
Network Architecture	2.3	The CKTP SCADA system does not appear to be accurately recording communication status data for the pump stations on the cellular WAN.		✸✸			
Network Architecture	2.7	Public IP addresses are assigned to IP nodes within the CKTP and SWWTP OT networks.			✸✸		

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
Network Architecture	2.7	There appear to be parallel entry points to the SWWTP OT network from external networks: one via SWWTP's Tempered Networks HIPswitch and one via a secure gateway used for the SWWTP business LAN wireless access point.			✸✸		
Network Architecture	2.9	Because of inherent security risks with VNC-based applications, HDR recommends transitioning away from VNC sessions for remote access to the Sewer Utility's OT networks.			✸✸		
Network Architecture	2.9	Users accessing the WWTP OT networks remotely share a common password, which means that no AAA measures are in place for remote access to the WWTP OT networks.			✸✸		
Network Architecture	2.9	MFA for remote access sessions to the WWTP OT networks would provide additional security for the network in conjunction with the adoption of AAA measures.			✸✸		
Network Architecture	2.10	The Sewer Utility's Tempered Networks Conductor instance has generic user accounts that do not allow for adequate user authentication or attributing of any security modifications made to a specific individual.			✸✸		
Network Architecture	2.10	No MFA measures are in place to secure access to the Sewer Utility's Tempered Networks Conductor instance.			✸✸		
Network Architecture	2.10	Multiple user types are allowed to assume remote control over SCADA PCs on the Sewer Utility's OT networks, which may be providing some users with more permissions and access to OT network resources than they require. Sewer Utility OT network remote access use cases need to be defined so that appropriate security controls can be identified and implemented.			✸✸		
Network Architecture	2.10	The Sewer Utility's Airwall edge services do not have current firmware versions installed.			✸✸		

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
Network Architecture	2.10	The HIPswitch 100g installed at CKTP appears to be limited to 5 Mbps of data throughput. Given the intended application for SCADA-related data exchange between CKTP and the other WWTPs, this amount of throughput will likely be inadequate for the Sewer Utility's near-term needs.		**			
Network Architecture	2.11	Some of the PCs on the CKTP OT network have likely been in service for 5 to 7 years and should be replaced as part of the Sewer Utility's planned Wonderware upgrade at CKTP.		**			
Network Architecture	2.11	Operating system login sessions are maintained on CKTP OT network PCs and a common username and password is shared by all users.			**		
Network Architecture	2.12	Unprotected OT network components share space with exposed plumbing and mechanical equipment in the CTKP administration and lab building electrical room.				**	
Network Architecture	2.12	Status and alarms are not monitored for UPSs that provide power to SCADA PCs and servers and OT network equipment. The installed UPSs also have no remote monitoring capability.				**	
Network Architecture	2.12	KPUD-owned Carrier Ethernet access switches that provide communication between KWWTP, MWWTP, and SWWTP and CKTP are not on UPS power.				**	
Network Architecture	2.12	The Sewer Utility's current strategy of allocating small, dedicated UPSs for OT network PCs, servers, and other critical loads provides very limited battery backup times for this equipment, leaving the Sewer Utility reliant on the proper functioning of the standby generators to keep the equipment online during power outages.				**	
Network Architecture	2.13	No automated or manual procedures are in place for establishing off-site backups of Sewer Utility WWTP SCADA data or ICS configuration and programming files.				**	

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
Network Architecture	2.13	No automated or manual backup procedures appear to be in place for backing up the Sewer Utility OT network PCs and servers.				✸✸	
Network Architecture	2.16	The Sewer Utility does not have a formal cybersecurity incident response program for the OT networks it manages.			✸✸		
Network Architecture	2.11	CKTP OT network has been set up as a workgroup. Implementing a domain for the OT network would allow the Sewer Utility to manage all user accounts and permissions on a single server and enable segmentation of the OT network to increase security and optimize network performance.	✸		✸		✸
Network Architecture	2.14	The Sewer Utility does not have software tools to monitor the CKTP OT network and manage its performance.	✸		✸		✸
Network Architecture	2.5	Several unmanaged switches at CKTP are recommended for replacement with managed switches to mitigate risks to network stability and security.		✸	✸		
Network Architecture	2.14	The Sewer Utility does not have a syslog server or other central repository for collecting CKTP OT network device logs and network event data.			✸		✸
Network Architecture	2.2	The access switch serving the CKTP SCADA PCs and historian server is an unmanaged switch, which propagates undesirable broadcast and multicast packets generated by the operating systems on those machines throughout the network.		✸			
Network Architecture	2.2	KWWTP OT network has no resilience because of a lack of access switch and cable path redundancy, and this lack of OT network redundancy may undermine liquid stream process redundancy.				✸	

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
Network Architecture	2.3	The pump station communication efficiency parameter values displayed at the CKTP SCADA HMI and logged in the CKTP historian may be misrepresenting actual VHF licensed radio WAN radio path performance because of the calculations used in the MTU PLC programming.	✸				
Network Architecture	2.4	An OM1 fiber-optic patch cable has been used to patch two OM3 fiber-optic cables at the fiber-optic patch panel within PNL 2920 in the CKTP power/blower building. This patch cable should be replaced with a suitable OM3 patch cable.		✸			
Network Architecture	2.4	There are instances of UTP Category cables with insufficient voltage insulation ratings connecting IP nodes within 480 VAC equipment enclosures at CKTP and PS-67.		✸			
Network Architecture	2.5	The Sewer Utility has not standardized on a specific managed switch, which can lead to stocking of additional spare switches to facilitate rapid switch replacement in the event of switch failure.	✸				
Network Architecture	2.5	All ports on most switches throughout the Sewer Utility OT networks are capping connected devices at the theoretical 100 Mbps limit inherent in the switch ports. As data volumes increase within the Sewer Utility's OT networks in the coming years, the port speeds supported by these switches may become a limiting factor.		✸			
Network Architecture	2.5	Several managed switches on Sewer Utility OT networks are accessible via manufacturer default username and password.			✸		
Network Architecture	2.6	The Sewer Utility has not implemented on-site tablet-based workflows for Sewer Utility staff, which can improve workforce efficiency and increase staff engagement with ICS software.					✸

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
Network Architecture	2.7	The subnet assigned to the CKTP OT network effectively limits the network to 254 connected devices. The Sewer Utility will require a larger pool of IP addresses to support additional devices in the future and adapt to the proliferation of IP devices that is becoming the norm in the industrial automation industry.		✸			
Network Architecture	2.7	Unused network switch ports are enabled and assigned to active VLANs throughout the Sewer Utility's OT networks.			✸		
Network Architecture	2.9	UltraVNC encryption plugin is not enabled. Security of VNC sessions used to establish remote access to WWTP OT networks could be increased by enabling encryption at the VNC application layer.			✸		
Network Architecture	2.10	On-call staff, QCC, and I&C technicians all share access to the Tempered Networks Kitsap Telemetry overlay network. This may be allowing access to PLCs and other OT network resources that on-call staff do not require access to and complicates management of third-party access to the Sewer Utility's OT network.			✸		
Network Architecture	2.10	Devices are included in the Tempered Networks Kitsap IC overlay network that County staff may not need to access remotely. If remote access is not required for these devices, they should be removed from the overlay network as a security precaution.			✸		
Network Architecture	2.10	HIPswitches are providing a single layer of defense at the periphery of the Sewer Utility's OT networks, which does not adhere to Defense-in-Depth strategies recommended by DHS and other information security organizations.			✸		
Network Architecture	2.10	Communication links between KWWTP, MWWTP, and SWWTP and CKTP have no redundancy.				✸	
Network Architecture	2.10	Pump station and CKTP MTU VHF radios have AES encryption disabled, which exposes the pump station VHF licensed radio WAN to eavesdropping and security risks.			✸		

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
Network Architecture	2.11	KWWTP, MWWTP, and SWWTP SCADA have likely been in service for 3 to 4 years and should be replaced as part of the Sewer Utility's planned Wonderware upgrade at the plants.		✸			
Network Architecture	2.12	Physical security at the Sewer Utility WWTPs could be improved by introducing camera systems and providing monitoring and alarming of more of the building entrances during hours when the WWTPs are unattended.			✸		
Network Architecture	2.12	Network cabinet and network panel PNL-8580A are routinely left unlocked.			✸		
Network Architecture	2.12	Construction activity at KWWTP is generating a significant amount of dust in the space occupied by KWWTP's Internet service demarcation appliance.				✸	
Network Architecture	2.13	Backups of PLC programming project files could be better organized to improve version control.				✸	
Network Architecture	2.13	The Sewer Utility is not leveraging virtualization for the PCs and servers in its OT networks. Recovering from loss of one of these physical machines or a disaster would require significantly more time and effort than a scenario where the Sewer Utility's ICS software is installed in a virtualized environment.				✸	
Network Architecture	2.12	In general, the network switches within the Sewer Utility's OT network have no on-board power supply or external 24 VDC power supply redundancy.				✸	
Network Architecture	2.14	The Sewer Utility does not maintain an organized system of easily accessible network device configuration file backups for managed switches and cellular routers within its OT networks.				✸	
Network Architecture	2.15	Sewer Utility has high-level network block diagrams for the WWTPs, but does not maintain comprehensive network architecture diagrams.					✸

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
Network Architecture	2.15	Sewer Utility does not maintain detailed fiber-optic patch panel schedules or have a consistently applied tagging system for fiber-optic patch panels and cables.					✸
Network Architecture	2.15	Sewer Utility practices for tagging copper Ethernet cables at both ends could be improved.					✸
ICS Hardware	3.5	The LEL transmitter on the CKTP headworks odor control fan ductwork is registering an IR source fault and is not monitoring combustible-gas concentration in the odor control system.		✸ ✸ ✸			
ICS Hardware	3.5	HDR observed that the thermal dispersion flowmeter installed on the aeration line for the CKTP aerated grit tank 1 stage 2 diffuser is measuring zero flow, while the positions of manual valves on either side of the instrument suggest that flow should be occurring.		✸ ✸ ✸			
ICS Hardware	3.5	Combustible-gas monitoring equipment at the MWWTP sludge pumping gallery, headworks odor control system, and WAS tank is non-functional.		✸ ✸ ✸			
ICS Hardware	3.5	Combustible-gas monitoring equipment at the SWWTP process building upper-floor process room is non-functional.		✸ ✸ ✸			
ICS Hardware	3.5	The SWWTP process building fire alarm panel has failed so SWWTP is not currently monitoring or alarming for fires.		✸ ✸ ✸			
ICS Hardware	3.5	Combustible-gas monitoring equipment at the PS-24 wet well is faulted.		✸ ✸ ✸			
ICS Hardware	3.5	Combustible-gas monitoring equipment at the PS-71 wet well is non-functional.		✸ ✸ ✸			

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
ICS Hardware	3.5	Operation of the SWWTP RDT is a highly manual process where operations staff have to target a reduced sludge thickness to avoid shutting down the thickened sludge pump on high discharge pressure because of reportedly undersized sludge discharge piping. This workaround is reducing the efficacy of the RDT because the equipment is not dewatering sludge to the extent that it could.		✸✸			✸✸
ICS Hardware	3.5	The SWWTP sludge storage tank level is not monitored. Operations staff have resorted to a manual method of controlling tank level that introduces significant risk of operator error and relies on a high-level switch with a non-ideal installation for alarming and shutdown of the sludge supply to the tank.		✸✸			✸
ICS Hardware	3.1	The Allen-Bradley MicroLogix 1500 PLCs installed at PS-4, PS-7, and PS-17 have been discontinued by the manufacturer and are nearing the end of their useful service life.		✸✸			
ICS Hardware	3.1	The Allen-Bradley SLC 500 PLCs installed at PS-24 and PS-71 are in the active mature phase of the manufacturer's product life cycle and are nearing the end of their useful service life.		✸✸			
ICS Hardware	3.1	HDR observed that the PLC controller battery alarm light was illuminated at the bar screen 1023 main control panel in the CKTP headworks building electrical room.				✸✸	
ICS Hardware	3.2	The OITs installed at PS-4, PS-17, PS-24, PS-71, and CP-300 at KWWTP are nearing the end of their useful service life.		✸✸			
ICS Hardware	3.3	OT network and ICS components within the CKTP digester control building control panel (PNL 6000) are exposed to significant levels of H_2S and high ambient temperatures. Installation of this panel in an area with a hazardous-area classification is an NEC violation. County electricians also indicated that H_2S corrosion has been a significant maintenance issue for control wiring at the nearby MCC within the building.				✸✸	

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
ICS Hardware	3.3	Status and alarms are not monitored for UPSs that provide power to ICS and instrumentation equipment. Many of the installed UPSs have no remote monitoring capability.				✸✸	
ICS Hardware	3.3	Several control panels at Sewer Utility facilities do not have battery backup power.				✸✸	
ICS Hardware	3.4	Sewer Utility staff have no means of monitoring or controlling KWWTP, MWWTP, and SWWTP from the existing CKTP SCADA PCs.					✸✸
ICS Hardware	3.4	Sewer Utility staff do not have access to near real-time status and alarm information for wastewater pump stations at CKTP.					✸✸
ICS Hardware	3.5	Based on discussions with Sewer Utility I&C technicians, HDR believes that the Sewer Utility does not have a formal calibration and maintenance program for field instrumentation and associated control loops.		✸✸			
ICS Hardware	3.5	Current CKTP effluent flow calculations provided by Trojan UV system are resulting in higher flows than those derived from an accounting of other CKTP flow measurements.	✸✸				
ICS Hardware	3.5	Automated control of the CKTP BNR process has proved to be unstable. Operators currently position the aeration control valves manually and have to frequently adjust blower header pressure set points based on process demand.	✸✸				
ICS Hardware	3.5	Unlike the other three CKTP aeration basins, aeration basin 1 has no DO probes installed. This is one of the deficiencies frustrating the Sewer Utility's BNR efforts at CKTP.	✸✸				
ICS Hardware	3.5	The chlorine residual and turbidity analyzers associated with the CKTP reclaimed-water filtration system were found powered down during HDR's site visit.		✸✸			

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
ICS Hardware	3.5	The low-level switch for the CKTP thickened sludge blending tank has failed and the tank's circulation pump and digester feed pumps are likely operating without a low-level shutdown interlock.		✹✹			
ICS Hardware	3.5	The Sewer Utility has no means of direct measurement for plant influent flow at MWWTP.	✹✹				
ICS Hardware	3.5	Some of the instrumentation related to the MWWTP headworks odor control system and its associated chemical system either is non-functional or has been removed. Systems are no longer operating per their original design.		✹✹			
ICS Hardware	3.5	The magmeter on the sludge line feeding the MWWTP GBT is severely corroded.		✹✹			
ICS Hardware	3.5	The MWWTP aeration basins have no DO probes or other analytical instruments for monitoring the BNR process.		✹✹			
ICS Hardware	3.5	The MWWTP SCADA system is not receiving a flow signal from the flow transmitter and totalizer on the plant W3 pump discharge piping.		✹✹			
ICS Hardware	3.5	Instrumentation within the MWWTP Trojan UV system has had recent issues and operations staff have reduced confidence in the system's UV dosing control.		✹✹			
ICS Hardware	3.5	The SWWTP effluent flow control valve is unable to maintain its position when commanded to close. The valve tries to maintain a closed position but eventually begins opening. SWWTP has no bypass piping around this valve, so the plant would need to shut down in order for the control valve to be serviced or replaced.		✹✹			
ICS Hardware	3.5	The SWWTP SBRs have no DO probes or other analytical instruments for monitoring the BNR process.		✹✹			

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
ICS Hardware	3.5	The ultrasonic level transducer measuring the PS-24 wet well level was observed to be coated with grime and dried scum. The condition of the transducer may be degrading the accuracy of the level measurement.		✸✸			
ICS Hardware	3.5	PS-34 has no PLC and the station's wet well level appears to be controlled by a level indicator and controller that monitors the wet well's radar level transmitter. Because of the age and condition of the control panel components, its undocumented modifications, and lack of PLC, PS-34 would be a good candidate for a control panel upgrade.		✸✸			
ICS Hardware	3.1	Sewer Utility staff have difficulty maintaining MCC DeviceNet networks at CKTP, which has the potential to increase downtime for equipment connected to the DeviceNet networks.		✸		✸	
ICS Hardware	3.4	The Sewer Utility may benefit from establishing a secure, dedicated space for ICS servers and critical network equipment.			✸	✸	
ICS Hardware	3.5	A condition assessment survey of existing instrumentation has yet to be performed. This effort would provide the most value if done on a process-by-process basis as part of process and equipment level-of-automation and performance optimization evaluations.	✸	✸			
ICS Hardware	3.5	Sewer Utility staff indicated that the level transmitter for the SWWTP thickened sludge storage tank is reporting level measurements that do not align with actual tank levels.		✸			✸
ICS Hardware	3.5	Short cycling of the pumps is a common occurrence at PS-24.	✸	✸			
ICS Hardware	3.1	Allen-Bradley has made an end-of-life announcement for the CompactLogix L3x PLCs installed in various panels at CKTP. These PLCs will be discontinued by the manufacturer as of December 2020.		✸			

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
ICS Hardware	3.1	The MWWTP blower building RIO control panel is installed above another control panel in a location that is not easily accessible by Sewer Utility staff.					✸
ICS Hardware	3.1	The Sewer Utility does not appear to have standardized on PLC platform I/O module types. I/O module standardization could help the Sewer Utility reduce spare-parts inventory and enforce its preferences.	✸				
ICS Hardware	3.2	The CP-300 OIT at KWWTP was experiencing a communication error during HDR's site visit.		✸			
ICS Hardware	3.2	The OIT at the master station CTU control panel in the SPB control room at CKTP appears to be out of service.		✸			
ICS Hardware	3.3	Several control panels at Sewer Utility facilities do not have 24 VDC power supply redundancy.				✸	
ICS Hardware	3.3	There is a mix of 120 VAC and 24 VDC control and power circuits within the Sewer Utility's industrial control panels and the voltages present are not always readily apparent without closer inspection of the components. To eliminate or reduce shock hazards for personnel, the Sewer Utility may wish to consider standardizing on 24 VDC power and controls and/or improved voltage segregation and identification for control panels introduced by future CIP projects.	✸				
ICS Hardware	3.3	The Sewer Utility is having difficulty maintaining desirable ambient temperatures within the MWWTP electrical room and some of the CKTP electrical rooms.	✸				

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
ICS Hardware	3.4	The CKTP SPB control room has only two standard-size monitors where SCADA screens can be displayed. Having large-format displays would make it so that SCADA screens are discernible from a greater distance and could be referenced more easily during staff discussions. Additional monitors/displays would allow staff to leave commonly referenced screens on display at all times.					✸
ICS Hardware	3.5	The Sewer Utility has no means of direct measurement for CKTP effluent flow.	✸				
ICS Hardware	3.5	The CKTP headworks odor control biofilter sprinkler control panel is out of service and watering of the biofilter is now a manual process for Sewer Utility staff. Replacing and/or introducing instrumentation to maintain desirable moisture levels in the biofilter via automation could improve Sewer Utility workforce efficiency and the effectiveness of the biofilter.					✸
ICS Hardware	3.5	Only CKTP aeration basin 4 has ammonium and nitrate probes installed to monitor nitrogen removal occurring in the basin.	✸				
ICS Hardware	3.5	The CKTP cogeneration system and digester gas conditioning system have been abandoned in place because of high material and maintenance costs and limited digester gas production.		✸			
ICS Hardware	3.5	One of the analytical probes associated with the SWWTP odor control system appears to have a splice in the probe's manufacturer cable, which may be degrading the accuracy of the probe's measurement or disrupting the signal entirely.		✸			
ICS Hardware	3.5	The thermal dispersion flow switch on the SWWTP RDT spray water supply line has been damaged. This may result in a shorter than expected useful service life for the switch.		✸			
ICS Hardware	3.5	The Sewer Utility is not currently monitoring BIOXIDE storage tank level at PS-71.		✸			

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
ICS Software	4.2	Lack of centralized management for ICS device data and SCADA visualizations has resulted in non-standardized programming objects and visualizations at the Sewer Utility's WWTPs.	✱✱✱				✱✱✱
ICS Software	4.2	Red and green on/off, open/closed color schemes are not consistently applied throughout the Sewer Utility's HMI and OIT screens.					✱✱✱
ICS Software	4.3	SCADA data are not being leveraged beyond data required for mandatory reporting.	✱✱	✱✱			✱✱
ICS Software	4.3	The Sewer Utility is not using data visualization tools to access and derive meaning from its historical SCADA data.	✱✱	✱✱			✱✱
ICS Software	4.2	Sewer Utility staff do not appear to have a means of shelving nuisance alarms or alarms associated with known issues.	✱✱				✱✱
ICS Software	4.2	Sewer Utility WWTP HMI screens do not appear to provide alarm priority information or allow for sorting and filtering of alarms by alarm priority.	✱✱				✱✱
ICS Software	4.3	The Sewer Utility has no historical data for the overwhelming majority of its SCADA tags, and the Sewer Utility is not capturing data for several processes and equipment.	✱✱				✱✱
ICS Software	4.1	The Sewer Utility does not have PLC programming standards in place and its PLC programming project files reflect a variety of conventions and programming objects implemented by multiple systems integrators.	✱✱				
ICS Software	4.2	The Sewer Utility's Wonderware InTouch software at its WWTPs is in, or will soon be entering, the mature support phase of the software developer's product life cycle, during which limited support is offered.		✱✱			
ICS Software	4.2	HMI overview and process screens could be updated to include more contextual information to facilitate operator situational awareness.					✱✱

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
ICS Software	4.2	Sewer Utility staff have no means of remotely resetting pump station alarms from CKTP HMI screens. The lack of remote alarm reset requires County staff to physically visit the pump stations to reset alarms.					✱✱
ICS Software	4.2	HDR observed that there are issues with communication of analog parameters between several pump stations and CKTP. Several pump station pop-up HMI screens appear to constantly display zero values for analog parameters and historian data are also logging constant, out-of-range values for these pump station parameters.		✱✱			
ICS Software	4.2	The Sewer Utility does not appear to have pump station remote monitoring capabilities for wet well level, force main pressure, pump speed, LEL, BIOXIDE/chemical storage tank level, power and energy parameters, or other analog parameters for the pump stations.	✱✱				
ICS Software	4.2	Alarm summary and alarm history HMI screens at SWWTP are not automatically updated to display current alarm information.		✱✱			
ICS Software	4.2	The CKTP Wonderware implementation is generating considerable alarm activity, much of which is caused by the same alarms.					✱✱
ICS Software	4.3	The Sewer Utility's Wonderware Historian and Historian Client software at CKTP is in the mature support phase of the software developer's product life cycle, during which limited support is offered.		✱✱			
ICS Software	4.3	The historical SCADA data for KWWTP, MWWTP, and SWWTP are accessible only via the SCADA PC at each WWTP and have not been imported to the Sewer Utility's historian at CKTP.					✱✱
ICS Software	4.3	The Sewer Utility's means of accessing its historical SCADA data are time-consuming, are ill-suited for handling large queries, and present a barrier to ad hoc data exploration.					✱✱

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
ICS Software	4.3	The Sewer Utility has not implemented automated reports for SCADA data at any of the WWTPs.					✸✸
ICS Software	4.4	There is no redundant alarm notification method for KWWTP, MWWTP, and SWWTP. Failure of the SCADA PC's analog telephony card or disruption of telephone service to the WWTP would result in loss of remote alarm notification for the WWTP.				✸✸	
ICS Software	4.1	Sewer Utility PLCs are running a variety of firmware versions.		✸			
ICS Software	4.2	At CKTP, alarm acknowledgments made at one HMI thick client are not being registered by other HMI thick clients.					✸
ICS Software	4.2	Horizontal alarm banner at the bottom of SWWTP HMI screens may be non-functional.	✸				
ICS Software	4.2	Sewer Utility staff have indicated that there are cases throughout the WWTP HMI process screens where the wrong engineering units are being displayed for equipment speed values.		✸			
ICS Software	4.2	Equipment pop-up windows/screens do not appear to have functionality to provide information on active alarms or conditions, not internal to the equipment, that are inhibiting the equipment from running.					✸
ICS Software	4.2	Equipment pop-up windows/screens could be developed to include additional electrical, diagnostic, and performance data as well as expanded motor start count information.					✸
ICS Software	4.2	Trend screens display current values against time only and do not provide meaningful situational awareness.					✸
ICS Software	4.2	Root-cause analysis and alarm suppression functionality have not been developed for the Sewer Utility's WWTP HMI systems.	✸				✸

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
ICS Software	4.2	HMI screens do not have troubleshooting text prompts or decision tree aids to help operators react to alarm conditions.					✸
ICS Software	4.4	Sewer Utility staff indicate that an unresolved issue with the Sewer Utility's WIN-911 implementation prevents operators from obtaining a listing of active alarms when calling in to the WIN-911 system.					✸
ICS Documentation	5.2	The Sewer Utility is currently logging process control changes in physical operator log books and not in a more readily accessible, electronic format that can be backed up to prevent loss of information.	✸				✸✸
ICS Documentation	5.5	The Sewer Utility does not have formal ICS standards documentation to guide third-party design and implementation efforts.	✸				✸
ICS Documentation	5.1	Record P&IDs are not maintained in consolidated drawing sets or located in one location.					✸
ICS Documentation	5.1	Record P&IDs for MWWTP are out of date.					✸
ICS Documentation	5.1	Aside from P&IDs recently developed for the SWWTP sludge thickening processes, no detailed P&IDs appear to be available for SWWTP.					✸
ICS Documentation	5.2	General control descriptions have yet to be added to the County's eO&M SharePoint site for the major processes at KWWTP, MWWTP, and SWWTP and wastewater pump stations.					✸
ICS Documentation	5.2	The Sewer Utility does not maintain as-implemented control strategies for its WWTPs and pump stations.					✸
ICS Documentation	5.2	PLC programming modifications may be occurring without documentation of changes made to process controls.					✸

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
ICS Documentation	5.3	The County eO&M SharePoint site is missing record drawings from 2018 control system upgrade at MWWTP.					✱
Other Software Packages	6.4	The Sewer Utility is not currently using data analytics or visualization software to derive insights from its CMMS, EMS, laboratory, SCADA, and other data sets outside of their respective software environments.	✱✱	✱✱			✱✱
Other Software Packages	6.2	It appears that the Sewer Utility has not generated any historical EMS data since the CKTP EMS was installed because the EMS software was never set to record any of the real-time power data that it monitors.		✱✱			✱✱
Other Software Packages	6.2	The Sewer Utility is not currently using power or energy data at the bus level or load level to establish plant, process, or asset baselines or to evaluate process and equipment performance.		✱✱			✱✱
Other Software Packages	6.2	Aside from Puget Sound Energy billing data and a few load-level power parameters recorded by the CKTP historian, HDR believes that the Sewer Utility has little to no historical power and energy data for its WWTP and wastewater pump station infrastructure.		✱✱			✱✱
Other Software Packages	6.1	Data entry of WWTP and pump station assets and their attributes into the LLumin database has yet to be completed.		✱✱			✱
Other Software Packages	6.1	The Sewer Utility's CMMS and SCADA data remain siloed and the Sewer Utility has not implemented automated work orders based on accumulated runtimes, alarms, and other events registered at the SCADA system.		✱			✱✱
Other Software Packages	6.3	HDR believes that the Sewer Utility laboratory data are recorded in Excel spreadsheets and do not currently reside on a database, which makes working with the data labor-intensive.					✱✱

Table 8-2. WWTP and pump station PLC summary

Section	Sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency
Other Software Packages	6.2	Several MCCs at CKTP have no power monitor installed, which prevents them from being included in the CKTP EMS.	✸	✸			✸
Other Software Packages	6.2	Power monitors installed at the KWWTP and MWWTP MCCs are not networked to the WWTP PLCs or SCADA PCs.	✸	✸			✸
Other Software Packages	6.2	The CKTP EMS and SCADA system are not monitoring power and energy data that may be available from power monitors and other electrical equipment at the Sewer Utility's pump stations.		✸			✸
Other Software Packages	6.2	CKTP standby generators and large electrical loads (e.g., aeration blowers) have not been integrated into the CKTP EMS.					✸
Other Software Packages	6.2	Power monitors installed at the CKTP UV disinfection facility have not been integrated into the CKTP EMS.					✸
Other Software Packages	6.2	With the exception of SWGR-2961, the CKTP EMS is not monitoring switch and breaker statuses for the major electrical distribution system buses at CKTP.					✸
Other Software Packages	6.2	The CKTP EMS one-line diagram screens have not been configured to display current breaker statuses for SWGR-2961.					✸

9 References

ANSI/ISA (American National Standards Institute/International Society of Automation)

2016 *ANSI/ISA-18.2-2016, Management of Alarm Systems for the Process Industries.*

DHS (U.S. Department of Homeland Security)

2016 *Recommended Practice: Improving Industrial Control System Cybersecurity with Defense-in-Depth Strategies.*

NFPA (National Fire Protection Association)

2021 *NFPA 70E: Standard for Electrical Safety in the Workplace.*

2020 *NFPA 820: Standard for Fire Protection in Wastewater Treatment and Collection Facilities.*

NIST (National Institute of Standards and Technology)

2015 *NIST Special Publication 800-82, Revision 2: Guide to industrial Control Systems Security.*

Rockwell Automation

2020a *MicroLogix 1500 Programmable Logic Controller Systems.* https://www.rockwellautomation.com/en-us/products/hardware/allen-bradley/discontinued-products/micrologix-1500-controllers.html. Viewed on September 1, 2020.

2020b *1769 CompactLogix L3x Controllers.* https://www.rockwellautomation.com/en-us/products/hardware/allen-bradley/programmable-controllers/small-controllers/compactlogix-family/compactlogix-1769-controllers.html. Viewed on September 1, 2020.

2020c *Product Lifecycle Status.* https://www.rockwellautomation.com/global/support/product-compatibility-migration/lifecycle-status/overview.page. Viewed on September 1, 2020.

Schneider Electric

2020 *APC Power Saving Back-UPS 1500 Runtime Graph.* https://www.apc.com/products/runtimegraph/runtime_graph.cfm?base_sku=BR1500G&chartSize=large. Viewed on September 1, 2020.

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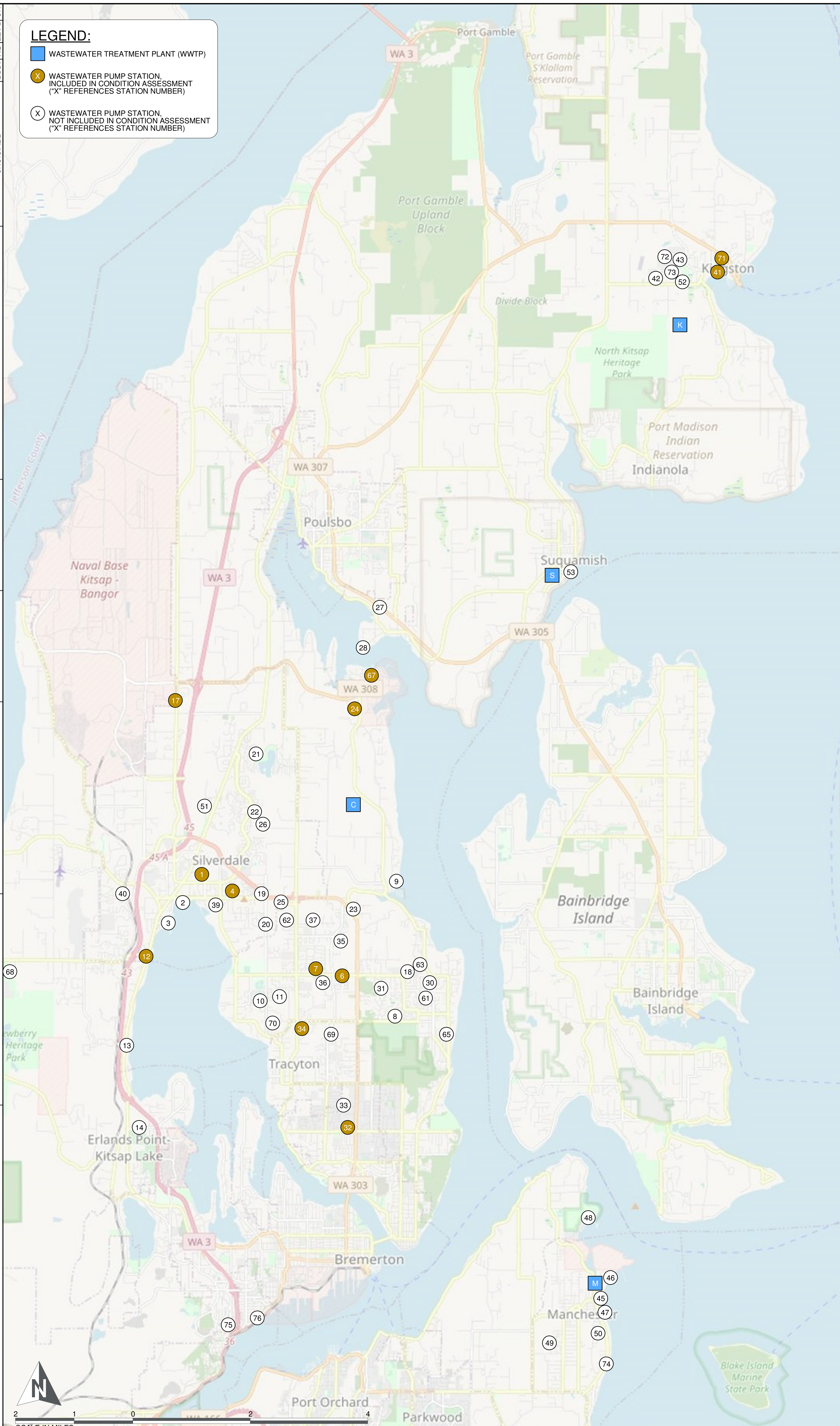
Appendix A

Site Maps



NO	DATE	BY	APPR	REVISIONS
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Fax: (425) 453-7107

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JMT DRAWN BY	08/31/2020 DATE
XXX CHECKED BY	XXX DATE
JMT APPROVED BY	08/31/2020 DATE
10231983 HDR PROJECT NUMBER	
KC-205-20 CLIENT PROJECT NUMBER	

KITSAP COUNTY WASHINGTON 18 57

Kitsap County Public Works
Sewer Utility Division
12351 Brownsville Highway NE
Poulsbo, WA 98370

KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

BAR IS 1 INCH ON ORIGINAL 11x17" DRAWING
0 1"

FIGURE A1

GENERAL
SITE MAP

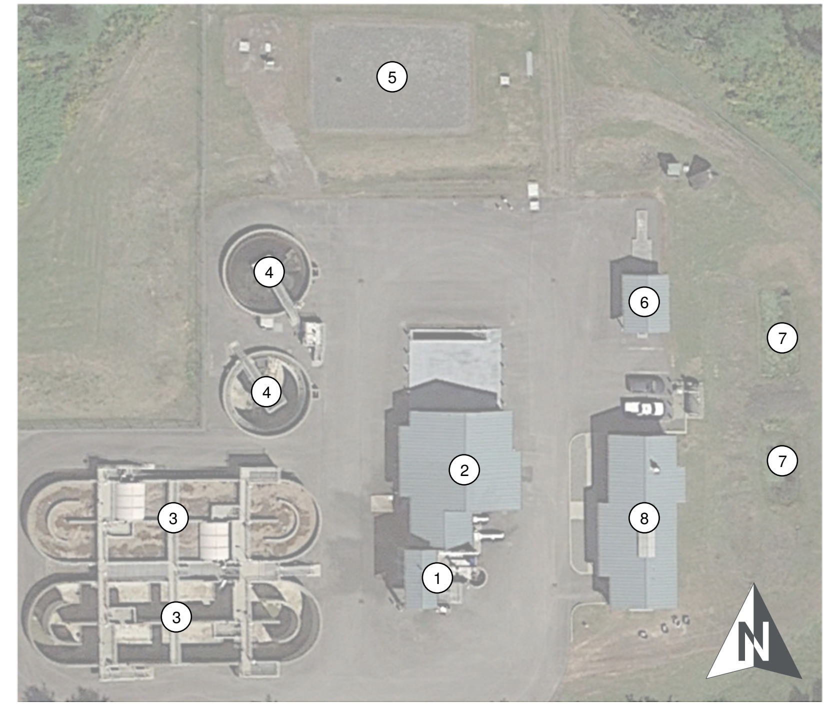
SHT 1 OF 2

CENTRAL KITSAP TREATMENT PLANT

250 125 0 250 500
SCALE IN FEET

CKTP SITE REFERENCE KEY: (X)

1. HEADWORKS
2. PRIMARY CLARIFIERS
3. AERATION BASINS
4. SECONDARY CLARIFIERS
5. UV DISINFECTION
6. GRAVITY THICKENERS
7. DIGESTERS
8. DIGESTER CONTROL BUILDING
9. WAS THICKENING BUILDING
10. POWER/BLOWER BUILDING
11. AERATION BASINS 3 & 4 ELECTRICAL BUILDING
12. RECLAIMED WATER BUILDING
13. SOLIDS PROCESSING BUILDING
14. CARBON ADDITION FACILITY
15. STORM WATER DECANT FACILITY
16. HEADWORKS BIOFILTER
17. COGEN AND DIGESTER GAS CONDITIONING FACILITY
18. WASTE GAS BURNER
19. ADMINISTRATION AND LAB BUILDING
20. MODULAR OFFICE (TRAILERS 103)
21. OPERATIONS FACILITIES BUILDING
22. SHOP AND EQUIPMENT MAINTENANCE BUILDING
23. SEPTAGE RECEIVING

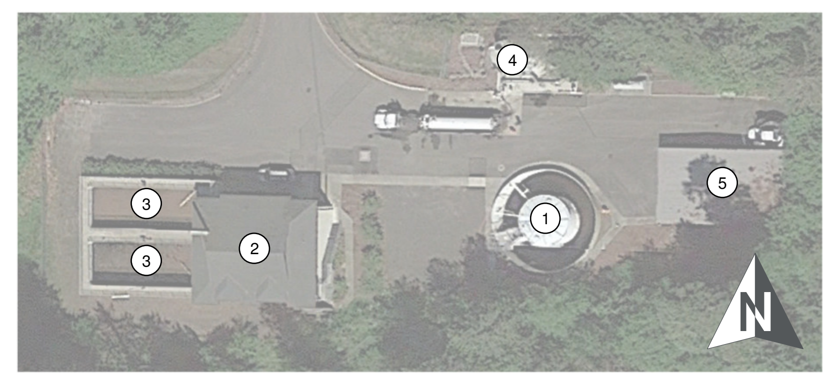


KINGSTON WASTEWATER TREATMENT PLANT

0 50 100
SCALE IN FEET

KWWTP SITE REFERENCE KEY: (X)

1. HEADWORKS
2. PROCESS BUILDING
3. OXIDATION DITCHES
4. SECONDARY CLARIFIERS
5. BIOFILTER
6. UV DISINFECTION
7. STORMWATER DETENTION PONDS
8. OPERATIONS BUILDING



SUQUAMISH WASTEWATER TREATMENT PLANT

0 25 50
SCALE IN FEET

SWWTP SITE REFERENCE KEY: (X)

1. SLUDGE STORAGE
2. PROCESS BUILDING
3. SBR BASINS
4. THICKENED SLUDGE STORAGE TANK
5. SERVICE BUILDING

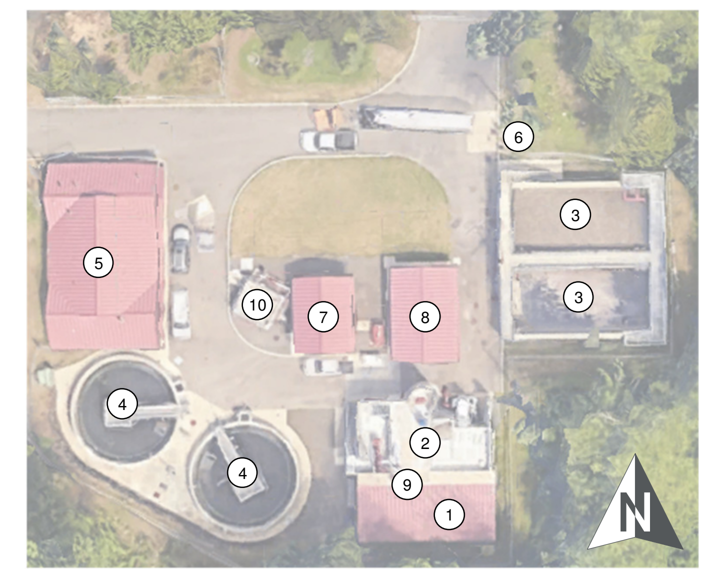
FACILITY LOCATIONS:

CENTRAL KITSAP TREATMENT PLANT (CKTP)
12351 Brownsville Highway NE
Poulsbo, WA 98370

KINGSTON WASTEWATER TREATMENT PLANT (KWWTP)
23055 S Kingston Road NE
Kingston, WA 98346

MANCHESTER WASTEWATER TREATMENT PLANT (MWWTP)
8020 E Caraway Road
Port Orchard, WA 98366

SUQUAMISH WASTEWATER TREATMENT PLANT (SWWTP)
18019 Division Avenue NE
Suquamish, WA 98392



MANCHESTER WASTEWATER TREATMENT PLANT

0 25 50
SCALE IN FEET

MWWTP SITE REFERENCE KEY: (X)

1. INFLUENT PUMP STATION
2. HEADWORKS
3. AERATION BASINS
4. SECONDARY CLARIFIERS
5. OPERATIONS BUILDING
6. SLUDGE LOADING FACILITY
7. GENERATOR BUILDING
8. BLOWER BUILDING
9. UV DISINFECTION
10. RAS/WAS SPLITTER BOX

NO	DATE	BY	APPR	REVISIONS
1	08/2020	JMT		TM-1: EXISTING SYSTEM OVERVIEW

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MH 08/31/2020	DRAWN BY / DATE	10231983	HDR PROJECT NUMBER
XXX XXX	CHECKED BY / DATE	KC-205-20	CLIENT PROJECT NUMBER

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Sewer Utility Division
12351 Brownsville Highway NE
Poulsbo, WA 98370

KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

BAR IS 1 INCH ON ORIGINAL 11"x17" DRAWING 0 1"

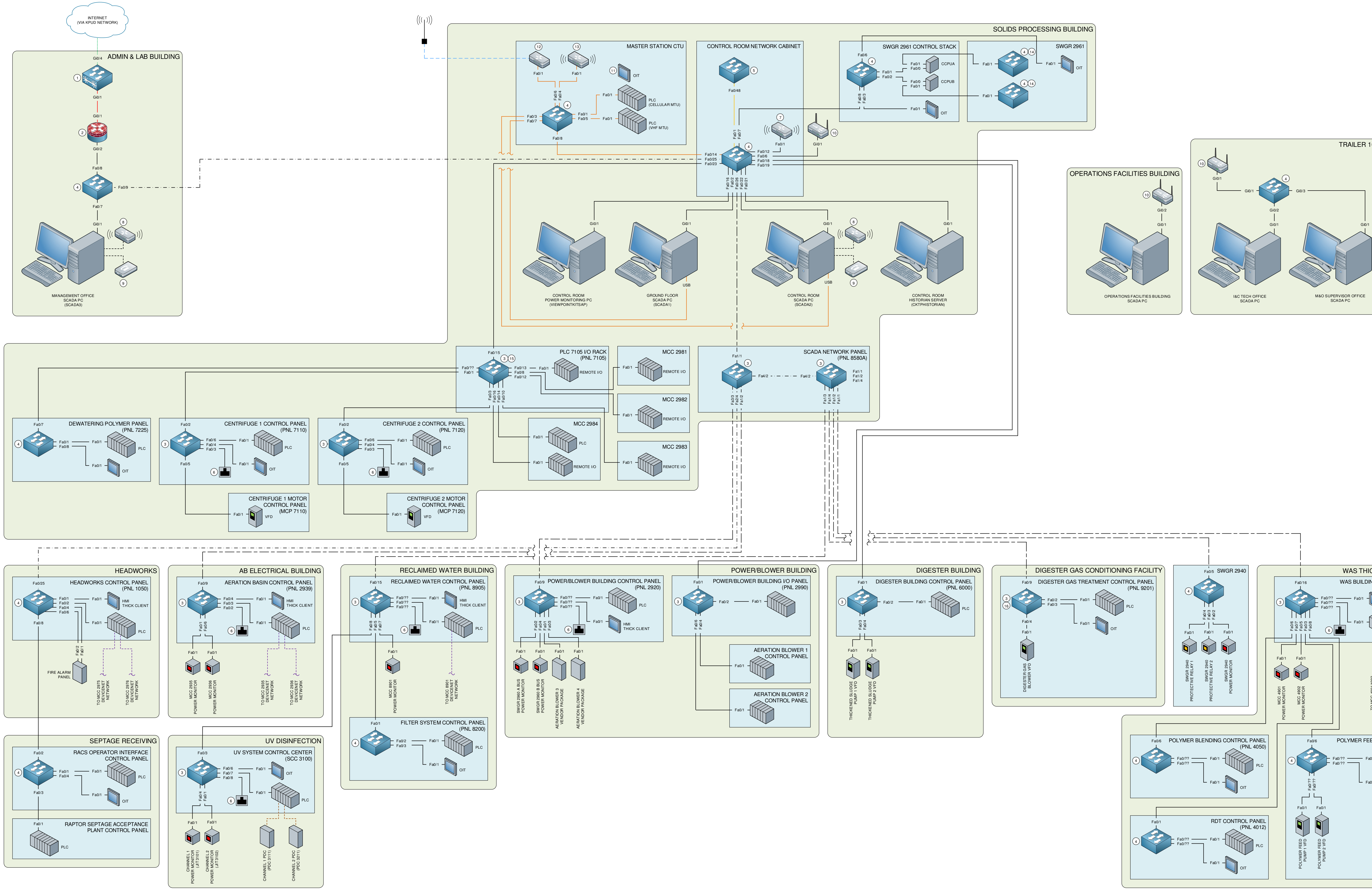
GENERAL
WWTP SITE MAPS

FIGURE A2

SHT 2 OF 2

Appendix B

Network Architecture Diagrams



GENERAL NOTES:

1. DRAWING REPRESENTS CONDITIONS OBSERVED DURING HDR SITE VISIT(S) AND DOES NOT REFLECT THE COUNTY'S FUTURE PLANNED WORK WITH QUALITY CONTROLS CORPORATION (QCC).
2. DRAWING DOES NOT SHOW FIBER-OPTIC PATCH PANELS OR ACTUAL PHYSICAL ROUTING OF FIBER PATHS. ONLY END-TO-END CONNECTIONS ARE SHOWN.
3. PHYSICAL CONNECTIONS ARE DEPICTED WITH VARIOUS LINE TYPES THAT INDICATE PROTOCOL AND CABLE TYPE. THE COLOR OF THE PHYSICAL CONNECTION INDICATES THE NETWORK OVER WHICH THE CONNECTION IS MADE. REFER TO LEGEND FOR DETAILS.
4. DRAWING DOES NOT SHOW STAND-ALONE CONTROL PANELS THAT ARE NOT NETWORKED TO THE PLANT PROCESS CONTROL SYSTEM (PCS).

KEY NOTES:

(1) KITSAP PUD (KPUD) OWNED CARRIER ETHERNET ACCESS SWITCH
(2) TEMPERED NETWORKS HIPSWITCH, 5 MBPS THROUGHPUT
(3) ETHERNET ACCESS SWITCH, MANAGED (LAYER 2)
(4) ETHERNET ACCESS SWITCH, UNMANAGED
(5) KITSAP COUNTY INFORMATION SERVICES (IS) ETHERNET ACCESS SWITCH, MANAGED (LAYER 2). OTHER IS NETWORK CONNECTION AT SWITCH NOT SHOWN.
(6) PROGRAMMING INTERFACE
(7) CELLULAR ROUTER
(8) CELLULAR MODEM FOR ALARM NOTIFICATION SYSTEM SMS MESSAGING
(9) ANALOG MODEM FOR ALARM NOTIFICATION SYSTEM VOICE MESSAGING. CONNECTION TO CKTP PHONE SYSTEM NETWORK AND PUBLIC SWITCHED TELEPHONE NETWORK (PSTN) NOT SHOWN.
(10) UNLICENSED 5 GHZ ACCESS POINT FOR IN-PLANT WIRELESS EXTENSION OF OT NETWORK
(11) OIT DISCONNECTED FROM PANEL ACCESS SWITCH
(12) ETHERNET RADIO FOR COMMUNICATIONS WITH LIFT STATIONS
(13) CELLULAR ROUTER FOR COMMUNICATIONS WITH LIFT STATIONS
(14) IP CONNECTIONS TO SWITCHGEAR BREAKERS NOT SHOWN
(15) TWO ETHERNET CONNECTIONS AT THIS SWITCH WERE NOT IDENTIFIED DURING HDR SITE VISITS
(16) COGEN SYSTEM CONTROL PANEL AND DIGESTER GAS CONDITIONING CHILLER CONTROL PANEL HAVE BEEN POWERED DOWN. ETHERNET CONNECTIONS FROM MANAGED SWITCH IN PNL 9201 TO DEVICES IN THESE CONTROL PANELS ARE NOT SHOWN ON THIS DRAWING.

LEGEND:

ETHERNET (COPPER)
ETHERNET (COAXIAL)
CARRIER ETHERNET (SINGLE-STRAND SINGLE-MODE FIBER-OPTIC)
ETHERNET (MULTI-MODE [OM1] FIBER-OPTIC)
ETHERNET (MULTI-MODE [OM3] FIBER-OPTIC)
SERIAL (COPPER)
SUQUAMISH WWTP OPERATIONAL TECHNOLOGY (OT) SUBNET
KITSAP COUNTY SEWER UTILITY OT TEMPERED NETWORKS WAN
CKTP BUSINESS LAN
KITSAP COUNTY SEWER UTILITY OT VHF RADIO WAN
DEVICENET
TRUNKED NETWORKS
CKTP PUMP STATION TELEMETRY SUBNET
MODBUS RTU
Fax/y FAST ETHERNET PORT (10/100 MBPS), x = SLOT #, y = PORT #
Gix/y GIGABIT ETHERNET PORT (10/100/1000 MBPS), x = SLOT #, y = PORT #

NO	DATE	BY	APPR	REVISIONS
1	08/2020	JMT		TM-1: EXISTING SYSTEM OVERVIEW

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Poulsbo, WA 98370

KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

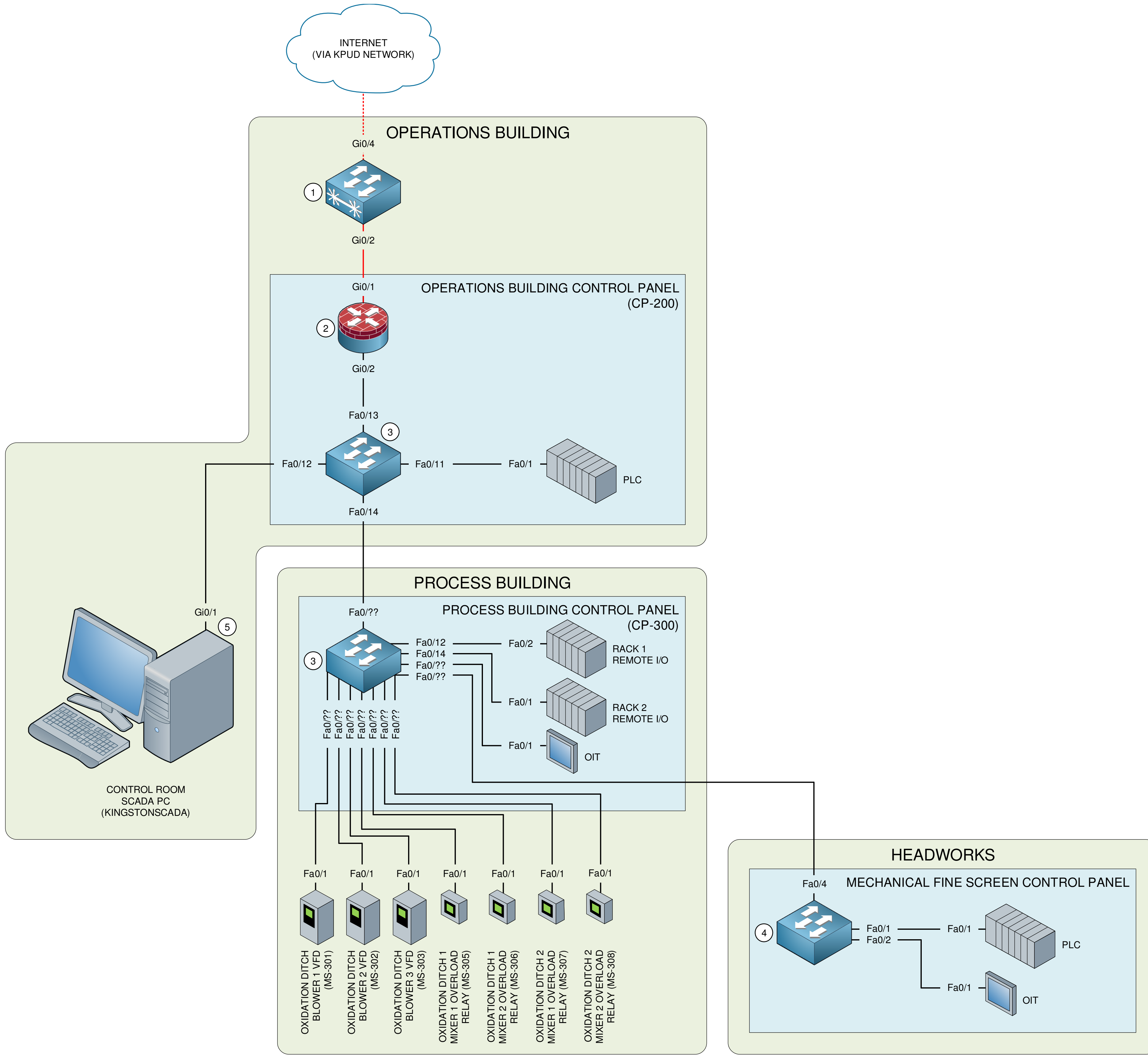
BAR IS 1 INCH ON ORIGINAL 22"x34" DRAWING 0 1"

GENERAL

CENTRAL KITSAP TREATMENT PLANT PHYSICAL NETWORK DIAGRAM

FIGURE B1

SHT 1 OF 4



GENERAL NOTES:

1. DRAWING REPRESENTS CONDITIONS OBSERVED DURING HDR SITE VISIT(S) AND DOES NOT REFLECT THE COUNTY'S FUTURE PLANNED WORK WITH QUALITY CONTROLS CORPORATION (QCC).
2. DRAWING DOES NOT SHOW FIBER-OPTIC PATCH PANELS OR ACTUAL PHYSICAL ROUTING OF FIBER PATHS. ONLY END-TO-END CONNECTIONS ARE SHOWN.
3. PHYSICAL CONNECTIONS ARE DEPICTED WITH VARIOUS LINE TYPES THAT INDICATE PROTOCOL AND CABLE TYPE. THE COLOR OF THE PHYSICAL CONNECTION INDICATES THE NETWORK OVER WHICH THE CONNECTION IS MADE. REFER TO LEGEND FOR DETAILS.

KEY NOTES:

1. KITSAP PUD (KPUD) OWNED CARRIER ETHERNET ACCESS SWITCH
2. TEMPERED NETWORKS HIPSWITCH, 75 MBPS THROUGHPUT
3. ETHERNET ACCESS SWITCH, MANAGED (LAYER 2)
4. ETHERNET ACCESS SWITCH, UNMANAGED
5. ALARM NOTIFICATION OCCURS OVER PUBLIC SWITCHED TELEPHONE NETWORK (PSTN) VIA ANALOG TELEPHONY CARD INSTALLED IN PLANT SCADA PC. CONNECTION TO PLANT TELEPHONE SYSTEM NETWORK AND PSTN NOT SHOWN.

LEGEND:

———	ETHERNET (COPPER)
– – – –	ETHERNET (COAXIAL)
········	CARRIER ETHERNET (SINGLE-STRAND SINGLE-MODE FIBER-OPTIC)
———	KINGSTON WWTP OPERATIONAL TECHNOLOGY (OT) SUBNET
——— (red)	KITSAP COUNTY SEWER UTILITY OT TEMPERED NETWORKS WAN
Fax/y	FAST ETHERNET PORT (10/100 MBPS), x = SLOT #, y = PORT #
Gix/y	GIGABIT ETHERNET PORT (10/100/1000 MBPS), x = SLOT #, y = PORT #

NO	DATE	BY	APPR	REVISIONS
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KITSAP COUNTY 18 57 WASHINGTON

Kitsap County Public Works
Sewer Utility Division
12351 Brownsville Highway NE
Poulsbo, WA 98370

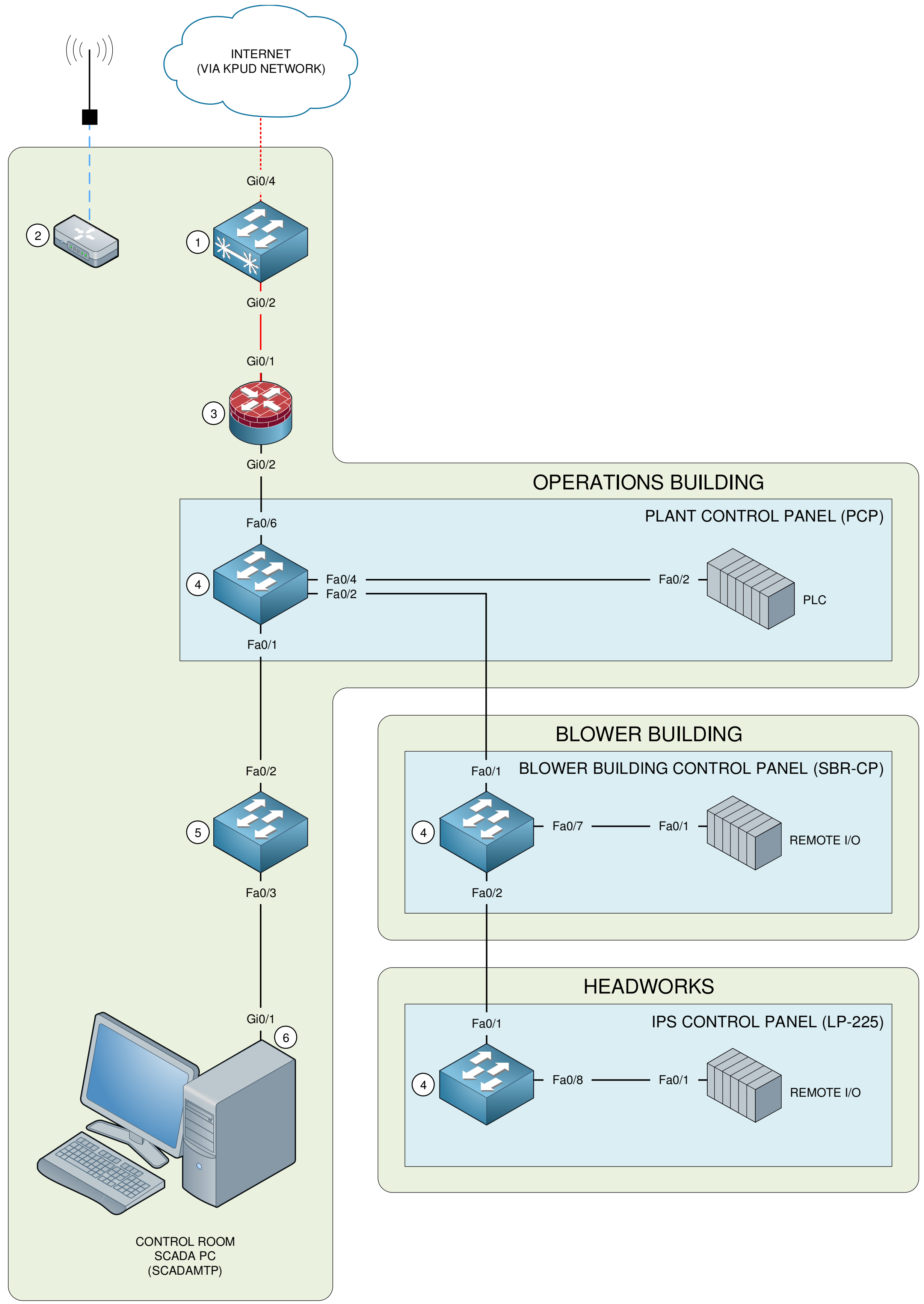
KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

BAR IS 1 INCH ON ORIGINAL 11"x17" DRAWING 0 1"

GENERAL
KINGSTON WWTP
PHYSICAL NETWORK DIAGRAM

FIGURE B2

SHT 2 OF 4



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KEY NOTES:

(1) KITSAP PUD (KPUD) OWNED CARRIER ETHERNET ACCESS SWITCH

(2) ETHERNET RADIO FOR FUTURE COMMUNICATIONS WITH MANCHESTER AREA LIFT STATIONS. VHF FREQUENCY TO BE DETERMINED.

(3) TEMPERED NETWORKS HIPSWITCH, 75 MBPS THROUGHPUT

(4) ETHERNET ACCESS SWITCH, MANAGED (LAYER 2)

(5) ETHERNET ACCESS SWITCH, UNMANAGED

(6) ALARM NOTIFICATION OCCURS OVER PUBLIC SWITCHED TELEPHONE NETWORK (PSTN) VIA ANALOG TELEPHONY CARD INSTALLED IN PLANT SCADA PC. CONNECTION TO PLANT TELEPHONE SYSTEM NETWORK AND PSTN NOT SHOWN.

LEGEND:

ETHERNET (COPPER)

ETHERNET (COAXIAL)

CARRIER ETHERNET (SINGLE-STRAND SINGLE-MODE FIBER-OPTIC)

MANCHESTER WWTP OPERATIONAL TECHNOLOGY (OT) SUBNET

KITSAP COUNTY SEWER UTILITY OT TEMPERED NETWORKS WAN

KITSAP COUNTY SEWER UTILITY OT VHF RADIO WAN

Fax/y FAST ETHERNET PORT (10/100 MBPS), x = SLOT #, y = PORT #

Gix/y GIGABIT ETHERNET PORT (10/100/1000 MBPS), x = SLOT #, y = PORT #

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OA	xxx	KC-205-20	
CHECKED BY	DATE	CLIENT PROJECT NUMBER	

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KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

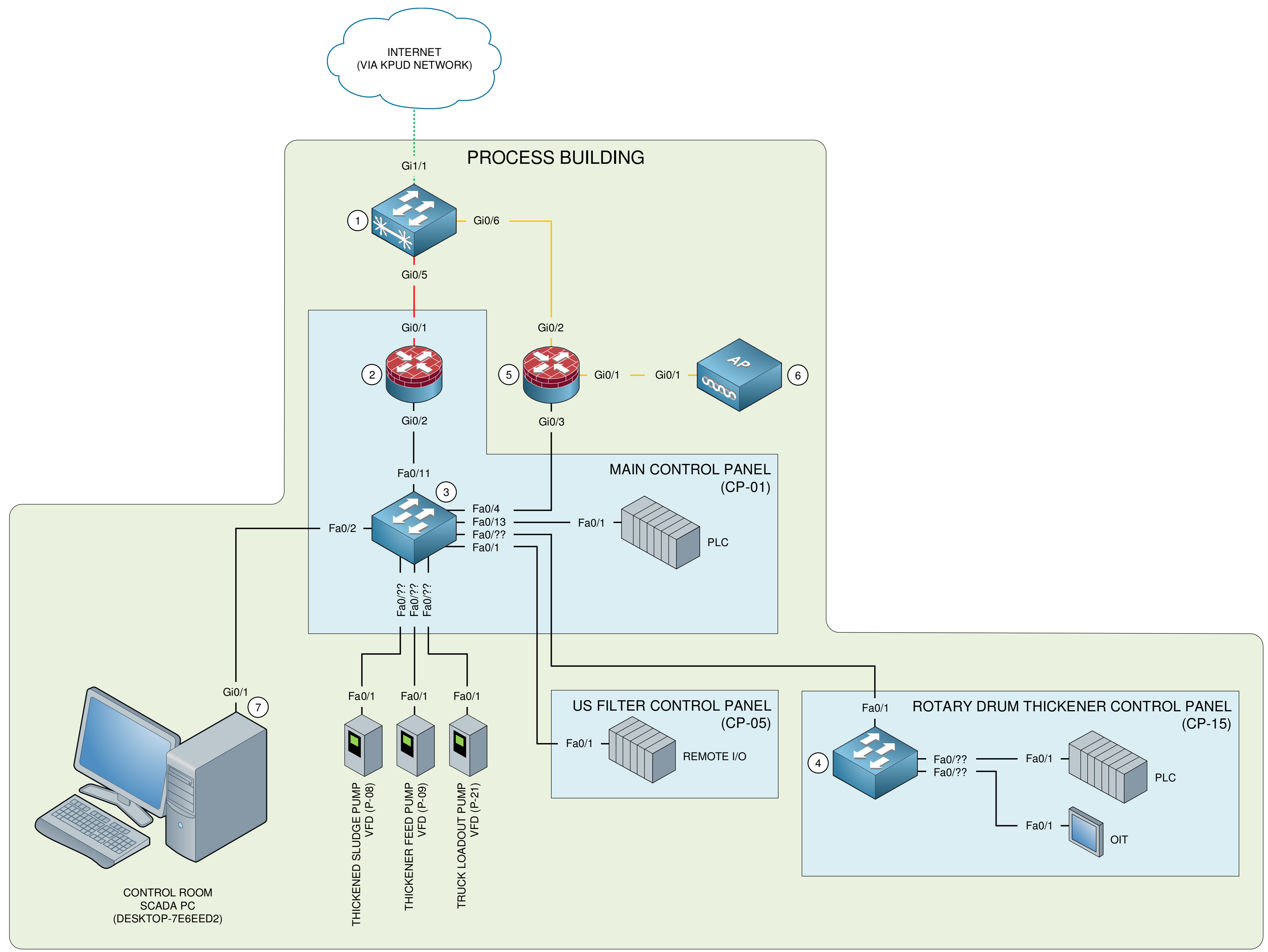
BAR IS 1 INCH ON ORIGINAL 11"x17" DRAWING 0 1"

GENERAL

MANCHESTER WWTP PHYSICAL NETWORK DIAGRAM

FIGURE B3

SHT 3 OF 4



GENERAL NOTES:

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3. PHYSICAL CONNECTIONS ARE DEPICTED WITH VARIOUS LINE TYPES THAT INDICATE PROTOCOL AND CABLE TYPE. THE COLOR OF THE PHYSICAL CONNECTION INDICATES THE NETWORK OVER WHICH THE CONNECTION IS MADE. REFER TO LEGEND FOR DETAILS.

KEY NOTES:

(1) KITSAP PUD (KPUD) OWNED CARRIER ETHERNET ACCESS SWITCH
(2) TEMPERED NETWORKS HIPSWITCH, 75 MBPS THROUGHPUT
(3) ETHERNET ACCESS SWITCH, MANAGED (LAYER 2)
(4) ETHERNET ACCESS SWITCH, UNMANAGED
(5) KITSAP COUNTY INFORMATION SERVICES (IS) SECURE GATEWAY (FIREWALL AND ROUTER)
(6) WIRELESS ACCESS POINT
(7) ALARM NOTIFICATION OCCURS OVER PUBLIC SWITCHED TELEPHONE NETWORK (PSTN) VIA ANALOG TELEPHONY CARD INSTALLED IN PLANT SCADA PC. CONNECTION TO PLANT TELEPHONE SYSTEM NETWORK AND PSTN NOT SHOWN.

LEGEND:

- ETHERNET (COPPER)
- ETHERNET (COAXIAL)
- CARRIER ETHERNET (SINGLE-STRAND SINGLE-MODE FIBER-OPTIC)
- SUQUAMISH WWTP OPERATIONAL TECHNOLOGY (OT) SUBNET
- KITSAP COUNTY SEWER UTILITY OT TEMPERED NETWORKS WAN
- SUQUAMISH WWTP BUSINESS LAN
- TRUNKED NETWORKS

Fax/y FAST ETHERNET PORT (10/100 MBPS), x = SLOT #, y = PORT #

Gix/y GIGABIT ETHERNET PORT (10/100/1000 MBPS), x = SLOT #, y = PORT #

NO	DATE	BY	APPR	REVISIONS
1	08/2020	JMT		TM-1: EXISTING SYSTEM OVERVIEW

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KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

BAR IS 1 INCH ON ORIGINAL 11"x17" DRAWING 0 1"

GENERAL

SUQUAMISH WWTP PHYSICAL NETWORK DIAGRAM

FIGURE B4

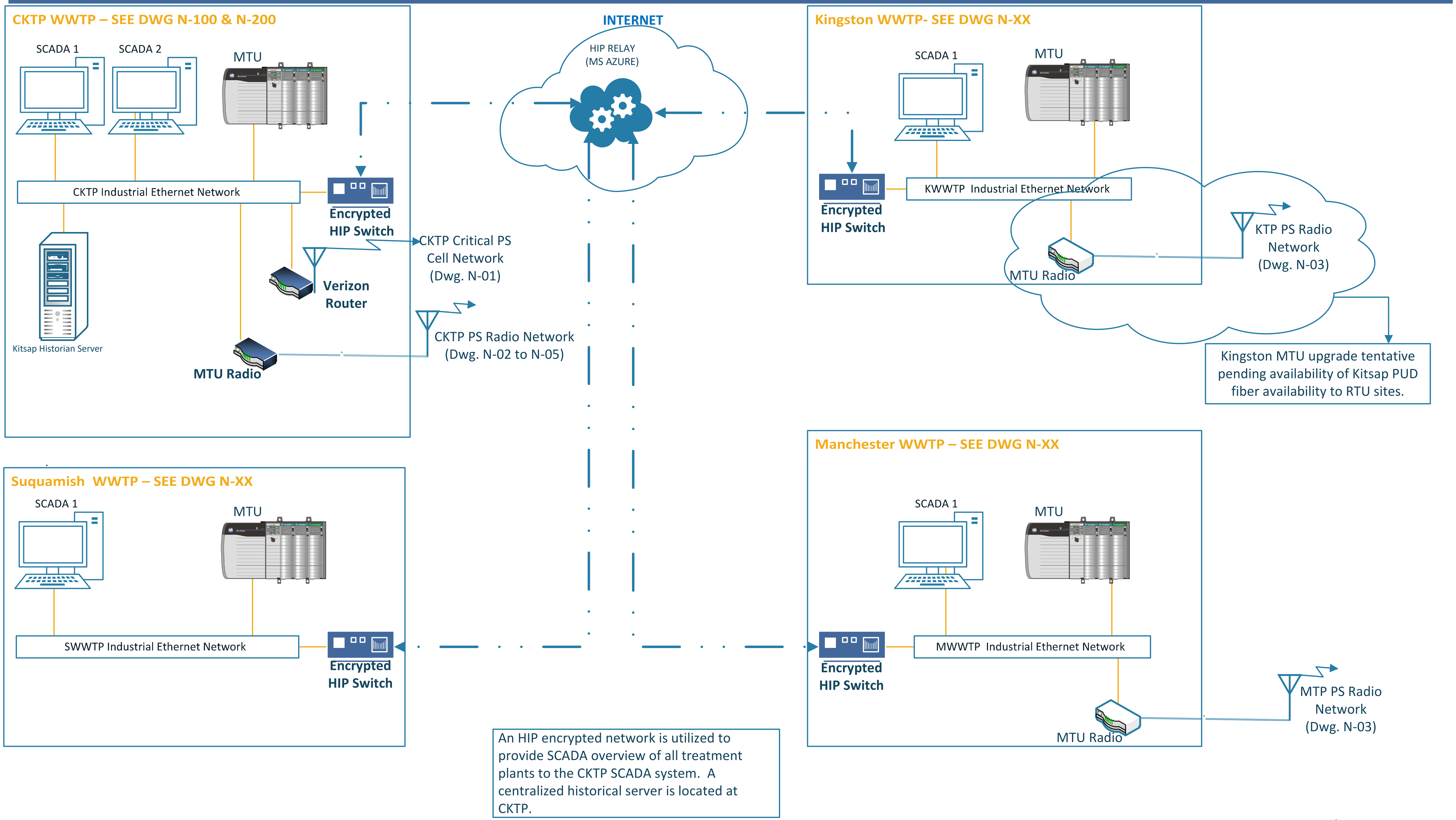
SHT 4 OF 4

Appendix C

QCC Network Design Diagrams

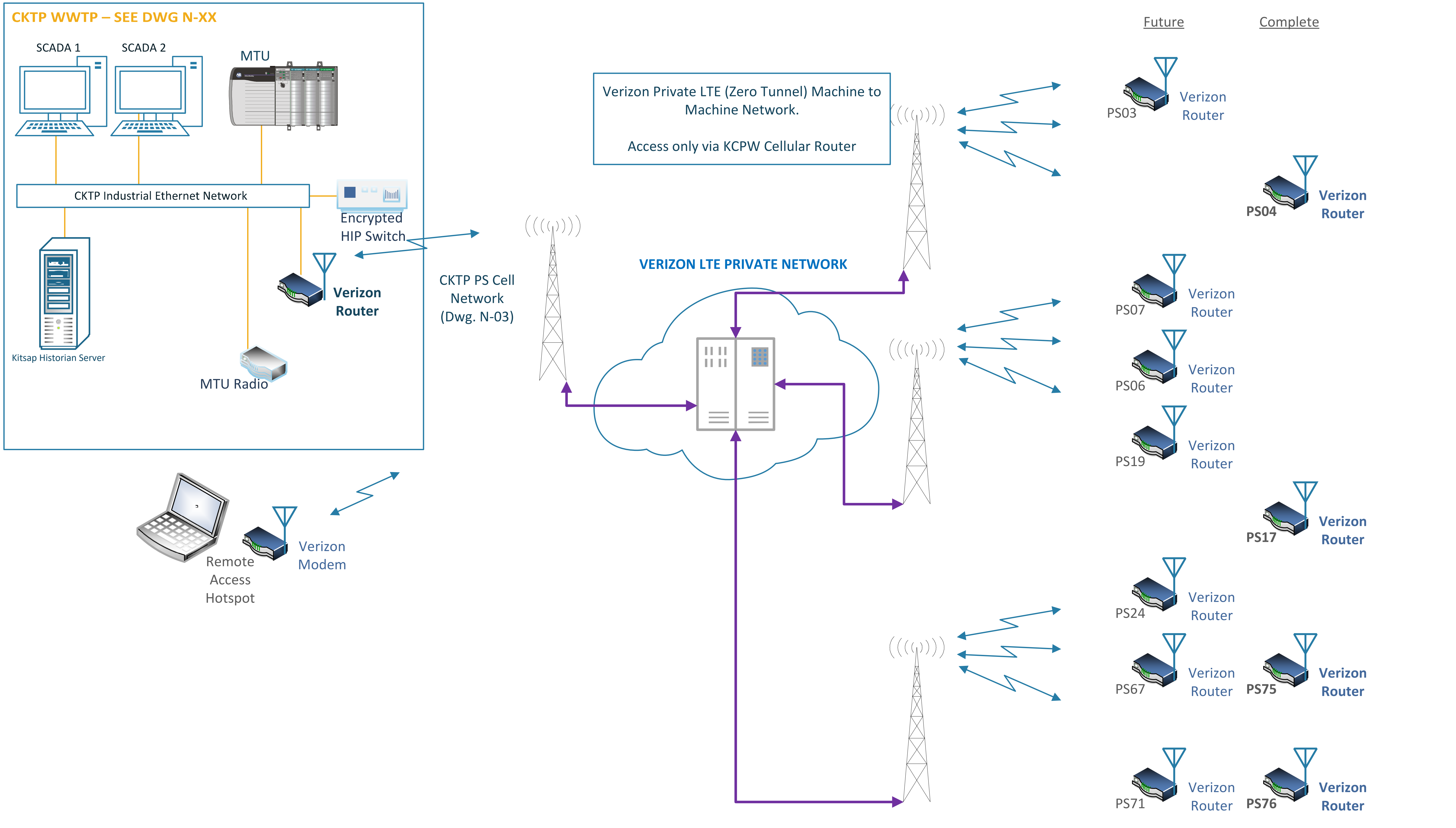
Wastewater Treatment Plants SCADA Network Overview

August 20, 2020

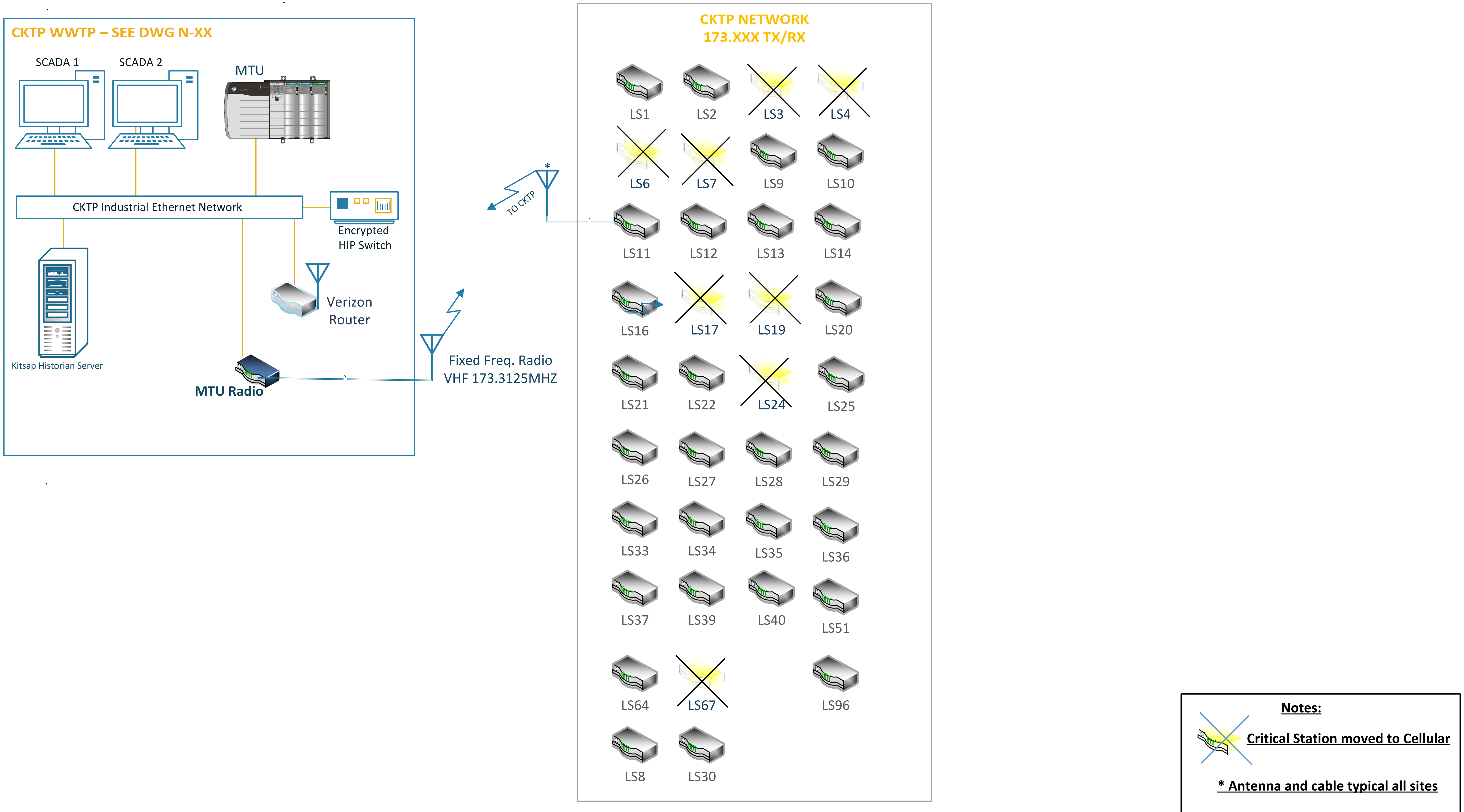


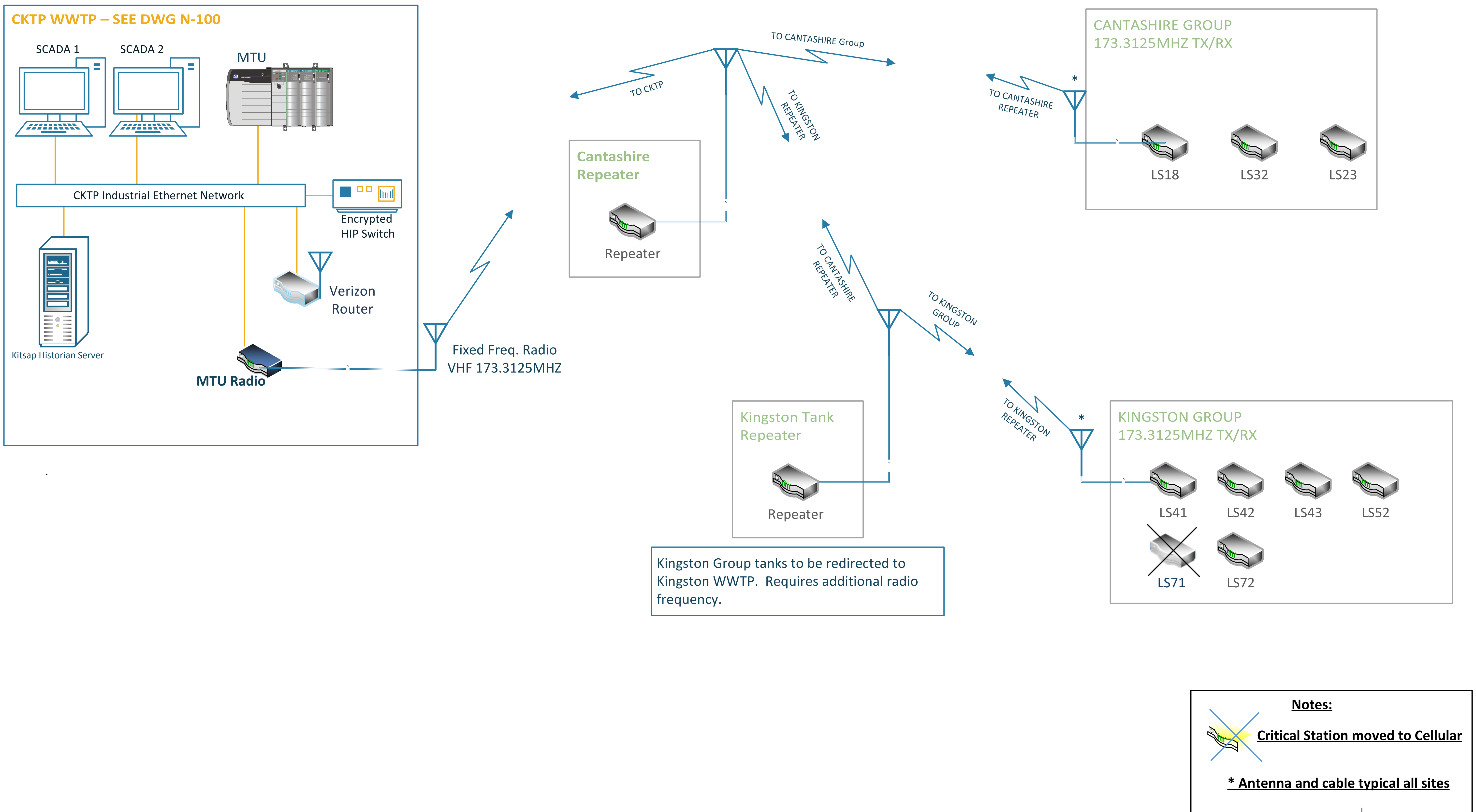
Pump Station Telemetry – Private Cellular (Critical Sites)

August 20, 2020



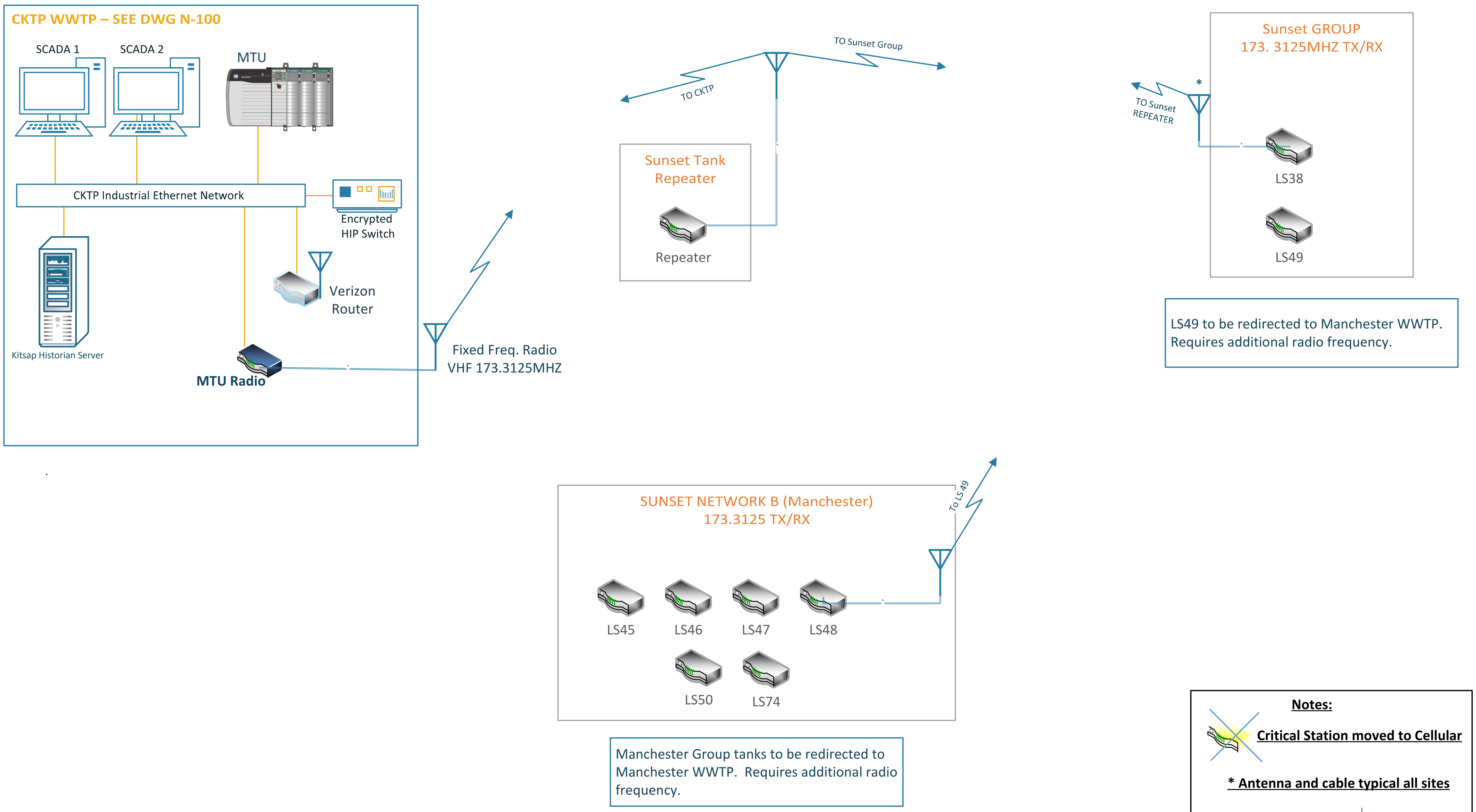
Pump Station Telemetry – Private Radio | CKTP Direct Sites

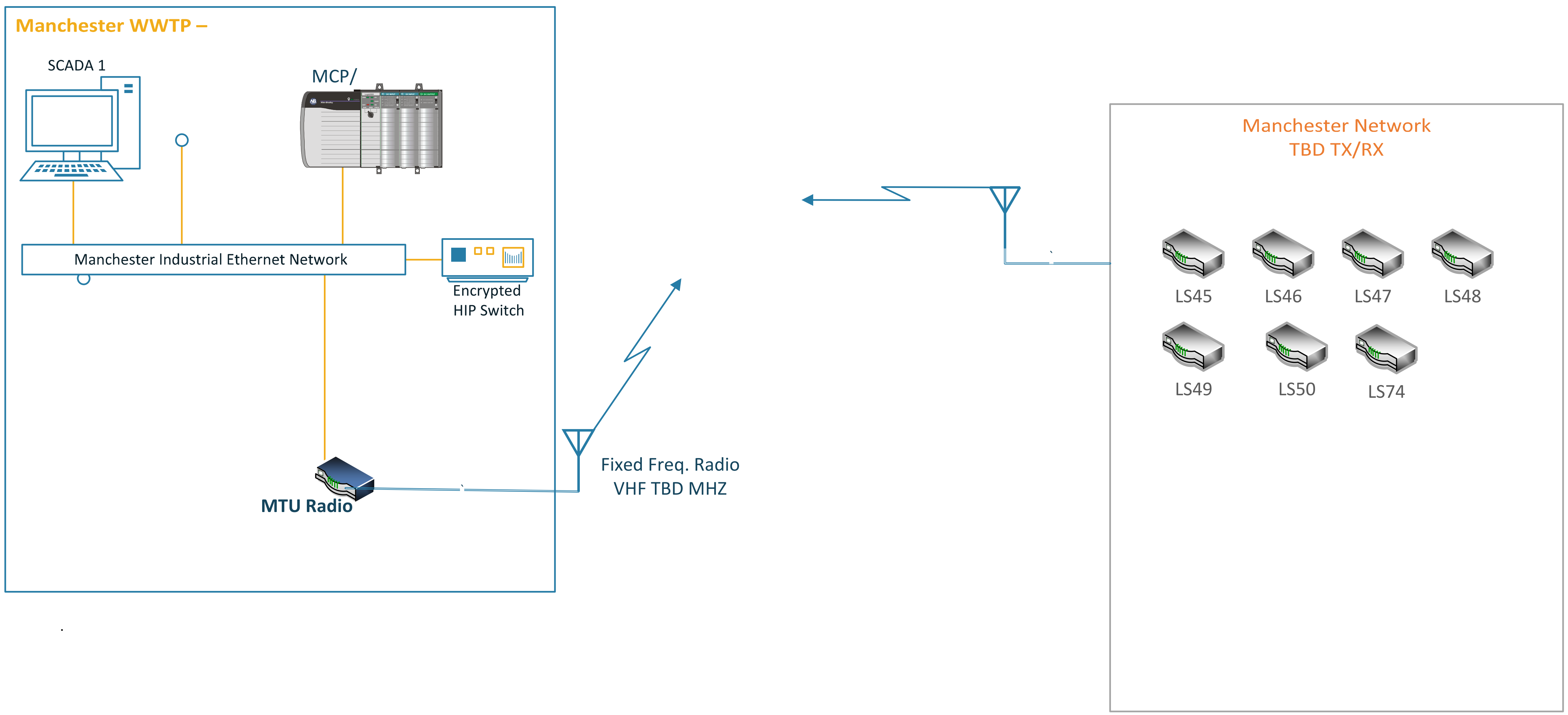



CKTP WWTP – SEE DWG N-100
SCADA 1
SCADA 2
MTU
CKTP Industrial Ethernet Network
Encrypted HIP Switch
Verizon Router
Kitsap Historian Server
MTU Radio
Fixed Freq. Radio VHF 173.3125MHZ
TO CKTP
TO CANTASHIRE Group
TO KINGSTON REPEATER
Cantashire Repeater
Repeater
CANTASHIRE GROUP
173.3125MHZ TX/RX
TO CANTASHIRE REPEATER
LS18
LS32
LS23
TO CANTASHIRE REPEATER
TO KINGSTON GROUP
Kingston Tank Repeater
Repeater
TO KINGSTON REPEATER
KINGSTON GROUP
173.3125MHZ TX/RX
LS41
LS42
LS43
LS52
LS71
LS72
Kingston Group tanks to be redirected to Kingston WWTP. Requires additional radio frequency.
Notes:
Critical Station moved to Cellular
* Antenna and cable typical all sites

Pump Station Telemetry – Private Radio | Sunset Repeater

August 20, 2020





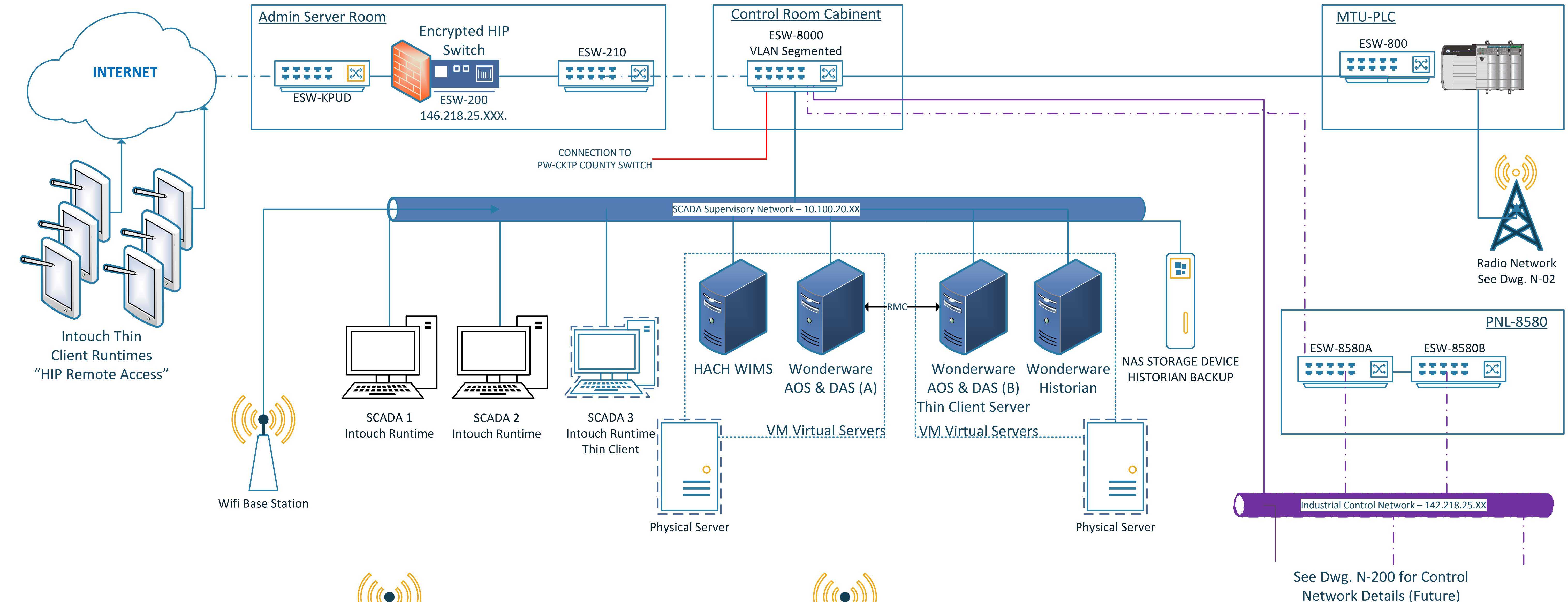
Notes:

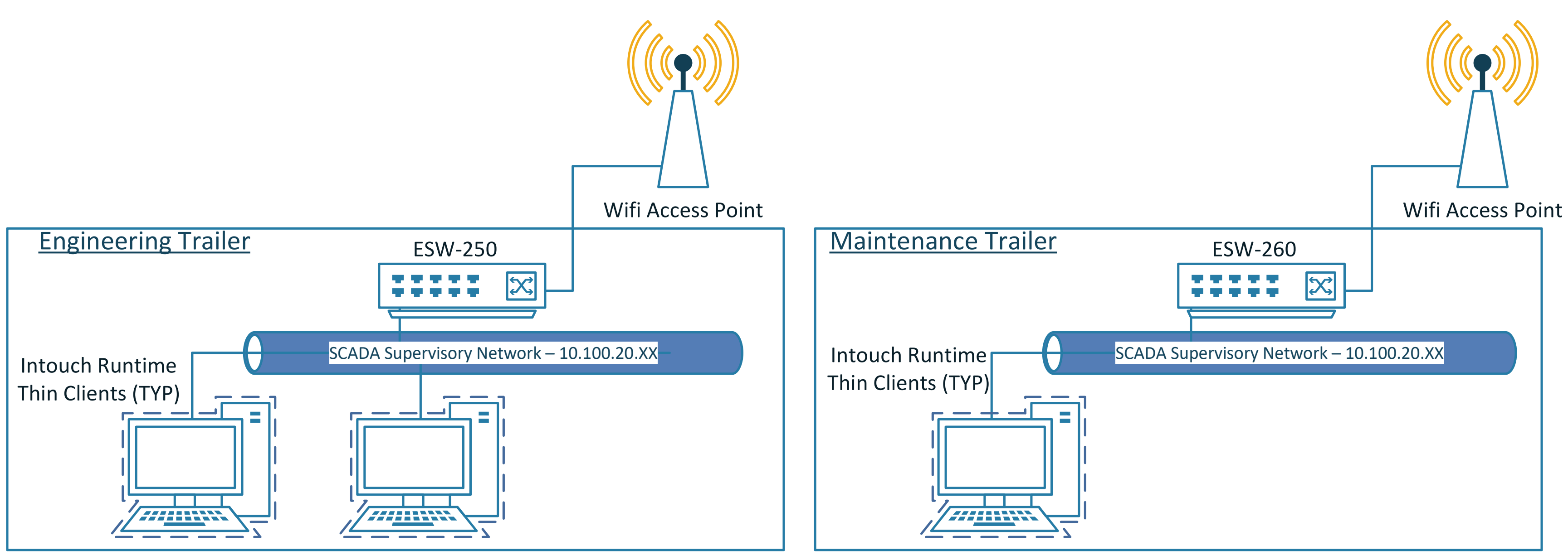
Critical Station moved to Cellular

*** Antenna and cable typical all sites**

CKTP INDUSTRIAL SCADA SUPERVISORY NETWORK - PRELIMINARY

August 20, 2020





Notes:

- New Supervisory SCADA network VLAN to be built for upgraded SCADA System. (IP Subnet TBD ex. 10.100.20.xx / 24). Configure existing ESW-8000 (Ntron 526FX) for overlapping VLAN port configurations per Ethernet Switch Schedule.
- Move MTU to new Supervisory SCADA Network.
- Configure HIP switch for remote user access to Thin Client Server.
- Configure HIP switch for remote WWTP for Historian connections.
- Control Panel HMI’s to remain and be configured as thin clients.

Appendix D

WWTP PLC I/O Summary and PLC and Remote I/O Module Summary

WWTP PLC Hardwired I/O Summary

Data collected by:	John Thomas
Dates collected:	August 2020

Facility	Building/area	Panel tag	PLC panel description	# of remote I/O drops	AI (4-20 mA)	AO (4-20 mA)	DI (24 VDC)	DI (120 VAC)	DO (24 VDC)	DO (120 VAC)	DO (relay)	Total I/O points
CKTP	Aeration basins 3 & 4 electrical building	PNL 2939	Aeration basins 3 & 4 electrical building control panel	0	33	12	0	27	0	2	0	74
CKTP	Digester control building	PNL 6000	Digester control building control panel	0	10	0	28	0	0	12	0	50
CKTP	Digester gas conditioning facility	PNL 9201	Digester gas treatment control panel	0	11	1	17	0	0	0	8	37
CKTP	Headworks building	PNL 1050	Headworks control panel	0	11	2	0	46	0	0	5	64
CKTP	Power/blower building	PNL 2920	Power/blower building blower room control panel	0	26	9	0	35	0	9	0	79
CKTP	Power/blower building	PNL 2990	Power/blower building electrical room control panel	1	29	13	105	3	0	31	0	181
CKTP	Reclaimed water building	PNL 8200	Filter system control panel	0	13	0	5	0	0	0	13	31
CKTP	Reclaimed water building	PNL 8905	Reclaimed water control panel	0	20	6	0	42	0	5	0	73
CKTP	Septage receiving	PNL 5010	Raptor septage acceptance plant control panel	0	2	0	0	18	0	0	14	34
CKTP	Septage receiving		RACS operator interface control panel	0	1	0	2	0	0	0	1	4
CKTP	Sludge processing building	MCC 2984	MCC 2984 control section	5	29	18	30	58	8	9	29	181
CKTP	Sludge processing building	PNL 7110	Centrifuge 1 control panel	0	12	3	35	0	0	0	18	68
CKTP	Sludge processing building	PNL 7120	Centrifuge 2 control panel	0	10	3	32	0	0	0	18	63
CKTP	Sludge processing building	PNL 7225	Dewatering polymer panel	0	8	2	32	0	15	0	0	57
CKTP	UV disinfection	SCC 3100	UV system control center	0	7	0	15	0	11	0	0	33
CKTP	WAS thickening building	PNL 4012	Rotary drum thickener control panel	0	0	3	0	12	0	7	0	22
CKTP	WAS thickening building	PNL 4050	Polymer blending control panel	0	7	1	0	12	0	0	8	28
CKTP	WAS thickening building	PNL 4080	Polymer feed control panel	0	1	0	0	4	0	0	4	9
CKTP	WAS thickening building	PNL 4905	WAS thickening building control panel	0	22	1	0	45	0	23	0	91
				CKTP TOTALS:	252	74	301	302	34	98	118	1,179
Kingston WWTP	Operations building	CP-200	Operations building control panel	2	23	2	109	0	92	0	0	226
				Kingston WWTP TOTALS:	23	2	109	0	92	0	0	226
Manchester WWTP	Operations building	PCP	Plant control panel	2	10	5	0	79	0	12	24	130
				Manchester WWTP TOTALS:	10	5	0	79	0	12	24	130
Suquamish WWTP	Process building	CP-01	Main control panel	1	17	6	57	42	41	0	0	163
Suquamish WWTP	Process building	CP-15	Rotary drum thickener control panel	0	3	4	0	11	0	0	6	24
				Suquamish WWTP TOTALS:	20	10	57	53	41	0	6	187

WWTP PLC and Remote I/O Module Summary

Data collected by:	John Thomas
Dates collected:	August 2020

Facility	Panel tag	Panel description	PLC/RIO	Rack	Slot	Model	Catalog #	I/O type	Voltage/current/ protocol	I/O channels used	I/O channel capacity
CKTP	MCC 2981	MCC 2981 control section	RIO	1	0	Bulletin 1769 Compact I/O	1769-AENTR	Ethernet Adapter	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	12	16
					2	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	0	16
					3	Bulletin 1769 Compact I/O	1769-OB16/A	DO	24 VDC	7	16
CKTP	MCC 2982	MCC 2982 control section	RIO	1	0	Bulletin 1769 Compact I/O	1769-AENTR	Ethernet Adapter	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	10	16
					2	Bulletin 1769 Compact I/O	1769-OW16/A	DO	Relay (VAC/VDC)	5	16
CKTP	MCC 2983	MCC 2983 control section	RIO	1	0	Bulletin 1769 Compact I/O	1769-AENTR	Ethernet Adapter	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	15	16
					2	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	14	16
					3	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	4	16
					4	Bulletin 1769 Compact I/O	1769-OW16/A	DO	Relay (VAC/VDC)	15	16
					5	Bulletin 1769 Compact I/O	1769-OW16/A	DO	Relay (VAC/VDC)	7	16
CKTP	MCC 2984	MCC 2984 control section	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IQ32/A	DI	24 VDC	12	32
					2	Bulletin 1769 Compact I/O	1769-OA16/A	DO	120 VAC	9	16
					3	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	3	8
					4	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	4	4
			RIO	1	0	Bulletin 1769 Compact I/O	1769-AENTR	Ethernet Adapter	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	10	16
					2	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	5	16
					3	Bulletin 1769 Compact I/O	1769-OW16/A	DO	Relay (VAC/VDC)	2	16
CKTP	PNL 1050	Headworks control panel	PLC	1	0	SLC 5/05	1747-L552	Controller	EtherNet/IP	N/A	N/A
					1	SLC 500 I/O	1747-SDN	Scanner	DeviceNet	N/A	N/A
					2	SLC 500 I/O	1747-SDN	Scanner	DeviceNet	N/A	N/A
					3	SLC 500 I/O	1746-IA16	DI	120 VAC	16	16
					4	SLC 500 I/O	1746-IA16	DI	120 VAC	16	16
					5	SLC 500 I/O	1746-IA16	DI	120 VAC	14	16
					7	SLC 500 I/O	1746-OW16	DO	Relay (VAC/VDC)	5	16
					9	SLC 500 I/O	1746-NI8	AI	4-20 mA	8	8
					10	SLC 500 I/O	1746-NI8	AI	4-20 mA	3	8
					12	SLC 500 I/O	1746-NO4I	AO	4-20 mA	2	4
CKTP	PNL 2002	Aeration blower 2 control panel	RIO	1	0	POINT I/O	1734-AENT/B	Ethernet Adapter	EtherNet/IP	N/A	N/A
					1	POINT I/O	1734-OE2C/C	AO	4-20 mA	2	2
					2	POINT I/O	1734-IA4/C	DI	120 VAC	3	4
CKTP	PNL 2920	Power/blower building blower room control panel	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	6	8
					2	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	7	8
					3	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	6	8
					4	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	7	8
					5	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	3	4
					6	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	3	4
					7	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	3	4
				2	9	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	8	16

Facility	Panel tag	Panel description	PLC/RIO	Rack	Slot	Model	Catalog #	I/O type	Voltage/current/ protocol	I/O channels used	I/O channel capacity
					10	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	9	16
					11	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	9	16
					12	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	9	16
					13	Bulletin 1769 Compact I/O	1769-OA16/A	DO	120 VAC	5	16
					14	Bulletin 1769 Compact I/O	1769-OA16/A	DO	120 VAC	4	16
CKTP	PNL 2939	Aeration basins 3 & 4 electrical building control panel	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-SDN/B	Scanner	DeviceNet	N/A	N/A
					2	Bulletin 1769 Compact I/O	1769-SDN/B	Scanner	DeviceNet	N/A	N/A
					3	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	6	8
					4	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	7	8
					5	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	6	8
					6	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	7	8
					7	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	7	8
				2	9	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	3	4
					10	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	3	4
					11	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	3	4
					12	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	3	4
					13	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	8	16
					14	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	10	16
					15	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	9	16
					16	Bulletin 1769 Compact I/O	1769-OA16/A	DO	120 VAC	2	16
CKTP	PNL 2990	Power/blower building electrical room control panel	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IQ32/A	DI	24 VDC	28	32
					2	Bulletin 1769 Compact I/O	1769-IQ32/A	DI	24 VDC	31	32
					3	Bulletin 1769 Compact I/O	1769-IQ32/A	DI	24 VDC	30	32
					4	Bulletin 1769 Compact I/O	1769-IQ32/A	DI	24 VDC	16	32
					5	Bulletin 1769 Compact I/O	1769-OA16/A	DO	120 VAC	15	16
					6	Bulletin 1769 Compact I/O	1769-OA16/A	DO	120 VAC	16	16
				2	7	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	8	8
					8	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	8	8
					9	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	6	8
					10	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	7	8
					11	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	3	4
					12	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	4	4
					13	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	4	4
CKTP	PNL 4012	Rotary drum thickener control panel	PLC	1	0	CompactLogix 5370	1769-L30ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	12	16
					2	Bulletin 1769 Compact I/O	1769-OA16/A	DO	120 VAC	7	16
					3	Bulletin 1769 Compact I/O	1769-OF8C/A	AO	4-20 mA	3	8
CKTP	PNL 4050	Polymer blending control panel	PLC	1	0	CompactLogix L3x	1769-L32E	Controller	EtherNet/IP	N/A	N/A
					3	Bulletin 1769 Compact I/O	1769-IF4/B	AI	4-20 mA	4	4
					4	Bulletin 1769 Compact I/O	1769-IF4/B	AI	4-20 mA	3	4
					5	Bulletin 1769 Compact I/O	1769-OF4/A	AO	4-20 mA	1	4
					6	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	12	16
					7	Bulletin 1769 Compact I/O	1769-OW16/A	DO	Relay (VAC/VDC)	8	16
CKTP	PNL 4080	Polymer feed control panel	PLC	1	0	CompactLogix L3x	1769-L32E	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IF4/B	AI	4-20 mA	1	4

Facility	Panel tag	Panel description	PLC/RIO	Rack	Slot	Model	Catalog #	I/O type	Voltage/current/ protocol	I/O channels used	I/O channel capacity
					2	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	4	16
					3	Bulletin 1769 Compact I/O	1769-OW8/A	DO	Relay (VAC/VDC)	4	8
CKTP	PNL 4905	WAS thickening building control panel	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-SDN/B	Scanner	DeviceNet	N/A	N/A
					3	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	8	8
					4	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	8	8
					5	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	6	8
					6	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	1	4
				2	8	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	10	16
					9	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	11	16
					10	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	15	16
					11	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	9	16
					12	Bulletin 1769 Compact I/O	1769-OA16/A	DO	120 VAC	11	16
					13	Bulletin 1769 Compact I/O	1769-OA16/A	DO	120 VAC	12	16
CKTP	PNL 5010	Raptor septage acceptance plant control panel	PLC	1	0	MicroLogix 1100	1763-L16AWA	AI	4-20 mA	2	2
								DI	120 VAC	10	10
								DO	Relay (VAC/VDC)	6	6
					1	MicroLogix I/O	1762-IA8	DI	120 VAC	8	8
					2	MicroLogix I/O	1762-OW8	DO	Relay (VAC/VDC)	8	8
CKTP	PNL 6000	Digester control building control panel	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IQ32/A	DI	24 VDC	18	32
					2	Bulletin 1769 Compact I/O	1769-IQ32/A	DI	24 VDC	10	32
					3	Bulletin 1769 Compact I/O	1769-OA16/A	DO	120 VAC	12	16
					4	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	8	8
					5	Bulletin 1769 Compact I/O	1769-IF4/B	AI	4-20 mA	2	4
CKTP	PNL 7105	PLC 7105 I/O rack	RIO	1	0	Bulletin 1769 Compact I/O	1769-AENTR	Ethernet Adapter	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	6	16
					2	Bulletin 1769 Compact I/O	1769-OB16/A	DO	24 VDC	1	16
					3	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	4	4
					4	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	4	4
					5	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	4	4
					6	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	2	4
					7	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	3	4
				2	8	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	4	4
					9	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	2	4
					10	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	3	4
					11	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	0	4
					12	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	4	4
					13	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	3	4
					14	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	4	4
					15	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	3	4
CKTP	PNL 7110	Centrifuge 1 control panel	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	4	8
					2	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	8	8
					3	Bulletin 1769 Compact I/O	1769-OF4/A	AO	4-20 mA	3	4
					4	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	14	16
					5	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	8	16

Facility	Panel tag	Panel description	PLC/RIO	Rack	Slot	Model	Catalog #	I/O type	Voltage/current/ protocol	I/O channels used	I/O channel capacity
					6	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	13	16
					7	Bulletin 1769 Compact I/O	1769-OW16/A	DO	Relay (VAC/VDC)	13	16
					8	Bulletin 1769 Compact I/O	1769-OW16/A	DO	Relay (VAC/VDC)	5	16
CKTP	PNL 7120	Centrifuge 2 control panel	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	4	8
					2	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	6	8
					3	Bulletin 1769 Compact I/O	1769-OF4/A	AO	4-20 mA	3	4
					4	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	14	16
					5	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	8	16
					6	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	10	16
					7	Bulletin 1769 Compact I/O	1769-OW16/A	DO	Relay (VAC/VDC)	13	16
					8	Bulletin 1769 Compact I/O	1769-OW16/A	DO	Relay (VAC/VDC)	5	16
CKTP	PNL 7225	Dewatering polymer panel	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	12	16
					2	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	12	16
					3	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	8	16
					4	Bulletin 1769 Compact I/O	1769-OB16/A	DO	24 VDC	13	16
					5	Bulletin 1769 Compact I/O	1769-OB16/A	DO	24 VDC	2	16
					6	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	4	4
					7	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	4	4
					8	Bulletin 1769 Compact I/O	1769-OF2/A	AO	4-20 mA	2	2
CKTP	PNL 8200	Filter system control panel	PLC	1	0	CompactLogix L3x	1769-L32E	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	5	16
					2	Bulletin 1769 Compact I/O	1769-OW16/A	DO	Relay (VAC/VDC)	13	16
					3	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	5	8
					4	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	8	8
CKTP	PNL 8905	Reclaimed water control panel	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-SDN/B	Scanner	DeviceNet	N/A	N/A
					3	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	6	8
					4	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	7	8
					5	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	7	8
					6	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	3	4
					7	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	3	4
				2	9	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	9	16
					10	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	12	16
					11	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	9	16
					12	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	12	16
					13	Bulletin 1769 Compact I/O	1769-OA16/A	DO	120 VAC	3	16
					14	Bulletin 1769 Compact I/O	1769-OA16/A	DO	120 VAC	2	16
CKTP	PNL 9201	Digester gas treatment control panel	PLC	1	0	CompactLogix L3x	1769-L32E	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	15	16
					2	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	2	16
					3	Bulletin 1769 Compact I/O	1769-OW16/A	DO	Relay (VAC/VDC)	8	16
					4	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	8	8
					5	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	3	8
					6	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	1	4
CKTP	SCC 3100	UV system control center	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A

Facility	Panel tag	Panel description	PLC/RIO	Rack	Slot	Model	Catalog #	I/O type	Voltage/current/ protocol	I/O channels used	I/O channel capacity
					1	ProSoft Technology	MV169E-MBS/A	Comm	Modbus RTU	N/A	N/A
					2	Bulletin 1769 Compact I/O	1769-IF4/B	AI	4-20 mA	4	4
					3	Bulletin 1769 Compact I/O	1769-IF4/B	AI	4-20 mA	3	4
					4	Bulletin 1769 Compact I/O	1769-OB16/B	DO	24 VDC	11	16
					5	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	15	16
CKTP		Master station CTU (VHF PLC)	PLC	1	0	CompactLogix L3x	1769-L35E	Controller	EtherNet/IP	N/A	N/A
CKTP		Master station CTU (Cellular PLC)	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A
CKTP		RACS operator interface control panel	PLC	1	0	MicroLogix 1100	1763-L16BWA	AI	4-20 mA	1	2
								DI	24 VDC	2	10
								DO	Relay (VAC/VDC)	1	6
Kingston WWTP	CP-200	Operations building control panel	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	13	16
					2	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	6	16
					3	Bulletin 1769 Compact I/O	1769-OB16/B	DO	24 VDC	15	16
					4	Bulletin 1769 Compact I/O	1769-OB16/B	DO	24 VDC	6	16
					5	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	2	4
					6	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	0	4
Kingston WWTP	CP-300	Process building control panel	RIO	1	0	Bulletin 1769 Compact I/O	1769-AENTR	Ethernet Adapter	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	14	16
					2	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	14	16
					3	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	14	16
					4	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	15	16
					5	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	14	16
					6	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	5	16
					7	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	13	16
					8	Bulletin 1769 Compact I/O	1769-IQ16/A	DI	24 VDC	1	16
					9	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	4	4
					10	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	3	4
			RIO	2	0	Bulletin 1769 Compact I/O	1769-AENTR	Ethernet Adapter	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-OB16/B	DO	24 VDC	16	16
					2	Bulletin 1769 Compact I/O	1769-OB16/B	DO	24 VDC	16	16
					3	Bulletin 1769 Compact I/O	1769-OB16/B	DO	24 VDC	16	16
					4	Bulletin 1769 Compact I/O	1769-OB16/B	DO	24 VDC	9	16
					5	Bulletin 1769 Compact I/O	1769-OB16/B	DO	24 VDC	14	16
					6	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	4	4
					7	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	4	4
					8	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	4	4
					9	Bulletin 1769 Compact I/O	1769-IF4I/A	AI	4-20 mA	2	4
					10	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	2	4
Manchester WWTP	PCP	Plant control panel	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	7	16
					2	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	6	16
					3	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	9	16
					4	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	3	16
					5	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	12	16
					6	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	8	16
					7	Bulletin 1769 Compact I/O	1769-OW8I/B	DO	Relay (VAC/VDC)	6	8

Facility	Panel tag	Panel description	PLC/RIO	Rack	Slot	Model	Catalog #	I/O type	Voltage/current/ protocol	I/O channels used	I/O channel capacity
					8	Bulletin 1769 Compact I/O	1769-OW8I/B	DO	Relay (VAC/VDC)	5	8
					9	Bulletin 1769 Compact I/O	1769-OA16/A	DO	120 VAC	12	16
					10	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	6	8
					11	Bulletin 1769 Compact I/O	1769-OF8C/A	AO	4-20 mA	2	8
Manchester WWTP	LP-225	Influent pump station control panel	RIO	1	0	Bulletin 1769 Compact I/O	1769-AENTR	Ethernet Adapter	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	12	16
					2	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	9	16
					3	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	7	16
					4	Bulletin 1769 Compact I/O	1769-OW8I/B	DO	Relay (VAC/VDC)	6	8
					5	Bulletin 1769 Compact I/O	1769-OW8I/B	DO	Relay (VAC/VDC)	4	8
					6	Bulletin 1769 Compact I/O	1769-OW8I/B	DO	Relay (VAC/VDC)	0	8
					7	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	3	8
					8	Bulletin 1769 Compact I/O	1769-OF8C/A	AO	4-20 mA	3	8
Manchester WWTP	SBR-CP	Aeration basins control panel	RIO	1	0	Bulletin 1769 Compact I/O	1769-AENTR	Ethernet Adapter	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	6	16
					2	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	0	16
					3	Bulletin 1769 Compact I/O	1769-OW8I/B	DO	Relay (VAC/VDC)	3	8
					4	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	1	8
Suquamish WWTP	CP-01	Main control panel	PLC	1	0	CompactLogix 5370	1769-L33ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	8	8
					2	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	5	8
					3	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	4	4
					4	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	2	4
					5	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	1	16
					6	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	16	16
					7	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	14	16
					8	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	11	16
					9	Bulletin 1769 Compact I/O	1769-OB16/B	DO	24 VDC	4	16
Suquamish WWTP	CP-05	US Filter control panel	RIO	1	0	Bulletin 1769 Compact I/O	1769-AENTR	Ethernet Adapter	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	4	8
					2	Bulletin 1769 Compact I/O	1769-IQ32/A	DI	24 VDC	26	32
					3	Bulletin 1769 Compact I/O	1769-IQ32/A	DI	24 VDC	31	32
					4	Bulletin 1769 Compact I/O	1769-OB32/A	DO	24 VDC	32	32
					5	Bulletin 1769 Compact I/O	1769-OB32/A	DO	24 VDC	5	32
Suquamish WWTP	CP-15	Rotary drum thickener control panel	PLC	1	0	CompactLogix 5370	1769-L30ER	Controller	EtherNet/IP	N/A	N/A
					1	Bulletin 1769 Compact I/O	1769-IA16/A	DI	120 VAC	11	16
					2	Bulletin 1769 Compact I/O	1769-OW8I/B	DO	Relay (VAC/VDC)	6	8
					3	Bulletin 1769 Compact I/O	1769-IF8/A	AI	4-20 mA	3	8
					4	Bulletin 1769 Compact I/O	1769-OF4CI/A	AO	4-20 mA	4	4

TM-2: SCADA Use Cases and Operational Needs

Sewer Utility SCADA Master Plan

Kitsap County Public Works
Sewer Utility Division

April 30, 2021

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Kitsap County Public Works, Sewer Utility Division
Sewer Utility SCADA Master Plan

TM-2: SCADA Use Cases and Operational Needs

April 30, 2021

Prepared by:

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I hereby certify that the technical memorandum was prepared under my direct supervision and that I am a duly registered Engineer under the laws of the State of Washington.

Contents

Tables

Figures

Abbreviations

A	ampere(s)
AAA	authentication, authorization, and accounting
AC	alternating current
ACP	access control policy
AES	Advanced Encryption Standard
ANSI	American National Standards Institute
AOI	Add-on Instruction
AUP	acceptable use policy
BI	Business Intelligence
BNR	biological nutrient removal
BOD	biological oxygen demand
CIP	capital improvement program
CKTP	Central Kitsap Treatment Plant
CMMS	computerized maintenance management system
CMP	change management policy
CO_2	carbon dioxide
COD	chemical oxygen demand
County	Kitsap County
CTU	central telemetry unit
DHS	U.S. Department of Homeland Security
DLR	device-level ring
DO	dissolved oxygen
DMR	Discharge Monitoring Report
DMZ	demilitarized zone
DNP3	Distributed Network Protocol 3
EMS	energy management system
eO&M	electronic operation and maintenance
ERP	enterprise resource planning
ft^3	cubic foot
FVNR	full-voltage non-reversing
FVR	full-voltage reversing
GbE	gigabit(s) Ethernet
GBT	gravity-belt thickener
GE	General Electric
H_2S	hydrogen sulfide
HDR	HDR Engineering, Inc.
HIM	human interface module
HIP	Host Identity Protocol
HMI	human-machine interface
HOA	Hand-Off-Auto
HPHMI	high-performance human-machine interface
hp	horsepower
HRT	hydraulic retention time
HTML5	Hypertext Markup Language revision 5
HTTPS	Hypertext Transfer Protocol Secure
Hz	hertz
I&C	instrumentation and controls
IAPP	International Association of Privacy Professionals

ICS	industrial control system
IDE	Integrated Development Environment
IEC	International Electrotechnical Commission
IGMP	Internet Group Management Protocol
I/O	input/output
IP	Internet Protocol
IR	infrared
IS	Information Services
ISA	International Society of Automation
ISP	information security policy
IT	Information Technology
KPI	key performance indicator
KPUD	Kitsap Public Utility District
kVA	kilovolt-ampere(s)
kVAR	kilovolt-ampere(s) reactive
kW	kilowatt(s)
kWh	kilowatt-hour(s)
KWWTP	Kingston Wastewater Treatment Plant
LAN	local area network
lb	pound
LEL	lower explosive limit
LIMS	laboratory information management system
mA	milliampere(s)
Master Plan	Sewer Utility SCADA Master Plan
Mbps	megabit(s) per second
MCC	motor control center
MDM	mobile device management
MFA	multi-factor authentication
MG	million gallons
M&O	maintenance and operations
MQTT	MQ Telemetry Transport
MTU	master telemetry unit
MWWTP	Manchester Wastewater Treatment Plant
N/A	not applicable
NAAT	North American Access Technologies, Inc.
NAS	network attached storage
NEC	National Electrical Code
NIST	National Institute of Standards and Technology
OIT	operator interface terminal
O&M	operation and maintenance
OM1	Optical Multi-mode 1
OM3	Optical Multi-mode 3
OOP	object-oriented programming
OSI	Open Systems Interconnection
OT	Operational Technology
P	phosphorus
P&ID	piping and instrumentation diagram
PC	personal computer
PDU	power distribution unit
PE	population equivalent
PF	power factor
PID	proportional-integral-derivative
PLC	programmable logic controller
PNL	panel
PS	pump station

QCC	Quality Controls Corporation
QoS	Quality of Service
RACS	Raptor Acceptance Control System
RAS	return activated sludge
RDP	Remote Desktop Protocol
RDS	Remote Desktop Services
RDT	rotary-drum thickener
RIO	remote input/output
RTU	remote telemetry unit
RVSS	reduced-voltage soft starter
SaaS	software as a service
SANS	SysAdmin, Audit, Network, and Security
SBR	sequencing batch reactor
SCADA	supervisory control and data acquisition
SD	Secure Digital
Sewer Utility	Public Works Sewer Utility Division
SFP	small form-factor pluggable
SIM	subscriber identification module
SNMP	Simple Network Management Protocol
SOP	standard operating procedure
SPB	solids processing building
SRT	solids retention time
SWGR	switchgear
SWWTP	Suquamish Wastewater Treatment Plant
Syslog	System Logging Protocol
TCP	Transmission Control Protocol
THD	total harmonic distortion
TM	technical memorandum
TN	total nitrogen
TS	total solids
TSS	total suspended solids
TWAS	thickened waste activated sludge
UDT	User-defined Data Type
UPS	uninterruptible power supply
UTP	unshielded twisted pair
UV	ultraviolet
V	volt(s)
VA	volt-ampere(s)
VAC	volt(s) alternating current
VDC	volt(s) direct current
VFD	variable-frequency drive
VHF	very high frequency
VLAN	virtual local area network
VM	virtual machine
VNC	Virtual Network Computing
VPN	virtual private network
W2	potable water
W3	service water
WAN	wide-area network
WAS	waste activated sludge
WIMS	Water Information Management Solution
WWTP	wastewater treatment plant

1 Introduction

This SCADA Use Cases and Operational Needs Technical Memorandum (TM)-2 documents Kitsap County (County) Public Works Sewer Utility Division's (Sewer Utility's) core objectives for its supervisory control and data acquisition (SCADA) system along with the system functionality required to meet the organization's future operational needs. TM-2 also includes recommended improvements for the SCADA system to resolve risks and deficiencies identified in TM-1 and gaps between existing functionality and the Sewer Utility's future needs. The content of TM-2 is based on information that HDR Engineering, Inc. (HDR) obtained from the County during workshops and staff interviews and field data already collected by HDR during site assessment visits conducted in August 2020.

1.1 Approach

TM-2 completes the second phase of the Sewer Utility SCADA Master Plan (Master Plan), assessing the future use and needs of the SCADA system with recommendations on how to fulfill identified future requirements. To begin this phase of the Master Plan, HDR facilitated an industry trends and core objectives workshop to provide a high-level overview of challenges that similar water and wastewater utilities are facing, currently available technology, and industry best practices that the Sewer Utility may wish to consider for its future SCADA system. The Sewer Utility was asked to prepare a list of core objectives for its future SCADA system prior to the workshop, and the latter half of the workshop was used to discuss these objectives and further define future system requirements.

The workshop was followed by several videoconference interviews with individuals responsible for operating and maintaining the Sewer Utility infrastructure. These interviews were used to discuss Sewer Utility staff experiences with the existing SCADA system, opportunities for increased automation, and future SCADA system functionality that they would find most valuable. The interviews also covered SCADA-derived data that are important to the various stakeholders and the information that these individuals would like to have more readily accessible in the future.

1.2 Technical Memorandum Organization

This subsection describes the structure of the TM and the annotation used to emphasize risks and deficiencies and recommended improvements.

1.2.1 Structure

TM-2 is organized into 11 sections, as described below.

Section 1: Introduction summarizes TM organization and the approach taken for the second phase of the Master Plan in preparation for TM-2.

Section 2: Industry Trends and Core Objectives Workshop includes an overview of the industry trends and core objectives workshop that HDR facilitated with Sewer Utility stakeholders along with key findings from the workshop.

Section 3: Core Objectives for Future SCADA System documents the core objectives for the Sewer Utility's future SCADA system.

Section 4: Sewer Utility Staff Interviews includes an overview of the Sewer Utility staff interviews that HDR facilitated with Sewer Utility stakeholders along with key findings from these interviews.

Section 5: Network Architecture: Future Needs and Recommended Improvements identifies the Sewer Utility's future needs related to its Operational Technology (OT) network architecture and describes the information and functionality that Sewer Utility staff would like to obtain from the OT network in the future. Based on comparison of current use cases to future needs of the Sewer Utility, the section presents recommended improvements for the OT network.

Section 6: ICS Hardware: Future Needs and Recommended Improvements identifies the Sewer Utility's future needs related to its industrial control system (ICS) hardware and describes the information and functionality that Sewer Utility staff would like to obtain from the ICS hardware in the future. Based on comparison of current use cases to future needs of the Sewer Utility, the section presents recommended improvements for the ICS hardware.

Section 7: ICS Software: Future Needs and Recommended Improvements identifies the Sewer Utility's future needs related to its ICS software and describes the information and functionality that Sewer Utility staff would like to obtain from the ICS software in the future. Based on comparison of current use cases to future needs of the Sewer Utility, the section presents recommended improvements for the ICS software.

Section 8: ICS Documentation: Future Needs and Recommended Improvements identifies the Sewer Utility's future needs related to its ICS documentation and describes the information that Sewer Utility staff would like to develop and maintain. Based on comparison of current use cases to future needs of the Sewer Utility, the section presents recommended improvements for ICS documentation.

Section 9: Other Software Packages: Future Needs and Recommended Improvements identifies the Sewer Utility's future needs related to non-ICS software packages and describes the information and functionality that Sewer Utility staff would like to obtain from the software in the future. Based on comparison of current use cases to future needs of the Sewer Utility, the section presents recommended improvements for non-ICS software.

Section 10: Risks and Deficiencies with Recommended Improvements Summary compiles the risks and deficiencies associated with the Sewer Utility's OT networks, SCADA system components, and associated infrastructure that were identified in TM-1 and previous sections of TM-2 and pairs them with the recommended improvement(s) that will mitigate the risk or resolve the deficiency.

Section 11: References lists the supporting source materials cited in TM-2.

1.2.2 Means of Emphasis

In any subsection where a risk or deficiency is identified, a summary risk or deficiency description is presented at the end of that subsection, as shown below, so that these risks and deficiencies are easily visible and can be quickly located.

> ✸ Identified risks and deficiencies are shown in condensed highlighted form like this throughout the TM.

In any subsection where a recommended improvement is proposed that will address one or more identified risks and deficiencies, a summary recommended improvement description is presented at the end of that subsection, as shown below, so that these recommended improvements are easily visible and can be quickly located.

> ✪ Recommended improvements are shown in condensed highlighted form like this throughout the TM.

Risks and deficiencies from TM-1 and TM-2 and the proposed recommended improvements are compiled in Section 10 in Table 10-2. The table is structured to associate the risks and deficiencies with the recommended improvements being proposed as a means of mitigating them.

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2 Industry Trends and Core Objectives Workshop

This section includes an overview of the industry trends and core objectives workshop that HDR facilitated with Sewer Utility stakeholders along with key findings from the workshop.

On November 16, 2020, HDR facilitated an industry trends and core objectives workshop with key stakeholders representing Sewer Utility management, operations, instrumentation and controls (I&C) technicians, and construction management. The goal of the workshop was to present currently available technology, applicable industry best practices, and modern approaches to SCADA system development and utility management for the Sewer Utility to consider before the SCADA master planning effort shifted to discussions that would document the future requirements of the SCADA system. The workshop was then used to discuss the Sewer Utility's core objectives for its SCADA system and further define some of the future requirements. The Sewer Utility capital improvement program (CIP) schedule was also discussed to identify established CIP projects where there may be an opportunity to implement recommended SCADA system improvements. Key presentation points from the workshop are highlighted in the following subsections.

2.1 Industry Challenges

The water and wastewater industry faces significant challenges including aging assets, budget constraints, stricter regulations, a workforce gap, and cybersecurity. Utilities with older programmable logic controller (PLC) technology now depend on systems that have reached the end of their useful life and/or are experiencing manufacturers phasing out technical support and replacement parts for the product line. Product life cycles for several ICS hardware and software elements are becoming shorter, requiring more frequent upgrades. The industry's migration to Internet Protocol (IP)-based networks and open operating systems (i.e., Windows) has introduced new cybersecurity risks and new skill-set requirements to mitigate them. Available technology promises to provide great value, but it is often complex and rapidly evolving. Many utilities are finding that they do not have enough staff with the necessary skill sets to keep up with current technology and address cybersecurity while continuing to operate and maintain the utility infrastructure.

To put new technology to work and modernize their control systems, utilities are also having to revisit their approach to data. Many utilities are data rich and information poor. Data are commonly trapped in silos that are difficult to access and that present barriers to combining diverse data sets to pursue the operational insights that will help the Sewer Utility improve. In the interest of raising current operational baselines, many utilities are pausing to look beyond more immediate needs so as to develop a road map toward an improved data program.

2.2 Current Technology

HDR presented a selection of current technology for the Sewer Utility to consider as potential elements for its future SCADA system. Because the Sewer Utility has already standardized on Allen-Bradley PLCs and Wonderware (now called AVEVA) HMI and historian software, the workshop highlighted current offerings from Rockwell Automation and AVEVA in addition to other relevant hardware and software technology. Some of these current offerings included:

- Allen-Bradley's latest ControlLogix 5580 and CompactLogix 5380 controller families
- Software elements of AVEVA System Platform 2020
- Motor controllers with Ethernet communication capability and their role in energy management and predictive maintenance programs
- Remote sensor solutions for conveyance applications
- Data analytics and visualization software platforms
- Offline and online applications of wastewater treatment plant (WWTP) models to derive operational set points

To demonstrate how data analytics and visualization software tools can combine diverse data sets to produce insightful visualizations, HDR presented two dashboards it developed using Sewer Utility historian and laboratory data obtained during the condition assessment phase of the Master Plan. Screen captures of the two dashboards are shown in Figure 2-1 and Figure 2-2. It should be noted that HDR made some broad assumptions to generate the liquid stream capacity summary portion of the dashboard depicted in Figure 2-1. The focus of the workshop's dashboard presentation was not about identifying actual process or operational deficiencies, but to provide Sewer Utility staff with the opportunity to see data analytics and visualization software in action and, hopefully, to spark some ideas for other insights staff would like to pursue in the future.

Figure 2-1. CKTP liquid stream and solids removal summary dashboard

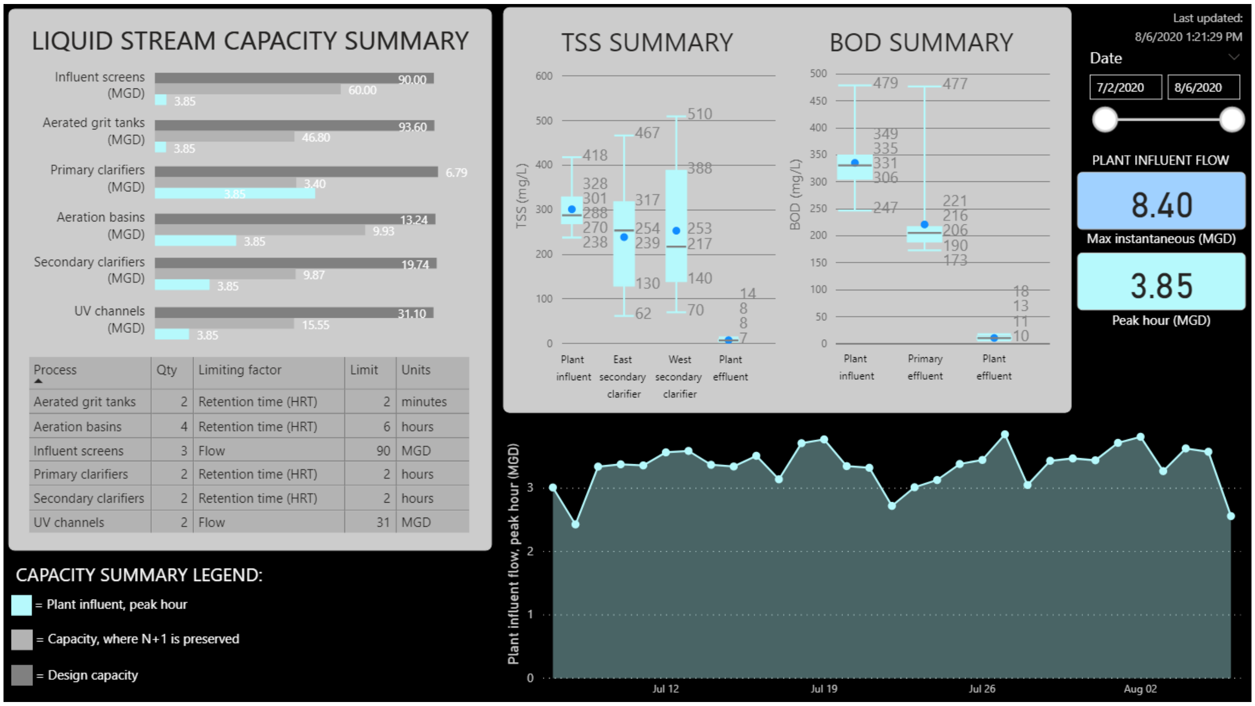
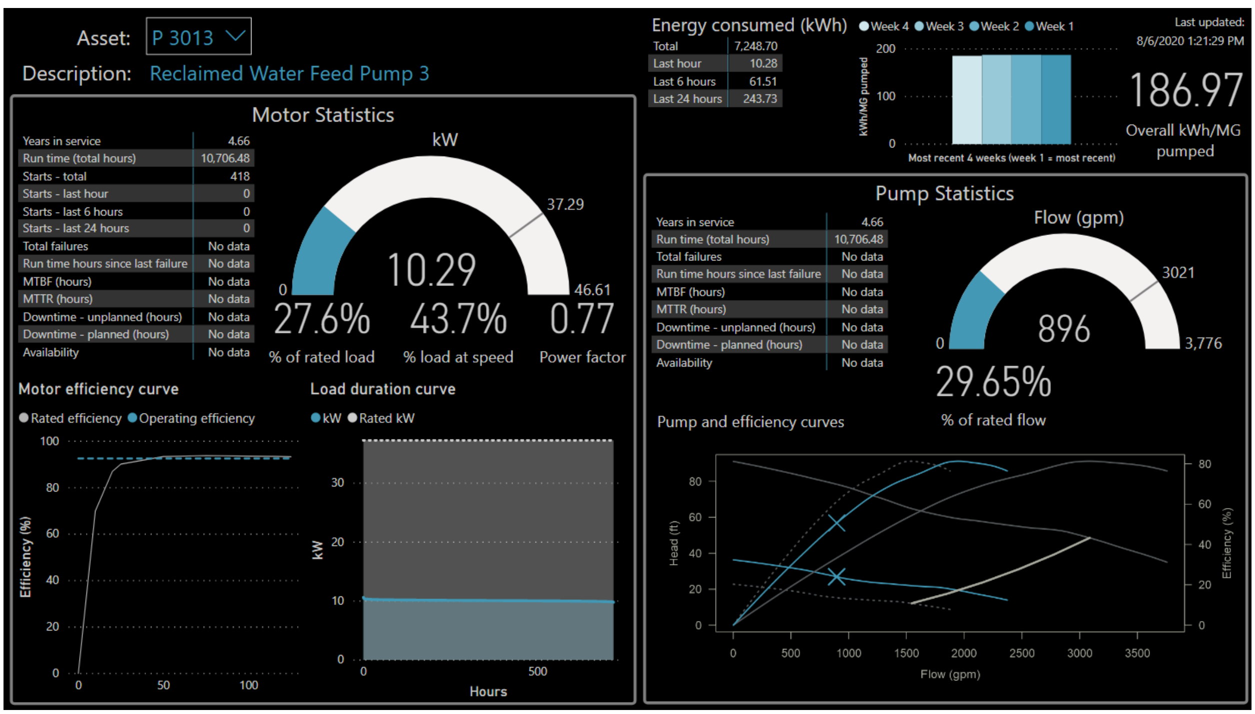


Figure 2-2. Pump asset health and performance dashboard



2.3 Best Practices

The best practices segment of the workshop focused on some of the approaches other utilities have taken to improve their operations that are considered industry best practices and would likely benefit the Sewer Utility. HDR discussed high-performance human-machine interface (HPHMI) principles that are guiding human-machine interface (HMI) screen development throughout much of the industry and have been integrated into industry standards like International Society of Automation (ISA) 101.01 (ANSI/ISA 2015). Examples of HPHMI concepts and how they have been applied to HMI platforms at other client facilities were presented in a before-and-after fashion to illustrate the migration from traditional to HPHMI screens. HDR emphasized the benefits of virtualization for ICS servers and presented an industrial demilitarized zone (DMZ) network architecture as a secure method for bridging the Sewer Utility Operational Technology (OT) and Information Technology (IT) networks. HDR also described how store-and-forward and report-by-exception functionality inherent to communication protocols like Distributed Network Protocol 3 (DNP3) and MQ Telemetry Transport (MQTT) could eliminate data gaps and reduce delays in alarm reporting for the Sewer Utility's remote pump stations.

2.4 Core Objectives for Future SCADA System

Prior to the workshop, the Sewer Utility provided HDR with a draft list of core objectives for its future SCADA system. These core objectives were discussed during the workshop to allow Sewer Utility staff to describe some of the drivers behind the objectives in more detail. The workshop participants also discussed various operational constraints and requirements in order to develop quantitative goals for certain elements of the future system, such as uninterruptible power supply (UPS) battery backup time requirements. Discussing the objectives also allowed the Sewer Utility to make some preliminary decisions on how certain technologies would be applied. For example, Sewer Utility staff concluded that they would like to migrate toward HPHMI graphics screens and standardize on Ethernet motor controllers, using hardwiring for the core control and monitoring signals and Ethernet data exchange for power and energy parameters and detailed alarm and warning information.

2.5 CIP Schedule and Budget Constraints/Opportunities

In an effort to identify projects in the CIP schedule that may be candidates for implementing some of the improvements recommended in the Master Plan, HDR walked through several pump station and WWTP projects included in Sewer Utility planning documents. Sewer Utility staff provided project status updates and, based on staff feedback, the Sewer Utility Six-Year Capital Facilities Plan 2020–2025 was determined to be the most relevant planning document (Sewer Utility 2019). Of the established projects at remote pump stations, the pump station upgrade planned for pump station (PS)-4 was determined to be a good candidate for a pilot project or first-out initiative for the remote pump station ICS infrastructure given the project's position in the CIP schedule.

2.6 Workshop Findings

Key findings that came out of the industry trends and core objectives workshop helped establish some of the requirements for the future Sewer Utility SCADA system. Some of these findings re-emphasized risks and deficiencies documented in TM-1. Table 2-1 provides a summary of the industry trends and core objectives workshop findings.

Table 2-1. Industry trends and core objectives workshop findings summary

Topic	Findings
Staff technological proficiency	Advancing the Sewer Utility's ICS technology without improving the current level of technological proficiency among Sewer Utility staff members is not likely to be successful. Staff will require training on new and existing technology. Documenting preferred workflows and standard operating procedures (SOPs) for the ICS technology that staff interact with would help supplement the training and provide staff with a self-service resource when they need a refresher.
	The Master Plan should identify two tiers of training for Sewer Utility staff: in-depth training for super-users like I&C technicians, and basic training for end users of technology.
Motor controllers	The Sewer Utility would like to standardize on Ethernet motor controllers for future projects. The Sewer Utility is interested in expanding the current practice of monitoring and archiving limited data from networked motor controllers to include more robust power, energy, alarm, and warning data. Hardwired signals will still be used for the core monitoring and control of the equipment.
	The Sewer Utility wants to eliminate DeviceNet from its infrastructure.
PLCs	The Sewer Utility does not believe that there are sufficient drivers at its facilities to justify the expense and additional complexity of hot-standby redundant controllers.
Historian	Quality Controls Corporation (QCC) will be implementing store-and-forward functionality as part of the AVEVA upgrades it is performing at the Sewer Utility remote WWTPs. This will allow the AVEVA software at the remote WWTPs to buffer data during loss of communications with the Central Kitsap Treatment Plant (CKTP) and forward the buffered data to the CKTP historian after communications are restored.
	QCC will be installing AVEVA Historian Client at the Sewer Utility WWTPs to provide staff with easier static and ad hoc trending functionality and improved access to historian data.
HPHMI	The Sewer Utility anticipates some resistance to HPHMI graphics screens from some veteran staff members but would like the Master Plan to include a migration to HPHMI concepts for the future Sewer Utility SCADA screens.
	HDR recommended that the Sewer Utility and QCC hold workshops with Sewer Utility stakeholders to develop standard color palette, symbols, color usage, screen hierarchy and layout, and other elements of the future SCADA graphics. This will help get stakeholder buy-in during the development process and guide QCC according to Sewer Utility preferences. The Sewer Utility is planning to have the first workshop with QCC in Q1 2021.
Industrial DMZ	The Sewer Utility would like the Master Plan to include an industrial DMZ approach to bridging the OT and IT networks.
	Once the Master Plan is complete, the Sewer Utility will have documentation that it can use to coordinate with the County Information Services (IS) department about required modifications to IS-managed infrastructure. Because of this coordination requirement, the County may need to find temporary solutions for remote access and other functionality through additional development of the Sewer Utility OT network.
OT network cable path redundancy	The Sewer Utility does not view network cable path redundancy as an immediate need for its WWTP OT networks, but would like it to be considered as a mid-term priority in the Master Plan.
Alarm notification system	The Sewer Utility's order of preference for on-call staff alarm notification and acknowledgment is: mobile app interface (e.g., WIN-911 Mobile), text message, and voice message.

Table 2-1. Industry trends and core objectives workshop findings summary

Topic	Findings
Sewer Utility ICS standards	The Sewer Utility would like to develop ICS standards documentation that could be handed to consultants and systems integrators to guide design and implementation. The standards would be required to be referenced in consultant specifications so that they become part of the contractor's scope.
	Sewer Utility ICS standards should include tagging conventions. Staff are challenged by lack of standard tagging conventions in existing programming.
ICS battery backup requirements	Minimum of 15 minutes for PLC control panels at CKTP.
	Minimum of 4–6 hours for CKTP ICS infrastructure required to maintain monitoring of remote pump stations and WWTPs and on-call staff alarm notification functionality.
	Minimum of 4–6 hours for ICS infrastructure at remote WWTPs that is required to maintain communication of active alarms to CKTP.
	Several hours for ICS infrastructure at critical pump stations that is required to maintain communication of wet well level and active alarms to CKTP.
	Battery backup times at less critical pump stations are not a priority for the Sewer Utility.
Remote access to SCADA screens	For the remote pump stations, the Sewer Utility would like to establish view-only remote monitoring and alarming via tablets, with the possibility of introducing control capability in the future.
	For the WWTPs, the Sewer Utility would like to establish remote monitoring and alarming via tablets, with limited control capability on a case-by-case basis.
	The Sewer Utility would like staff at all four WWTPs to have access to all Sewer Utility SCADA screens from the HMI workstations.
	The Sewer Utility would like to establish view-only monitoring and alarming of all Sewer Utility infrastructure at the County Public Works Annex facility in Bremerton.
Backup ICS servers	The Sewer Utility would like the Master Plan to consider implementing backup ICS server(s) at the County Public Works Annex facility.
Processes with high priority for automation/ICS improvements	The Sewer Utility indicated that the following processes and facilities were a higher priority for automation and/or ICS upgrades: • Biological nutrient removal (BNR) processes • CKTP septage receiving • CKTP digesters • The Suquamish WWTP, in general, because of highly manual operation • CKTP liquid balancing • CKTP solids balancing • CKTP recycled water
Alignment of Master Plan implementation plan and CIP schedule	The PS-4 upgrade project in the Sewer Utility CIP would be a good candidate for a pilot project or first-out initiative for the remote pump station ICS infrastructure.

3 Core Objectives for Future SCADA System

This section documents the core objectives for the Sewer Utility's future SCADA system. These core objectives will guide the remainder of the SCADA master planning efforts and serve as a benchmark for follow-on implementation work.

3.1 Core Objectives Development

HDR requested that the Sewer Utility develop draft core objectives for its future SCADA system prior to the industry trends and core objectives workshop. The draft core objectives were discussed during the workshop and the Sewer Utility had the opportunity to refine them based on the workshop discussion and subsequent stakeholder interviews.

3.2 Core Objectives for Future SCADA System

The Sewer Utility's core objectives for its future SCADA system are listed below:

1. *Design, build, and maintain a secure and stable ICS*
    - 1.1. *Continue development of the Sewer Utility industrial network*
    - 1.2. *Upgrade Wonderware and alarm monitoring/dial-out software*
    - 1.3. *Develop standards and naming conventions and reflect in future specifications*
    - 1.4. *Identify control power backup system requirements*

2. *Improve access to and use of SCADA*
    - 2.1. *Provide stable remote access to SCADA from all treatment plants and Public Works Annex*
    - 2.2. *Standardize HMI and alarm screens—programming object and visualizations*
    - 2.3. *Make improvements to SCADA Historian including:*
        - 2.3.1. *Backup procedures, tag identification and hierarchy, operator access to trending features*
        - 2.3.2. *Integration with business and operating software platforms (i.e., Hach WIMS, CMMS, and other Business Intelligence platforms)*
    - 2.4. *Implement use of SCADA remote tablets for unattended monitoring of plants and pump stations*

3. *Develop an Automation and Information Technology Plan*
    - 3.1. *Develop pump station (and WWTP) monitoring and control strategy: improved monitoring in the short term with potential control capability in the long term*
    - 3.2. *Identify near-term and long-term automation improvements to maintain treatment process control and/or provide operational resilience*
    - 3.3. *Incorporate energy monitoring software/hardware to support Strategic Energy Management Plan*
    - 3.4. *Identify opportunities to improve regulatory compliance monitoring*
    - 3.5. *Identify workgroup dashboards*

4. *Develop administrative program for maintaining Sewer Utility ICS*

4.1. Staffing to support to include skill sets/abilities, roles, and responsibilities
4.2. Develop backup procedures for server information, programming files, etc.
4.3. Implement Alarm Management Philosophy procedures
4.4. Develop procedures for firmware management

4 Sewer Utility Staff Interviews

This section includes an overview of the Sewer Utility staff interviews that HDR facilitated with Sewer Utility stakeholders along with key findings from these interviews.

4.1 Operations Staff Interview

On November 24, 2020, HDR held an interview with Sewer Utility operations staff members to discuss their current interaction with SCADA HMI screens, known ICS deficiencies, and features and functionality that they would like to see implemented in the future SCADA system. Table 4-1 provides a summary of the key findings from the interview.

Table 4-1. Operations staff interview key findings summary

Topic	Findings
Lack of process flow measurement	Manchester Wastewater Treatment Plant (MWWTP) does not have a flowmeter for monitoring waste activated sludge (WAS) flow to the WAS tanks. Operations staff currently operate based on level in the WAS tanks and would prefer to have WAS flow information like they do at Kingston Wastewater Treatment Plant (KWWTP) and CKTP.
	None of the remote WWTPs have a flowmeter for monitoring thickened sludge flow during truck loadout activities. Lack of flow/volume measurement has led to issues where truck operators stop loading too early to avoid drawing down the thickened sludge storage tanks too far. Operating off of level or sight glass has proved challenging, particularly at the Suquamish Wastewater Treatment Plant (SWWTP), where the thickened sludge blending tank has a conical bottom. The Sewer Utility is basing CKTP incoming thickened sludge volumes from the remote WWTPs based on the assumption of full truckloads and is likely overestimating volumes if trucks are partially full.
Analytical probes for MWWTP and SWWTP	Sewer Utility operations staff expressed a desire to reintroduce analytical probes to the basins at MWWTP and SWWTP. These instruments would reduce the amount of manual probe measurements required by operations staff and would enable more automated control of the process. Lack of analytical instruments for these WWTPs was identified as a deficiency in TM-1.
Alarms	SWWTP recently had an issue where a PLC went offline and there was no alarm to alert operators that SCADA HMI screens were not being refreshed. Sewer Utility staff believe that this issue has since been corrected but believe that other WWTPs may not be receiving communication alarms for PLCs.
	Sewer Utility operations staff believe that they are not receiving signal out-of-range alarms at SCADA HMI screens for lost analog signals from some field instruments. An event occurred at MWWTP where the influent pump station level continued to report a static normal wet well level, but the wet well was actually much higher, and a manual pump down had to be initiated.
	No alarms are in place for composite samplers at all WWTPs. Power bumps have thrown off sampler performance and operators are not notified that there is a problem.
	Sewer Utility operations staff report that power bumps also cause some variable-frequency drives (VFDs) to go into an alarm state and, when VFD faults are not monitored at SCADA, operators are not notified of the problem.

Table 4-1. Operations staff interview key findings summary

Topic	Findings
	Power bumps can cause the MWWTP mixing channel blower to go into an alarm state that is indicated only locally. Operators have to regularly enter the building on their rounds to confirm that the alarm is not active.
	Sewer Utility operations staff believe that the high level alarm for MWWTP waste tanks is set at a level where both tanks need to be nearly full before the alarm activates. A baffle at roughly 9 feet is below this alarm set point. Once the level in the first waste tank exceeds baffle height, the process spills into the second tank. Operators would like to receive a warning when level reaches or nears this baffle height so that they are alerted when the second tank begins to fill. HDR reviewed SCADA HMI screens and it appears that the WAS tank high level alarm set points can be adjusted as desired via the HMI.
Improved automation	The MWWTP blowers are constant speed and operate on a fixed time sequence where they run in a 4-hour sequence, 5 days per week. During power bumps, this time sequence can be disrupted and operators have to manually place blowers in auto at noon to restore the sequence. Operations staff would like to have operator-adjustable scheduling and timer functionality at the SCADA HMI so that they could have more flexibility in operating the blowers. Operators would also like to see the constant-speed blowers changed to variable speed, which will likely happen as part of the upgrade to the plant for new total nitrogen (TN) limits.
	MWWTP is the only remote plant that does not have a SCADA-controlled sludge wasting valve. Sludge wasting is still a manual process and operators would like it to be automated.
Additional information at SCADA HMI screens	Sewer Utility operations staff would like to have more detailed information on ultraviolet (UV) systems available at the HMIs for all plants. They would like to see which bulbs are failed, UV intensities, and other parameters to help them better monitor system performance.
	Sewer Utility operations staff indicated that they would find more detailed information and alarming from vendor systems and motor controllers useful if it were made available at the HMI screens.
	Sewer Utility operations supervisors indicated that they would be very interested in monitoring process key performance indicators (KPIs) like hydraulic retention time (HRT) and solids retention time (SRT) at the SCADA HMI screens—particularly for aeration basins and clarifiers.
	In addition to alarming for composite sampler faults at the SCADA HMIs, Sewer Utility operations staff would like to be able to monitor sample counts and when samples are being taken.
CKTP control room upgrade	Sewer Utility operations staff would like to be able to see the same SCADA HMI screens that are at the remote WWTPs from the CKTP control room.
	Sewer Utility operations staff would like to have large-format displays at the CKTP control room where they can see overview screens at a glance.
Reporting	Current reporting methodology is to manually enter flow data into Excel spreadsheets to give to the lab for Discharge Monitoring Report (DMR) reporting.
	Sewer Utility operations staff indicated that having these flow data and laboratory data available in one pane of glass would be useful. They believe that Hach Water Information Management Solution (WIMS) software will provide this functionality.

- MWWTP does not have a flowmeter for monitoring WAS flow to the WAS tanks.
- The Sewer Utility is likely overestimating the thickened sludge volumes received at CKTP from remote WWTPs because none of the remote WWTPs have a flowmeter for monitoring thickened sludge flow during truck loadout activities.
- PLC status monitoring and alarming may not be effectively applied for all WWTP PLCs.
- Sewer Utility operations staff believe that they are not receiving signal out-of-range alarms at SCADA HMI screens for lost analog signals from some field instruments.
- There are no SCADA alarms or monitoring in place for composite samplers at all WWTPs.
- Some WWTP VFDs do not have VFD fault alarms monitored at SCADA.
- MWWTP headworks mixing channel blower fault is not monitored at SCADA.
- Operators have no means of managing the MWWTP blower operating time sequence via the SCADA HMI screens.
- MWWTP lacks SCADA control for the sludge wasting valve so the sludge wasting process is entirely manual.
- Sewer Utility operations staff would like to have more detailed information on UV systems available at the HMIs for all plants.

4.2 I&C Technician Staff Interview

On November 25, 2020, HDR held an interview with Sewer Utility I&C technician staff to discuss known ICS deficiencies, current challenges, and features and functionality that they would like to see implemented in the future SCADA system. Table 4-2 provides a summary of the key findings from the interview.

Table 4-2. I&C technician staff interview key findings summary

Topic	Findings
High-priority improvements	I&C technicians consider the following items to be high priorities for near-term improvements to the Sewer Utility ICS: • Implement HPHMI graphics concepts at WWTP SCADA screens • Standardize on PLC firmware versioning throughout WWTPs and pump stations • Improve remote pump station telemetry • Eliminate DeviceNet networks, with the CKTP headworks motor control centers (MCCs) being a high priority because of multiple past maintenance events

Table 4-2. I&C technician staff interview key findings summary

Topic	Findings
Tag naming convention	The Sewer Utility needs a standardized tag naming convention for the AVEVA SCADA system. I&C technicians like descriptive tags because the association to actual equipment is more obvious. Including equipment tags in the SCADA tag has value in maintaining a link to the piping and instrumentation diagrams (P&IDs). A facility code will also need to be included in the SCADA tags to support integration of tags from all WWTPs. The Sewer Utility intends to develop a preferred tag naming convention internally and in coordination with QCC.
SCADA thin clients	The Sewer Utility has decided to transition to SCADA HMI thin client configuration for panel personal computers (PCs) in the electrical rooms at CKTP. Preservation of local HMI functionality during an OT network outage was discussed, and the Sewer Utility is comfortable running the plant in manual without SCADA HMIs and believes that the benefits of centralized SCADA management outweigh the ability to preserve limited local control during OT network outages.
In-house automation programming capabilities	As mentioned in TM-1, the SCADA system is currently monitoring significantly more tags than the historian is archiving. If possible, the Sewer Utility would like to handle adding select currently available tags to the historian. I&C technicians indicated that they may need some training to get them started down the right path.
	I&C technicians are less comfortable making PLC programming and HMI configuration changes to incorporate additional alarms or standardize input/output (I/O) for different assets. This work may be done in-house as a mid-term project once more training has been provided.
ICS set point management	I&C technicians would like the ability to track ICS set point changes made at the SCADA HMI and know when changes were made and by whom.
	I&C technicians would like to have appropriate set points documented somewhere so that the Sewer Utility had an authoritative document to help manage set point drift.
Training and staffing	Sewer Utility staff will require training to support the modernization of the Sewer Utility ICS and OT network. Some of the required training will be focused on improving operations staff proficiency with Windows and general technology elements, which will hopefully reduce the amount of IT help desk type issues that I&C technicians are required to respond to. Other identified training will be centered around I&C technicians, including: • Network technology and communications • Network management • AVEVA software training
	The Sewer Utility has had difficulty sourcing I&C technicians and may need to consider grooming younger operations staff who demonstrate an interest in ICS technology.
	It is likely that the Sewer Utility will eventually require a more senior resource with network experience to manage the Sewer Utility OT network.
Instrument calibration	The laboratory staff currently provides preventive maintenance on analytical instruments at the WWTPs.
	Sewer Utility preference is to keep instrument calibration responsibilities under operations and/or laboratory staff. This will leave I&C technicians free to focus on other tasks for which they have unique skill sets.

> ✸ The Sewer Utility needs a standardized tag naming convention for the AVEVA SCADA system.

4.3 Construction and CIP Staff Interview

On December 3, 2020, HDR held an interview with Sewer Utility construction and CIP staff to discuss the need for Sewer Utility ICS standards, current state of control strategy documentation, and features and functionality that they would like to see implemented in the future SCADA system. Table 4-3 provides a summary of the key findings from the interview.

Table 4-3. Construction and CIP staff interview key findings summary

Topic	Findings
Sewer Utility ICS standards	Lack of Sewer Utility ICS standards has contributed to one-off implementations and recent project shortcomings. This deficiency was documented in TM-1.
	The Sewer Utility would prefer to include development of ICS standards documentation as an amendment to ongoing facilities planning efforts rather than executing a separate project.
	The Sewer Utility and QCC have scheduled workshops for January to begin fleshing out requirements for HPHMI screen development. These workshops will be the first step toward standardization of Sewer Utility SCADA HMI screens.
	Once Sewer Utility ICS standards documentation is developed, the Sewer Utility would like to establish annual reviews of the standards documentation and ICS infrastructure to keep the standards current and to identify upcoming ICS upgrade/replacement projects that need to be included in CIP planning. Monitoring for hardware and software obsolescence should be a factor in these periodic reviews.
Control strategies	In general, the Sewer Utility lacks good control strategy documentation that reflects current ICS implementation. This deficiency was documented in TM-1.
	Some documentation from recent construction projects could be used as a starting point. Some past design projects have control strategies in the design specifications, but these are unlikely to have been updated based on programming implemented during construction phases.

4.4 Laboratory Staff Interview

On December 3, 2020, HDR held an interview with Sewer Utility laboratory staff to discuss their current use of SCADA data, known ICS deficiencies, and features and functionality that they would like to see implemented in the future SCADA system. Table 4-4 provides a summary of the key findings from the interview.

Table 4-4. Laboratory staff interview key findings summary

Topic	Findings
Access to SCADA system for laboratory staff	Laboratory staff currently have no access to SCADA HMI screens or historical SCADA data.
	Sewer Utility operations staff enter daily WWTP flow data into Excel spreadsheets and transfer to laboratory staff via email or thumb drive.

Table 4-4. Laboratory staff interview key findings summary

Topic	Findings
	Laboratory staff would like to know what mode the WWTPs are running in. Without access to SCADA HMI screens, laboratory staff rely on operators to inform them when CKTP transitions from winter to summer operations.
	Sewer Utility staff would like to implement read-only access to SCADA HMI screens for all WWTPs at the laboratory. One or more large-format displays would be helpful in providing laboratory staff with an at-a-glance view of operating conditions and alarms for all WWTPs.
Current and future SCADA data needs at the laboratory and additional instrumentation	Flow data are and will continue to be very important information for the laboratory. The following are some of the higher-priority WWTP flow data identified: • Influent and effluent flows are required for DMR reporting • Thickened sludge flows • Blended sludge tank flows • Scum pump flows • Flow to CKTP sand filters • Flow from CKTP recycled water system • Flow from potable water (W2)/service water (W3) pumps
	Laboratory staff would also like to receive data from analytical instruments, including: • Primary parameter: dissolved oxygen (DO), pH, ammonia, nitrate, nitrite, etc. • In addition to analog values from the probes, laboratory staff would like low and high alarms, as well as calibration and out-of-range alarms • Turbidity on CKTP reclaimed water from existing turbidimeter
	KWWTP and MWWTP currently have pH probes and data may be logged on Secure Digital (SD) cards. Integrating analog inputs from these probes to SCADA would be beneficial.
	UV transmittance data would be very beneficial for laboratory staff so that they do not need to manually obtain data.
	Laboratory staff would like to have alarms and other data from composite samplers. Laboratory staff need to know when samplers fail.
	For WWTP solid stream, flows are the most important data but gas production and carbon dioxide (CO_2) percentages could also be helpful down the road.
	Suspended solids probes in the aeration basins and return activated sludge (RAS) lines would be beneficial to the laboratory for SRT calculations and other uses.
	The Sewer Utility would like to be able to record the volume for thickened sludge that is transported from the remote WWTPs to CKTP. Currently, the Sewer Utility assumes full truck volumes, but this may not be the case. If flowmeters were installed on truck loadout stations, volume could be calculated via the flowmeter and recorded, allowing for tracking of more accurate volumes.
	The Sewer Utility would like to have a septage receiving station that records incoming septage flows. Currently, the Sewer Utility bases incoming septage volume on truck weight.
Composite samplers	The existing composite samplers at the WWTPs are reaching the end of their useful life and replacement parts are becoming unavailable. The Sewer Utility is in the process of getting quotes for samplers that they believe will be less maintenance intensive.

✸ Laboratory staff currently have no access to SCADA HMI screens or historical SCADA data.

4.5 Maintenance Staff Interview

On December 10, 2020, HDR held an interview with Sewer Utility maintenance staff to discuss their current use of SCADA HMI screens, current and planned use of the LLumin computerized maintenance management system (CMMS), potential SCADA integration with LLumin, future predictive maintenance efforts, and features and functionality that they would like to see implemented in the future SCADA system. Table 4-5 provides a summary of the key findings from the interview.

Table 4-5. Maintenance staff interview key findings summary

Topic	Findings
Maintenance staff current interaction with SCADA HMI screens	The Public Works Facilities crew already monitors pump station SCADA screens remotely, mainly for alarms.
	The Sewer Utility maintenance and operations (M&O) supervisor and CMMS manager each have a SCADA PC at their desks. The CMMS manager currently handles monitoring of alarms and communicating alarms to maintenance and facilities staff. SCADA alarm monitoring and response coordination duties will eventually be transitioned to an individual within the Public Works Facilities crew.
Current preventive and corrective maintenance practices	Staff still fill out paper-based malfunction reports, which are then manually entered into LLumin.
	Equipment runtimes are manually collected and entered into LLumin.
	LLumin is cloud-hosted software as a service (SaaS) and maintenance staff are currently accessing via tablets, mobile phones, and PCs.
Remaining implementation effort and future goals for LLumin system	The first step is to complete development of an accurate active inventory of Sewer Utility assets within LLumin. The Sewer Utility is implementing an asset hierarchy using a parent-child relationship.
	Sewer Utility maintenance staff would like to migrate from calendar-based preventive maintenance to automated scheduling for preventive maintenance based on equipment runtimes.
	Sewer Utility staff would like to explore integrating SCADA alarms related to maintenance activity into LLumin, so that corrective maintenance work orders could be automated rather than having to rely on word-of-mouth.
	Sewer Utility staff would like to start using LLumin performance dashboards to forecast maintenance requirements, trend asset performance, and display uptime/availability statistics for assets.
	Sewer Utility staff would like to see maintenance staff start entering in log data for maintenance activity into the work orders in LLumin so that other staff can keep abreast of status and findings. This functionality is already built into LLumin.
	Sewer Utility staff would also like to start using the inventory management functionality within LLumin to manage spare-parts inventory.
SCADA integration with LLumin	The Sewer Utility has already purchased the SCADA integration module for LLumin, but has not deployed it because of County IS department challenges and security concerns. This lack of SCADA integration has prevented the Sewer Utility from leveraging many of LLumin's advanced features.
Future predictive maintenance use cases	The Sewer Utility does not currently have staff for a full-fledged predictive maintenance program, including oil sample analysis.
	Sewer Utility staff are interested in force main pressure monitoring as a predictive maintenance input in the future.

Table 4-5. Maintenance staff interview key findings summary

Topic	Findings
	Future predictive maintenance initiatives would begin with the most critical assets. Also, the cogeneration system at CKTP, if the Sewer Utility is required to bring that system back online someday.
Dashboarding and data visualization	Sewer Utility management staff would like to have a heat map dedicated to each of the four drainages and the WWTPs and pump stations associated with them. These heat maps would provide an at-a-glance, color-based indication of capacity and current maintenance issues. For example, a lead/lag pump station that is down one pump might be displayed in yellow, while a station that is offline for maintenance might be displayed in red.
	Discussed how dashboarding/data visualization software tool may be the best option for customizing heat maps and visualizations for runtimes, availability, and other asset performance data. This would enable more flexibility and control over the outcome. • LLumin may be able to offer some valuable visualizations, but will likely not meet all of the Sewer Utility's needs • It would be expensive and more difficult for Sewer Utility staff to maintain if visualizations were done in SCADA • Hach WIMS is not likely to have much native functionality to support this type of content
Future SCADA access requirements for maintenance staff	The CMMS manager will not require access to SCADA HMI screens after alarm monitoring and response coordination duties are transitioned to Public Works Facilities staff.
	The Sewer Utility M&O supervisor will still require a SCADA PC in his office.
	There should be a common SCADA PC in the new modular offices that will be shared by various staff.
	The Sewer Utility operations manager does not need a SCADA PC in his office and could use one in a common area within the administration and laboratory building at CKTP.
	The lead mechanic specialist at CKTP and the lead maintenance technician in the Public Works Facilities group responsible for Sewer Utility infrastructure will both need SCADA PCs.

✸ Equipment runtimes are manually collected and entered into Sewer Utility CMMS.

4.6 Public Works Management and Stormwater Division Staff Interview

On December 10, 2020, HDR held an interview with Public Works management and Stormwater Division staff to provide a project status update, share some of the technology presented in the industry trends and core objectives workshop that may be of interest to the Stormwater Division, and discuss information that management staff would find valuable if SCADA data were made more readily available. Table 4-6 provides a summary of the key findings from the interview.

Table 4-6. Public Works management and Stormwater Division staff interview key findings summary

Topic	Findings
Management access to SCADA data	Sewer Utility management staff would like to have access to real-time flow data and other engineering-focused data.
	Sewer Utility management staff would be interested in getting email notifications when certain parameters exceed or fall below set thresholds.
	Public Works management staff would be very interested in integrating financial data with SCADA and other data sets. Having financially based metrics for forecasting operating costs would be a big benefit.
Remote field instrumentation and telemetry for Stormwater Division	Stormwater Division staff are interested in further discussions of how they might implement field instrumentation monitoring.
Current Sewer Utility management dashboarding and visualization practices	Sewer Utility management currently uses dashboards native to ArcGIS software.
Other potential data unification use cases at Public Works	Public Works management discussed how integrating customer metering into SCADA infrastructure or other County-maintained networks would eliminate manual data collection for meter readings.
Public Works ERP software	Public Works will be implementing Workday ERP for its enterprise resource planning (ERP) software most likely in late summer 2021. The Workday ERP system would be the source for Sewer Utility financial data.

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5 Network Architecture: Future Needs and Recommended Improvements

This section identifies the Sewer Utility's future needs related to its OT network architecture and describes the information and functionality that Sewer Utility staff would like to obtain from the OT network in the future. The future needs presented are derived from information obtained from Sewer Utility staff during site assessment visits, workshops, and staff interviews. Based on comparison of current use cases to future needs of the Sewer Utility, the section presents recommended improvements for the OT network.

5.1 Future Needs

This subsection describes the Sewer Utility's future needs as they relate to the OT network.

5.1.1 Central Monitoring Location for Sewer Utility Pump Stations and WWTPs

The Sewer Utility wants to establish a central monitoring location at the Central Kitsap Treatment Plant (CKTP) where staff can monitor all conveyance system pump stations and WWTPs. This central hub will enable utility-wide visibility and eliminate key technical barriers that have prevented the organization from operating as a unified utility rather than separate, distributed operational groups. To establish this central monitoring location, the Sewer Utility will need secure and reliable communications between CKTP and the remote pump stations and WWTPs. The central monitoring location will also require improvements to the existing CKTP control room to incorporate workstations, large-format displays, network components, and other functional requirements.

5.1.2 Secondary Monitoring Location for Sewer Utility Pump Stations and WWTPs

The Sewer Utility wants to establish a secondary monitoring location at the County Public Works Annex facility in Bremerton. This facility will provide the Sewer Utility with another location for monitoring all pump stations and WWTPs and viewing active alarms. Access to the Sewer Utility SCADA screens from this facility should be view-only.

5.1.3 Improved Remote Pump Station Telemetry

A significantly improved telemetry solution is necessary to establish near-real-time monitoring and alarming for the remote pump stations. The Sewer Utility requires more immediate notification of critical pump station alarms (e.g., high wet well level) than the current approach of round-robin polling via VHF licensed radio telemetry can provide, with current polling cycle times of around 8 minutes. To improve visibility into remote pump station operations and performance, the Sewer Utility also needs a means of closing the data gaps that come from traditional round-robin polling, where the CKTP

SCADA system receives a snapshot of current pump station statuses each time the pump station is polled but is left with no data for the time between polls.

5.1.4 Mobile Access

The Sewer Utility would like to establish secure remote access to WWTP and pump station SCADA screens for on-call operators from County-issued tablets. Initially, remote access for operations staff would be view-only monitoring for the pump stations and WWTPs, with some case-by-case exceptions for limited control capability at the WWTPs. However, the Sewer Utility would like the ability to expand the control capabilities of operations staff in the future.

Sewer Utility I&C technicians will also require a secure means of accessing the OT network from County-issued laptops so that they can assess conditions and assist with troubleshooting remotely. This remote access would enable I&C technicians to better diagnose ICS conditions remotely and determine whether an immediate response is necessary, potentially reducing the number of after-hours site visits for I&C technicians.

In the coming years, the Sewer Utility would also like to implement tablet-based workflows for on-site staff that involve other software applications, such as the Sewer Utility’s CMMS, LLumin.

5.1.5 Secure Access to ICS Data from the Business LAN

To leverage ICS data fully, they must be made more accessible. Several Sewer Utility staff members on the Sewer Utility business local area network (LAN) base decisions on ICS data but do not require direct access to SCADA screens or other ICS software applications. These users will need a means of accessing ICS data stores securely from personal computers (PCs) and laptops that also provide them with access to the Internet. ICS data may also need to be available to software applications hosted on the business LAN to enable merging of ICS data with financial information and other organizational data stores hosted on the business LAN.

5.1.6 Improved OT Network Resilience

As the Sewer Utility becomes more reliant on ICS and other data for day-to-day operations, decision making, and planning, the network architecture serving these data will need to be highly available. With the expansion of the Sewer Utility’s remote monitoring capabilities, the network components that establish the Sewer Utility’s ability to monitor remote pump stations and WWTPs from CKTP will become critical. Revisions to the CKTP OT network topology will be required to reduce single points of failure and to provide redundancy for certain critical network components, servers, and cable paths. Unmanaged switches at critical locations within the OT network will need to be replaced with managed switches to support segmentation, packet filtering, and other means of establishing a more fault-tolerant network. The migration to physical redundancy for some of the more critical elements will also require software and component configuration.

The Sewer Utility has indicated that establishing cable path redundancy is not considered an immediate need, especially for the remote WWTPs. Furthermore, the funding required for a standalone project to establish a more resilient network topology, in terms of cable path redundancy, would be difficult to justify. Instead, the Sewer Utility would like to take advantage of opportunities presented by other CIP projects to install redundant cable paths in the future. Most likely, cable path redundancy for critical network segments will be achieved in phases, and the Master Plan will prioritize redundant cable paths that can be achieved with minimal cost and effort.

5.1.7 Extend OT Network and ICS Infrastructure Battery Backup Power Duration for Critical Components

The Sewer Utility would like to establish a minimum of 4 to 6 hours of UPS battery backup power for ICS servers and all network components involved in the communication of alarms from remote WWTPs to CKTP and from CKTP out to on-call staff. The Sewer Utility would also like to maintain several hours of battery backup power for wet well high level and other alarms at critical remote pump stations. For individual PLC control panels at CKTP, the Sewer Utility would like to maintain a minimum of 15 minutes of UPS battery backup power.

5.1.8 Increased Network Throughput

The industrial automation industry is migrating away from Fast Ethernet (100 megabits per second [Mbps]) port speeds and is establishing 1-gigabit Ethernet (GbE) as the new standard for Ethernet ports on many new PLCs, panel PCs, and industrial Ethernet switches. Currently, nearly all Ethernet switches within the Sewer Utility OT network are capping connected devices at the theoretical 100 Mbps limit inherent in the switch ports. As the Sewer Utility modernizes its SCADA system, additional devices will be added to the OT network, data flow between servers and clients will increase, and, as new software tools make data repositories more accessible, staff interaction with the SCADA system will increase. These and other factors will contribute to an increase in OT network traffic. The Sewer Utility will need to increase throughput at some locations within the OT network to avoid performance degradations in the coming years and to take advantage of the higher port speeds that come with modern devices. Communication paths for the remote WWTPs will also require sufficient throughput to support the necessary data exchange between facilities.

5.1.9 Improved Backup Procedures and Business Continuity Preparedness

The Sewer Utility needs to implement routine backup procedures for its ICS servers. This will prevent significant loss of ICS historical data, configuration files, and programming files in the event of a server failure. The ICS server backup solution should include backing up ICS data and files to a cloud or off-site location to guard against a catastrophic event at CKTP where both production and backup servers are impacted. As an off-site backup location, the Sewer Utility would like to implement a backup server at the County Public Works Annex facility in Bremerton.

The Sewer Utility also needs to improve its business continuity and emergency response planning and adopt an approach for its ICS servers that will limit the time and effort required to replace the physical hardware, install and configure the software, and restore the device to full functionality. If the Sewer Utility has formal emergency response plan and/or business continuity plan documentation, at a minimum, these documents should identify ICS stakeholders and the individuals who should be contacted to assess and restore the ICS during an emergency.

5.1.10 Improved Cybersecurity Measures

The Sewer Utility would like to apply cybersecurity mitigations within its existing OT network to lessen risks to an acceptable tolerance by implementing a more secure foundation for the OT network's expansion in the future. The future OT network architecture needs to be consistent with information security industry best practices and recommendations of industry authorities like the U.S. Department of Homeland Security (DHS), ISA, and National Institute of Standards and Technology (NIST). Part of improving the Sewer Utility's cybersecurity posture will require having adequately trained staff and established procedures. Staff will need to be trained in the identification of cybersecurity incidents and will need to have a documented program for responding to these events.

5.1.11 OT Network and Telemetry Monitoring Capability

With an increased reliance on the OT network, the Sewer Utility will need a means of monitoring OT network activity and performance to alert staff to abnormalities, inform network troubleshooting efforts, and establish accounting of individual user activities. Monitoring network performance will allow the Sewer Utility to establish baselines for bandwidth usage at critical network appliances, typical telemetry uptime for the remote sites, and typical traffic patterns of connected devices. These baselines will enable the Sewer Utility to respond when conditions diverge from normal, potentially preempting network outages and other significant performance degradations.

Accounting of user activity will enable the Sewer Utility to attribute ICS set point adjustments, file modifications, and other changes to specific users. Accounting information can help the Sewer Utility ensure that established operational procedures are being followed, identify authors of changes who may have more information for why the changes were made, and determine where additional staff education may be required. Accounting and auditing are also critical cybersecurity measures.

In addition to network performance monitoring and accounting of user activity, the Sewer Utility's OT network monitoring capability will need to include monitoring of critical OT network devices. This includes alarms and warnings related to communication status for critical OT network devices like PLCs and servers as well as alarms for the UPSs and 24-volt direct current (VDC) power supplies that keep these critical devices powered.

5.2 Recommended Improvements

This subsection describes the recommended improvements related to the OT network. Note, the recommended improvements related to cybersecurity are based on current information security industry best practices and recognized standards. However, the Sewer Utility will still need to evaluate them against its risk tolerance. Also, the cyber threat landscape is continually changing and new vulnerabilities and tactics are emerging constantly. HDR recommends that the Sewer Utility re-review the recommended improvements shortly before design and/or implementation efforts to ensure that they remain consistent with changes to cyber threats, recognized mitigations, industry-recognized standards, and the Sewer Utility's risk tolerance.

5.2.1 Upgrade CKTP Control Room

An upgrade to the existing control room in the solids processing building (SPB) at CKTP will be required to convert the space into a suitable centralized monitoring location for all Sewer Utility pump stations and WWTPs. Large-format displays are recommended for both static display of overview screens for the remote pump station and WWTPs and for ad hoc display of operator-selected screens to support group discussion and decision making. A minimum of two SCADA PCs with access to HMI screens and historian client and data visualization and dashboarding software applications are also recommended. Four monitors are recommended for each PC to enable simultaneous display of multiple software application screens and to provide operators with the flexibility to customize display content according to their preferences. An example of one possible configuration for a control room operator workstation with four monitors and large-format displays is depicted in Figure 5-1.

Figure 5-1. Example four-monitor operator workstation configuration with large-format displays

Source: HydroLogic Research (2021).

To meet the Sewer Utility's goal for maintaining remote pump station and WWTP monitoring and alarm capability during power outages at CKTP, a minimum of 4 hours of battery backup power should be provided for the control room workstations and large-format display hardware. The same duration of battery backup power should also be provided for the servers and network components serving the HMI screen content.

5.2.2 Extend OT Network to County Public Works Annex Facility

To support the Sewer Utility's goal of establishing a secondary monitoring location for its WWTPs and remote pump stations at the County Public Works Annex facility in Bremerton, the OT network will need to be extended to incorporate dedicated hardware at that facility. HDR recommends that the Sewer Utility install a Host Identity Protocol (HIP)switch at the facility and include a dedicated SCADA PC at that facility within the Sewer Utility's Tempered Networks Airwall system deployment. If the Sewer Utility decides to install backup ICS server(s) at the facility, this hardware would also be included in the Tempered Networks Airwall system to enable backups to occur between CKTP and the facility.

5.2.3 Remote Pump Station and WWTP Telemetry Improvements

Migrate Pump Stations from VHF Licensed Radio WAN to Cellular WAN

To help reduce long polling times for its remote pump stations, the Sewer Utility will need to transition to a wireless communication technology with higher bandwidth. Given the lack of clear line-of-sight between most pump stations and the nearest WWTP and the high costs of installing fiber-optic cable to the remote stations, HDR recommends that the Sewer Utility continue the work it began with Quality Controls Corporation (QCC) to migrate its remote pump stations to the cellular wide-area network (WAN). Critical pump stations and those with historically poor communications should be prioritized for near-term migration, while less critical pump stations could be transitioned over a longer period as time and funding allow. Prior to planning the cutover for each site, a site survey should be performed to assess the signal strength of the Verizon Wireless network at the pump station location. Sites with poor signal strength may require outdoor and/or directional antennas to establish acceptable signal strength for a pump station telemetry application.

Latency with cellular networks is difficult to predict because of several variables that are beyond the end user's control, many of which have to do with the cellular service provider's infrastructure. As the number of pump stations introduced to the cellular WAN increases, the Sewer Utility may find that a second cellular router at CKTP will be required to mitigate latency and performance issues encountered with all remote pump stations communicating through one cellular router. A second cellular router would also provide a layer of redundancy for the communication links between the remote pump stations and CKTP. If a second cellular router is implemented, the idea would be to split the remote pump stations between the two routers so that remote pump station telemetry is divided into two parallel channels handling half of the remote pump station communication traffic. The Sewer Utility would also configure to two cellular routers at CKTP for redundancy so that pump stations communicating through one of the routers fail over to the other router during sustained loss of communications through their primary router.

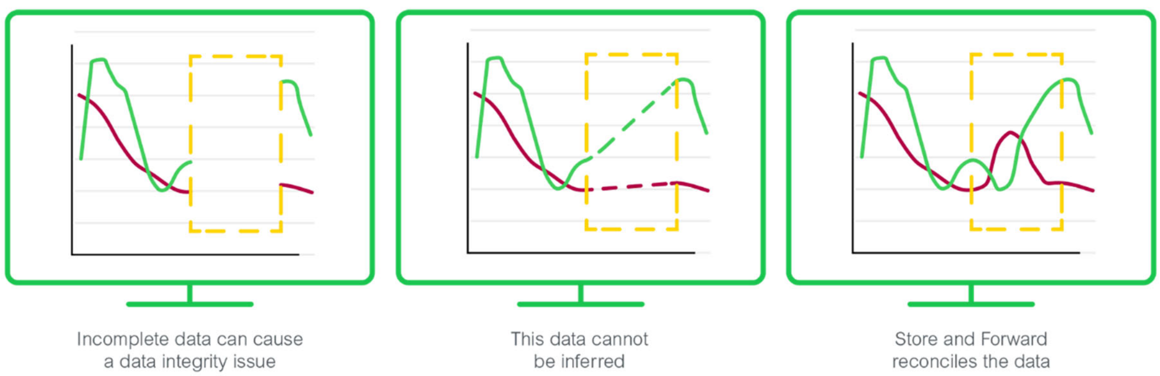
HDR recommends leaving the very high frequency (VHF) licensed radios in place for the more critical stations and implementing routing and communication driver configuration so that the stations revert to the VHF licensed radio WAN when communications over the cellular WAN are lost.

Implement Store-and-Forward and Exception Reporting for Remote Pump Station Telemetry and Eliminate PLC Data Concentrator for Cellular WAN

Migrating the remote pump stations to the cellular WAN will certainly improve polling times, but this measure alone will not be sufficient to achieve the Sewer Utility's goal of near-real-time monitoring and alarming for its remote pump stations. Even with the higher bandwidth of cellular communications, round-robin polling for the 62 pump stations could take up to 2 or 3 minutes to complete a polling cycle. This approach would still leave the utility with sporadic snapshots of each pump station's status and no means of monitoring continuous analog values or determining time stamps of when events and state changes actually occur. Similarly, the Sewer Utility would have no way of backfilling pump station data in the event of communications outages.

To resolve this issue, HDR recommends that the Sewer Utility implement a remote pump station telemetry solution that incorporates store-and-forward functionality. As depicted in Figure 5-2, store-and-forward eliminates data loss due to polling cycle times and communication outages. Real-time data are time-stamped and stored in a PLC, gateway, or software buffer to be forwarded when data communications are available. Two common open protocols that support this functionality are DNP3 and MQTT. The existing Allen-Bradley MicroLogix 1400 PLCs installed in the remote telemetry unit (RTU) panels at the pump stations support DNP3, which makes this protocol an attractive option because the Sewer Utility's investment in the existing hardware could be preserved.

Figure 5-2. Depiction of store-and-forward functionality

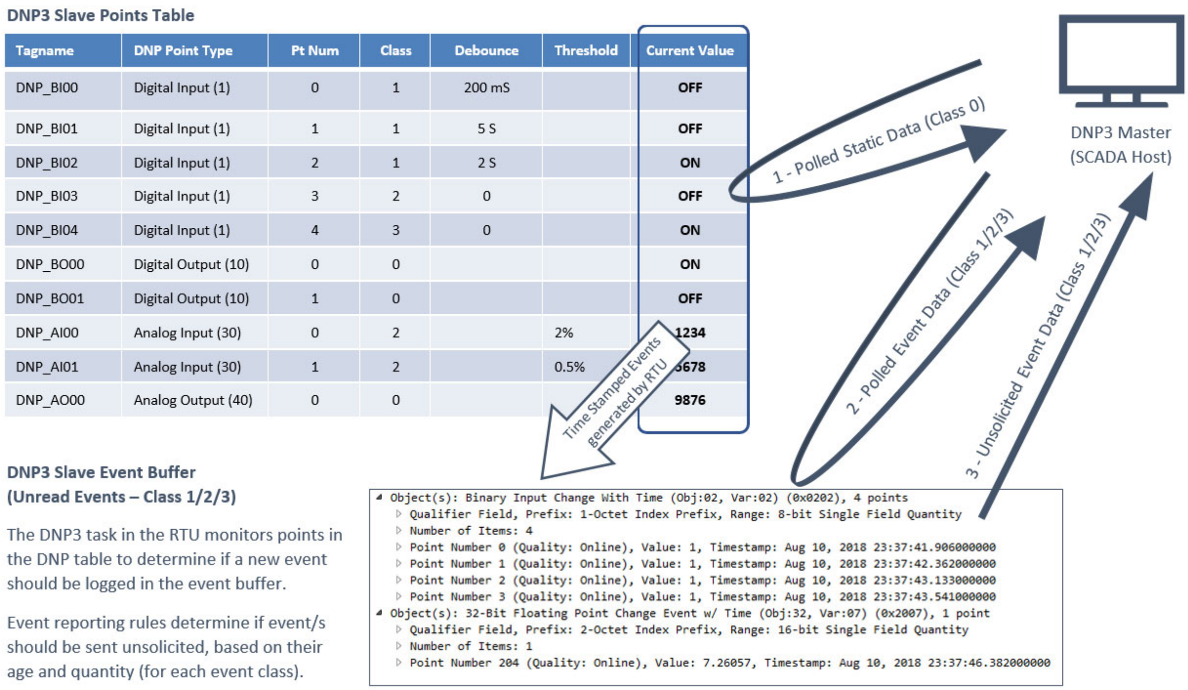


Source: Schneider Electric.

In addition to implementing store and forward, HDR recommends that the Sewer Utility replace round-robin polling with a report-by-exception telemetry solution. This would transition the remote pump station telemetry to event-based communications, where data exchange is tailored to capture changes in state, alarms, and deadband traversals for analog values. Compared with round-robin polling, where the same parameters are polled every cycle regardless of whether they communicate new information, report by exception can reduce data exchange volumes significantly. This is ideal for low-bandwidth environments like cellular applications where data usage rates apply.

Report-by-exception schemes typically consist of scheduled event and integrity polls, where time-stamped events are polled at a set interval and all current values are polled at a significantly longer interval, the latter polling cycle functioning in much the same way as round-robin polling. However, typical report-by-exception implementations also include functionality to enable the remote station to initiate communications with the master to communicate high-priority events (e.g., wet well high level, in the case of a wastewater pump station application) as well as events that have resided in the event buffer without being polled for a set period. Figure 5-3 illustrates how report by exception is handled by DNP3, one of the common open protocols designed with this functionality in mind. Again, the existing Allen-Bradley MicroLogix 1400 PLCs installed in the RTU panels at the pump stations support DNP3.

Figure 5-3. DNP3 report-by-exception functionality summary

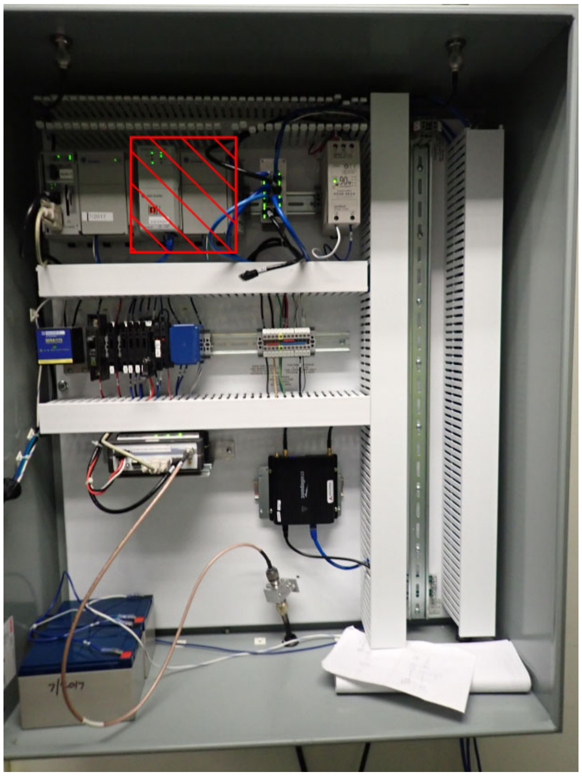


Tagname	DNP Point Type	Pt Num	Class	Debounce	Threshold	Current Value
DNP_BI00	Digital Input (1)	0	1	200 mS		OFF
DNP_BI01	Digital Input (1)	1	1	5 S		OFF
DNP_BI02	Digital Input (1)	2	1	2 S		ON
DNP_BI03	Digital Input (1)	3	2	0		OFF
DNP_BI04	Digital Input (1)	4	3	0		ON
DNP_BO00	Digital Output (10)	0	0			ON
DNP_BO01	Digital Output (10)	1	0			OFF
DNP_AI00	Analog Input (30)	0	2		2%	1234
DNP_AI01	Analog Input (30)	1	2		0.5%	5678
DNP_AO00	Analog Output (40)	0	0			9876

Source: Brodersen (2020).

Currently, the Sewer Utility has a master telemetry unit (MTU) PLC installed at CKTP that is serving as a data concentrator for the few remote pump stations on the cellular WAN (see Figure 5-4, where data concentrator PLC is indicated by a red box with diagonal hatching). The PLC is an Allen-Bradley CompactLogix 1769-L33ER processor, which does not support DNP3 natively. QCC has implemented a form of report-by-exception functionality via PLC programming logic for the sites on the cellular WAN, where the remote sites initiate communication for significant state and analog value changes and the MTU PLC polls the remote pump stations when no exception reports are received within a set time interval. This solution is a significant improvement over the round-robin polling on the VHF licensed radio WAN, but it does not provide store-and-forward functionality or time-stamped events that would allow the Sewer Utility to assign accurate times to events and eliminate data loss due to communication outages.

Figure 5-4. Cellular WAN data concentrator PLC at CKTP SPB control room



Though third-party communication modules could be incorporated into the existing MTU PLC implementation to have the PLC serve as a DNP3 master so that the Sewer Utility could receive the benefits of the DNP3 protocol, the MTU PLC is serving only as a middleman in the data exchange between the existing Wonderware system and the remote pump stations. A much simpler approach would be to eliminate the MTU PLC and have the SCADA server at CKTP serve as the DNP3 master. AVEVA (formerly Wonderware) offers Telemetry Server software that integrates with its System Platform offering. The software is purpose-built for remote site telemetry applications, supports DNP3, and has a relatively simple user interface that would be easier for Sewer Utility staff to configure and maintain than the PLC programming logic within the MTU PLC. Furthermore, eliminating the MTU PLC would reduce the number of single points of failure in the remote pump station telemetry communication pathway and reduce overall telemetry latency by removing an additional processing step.

Improve Communication Status Monitoring and Alarming for Remote Pump Station Telemetry

The Sewer Utility needs to have an accurate picture of remote pump station communication status and performance so that alarms can be generated when communications are lost and corrective action can be taken to remedy consistently poor performance. At a minimum, uptime percentages should be calculated as a ratio of successful versus attempted polls for each pump station. HDR recommends that uptime percentages be displayed at the HMI for the previous 24 hours and all history since the last manual reset. Pump stations that retain backup VHF licensed radio links should have separate uptime percentages calculated and displayed for cellular and VHF licensed radio links. Sewer Utility staff should have the ability to configure the timer interval and/or number of consecutive unsuccessful polls that would initiate a loss of communications alarm via the HMI.

Implement HIPswitch Cellular Failover Functionality to Establish Communication Link Redundancy for WWTPs

Currently, the Sewer Utility's HIPswitches at the WWTPs are configured only for wired communications. An outage within the Kitsap Public Utility District (KPUD) network has the potential to disrupt communications between one or more remote WWTPs and CKTP. Though store-and-forward functionality is recommended for the remote WWTP SCADA servers to avoid data loss in the event of a communication outage (discussed in Section 7), this functionality will not resolve the loss of alarm notification at CKTP for the WWTP(s) impacted by the KPUD network outage. To preserve alarm notification for the remote WWTPs in the event of a KPUD network outage, HDR recommends that the WWTP HIPswitches be configured for failover to cellular communications. This will require that the HIPswitches be provisioned with a cellular expansion module and a subscriber identification module (SIM) card activated on the Sewer Utility's cellular WAN.

5.2.4 CKTP OT Network Upgrades

Consolidate CKTP OT Network Servers, Distribution Switches, and Other Appliances in a Network Rack Environment within the SPB

HDR recommends standardizing on rack-mounted servers and distribution switches for the OT network and consolidating this infrastructure in one or more enclosed network racks within the CKTP SPB. Consolidating this equipment in a network rack environment will provide several benefits:

- Equipment will be located in an enclosure that can be locked to restrict access
- Rack-mounted power distribution units (PDUs) allow for a clean and simple redundant power supply solution using factory-issued power cords for the equipment
- Cable management hardware mounted to the rack will allow the Sewer Utility to establish clean and organized patch cabling between devices
- Reduces cabling that needs to be run throughout the building
- Greatly simplifies maintenance and replacement of equipment
- Results in a smaller equipment footprint compared with tower servers and having devices distributed throughout the building

Network racks should be sized for standard 19-inch equipment and have seismic testing certifying their suitability for installation in the seismic zone applicable to CKTP. The rack cabinet enclosures should also be sufficiently wide to accommodate vertical cable management hardware on either side of the rack. An example four-post network rack cabinet certified to meet Zone 4 requirements is depicted in Figure 5-5.

Figure 5-5. Example four-post seismic network rack cabinet

Source: Chatsworth (2020).

The SPB control room and the space identified in the ground floor of the SPB annex in TM-1 are the two best candidates for locating the future network racks. The SPB annex location has the benefit of providing a dedicated space for critical OT network servers and components where room access could be restricted to the few Sewer Utility staff members qualified to service the equipment by means of a key card access system. However, significant costs would be involved with repurposing the space and routing network and power cabling to that location, as described in TM-1. The SPB control room has the advantage of significantly reduced costs because the room is already climate-controlled and incoming communication cables already terminate at that location. However, servers and network equipment generate noise, which may impact the quality of the control room environment for Sewer Utility staff. Sound mitigation may be required at this location. The control room will also be accessed by several staff members, reducing the physical security measures in place for the network rack(s).

Once a better idea of spatial requirements is determined for the network rack(s) in Phase 4 of the Master Plan, the future location for this infrastructure should be discussed further with Sewer Utility stakeholders.

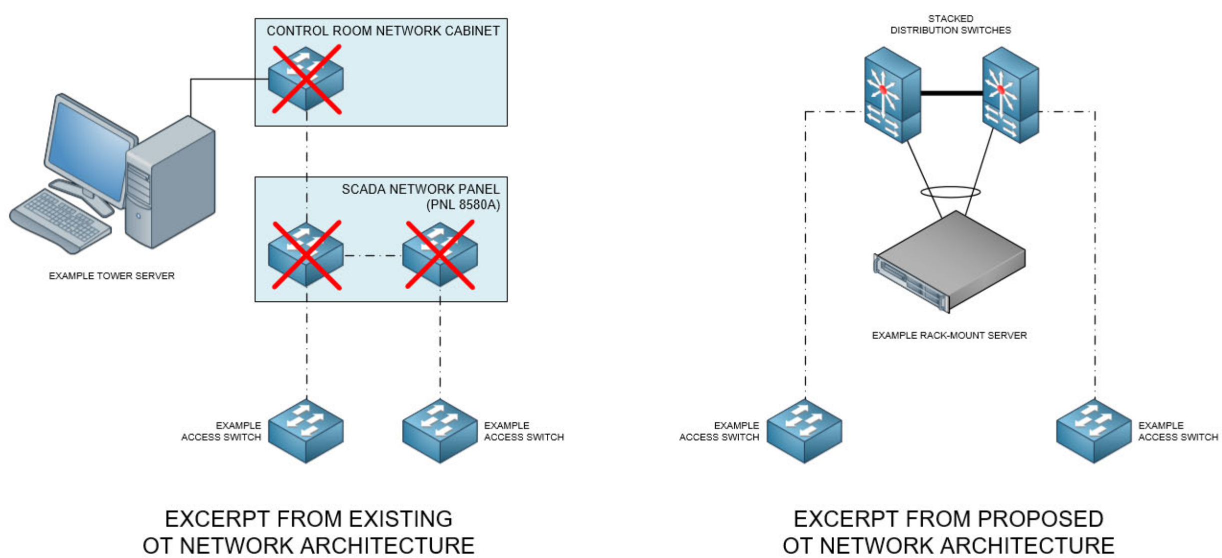
Upgrade to Stacked Layer 3 Distribution Switches at CKTP SPB

Currently, the most critical switch in the Sewer Utility OT network is an unmanaged switch in the SPB at CKTP. This switch is handling all traffic between ICS servers, SCADA clients, and PLCs at CKTP, as well as remote connections to the CKTP OT network established via the Tempered Networks WAN. To eliminate this single point of failure and to establish routing capabilities at the OT network distribution layer that will enable segmentation of the network, HDR recommends replacing the unmanaged switch with stacked Layer 3 distribution switches.

The stacking capability of these switches will provide switch-level redundancy for critical ICS servers and downstream access switches for which cable path redundancy is provided. The Layer 3 functionality of these multilayer switches allows for network traffic to be routed between subnets and virtual local area networks (VLANs). This will enable the Sewer Utility to instate some network security best practices such as placing devices that do not need to communicate with one another in separate broadcast domains while maintaining their ability to communicate with ICS servers and other shared resources. For reference, Layer 3 refers to a specific layer within the Open Systems Interconnection (OSI) Model (see Figure 2-11 in TM-1). Layer 3 switches handle network packets and recognize IP addresses and other packet header information required to route packets between broadcast domains.

To eliminate additional single points of failure and a potential bottleneck in the CKTP OT network, HDR also recommends eliminating the two managed switches in panel (PNL) 8580A (also located in the SPB). The fiber-optic cable connections received by these switches from the various access switches throughout the plant would instead be patched directly to the proposed stacked Layer 3 distribution switches, eliminating an unnecessary hop in the OT network architecture. Figure 5-6 depicts how the relevant excerpt of the existing CKTP OT network would be modified to eliminate the existing switches discussed above (shown crossed out with red Xs in the figure) and to replace them with stacked Layer 3 distribution switches. For reference, the complete physical network diagram for the existing CKPT OT network can be found in Appendix B of TM-1.

Figure 5-6. Excerpts from existing and proposed CKTP OT network architecture



Modifications to CKTP Administration and Laboratory Building Electrical Room

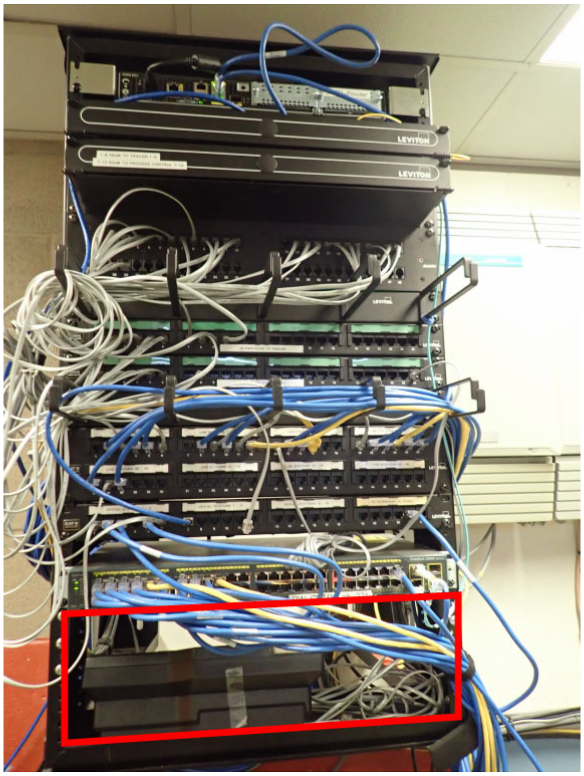
The CKTP administration and laboratory building electrical room contains mechanical and electrical equipment along with network components for both the OT network and business LAN. The costs involved with relocating the mechanical equipment and rerouting the air and water lines to eliminate the impact to the electrical and network equipment because of equipment failure or a burst or leaking pipe would likely be considerable. An exploration of the work required is also beyond the scope of the Master Plan. Relocating the electrical and business LAN network rack and rerouting all new power and communications cables would also be costly and would require a significant disruption to Sewer Utility operations in the building.

Assuming that the mechanical equipment, water and air piping, and electrical and network equipment will continue to share the electrical room, HDR recommends relocating the OT network HIPswitch to the new network rack(s) location in the SPB. The HIPswitch is critical for maintaining communication with the remote WWTPs and its relocation will result in a less risk-prone environment for the device while also reducing the need for Sewer Utility staff to enter the administration and laboratory building electrical room to maintain the OT network. To facilitate the relocation in the near term, a 1 GbE, multi-mode fiber-optic small form-factor pluggable (SFP) module would be introduced to the combination port on the KPUD Carrier Ethernet switch where the existing Category cable connection to the HIPswitch is made (see Figure 5-7). The SFP module could then be patched to the existing fiber-optic patch panel mounted to the electrical room communications backboard to establish a connection to the SPB communications cabinet via the existing fiber-optic cable between the two buildings. The Category cable along with the HIPswitch, 24 VDC power supply components, and OT network switch mounted to the communications backboard would be removed.

Figure 5-7. Proposed SFP module installation in KPUD Carrier Ethernet combination port

The UPS sitting on the floor of the electrical room that is powering the 24 VDC power supply for the OT network components will no longer be necessary and is in a risk-prone location to begin with. This UPS should be removed. However, HDR recommends that UPS power be provided for the KPUD Carrier Ethernet switch located in the electrical room network rack because the device is a critical component that the OT network relies on for wired communications to endpoints outside of CKTP. One option for providing UPS power to the device would be to install a UPS in the existing electrical room network rack. There appears to be sufficient space at the bottom of the rack if the telephone equipment and cabling placed there were to be removed (see Figure 5-8). If the UPS were dedicated to the KPUD Carrier Ethernet switch and were not also used to power all of the business LAN components also installed in the network rack, a 1,500-volt-ampere (VA) UPS should be more than enough to meet the Sewer Utility's goal of 4 to 6 hours of battery backup time.

Figure 5-8. Proposed location of UPS in existing administration and laboratory building network rack



5.2.5 General OT Network Upgrades

Establish Standard Layer 2 Managed Access Switch with Gigabit Downlink Ports for Future OT Network Applications and Replacement of Select Unmanaged Switches

To provide Sewer Utility staff with a uniform management interface for maintaining OT network access switches and to reduce spare switch inventory requirements in the future, HDR recommends that the Sewer Utility standardize on a managed access switch for the OT network. The standard switch should support Layer 2 management functionality to allow for network segmentation, traffic filtering (Internet Group Management Protocol [IGMP] snooping, in particular), and implementation of cybersecurity controls. Full-duplex switching to mitigate packet collisions and Simple Network Management Protocol (SNMP) and port-mirroring capabilities to facilitate network monitoring and troubleshooting are additional recommended features of the standard switch. The switch should also have gigabit downlink ports to accommodate the gigabit port speeds of modern ICS devices.

Once the new standard OT network access switch is selected, HDR recommends that it be used to replace the unmanaged switches recommended for replacement in TM-1. The Sewer Utility's standard OT network access switch should also be documented in the Sewer Utility ICS standards proposed later in this TM so that future design projects incorporate the standard into their contract documents.

Establish Cable Path Redundancy for Critical Segments of the OT Network

The current OT network at the Sewer Utility WWTPs consists of single fiber-optic and copper Category cable connections between buildings and process areas. For increased OT network resilience, HDR recommends that the Sewer Utility establish redundant cable paths for critical OT network segments, particularly between building access switches at CKTP and the proposed distribution switch stack in the SPB. The recommended topology for this physical layer redundancy is a redundant star (as shown in Figure 5-9). The advantages and disadvantages of a redundant star topology, as compared with other common network topologies (ring, star, and linear), are provided in Table 5-1.

Figure 5-9. Redundant star topology

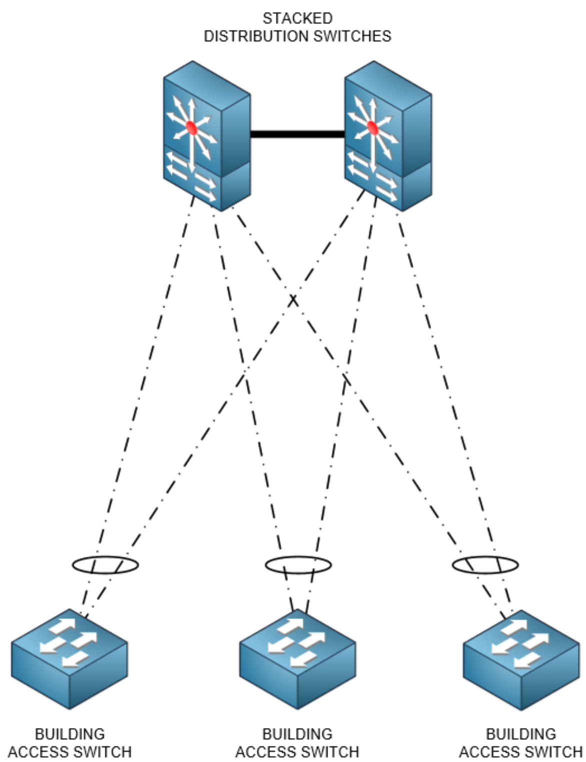


Table 5-1. Network topology advantages and disadvantages

Topology	Advantages	Disadvantages
Redundant star	• Fast convergence in the event of connection loss. • Predictable and consistent network performance because of consistent number of hops. • Provides resilience for multiple connection losses. • No inherent bottlenecks in design reduces likelihood of segment over-subscription.	• Additional cables, conduits, and associated costs. • Increased configuration complexity (compared to start, linear, or extended-star topologies).

Table 5-1. Network topology advantages and disadvantages

Topology	Advantages	Disadvantages
Ring	• Fewer cables and conduits and lower associated costs. • Provides resilience for one connection loss. • Reduced bottleneck potential (when compared to extended-star) with two potential paths. This reduces likelihood of segment over-subscription.	• Longer convergence times in the event of connection loss. • Most complex configuration. • Less predictable and consistent network performance because of variable number of hops. • Bottlenecks can still occur on segments near distribution switches resulting in segment over-subscription.
Linear, star, or extended-star	• Least amount of cables and conduits and lowest associated costs. • Simple implementation.	• No resilience. Connection loss results in communication outage. • Inherent bottlenecks on segments near distribution switches (in the case of linear or extended-star topologies). These bottlenecks can result in segment over-subscription.

Though a redundant star topology is recommended, there will be cases where the cost of implementing this topology is prohibitive. In these cases, a portion of the OT network might be broken out into a ring topology, or a non-critical access switch connected via one duct bank might be left with one fiber-optic path to the distribution switch stack. Similarly, the best practice of physically separate routes for the redundant cables must also be considered with the cost of implementation. For example, the cost of installing a new 100-foot-long duct bank to provide a completely separate physical fiber path may be hard to justify when a spare conduit exists in an existing duct bank where the other redundant fiber-optic cable is already installed.

As redundant fiber-optic cable paths are considered, HDR recommends that the Sewer Utility consider transitioning to single-mode fiber-optic cable for communication links where significant network traffic volumes are anticipated. Single-mode fiber-optic cable supports significantly increased throughput, which will allow the Sewer Utility to benefit from the multi-gigabit throughput capabilities of today's network components and be better positioned to take advantage of the throughput capabilities of future technology. In particular, the existing fiber-optic cable between the CKTP administration and laboratory building electrical room and the SPB is recommended for near-term replacement with single-mode fiber-optic cable. All traffic associated with remote WWTPs, remote access to the OT network, and access to the ICS DMZ from the Sewer Utility business LAN will occur over this fiber, and the length of the existing multi-mode (Optical Multi-mode 1 [OM1]) cable is already at or near the cable's maximum distance threshold for theoretical 1 GbE.

5.2.6 ICS and OT Network Power Supply Improvements

Establish Robust UPS Battery Backup Solution for ICS and OT Network Infrastructure

To meet the Sewer Utility's goals of establishing a minimum of 4 to 6 hours of battery backup power for CKTP ICS infrastructure required to maintain monitoring of remote pump stations and WWTPs and on-call staff alarm notification functionality, the Sewer Utility will need to implement an improved UPS solution for the CKTP SPB. Though dedicated industrial-grade UPSs installed in network racks and cabinets and at critical PCs could meet the Sewer Utility's goals, a centralized approach to UPS power distribution would reduce the number of UPSs that need to be maintained and monitored while providing more flexibility for future modifications to the ICS infrastructure.

HDR recommends installing a three-phase, 120/208-volt alternating current (VAC), online double-conversion type UPS system at the CKTP SPB. The UPS system would consist of a UPS cabinet with a modular design to allow for expansion of capacity in the future, a battery cabinet, and a combination transformer/maintenance bypass cabinet to step down a three-phase 480 VAC power feed to 208 VAC and allow Sewer Utility staff to bypass the UPS system for maintenance. The UPS system would feed a downstream three-phase 120/208 VAC panelboard for distribution of UPS power to the critical ICS loads within the SPB. An example of such a system that HDR recently designed for a local wastewater utility is depicted in Figure 5-10.

Figure 5-10. Example three-phase UPS system recently installed at a local wastewater utility

Because of the significantly smaller scale of the ICS infrastructure at the remote WWTPs, it is likely that the Sewer Utility can meet its goal of establishing a minimum of 4 to 6 hours of battery backup power for ICS infrastructure required to maintain communication of active alarms to CKTP by installing one or more standalone online double-conversion UPSs with an extended runtime option and external battery packs. ICS and related infrastructure requiring UPS power at the remote WWTPs would include the HIPswitches, KPUD Carrier Ethernet switches, SCADA server(s) and PC(s), main plant PLC, telephony or cellular modems required for the alarm notification system, and network switches involved in maintaining communication between these devices. Depending on the critical ICS loads requiring UPS power, these UPSs may be single-phase 120 VAC or three-phase 208 VAC.

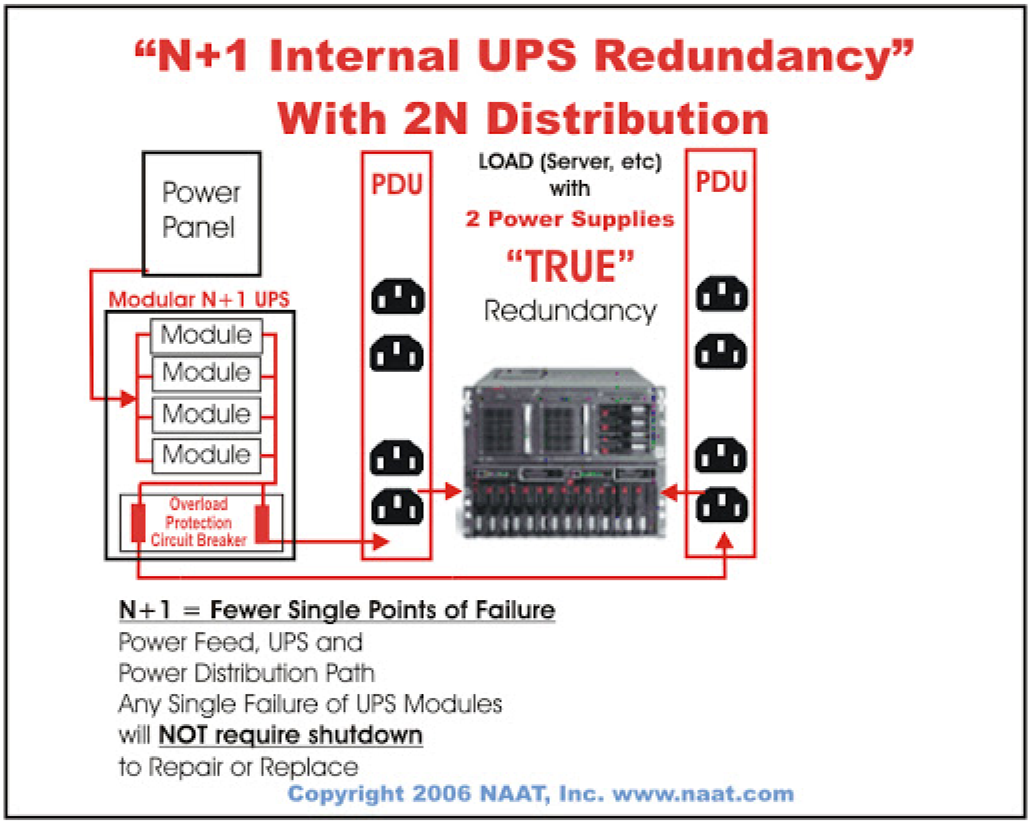
The approach of a standalone online double-conversion UPS is also recommended for the Sewer Utility's PLC and remote input/output (RIO) control panels currently without battery backup power at its WWTPs and remote pump stations, as indicated in TM-1. Per Sewer Utility goals for battery backup times, PLC control panels at CKTP would need to be sized for a minimum of 15 minutes of battery backup power. Other PLCs and RIO panels at remote WWTPs and pump stations would be subject to the 4- to 6-hour battery backup requirement.

HDR recommends that all UPSs provided for Sewer Utility ICS and OT network infrastructure be monitored by the SCADA system and that UPS status, warnings, and alarms be integrated into the Sewer Utility's SCADA HMI screens and alarm notification system. This includes the dedicated UPSs installed in the WWTP PLC panels. Most of the existing UPSs in WWTP PLC panels have no status and alarm contacts or capability for remote monitoring over Ethernet. HDR recommends that these UPSs be replaced with online double conversion UPSs with status and alarm contacts and/or Ethernet communication options that support integration with SCADA software via standard industrial Ethernet protocols like Modbus Transmission Control Protocol (TCP).

Standardize on Redundant Onboard Power Supplies and 24 VDC Power Supplies for ICS and OT Network Infrastructure

To avoid a scenario where the power supply redundancy provided by a UPS is undermined by failure of a single onboard power supply or a single 24 VDC power supply downstream from the UPS, HDR recommends that the Sewer Utility standardize on carrying through power supply redundancy to the ICS and OT network devices. For rack-mounted OT network switches, servers, and other network appliances, this would mean standardizing on dual onboard power supplies. Network racks would be provisioned with two PDUs, each powered from a separate circuit in the upstream UPS panelboard. The dual onboard power supplies of each device would be split between the two PDUs. Figure 5-11 depicts a simplified overview of this approach.

Figure 5-11. Overview of power supply and distribution redundancy for network rack components



Source: NAAT (2021).

For DIN-rail mounted components, this would mean standardizing on redundant 24 VDC power supplies and a redundancy module in control panels so that a failure of one power supply does not result in loss of all ICS and OT network components served by the control panel's 24 VDC power distribution. The redundancy module is required to effectively isolate the two 24 VDC power supplies so that a fault impacting one of the supplies does not impact the other and undermine the component-level redundancy. Figure 5-12 depicts an example 24 VDC power supply implementation where two 24 VDC power supplies and a redundancy module are used.

Figure 5-12. Example redundant 24 VDC power supply application

Source: Phoenix Contact (2021).

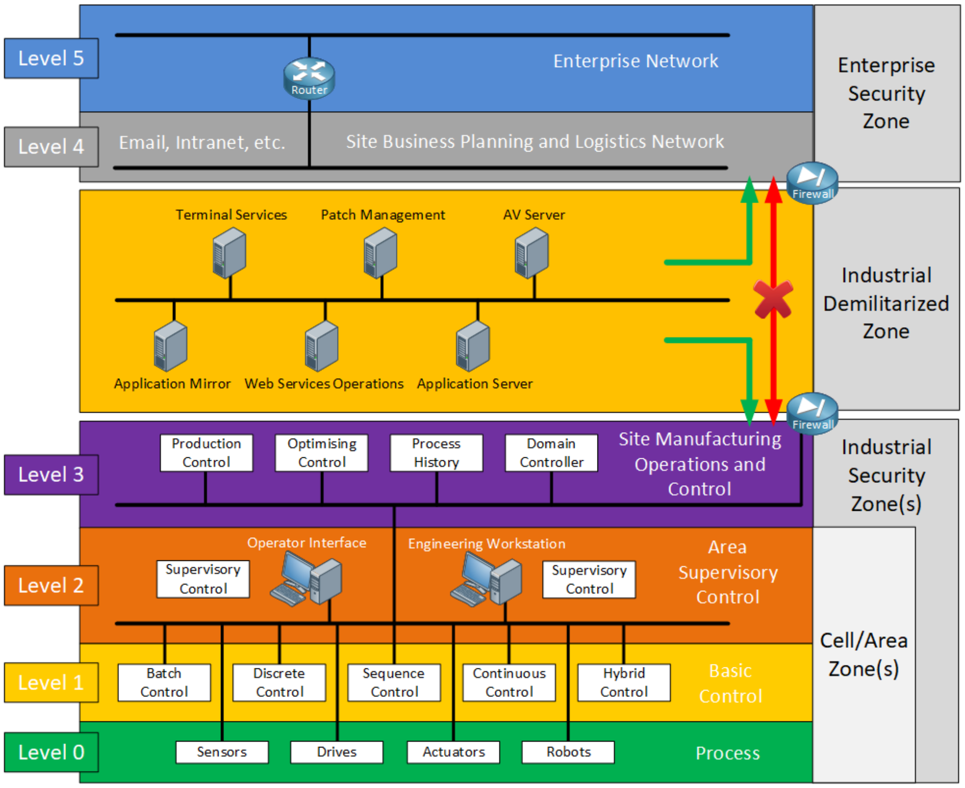
To implement this approach, upgrades to existing control panel 24 VDC power distribution could be made as time and operation and maintenance (O&M) budget allow and/or coordinated with other recommended improvements affecting the control panels. To ensure that future control panels and OT network upgrades adhere to this standard approach, these requirements should also be documented in the Sewer Utility ICS standards proposed later in this TM so that future design projects incorporate the standard into their contract documents.

5.2.7 Secure Remote Access and Data Exchange with Business LAN

Establish an Industrial DMZ between Sewer Utility Business LAN and OT Network

Critical infrastructure networks like the Sewer Utility's OT network require isolation from the Internet and less trusted networks (e.g., the Sewer Utility business LAN) within the enterprise zone to protect them from external threats. However, there are many benefits to establishing controlled data exchange between enterprise zone assets and industrial zone (OT network) assets that can allow an organization to optimize its operations and increase efficiency. To securely implement data flows between these two zones, information security industry best practices dictate that all cross-zone traffic be handled by applications and services residing in an industrial DMZ. This network architecture establishes a single entry to the industrial DMZ from the enterprise zone via a firewall and a single entry to the industrial zone from the industrial DMZ via a firewall. A general depiction of the proposed industrial DMZ is shown in Figure 5-13, between Levels 3 and 4 of the Purdue Model for Control Hierarchy, an industry standard used to organize networks into functional and security zones. Because the applications and services within the industrial DMZ will be either the endpoint of all inbound traffic to the industrial DMZ or the originator of all outbound traffic from the industrial DMZ, a direct connection between enterprise zone and industrial zone assets is avoided. It is recommended that the Sewer Utility implement an industrial DMZ to handle data exchange between the industrial and enterprise zones and improve the security provided for ICS assets.

Figure 5-13. Purdue Model for Control Hierarchy



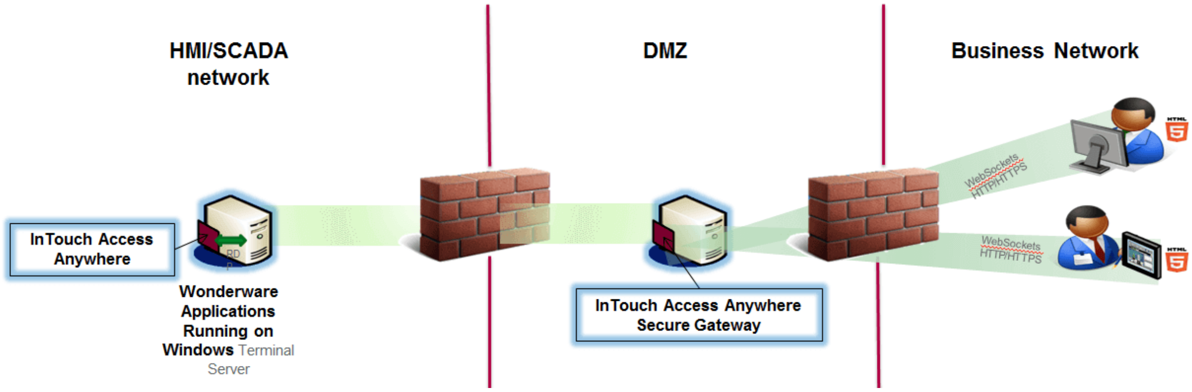
Source: NetworkLessons.com

Implement Secure Mobile Access to SCADA HMI Screens for Remote and On-site Staff

With the exception of Sewer Utility I&C technicians and third-party systems integrators, most Sewer Utility staff will not need mobile access to OT network resources beyond the SCADA HMI screens for the remote pump stations and WWTPs. To adhere to the information security industry Principle of Least Privilege, these users should be granted access only to the resources that they need to interface with to perform their job function. Read or read/write privileges should also be tailored to the specific user and his/her responsibilities.

The Sewer Utility's SCADA software platform vendor, AVEVA, offers a remote access solution developed specifically for operators, supervisory staff, and other users whose remote access to the OT network is limited to SCADA HMI screens. This software, called AVEVA InTouch Access Anywhere, is designed to work with Microsoft Remote Desktop Services (RDS) where remote connections to a Remote Desktop Server hosting the InTouch Access Anywhere software application are established via a Remote Desktop Gateway, typically located in an industrial DMZ. Figure 5-14 presents a simplified diagram of a typical AVEVA Intouch Access Anywhere deployment. This solution allows mobile users to access SCADA HMI screens via a Hypertext Markup Language revision 5 (HTML5)-compliant web browser and requires no client software installation or maintenance on the mobile device.

Figure 5-14. Typical AVEVA Intouch Access Anywhere network architecture



Source: AVEVA (2020).

The use of RDS and an industrial DMZ for remote access to OT networks is a widely deployed framework endorsed by DHS, NIST, Rockwell Automation, Cisco, and several other industry organizations and manufacturers. This approach also leverages AVEVA's standard offering for remote access applications, for which support and security patches can be expected from the software vendor. For these reasons, HDR recommends that the Sewer Utility implement AVEVA InTouch Access Anywhere for mobile access to the Sewer Utility's SCADA HMI screens.

It should be noted that this approach will require mobile users to access the industrial DMZ in a secure manner that should include multi-factor authentication (MFA). The standard approach would be for users to access the industrial DMZ through the Sewer Utility business LAN via the virtual private network (VPN) service maintained by the County IS department. This approach would require coordination and involvement with the County IS department but would allow the Sewer Utility to make use of existing IT infrastructure and software licensing. Alternatively, the Sewer Utility could consider establishing mobile access to the industrial DMZ via the Tempered Networks Airwall system. This approach would involve installing Airwall client software on County-issued mobile devices and implementing a specific-use overlay network that provides the mobile devices with access only to the Remote Desktop Gateway. While this approach would reduce or eliminate County IS department involvement, it would incur the costs of additional Airwall client licenses. Because tablet-based workflows for Sewer Utility staff are anticipated to eventually involve dashboards and data visualizations served by software application(s) hosted on the Sewer Utility business LAN, HDR recommends that the Sewer Utility aim for the standard approach in the long term. However, the Sewer Utility could consider access via the Tempered Networks Airwall system as a temporary solution pending coordination with the County IS department.

An additional recommendation is that mobile device management (MDM) software be used to monitor, control, and update County-issued mobile devices, if this is not already implemented by the County IS department. This software would allow the County IS department to manage content on the devices, deploy operating system updates and software patches, monitor use, and make use of device location tracking. In the event that mobile devices are lost or stolen, MDM software can be used to remotely lock the device and/or wipe data and software from the device.

Implement Secure Remote Access to OT Network for I&C Technicians and Contracted Systems Integrators

Sewer Utility I&C technicians and contracted systems integrators will require remote access to additional OT network resources beyond the SCADA HMI screens to maintain and troubleshoot the OT network remotely. While the current Virtual Network Computing (VNC)-based remote access solution is capable of providing these users with the access they require, HDR recommends transitioning to a remote access solution without the inherent security risks of VNC. For the same reasons indicated for mobile access to the Sewer Utility SCADA HMI screens, HDR recommends that RDS be used to establish remote access for more technical users who require greater privileges and permissions on the OT network.

These users would initiate remote connections using Remote Desktop Protocol (RDP) from County-issued or whitelisted systems integrator laptops to engineering workstation(s) on the OT network where necessary applications reside. Remote sessions would be established via the same Remote Desktop Gateway in the industrial DMZ that is used by the Sewer Utility's mobile users. As with the mobile access solution proposed above, the same two methods of accessing the industrial DMZ apply (County IS department managed VPN service or Tempered Networks Airwall system) and HDR recommends that MFA also be included in the remote access for these more privileged users.

The Sewer Utility should consider the use cases for privileged remote access carefully. The ability to edit PLC programming and HMI graphics remotely can potentially reduce emergency response times and costs associated with systems integrator site visits. However, in general, the associated permissions should not be left in place indefinitely. Also, remote access to servers and network switches with administrator-level privileges is not recommended.

5.2.8 OT Network Configuration, Management, and Backup Improvements

Develop and Implement an Improved OT Network Segmentation Scheme

To reduce cybersecurity risks and adopt industry best practices, HDR recommends that the Sewer Utility discontinue use of public IP addresses for OT network devices. The existing subnetting scheme also needs to be modified to both accommodate additional IP devices in the future (the CKTP OT network is currently limited to 254 devices) and to establish zones and conduits consistent with ISA/International Electrotechnical Commission (IEC) 62443 recommendations to limit the network traffic to required operational functions (ISA/IEC 2020). For example, once the CKTP control panel operator interface terminals (OITs) are migrated to a thin client implementation, they will require communication with the SCADA server(s) but will not require direct communication with any of the plant PLCs. Partitioning the OITs onto a separate subnet from the plant PLCs is one example of how the OT network could be segmented. HDR will propose recommendations for OT network segmentation in Phase 4 of the Master Plan as part of the system architecture conceptual design.

Implement a Domain for the CKTP OT Network

HDR recommends that the Sewer Utility implement a domain for the CKTP OT network to reduce the labor involved with maintaining the network as it evolves and to enable PCs and servers on different subnets to communicate after the network is segmented. Once recommended authentication, authorization, and accounting (AAA) measures are in place, there will be several users, PCs, and servers for which security and permissions need to be managed. Having one server from which to manage all of these settings will eliminate the need to separately configure them on each PC and server and eliminate the possibility of user permissions not being universally applied to the various OT network resources. Establishing a secondary domain controller as a resilience measure should also be considered, as this would allow remote users to continue accessing the OT network and other software packages that rely on Active Directory to authenticate users to continue functioning in the event of an outage to the primary domain controller.

Because of the very small size of the OT networks at the remote plants, there would be little to no benefit of establishing a domain for each of the remote plants. HDR recommends that these plants remain as workgroups.

Improve AAA Measures for OT Network

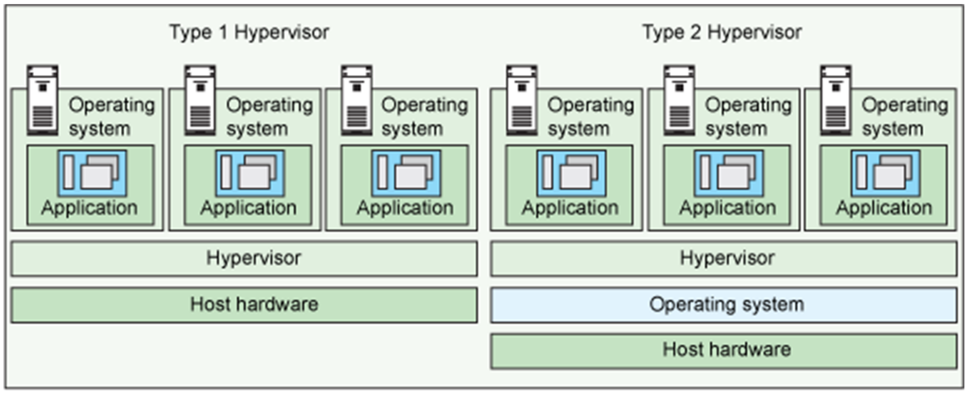
HDR recommends establishing unique user accounts for each individual requiring access to the OT network PCs and servers. Shared user accounts should be eliminated. To simplify management of user accounts, security policies and permissions are best made at the group level rather than for each user account. This allows for role-based permissions to be established for each type of user (group) and then universally applied to all users added to the corresponding group. While on site at the Sewer Utility WWTPs, users should be required to log in to PCs and servers with their unique usernames and passwords and the operating systems for these devices should be configured to log the user out on inactivity. Concurrent logins should also be restricted.

HDR also recommends that the Sewer Utility begin logging and monitoring user activity on the OT network. Though login attempts, session times, and various event data can be viewed via operating system logs and Microsoft Active Directory (software that will be introduced as part of the CKTP OT network domain implementation), third-party software tools for network and user activity monitoring can provide much simpler user interfaces, which will be more approachable for Sewer Utility staff as they acquire network management experience. The selected network monitoring software should have functionality to send alerts to Sewer Utility staff tasked with administering the OT network for potential security events such as multiple failed login attempts. Maintaining user activity logs will also allow Sewer Utility staff to research specific events that occur on the network and attribute them to individual user accounts.

Establish Virtualized Environments for all ICS Servers

To benefit from the advantages of virtualization described in TM-1, HDR recommends that the Sewer Utility establish virtualized environments for all ICS servers. This will require selection of a Type 1 (or bare-metal) hypervisor to standardize on for the Sewer Utility OT network. A Type 1 hypervisor differs from a Type 2 hypervisor in that the software runs directly on the physical server (or host) hardware and not on a host operating system (see Figure 5-15). This yields significant performance and stability benefits because the hypervisor has direct control over the server system resources and is not having to broker commands through an operating system or sacrifice system resources to operating system overhead. Physical servers running Type 1 hypervisors are dedicated to virtualization purposes and cannot be used for anything other than serving guest virtual machines (VMs).

Figure 5-15. Type 1 and Type 2 hypervisor environments



Source: IBM (2020).

Two widely used Type 1 hypervisors that are both supported by AVEVA System Platform 2020, the current offering of the Sewer Utility's SCADA HMI software, are Microsoft Hyper-V and VMware ESXi. Either hypervisor would be suitable for the Sewer Utility's needs. Hyper-V licensing is typically less expensive than VMware, but VMware has several software offerings to expand the functionality of its virtualization services. In HDR's opinion, a significant factor in the selection of a hypervisor should be the level of familiarity that County staff and QCC have with the two hypervisors. If the individuals likely to be supporting the virtualized infrastructure have more experience or a strong preference for one hypervisor over another, that would be good grounds for a selection to be made. QCC may have already made a determination as to which hypervisor to use as part of the ongoing AVEVA System Platform upgrade.

In general, most of the PCs on the OT network should be relatively uniform in terms of setup and configuration and should not be hosting important ICS files or applications locally. ICS files and applications should be hosted on the ICS servers. Therefore, there should not be a driver to virtualize the OT network PCs. However, the Sewer Utility I&C technicians will likely require a Type 2 hypervisor to have access to various versions of Rockwell applications and other automation software and to contain those applications in a controlled environment so that they do not bog down host machine resources. There are also several network monitoring and security applications that run more effectively in a Linux environment, so I&C technicians would benefit from the ability to host a Linux distribution on their PCs in the future.

Establish Automated Backup Procedures for ICS Servers That Includes On-premise and Off-site Storage

HDR recommends that the Sewer Utility implement automated backup procedures for critical ICS servers to prevent significant data loss and improve the Sewer Utility's ability to recover from hardware failures, cyberattacks, and catastrophic events. At a minimum, the Sewer Utility's backup solution should include daily image-level backups of VMs and weekly bare-metal backups (a backup procedure that allows staff to recreate the host server on a new physical machine with minimal reinstallation and configuration) for critical ICS servers at the four WWTPs. Backups should be saved to a physically separate backup server or network attached storage (NAS) device at CKTP as well as an off-site data store. For the off-site data store, the Sewer Utility could implement a dedicated backup server at the County Public Works Annex facility in Bremerton and/or lease cloud storage. The Sewer Utility should also incorporate the practice of periodic file recovery from backup testing to confirm the integrity of backups and ensure that backup procedures are occurring as intended.

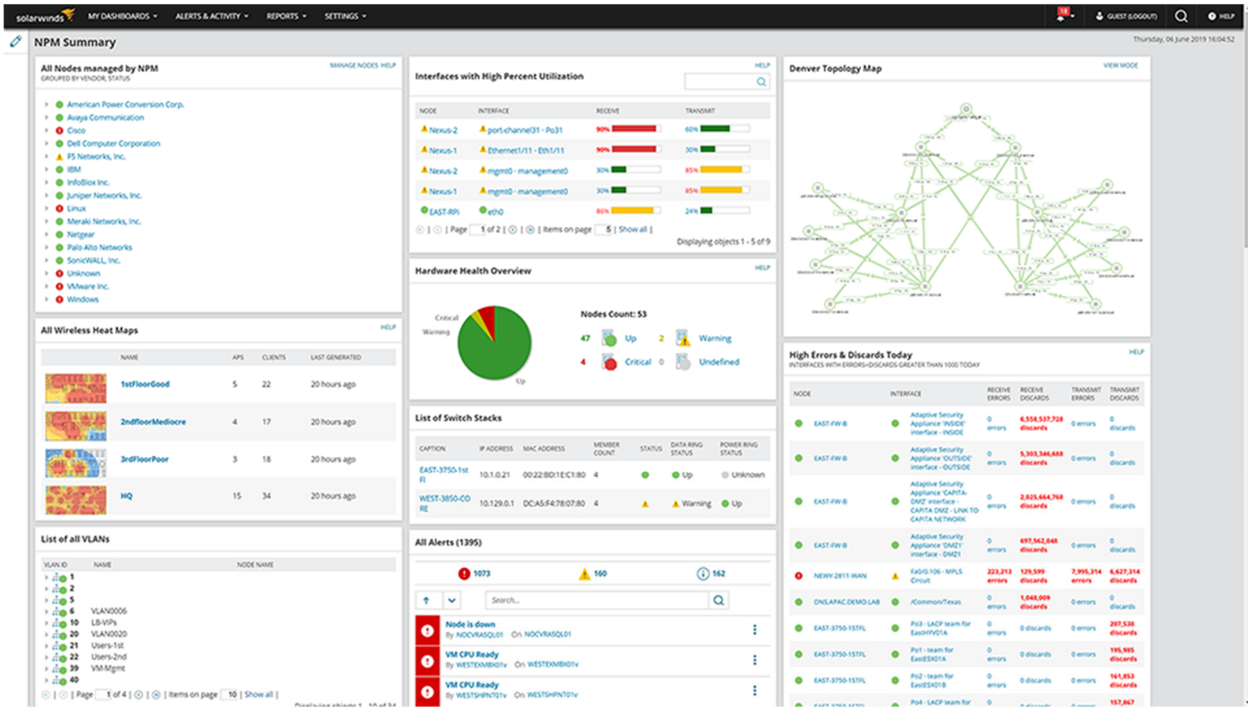
Though it is possible to automate backup processes by developing scripts and scheduling backup tasks at the operating system level, this process is labor-intensive and requires a level of expertise that may take some time for the Sewer Utility to develop with in-house staff. Backups over WANs can also become challenging because of throughput limitations and can greatly benefit from WAN acceleration services provided via third-party backup software solutions. Third-party backup software providers, such as Veeam and Altaro, offer extremely simplified user interfaces that allow users with limited technical background to easily configure and schedule backups of VMs and physical servers to on-premise, off-site, and cloud data stores. HDR recommends that the Sewer Utility leverage a solution from a third-party backup software provider to simplify the associated OT network management effort for Sewer Utility staff and to optimize the backup-related data exchange occurring over the Tempered Networks WWTP WAN.

Implement OT Network Performance Monitoring and Logging Capabilities

Several new devices will be introduced to the OT network in the coming years that will increase the network's complexity and the maintenance burden on Sewer Utility staff. As ICS and other data trafficked by the OT network become more readily accessible to Sewer Utility staff and those data sets are made integral to decision-making and planning processes, the Sewer Utility will become more reliant on the OT network for day-to-day operations. With this in mind, the Sewer Utility will require a means of efficiently monitoring network performance and logging network events to alert staff to potential issues before they degrade into significant network outages and to support troubleshooting and root-cause analysis efforts.

There are a vast number of approaches to network performance monitoring and logging, and, not surprisingly, the opinions of systems administrators on this topic are varied. Because Sewer Utility staff do not have a background in network administration, HDR recommends that the Sewer Utility implement a solution based on licensed software that includes vendor support, high-quality documentation, and access to training for Sewer Utility staff. Many of these software offerings feature relatively intuitive, customizable dashboards to help focus the user's attention on important metrics and information. An example dashboard from one vendor offering is shown in Figure 5-16.

Figure 5-16. Example network performance monitoring dashboard from SolarWinds



Source: SolarWinds Worldwide (2021).

Included in the Sewer Utility's solution should be a System Logging Protocol (Syslog) server on the OT network that receives Syslog messages, SNMP traps, and Windows event logs from OT network switches, firewalls, servers, PCs, and other network appliances. The Syslog server will establish a central logging repository for all OT network infrastructure, which will simplify monitoring and backup efforts. The Sewer Utility will also require software running on a separate server (virtual, not necessarily physical) to provide Sewer Utility staff with an intuitive user interface for monitoring network performance, auditing logs, and troubleshooting network events.

HDR recommends that the Sewer Utility implement a separate subnet dedicated to network management. This will establish a degree of isolation between network management traffic and critical network traffic related to SCADA and PLC-to-PLC communications, and allow the Sewer Utility to prioritize the latter (e.g., leveraging Quality of Service [QoS]). By placing network management traffic out-of-band from the production environment, the Sewer Utility will increase the likelihood that staff can access OT network devices during a network disruption affecting the production environment. Establishing a separate subnet for network management will also allow the Sewer Utility to more tightly control access to the Syslog server, making it more difficult for malicious actors to modify or delete logs to cover their tracks.

5.2.9 Cybersecurity Improvements

Perform ICS Server, PC, and OT Network Device Hardening to Mitigate Common Cybersecurity Risks

HDR recommends that the Sewer Utility perform an initial vulnerability assessment for its ICS server, PC, and OT network device infrastructure to provide configuration changes that will harden the devices against common cybersecurity vulnerabilities. Typical hardening procedures include, but are not limited to, changing default usernames and passwords; disabling unused network switch ports and assigning them to an unused VLAN (i.e., black hole VLAN); removal of non-essential programs on servers and PCs; upgrading to current firmware, software version, and security patches; and requiring the use of Hypertext Transfer Protocol Secure (HTTPS) when accessing web interfaces for device configuration. This effort should also include enabling Advanced Encryption Standard (AES) encryption on the radios involved in the Sewer Utility pump station VHF licensed radio WAN.

As part of the initial device hardening effort, the implemented hardening measures should be recorded in internal documentation that can be used as a reference for hardening devices added to the OT network at a later date. The internal documentation can also be used as the basis for scheduled configuration audits, where the Sewer Utility conducts a periodic review of ICS server, PC, and OT network device configurations to bring devices into compliance with standard hardening measures as well as updating the standard measures to address current firmware versions and known vulnerabilities. Non-sensitive information captured in this internal documentation should be included in the proposed Sewer Utility ICS standards so that contractors on future projects are held to minimum configuration and device hardening requirements.

Establish Unique User Accounts and Implement MFA for Tempered Networks Conductor Management

The Sewer Utility's Tempered Networks Conductor instance is cloud-hosted and requires users to authenticate over the Internet. Because the Conductor serves a critical role in establishing security policies and permissions for much of the Sewer Utility's OT network, access to the Conductor's web interface needs to be tightly controlled and changes to configurations and security policies should be attributable to specific individuals. HDR recommends that the Sewer Utility discontinue the use of generic user accounts for the Conductor and establish unique user accounts for the few individuals who require access to the Conductor. A general administrator account with full permissions should still be maintained for the purposes of creating and removing user accounts, but HDR recommends that login credentials for the administrator account not be shared with contracted systems integrators or other external parties. Once unique user accounts have been established, HDR recommends that the Sewer Utility implement MFA for accessing the Conductor web interface as an additional security control. MFA would apply to both the administrator account and unique user accounts.

Implement Role-based Overlay Networks for the Sewer Utility Tempered Networks Airwall System

HDR recommends implementing role-based overlay networks for the Sewer Utility Tempered Networks Airwall system that are configured to restrict access for member devices according to the Principle of Least Privilege. The following preliminary overlay networks are recommended. Note, these recommended overlay networks may be modified as the system architecture conceptual design is developed in Phase 4 of the Master Plan:

- **KWWTP:** This new overlay network would be dedicated to the data exchange between the SCADA server at the Kingston Wastewater Treatment Plant (KWWTP) and the SCADA servers at CKTP. Static membership would include the SCADA servers at the two WWTPs and any other OT network resource necessary to send real-time and buffered historical data to CKTP and for managed AVEVA InTouch HMI application updates to be pushed out to KWWTP from CKTP.
- **MWWTP:** This new overlay network would be dedicated to the data exchange between the SCADA server at the Manchester Wastewater Treatment Plant (MWWTP) and the SCADA servers at CKTP. Static membership would include the SCADA servers at the two WWTPs and any other OT network resource necessary to send real-time and buffered historical data to CKTP and for managed AVEVA InTouch HMI application updates to be pushed out to MWWTP from CKTP.
- **SWWTP:** This new overlay network would be dedicated to the data exchange between the SCADA server at the Suquamish Wastewater Treatment Plant (SWWTP) and the SCADA servers at CKTP. Static membership would include the SCADA servers at the two WWTPs and any other OT network resource necessary to send real-time and buffered historical data to CKTP and for managed AVEVA InTouch HMI application updates to be pushed out to SWWTP from CKTP.
- **Remote facilities:** This new overlay network would be dedicated to providing each remote WWTP and the County Public Works Annex with access to SCADA HMI screens for other WWTPs and the remote pump stations. Static membership would include a SCADA PC at each remote WWTP, a dedicated PC at the County Public Works Annex facility, and the Remote Desktop Gateway at CKTP.
- **Public Works Annex:** This new overlay would be dedicated to the data exchange between the CKTP SCADA servers and the backup server(s) at the County Public Works Annex facility required to support recommended off-site backup procedures. Static membership would include the CKTP SCADA servers, the County Public Works Annex facility backup server(s), and any other OT network resource necessary to support backup procedures.

  Note, if the Sewer Utility decides not to implement backup server(s) at the County Public Works Annex facility, this overlay network would not be necessary.
- **Kitsap IC:** This existing overlay network would be dedicated to the Sewer Utility I&C technicians and their immediate remote access needs. Static membership would include the Sewer Utility I&C technician laptop(s) and the Remote Desktop Gateway servers at the WWTPs. The static overlay network configuration would allow I&C technicians to establish remote desktop connections to servers and PCs at the various WWTPs via the Remote Desktop Gateway servers. For scenarios where I&C technicians require direct remote access to a PLC or other OT network resource that cannot be accessed via one of the PCs at the WWTPs, I&C technicians could temporarily add the device to the Kitsap IC overlay network. Once I&C technicians are finished with remote maintenance or troubleshooting for the device, it is recommended that they remove it from the overlay network.

  Note, if the Sewer Utility elects to provide I&C technicians with remote access to the WWTP Remote Desktop Gateway servers via the VPN service managed by the

County IS department, the static overlay network membership would include only the I&C technician laptop(s).

- **Remote support:** This existing overlay network would be dedicated to contracted systems integrators and their immediate remote access needs. Static membership would include one systems integrator laptop or PC at a time. This static overlay network configuration would not allow contracted systems integrator access to Sewer Utility OT network resources by default. When systems integrators require remote access to the OT network, the scope of their access requirements should be clearly defined so that Sewer Utility I&C technicians can add the appropriate servers, PCs, PLCs, and/or other OT network resources to the overlay network as needed. Once the systems integrator is finished with his/her work, all Sewer Utility OT network resources should be removed from the overlay network.
- **Mobile SCADA:** This new overlay would be dedicated to Sewer Utility staff requiring mobile access to the SCADA HMI screens. Static membership would include operations and supervisory staff tablets and/or laptops and the Remote Desktop Gateway server at CKTP.

  Note, if the Sewer Utility elects to provide staff with remote access to the CKTP Remote Desktop Gateway server via the VPN service managed by the County IS department, this overlay network would not be necessary.

Introduce OT Network Firewall Layer Upstream from WWTP Tempered Networks HIPswitches

The HIPswitches deployed at the Sewer Utility WWTPs are providing a single layer of defense at the periphery of the WWTP OT networks. HDR recommends introducing a firewall upstream from each WWTP HIPswitch as an additional security layer. In general, these firewalls would be configured to deny all except for necessary routes, ports, and protocols. The upstream firewall will also provide the Sewer Utility with the benefit of auditable firewall logs, which can be analyzed to detect abnormal activity originated from inside or outside of the OT network. If the Sewer Utility will be responsible for auditing the firewall logs, the logs should be pushed to the proposed Syslog server on the OT network. Otherwise, the logs would be routed as directed by the County IS department according to its logging practices.

Develop a Formal Cybersecurity Incident Response Program

HDR recommends that the Sewer Utility establish a formal cybersecurity incident response program that meets the following criteria:

- Establishes procedures to prepare for cybersecurity threats
- Enables staff to identify when cybersecurity incidents occur
- Indicates which individuals and agencies to contact once a cybersecurity incident is discovered
- Guides response to cybersecurity incidents
- Identifies coordination points and dependencies involving County IS and/or third-party service providers (e.g., Verizon Wireless)

- Includes guidelines for adequately documenting cybersecurity incidents and their resolutions
- Defines disaster recovery procedures, including definition of recovery time and recovery point objectives

Once this program is developed, it should be updated and practiced at regular intervals so that Sewer Utility staff can respond quickly and effectively should a cybersecurity incident occur.

- ✪ Upgrade CKTP control room.
- ✪ Extend OT network to County Public Works Annex facility.
- ✪ Migrate pump stations from VHF licensed radio WAN to cellular WAN.
- ✪ Implement store-and-forward and exception reporting for remote pump station telemetry and eliminate PLC data concentrator for cellular WAN.
- ✪ Improve communication status monitoring and alarming for remote pump station telemetry.
- ✪ Implement HIPswitch cellular failover functionality to establish communication link redundancy for WWTPs.
- ✪ Consolidate CKTP OT network servers, distribution switches, and other appliances in a network rack environment within the SPB.
- ✪ Upgrade to stacked Layer 3 distribution switches at CKTP SPB.
- ✪ Modifications to CKTP administration and laboratory building electrical room.
- ✪ Establish standard Layer 2 managed access switch with gigabit downlink ports for future OT network applications and replacement of select unmanaged switches.
- ✪ Establish cable path redundancy for critical segments of the OT network.
- ✪ Establish robust UPS battery backup solution for ICS and OT network infrastructure.
- ✪ Standardize on redundant onboard power supplies and 24 VDC power supplies for ICS and OT network infrastructure.
- ✪ Establish an industrial DMZ between Sewer Utility business LAN and OT network.
- ✪ Implement secure mobile access to SCADA HMI screens for remote and on-site staff.

- ✪ Implement secure remote access to OT network for I&C technicians and contracted systems integrators.
- ✪ Develop and implement an improved OT network segmentation scheme.
- ✪ Implement a domain for the CKTP OT network.
- ✪ Improve AAA measures for OT network.
- ✪ Establish virtualized environments for all ICS servers.
- ✪ Establish automated backup procedures for ICS servers that include on-premise and off-site storage.
- ✪ Implement OT network performance monitoring and logging capabilities.
- ✪ Perform ICS server, PCs, and OT network device hardening to mitigate common cybersecurity risks.
- ✪ Establish unique user accounts and implement MFA for Tempered Networks Conductor management.
- ✪ Implement role-based overlay networks for the Sewer Utility Tempered Networks Airwall system.
- ✪ Introduce OT network firewall layer upstream from WWTP Tempered Networks HIPswitches.
- ✪ Develop a formal cybersecurity incident response program.

6 ICS Hardware: Future Needs and Recommended Improvements

This section identifies the Sewer Utility's future needs related to its ICS hardware and describes the information and functionality that Sewer Utility staff would like to obtain from the ICS hardware in the future. The future needs presented are derived from information obtained from Sewer Utility staff during site assessment visits, workshops, and staff interviews. Based on comparison of current use cases to future needs of the Sewer Utility, the section presents recommended improvements for the ICS hardware.

6.1 Future Needs

This subsection describes the Sewer Utility's future needs as they relate to the ICS hardware.

6.1.1 Establish the Next PLC Platform Standard for the ICS

The Sewer Utility needs to select PLC technology to replace existing PLCs that are reaching the end of their useful life and to establish a new Sewer Utility standard moving forward to guide future ICS upgrades. The Sewer Utility needs to standardize on PLC platform(s) for both WWTP process control applications and for remote pump station control applications. The selected PLC platform(s) must meet the Sewer Utility's technical requirements, support integration of an increasing number of Ethernet devices, be compatible with existing PLC programming logic, and be actively supported by the manufacturer for the next 10 to 15 years. The Sewer Utility has identified that hot-standby controller redundancy is not required for any of the WWTP or pump station applications. Because the Sewer Utility has already standardized on Allen-Bradley for PLCs throughout its ICS infrastructure, the selection will be made from Allen-Bradley's most current product offerings.

Note, because the Sewer Utility has already standardized on MicroLogix 1400 PLCs for remote pump station RTU applications and has recently installed these PLCs at remote pump stations, Phase 3 of the Master Plan will focus on identifying standard applications for these PLCs and will not evaluate a replacement product.

6.1.2 Motor Controllers

Standardize on Motor Controllers with Ethernet Capability and Hardwired Signals for Control and Core Monitoring

The Sewer Utility would like to standardize on Ethernet motor controllers for future projects. The Sewer Utility is also interested in expanding the current practice of monitoring and archiving limited data from networked motor controllers to include more robust power, energy, alarm, and warning data. Hardwired signals will still be used for core monitoring (e.g., running, in auto, and in hand status, motor high temperature, etc.) and control of the equipment.

Eliminate DeviceNet Networks at CKTP

The Sewer Utility would like to eliminate DeviceNet networks within the CKTP motor control centers (MCCs). Replacement overload relays, variable-frequency drives (VFDs), and reduced-voltage soft starters (RVSSs) will require Ethernet communication capability to conform to the Sewer Utility's desired standard for motor controllers. The Sewer Utility would like to prioritize elimination of the DeviceNet networks within the CKTP headworks MCCs because these networks have been in service the longest and have generated more maintenance issues.

6.1.3 Establish the Next OIT Standard for the ICS

The Sewer Utility needs to select OIT technology to replace existing OITs that are reaching the end of their useful life and to establish a new Sewer Utility standard moving forward to guide future ICS upgrades. The Sewer Utility needs to standardize on an OIT solution that meets the Sewer Utility's technical requirements, integrates easily with Allen-Bradley PLCs, and is actively supported by the manufacturer for the next 5 to 10 years.

6.1.4 Thickened Sludge Truck Loadout Flow Monitoring at Remote WWTPs

The Sewer Utility would like to have a more accurate accounting of thickened sludge volumes received at CKTP from the remote WWTPs. Truck operators currently rely on thickened sludge storage tank level measurement and sight glasses to draw down the tanks and, without a means to measure actual volumes received by the trucks, the Sewer Utility is assuming full truck volumes for each trip. The Sewer Utility would like to install flowmeters for thickened sludge storage tank truck loadout stations at the remote WWTPs to establish a means for determining actual thickened sludge volumes transported to CKTP.

6.1.5 Implement Monitoring and Alarming for Composite Samplers

The Sewer Utility would like to implement monitoring and alarming for the composite samplers at its WWTPs. Sewer Utility staff need to be alerted to composite sampler faults via the SCADA system and would also like to view sample counts and when samples are in progress at the SCADA HMI.

6.1.6 Improved SCADA Monitoring of UV System at Remote WWTPs

Sewer Utility staff would like to have more detailed information on the remote WWTP ultraviolet (UV) systems available at the SCADA HMI screens. The ability to see which bulbs are failed, UV intensities, and other parameters would help them better monitor system performance. Having access to real-time and historical UV transmittance would also reduce the manual data collection effort for laboratory staff.

6.1.7 Implement CKTP Instrumentation and Automation Improvements

Establish an Improved Means of Plant Effluent Flow Monitoring

The Sewer Utility would like to improve its current approach to CKTP effluent flow monitoring described in TM-1. If implementing direct flow measurement is infeasible, the Sewer Utility would like to refine current indirect flow derivation to maximize accuracy and reduce the manual effort involved in the review and management of flow totals.

Automate and Optimize BNR Process Control

The Sewer Utility needs to transition from manual aeration control to automated control of the biological nutrient removal (BNR) process at CKTP. The Sewer Utility has already identified this as a high-priority initiative prior to the Master Plan and is working with Murraysmith, HDR, and QCC to develop and implement a solution as part of a separate facilities planning task.

Liquid Stream Flow Balance Monitoring

The Sewer Utility would like the ability to monitor a comprehensive liquid stream flow balance for CKTP. However, the Sewer Utility does not have flow measurement for the plant wastewater pump station return flow to upstream of the primary diversion channel, which is preventing a full accounting of liquid stream flows. Flow monitoring for this return flow would need to be implemented to enable a comprehensive liquid stream flow balance.

Solid Stream Flow Balance Monitoring

The Sewer Utility would like the ability to monitor a comprehensive solid stream flow balance for CKTP. However, the Sewer Utility does not have flow measurement for some solid stream processes, which is preventing a full accounting of solid stream flows. Flow monitoring for the following processes would need to be implemented to enable a comprehensive solid stream flow balance:

- Primary sludge flow to gravity-belt thickeners (GBTs)
- Primary and secondary scum flow to GBTs (currently primary and secondary clarifiers are served by the same scum pumps)
- Incoming septage flow received at septage receiving station
- Mixed liquor distribution channel foam wasting flow to digesters
- Thickened sludge flow from each GBT to thickened sludge blending tank (currently only combined flow is monitored)
- Hauled sludge flow to thickened sludge blending tank
- Digested sludge flow from each digester to centrifuges (currently only combined flow is monitored)

6.1.8 Implement KWWTP Instrumentation and Automation Improvements

Liquid Stream Flow Balance Monitoring

The Sewer Utility would like the ability to monitor a comprehensive liquid stream flow balance for KWWTP. However, the Sewer Utility does not have flow measurement for some liquid stream processes, which is preventing a full accounting of liquid stream flows. Flow monitoring for the following processes would need to be implemented to enable a comprehensive solid stream flow balance:

- Biofilter sump flow to oxidation ditches
- Process building sump flow to headworks
- Potable water (W2) flow to plant processes

Solid Stream Flow Balance Monitoring

The Sewer Utility would like the ability to monitor a comprehensive solid stream flow balance for KWWTP. However, the Sewer Utility does not have flow measurement for the secondary scum flow from the secondary scum pumps to the waste activated sludge (WAS)/thickened waste activated sludge (TWAS) tanks, which is preventing a full accounting of solid stream flows.

6.1.9 Implement MWWTP Instrumentation and Automation Improvements

Liquid Stream Flow Balance Monitoring

The Sewer Utility would like the ability to monitor a comprehensive liquid stream flow balance for MWWTP. However, the Sewer Utility does not have flow measurement for some liquid stream processes, which is preventing a full accounting of liquid stream flows. Flow monitoring for the following processes would need to be implemented to enable a comprehensive solid stream flow balance:

- Plant influent flow
- Odor control blowdown sump flow to headworks
- W2 flow to plant processes
- Service water (W3) flow to plant processes
- In-plant pump station flow to headworks

Solid Stream Flow Balance Monitoring

The Sewer Utility would like the ability to monitor a comprehensive solid stream flow balance for MWWTP. However, the Sewer Utility does not have flow measurement for some solid stream processes, which is preventing a full accounting of solid stream flows. Flow monitoring for the following processes would need to be implemented to enable a comprehensive solid stream flow balance:

- WAS flow to WAS tanks
- Secondary scum flow to WAS/TWAS tanks

Aeration Basin Aeration Control Upgrades

Sewer Utility staff would like to upgrade the existing constant-speed blowers to VFD-controlled blowers to reduce energy consumption and improve aeration control. Sewer Utility staff would also like to install analytical probes within the aeration basins to reduce manual probe measurement requirements and to allow for automated control of the blowers. The Sewer Utility has identified a potential CIP project to upgrade the plant to meet new total nitrogen (TN) limits and these aeration basin aeration control upgrades would be included in that effort. In the meantime, Sewer Utility staff would like to have the ability to schedule and adjust the current blower operation time sequence from the SCADA HMI.

Implement SCADA Control of Sludge Wasting

The WAS pump at MWWTP is no longer in service and operations staff now use the two return activated sludge (RAS) pumps for sludge wasting to the WAS tanks, similar to the configuration at KWWTP. However, unlike KWWTP, the isolation valve on the WAS line to the WAS tanks is a manual valve so operations staff must manually position the valve to send WAS flow to the WAS tanks. The Sewer Utility would like to be able to control this valve from SCADA so that the sludge wasting process can be automated.

Integrate Headworks Mixing Channel Blower Alarm at SCADA

Sewer Utility staff would like to receive an alarm at SCADA when the mixing channel blower at the headworks building has faulted. Currently, operations staff are required to manually check in on the equipment while conducting their rounds to confirm that the equipment is not in alarm state.

6.1.10 Implement SWWTP Instrumentation and Automation Improvements

Liquid Stream Flow Balance Monitoring

The Sewer Utility would like the ability to monitor a comprehensive liquid stream flow balance for SWWTP. However, the Sewer Utility does not have flow measurement for some liquid stream processes, which is preventing a full accounting of liquid stream flows. Flow monitoring for the following processes would need to be implemented to enable a comprehensive solid stream flow balance:

- Drain collection pump station flow to headworks equipment
- W3 flow to plant processes

Analytical Probe Monitoring for SBRs

Sewer Utility staff would like to install analytical probes within the sequencing batch reactors (SBRs) to reduce manual probe measurement requirements and to allow for automated control of the aeration blower speed and runtimes.

Improved Dewatering Performance

Sewer Utility staff would like to resolve the issue causing the thickened sludge pump to trip on high pressure at increased sludge concentrations. Resolving the issue would eliminate the need for manually operating the rotary-drum thickener (RDT) and allow the Sewer Utility to fully utilize the RDT to increase the degree of dewatering achieved at the plant.

Stable Effluent Control Valve Control

The Sewer Utility needs to restore stable position control for the effluent control valve so that operations staff can control the valve from SCADA and rely on it to maintain its position.

Sludge Storage Tank Level Measurement

The Sewer Utility needs to implement reliable level measurement for the SWWTP sludge storage tank. A more permanent installation for the backup high level float switch is also required.

Thickened Sludge Storage Tank Level Measurement

The Sewer Utility would like to improve the reliability of the SWWTP thickened sludge storage tank level measurement.

6.1.11 Implement Remote Pump Station Instrumentation and Automation Improvements

Force Main Pressure Monitoring

The Sewer Utility would like to standardize on force main pressure monitoring at its critical remote pump stations. With the addition of force main pressure data with already available flow data from pump station flowmeters, Sewer Utility staff will have the ability to monitor pump performance and receive advanced indicators of pump health degradation and/or potential issues within conveyance system force mains.

6.2 Recommended Improvements

This subsection describes the recommended improvements related to ICS hardware.

6.2.1 Establish Sewer Utility PLC Platform Standard and Schedule Replacement of Select WWTP and Remote Pump Station PLCs

In Phase 3 of the Master Plan, new PLC platform(s) will be identified to replace existing PLCs that are reaching the end of their useful life and to establish a new Sewer Utility standard moving forward to guide future ICS upgrades. In addition to defining the standard PLC platform(s), the Sewer Utility’s preferred input/output (I/O) module types should also be determined so that appropriate model numbers can be identified in the Sewer Utility’s ICS standards documentation in an effort to reduce spare-parts inventory in the future.

Once new PLC platform standards have been identified, PLC replacement projects will be identified in Phase 5 of the Master Plan to upgrade PLCs that are reaching the end of their useful life and/or are no longer supported by the manufacturer. Based on years in service, manufacturer support, and criticality of the application, HDR recommends that the Sewer Utility prioritize PLC replacement as indicated in Table 6-1.

Table 6-1. PLC replacement priority

Priority	Facility	Panel tag	Panel description	Year installed
1	PS-24	N/A	Main control panel	2000
2	PS-4	N/A	Main control panel	2004
2	PS-17	N/A	Main control panel	2004
2	PS-7	N/A	Main control panel	2007
3	PS-71	N/A	Main control panel	2004
4	CKTP	PNL 1021	Influent screen 1 main control panel	2010
4	CKTP	PNL 1023	Influent screen 3 main control panel	2010
4	CKTP	PNL 1026	Screwpactor main control panel	2010
4	CKTP	PNL 1050	Headworks control panel	2010
4	CKTP	PNL 1111	Grit washer 1 control panel	2010
4	CKTP	PNL 1112	Grit washer 2 control panel	2010
5	CKTP	N/A	Raptor Acceptance Control System (RACS) operator interface control panel	2010
5	CKTP	PNL 5010	Raptor septage acceptance plant control panel	2010
6	CKTP	PNL 4050	Polymer blending system control panel	2014
6	CKTP	PNL 4080	Polymer feed system control panel	2014
6	CKTP	PNL 8200	Filter system control panel	2014
6	CKTP	PNL 9201	Digester gas treatment control panel[a]	2014
6	CKTP	N/A	Master station central telemetry unit (CTU) (radio)	2017

a. PLC replacement not required if cogeneration system is not returned to service.

6.2.2 Develop a Standard Approach for Monitoring and Control of Motorized Equipment

HDR recommends that the Sewer Utility develop a standard approach for monitoring and control of motor controllers throughout its infrastructure. The main motor controller categories needing standardization include full-voltage non-reversing (FVNR) starters, full-voltage reversing (FVR) starters, VFDs, RVSSs, electric actuators for isolation gates/valves, and electric actuators for modulating gates/valves. The standard approach should define requirements for the following, at a minimum:

- Local indication lights, selector switches, pushbuttons, runtime meter, human interface module (HIM), and other instrumentation required at the MCC unit door or motor starter/VFD enclosure (this would not apply to electric actuators)

- Hardwired I/O between the motor controller and SCADA
- Ethernet parameters communicated between the motor controller and SCADA (this would not apply to electric actuators)
- Graphical representation of motor/asset at SCADA HMI process-level and equipment-level screens and pop-up windows
- Associated alarms and alarm priorities
- Means of communicating alarms or conditions, external to the equipment, that are inhibiting the equipment from running
- Parameters to be recorded within the Sewer Utility historian

Defining standard approaches to monitoring and control of motorized equipment will enable QCC or another systems integrator to develop standard automation programming templates for each type of motorized equipment that can then be consistently applied to future ICS upgrades for the Sewer Utility and documented in the proposed Sewer Utility ICS standards documentation. Examples of standard automation programming templates include Add-on Instructions (AOIs) and User-defined Data Types (UDTs) used within Rockwell Automation Studio 5000 Logix Designer project files and AVEVA Asset Library template objects deployed within AVEVA System Platform.

HDR recommends that the standards related to motor controllers be determined prior to the replacement of DeviceNet networks in the CKTP MCCs. This will help to ensure that Sewer Utility preferences are applied to the equipment within these MCCs, which represents a significant portion of the Sewer Utility's assets.

It should be noted that vendor package equipment like aeration blowers requires special consideration and should be handled on a case-by-case basis depending on Sewer Utility preferences and vendor capabilities.

6.2.3 Develop a Standard Approach for Monitoring Remote Pump Stations

HDR recommends that the Sewer Utility develop a standard approach for monitoring its remote pump stations. The existing RTUs currently communicate pump runtimes and a set of bits that, with some exceptions, represent standard status and alarm states for all pump stations. A few stations also communicate flow. The proposed telemetry improvements will allow the Sewer Utility to obtain additional parameters in near real-time. HDR recommends that the Sewer Utility evaluate the information it would like to obtain from its pump stations and then standardize on the instrumentation, PLC and RTU programming, and SCADA HMI graphics representation. The standard approach should define requirements for the following, at a minimum:

- Analog process values to monitor at SCADA (e.g., wet well level, flow, force main pressure, chemical tank level).
- Process alarms (e.g., wet well high level, low flow when pumps are running, high force main pressure, low chemical tank level) and alarm priorities.
- Equipment status, alarms, and alarm priorities.

- Pump station alarms (e.g., smoke detected, flood, intrusion) and alarm priorities.
- Generator and electrical distribution system status, power and energy parameters, alarms, and alarm priorities.
- Pump power and energy parameters.
- Graphical representation of pump station at SCADA HMI process-level and equipment-level screens and pop-up windows. SCADA HMI pump station template(s) should be developed to hide or otherwise remove content and parameters that have not been implemented at a given pump station so that it is clear to Sewer Utility staff which parameters are actually being monitored.
- Parameters to be recorded within the Sewer Utility historian.

As with the monitoring and control of motorized equipment, defining standard approaches to monitoring of remote pump stations will enable QCC or another systems integrator to develop standard automation programming templates that can then be consistently applied to future ICS upgrades for the Sewer Utility and documented in the proposed Sewer Utility ICS standards documentation.

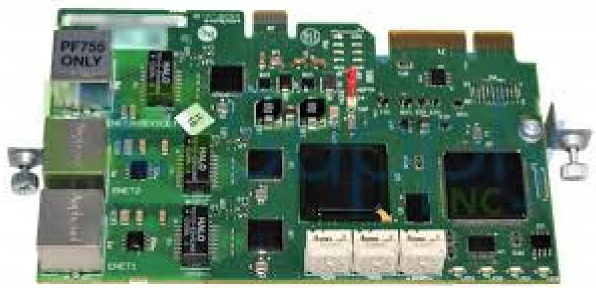
6.2.4 Replace CKTP MCC DeviceNet Networks with Ethernet-capable Motor Controllers

To support the Sewer Utility's goal of eliminating DeviceNet networks from its infrastructure while preserving as much of the recent investment in CKTP MCC infrastructure as possible, HDR recommends retrofitting existing CKTP MCC units rather than a complete replacement of the MCC lineups. The following paragraphs describe specific recommendations involved with the retrofit work.

VFD Communication Adapter/Module Replacement

Two types of Allen-Bradley VFDs are installed within the CKTP MCCs containing DeviceNet networks: PowerFlex 700 alternating-current (AC) drives (in the headworks MCCs) and PowerFlex 753 AC drives (in the MCCs installed as part of the Resource Recovery project). Allen-Bradley provides a 20-COMM-E EtherNet/IP adapter (see Figure 6-1 [left]) for the PowerFlex 700 series drives and a 20-750-ENETR EtherNet/IP option module (see Figure 6-1 [right]) for the PowerFlex 750 series drives. These components could be used to replace the DeviceNet adapters/modules in the existing VFDs to enable Ethernet communication for the drives using the EtherNet/IP protocol that the existing Allen-Bradley PLCs support natively. Both of these components are in the active support phase of the manufacturer's product life cycle and would present an opportunity for extending the life of the existing VFDs while also removing them from the DeviceNet network (Rockwell Automation 2020a).

Figure 6-1. 20-COMM-E EtherNet/IP adapter and 20-750-ENETR EtherNet/IP option module

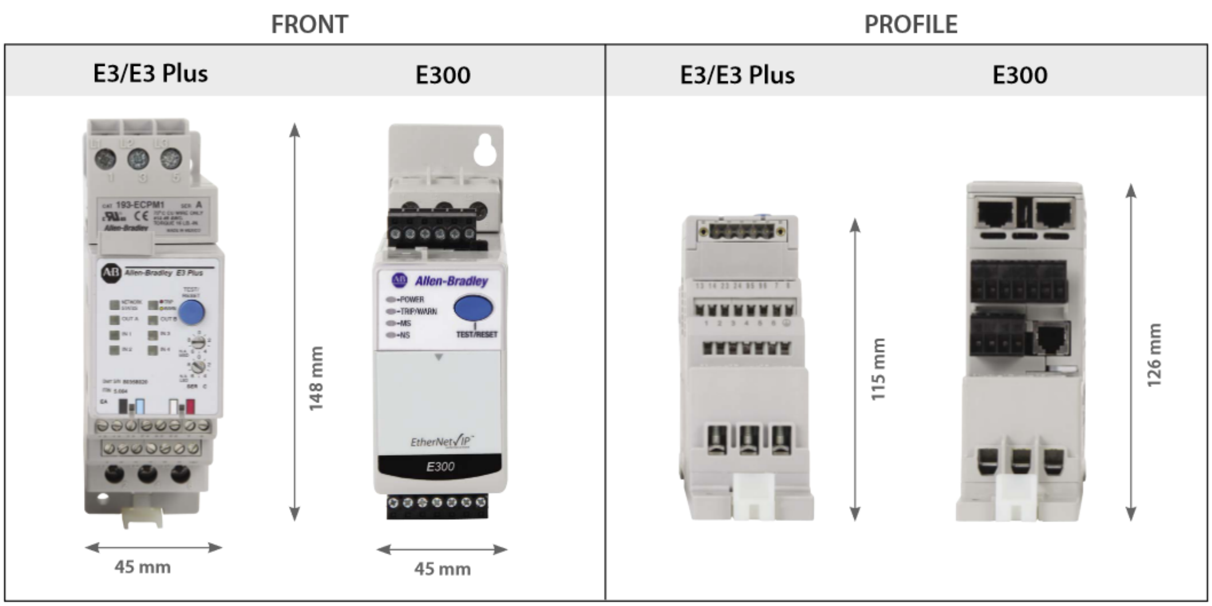


Source: Rockwell Automation.

Overload Relay Replacement

Allen-Bradley E3 Plus electronic overload relays are installed in the CKTP MCCs containing DeviceNet networks. The DeviceNet communication capability is integral to these relays and no module or adapter swap-out option is available. Allen-Bradley has also discontinued the E3 Plus electronic overload relay product line and is encouraging migration to its E300 electronic overload relay family, which has native EtherNet/IP communication capability (Rockwell Automation 2020a). Fortunately, the manufacturer has developed the E300 with retrofits in mind and the footprint of the two overload relays is identical (see Figure 6-2), though the E300 is a little deeper to support RJ45 connections. HDR recommends replacing the E3 Plus electronic overload relays with E300 electronic overload relays or other most current manufacturer offering at the time the DeviceNet network replacement work is implemented.

Figure 6-2. Allen-Bradley E3 Plus and E300 electronic overload relay dimensions



Source: Rockwell Automation (2019).

Some of the MCC units containing E3 Plus electronic overload relays also contain Allen-Bradley Point I/O or DeviceNet Starter Auxiliary components to handle additional hardwired I/O that could not be accommodated by the inputs and outputs integral to the E3 Plus relay. These components are also included in the DeviceNet network and are recommended for replacement with expansion I/O modules compatible with the new E300 relays.

Additional MCC Unit Modifications, Field Wiring, and PLC I/O Expansion

The DeviceNet MCCs at CKTP currently rely on the DeviceNet networks for virtually all monitoring and control between the MCC units and the PLCs. In order for the Sewer Utility to establish its preference of hardwired I/O for core monitoring and control points, additional modifications will be required at the MCC units. Currently, hardwired I/O from field devices like selector switches and motor winding thermostats are wired directly to inputs at the overload relay, VFD, or expansion I/O device. These signals will need to remain in place after the VFD and overload relay upgrades, yet some of these signals will also need to be sent to the PLC control panels in the electrical room to satisfy the Sewer Utility's preference of hardwired I/O for signals such as in auto status and motor high temperature alarm. This will likely require introducing control relays and additional field wiring terminals to the MCC units, which would in turn require that there be sufficient space in the existing MCC units to accommodate these additional components. HDR recommends that the Sewer Utility verify MCC unit sizing requirements for implementing the Sewer Utility's standards for monitoring and control of motorized equipment as part of a detailed design phase preceding the DeviceNet network replacement.

The PLC control panels within the electrical rooms housing the MCCs will also need to have additional I/O modules and field terminal blocks added to accommodate the new hardwired I/O from the MCC units. This hardwired I/O will be significant and may require the addition of RIO racks within the existing enclosures, subpanel replacement, and/or new control panels (if existing control panels have insufficient space available). New conduit and control wiring will also be required in the electrical room to establish hardwired I/O connections between the MCC units and control panel(s). The existing DeviceNet scanner modules in the PLC racks would be removed once they are no longer required.

New MCC Ethernet Networks

In addition to the hardwired I/O, the new VFD communication adapters/modules and overload relays will require Ethernet connections to the OT network to support monitoring of power, energy, and detailed alarm and warning parameters. HDR recommends that the Sewer Utility use shielded Category 6 cable with 600-volt (V) insulation for these Ethernet connections and that the cables be installed as homeruns from the individual MCC units to one or more managed network switches within the electrical room PLC control panel(s). Though the proposed overload relays and VFD communication modules support device-level ring (DLR), HDR does not recommend pursuing a ring architecture to reduce the Ethernet cabling requirements between the MCCs and PLC control panel(s). DLR topologies require disruptions when devices are added to or removed from the network, limit network switch options because of the requirement of DLR-capable ports, introduce additional complexity and configuration requirements to the OT network, and are much more difficult to troubleshoot when a ring participant misbehaves and disrupts the network.

PLC Programming Modifications

PLC programming modifications will be required to realign existing AOIs, UDTs, subroutines, and communications configuration based on DeviceNet communications with a combination of hardwired I/O points and EtherNet/IP data exchange. The existing PLC programming will also need to be modified and expanded to align with the Sewer Utility's standards for monitoring and control of motorized equipment and to incorporate additional parameters related to power, energy, alarms, and warnings that are not already covered. Existing PLC programming related to process control would not likely require significant modifications.

6.2.5 Establish Sewer Utility OIT Platform Standard and Schedule Replacement of Select WWTP and Remote Pump Station OITs

In Phase 3 of the Master Plan, a new OIT platform will be identified to replace existing OITs that are reaching the end of their useful life and to establish a new Sewer Utility standard moving forward to guide future ICS upgrades. The following three significant factors are anticipated to contribute to the selection of the new OIT platform:

- Potential for reuse of existing OIT application files
- Licensing requirements and costs
- Potential for leveraging Sewer Utility standard template objects developed for AVEVA platform

Once new OIT platform standards have been identified, OIT replacement projects will be identified in Phase 5 of the Master Plan to upgrade OITs that are reaching the end of their useful life and/or are no longer supported by the manufacturer. Based on years in service, manufacturer support, and criticality of the application, HDR recommends that the Sewer Utility prioritize OIT replacement as indicated in Table 6-2. Other OITs identified in TM-1 as nearing the end of a typical 7- to 10-year service life in the coming years should be evaluated on a case-by-case basis and could be replaced as time and funding allow.

Table 6-2. OIT replacement priority

Priority	Facility	Panel tag	Panel description	Year installed
1	PS-24	N/A	Main control panel	2000
2	PS-4	N/A	Main control panel	2004
2	PS-17	N/A	Main control panel	2004
2	PS-71	N/A	Main control panel	2004
3	KWWTP	CP-300	Process building control panel[a]	2004
4	CKTP	N/A	RACS operator interface control panel	2010

a. OIT replacement may not provide much benefit with SCADA PC in nearby control room and OIT could be eliminated instead.

6.2.6 Develop a Formal Instrument Calibration and Maintenance Program

HDR recommends that the Sewer Utility develop a formal instrument calibration and maintenance program for its WWTPs and remote pump stations. At a minimum the program should accomplish the following objectives:

- Determine the individuals responsible for scheduling calibration events, performing calibration procedures, maintaining program documentation, and reviewing calibration records to determine when additional corrective action is required.
- Maintain an accurate inventory of installed instrumentation with manufacturer, model, and part number(s).
- Document instrument range, last calibration date, next calibration date, accuracy requirements, most recent calibrated zero and span settings for analog instruments, and most recent calibrated set point (rising or falling) and deadband settings for switches.
- Document instrument-specific calibration procedures based on instrument manufacturer recommendations. Calibration procedures should include steps to test the instrument sensor (input), instrument 4–20 milliampere (mA) output or switch contact state, and instrument loop, including verification of correct value/state being displayed at the HMI or OIT.
- Document ideal frequency of calibration activities based on manufacturer recommendations, field observations, instrument criticality, and past instrument performance.
- Schedule calibration activities and ensure that they are performed and documented.
- Maintain calibration records that document as-found settings, as-found test results, final calibration settings, final calibration test results, field observations, individual(s) who performed the calibration, and date of calibration.
- Identify instruments that require additional maintenance or replacement.

Several commercially available software options can simplify management of an instrument calibration and maintenance program. However, the Sewer Utility may be able to avoid additional software license costs by leveraging LLumin for the scheduling and tracking of calibration activities if instruments are included in the LLumin asset database. If the Sewer Utility elects to contract with a testing firm to perform calibration activities, HDR recommends that the Sewer Utility require that calibrations performed are traceable to NIST and that requirements for documentation produced by the testing firm be stipulated clearly in the contract.

6.2.7 CKTP Digester Building PNL 6000 Relocation and MCC Replacement

HDR recommends that the Sewer Utility relocate PNL 6000 or establish a replacement PLC control panel in a properly conditioned environment that does not have a hazardous-area classification. HDR also recommends that the Sewer Utility plan for the replacement of the digester building MCC as part of the next CIP project involving the digesters or within the next 3 years, whichever occurs first. Because of the poor environmental conditions within the digester building, HDR recommends that the replacement MCC be installed elsewhere. Because the MCC replacement is beyond the scope of the Master Plan, it should be included in the electrical recommendations from the ongoing facilities planning effort led by Murraysmith so that it can be incorporated into the Sewer Utility's CIP budget and schedule. HDR believes that Murraysmith is already planning on making this recommendation.

6.2.8 Include Integration of Composite Sampler Alarms and Monitoring with Replacement of Existing Samplers

The Sewer Utility is preparing to replace the composite samplers at its WWTPs and is evaluating quotes received from vendors. Because the Sewer Utility wishes to monitor sampler alarms and status at SCADA, HDR recommends that the Sewer Utility communicate its requirements for SCADA monitoring to the vendors so that the appropriate hardwired and communication options can be considered. Once samplers are replaced, available alarms and statuses should then be incorporated into the WWTP SCADA HMI screens and alarm notification system.

6.2.9 Evaluate Remaining Years of Useful Service Life for Remote WWTP UV Systems to Determine Best Approach for Improved SCADA Monitoring of the UV Systems

The existing UV systems at the remote WWTPs are TrojanUV3000B systems with the basic controller option. These basic controllers provide contacts for monitoring of bank status and a common alarm, but do not support additional remote monitoring or control functionality. TrojanUV does have a Touch Smart Controller option for the TrojanUV3000B systems that could replace the existing basic controllers (see Figure 6-3). The Touch Smart Controller would provide the following limited additional monitoring and control capabilities:

- Low and high water level alarms (if optional level probes are installed)
- Remote system on/off control
- Remote system enable/disable
- Remote turning on of additional bank
- Common alarm is replaced with common minor alarm and common major alarm
- Low UV intensity alarm
- Bank UV intensity alarm
- Average UV intensity (4–20 mA)
- Color touchscreen display for improved operator interface

Figure 6-3. TrojanUV3000B Touch Smart Controller

Source: TrojanUV (2018).

While the Touch Smart Controller would provide some additional remote monitoring and control capabilities, it would not provide individual lamp status, detailed alarming, and other parameters available with some of the vendor's system offerings. HDR recommends evaluating the remaining years of useful service life for the remote WWTP UV systems prior to making a decision on controls upgrades for these systems. If the UV systems will require replacement in the next 3 to 5 years, HDR would recommend waiting to implement improved monitoring and control until the system is replaced and a more complete monitoring and control solution can be specified.

Once the UV systems and/or controllers are replaced, HDR recommends providing PLC programming and SCADA HMI screen modifications to implement an equipment-level HMI screen for the UV system where more detailed status and alarm information can be monitored. Embedded trends showing UV intensity and plant effluent flow are also recommended for this screen so that the UV controller's flow-pacing control functionality can be monitored.

6.2.10 Implement CKTP Instrumentation and Automation Improvements

Instrumentation Upgrades and Replacement

The following items include HDR recommendations for additional instrumentation and servicing and replacement of failed instrumentation at CKTP. Note, these recommendations are general and, in some cases, would require further evaluation beyond the scope of the Master Plan to determine feasibility and detailed design requirements. Confirmation of appropriate instrument technology, installation location, and specification requirements for new instruments should be determined through a more detailed design process.

- Perform an alternatives analysis for implementing a direct means of plant effluent flow measurement to assess costs and feasibility of available options.
- Provide additional analytical probes and, potentially, aeration flowmeters per recommendations from a separate BNR optimization task in the Sewer Utility facility planning program.
- Consider installing a flowmeter on the plant wastewater pump station discharge line to obtain a return flow measurement to upstream of the primary diversion channel. Based on a cursory review of record drawings, it appears that there is not adequate room to install a magmeter in the existing wastewater pump station valve vault. A magmeter could be installed in a new meter vault downstream from the valve vault potentially.
- Consider installing a flowmeter on the primary sludge line to GBTs to monitor primary sludge flow from the primary sludge pumps.
- Consider installing a flowmeter on the scum line to GBTs to monitor primary and secondary scum flow from the scum pumps.
- Consider installing a flowmeter on the mixed liquor line from the mixed liquor distribution channel foam wasting sump to monitor mixed liquor flow to the digesters.
- Consider installing flowmeters on the thickened sludge lines from the GBTs to the thickened sludge blending tank to monitor individual thickened sludge flows from each GBT.
- Consider installing a flowmeter on the thickened sludge line from the hauled sludge receiving station to the thickened sludge blending tank to monitor hauled sludge flows received from remote WWTPs.
- Consider installing flowmeters on the digested sludge lines from the digesters to the centrifuges to monitor individual digested sludge flows from each digester.
- During next septage receiving station upgrade, ensure that the replacement vendor package system includes incoming septage flow monitoring.
- Service or replace the lower explosive limit (LEL) transmitter on the headworks odor control fan ductwork.
- Service or replace the chlorine residual and turbidity analyzers associated with the reclaimed water system.
- Service or replace the thermal dispersion flowmeter installed on the aeration line for the aerated grit tank 1 stage 2 diffuser.
- Consider installing suspended solids probes in the aeration basins (or potentially one probe to represent all basins in the mixed liquor distribution channel) and WAS pump discharge line to support automated calculation of hydraulically determined solids retention time (SRT). If installation of a suspended solids probe on the WAS pumps discharge line is infeasible, a probe could be installed on the RAS pumps discharge line with the assumption that the suspended solids profile would be the same.

Automation Improvements

The following items include HDR recommendations for automation improvements at CKTP:

- Develop a SCADA HMI screen (or modify existing) for monitoring the comprehensive liquid stream flow balance for the plant along with hydraulic retention time (HRT) values for tanks, basins, and clarifiers. HDR recommends that real-time and daily peak-hour flow data be displayed within the context of the associated process/pump system design capacity. If the plant effluent flow monitoring alternatives analysis determines that direct flow measurement is infeasible, the liquid stream flow balance SCADA HMI screen should provide a comparison of derived effluent flow values based on UV system flow-over-the-weir calculations and calculated effluent flow from individual liquid stream flow measurements.
- Develop a SCADA HMI screen for monitoring the comprehensive solid stream flow balance for the plant along with detention time values for GBTs, digesters, and the thickened sludge blending tank. HDR recommends that real-time and daily peak-hour flow data be displayed within the context of the associated process/pump system design capacity.
- Provide PLC programming and SCADA HMI modifications to monitor mixed liquor suspended solids and WAS suspended solids and to calculate hydraulically determined SRT. HDR recommends that the Sewer Utility continue operating based on laboratory-determined SRT while comparing performance of the hydraulically determined SRT calculated via the SCADA system with lab data. This comparison should be used to determine ideal suspended solids probe location(s) for the aeration basins/mixed liquor distribution channel and, if SRT values calculated via the SCADA system are found to align reasonably well with laboratory-determined SRT values, to evaluate the potential for implementing automated SRT control at the plant.
- Provide PLC programming and SCADA HMI modifications to restore automated control of the BNR process per recommendations from the separate BNR optimization task in the Sewer Utility facility planning program.
- Develop a SCADA HMI screen to provide operators with situational awareness for the load shedding and emergency load sequencing during planned and unplanned transitions between utility and standby generator power. Currently, when utility power is lost and standby generator(s) are started, Sewer Utility staff must rely on institutional knowledge to determine which loads will be allowed to resume operation and in which order. There are multiple sequence levels and time delays implemented in PLC logic that are not transparent to the operators, making it difficult to understand when a load should resume operation and when to take action if it fails to do so. HDR recommends that loads governed by load sequencing are grouped according to their sequence level on the proposed SCADA HMI screen. The screen should indicate whether the loads will be called to run when their sequence level is reached, after which their running status should be displayed and alerts provided when loads fail to run. Real-time countdowns should also be displayed for each sequence level so that operators have more context for when equipment operations will be restored. The Sewer Utility could also consider displaying live power (kW) values for the

sequenced loads that have been called to run along with cumulative generator loading. This information would support analysis of how effectively the loads are allocated among the sequence levels and may inform troubleshooting efforts.

As part of the effort to develop the proposed SCADA HMI screen, HDR recommends that the PLC programming logic related to the load shedding and emergency load sequencing be reviewed. HDR's cursory review of some of this logic as part of the BNR optimization effort uncovered some errors that should be corrected. It is also possible that the emergency load sequencing logic may not have been modified to incorporate loads added by recent construction projects.

- Replace the headworks odor control biofilter sprinkler control panel and associated instrumentation to restore automated control of the biofilter sprinklers/soaker hose. As part of the control panel replacement, HDR recommends that SCADA manual controls also be implemented as an optional override of the sprinkler control panel to allow operations staff to manually initiate and schedule timer-based watering of the biofilter from SCADA HMIs.
- Provide PLC programming modifications to establish a low-level shutdown interlock for the thickened sludge blending tank circulation pump and digester feed pumps based on tank level transmitter measurement to support elimination of the thickened sludge blending tank low level switch. Alternatively, replace the low level switch.
- Record drawings indicate that the primary clarifier drives are not monitored for high torque warnings or alarms at SCADA. HDR recommends that the Sewer Utility establish monitoring of high torque warning and high-high torque shutdown conditions at SCADA for its primary clarifiers.

6.2.11 Implement KWWTP Instrumentation and Automation Improvements

Instrumentation Upgrades and Replacement

The following items include HDR recommendations for additional instrumentation and servicing and replacement of failed instrumentation at KWWTP. Note, these recommendations are general and, in some cases, would require further evaluation beyond the scope of the Master Plan to determine feasibility and detailed design requirements. Confirmation of appropriate instrument technology, installation location, and specification requirements for new instruments should be determined through a more detailed design process.

- Consider installing a flowmeter for the thickened sludge storage tank truck loadout station.
- Consider installing a flowmeter on the biofilter sump pump station discharge line to monitor biofilter drainage flow to the oxidation ditches.
- Consider installing a flowmeter on the process building sump pump station discharge line to monitor return flow to the headworks.
- Consider installing a flowmeter on the W2 line downstream from the hydropneumatic tank to monitor W2 flow to plant processes.

- Consider installing a flowmeter on the secondary scum pump discharge line to monitor secondary scum flow to the WAS/TWAS tanks.
- HDR recommends that the Sewer Utility consider installation of suspended solids probes in the oxidation ditches and WAS line at KWWTP based on the outcome of suspended solids probe and hydraulically determined SRT calculation performance at CKTP.

Automation Improvements

The following items include HDR recommendations for automation improvements at KWWTP:

- Develop a SCADA HMI screen for monitoring the comprehensive liquid stream flow balance for the plant along with HRT values for tanks, oxidation ditches, and clarifiers. HDR recommends that real-time and daily peak-hour flow data be displayed within the context of the associated process/pump system design capacity.
- Develop a SCADA HMI screen for monitoring the comprehensive solid stream flow balance for the plant along with detention time values for WAS and TWAS tanks. HDR recommends that real-time and daily peak-hour flow data be displayed within the context of the associated process/pump system design capacity.
- If the Sewer Utility experiences favorable results with the suspended solids probes and hydraulically determined SRT calculations at CKTP, provide PLC programming and SCADA HMI modifications to monitor mixed liquor suspended solids and WAS suspended solids and to calculate hydraulically determined SRT at KWWTP. HDR recommends that the Sewer Utility continue operating based on laboratory-determined SRT while comparing performance of the hydraulically determined SRT calculated via the SCADA system with lab data. This comparison should be used to determine ideal suspended solids probe location(s) for the oxidation ditches and, if SRT values calculated via the SCADA system are found to align reasonably well with laboratory-determined SRT values, to evaluate the potential for implementing automated SRT control at the plant.

6.2.12 Implement MWWTP Instrumentation and Automation Improvements

Instrumentation Upgrades and Replacement

The following items include HDR recommendations for additional instrumentation and servicing and replacement of failed instrumentation at MWWTP. Note, these recommendations are general and, in some cases, would require further evaluation beyond the scope of the Master Plan to determine feasibility and detailed design requirements. Confirmation of appropriate instrument technology, installation location, and specification requirements for new instruments should be determined through a more detailed design process.

- Consider installing a flowmeter for the thickened sludge storage tank truck loadout station.

- Provide a means of plant influent flow monitoring. HDR recommends evaluating installation of an ultrasonic or radar level instrument at the existing Parshall flume downstream from the grit chamber to obtain this flow measurement.
- Replace the magmeter on the sludge line feeding the GBT.
- Consider installing a flowmeter on the odor control blowdown sump discharge line to the headworks to monitor blowdown return from odor control.
- Consider installing a flowmeter on the W2 line downstream from the hydropneumatic tank to monitor W2 flow to plant processes.
- Service or replace the flowmeter on the W3 line to restore monitoring of W3 flow to plant processes.
- Consider installing a flowmeter on the in-plant pump station discharge line to obtain return flow measurement to the headworks.
- Consider installing a flowmeter on the WAS line from the RAS pump station to the WAS tanks to monitor WAS flow.
- Consider installing a flowmeter on the secondary scum pump discharge line to monitor secondary scum flow to the WAS/TWAS tanks.
- HDR recommends that the Sewer Utility consider installation of suspended solids probes in the aeration basins and WAS line at MWWTP based on the outcome of the suspended solids probe and hydraulically determined SRT calculation performance at CKTP.
- Install analytical probes in the aeration basins to monitor the BNR process as part of the plant upgrade to adapt to new TN limits.
- Install a level transmitter for the sodium hypochlorite tank and install local indication of tank level at the location from which the tank is filled. For reduced maintenance and avoiding the need to modify the existing tank, HDR recommends considering radar level measurement technology that can measure level through plastic tank ceilings. This would allow the sensor to be installed on a wall-mounted bracket without disturbing the tank.
- Service or replace non-functional combustible gas-monitoring equipment in the sludge pumping gallery, headworks odor control system, and WAS tanks.

Automation Improvements

The following items include HDR recommendations for automation improvements at MWWTP:

- Develop a SCADA HMI screen for monitoring the comprehensive liquid stream flow balance for the plant along with HRT values for tanks, basins, and clarifiers. HDR recommends that real-time and daily peak-hour flow data be displayed within the context of the associated process/pump system design capacity.
- Develop a SCADA HMI screen for monitoring the comprehensive solid stream flow balance for the plant along with detention time values for the WAS and TWAS tanks.

HDR recommends that real-time and daily peak-hour flow data be displayed within the context of the associated process/pump system design capacity.

- If the Sewer Utility experiences favorable results with the suspended solids probes and hydraulically determined SRT calculations at CKTP, provide PLC programming and SCADA HMI modifications to monitor mixed liquor suspended solids and WAS suspended solids and to calculate hydraulically determined SRT at MWWTP. HDR recommends that the Sewer Utility continue operating based on laboratory-determined SRT while comparing performance of the hydraulically determined SRT calculated via the SCADA system with lab data. This comparison should be used to determine ideal suspended solids probe location(s) for the aeration basins and, if SRT values calculated via the SCADA system are found to align reasonably well with laboratory-determined SRT values, to evaluate the potential for implementing automated SRT control at the plant.
- Until BNR process upgrades due to new TN limits are determined, provide PLC programming and SCADA HMI screen modifications to allow operations staff to schedule and adjust aeration blower operation time sequence from SCADA HMIs. Functionality should include the ability to set unique on/off time durations for each day of the week.
- Install an electrically actuated isolation valve on the WAS line to the WAS tanks to enable SCADA control of the sludge wasting process. This will also require PLC programming and SCADA HMI screen modifications to add functionality for operations staff to manually open and close the valve from SCADA HMIs.
- Wire a fault signal from the mixing channel blower motor starter to the discrete input at the LP-225 RIO rack in the headworks building and provide PLC programming and SCADA HMI screen modification to integrate the fault alarm. This alarm could then be used to alert operations staff to mixing channel blower failures, improving operator response time, and eliminating the need for staff to visit the building to check equipment status.

6.2.13 Implement SWWTP Instrumentation and Automation Improvements

Instrumentation Upgrades and Replacement

The following items include HDR recommendations for additional instrumentation and servicing and replacement of failed instrumentation at SWWTP. Note, these recommendations are general and, in some cases, would require further evaluation beyond the scope of the Master Plan to determine feasibility and detailed design requirements. Confirmation of appropriate instrument technology, installation location, and specification requirements for new instruments should be determined through a more detailed design process.

- Service or replace the combustible gas monitoring equipment in the process building upper floor process room.
- Consider installing a flowmeter for the thickened sludge storage tank truck loadout station.

- Verify calibration of the thickened sludge storage tank level transmitter. After calibrating, record a series of measured level values versus actual tank level during two or three tank loadout operations. If accuracy and repeatability of level measurement are unacceptable, consider installing a radar level transmitter to replace the pressure-based level transmitter currently installed in a non-ideal location on the pump suction line. Record drawings indicate that a spare 6-inch nozzle was provided on the tank for a future instrument, which could be used for installation of the radar level transmitter.
- Consider installing a radar level transmitter for monitoring and control of sludge storage tank level. Provide a more permanent and less failure-prone installation for the sludge storage tank high level switch so that it can provide a reliable backup high level interlock and alarm.
- Install DO probes in the SBRs. Depending on the outcome of ongoing facility planning, the Sewer Utility may wish to consider additional analytical probes to facilitate improved monitoring and control of the BNR process. In addition to monitoring and control functionality, pH probes, for example, could supplement and/or reduce the number of manual measurements required by operations staff.
- Replace the damaged thermal dispersion flow switch on the RDT spray water supply line.
- HDR recommends that the Sewer Utility consider installation of suspended solids probes in the SBRs and WAS line at SWWTP based on the outcome of the suspended solids probe and hydraulically determined SRT calculation performance at CKTP.
- Consider installing a flowmeter on the discharge line from the drain collection pump station to monitor return flow to the headworks equipment.
- Consider installing a flowmeter on the W3 line downstream from the reclaimed water pumps to monitor W3 flow to plant processes.
- Service or replace the process building fire alarm system.

Automation Improvements

The following items include HDR recommendations for automation improvements at SWWTP:

- Develop a SCADA HMI screen for monitoring the comprehensive liquid stream flow balance for the plant along with HRT values for SBRs and tanks. HDR recommends that real-time and daily peak-hour flow data be displayed within the context of the associated process/pump system design capacity.
- Develop a SCADA HMI screen for monitoring the comprehensive solid stream flow balance for the plant along with detention time values for the sludge storage tank. HDR recommends that real-time and daily peak-hour flow data be displayed within the context of the associated process/pump system design capacity.
- Service or replace the effluent flow control valve to restore its ability to maintain positions from SCADA-issued commands. Because this will likely require a plant

shutdown, because of the lack of bypass piping for the valve, HDR recommends that the Sewer Utility identify other improvements/upgrades at the plant that would also require a shutdown to perform so as to maximize its benefit from the outage. Unfortunately, there do not seem to be options for installing bypass piping around the valve in its current position. To install a bypass the Sewer Utility would need to evaluate modifications to existing piping, particularly the overflow pipe that connects to the effluent line immediately downstream from the valve.

- Eliminating the manual RDT operation at reduced dewatering efficiency is a high priority for the Sewer Utility. As indicated in TM-1, Sewer Utility staff have a theory about undersized piping on the thickened sludge pump discharge creating high discharge pressures during pump operation that shut the pump down. HDR recommends that the Sewer Utility perform an assessment to diagnose the issue so that appropriate corrective action can be taken. As a first step in this assessment, HDR recommends that the Sewer Utility confirm that plug valves on the discharge line are fully open and that throttled valves are not contributing to increased discharge pressure. HDR also recommends verifying the pump's discharge pressure switch set point and comparing that with the pump curve to confirm that the high-pressure set point is appropriate. Assuming that throttled valves and/or an inappropriate high-pressure set point are not the root cause, an evaluation of pump selection and discharge piping size would be recommended along with a site visit conducted by a pump system subject matter expert to identify potential low-cost mitigations.

6.2.14 Remote Pump Station Instrumentation and Automation

Instrumentation Upgrades and Replacement

The following items include HDR recommendations for additional instrumentation and servicing and replacement of failed instrumentation at Sewer Utility remote pump stations. Note, these recommendations are general and, in some cases, would require further evaluation beyond the scope of the Master Plan to determine feasibility and detailed design requirements. Confirmation of appropriate instrument technology, installation location, and specification requirements for new instruments should be determined through a more detailed design process.

- Install pressure transmitters on remote pump station force mains. This will allow the Sewer Utility to monitor and trend force main pressures over time, allowing for early detection of force main breaks, grease and/or sediment build-up, and plugging. When combined with wet well level and pump discharge flow, force main pressure will also enable the Sewer Utility to monitor actual pump station system curves, evaluate where lift station pumps are operating on their pump curves, and more effectively monitor and control pump performance.
- Service or replace the combustible gas monitoring equipment at the PS-24 wet well.
- Consider replacement of the PS-24 wet well level transducer and transmitter, as they have likely been in service for roughly 20 years. If the level transducer is replaced, HDR recommends providing a submergence shield for the new transducer given the conditions to which the existing transducer has been exposed. If instrument

replacement is deferred, HDR recommends cleaning the wet well level transducer and performing calibration to verify that level measurement accuracy and repeatability are acceptable.

- Install a level transmitter for the PS-71 BIOXIDE storage tank. For reduced maintenance and avoiding the need to modify the existing tank, HDR recommends considering radar level measurement technology that can measure level through plastic tank ceilings. This would allow the sensor to be installed on a wall-mounted bracket without disturbing the tank.
- Service or replace the combustible-gas monitoring equipment at the PS-71 wet well.

Automation Improvements

The following items include HDR recommendations for automation improvements at the Sewer Utility remote pump stations:

- Develop SCADA HMI screens to provide a summary-level, process flow diagram depiction of the conveyance system associated with each WWTP. Currently, the pump station SCADA HMI screens appear to consist only of a map screen for selecting specific pump stations, a summary status and alarm screen for all pump stations, and pump station specific pop-up screens. The current screens do not appear to provide depiction of where the specific pump stations are situated within the conveyance system, which requires operators to rely on institutional knowledge to recall where pump stations pump to and which pump stations will need to be considered in the event of conveyance system disruptions (e.g., a downstream pump station outage).

  HDR recommends that the summary conveyance system screens display pump running status, flow, force main pressure, and indication of whether or not an alarm is active for each pump station.
- To assist with prioritizing response to pump station emergencies, the Sewer Utility may wish to implement time-to-overflow monitoring for its critical (or all) pump stations. This would involve using the wet well level measurement to calculate change in wet well volume over time and to then extrapolate the time remaining until the wet well level exceeds top elevation, volume exceeds overflow storage capacity, and/or other spill point triggers. These calculations could be initiated by alarms related to reductions in pump station pump capacity (e.g., power failure, pump faults, etc.) and could also be manually enabled and disabled by operations staff as required. The estimated time remaining would be displayed at the individual pump station SCADA HMI screens and could also be incorporated into the proposed summary-level conveyance system screens.
- For pump stations with VFDs where real-time monitoring of pump power (kW) and flow is or could be implemented, the Sewer Utility could consider modifying existing PLC programming logic to favor energy efficient operating points while within normal level range in the wet well. This could be done by calculating gallons pumped per kW consumed in real-time and providing that value as feedback to the pump speed control loop. The pump speed control loop would then make an incremental adjustment to the speed, either increasing or decreasing, depending on the direction

of the last speed adjustment and whether or not the new operating point is an improvement from the previous operating point. The speed range would still be bounded by minimum and maximum speed set points configured at the VFD and, if desired, as further constrained by operator entry at the pump station OIT. Energy efficiency prioritization would also be overridden by variable-level-based speed control when the wet well level rises above the upper threshold of an operator-entered normal level range.

Compared to more traditional control methods like constant-level control, where pump speed is modulated in an attempt to match outgoing flow to incoming flow at the pump station, and variable-level control, where the pump speed is modulated evenly throughout a set level range, this control method leverages the available system response time buffer provided by the wet well's capacity to maximize the efficiency of the pumping system. This approach also allows the controls to adapt to changes in the pump station system curve influenced by fluctuating wet well levels and gradual increases in force main friction head over time, as opposed to maintaining one preferred operating speed derived through theoretical analysis or historical observations.

While the energy savings potential of this control method will vary depending on pump station characteristics, implementing these controls would consist mainly of minor PLC programming and OIT graphics modifications and would not require significant investment. If applied to several pump stations, particularly those with larger pumps, the combined energy savings may be significant. If the Sewer Utility is interested in applying this alternative control method, HDR recommends that baseline energy consumption be established for the existing controls prior to introducing the alternative control method. This will provide a means of comparison and could be used to justify the application of energy-efficiency-based speed control to additional remote pump stations. Pump station capacity should also be evaluated prior to attempting to implement this alternate control method. Pump stations with undersized wet wells for present day flows and/or where pumps are already having to operate near full speed to keep up with incoming flows for the vast majority of their runtime would not have enough operating speed flexibility to be good candidates for this particular pursuit of energy savings.

- As part of the recommended PS-24 PLC upgrade, HDR recommends that the hardwired relay logic and PLC programming for the existing pump controls be reviewed to confirm as-implemented conditions, which may be contributing to the pump short cycling occurring at the pump station. The proposed telemetry upgrades will also allow the Sewer Utility to begin monitoring near-real-time wet well level, flow, and pump on and off transitions, which will aid in the analysis of current level set points. After review of existing controls and near-real-time pump station data, HDR recommends implementing appropriate control improvements to reduce or eliminate pump short cycling at the station to increase the useful service life of the equipment.
- HDR recommends that a control system upgrade occur at PS-34. The control system upgrade would include replacement of the existing control panel with a PLC-based control panel and an OIT for improved local monitoring and control functionality. HDR recommends that the Sewer Utility use the control system upgrade as an opportunity

to bring the station into conformance with the Sewer Utility ICS standards documentation proposed later in this TM.

- HDR recommends evaluating remote alarm reset functionality for select remote pump station alarms. While high wet well level and other critical alarms certainly warrant a site visit by Public Works Facilities staff, there may be some less critical alarms that could be reset remotely to avoid unnecessary site visits. For example, remote resetting of VFD faults to help restore pump functionality after a power bump at a remote pump station that frequently experiences power issues could be beneficial so long as the remote reset capability were not abused. Note, remote reset capability will likely require additional hardwiring at the remote pump station, in addition to PLC programming and SCADA HMI screen modifications.

- ✪ Establish Sewer Utility PLC platform standard and schedule replacement of select WWTP and remote pump station PLCs.
- ✪ Develop a standard approach for monitoring and control of motorized equipment.
- ✪ Develop a standard approach for monitoring remote pump stations.
- ✪ Replace CKTP MCC DeviceNet networks with Ethernet-capable motor controllers.
- ✪ Establish Sewer Utility OIT platform standard and schedule replacement of select WWTP and remote pump station OITs.
- ✪ Develop a formal instrument calibration and maintenance program.
- ✪ Implement CKTP digester building PNL 6000 relocation and MCC replacement.
- ✪ Include integration of composite sampler alarms and monitoring with replacement of existing samplers.
- ✪ Evaluate remaining years of useful service life for remote WWTP UV systems to determine best approach for improved SCADA monitoring of the UV systems.
- ✪ Implement CKTP instrumentation and automation improvements.
- ✪ Implement KWWTP instrumentation and automation improvements.
- ✪ Implement MWWTP instrumentation and automation improvements.
- ✪ Implement SWWTP instrumentation and automation improvements.

✪ Implement remote pump station instrumentation and automation improvements.

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7 ICS Software: Future Needs and Recommended Improvements

This section identifies the Sewer Utility's future needs related to its ICS software and describes the information and functionality that Sewer Utility staff would like to obtain from the ICS software in the future. The future needs presented are derived from information obtained from Sewer Utility staff during site assessment visits, workshops, and staff interviews. Based on comparison of current use cases to future needs of the Sewer Utility, the section presents recommended improvements for the ICS software.

7.1 Future Needs

This subsection describes the Sewer Utility's future needs as they relate to the ICS software.

7.1.1 Establish Centrally Managed, Standards-based HMI and Historian Platform for the WWTPs

The Sewer Utility and QCC have elected to migrate from standalone Wonderware InTouch runtime installations at the various WWTP SCADA PCs and panel PCs to AVEVA System Platform. This upgrade is intended to meet the Sewer Utility's future needs of establishing a central repository for all Sewer Utility historical SCADA data, addressing the lack of standardization in SCADA HMI graphics between the Sewer Utility's WWTPs, and enabling the ability to monitor all Sewer Utility infrastructure at any WWTP. AVEVA System Platform software will be installed on servers at CKTP, which will establish a centralized historian for all WWTPs and pump stations, a centralized development environment, and a repository for standardized HMI graphics objects and AVEVA InTouch applications.

7.1.2 Implement HPHMI Concepts for WWTP SCADA HMI Screens

As part of the effort to standardize its SCADA HMI graphics throughout its infrastructure, the Sewer Utility would like to incorporate HPHMI concepts to improve operator situational awareness and overall effectiveness of the SCADA HMI screens. Some of the HPHMI concepts the Sewer Utility would like to consider as part of its SCADA HMI graphics standards development include:

- Limited, consistent, and intentional use of color, with color not being the only means of communicating status
- No distracting animations or three-dimensional depictions
- Analog values presented with context of desirable/normal operating range, set point and alarm thresholds, and deadband ranges, where applicable
- Consistent screen hierarchy with progressive exposure to more detailed information
- Logical and consistent screen navigation

- Embedded and properly formatted historical trends
- Prioritized alarms indicated via redundant methods (e.g., color, text, and/or shape), with use of flashing or animation for unacknowledged alarms
- Display where alarms have been suppressed
- Provide links or pop-ups to alarm rationalization information (e.g., consequences, potential causes, and corrective actions)

7.1.3 Implement Real-time Monitoring and Historical Trending of WWTP KPIs

Sewer Utility staff would be like to have the ability to monitor WWTP process key performance indicators (KPIs) such as HRT and SRT at the SCADA HMI screens. Staff would also like to have access to historical values for WWTP KPIs for dashboarding and data visualization purposes.

7.1.4 Improve Accessibility of Historical SCADA Data

To fully leverage its historical SCADA data, the Sewer Utility needs simple interfaces for staff to view trends and work with the data. The SCADA data from all WWTPs and pump stations also need to reside in a central repository so that the Sewer Utility does not have to work from data stores scattered throughout its infrastructure. Historical data will also need to be made available to several Sewer Utility and Public Works users and software platforms external to the Sewer Utility OT network. For example, Sewer Utility management staff would like to have access to flow and other engineering-focused data derived from the Sewer Utility ICS and Public Works management staff have expressed an interest in combining select operational data with financial information derived from their enterprise resource planning (ERP) software.

7.1.5 Mitigate Loss of SCADA Data from Remote WWTPs during Communication Outages

The transition to a centralized historian will require SCADA data from the remote WWTPs to be communicated to the historian server at CKTP. The communication conduits involved in this data exchange are subject to outages, which could result in historian data gaps for the remote WWTPs if not accounted for in the AVEVA software configuration. Store-and-forward functionality will need to be implemented for the AVEVA software installed at the remote WWTPs to ensure that real-time data are stored locally during disruptions in communications with the CKTP historian and then forwarded once communications are reestablished. AVEVA software has this capability and HDR believes that QCC is already planning to leverage it for the remote WWTPs and CKTP historian.

7.1.6 Migrate to Thin Client Configuration for CKTP HMIs

As part of its AVEVA System Platform upgrade, the Sewer Utility has decided to adopt a thin client deployment for the various panel PCs that will serve as process area SCADA HMIs at CKTP. This approach will remove the AVEVA InTouch runtime installations at the various panel PCs, which will eliminate the need to separately patch and update each runtime installation, resolve ongoing alarm acknowledgement propagation issues, and allow for centralized management of the Sewer Utility's SCADA HMI software application. Sewer Utility staff will still require read and write access to the SCADA HMI screens and historical trends from the panel PCs and must be able to acknowledge alarms from these locations.

7.1.7 Improved Alarm Notification System

The Sewer Utility needs its on-call operations and supervisory staff to have better access to active alarms and their acknowledged/unacknowledged status via mobile phones. The Sewer Utility would prefer to have an implementation that includes a mobile app as the user interface to eliminate the need for staff to call into the alarm notification system and listen to alarm information. Sewer Utility staff have also identified some outstanding issues with the existing system that need to be resolved.

7.1.8 PLC Firmware Standardization

Sewer Utility staff have identified PLC firmware standardization as a high priority. The Sewer Utility would like to establish a standard firmware version for each of the PLC controller types it maintains throughout its infrastructure and to then bring its PLCs into firmware version alignment. This will reduce the number of Rockwell Automation Studio 5000 and RSLogix 500 software versions the Sewer Utility needs to support while also enabling the PLC controllers on older firmware to benefit from security patches and optimized controller features available in a more recent firmware version.

7.1.9 Establish Tracking of ICS Set Point Changes

The Sewer Utility would like to have the ability to track ICS set point changes made at the SCADA HMI. Knowing when changes were made and by whom will help the Sewer Utility manage set point drift and identify the individual(s) who can provide operational context for why changes may have been made.

7.1.10 Provide Read-only Access to WWTP SCADA HMI Screens at Laboratory

Laboratory staff currently have no access to WWTP SCADA HMI screens and rely on word-of-mouth to keep abreast of current operating modes at the Sewer Utility's WWTPs. To give laboratory staff insight into current WWTP operations and notification of relevant alarms, the Sewer Utility would like to implement read-only access to WWTP SCADA HMI screens at the laboratory.

7.2 Recommended Improvements

This subsection describes the recommended improvements related to ICS software.

7.2.1 Upgrade WWTP Standalone SCADA HMI Installations to AVEVA System Platform with Managed InTouch Applications and Standardized Templates Based on HPHMI Concepts

To establish centralized management of the Sewer Utility SCADA HMI applications, the Sewer Utility and QCC are in the process of installing AVEVA System Platform on servers within the CKTP OT network. This will allow the Sewer Utility to manage its various AVEVA InTouch HMI applications from the ArchestrA Integrated Development Environment (IDE) tool within the System Platform software package. HDR believes that QCC is taking the approach of converting the standalone InTouch HMI applications at the Sewer Utility WWTPs to managed InTouch HMI applications, which will allow for centralized modification and deployment of the InTouch HMI applications. This approach will streamline SCADA HMI screen development and management and is consistent with HDR recommendations.

The upgrade to AVEVA System Platform will also enable an object-oriented approach to standardizing the representation of Sewer Utility assets and the operator interface for monitoring and controlling them. HDR recommends this approach because it will allow the Sewer Utility to develop templates for common assets like pumps, mixers, and control valves and to then reuse that content for like assets throughout the Sewer Utility infrastructure. Attributes like color, symbology, I/O structure, status and alarm indication, tag structure and naming conventions, and control interfaces would be defined within the template so that any later revisions required would automatically be pushed out to the various objects derived from the template. This way, a decision to change the running color of a pump, for example, would not require modifying every instance of a pump throughout all of the Sewer Utility SCADA HMI screens. The Sewer Utility can also leverage pre-built templates from AVEVA Industrial Graphics (formerly known as ArchestrA Graphics) and AVEVA Asset Library to reduce the amount of development required. Several of these out-of-the-box templates have been developed specifically for HPHMI implementations.

Developing standard templates based on HPHMI concepts and applying them to the Sewer Utility’s existing InTouch HMI applications will be a significant effort, but this upfront investment will reduce the cost and effort to maintain and modify the SCADA HMI screens in the future and will resolve the current lack of consistency throughout the Sewer Utility’s WWTP SCADA HMI screens. The Sewer Utility and QCC have already scheduled workshops to begin determining visual and functional requirements for the future SCADA HMI screens along with the templates that will form the building blocks within AVEVA System Platform. These workshops should include discussions on which HPHMI concepts the Sewer Utility would like to apply to its future SCADA HMI screens along with its preferences for screen hierarchy and navigation. A workshop approach is consistent with HDR recommendations. Sewer Utility stakeholders need to be involved early and often during the SCADA HMI screen development process to ensure that the final implementation meets the Sewer Utility’s needs and expectations.

7.2.2 Establish Access to All Sewer Utility SCADA HMI Screens at Each WWTP Control Room and at the County Public Works Annex Facility

The Sewer Utility would like to establish access to all Sewer Utility SCADA HMI screens at each WWTP control room and the County Public Works Annex facility so that staff can obtain a more comprehensive view of Sewer Utility operations from multiple locations. Though the objective for each facility is the same, the recommended software installation and configuration approach differs slightly between them.

For the remote WWTPs, a local AVEVA InTouch HMI runtime installation running the InTouch application for each respective WWTP will be required so that the SCADA HMI screens for the WWTP remain functional during a communication outage between the plant and CKTP. The remote WWTPs will also require local installations of select AVEVA Communication Driver components to facilitate communications between the InTouch application and the Allen-Bradley PLCs and other devices installed at the WWTP. However, the remote WWTPs will not require local installations of InTouch applications for other WWTPs and the remote pump stations because there are no local devices serving information to those InTouch applications and loss of communications to CKTP would disrupt functionality for the SCADA HMI screens included in those applications. Instead, HDR recommends that access to other WWTP and remote pump station SCADA HMI screens be provided via RDS and AVEVA's InTouch Access Anywhere software. This approach would allow Sewer Utility staff to access those screens via an HTML5-compliant web browser, simplifying the local software configuration requirements at the remote WWTPs.

Similarly, HDR recommends that RDS and InTouch Access Anywhere be used to provide access to all Sewer Utility SCADA HMI screens from a dedicated PC at the County Public Works Annex facility.

At CKTP, PCs in the control room will have InTouch HMI runtime installations running the InTouch application for CKTP and the remote pump stations. HDR does not believe that AVEVA supports running two or more parallel InTouch applications on the same machine, which presents challenges to running InTouch applications for the remote WWTPs on the CKTP control room PCs. For access to SCADA HMI screens for the remote plants, HDR recommends that RDS and InTouch Access Anywhere be used. This will avoid having to implement VMs on the control room PCs to support running parallel InTouch applications or requiring Sewer Utility staff to open and close InTouch applications each time they wish to see SCADA HMI screens from a different WWTP.

7.2.3 Complete Migration to Thin Client Configuration for CKTP HMIs

As part of its AVEVA System Platform upgrade, the Sewer Utility and QCC are planning to adopt a thin client deployment for the various panel PCs that will serve as process area SCADA HMIs at CKTP. This migration would meet the Sewer Utility's objectives of eliminating the need to separately patch and update several runtime installations, resolving ongoing alarm acknowledgement propagation issues, and allowing for centralized management of the Sewer Utility's SCADA HMI software application. Based on the Sewer Utility's stated objectives, this approach is consistent with HDR recommendations.

7.2.4 Determine Standard PLC Firmware Versions for the Sewer Utility and Perform Firmware Upgrades

HDR recommends inventorying the Sewer Utility's PLCs that are not slated for near-term replacement and determining the most recent firmware version that its controllers support. Rockwell Automation provides a Product Compatibility and Download Center service on its website, which is an excellent tool for selecting specific Allen-Bradley controllers and the applicable PLC programming software to view firmware compatibility (Rockwell Automation 2020c). Once this information is compiled, the Sewer Utility should select the most recent firmware version that all PLCs within a given product line can support and establish that firmware version as a Sewer Utility standard. Note, HDR recommends that the Sewer Utility consult QCC and North Coast Electric (local Rockwell Automation distributor) before making final firmware version selections. It is not uncommon for certain firmware versions to have significant bugs and known issues, and individuals who regularly work with the controllers will have experience with several firmware versions and may be able to provide insight that influences the Sewer Utility's firmware selections.

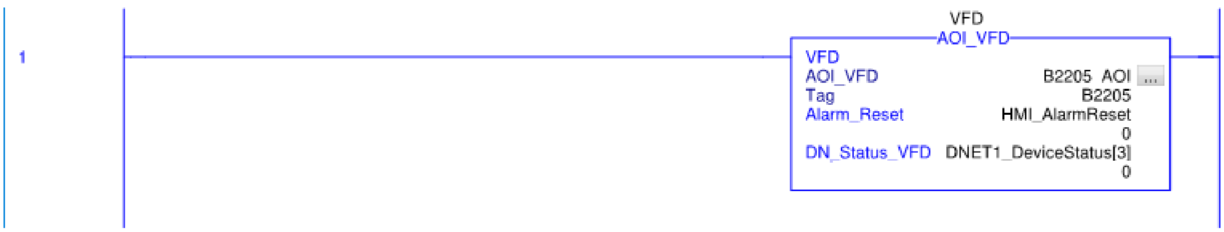
After the Sewer Utility finalizes its PLC firmware standards, HDR recommends that the selected PLC firmware versions be documented in the proposed Sewer Utility ICS standards documentation. The Sewer Utility should then work with a systems integrator to schedule the PLC firmware upgrades to bring the Sewer Utility's PLC inventory into firmware alignment. HDR also recommends that the Sewer Utility schedule recurring reviews of available firmware versions from the manufacturer to assess the criticality of upgrading to the most recent firmware version. Significant security patches and performance improvements would be drivers for adopting newer firmware versions, while minor fixes may not justify the time and expense of keeping up with every new version released by the manufacturer. When new firmware versions are adopted and deployed throughout the Sewer Utility's PLC inventory, the Sewer Utility's ICS standards documentation should be updated accordingly.

7.2.5 Develop PLC Programming Standards and Leverage Them to Standardize Future PLC Programming Work Products

As part of the Sewer Utility's effort to standardize its ICS infrastructure, HDR recommends that the Sewer Utility work with QCC or another local systems integrator to develop a standard approach to PLC program development for the Sewer Utility. The standard approach should then be documented as part of the Sewer Utility's ICS standards. The PLC programming standards should document elements like preferred PLC programming project file organization; appropriate level of annotation; tagging conventions; use of tag descriptions; program and routine naming conventions; use of ladder logic and function block diagram; and standard AOIs, UDTs, and subroutines that are to be used for common applications throughout the Sewer Utility ICS infrastructure. Examples of standard AOIs, UDTs, and subroutines include those described in Section 6.2.2 for the standard approach for monitoring and controlling motorized equipment. Once the PLC programming standards are developed and documented, they should be applied to future PLC programming efforts.

To avoid having to develop the PLC programming standards as a standalone project, HDR recommends that the standards development work be embedded in the scope of a near-term implementation project. This will allow the standards to be applied to the project and revised based on feedback from actual implementation efforts. The Sewer Utility also already has several “standard” AOIs and UDTs that were applied in the PLC programming for the PLCs added under the CKTP Resource Recovery project (see Figure 7-1 for an example of an AOI being called for the classifying selector blower [B2205]). Though these AOIs and UDTs may require some modification to best serve the Sewer Utility’s needs, they could provide a starting point in the standards development process. QCC, or another local systems integrator that is engaged to develop the software portion of the standards, will likely have in-house standard approaches and programming objects that could be used to jumpstart the standards development, as well.

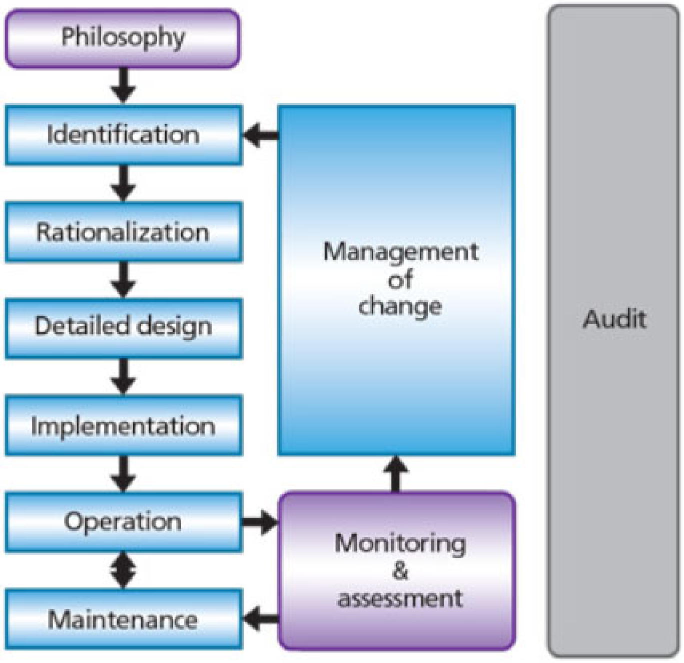
Figure 7-1. Example AOI for VFD equipment called in CKTP PLC 2939 programming



7.2.6 Implement an Alarm Management Program Based on ISA-18.2

HDR recommends that the Sewer Utility implement an alarm management program based on ISA-18.2, an industry standard for alarm management (ANSI/ISA 2016). A flow diagram depicting the ISA-18.2 alarm management process in terms of an alarm’s life cycle is presented in Figure 7-2.

Figure 7-2. ANSI/ISA-18.2 alarm management flow diagram



Source: Yokogawa (2017).

The Sewer Utility began an ISA-18.2 initiative in recent years, and HDR believes that some of the initial groundwork for instituting an alarm management program is already completed. The proposed alarm management program will inform the Sewer Utility's efforts to standardize PLC programming and SCADA HMI graphics development, so HDR recommends that the Sewer Utility continue developing its alarm management program in parallel with or prior to other ICS automation programming efforts. Among other improvements, the recommended ISA-18.2 alarm management program should address the following deficiencies identified in TM-1 and TM-2:

- There is a high volume of alarm activity at CKTP Wonderware implementation, much of the activity being from the same alarms
- Sewer Utility staff do not have means of shelving nuisance alarms or alarms associated with known issues
- SCADA HMI screens do not provide alarm priority information or allow for sorting and filtering of alarms by alarm priority
- Root-cause analysis and alarm suppression functionality have not been developed for SCADA HMI screens
- SCADA HMI screens do not have troubleshooting text prompts or decision tree aids to help operations staff react to alarm conditions
- Alarm summary and alarm history screens at SWWTP are not automatically updated to display current alarm information

- Monitored alarms should include PLC faults and communication errors so that Sewer Utility staff are alerted when PLCs and RIO racks are experiencing performance issues
- Monitored alarms should include signal out-of-range alarms for all analog signals so that Sewer Utility staff are notified when current-based signals fall outside of the 4–20 mA range

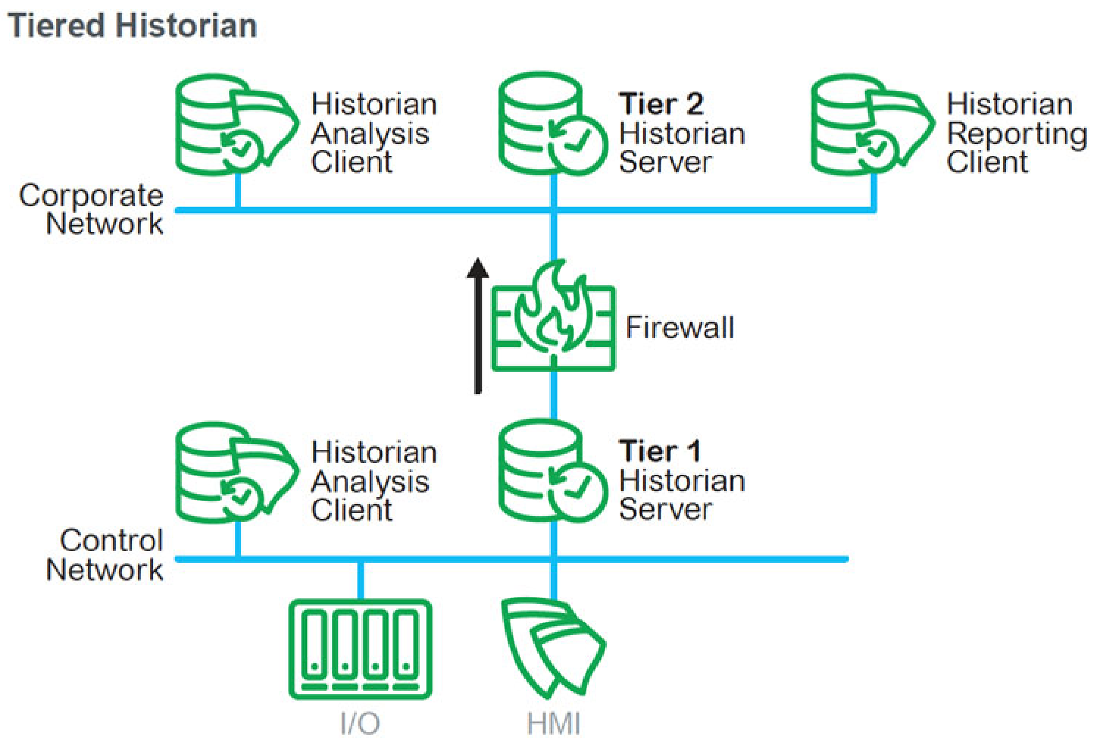
As part of the proposed alarm management program, HDR recommends that data related to ICS alarms be captured in the historian or other database environment and made available to users on the Sewer Utility business LAN. Third-party alarm management software or dashboarding tools like Tableau and Microsoft Power Business Intelligence (BI) could then be leveraged to develop visualizations and reports that would help the Sewer Utility manage alarms and alarm responsiveness.

7.2.7 Establish a Tiered Historian Implementation at CKTP to Centralize Sewer Utility Historical ICS Data and Provide Secure Access to Historical ICS Data from the Sewer Utility Business LAN

HDR recommends that the Sewer Utility establish a central historian at CKTP for consolidating ICS data received from all Sewer Utility WWTPs and remote pump stations. PCs and thin clients on the Sewer Utility OT networks would access data from this central historian to display embedded trends. HDR also recommends that the Sewer Utility implement AVEVA Historian Client software to simplify access to historian data and to facilitate the development of static and ad hoc trends from the PCs on OT networks. HDR believes that QCC and the Sewer Utility are already planning to implement this software as part of the ongoing AVEVA System Platform upgrade. As part of this effort, the Sewer Utility will need to implement store-and-forward functionality for the remote WWTPs so that ICS data received from those plants are not lost during communication outages between the remote WWTPs and CKTP.

To provide access to historian data for users on the Sewer Utility business LAN and County enterprise networks, HDR recommends that the Sewer Utility establish a “Tier 2” historian on the Sewer Utility business LAN at CKTP. A high-level network architecture depicting the proposed implementation is shown in Figure 7-3. The central historian on the OT network, or “Tier 1” historian, would replicate data through the proposed industrial DMZ (depicted as a firewall in Figure 7-3) to the “Tier 2” historian. The one-way nature of this data flow and limited open port requirements would simplify industrial DMZ firewall configuration, improve OT network security controls, and significantly reduce the network traffic traversing the industrial DMZ firewall(s) compared with a scenario where business LAN users are required to access the “Tier 1” historian on the OT network for their data analysis needs. With a dedicated historian for users on the Sewer Utility business LAN and County enterprise network, these users could then use AVEVA Historian Client, dashboarding and data visualization tools, and other software packages to view and analyze the ICS data and inform organizational decisions.

Figure 7-3. High-level tiered historian network architecture



Source: Schneider Electric (2015).

7.2.8 Broaden the Data Set Archived by the Sewer Utility Historian to Establish Foundations for More Comprehensive Process- and Asset-level Health and Performance Monitoring

Preliminary Improvements

HDR recommends that the Sewer Utility audit currently available parameters already monitored by its PLCs and configure the historian to historize parameters of interest. As indicated in Section 4.3.3 of TM-1, many tags within the existing Wonderware system are not being recorded in the CKTP historian or remote WWTP LGH files. Many of these tags could serve as inputs to a predictive maintenance program and help establish baselines for future process and asset health and performance monitoring efforts. Table 7-1 includes a summary of parameters that HDR recommends the Sewer Utility consider for incorporating into its historian.

Table 7-1. Summary of available equipment and process parameters to consider including in historian

Parameter	Alarm/ command/ status	Description
In Auto	Status	Indicates that the equipment's Hand-Off-Auto (HOA) selector switch(es) are placed in Auto and that equipment is being controlled by SCADA. Recording time stamps when this status changes can help determine asset availability, when maintenance/troubleshooting events are occurring and for how long, and current and past levels of automation achieved at the plant.
Close/open command	Command	Indicates an open or close command sent to a gate/valve actuator. The Sewer Utility is currently recording open and/or closed status for several of its isolation gate/valve actuators, but it is not recording the open or close commands actually sent to the equipment from SCADA. Recording open/close commands and open/closed status enables analysis and trending of gate/valve travel times as a predictive maintenance input.
Position command	Command	Indicates the position set point sent to the gate/valve actuator from the PLC. The Sewer Utility is currently recording position feedback for most modulating gate/valve actuators, but it is not recording the position command set points actually sent to the equipment from SCADA. Recording both position command and feedback values enables analysis of equipment response to position control, trending of gate/valve travel times as a predictive maintenance input, provides more insight into the effectiveness and stability of proportional-integral-derivative (PID) control loops, and can aid troubleshooting efforts.
Start/stop command	Command	Indicates a start/stop command sent to a motor controller or equipment package. The Sewer Utility is currently recording running status for most assets but it is not recording the start/stop commands actually sent to the equipment from SCADA. Recording start/stop commands and running status and their timestamps can aide troubleshooting efforts and root cause analysis when equipment does not respond as expected to start/stop commands.
Speed command	Command	Indicates the speed set point sent to the VFD from the PLC. The Sewer Utility is currently recording speed feedback for most variable-speed equipment, but it is not recording the speed command set points actually sent to the equipment from SCADA. Recording both speed command and feedback values enables analysis of equipment response to speed control, provides more insight into the effectiveness and stability of PID control loops, and can aid troubleshooting efforts.
Set point	Command	Indicates the target set point of a control loop (PID, or otherwise) or alarm threshold. In general, the Sewer Utility is not currently recording operator-adjustable or PID-determined set point values. HDR recommends recording these values each time that they are adjusted. Having a history of adjustable set point values can provide context to control loop performance, determine when changes were made and by whom, and enable comparison of process performance based on differing set point values.
Energy consumption (kilowatt-hour [kWh])	Status	Indicates equipment's total energy consumption since parameter was last reset. The Sewer Utility is currently recording power in kilowatts (kW) for many of its networked motor controllers. However, the Sewer Utility is not recording actual energy consumption for these assets. Though energy consumption can be calculated from historical power values, the accuracy of these calculations depends on how frequently the power values are recorded and can place additional processing burden on the PLCs or ICS software responsible for the calculations. Most Ethernet-capable motor controllers offer energy consumption in kWh as a parameter and HDR recommends recording these values in lieu of calculating them from recorded power values. Energy consumption is critical to evaluating asset O&M costs and performance.

Table 7-1. Summary of available equipment and process parameters to consider including in historian

Parameter	Alarm/ command/ status	Description
Power data (amps, volts, power, and power factor)	Status	Indicates motor amps, volts, power, and power factor. The Sewer Utility is currently recording some or all of these power parameters for its networked motor controllers, but there are instances where some of these parameters are not being recorded. HDR recommends that the Sewer Utility standardize on recording these parameters for motor controllers as they provide important data for analyzing asset health and performance and can be used to trigger predictive maintenance activities. Note, to reduce tag counts and programming complexity, HDR recommends that the Sewer Utility continue its practice of monitoring and recording average amps, average volts, total power, and total power factor. Ethernet-capable motor controllers will already communicate alarms and warnings for phase imbalances, so logging load-level per phase power data is unlikely to yield many benefits. However, the Sewer Utility should consider monitoring and recording per phase power parameters for generators and larger motors (e.g., larger than 100 horsepower [hp]).
Fail/fault	Alarm	Indicates that the equipment has an active failure or fault that is preventing it from running. Several hardwired fail and fault signals are being monitored by the Sewer Utility's SCADA system and not all of them are recorded in the historian. Some of these are generated by overload relay contacts, VFD fault outputs, or common alarm contacts. Recording time stamps when fail or fault alarms occur and when they are reset is a key input to determining asset availability and analyzing past asset performance. Whenever possible, the specific failure or fault should be identified in the tag description to provide context for the alarm. For example, motor overload, VFD fault, fail to run when called, motor winding high temperature, submersible pump motor leak, etc., provide much more context than a generic equipment fail alarm.
Networked equipment alarms and warnings	Alarm	Indication of specific equipment alarm or warning. Ethernet-capable motor controllers, vendor package controllers, power monitors, and other devices are capable of communicating alarms and warnings on a much more granular scale than can be achieved with hardwiring. Not all of these alarms and warnings may be worth recording in a historian. Furthermore, if an organization were to include every alarm and warning available in its historian, it would quickly see its tag count explode, which may trigger increased licensing costs. Many manufacturers make alarm and warning codes available via Ethernet communications. These codes are used to look up alarm/warning descriptions and troubleshooting steps in the manufacturer manuals. Recording alarm and warning code values allows for tracking of several alarms and events with one or a few tags. When available, HDR recommends that the Sewer Utility include alarm and warning codes in its historian along with specific, critical alarms it wishes to monitor separately.

Improvements to Align with Future Upgrades

When process upgrades or equipment replacements initiate changes to ICS infrastructure, HDR recommends that the Sewer Utility take advantage of these opportunities to implement monitoring and recording of the parameters listed in Table 7-1 for the assets that do not currently have these parameters available. This would be in addition to the parameters that the Sewer Utility has already standardized on recording (e.g., running status, runtime hours, level, flow, pressure, analytical probe measurements, process switch status, etc.). Note that monitoring and recording parameters listed in Table 7-1 may require updating PLC programming, field wiring, and Ethernet device configuration to implement standardized I/O for like assets.

In addition to those parameters, Table 7-2 includes a summary of additional parameters that HDR recommends the Sewer Utility consider for incorporating into its historian. These additional parameters will likely require additional instrumentation and/or field wiring to incorporate.

Table 7-2. Summary of additional equipment and process parameters to consider including in historian

Parameter	Alarm/ command/ status	Description
Actuator torque	Status	Indicates the torque that a gate/valve actuator is generating. Most electric actuator manufacturers offer an analog torque signal as a 4–20 mA output. Monitoring and recording actuator opening and closing torque can inform predictive maintenance efforts by comparing current torque profiles against historical baselines.
Pump suction and discharge pressure	Status	Indicates the suction and discharge pressures experienced by a pump. Monitoring and recording suction and discharge pressures for a pump or group of parallel pumps enables calculation of the total head that a pump is producing. This is an important value for determining where a pump is operating along its pump curve, its operating efficiency point, and how the pump's operating point may be changing over time. This information can be applied to predictive and proactive maintenance efforts and to prioritize assets for energy optimization initiatives.
Liquid stream and solid stream low and flow totalization	Status	Indicates process flows and volumes. HDR recommends that the Sewer Utility standardize on monitoring and recording all significant liquid stream and solid stream flows within its WWTPs. In addition to receiving a flow signal, HDR recommends that the Sewer Utility standardize on receiving an accumulated volume pulse signal from the flowmeter, when available, as the primary source for flow totalization rather than calculating flow totals from instantaneous flow measurements at the PLC. Flow totalization based on pulse count is typically more accurate. Having accurate flow and volume data will allow for derivation of comprehensive liquid stream and solid stream balances and will inform efforts to determine where pumps are operating along their pump and efficiency curves.

7.2.9 Upgrade Alarm Notification System

HDR recommends that the Sewer Utility upgrade its WIN-911 alarm notification system to a current version that is supported by the software vendor. As part of this upgrade, the Sewer Utility should evaluate incorporating the software's Mobile-911 app to provide on-call operations and supervisory staff with better access to active alarms and their acknowledged/unacknowledged status via mobile phones. HDR believes that QCC and the Sewer Utility are already planning on upgrading the WIN-911 software as part of the ongoing Systems Platform upgrade.

7.2.10 Provide Read-only Access to WWTP SCADA HMI Screens at Laboratory

To meet the Sewer Utility's objective of providing laboratory staff with read-only access to WWTP SCADA HMI screens, HDR recommends that RDS and AVEVA InTouch

Access Anywhere be used to enable access to the screens from one or more PCs within the laboratory via an HTML5-compliant web browser. Alternatively, or in addition to the PC(s), one or more large-format displays would be helpful in providing laboratory staff with an at-a-glance view of operating conditions and alarms for all WWTPs.

- ✪ Upgrade WWTP standalone SCADA HMI installations to AVEVA System Platform with managed InTouch applications and standardized templates based on HPHMI concepts.
- ✪ Establish access to all Sewer Utility SCADA HMI screens at each WWTP control room and at the County Public Works Annex facility.
- ✪ Complete migration to thin client configuration for CKTP HMIs.
- ✪ Determine standard PLC firmware versions for the Sewer Utility and perform firmware upgrades.
- ✪ Develop PLC programming standards and leverage them to standardize future PLC programming work products.
- ✪ Implement an alarm management program based on ISA-18.2.
- ✪ Establish a tiered historian implementation at CKTP to centralize Sewer Utility historical ICS data and provide secure access to historical ICS data from the Sewer Utility business LAN.
- ✪ Broaden the data set archived by the Sewer Utility historian to establish foundations for more comprehensive process- and asset-level health and performance monitoring.
- ✪ Upgrade alarm notification system.
- ✪ Provide read-only access to WWTP SCADA HMI screens at laboratory.

8 ICS Documentation: Future Needs and Recommended Improvements

This section identifies the Sewer Utility's future needs related to its ICS documentation and describes the information that Sewer Utility staff would like to develop and maintain. The future needs presented are derived from information obtained from Sewer Utility staff during site assessment visits, workshops, and staff interviews. Based on comparison of current use cases to future needs of the Sewer Utility, the section presents recommended improvements for ICS documentation.

8.1 Future Needs

This subsection describes the Sewer Utility's future needs as they relate to ICS documentation.

8.1.1 Develop Sewer Utility ICS Standards Documentation

The Sewer Utility would like to develop ICS standards documentation that could be handed to consultants and systems integrators to guide design and implementation for future projects. These standards would be required to be referenced in consultant specifications so that they become part of the contractor's scope. Once Sewer Utility ICS standards documentation is developed, the Sewer Utility would like to establish annual reviews of the standards documentation and ICS infrastructure to keep the standards current and to identify upcoming ICS upgrade/replacement projects that need to be included in CIP planning. Monitoring for hardware and software obsolescence should be a factor in these periodic reviews.

8.1.2 Develop Control Strategy Documentation for Sewer Utility ICS Processes

The Sewer Utility would like to develop control strategy documentation to capture as-implemented automation programming and process control for the various WWTP and pump station processes throughout its infrastructure. This documentation would be a resource that operations staff could consult to obtain an understanding of local and SCADA HMI controls, interlocks, and alarms without having to decipher equipment and process functionality from wiring diagrams, PLC programming logic, and equipment O&M documentation. The Sewer Utility would also like to have an authoritative document to keep track of appropriate set points to help manage set point drift. Control strategy documentation could also be used for this purpose.

8.1.3 SOPs and Documented Workflows for ICS Technology

The Sewer Utility has identified that its staff will require training to support modernization of the Sewer Utility ICS. However, once initial or recurring training sessions conclude, staff will likely need periodic reminders, particularly for procedures that occur infrequently. The Sewer Utility would like to document preferred workflows and standard operating procedures (SOPs) for the ICS technology that staff interact with to help supplement training and provide staff with a self-service resource when they need a refresher. The Sewer Utility will also require policies to ensure that certain SOPs are enforceable.

8.2 Recommended Improvements

This subsection describes the recommended improvements related to ICS documentation.

8.2.1 Develop Sewer Utility ICS Standards Documentation

The Sewer Utility's goal of developing ICS standards documentation to guide future design and implementation efforts is consistent with HDR recommendations. As the Sewer Utility's ICS infrastructure grows and changes in complexity and technology, it is critical to define and standardize the implementation and configuration practices to ensure that the system is easy to maintain, expand, and develop. ICS standards provide an organization's staff and contractors with a clear set of guidelines to follow when modifying or adding elements to ICS infrastructure. When standards are well-developed and documented, expectations for quality, work approach, and results are easily ascertainable from the standards documents. This helps an organization ensure that work is performed in a consistent and desirable manner throughout the SCADA system and establishes a basis for effectively managing the performance of internal and contracted staff.

With the upgrade to a new, centralized SCADA HMI and historian platform, the Sewer Utility has an opportunity to document how this new technology should be integrated into a high-functioning SCADA system before the integration work is complete. The Sewer Utility and QCC have already decided to adopt an object-oriented programming (OOP) approach for the SCADA platform by selecting AVEVA System Platform to develop a template library of common automation objects that can be applied widely throughout the Sewer Utility's infrastructure. As discussed previously in this TM, several of the PLC programs running at the Sewer Utility's WWTPs already leverage AOIs and UDTs, which is also consistent with an OOP approach. These existing AOIs and UDTs may be modified or replaced to create a standard library of PLC programing objects for the Sewer Utility moving forward. Having an OOP foundation in place and well-documented in formal standards is consistent with industry best practices.

To support modernization and development of the Sewer Utility's ICS infrastructure, HDR recommends that the following standards documents be developed to capture Sewer Utility preferences and standard programming object libraries:

- **PLC programming standards:** This standards documentation would consist of written guidelines with screenshots and programming files that specify requirements and standard programming objects for all Allen-Bradley PLC platform programming and configuration work.
- **HMI graphics standards:** This standards documentation would consist of written guidelines with screenshots and programming files that specify requirements and standard programming objects for graphics development and configuration work associated with AVEVA System Platform.

- **ICS control and telemetry panel hardware standards:** This standards documentation would consist of written guidelines and template drawings that specify hardware component requirements; general control panel interior and exterior layouts; power distribution methodology; and fabrication, testing, and installation requirements for new ICS control and telemetry panels at Sewer Utility WWTPs and pump stations. The standards would also document network device configuration and hardening requirements for Ethernet switches, cellular gateways, and other network components to be installed within these panels.

8.2.2 Institute Sewer Utility ICS Standards Documentation Governance

The development of ICS standards often entails a significant investment of time and money for an organization. This investment is wasted if standards are not enforced or maintained. To ensure that any standards documents that are developed remain a valuable resource for the Sewer Utility, it is important that the standards be perceived as living documents and responsibility for their maintenance and enforcement is clearly assigned.

HDR recommends that the ICS standards be managed, maintained, and updated by a Standards Committee. Members of the committee would be technically qualified individuals with a willingness and interest to participate in maintaining the standards. A selected representative from each internal group impacted by the control system should be included on the Standards Committee. The committee should schedule periodic reviews of the standards documentation to adapt it to product obsolescence, incorporate lessons learned on recent design or implementation projects, and align it with changes in Sewer Utility preferences.

An ICS standards manager will also be required at the Sewer Utility to enforce and continue to develop the standards. This may be a single individual or a team of individuals assigned to this role. The individual(s) in charge of the standards documentation is responsible for revising the standards to incorporate any modifications or additions that need to be made as the SCADA system evolves, and for reviewing the work products of internal and contracted staff to ensure that the standards are being followed. It is also the responsibility of this individual to maintain careful version control of the standards documents and files and to ensure that work being put out to bid has appropriate references to relevant Sewer Utility ICS standards so that bidding contractors are aware of the standards and include effort to adhere to them in their bids.

8.2.3 Develop and Maintain Control Strategy Documentation

HDR recommends that the Sewer Utility develop and maintain control strategies to document how WWTP and pump station processes and equipment are controlled locally and via SCADA. These documents are critical for understanding how WWTP and pump station processes are operating, and for evaluating their performance based on data obtained through SCADA. Control strategies are also an extremely useful tool for familiarizing new staff with Sewer Utility infrastructure, which can help the Sewer Utility mitigate knowledge transfer challenges as senior staff retire in the coming years. These documents would also be very useful supporting documentation for the AVEVA System Platform upgrade and unit process optimization efforts being conducted as part of the ongoing facilities planning work. Making control strategy documentation available to Sewer Utility staff on the County electronic operation and maintenance (eO&M) SharePoint site would be one way of providing easy access to the information.

An important consideration to be included in the control strategy development is to establish procedures and assign responsibility for updating control strategy documentation when controls are modified so that the documentation remains current and accurate. Long-term set point changes, PLC programming modifications, and SCADA HMI graphics updates should prompt a review of applicable control strategies to align them with the current state of the ICS. This is a best practice but it is also a tedious one. As with the proposed ICS standards, maintaining control strategy documentation needs to be embedded in the Sewer Utility's culture of stewardship or, over time, the documents will drift away from the processes they are meant to summarize and will lose their value.

8.2.4 Establish Electronic Records for Operator Logs

HDR recommends that the Sewer Utility find an appropriate software solution for recording operator log information and establish the practice of logging daily notes, observations, and activities in an electronic format. This will greatly improve the Sewer Utility's ability to access past operator log information and provide some protection against the loss of valuable information in the event of lost or damaged physical logbooks. Implementing standard formatting for electronic operator logs would also allow for log data to be used by other software packages.

8.2.5 Update WWTP and Pump Station P&IDs and Compile Current Consolidated P&ID Sets on County eO&M SharePoint Site

HDR recommends that the Sewer Utility compile relevant piping and instrumentation diagrams (P&IDs) from past design projects into consolidated P&ID sets for each WWTP and pump station. These sets should then be reviewed against actual installed infrastructure so that the P&IDs can be updated where necessary. Because of lack and/or age of P&ID documentation for SWWTP and MWWTP, the Sewer Utility may need to develop new P&IDs based on as-built conditions at these facilities. Once consolidated P&ID sets have been updated to reflect as-built conditions, HDR recommends including these compiled sets on the Sewer Utility eO&M SharePoint site to provide staff and contractors with easy access to these important record documents.

8.2.6 Develop and Maintain OT Network Architecture Diagrams and Fiber-optic Patch Panel Schedules

HDR recommends that the Sewer Utility establish the practice of maintaining network architecture diagrams (physical and logical) for the four WWTPs. This documentation will assist Sewer Utility staff in maintaining the OT network and with planning network modifications. The documentation will also enable consultants and systems integrators to familiarize themselves with the OT network infrastructure much more quickly, saving the Sewer Utility the expense of third parties having to as-built or field-determine conditions. As part of the network documentation, HDR also recommends that the Sewer Utility develop and maintain an asset inventory for OT network devices.

HDR also recommends that the Sewer Utility maintain accurate fiber-optic patch panel schedules that document to and from information for each fiber-optic pair, as well as information about the fiber-optic cable and patch panels. HDR can provide a template schedule upon request. Another recommendation is that the Sewer Utility standardize on a tagging convention for the fiber-optic patch panels and cables throughout its OT network infrastructure. This tagging convention should be included in the Sewer Utility ICS standards documentation.

8.2.7 Develop Policies, SOPs, and Documented Workflows for ICS Technology

As the Sewer Utility becomes more reliant on ICS technology for day-to-day operations, staff will need to learn new skills and become familiar with a variety of user interfaces and procedures. Initial and periodic training will help streamline staff interaction with the technology, but having self-service resources to turn to as needed will boost staff efficiency and avoid scenarios where more technically proficient staff are frequently distracted with requests for assistance with navigating the technology. These self-service resources will also assist I&C technicians with more technical tasks that are not frequently performed, giving them a script to follow instead of having to consult manufacturer documentation and trying to remember what was done before.

For these reasons, HDR recommends that the Sewer Utility develop SOPs and documented workflows for its ICS technology. The best time to develop this documentation is during implementation, so getting in the practice of documenting procedures in parallel with execution is critical to making sure documentation happens in an efficient manner. Typical SOPs and workflow documentation for ICS technology include step-by-step instructions with supporting screenshots so that readers can follow along with their PCs or tablets. References to manufacturer literature can also be provided where detailed background information is required, but, ideally, the SOPs and workflows should be able to stand on their own as a one-stop resource to successfully execute the task.

HDR also recommends that the Sewer Utility develop policies that set the standards of behavior for activities involving the ICS and OT networks. For example, an acceptable use policy (AUP) outlines the constraints and practices that employees must agree to in order to access the OT networks. The County IS department likely already has an AUP in place for other County networks and Internet access, which could be modified or adapted to apply to the Sewer Utility OT networks. Other common useful policies include an access control policy (ACP), change management policy (CMP), and information security policy (ISP). These policies define the standards of behavior for items like password complexity, securing of County-issued laptops and tablets, documentation requirements for network device configuration changes, and adherence to established security controls. It should be noted that these policies can also be applied to third-party contractors requiring access to Sewer Utility ICS and OT network resources.

To help formulate policies, the Sewer Utility may benefit from selecting an industry-recognized standards framework on which to base its policies and procedures. The NIST Cybersecurity Framework and ISA 62443 standards are the two most frequently adopted standards for these purposes. While these standards contain valuable insights and best practices, they can be cumbersome to digest for those less familiar with the subject matter. To fast-track policy development while staff gain familiarity with new concepts, the Sewer Utility may wish to consider starting from templates that organizations like the SysAdmin, Audit, Network, and Security (SANS) Institute and International Association of Privacy Professionals (IAPP) have made publicly available online.

- ✪ Develop Sewer Utility ICS standards documentation.
- ✪ Institute Sewer Utility ICS standards documentation governance.
- ✪ Develop and maintain control strategy documentation.
- ✪ Establish electronic records for operator logs.
- ✪ Update WWTP and pump station P&IDs and compile current consolidated P&ID sets on County eO&M SharePoint site.
- ✪ Develop and maintain OT network architecture diagrams and fiber-optic patch panel schedules.
- ✪ Develop policies, SOPs, and documented workflows for ICS technology.

9 Other Software Packages: Future Needs and Recommended Improvements

This section identifies the Sewer Utility's future needs related to non-ICS software packages and describes the information and functionality that Sewer Utility staff would like to obtain from the software in the future. The future needs presented are derived from information obtained from Sewer Utility staff during site assessment visits, workshops, and staff interviews. Based on comparison of current use cases to future needs of the Sewer Utility, the section presents recommended improvements for non-ICS software.

9.1 Future Needs

This subsection describes the Sewer Utility's future needs as they relate to non-ICS software.

9.1.1 Establish Data Exchange between SCADA and LIMS

The Sewer Utility would like to eliminate the current manual data entry process involved with communicating WWTP flows to the laboratory by implementing a software solution where SCADA data needed by laboratory staff are automatically acquired from the Sewer Utility SCADA system. Laboratory staff are also interested in obtaining additional data from SCADA, such as dissolved oxygen (DO), pH, ammonia, nitrate, nitrite, and other measurements from WWTP analytical probes. Integrating SCADA with laboratory information management system (LIMS) software used by the laboratory would establish the necessary data exchange and eliminate the current lag in the manual data delivery to laboratory staff.

9.1.2 Establish Data Exchange between SCADA and CMMS

The Sewer Utility would like to eliminate the current manual data collection and entry process involved with inputting equipment runtimes into LLumin by implementing a software solution where SCADA runtime information is automatically acquired by LLumin from the Sewer Utility SCADA system. The Sewer Utility is also interested in exploring applications for other SCADA alarm and status data within LLumin in the future for potentially automating the generation of preventive, corrective, and/or predictive maintenance work orders.

9.1.3 Develop Dashboards and Data Visualizations to Deepen Insight into Sewer Utility Operations

The Sewer Utility would like to have dashboards and data visualizations that provide high-level summaries of past, current, and projected operational statuses for the Sewer Utility's various organizational groups. For example, Sewer Utility management staff have expressed interest in developing a heat map for each of the Sewer Utility's drainages where color is used to communicate current capacity and maintenance-related issues associated with the drainage's WWTP and pump stations. Many of the Sewer Utility management and other County staff requiring access to these dashboards/data visualizations will reside on the Sewer Utility business LAN or other County networks. This will require that Sewer Utility SCADA historian data and other data stores on the OT network be made available to the software serving the dashboards/data visualizations while preserving the security of the OT network.

9.2 Recommended Improvements

This subsection describes the recommended improvements related to non-ICS software.

9.2.1 Complete Hach WIMS Implementation and Establish Data Exchange with AVEVA System Platform

The Sewer Utility has selected Hach WIMS as its new LIMS and would like to see the software become a shared resource for the various Sewer Utility operational groups. As part of its ongoing implementation of Hach WIMS, the Sewer Utility would like to leverage the Hach WIMS SCADA Interface software module to automatically acquire data from its SCADA system. Once the Sewer Utility has Hach WIMS up and running, HDR recommends that staff explore the software's features and compile a list of the specific SCADA data from the various WWTPs that would be beneficial to automatically import into Hach WIMS. With the SCADA data defined, the Sewer Utility would then configure automated imports of the desired data within the Hach WIMS software. After data exchange between Hach WIMS and the Sewer Utility historian is established, staff will also have the ability to select specific SCADA tags and date ranges for ad hoc data imports and trend analysis from within Hach WIMS.

Because several of the Sewer Utility Hach WIMS users will be working from PCs on the Sewer Utility business LAN, HDR recommends that the server running Hach WIMS software be located on the business LAN and that the software be configured to interface with the "Tier 2" historian proposed for the business LAN. In the interim, while the industrial DMZ has yet to be implemented, the Hach WIMS server may need to be deployed on the CKTP OT network to establish data exchange with the CKTP historian. Under this deployment, for OT network security purposes, HDR recommends that the Hach WIMS server be accessed only by PCs on the OT network and that the Sewer Utility resist the temptation to implement dual-homed machines (i.e., one PC or server with connections to both the business LAN and OT network).

9.2.2 Complete Asset Creation and Data Entry Required for LLumin Implementation, Establish Automatic Importing of Asset Runtimes, and Develop a Plan for Automating Work Order Generation

The Sewer Utility is in the process of establishing a parent-child asset hierarchy for its infrastructure within the LLumin software. Some configuration and data entry work remains to be completed before all Sewer Utility assets are represented within the LLumin platform. This initial effort should be completed so that asset identifiers and relationships are defined prior to establishing connections to other software platforms and linking asset attributes and data points between them. HDR believes that the LLumin implementation is a high priority for the Sewer Utility and that staff will complete this work in the near future.

Once the foundational work is completed, HDR recommends that the Sewer Utility establish automatic importing of asset runtimes from the Sewer Utility historian. HDR believes that the Sewer Utility has already purchased the LLumin software module required to integrate LLumin with its SCADA system (LLumin Machine Interface Server). However, implementing the data exchange securely requires careful planning because of the cloud-hosted, software as a service (SaaS) nature of the Sewer Utility's LLumin implementation. To reduce the Sewer Utility's cyber threat exposure, HDR recommends that the LLumin platform be configured to interface with the "Tier 2" historian proposed for the business LAN. This approach would eliminate direct communication between the LLumin cloud instance and the Sewer Utility OT network, while still providing access to asset runtime data. LLumin Machine Interface Server can be implemented as a cloud-hosted service or an on-premise solution, where it runs as a Windows service. HDR recommends that the Sewer Utility take the latter approach, as it will simplify the data exchange with cloud-hosted resources and allow for aggregate data to be sent out to the cloud instead of handling historian tags individually.

After Sewer Utility staff have become more familiar with the LLumin platform and automated importing of asset runtimes has been successfully implemented, HDR recommends that the Sewer Utility develop a plan to leverage additional functionality within the LLumin platform. The LLumin software supports asset-specific, rule-based generation of work orders, which could significantly streamline scheduling for maintenance staff and reduce asset downtime. To take advantage of this functionality, the Sewer Utility would need to identify asset runtime thresholds, alarms, events, and/or analog value set points (e.g., pump high discharge pressure) that should trigger a work order within the LLumin system. Identifying this information for all assets at once would be a significant effort, so HDR recommends that the Sewer Utility select a small sample of assets on which to pilot the approach at first. Once rules have been established and implemented within LLumin for the first asset sample, the Sewer Utility could then evaluate how the work order automation could be tweaked to improve its efficacy. Assuming the Sewer Utility experiences favorable results with automation of work orders within LLumin, HDR recommends that the Sewer Utility develop a schedule for deploying the approach to its remaining assets, where applicable.

Note, if the Sewer Utility wishes to pursue alarm- or event-based work order generation on a near-real-time basis, periodic data exchange between LLumin and the historian may not be sufficient. LLumin's Machine Interface Server software module would need to communicate with AVEVA System Platform, in this case, which would likely require relocating the LLumin Machine Interface Server software to the CKTP OT network or industrial DMZ and implementing additional security controls. HDR recommends starting with data exchange between LLumin and the "Tier 2" historian, initially, and then considering expansion of the LLumin system after the Sewer Utility's CMMS program is further developed.

9.2.3 Select a Data Analytics and Visualization Software Platform and Develop In-house Skill Sets through Creation of Initial Dashboards

AVEVA System Platform, LLumin, Hach WIMS, and other software that the Sewer Utility has implemented all have some degree of native dashboarding and data visualization capabilities, and HDR recommends that the Sewer Utility explore this functionality and apply it where the software can meet the Sewer Utility's needs. However, there can be challenges to using these purpose-built software platforms for analyzing data from outside of their design scope or for creating custom visualizations to answer specific questions that do not land well within the software's niche. As the Sewer Utility's data sets become broader and more accessible and Sewer Utility staff have more opportunities to interact with the data, the Sewer Utility will need a flexible data analytics and visualization software tool that can ingest data from a wide variety of data sources. The software tool will also need to be self-service with a relatively intuitive user interface so as to empower staff to look for answers on their own and enable them to easily share findings with other stakeholders.

HDR recommends that the Sewer Utility select a suitable software solution for general data analytics and visualization purposes throughout the organization and to then begin developing the ability to create and manipulate dashboards and visualizations in-house. Turning data into insights is an iterative process, which means that reliance on third parties for dashboard development and other data-driven initiatives adds cost and time to every iteration. Having staff with the skill sets to solicit input from stakeholders and to then take ideas and develop them into meaningful dashboards and reports that present useful information is an integral part of growing an organization's data program.

A good first step to cultivating these in-house skill sets would be to identify staff members who have the interest and availability to acquire these skills, schedule initial online training to familiarize them with the selected software solution, and then have them create a few dashboards centered around currently available data. The first dashboards produced may not be perfect, but their creation will establish an internal process that the Sewer Utility can refine over time. And as in-house skill sets also develop over time, the Sewer Utility will be in a better position to delve into more technical approaches to data analysis and, potentially, to explore some of the emerging technologies like machine-learning that may have big impacts in terms of process control and utility management in the coming years.

9.2.4 Begin Leveraging the Sewer Utility's Power and Energy Data

Energy consumption is a considerable expense for a wastewater utility and also serves as a good metric for quantifying the utility's overall operational efficiency when it comes to electrical power. However, a utility cannot improve what it cannot measure, and electric bills alone will not provide sufficient information for a utility to identify opportunities for efficiency gains at the equipment, process, and procedural levels. Submetering is critical to enabling these insights. Monitoring power flows through the electrical distribution system at the bus and load levels allows a utility to track where energy is being consumed within its infrastructure. And when historical energy data are paired with other parameters that represent the total product handled or level of treatment achieved over the same time frame, useful performance metrics are created that can be used to establish baselines, set goals, and measure progress toward those goals over time.

Fortunately, the Sewer Utility has made past investments in submetering that could be put to work in the development of an energy management program. Power monitors are installed at many of the major electrical distribution system buses throughout the Sewer Utility's WWTPs and several pump stations. However, the data available from these power monitors are not being used and, in many cases, not even recorded for future use. The Sewer Utility also already has the capability to monitor power and energy data at the load level for equipment powered from the DeviceNet MCCs at CKTP, some of the WWTP aeration blowers, and select other loads. Yet, load-level energy data are not being used either.

Initial Power and Energy Data Acquisition

As a first step in developing an energy management program, HDR recommends that the Sewer Utility harvest its low-hanging fruit by beginning to record historical power and energy data from installed power monitors and network-capable motor controllers, where it is not already doing so. In some cases, this may require installation of network cabling to establish communications with power monitors that are not currently communicating with the Sewer Utility SCADA system. For Ethernet-capable power monitors that are not currently communicating with a PLC, the Sewer Utility should consider direct communication between the power monitor and its AVEVA SCADA software. This would eliminate the need for additional PLC programming and gateway modules to enable the PLC to communicate with the power monitor via an Ethernet protocol that the PLC does not support natively (e.g., Modbus TCP in the case of Allen-Bradley CompactLogix controllers). Once communications are established and tags are defined within AVEVA System Platform, HDR recommends recording the power and energy parameters listed in Table 9-1 within the Sewer Utility's centralized historian.

Table 9-1. Recommended power and energy parameters for initial energy management program baselines by application

Application	Parameter description	Parameter engineering unit
Power monitor	Total real power	kW
	Total reactive power	Kilovolt-amperes reactive (kVAR)
	Total apparent power	Kilovolt-amperes (kVA)
	Received energy	kWh
	Delivered energy (only for buses with a connected generator)	kWh
	Power factor	PF
	Phase currents (phases A, B, and C)	Amperes (A)
	Phase-to-phase voltages (V_{ab}, V_{bc}, and (V_{ca})	VAC
	Frequency	Hertz (Hz)
	Total harmonic distortion (THD), current	THD_I
	Total harmonic distortion, voltage	THD_V

Table 9-1. Recommended power and energy parameters for initial energy management program baselines by application

Application	Parameter description	Parameter engineering unit
Motor controller	Total real power	kW
	Total energy consumed	kWh
	Average amps	A
	Average voltage	VAC
	Total power factor	PF

While the instantaneous power-related parameters would not have an application in the energy-based KPIs discussed later in this subsection, they do provide valuable information about the state of the electrical distribution system and equipment performance. Power information can be used to monitor electrical capacity, phase balance, and levels of harmonic distortion at the various electrical buses. This information is useful for evaluating the existing infrastructure's capacity to accept additional electrical loads and for assessing when harmonic distortion is approaching unacceptable levels. As mentioned previously in this TM, load-level power information can be a valuable input for analyzing asset health and performance and can be used to trigger predictive maintenance activities.

Transition from EnerVista Viewpoint Monitoring Software at CKTP

Though the existing General Electric (GE) EnerVista Viewpoint Monitoring software installed on the power monitoring PC in the CKTP SPB control room is capable of monitoring and recording these parameters for networked power monitors at CKTP, and has several additional features, this software does not present a solution for all of the Sewer Utility's WWTPs and pump stations without additional investment in software licensing and OT network configuration. Instead of expanding the GE EnerVista Viewpoint Monitoring software platform as a parallel system to the AVEVA deployment, which would result in another data silo to manage, HDR recommends that the Sewer Utility leverage AVEVA software to monitor and record the Sewer Utility's power and energy data moving forward. It should be noted that the EnerVista Viewpoint Monitoring software is only one component within GE's EnerVista software suite, and that this software suite can serve as a valuable platform for in-depth analysis and management of a utility's electrical distribution infrastructure and protective relaying. However, given the scale of the Sewer Utility's infrastructure, HDR does not see further investment in the EnerVista platform providing significant returns for the Sewer Utility.

Plan for Installation of Additional Power Monitors and Future Ethernet Motor Controllers

HDR recommends that the Sewer Utility plan on installing Ethernet-capable power monitors at all major electrical distribution buses (e.g., MCCs, switchgear [SWGR], switchboards) as this equipment is replaced and/or upgraded in the coming years. The Sewer Utility could also consider installation of Ethernet-capable power monitors for equipment not slated for near-term improvements as funding allows. When selecting power monitor hardware, it is important that the power monitor is capable of communicating power and energy parameters via an Ethernet protocol. Several power monitors have Ethernet ports but are capable of serving only a web browser interface and cannot be integrated into SCADA platforms.

As discussed previously, HDR also recommends that future motor controllers be provided with Ethernet communications so that the recommended power and energy data can be monitored and recorded.

Define Energy-based Metrics and Establish Baselines

HDR recommends that the Sewer Utility determine energy-based metrics to be used as KPIs for evaluating its operations and to then leverage these KPIs to establish baselines at each of its WWTP and remote pump station facilities. Some examples of potential KPIs are provided in Table 9-2. The application column of the table indicates the scope of the equipment and process(es) evaluated by the KPI. For example, WWTP would indicate that the energy consumed by the entire WWTP is to be considered, while secondary treatment would indicate that only the loads associated with secondary treatment equipment would be considered in calculating the KPI value.

Table 9-2. Example energy-based KPIs for wastewater infrastructure

Application	KPI description	KPI engineering unit
WWTP	Energy consumed per volume treated	kWh/million gallons (MG)
WWTP	Energy consumed per pound (lb) of biological oxygen demand (BOD) removed	kWh/lb BOD
WWTP	Energy consumed per population served per year	kWh/population equivalent (PE)/year
Preliminary treatment	Energy consumed per volume treated	kWh/MG
Preliminary treatment: screenings equipment	Energy consumed per volume of screenings removed	kWh/cubic foot (ft^3)
Preliminary treatment: grit removal equipment	Energy consumed per volume of grit removed	kWh/ft^3
Primary treatment	Energy consumed per pound of total suspended solids (TSS) removed	kWh/lb TSS
Primary treatment	Energy consumed per pound of phosphorus (P) removed	kWh/lb P
Primary treatment	Energy consumed per pound of BOD removed	kWh/lb BOD
Primary treatment	Energy consumed per pound of chemical oxygen demand (COD) removed	kWh/lb COD
Secondary treatment	Energy consumed per pound of total nitrogen removed	kWh/lb TN
Secondary treatment	Energy consumed per pound of phosphorus removed	kWh/lb P
Secondary treatment	Energy consumed per pound of BOD removed	kWh/lb BOD
Secondary treatment	Energy consumed per pound of COD removed	kWh/lb COD

Table 9-2. Example energy-based KPIs for wastewater infrastructure

Application	KPI description	KPI engineering unit
UV system	Energy consumed per volume treated	kWh/MG
Reclaimed water system	Energy consumed per volume of reclaimed water produced	kWh/MG
Solids treatment	Energy consumed per volume treated	kWh/MG
Solids treatment	Energy consumed per pound of total solids (TS) removed	kWh/lb TS
Solids treatment: GBTs	Energy consumed per volume treated	kWh/MG
Solids treatment: GBTs	Energy consumed per pound of total solids treated	kWh/lb TS
Solids treatment: RDTs	Energy consumed per volume treated	kWh/MG
Solids treatment: RDTs	Energy consumed per pound of total solids treated	kWh/lb TS
Solids treatment: GBTs	Energy consumed per volume treated	kWh/MG
Solids treatment: GBTs	Energy consumed per pound of total solids treated	kWh/lb TS
Solids treatment: anaerobic digesters	Energy consumed per volume treated	kWh/MG
Solids treatment: centrifuges	Energy consumed per volume treated	kWh/MG
Solids treatment: centrifuges	Energy consumed per pound of total solids treated	kWh/lb TS
Pump station	Energy consumed per volume treated	kWh/MG
Pump (individual)	Energy consumed per volume pumped	kWh/MG

As the data required to track these KPIs are integrated into the AVEVA platform and collected by the historian, it will take some time before sufficient historical data are compiled to adequately establish baselines for current operations. Ideally, baselines are established from at least 1 year's worth of data so that weather and seasonal variation factors can be accounted for, enabling the Sewer Utility to contrast current performance with the same month or season from prior years. However, KPIs that apply to the entire WWTP could be assessed from past electrical billing information as a start, if the Sewer Utility is not already doing so.

In terms of the software used to monitor and track energy-based KPIs, HDR recommends that the Sewer Utility consider developing dashboards with the selected data analytics and visualization software. Hach WIMS also has some energy usage tracking functionality that may prove useful to the Sewer Utility.

Set Goals and Measure Progress

Once the Sewer Utility has established adequate baseline energy data to support the KPIs it is interested in monitoring, HDR recommends that the baselines be reviewed to identify processes and equipment where energy efficiency measures are most likely to yield benefits. Targeted goals would then be set and the KPIs would be used to measure progress toward those goals. Conducting a formal energy audit prior to establishing goals would likely help identify quick wins and potential high-yield returns on investment in infrastructure or operational change, which would assist with the goal-setting process.

- ✪ Complete Hach WIMS implementation and establish data exchange with AVEVA System Platform.
- ✪ Complete asset creation and data entry required for LLumin implementation, establish automatic importing of asset runtimes, and develop a plan for automating work order generation.
- ✪ Select a data analytics and visualization software platform and develop in-house skill sets through creation of initial dashboards.
- ✪ Begin leveraging the Sewer Utility's power and energy data.

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10 Risks and Deficiencies with Recommended Improvements Summary

Table 10-2 compiles the risks and deficiencies associated with the Sewer Utility's OT networks, SCADA system components, and associated infrastructure that were identified in TM-1 and previous sections of TM-2. These risks and deficiencies are paired with the recommended improvement(s) that will mitigate the risk or resolve the deficiency. Subsection references are provided to help readers locate the specific subsections where the risks, deficiencies, and recommended improvements are described in detail. Note, some recommended improvements are simple enough that a summary description in a previous subsection of this TM was unwarranted. In these cases, recommended improvements are provided directly in Table 10-2 and appear without a subsection reference.

As an expansion of the risk and deficiency summary table provided in TM-1, Table 10-2 preserves the correlation of each risk and deficiency to one or more of the organizational improvement categories introduced in Section 7 of TM-1. Applicable organizational improvement categories are denoted with one or more ✸ symbols in their respective columns. To help communicate the significance of various risks and deficiencies, a ranking system was applied in TM-1 based on the quantity of ✸ symbols shown for a given organizational improvement category. These rankings have been carried over from TM-1 and are repeated in Table 10-1 for the reader's convenience. Risks and deficiencies from each TM-1 and TM-2 section are sorted in Table 10-2 so that the most significant risks and deficiencies from each section appear first.

Table 10-1. Risk and deficiency ranking system description

Ranking	Description
✸✸✸	**Major** risk or deficiency. Immediate corrective measures are recommended and/or major organizational health benefit(s) to be gained from related improvements.
✸✸	**Moderate** risk or deficiency. Near-term corrective measures are recommended and/or significant organizational health benefit(s) to be gained from related improvements.
✸	**Minor** risk or deficiency. Corrective measures are recommended, but likelihood and/or impact of failure/event may be low. Some organizational health benefit(s) to be gained from related improvements.

This ranking system is also meant to communicate the priority level of the recommended improvement(s), which can be used to distinguish between recommendations requiring immediate action or decisions, items that will need to be considered for near-term planning, and more long-term initiatives. In a subsequent phase of the Master Plan, these recommendations will be grouped into phases of a proposed implementation plan and the recommendation priority level will be one of the factors used to determine how the various implementation plan phases are sequenced.

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: Network Architecture	2.7	There is a direct connection between CKTP business LAN and OT network switches in the SPB control room network cabinet. This direct connection between the business LAN and OT network presents a significant security risk for the OT network.			✸✸✸			• HDR recommends eliminating this connection and believes that Sewer Utility staff have already disconnected the Category cable connecting the two network switches. • Establish an industrial DMZ between Sewer Utility business LAN and OT network.	5.2.7
TM-1: Network Architecture	2.7	A cellular router was found connected to the unmanaged OT network switch in the SPB control room network cabinet. The device could provide a backdoor into the CKTP OT network for external devices that the Sewer Utility has no control over, bypassing security measures in place for the network. Sewer Utility staff have since disconnected the cellular router from the network.			✸✸✸			HDR recommends removing the cellular router from the OT network and believes that Sewer Utility staff have already done so.	---
TM-1: Network Architecture	2.13	No automated or manual backup procedures appear to be in place for the historical SCADA data contained on the CKTP historian. Failure of the CKTP historian server could result in loss of CKTP's historical SCADA data.				✸✸✸		• Extend OT network to County Public Works Annex facility. • Establish automated backup procedures for ICS servers that include on-premise and off-site storage.	5.2.2 5.2.8
TM-1: Network Architecture	2.13	Historical SCADA data for KWWTP, MWWTP, and SWWTP may exist only on external hard drives connected to the SCADA PCs at the WWTPs. Failure of the external hard drive or a catastrophic event that impacts the SCADA PC and external hard drive may result in loss of the WWTP's historical SCADA data.				✸✸✸		• Establish automated backup procedures for ICS servers that include on-premise and off-site storage. • Establish a tiered historian implementation at CKTP to centralize Sewer Utility historical ICS data and provide secure access to historical ICS data from the Sewer Utility business LAN.	5.2.8 7.2.7
TM-1: Network Architecture	2.3	Pump stations on the VHF licensed radio WAN experience long delays in communication of pump station statuses and alarms, which have presented challenges to County staff in providing timely responses to critical pump station alarms and accurate calculations of accumulated equipment runtimes.	✸✸				✸	• Migrate pump stations from VHF licensed radio WAN to cellular WAN. • Implement store-and-forward and exception reporting for remote pump station telemetry and eliminate PLC data concentrator for cellular WAN.	5.2.3
TM-1: Network Architecture	2.2	Given the current network arrangement, the most critical network switch in the CKTP OT network is a single point of failure for the network.				✸✸		Upgrade to stacked Layer 3 distribution switches at CKTP SPB.	5.2.4
TM-1: Network Architecture	2.2	CKTP OT network arrangement in PNL 8580A has created multiple single points of failure for communication between CKTP SCADA nodes and all of the plant PLCs.				✸✸		Upgrade to stacked Layer 3 distribution switches at CKTP SPB.	5.2.4
TM-1: Network Architecture	2.2	CKTP OT network has no resilience because of a lack of access switch and cable path redundancy, and there are instances where lack of OT network redundancy may undermine process redundancy.				✸✸		Establish cable path redundancy for critical segments of the OT network.	5.2.5
TM-1: Network Architecture	2.2	Improving CKTP OT network resilience could prevent loss of SCADA monitoring and control functionality and continue logging of historical SCADA data in the event of singular network component or cable failure.				✸✸		• Upgrade to stacked Layer 3 distribution switches at CKTP SPB. • Establish cable path redundancy for critical segments of the OT network.	5.2.4 5.2.5

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: Network Architecture	2.3	Currently, Sewer Utility staff do not have a central location where all WWTP SCADA systems can be monitored and controlled.					✸✸	• Upgrade CKTP control room. • Establish access to all Sewer Utility SCADA HMI screens at each WWTP control room and at the County Public Works Annex facility.	5.2.1 7.2.2
TM-1: Network Architecture	2.3	The lower bandwidth inherent in VHF-based telemetry is ill-suited for increased data exchange between the pump stations and the CKTP SCADA system and would constrain the Sewer Utility's objective of near-real-time monitoring and alarming for wastewater pump stations.		✸✸				• Migrate pump stations from VHF licensed radio WAN to cellular WAN. • Implement store-and-forward and exception reporting for remote pump station telemetry and eliminate PLC data concentrator for cellular WAN.	5.2.3
TM-1: Network Architecture	2.3	Four of the six pump stations with historically poor VHF communications remain on the VHF licensed radio WAN. Planned modifications for the Manchester area pump stations may improve communications for those pump stations.		✸✸				• Migrate pump stations from VHF licensed radio WAN to cellular WAN. • Implement store-and-forward and exception reporting for remote pump station telemetry and eliminate PLC data concentrator for cellular WAN.	5.2.3
TM-1: Network Architecture	2.3	The CKTP SCADA system does not appear to be accurately recording communication status data for the pump stations on the cellular WAN.		✸✸				Improve communication status monitoring and alarming for remote pump station telemetry.	5.2.3
TM-1: Network Architecture	2.7	Public IP addresses are assigned to IP nodes within the CKTP and SWWTP OT networks.			✸✸			Develop and implement an improved OT network segmentation scheme.	5.2.8
TM-1: Network Architecture	2.7	There appear to be parallel entry points to the SWWTP OT network from external networks: one via SWWTP's Tempered Networks HIPswitch and one via a secure gateway used for the SWWTP business LAN wireless access point.			✸✸			HDR recommends eliminating the connection between the secure gateway and the SWWTP OT network. Sewer Utility staff have indicated that they will investigate the intended use for the connection so that its functionality can be migrated to the Tempered Networks Airwall system, if needed, and will then make the disconnection.	---
TM-1: Network Architecture	2.9	Because of inherent security risks with VNC-based applications, HDR recommends transitioning away from VNC sessions for remote access to the Sewer Utility's OT networks.			✸✸			• Implement secure mobile access to SCADA HMI screens for remote and on-site staff. • Implement secure remote access to OT network for I&C technicians and contracted systems integrators.	5.2.7
TM-1: Network Architecture	2.9	Users accessing the WWTP OT networks remotely share a common password, which means that no AAA measures are in place for remote access to the WWTP OT networks.			✸✸			• Implement secure mobile access to SCADA HMI screens for remote and on-site staff. • Implement secure remote access to OT network for I&C technicians and contracted systems integrators.	5.2.7
TM-1: Network Architecture	2.9	MFA for remote access sessions to the WWTP OT networks would provide additional security for the network in conjunction with the adoption of AAA measures.			✸✸			• Implement secure mobile access to SCADA HMI screens for remote and on-site staff. • Implement secure remote access to OT network for I&C technicians and contracted systems integrators.	5.2.7
TM-1: Network Architecture	2.10	The Sewer Utility's Tempered Networks Conductor instance has generic user accounts that do not allow for adequate user authentication or attributing of any security modifications made to a specific individual.			✸✸			Establish unique user accounts and implement MFA for Tempered Networks Conductor management.	5.2.9
TM-1: Network Architecture	2.10	No MFA measures are in place to secure access to the Sewer Utility's Tempered Networks Conductor instance.			✸✸			Establish unique user accounts and implement MFA for Tempered Networks Conductor management.	5.2.9

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: Network Architecture	2.10	Multiple user types are allowed to assume remote control over SCADA PCs on the Sewer Utility's OT networks, which may be providing some users with more permissions and access to OT network resources than they require. Sewer Utility OT network remote access use cases need to be defined so that appropriate security controls can be identified and implemented.			✸✸			• Implement secure mobile access to SCADA HMI screens for remote and on-site staff. • Implement role-based overlay networks for the Sewer Utility Tempered Networks Airwall system.	5.2.7 5.2.9
TM-1: Network Architecture	2.10	The Sewer Utility's Airwall edge services do not have current firmware versions installed.			✸✸			Perform ICS server, PCs, and OT network device hardening to mitigate common cybersecurity risks.	5.2.9
TM-1: Network Architecture	2.10	The HIPswitch 100g installed at CKTP appears to be limited to 5 Mbps of data throughput. Given the intended application for SCADA-related data exchange between CKTP and the other WWTPs, this amount of throughput will likely be inadequate for the Sewer Utility's near-term needs.		✸✸				HDR recommends replacing this HIPswitch with a Tempered Networks Airwall gateway capable of greater data throughput.	---
TM-1: Network Architecture	2.11	Some of the PCs on the CKTP OT network have likely been in service for 5 to 7 years and should be replaced as part of the Sewer Utility's planned Wonderware upgrade at CKTP.		✸✸				HDR recommends replacing the PCs and servers on the OT network that have been in service for more than 5 years. HDR believes that the CKTP historian is being replaced by QCC as part of a planned upgrade to the Sewer Utility AVEVA software.	---
TM-1: Network Architecture	2.11	Operating system login sessions are maintained on CKTP OT network PCs and a common username and password is shared by all users.			✸✸			Improve AAA measures for OT network.	5.2.8
TM-1: Network Architecture	2.12	Unprotected OT network components share space with exposed plumbing and mechanical equipment in the CTKP administration and lab building electrical room.				✸✸		Implement modifications to CKTP administration and laboratory building electrical room.	5.2.4
TM-1: Network Architecture	2.12	Status and alarms are not monitored for UPSs that provide power to SCADA PCs and servers and OT network equipment. The installed UPSs also have no remote monitoring capability.				✸✸		Establish robust UPS battery backup solution for ICS and OT network infrastructure.	5.2.6
TM-1: Network Architecture	2.12	KPUD-owned Carrier Ethernet access switches that provide communication between KWWTP, MWWTP, and SWWTP and CKTP are not on UPS power.				✸✸		Establish robust UPS battery backup solution for ICS and OT network infrastructure.	5.2.6
TM-1: Network Architecture	2.12	The Sewer Utility's current strategy of allocating small, dedicated UPSs for OT network PCs, servers, and other critical loads provides very limited battery backup times for this equipment, leaving the Sewer Utility reliant on the proper functioning of the standby generators to keep the equipment online during power outages.				✸✸		Establish robust UPS battery backup solution for ICS and OT network infrastructure.	5.2.6
TM-1: Network Architecture	2.13	No automated or manual procedures are in place for establishing off-site backups of Sewer Utility WWTP SCADA data or ICS configuration and programming files.				✸✸		Establish automated backup procedures for ICS servers that include on-premise and off-site storage.	5.2.8
TM-1: Network Architecture	2.13	No automated or manual backup procedures appear to be in place for backing up the Sewer Utility OT network PCs and servers.				✸✸		Establish automated backup procedures for ICS servers that include on-premise and off-site storage.	5.2.8
TM-1: Network Architecture	2.16	The Sewer Utility does not have a formal cybersecurity incident response program for the OT networks it manages.			✸✸			Develop a formal cybersecurity incident response program.	5.2.9

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: Network Architecture	2.11	CKTP OT network has been set up as a workgroup. Implementing a domain for the OT network would allow the Sewer Utility to manage all user accounts and permissions on a single server and enable segmentation of the OT network to increase security and optimize network performance.	✸		✸		✸	Implement a domain for the CKTP OT network.	5.2.8
TM-1: Network Architecture	2.14	The Sewer Utility does not have software tools to monitor the CKTP OT network and manage its performance.	✸		✸		✸	Implement OT network performance monitoring and logging capabilities.	5.2.8
TM-1: Network Architecture	2.5	Several unmanaged switches at CKTP are recommended for replacement with managed switches to mitigate risks to network stability and security.		✸	✸			Establish standard Layer 2 managed access switch with gigabit downlink ports for future OT network applications and replacement of select unmanaged switches.	5.2.5
TM-1: Network Architecture	2.14	The Sewer Utility does not have a Syslog server or other central repository for collecting CKTP OT network device logs and network event data.			✸		✸	Implement OT network performance monitoring and logging capabilities.	5.2.8
TM-1: Network Architecture	2.2	The access switch serving the CKTP SCADA PCs and historian server is an unmanaged switch, which propagates undesirable broadcast and multicast packets generated by the operating systems on those machines throughout the network.		✸				Upgrade to stacked Layer 3 distribution switches at CKTP SPB.	5.2.4
TM-1: Network Architecture	2.2	KWWTP OT network has no resilience because of a lack of access switch and cable path redundancy, and this lack of OT network redundancy may undermine liquid stream process redundancy.				✸		No recommended improvement. Based on input from the Sewer Utility, the Master Plan will focus on higher-priority risks and deficiencies.	---
TM-1: Network Architecture	2.3	The pump station communication efficiency parameter values displayed at the CKTP SCADA HMI and logged in the CKTP historian may be misrepresenting actual VHF licensed radio WAN radio path performance because of the calculations used in the MTU PLC programming.	✸					Improve communication status monitoring and alarming for remote pump station telemetry.	5.2.3
TM-1: Network Architecture	2.4	An OM1 fiber-optic patch cable has been used to patch two Optical Multi-mode 3 (OM3) fiber-optic cables at the fiber-optic patch panel within PNL 2920 in the CKTP power/blower building. This patch cable should be replaced with a suitable OM3 patch cable.		✸				Replace patch cable with suitable OM3 patch cable.	---
TM-1: Network Architecture	2.4	There are instances of unshielded twisted pair (UTP) Category cables with insufficient voltage insulation ratings connecting IP nodes within 480 VAC equipment enclosures at CKTP and PS-67.		✸				For network connections to enclosures containing 480 VAC equipment, include requirement for shielded Category cables with 600 VAC insulation rating in proposed Sewer Utility ICS standards documentation.	---
TM-1: Network Architecture	2.5	The Sewer Utility has not standardized on a specific managed switch, which can lead to stocking of additional spare switches to facilitate rapid switch replacement in the event of switch failure.	✸					Establish standard Layer 2 managed access switch with gigabit downlink ports for future OT network applications and replacement of select unmanaged switches.	5.2.5
TM-1: Network Architecture	2.5	All ports on most switches throughout the Sewer Utility OT networks are capping connected devices at the theoretical 100 Mbps limit inherent in the switch ports. As data volumes increase within the Sewer Utility's OT networks in the coming years, the port speeds supported by these switches may become a limiting factor.		✸				Establish standard Layer 2 managed access switch with gigabit downlink ports for future OT network applications and replacement of select unmanaged switches.	5.2.5
TM-1: Network Architecture	2.5	Several managed switches on Sewer Utility OT networks are accessible via manufacturer default username and password.			✸			Perform ICS server, PCs, and OT network device hardening to mitigate common cybersecurity risks.	5.2.9

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: Network Architecture	2.6	The Sewer Utility has not implemented on-site tablet-based workflows for Sewer Utility staff, which can improve workforce efficiency and increase staff engagement with ICS software.					✸	Implement secure mobile access to SCADA HMI screens for remote and on-site staff.	5.2.7
TM-1: Network Architecture	2.7	The subnet assigned to the CKTP OT network effectively limits the network to 254 connected devices. The Sewer Utility will require a larger pool of IP addresses to support additional devices in the future and adapt to the proliferation of IP devices that is becoming the norm in the industrial automation industry.		✸				Develop and implement an improved OT network segmentation scheme.	5.2.8
TM-1: Network Architecture	2.7	Unused network switch ports are enabled and assigned to active VLANs throughout the Sewer Utility's OT networks.			✸			Perform ICS server, PCs, and OT network device hardening to mitigate common cybersecurity risks.	5.2.9
TM-1: Network Architecture	2.9	UltraVNC encryption plugin is not enabled. Security of VNC sessions used to establish remote access to WWTP OT networks could be increased by enabling encryption at the VNC application layer.			✸			• Implement secure mobile access to SCADA HMI screens for remote and on-site staff. • Implement secure remote access to OT network for I&C technicians and contracted systems integrators.	5.2.7
TM-1: Network Architecture	2.10	On-call staff, QCC, and I&C technicians all share access to the Tempered Networks Kitsap Telemetry overlay network. This may be allowing access to PLCs and other OT network resources that on-call staff do not require access to and complicates management of third-party access to the Sewer Utility's OT network.			✸			Implement role-based overlay networks for the Sewer Utility Tempered Networks Airwall system.	5.2.9
TM-1: Network Architecture	2.10	Devices are included in the Tempered Networks Kitsap IC overlay network that County staff may not need to access remotely. If remote access is not required for these devices, they should be removed from the overlay network as a security precaution.			✸			Implement role-based overlay networks for the Sewer Utility Tempered Networks Airwall system.	5.2.9
TM-1: Network Architecture	2.10	HIPswitches are providing a single layer of defense at the periphery of the Sewer Utility's OT networks, which does not adhere to Defense-in-Depth strategies recommended by DHS and other information security organizations.			✸			Introduce OT network firewall layer upstream from WWTP Tempered Networks HIPswitches.	5.2.9
TM-1: Network Architecture	2.10	Communication links between KWWTP, MWWTP, and SWWTP and CKTP have no redundancy.				✸		Implement HIPswitch cellular failover functionality to establish communication link redundancy for WWTPs.	5.2.3
TM-1: Network Architecture	2.10	Pump station and CKTP MTU VHF radios have AES encryption disabled, which exposes the pump station VHF licensed radio WAN to eavesdropping and security risks.			✸			Perform ICS server, PCs, and OT network device hardening to mitigate common cybersecurity risks.	5.2.9
TM-1: Network Architecture	2.11	KWWTP, MWWTP, and SWWTP SCADA servers have likely been in service for 3 to 4 years and should be replaced as part of the Sewer Utility's planned Wonderware upgrade at the plants.		✸				HDR recommends replacing these SCADA servers and believes that the server replacement is being performed by QCC as part of a planned upgrade to the Sewer Utility AVEVA software.	---
TM-1: Network Architecture	2.12	Physical security at the Sewer Utility WWTPs could be improved by introducing camera systems and providing monitoring and alarming of more of the building entrances during hours when the WWTPs are unattended.			✸			Because physical security for the WWTPs affects all Sewer Utility assets, not just the OT network and ICS infrastructure, HDR recommends that the Sewer Utility consider site security improvements as part of the larger ongoing Sewer Utility Facilities Plan effort.	---
TM-1: Network Architecture	2.12	Network cabinet and network panel PNL-8580A are routinely left unlocked.			✸			HDR recommends establishing the protocol of locking or otherwise restricting access to network cabinets and future network racks.	---

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: Network Architecture	2.12	Construction activity at KWWTP is generating a significant amount of dust in the space occupied by KWWTP's Internet service demarcation appliance.				✸		HDR believes that construction activities are now completed. The Sewer Utility should survey the dust accumulated on the device and coordinate with KPUD, if buildup is considerable. Dusting with compressed air would likely remedy the situation.	---
TM-1: Network Architecture	2.13	Backups of PLC programming project files could be better organized to improve version control.				✸		HDR recommends that the Sewer Utility store all PLC programming project files for all WWTPs and pump stations on an OT network file server at CKTP. HDR also recommends that the Sewer Utility develop a standard file naming convention for PLC programming project files that incorporates the date of last modification in the filename using a YYYY-MM-DD format. This will allow various versions to be easily sorted by last modification date. The file naming convention should be included in the Sewer Utility ICS standards documentation.	---
TM-1: Network Architecture	2.13	The Sewer Utility is not leveraging virtualization for the PCs and servers in its OT networks. Recovering from loss of one of these physical machines or a disaster would require significantly more time and effort than a scenario where the Sewer Utility's ICS software is installed in a virtualized environment.				✸		Establish virtualized environments for all ICS servers.	5.2.8
TM-1: Network Architecture	2.12	In general, the network switches within the Sewer Utility's OT network have no on-board power supply or external 24 VDC power supply redundancy.				✸		Standardize on redundant onboard power supplies and 24 VDC power supplies for ICS and OT network infrastructure.	5.2.6
TM-1: Network Architecture	2.14	The Sewer Utility does not maintain an organized system of easily accessible network device configuration file backups for managed switches and cellular routers within its OT networks.				✸		HDR recommends that the Sewer Utility store all configuration files for all OT network devices on an OT network file server at CKTP. HDR also recommends that the Sewer Utility develop a standard file naming convention network device configuration files that incorporates the date of last modification in the filename using a YYYY-MM-DD format. This will allow various versions to be easily sorted by last modification date. The file naming convention should be included in the Sewer Utility ICS standards documentation.	---
TM-1: Network Architecture	2.15	The Sewer Utility has high-level network block diagrams for the WWTPs, but does not maintain comprehensive network architecture diagrams.					✸	Develop and maintain OT network architecture diagrams and fiber-optic patch panel schedules.	8.2.6
TM-1: Network Architecture	2.15	The Sewer Utility does not maintain detailed fiber-optic patch panel schedules or have a consistently applied tagging system for fiber-optic patch panels and cables.					✸	Develop and maintain OT network architecture diagrams and fiber-optic patch panel schedules.	8.2.6
TM-1: Network Architecture	2.15	The Sewer Utility practices for tagging copper Ethernet cables at both ends could be improved.					✸	HDR recommends that the Sewer Utility standardize on a tagging convention for the copper Ethernet cables throughout its OT network infrastructure. Cable tags should be applied to all new cables. HDR recommends that the Sewer Utility take the opportunity to apply cable tags to existing cables when other activities prompt staff to interact with the cables or devices that they connect. The copper Ethernet tagging convention should be included in the Sewer Utility ICS standards documentation.	---
TM-1: ICS Hardware	3.5	The LEL transmitter on the CKTP headworks odor control fan ductwork is registering an infrared (IR) source fault and is not monitoring combustible-gas concentration in the odor control system.		✸✸✸				Implement CKTP instrumentation and automation improvements.	6.2.10

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: ICS Hardware	3.5	HDR observed that the thermal dispersion flowmeter installed on the aeration line for the CKTP aerated grit tank 1 stage 2 diffuser is measuring zero flow, while the positions of manual valves on either side of the instrument suggest that flow should be occurring.		★★★				Implement CKTP instrumentation and automation improvements.	6.2.10
TM-1: ICS Hardware	3.5	Combustible-gas monitoring equipment at the MWWTP sludge pumping gallery, headworks odor control system, and WAS tank is non-functional.		★★★				Implement MWWTP instrumentation and automation improvements.	6.2.12
TM-1: ICS Hardware	3.5	Combustible-gas monitoring equipment at the SWWTP process building upper-floor process room is non-functional.		★★★				Implement SWWTP instrumentation and automation improvements.	6.2.13
TM-1: ICS Hardware	3.5	The SWWTP process building fire alarm panel has failed so SWWTP is not currently monitoring or alarming for fires.		★★★				Implement SWWTP instrumentation and automation improvements.	6.2.13
TM-1: ICS Hardware	3.5	Combustible-gas monitoring equipment at the PS-24 wet well is faulted.		★★★				Implement remote pump station instrumentation and automation improvements.	6.2.14
TM-1: ICS Hardware	3.5	Combustible-gas monitoring equipment at the PS-71 wet well is non-functional.		★★★				Implement remote pump station instrumentation and automation improvements.	6.2.14
TM-1: ICS Hardware	3.5	Operation of the SWWTP RDT is a highly manual process where operations staff have to target a reduced sludge thickness to avoid shutting down the thickened sludge pump on high discharge pressure because of reportedly undersized sludge discharge piping. This workaround is reducing the efficacy of the RDT because the equipment is not dewatering sludge to the extent that it could.		★★			★★	Implement SWWTP instrumentation and automation improvements.	6.2.13
TM-1: ICS Hardware	3.5	The SWWTP sludge storage tank level is not monitored. Operations staff have resorted to a manual method of controlling tank level that introduces significant risk of operator error and relies on a high-level switch with a non-ideal installation for alarming and shutdown of the sludge supply to the tank.		★★			★	Implement SWWTP instrumentation and automation improvements.	6.2.13
TM-1: ICS Hardware	3.1	The Allen-Bradley MicroLogix 1500 PLCs installed at PS-4, PS-7, and PS-17 have been discontinued by the manufacturer and are nearing the end of their useful service life.		★★				Establish Sewer Utility PLC platform standard and schedule replacement of select WWTP and remote pump station PLCs.	6.2.1
TM-1: ICS Hardware	3.1	The Allen-Bradley SLC 500 PLCs installed at PS-24 and PS-71 are in the active mature phase of the manufacturer's product life cycle and are nearing the end of their useful service life.		★★				Establish Sewer Utility PLC platform standard and schedule replacement of select WWTP and remote pump station PLCs.	6.2.1
TM-1: ICS Hardware	3.1	HDR observed that the PLC controller battery alarm light was illuminated at the bar screen 1023 main control panel in the CKTP headworks building electrical room.				★★		HDR recommends that Sewer Utility I&C technicians investigate and replace the controller battery, if necessary.	
TM-1: ICS Hardware	3.2	The OITs installed at PS-4, PS-17, PS-24, PS-71, and CP-300 at KWWTP are nearing the end of their useful service life.		★★				Establish Sewer Utility OIT platform standard and schedule replacement of select WWTP and remote pump station OITs.	6.2.5

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: ICS Hardware	3.3	OT network and ICS components within the CKTP digester control building control panel (PNL 6000) are exposed to significant levels of hydrogen sulfide (H_2S) and high ambient temperatures. Installation of this panel in an area with a hazardous-area classification is a National Electrical Code (NEC) violation. County electricians also indicated that H_2S corrosion has been a significant maintenance issue for control wiring at the nearby MCC within the building.				★★		Implement CKTP digester building PNL 6000 relocation and MCC replacement.	6.2.7
TM-1: ICS Hardware	3.3	Status and alarms are not monitored for UPSs that provide power to ICS and instrumentation equipment. Many of the installed UPSs have no remote monitoring capability.				★★		Establish robust UPS battery backup solution for ICS and OT network infrastructure.	5.2.6
TM-1: ICS Hardware	3.3	Several control panels at Sewer Utility facilities do not have battery backup power.				★★		Establish robust UPS battery backup solution for ICS and OT network infrastructure.	5.2.6
TM-1: ICS Hardware	3.4	Sewer Utility staff have no means of monitoring or controlling KWWTP, MWWTP, and SWWTP from the existing CKTP SCADA PCs.					★★	Establish access to all Sewer Utility SCADA HMI screens at each WWTP control room and at the County Public Works Annex facility.	7.2.2
TM-1: ICS Hardware	3.4	Sewer Utility staff do not have access to near-real-time status and alarm information for wastewater pump stations at CKTP.					★★	• Migrate pump stations from VHF licensed radio WAN to cellular WAN. • Implement store-and-forward and exception reporting for remote pump station telemetry and eliminate PLC data concentrator for cellular WAN.	5.2.3
TM-1: ICS Hardware	3.5	Based on discussions with Sewer Utility I&C technicians, HDR believes that the Sewer Utility does not have a formal calibration and maintenance program for field instrumentation and associated control loops.		★★				Develop a formal instrument calibration and maintenance program.	6.2.6
TM-1: ICS Hardware	3.5	Current CKTP effluent flow calculations provided by the TrojanUV system are resulting in higher flows than those derived from an accounting of other CKTP flow measurements.	★★					Implement CKTP instrumentation and automation improvements.	6.2.10
TM-1: ICS Hardware	3.5	Automated control of the CKTP BNR process has proved to be unstable. Operators currently position the aeration control valves manually and have to frequently adjust blower header pressure set points based on process demand.	★★					Implement CKTP instrumentation and automation improvements.	6.2.10
TM-1: ICS Hardware	3.5	Unlike the other three CKTP aeration basins, aeration basin 1 has no DO probes installed. This is one of the deficiencies frustrating the Sewer Utility's BNR efforts at CKTP.	★★					Implement CKTP instrumentation and automation improvements.	6.2.10
TM-1: ICS Hardware	3.5	The chlorine residual and turbidity analyzers associated with the CKTP reclaimed-water filtration system were found powered down during HDR's site visit.		★★				Implement CKTP instrumentation and automation improvements.	6.2.10
TM-1: ICS Hardware	3.5	The low-level switch for the CKTP thickened sludge blending tank has failed and the tank's circulation pump and digester feed pumps are likely operating without a low-level shutdown interlock.		★★				Implement CKTP instrumentation and automation improvements.	6.2.10
TM-1: ICS Hardware	3.5	The Sewer Utility has no means of direct measurement for plant influent flow at MWWTP.	★★					Implement MWWTP instrumentation and automation improvements.	6.2.12

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: ICS Hardware	3.5	Some of the instrumentation related to the MWWTP headworks odor control system and its associated chemical system either is non-functional or has been removed. Systems are no longer operating per their original design.		✸✸				HDR believes that the condition of the MWWTP headworks odor control system warrants evaluation of the system as part of the ongoing Sewer Utility Facilities Plan effort. Upgrade or replacement of the failed instrumentation should be determined after the entire system is evaluated for replacement or upgrade.	---
TM-1: ICS Hardware	3.5	The magmeter on the sludge line feeding the MWWTP GBT is severely corroded.		✸✸				Implement MWWTP instrumentation and automation improvements.	6.2.12
TM-1: ICS Hardware	3.5	The MWWTP aeration basins have no DO probes or other analytical instruments for monitoring the BNR process.		✸✸				Implement MWWTP instrumentation and automation improvements.	6.2.12
TM-1: ICS Hardware	3.5	The MWWTP SCADA system is not receiving a flow signal from the flow transmitter and totalizer on the plant W3 pump discharge piping.		✸✸				Implement MWWTP instrumentation and automation improvements.	6.2.12
TM-1: ICS Hardware	3.5	Instrumentation within the MWWTP TrojanUV system has had recent issues and operations staff have reduced confidence in the system's UV dosing control.		✸✸				Evaluate remaining years of useful service life for remote WWTP UV systems to determine best approach for improved SCADA monitoring of the UV systems.	6.2.7
TM-1: ICS Hardware	3.5	The SWWTP effluent flow control valve is unable to maintain its position when commanded to close. The valve tries to maintain a closed position but eventually begins opening. SWWTP has no bypass piping around this valve, so the plant would need to shut down in order for the control valve to be serviced or replaced.		✸✸				Implement SWWTP instrumentation and automation improvements.	6.2.13
TM-1: ICS Hardware	3.5	The SWWTP SBRs have no DO probes or other analytical instruments for monitoring the BNR process.		✸✸				Implement SWWTP instrumentation and automation improvements.	6.2.13
TM-1: ICS Hardware	3.5	The ultrasonic level transducer measuring the PS-24 wet well level was observed to be coated with grime and dried scum. The condition of the transducer may be degrading the accuracy of the level measurement.		✸✸				Implement remote pump station instrumentation and automation improvements.	6.2.14
TM-1: ICS Hardware	3.5	PS-34 has no PLC and the station's wet well level appears to be controlled by a level indicator and controller that monitors the wet well's radar level transmitter. Because of the age and condition of the control panel components, its undocumented modifications, and lack of PLC, PS-34 would be a good candidate for a control panel upgrade.		✸✸				Implement remote pump station instrumentation and automation improvements.	6.2.14
TM-1: ICS Hardware	3.1	Sewer Utility staff have difficulty maintaining MCC DeviceNet networks at CKTP, which has the potential to increase downtime for equipment connected to the DeviceNet networks.		✸		✸		• Develop a standard approach for monitoring and control of motorized equipment. • Replace CKTP MCC DeviceNet networks with Ethernet-capable motor controllers.	6.2.2 6.2.3
TM-1: ICS Hardware	3.4	The Sewer Utility may benefit from establishing a secure, dedicated space for ICS servers and critical network equipment.			✸	✸		Consolidate CKTP OT network servers, distribution switches, and other appliances in a network rack environment within the SPB.	5.2.4
TM-1: ICS Hardware	3.5	A condition assessment survey of existing instrumentation has yet to be performed. This effort would provide the most value if done on a process-by-process basis as part of process and equipment level-of-automation and performance optimization evaluations.	✸	✸				• Develop a formal instrument calibration and maintenance program. • HDR recommends incorporating instrument condition assessment into the proposed instrument calibration and maintenance program.	6.2.6

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: ICS Hardware	3.5	Sewer Utility staff indicated that the level transmitter for the SWWTP thickened sludge storage tank is reporting level measurements that do not align with actual tank levels.		✸			✸	Implement SWWTP instrumentation and automation improvements.	6.2.13
TM-1: ICS Hardware	3.5	Short cycling of the pumps is a common occurrence at PS-24.	✸	✸				Implement remote pump station instrumentation and automation improvements.	6.2.14
TM-1: ICS Hardware	3.1	Allen-Bradley has made an end-of-life announcement for the CompactLogix L3x PLCs installed in various panels at CKTP. These PLCs were discontinued by the manufacturer in December 2020.		✸				Establish Sewer Utility PLC platform standard and schedule replacement of select WWTP and remote pump station PLCs.	6.2.1
TM-1: ICS Hardware	3.1	The MWWTP blower building RIO control panel is installed above another control panel in a location that is not easily accessible by Sewer Utility staff.					✸	HDR recommends that the control panel be relocated to a more accessible location when there are other drivers for control modifications in the blower building. The potential upgrade to variable-speed aeration blowers might be a good opportunity for relocation of this panel.	---
TM-1: ICS Hardware	3.1	The Sewer Utility does not appear to have standardized on PLC platform I/O module types. I/O module standardization could help the Sewer Utility reduce spare-parts inventory and enforce its preferences.	✸					Establish Sewer Utility PLC platform standard and schedule replacement of select WWTP and remote pump station PLCs.	6.2.1
TM-1: ICS Hardware	3.2	The CP-300 OIT at KWWTP was experiencing a communication error during HDR's site visit.		✸				The communication error may have been due to construction activities and in-progress automation work. HDR recommends that the Sewer Utility investigate and take corrective action if the communication error persists.	---
TM-1: ICS Hardware	3.2	The OIT at the master station CTU control panel in the SPB control room at CKTP appears to be out of service.		✸				HDR does not believe that there is a significant driver for replacing this OIT because it is located in the control room where Sewer Utility staff will have access to SCADA HMI screens and PCs from which OT network devices can be accessed. No further action is recommended.	---
TM-1: ICS Hardware	3.3	Several control panels at Sewer Utility facilities do not have 24 VDC power supply redundancy.				✸		Standardize on redundant onboard power supplies and 24 VDC power supplies for ICS and OT network infrastructure.	5.2.6
TM-1: ICS Hardware	3.3	There is a mix of 120 VAC and 24 VDC control and power circuits within the Sewer Utility's industrial control panels and the voltages present are not always readily apparent without closer inspection of the components. To eliminate or reduce shock hazards for personnel, the Sewer Utility may wish to consider standardizing on 24 VDC power and controls and/or improved voltage segregation and identification for control panels introduced by future CIP projects.	✸					HDR recommends that the Sewer Utility standardize on 24 VDC power and controls, where possible, as well as control panel voltage segregation best practices. These requirements should be included in the proposed Sewer Utility ICS standards documentation.	---
TM-1: ICS Hardware	3.3	The Sewer Utility is having difficulty maintaining desirable ambient temperatures within the MWWTP electrical room and some of the CKTP electrical rooms.	✸					HDR believes that this deficiency has been captured in the condition assessments led by Murraysmith and that the facilities planning effort will address these issues.	---
TM-1: ICS Hardware	3.4	The CKTP SPB control room has only two standard-size monitors where SCADA screens can be displayed. Having large-format displays would make it so that SCADA screens are discernible from a greater distance and could be referenced more easily during staff discussions. Additional monitors/displays would allow staff to leave commonly referenced screens on display at all times.					✸	Upgrade CKTP control room.	5.2.1
TM-1: ICS Hardware	3.5	The Sewer Utility has no means of direct measurement for CKTP effluent flow.	✸					Implement CKTP instrumentation and automation improvements.	6.2.10

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: ICS Hardware	3.5	The CKTP headworks odor control biofilter sprinkler control panel is out of service and watering of the biofilter is now a manual process for Sewer Utility staff. Replacing and/or introducing instrumentation to maintain desirable moisture levels in the biofilter via automation could improve Sewer Utility workforce efficiency and the effectiveness of the biofilter.					✸	Implement CKTP instrumentation and automation improvements.	6.2.10
TM-1: ICS Hardware	3.5	Only CKTP aeration basin 4 has ammonium and nitrate probes installed to monitor nitrogen removal occurring in the basin.	✸					Implement CKTP instrumentation and automation improvements.	6.2.10
TM-1: ICS Hardware	3.5	The CKTP cogeneration system and digester gas conditioning system have been abandoned in place because of high material and maintenance costs and limited digester gas production.		✸				HDR believes that the condition of the CKTP cogeneration system warrants evaluation of the system as part of the ongoing Sewer Utility Facilities Plan effort. Until there are financial or process-related drivers for recommissioning the cogeneration system, HDR has no recommendations for further investment in associated I&C infrastructure.	---
TM-1: ICS Hardware	3.5	One of the analytical probes associated with the SWWTP odor control system appears to have a splice in the probe's manufacturer cable, which may be degrading the accuracy of the probe's measurement or disrupting the signal entirely.		✸				HDR believes that the SWWTP odor control system is likely nearing the end of its useful service life and should be considered for replacement as part of the ongoing facilities planning effort. Because this system is already being operated manually, HDR does not recommend replacing or upgrading system instrumentation that will become obsolete once the odor control system is in replaced.	---
TM-1: ICS Hardware	3.5	The thermal dispersion flow switch on the SWWTP RDT spray water supply line has been damaged. This may result in a shorter than expected useful service life for the switch.		✸				Implement SWWTP instrumentation and automation improvements.	6.2.13
TM-1: ICS Hardware	3.5	The Sewer Utility is not currently monitoring BIOXIDE storage tank level at PS-71.		✸				Implement remote pump station instrumentation and automation improvements.	6.2.14
TM-1: ICS Software	4.2	Lack of centralized management for ICS device data and SCADA visualizations has resulted in non-standardized programming objects and visualizations at the Sewer Utility's WWTPs.	✸✸✸				✸✸✸	Upgrade WWTP standalone SCADA HMI installations to AVEVA System Platform with managed InTouch applications and standardized templates based on HPHMI concepts.	7.2.1
TM-1: ICS Software	4.2	Red and green on/off, open/closed color schemes are not consistently applied throughout the Sewer Utility's HMI and OIT screens.					✸✸✸	Upgrade WWTP standalone SCADA HMI installations to AVEVA System Platform with managed InTouch applications and standardized templates based on HPHMI concepts.	7.2.1
TM-1: ICS Software	4.3	SCADA data are not being leveraged beyond data required for mandatory reporting.	✸✸	✸✸			✸✸	• Broaden the data set archived by the Sewer Utility historian to establish foundations for more comprehensive process- and asset-level health and performance monitoring. • Complete Hach WIMS implementation and establish data exchange with AVEVA System Platform. • Complete asset creation and data entry required for LLumin implementation, establish automatic importing of asset runtimes, and develop a plan for automating work order generation. • Select a data analytics and visualization software platform and develop in-house skill sets through creation of initial dashboards.	7.2.8 9.2.1 9.2.2 9.2.3
TM-1: ICS Software	4.3	The Sewer Utility is not using data visualization tools to access and derive meaning from its historical SCADA data.	✸✸	✸✸			✸✸	Select a data analytics and visualization software platform and develop in-house skill sets through creation of initial dashboards.	9.2.3

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: ICS Software	4.2	Sewer Utility staff do not appear to have a means of shelving nuisance alarms or alarms associated with known issues.	✱✱				✱✱	Implement an alarm management program based on ISA-18.2.	7.2.6
TM-1: ICS Software	4.2	Sewer Utility WWTP HMI screens do not appear to provide alarm priority information or allow for sorting and filtering of alarms by alarm priority.	✱✱				✱✱	Implement an alarm management program based on ISA-18.2.	7.2.6
TM-1: ICS Software	4.3	The Sewer Utility has no historical data for the overwhelming majority of its SCADA tags, and the Sewer Utility is not capturing data for several processes and equipment.	✱✱				✱✱	Broaden the data set archived by the Sewer Utility historian to establish foundations for more comprehensive process- and asset-level health and performance monitoring.	7.2.8
TM-1: ICS Software	4.1	The Sewer Utility does not have PLC programming standards in place and its PLC programming project files reflect a variety of conventions and programming objects implemented by multiple systems integrators.	✱✱					Develop PLC programming standards and leverage them to standardize future PLC programming work products.	7.2.5
TM-1: ICS Software	4.2	The Sewer Utility's Wonderware InTouch software at its WWTPs is in, or will soon be entering, the mature support phase of the software developer's product life cycle, during which limited support is offered.		✱✱				Upgrade WWTP standalone SCADA HMI installations to AVEVA System Platform with managed InTouch applications and standardized templates based on HPHMI concepts.	7.2.1
TM-1: ICS Software	4.2	HMI overview and process screens could be updated to include more contextual information to facilitate operator situational awareness.					✱✱	Upgrade WWTP standalone SCADA HMI installations to AVEVA System Platform with managed InTouch applications and standardized templates based on HPHMI concepts.	7.2.1
TM-1: ICS Software	4.2	Sewer Utility staff have no means of remotely resetting pump station alarms from CKTP HMI screens. The lack of remote alarm reset requires County staff to physically visit the pump stations to reset alarms.					✱✱	Implement remote pump station instrumentation and automation improvements.	6.2.14
TM-1: ICS Software	4.2	HDR observed that there are issues with communication of analog parameters between several pump stations and CKTP. Several pump station pop-up HMI screens appear to constantly display zero values for analog parameters and historian data are also logging constant, out-of-range values for these pump station parameters.		✱✱				Develop a standard approach for monitoring remote pump stations.	6.2.3
TM-1: ICS Software	4.2	The Sewer Utility does not appear to have pump station remote monitoring capabilities for wet well level, force main pressure, pump speed, LEL, BIOXIDE/chemical storage tank level, power and energy parameters, or other analog parameters for the pump stations.	✱✱					• Develop a standard approach for monitoring remote pump stations. • Remote pump station instrumentation and automation improvements.	6.2.3 6.2.14
TM-1: ICS Software	4.2	Alarm summary and alarm history HMI screens at SWWTP are not automatically updated to display current alarm information.		✱✱				Implement an alarm management program based on ISA-18.2.	7.2.6
TM-1: ICS Software	4.2	The CKTP Wonderware implementation is generating considerable alarm activity, much of which is caused by the same alarms.					✱✱	Implement an alarm management program based on ISA-18.2.	7.2.6
TM-1: ICS Software	4.3	The Sewer Utility's Wonderware Historian and Historian Client software at CKTP is in the mature support phase of the software developer's product life cycle, during which limited support is offered.		✱✱				• Upgrade WWTP standalone SCADA HMI installations to AVEVA System Platform with managed InTouch applications and standardized templates based on HPHMI concepts. • Establish a tiered historian implementation at CKTP to centralize Sewer Utility historical ICS data and provide secure access to historical ICS data from the Sewer Utility business LAN.	7.2.1 7.2.7

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: ICS Software	4.3	The historical SCADA data for KWWTP, MWWTP, and SWWTP are accessible only via the SCADA PC at each WWTP and have not been imported to the Sewer Utility's historian at CKTP.					✸✸	Establish a tiered historian implementation at CKTP to centralize Sewer Utility historical ICS data and provide secure access to historical ICS data from the Sewer Utility business LAN.	7.2.7
TM-1: ICS Software	4.3	The Sewer Utility's means of accessing its historical SCADA data are time-consuming, are ill-suited for handling large queries, and present a barrier to ad hoc data exploration.					✸✸	Establish a tiered historian implementation at CKTP to centralize Sewer Utility historical ICS data and provide secure access to historical ICS data from the Sewer Utility business LAN.	7.2.7
TM-1: ICS Software	4.3	The Sewer Utility has not implemented automated reports for SCADA data at any of the WWTPs.					✸✸	• Establish a tiered historian implementation at CKTP to centralize Sewer Utility historical ICS data and provide secure access to historical ICS data from the Sewer Utility business LAN. • Complete Hach WIMS implementation and establish data exchange with AVEVA System Platform. • Complete asset creation and data entry required for LLumin implementation, establish automatic importing of asset runtimes, and develop a plan for automating work order generation. • Select a data analytics and visualization software platform and develop in-house skill sets through creation of initial dashboards.	7.2.7 9.2.1 9.2.2 9.2.3
TM-1: ICS Software	4.4	There is no redundant alarm notification method for KWWTP, MWWTP, and SWWTP. Failure of the SCADA PC's analog telephony card or disruption of telephone service to the WWTP would result in loss of remote alarm notification for the WWTP.				✸✸		Implement HIPswitch cellular failover functionality to establish communication link redundancy for WWTPs.	5.2.3
TM-1: ICS Software	4.1	Sewer Utility PLCs are running a variety of firmware versions.		✸				Determine standard PLC firmware versions for the Sewer Utility and perform firmware upgrades.	7.2.4
TM-1: ICS Software	4.2	At CKTP, alarm acknowledgments made at one HMI thick client are not being registered by other HMI thick clients.					✸	Complete migration to thin client configuration for CKTP HMIs.	7.2.3
TM-1: ICS Software	4.2	Horizontal alarm banner at the bottom of SWWTP HMI screens may be non-functional.	✸					• Upgrade WWTP standalone SCADA HMI installations to AVEVA System Platform with managed InTouch applications and standardized templates based on HPHMI concepts. • Implement an alarm management program based on ISA-18.2.	7.2.1 7.2.6
TM-1: ICS Software	4.2	Sewer Utility staff have indicated that there are cases throughout the WWTP HMI process screens where the wrong engineering units are being displayed for equipment speed values.		✸				• Upgrade WWTP standalone SCADA HMI installations to AVEVA System Platform with managed InTouch applications and standardized templates based on HPHMI concepts. • HDR recommends that Sewer Utility staff compile a list of known engineering unit conflicts so that I&C technicians and/or systems integrators can correct the issues.	7.2.1
TM-1: ICS Software	4.2	Equipment pop-up windows/screens do not appear to have functionality to provide information on active alarms or conditions, not internal to the equipment, that are inhibiting the equipment from running.					✸	Implement an alarm management program based on ISA-18.2.	7.2.6
TM-1: ICS Software	4.2	Equipment pop-up windows/screens could be developed to include additional electrical, diagnostic, and performance data as well as expanded motor start count information.					✸	• Develop a standard approach for monitoring and control of motorized equipment. • Upgrade WWTP standalone SCADA HMI installations to AVEVA System Platform with managed InTouch applications and standardized templates based on HPHMI concepts.	6.2.2 7.2.1

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: ICS Software	4.2	Trend screens display current values against time only and do not provide meaningful situational awareness.					✸	Upgrade WWTP standalone SCADA HMI installations to AVEVA System Platform with managed InTouch applications and standardized templates based on HPHMI concepts.	7.2.1
TM-1: ICS Software	4.2	Root-cause analysis and alarm suppression functionality have not been developed for the Sewer Utility's WWTP HMI systems.	✸				✸	Implement an alarm management program based on ISA-18.2.	7.2.6
TM-1: ICS Software	4.2	HMI screens do not have troubleshooting text prompts or decision tree aids to help operators react to alarm conditions.					✸	Implement an alarm management program based on ISA-18.2.	7.2.6
TM-1: ICS Software	4.4	Sewer Utility staff indicate that an unresolved issue with the Sewer Utility's WIN-911 implementation prevents operators from obtaining a listing of active alarms when calling in to the WIN-911 system.					✸	Upgrade alarm notification system.	7.2.9
TM-1: ICS Documentation	5.2	The Sewer Utility is currently logging process control changes in physical operator log books and not in a more readily accessible, electronic format that can be backed up to prevent loss of information.	✸				✸✸	Establish electronic records for operator logs.	8.2.4
TM-1: ICS Documentation	5.5	The Sewer Utility does not have formal ICS standards documentation to guide third-party design and implementation efforts.	✸				✸	Develop Sewer Utility ICS standards documentation.	8.2.1
TM-1: ICS Documentation	5.1	Record P&IDs are not maintained in consolidated drawing sets or located in one location.					✸	Update WWTP and pump station P&IDs and compile current consolidated P&ID sets on County eO&M SharePoint site.	8.2.5
TM-1: ICS Documentation	5.1	Record P&IDs for MWWTP are out of date.					✸	Update WWTP and pump station P&IDs and compile current consolidated P&ID sets on County eO&M SharePoint site.	8.2.5
TM-1: ICS Documentation	5.1	Aside from P&IDs recently developed for the SWWTP sludge thickening processes, no detailed P&IDs appear to be available for SWWTP.					✸	Update WWTP and pump station P&IDs and compile current consolidated P&ID sets on County eO&M SharePoint site.	8.2.5
TM-1: ICS Documentation	5.2	General control descriptions have yet to be added to the County's eO&M SharePoint site for the major processes at KWWTP, MWWTP, and SWWTP and wastewater pump stations.					✸	Develop and maintain control strategy documentation.	8.2.3
TM-1: ICS Documentation	5.2	The Sewer Utility does not maintain as-implemented control strategies for its WWTPs and pump stations.					✸	Develop and maintain control strategy documentation.	8.2.3
TM-1: ICS Documentation	5.2	PLC programming modifications may be occurring without documentation of changes made to process controls.					✸	Develop and maintain control strategy documentation.	8.2.3
TM-1: ICS Documentation	5.3	The County eO&M SharePoint site is missing record drawings from 2018 control system upgrade at MWWTP.					✸	Upload applicable record drawings to County eO&M SharePoint site.	---
TM-1: Other Software Packages	6.4	The Sewer Utility is not currently using data analytics or visualization software to derive insights from its CMMS, energy management system (EMS), laboratory, SCADA, and other data sets outside of their respective software environments.	✸✸	✸✸			✸✸	Select a data analytics and visualization software platform and develop in-house skill sets through creation of initial dashboards.	9.2.3
TM-1: Other Software Packages	6.2	It appears that the Sewer Utility has not generated any historical EMS data since the CKTP EMS was installed because the EMS software was never set to record any of the real-time power data that it monitors.		✸✸			✸✸	Begin leveraging the Sewer Utility's power and energy data.	9.2.4

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-1: Other Software Packages	6.2	The Sewer Utility is not currently using power or energy data at the bus level or load level to establish plant, process, or asset baselines or to evaluate process and equipment performance.		✸✸			✸✸	Begin leveraging the Sewer Utility's power and energy data.	9.2.4
TM-1: Other Software Packages	6.2	Aside from Puget Sound Energy billing data and a few load-level power parameters recorded by the CKTP historian, HDR believes that the Sewer Utility has little to no historical power and energy data for its WWTP and wastewater pump station infrastructure.		✸✸			✸✸	Begin leveraging the Sewer Utility's power and energy data.	9.2.4
TM-1: Other Software Packages	6.1	Data entry of WWTP and pump station assets and their attributes into the LLumin database has yet to be completed.		✸✸			✸	Complete asset creation and data entry required for LLumin implementation, establish automatic importing of asset runtimes, and develop a plan for automating work order generation.	9.2.2
TM-1: Other Software Packages	6.1	The Sewer Utility's CMMS and SCADA data remain siloed and the Sewer Utility has not implemented automated work orders based on accumulated runtimes, alarms, and other events registered at the SCADA system.		✸			✸✸	Complete asset creation and data entry required for LLumin implementation, establish automatic importing of asset runtimes, and develop a plan for automating work order generation.	9.2.2
TM-1: Other Software Packages	6.3	HDR believes that the Sewer Utility laboratory data are recorded in Excel spreadsheets and do not currently reside on a database, which makes working with the data labor-intensive.					✸✸	Complete Hach WIMS implementation and establish data exchange with AVEVA System Platform.	9.2.1
TM-1: Other Software Packages	6.2	Several MCCs at CKTP have no power monitor installed, which prevents them from being included in the CKTP EMS.	✸	✸			✸	Begin leveraging the Sewer Utility's power and energy data.	9.2.4
TM-1: Other Software Packages	6.2	Power monitors installed at the KWWTP and MWWTP MCCs are not networked to the WWTP PLCs or SCADA PCs.	✸	✸			✸	Begin leveraging the Sewer Utility's power and energy data.	9.2.4
TM-1: Other Software Packages	6.2	The CKTP EMS and SCADA system are not monitoring power and energy data that may be available from power monitors and other electrical equipment at the Sewer Utility's pump stations.		✸			✸	Begin leveraging the Sewer Utility's power and energy data.	9.2.4
TM-1: Other Software Packages	6.2	CKTP standby generators and large electrical loads (e.g., aeration blowers) have not been integrated into the CKTP EMS.					✸	Begin leveraging the Sewer Utility's power and energy data.	9.2.4
TM-1: Other Software Packages	6.2	Power monitors installed at the CKTP UV disinfection facility have not been integrated into the CKTP EMS.					✸	Begin leveraging the Sewer Utility's power and energy data.	9.2.4
TM-1: Other Software Packages	6.2	With the exception of SWGR-2961, the CKTP EMS is not monitoring switch and breaker statuses for the major electrical distribution system buses at CKTP.					✸	• Begin leveraging the Sewer Utility's power and energy data. • Because HDR is not recommending further investment in the GE EnerVista Viewpoint Monitoring software, implementation of breaker and switch status monitoring via this software is not recommended. If Sewer Utility staff would find this information useful, the requisite signals could be integrated into AVEVA System Platform and SCADA HMI screens could be developed to present this information in one-line diagram context.	9.2.4
TM-1: Other Software Packages	6.2	The CKTP EMS one-line diagram screens have not been configured to display current breaker statuses for SWGR-2961.					✸	• Begin leveraging the Sewer Utility's power and energy data. • Because HDR is not recommending further investment in the GE EnerVista Viewpoint Monitoring software, implementation of breaker and switch status monitoring via this software is not recommended. If Sewer Utility staff would find this information useful, the requisite signals could be integrated into AVEVA System Platform and SCADA HMI screens could be developed to present this information in one-line diagram context.	9.2.4

Table 10-2. Risks and deficiencies with recommended improvements summary

TM and section	TM sub-section	Risk or deficiency	Operational optimization	Infrastructure stability and modernization	Cybersecurity risk mitigation	Critical system resilience	Workforce efficiency	Recommended improvement(s)	TM-2 sub-section
TM-2: Sewer Utility Staff Interviews	4.1	MWWTP lacks SCADA control for the sludge wasting valve so the sludge wasting process is entirely manual.	✸✸				✸✸	Implement MWWTP instrumentation and automation improvements.	6.2.12
TM-2: Sewer Utility Staff Interviews	4.3	Laboratory staff currently have no access to SCADA HMI screens or historical SCADA data.	✸	✸			✸✸	Provide read-only access to WWTP SCADA HMI screens at laboratory.	7.2.10
TM-2: Sewer Utility Staff Interviews	4.5	Equipment runtimes are manually collected and entered into Sewer Utility CMMS.	✸✸				✸✸	Complete asset creation and data entry required for LLumin implementation, establish automatic importing of asset runtimes, and develop a plan for automating work order generation.	9.2.2
TM-2: Sewer Utility Staff Interviews	4.1	MWWTP does not have a flowmeter for monitoring WAS flow to the WAS tanks.	✸✸				✸	Implement MWWTP instrumentation and automation improvements.	6.2.12
TM-2: Sewer Utility Staff Interviews	4.1	PLC status monitoring and alarming may not be effectively applied for all WWTP PLCs.		✸✸			✸	Implement an alarm management program based on ISA-18.2.	7.2.6
TM-2: Sewer Utility Staff Interviews	4.1	Sewer Utility operations staff believe that they are not receiving signal out-of-range alarms at SCADA HMI screens for lost analog signals from some field instruments.		✸✸			✸	Implement an alarm management program based on ISA-18.2.	7.2.6
TM-2: Sewer Utility Staff Interviews	4.1	There are no SCADA alarms or monitoring in place for composite samplers at all WWTPs.		✸			✸	Include integration of composite sampler alarms and monitoring with replacement of existing samplers.	6.2.8
TM-2: Sewer Utility Staff Interviews	4.1	Some WWTP VFDs do not have VFD fault alarms monitored at SCADA.		✸			✸	Develop a standard approach for monitoring and control of motorized equipment.	6.2.2
TM-2: Sewer Utility Staff Interviews	4.1	MWWTP headworks mixing channel blower fault is not monitored at SCADA.		✸			✸	Implement MWWTP instrumentation and automation improvements.	6.2.12
TM-2: Sewer Utility Staff Interviews	4.1	Operators have no means of managing the MWWTP blower operating time sequence via the SCADA HMI screens.	✸				✸	Implement MWWTP instrumentation and automation improvements.	6.2.12
TM-2: Sewer Utility Staff Interviews	4.1	Sewer Utility operations staff would like to have more detailed information on UV systems available at the HMIs for all plants.		✸			✸	Evaluate remaining years of useful service life for remote WWTP UV systems to determine best approach for improved SCADA monitoring of the UV Systems.	6.2.9
TM-2: Sewer Utility Staff Interviews	4.1	The Sewer Utility is likely overestimating the thickened sludge volumes received at CKTP from remote WWTPs because none of the remote WWTPs have a flowmeter for monitoring thickened sludge flow during truck loadout activities.	✸					• Implement KWWTP instrumentation and automation improvements. • Implement MWWTP instrumentation and automation improvements. • Implement SWWTP instrumentation and automation improvements.	6.2.11 6.2.12 6.2.13
TM-2: Sewer Utility Staff Interviews	4.2	The Sewer Utility needs a standardized tag naming convention for the AVEVA SCADA system.					✸	Upgrade WWTP standalone SCADA HMI installations to AVEVA System Platform with managed InTouch applications and standardized templates based on HPHMI concepts.	7.2.1

11 References

ANSI/ISA (American National Standards Institute/International Society of Automation)

2015 *ANSI/ISA-101.01-2015, Human Machine Interfaces for Process Automation Systems.*

2016 *ANSI/ISA-18.2-2016, Management of Alarm Systems for the Process Industries.*

AVEVA

2020 AVEVA Intouch Access Anywhere. https://www.aveva.com/en/products/aveva-intouch-access-anywhere/. Viewed on December 7, 2020.

Brodersen

2020 *DNP3 Slave.* https://brodersen.com/dnp3slave/. Viewed on December 4, 2020.

Chatsworth Products (Chatsworth)

2020 *Z4-Series Seismic Frame Cabinet System.* https://www.chatsworth.com/en-us/products/cabinets-enclosures-containment/network-cabinets/critical-facilities/z4-series-seismicframe-cabinet-system?sourcecall=googleads&insitesid=1454&gclid=Cj0KCQiAzsz-BRCCARIsANotFgO9x--WnD6J1tQhE4riK-OnMdRuuAD9k5_ZjIEJbugm8tXSah8y-ssaAst3EALw_wcB. Viewed on December 11, 2020.

HydroLogic Research

2021 *Water Control Room.* https://www.hydrologic.com/themes/water-control-room/. Viewed on January 4, 2021.

IBM (International Business Machines Corporation)

2020 Learn About Hypervisors, System Virtualization, and How It Works in a Cloud Environment. https://developer.ibm.com/articles/cl-hypervisorcompare/. Viewed on December 13, 2020.

ISA/IEC (International Society of Automation/International Electrotechnical Commission)

2020 ISA/IEC 62443-3-2:2020. *Security for Industrial Automation and Control Systems – Part 3.2: Security Risk Assessment for System Design.*

NAAT (North American Access Technologies, Inc.)

2021 *Cooling – Data Centers, Servers and Communications.* http://us.naat.com/Data%20Centers/cooling.html. Viewed on January 4, 2021.

Phoenix Contact

2021 *ACB Technology.* https://www.phoenixcontact.com/online/portal/sg?1dmy&urile=wcm:path:/sgen/web/main/products/technology_pages/subcategory_pages/ACB_Technology/2f1942c6-2dd9-4dd0-b01d-1c44e9f4d7d0. Viewed on January 4, 2021.

Rockwell Automation

2019 *Migration Solutions: E3/E3 Plus to E300/E200 Electronic Overload Relay.* https://literature.rockwellautomation.com/idc/groups/literature/documents/pp/migrat-pp042_-en-p.pdf

2020a *Product Lifecycle Status.* https://www.rockwellautomation.com/global/support/product-compatibility-migration/lifecycle-status/overview.page. Viewed on December 18, 2020.

2020b *193 IEC E3 Plus Relays.* https://www.rockwellautomation.com/en-us/products/hardware/allen-bradley/discontinued-products/193-iec-e3-plus-relays.html#resources. Viewed on December 18, 2020.

2020c *Product Compatibility and Download Center.* https://compatibility.rockwellautomation.com/Pages/home.aspx. Viewed on December 24, 2002.

Schneider Electric

2015 *Optimize Configurations of Wonderware InTouch Machine Edition and Wonderware Historian for Improved Data Collection.* http://blog.wonderware.com/2015/06/optimize-configurations-of-wonderware.html.

Sewer Utility (Kitsap County Public Works Sewer Utility)

2019 *Six-Year Capital Facilities Plan 2020–2025.*

SolarWinds Worldwide, LLC

2021 *Network Performance Monitor.* https://www.solarwinds.com/network-performance-monitor. Viewed on January 5, 2021.

TrojanUV

2018 *TrojanUV3000B: Wastewater Disinfection.* https://www.resources.trojanuv.com/wp-content/uploads/2018/07/TrojanUV3000B-Brochure.pdf.

Yokogawa

2017 *Effective Alarm Management Planning Using ANSI/ISA-18.2.* https://www.yokogawa.com/us/library/resources/media-publications/effective-alarm-management-planning-using-ansiisa-182/.

TM-3: Technology Selection

Sewer Utility SCADA Master Plan

Kitsap County Public Works
Sewer Utility Division

December 10, 2021

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Kitsap County Public Works, Sewer Utility Division
Sewer Utility SCADA Master Plan

TM-3: Technology Selection

December 10, 2021

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I hereby certify that the technical memorandum was prepared under my direct supervision and that I am a duly registered Engineer under the laws of the State of Washington.

Contents

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Abbreviations

°F	degree(s) Fahrenheit
AD	Active Directory
BGP	Border Gateway Protocol
CIP	Common Industrial Protocol
CKTP	Central Kitsap Treatment Plant
CMMS	computerized maintenance management system
County	Kitsap County
DLR	Device Level Ring
DMZ	demilitarized zone
DNP3	Distributed Network Protocol 3
DS	Domain Server
EIGRP	Enhanced Interior Gateway Routing Protocol
FNF	flexible netflow
FT	FactoryTalk
GB	gigabyte(s)
Gbps	gigabit(s) per second
HDR	HDR Engineering, Inc.
HMI	human-machine interface
HSRP	Hot Standby Router Protocol
I&C	instrumentation and controls
ICS	industrial control system
IEEE	Institute of Electrical and Electronics Engineers
IGMP	Internet Group Management Protocol
I/O	input/output
IoT	Internet of Things
IP	Internet Protocol
IS-IS	Intermediate System to Intermediate System
LAN	local-area network
LED	light-emitting diode
LIMS	laboratory information management system
LTE	Long-Term Evolution
M2M	machine-to-machine
Master Plan	*Sewer Utility SCADA Master Plan*
MB	megabyte(s)
Mbps	megabit(s) per second
MCC	motor control center
MOD	module
N/A	not applicable
NFPA	National Fire Protection Association
NMS	network monitoring system
OSPF	Open Shortest Path First
OT	Operational Technology
PBR	Policy-Based Routing
PC	personal computer
PCAP	Network Packet Analyzer and Capture
PLC	programmable logic controller
QCC	Quality Controls Corporation
QoS	quality of service
RIO	remote input/output
RIP	Routing Information Protocol
RTD	resistance temperature detector
RTU	remote telemetry unit

SA	sensor/actuator
SCADA	supervisory control and data acquisition
SD	Secure Digital
SDN	software-defined network
Sewer Utility	Public Works Sewer Utility Division
SFP	small form-factor pluggable
SNMP	Simple Network Management Protocol
SPB	solids processing building
SVI	Switched Virtual Interface
TM	technical memorandum
TM-2	*SCADA Use Cases and Operational Needs Technical Memorandum*
TM-3	*Technology Selection Technical Memorandum*
TM-4	*Sewer Utility SCADA Master Plan Technical Memorandum*
TP/TX	Transport Protocol/Transmit
uRPF	Unicast Reverse Path forwarding
USB	Universal Serial Bus
UV	ultraviolet
V	volt(s)
VAC	volt(s) alternating current
VDC	volt(s) direct current
VM	virtual machine
VRF	Virtual Routing and Forwarding
VRRP	Virtual Router Redundancy Protocol
WAN	wide-area network
WIMS	Water Information Management Solution
WWTP	wastewater treatment plant

1 Introduction

This *Technology Selection Technical Memorandum* (TM-3) documents the specific hardware and software platforms selected to become the new standard for the Kitsap County (County) Public Works Sewer Utility Division (Sewer Utility) supervisory control and data acquisition (SCADA) system. This technical memorandum (TM) describes the evaluation approach by which these technological elements were selected based on the Sewer Utility's existing infrastructure and its future operational needs identified in the *SCADA Use Cases and Operational Needs Technical Memorandum* (TM-2). These platforms will serve as the building blocks for the system architecture conceptual design to be developed in the subsequent *Sewer Utility SCADA Master Plan Technical Memorandum* (TM-4).

1.1 Approach

TM-3 completes the third phase of the *Sewer Utility SCADA Master Plan* (Master Plan), which is to identify the hardware and software platforms that will be the foundational SCADA equipment for use by the Sewer Utility going forward. The hardware and software selections are based on the existing SCADA equipment condition and useful life cycle as well as the Operational Needs and Deficiencies Assessment completed in the previous TMs.

In addition, the hardware and software selections identified in this TM-3 support the requirements needed to appropriately design the conceptual control system architecture in Phase 4.

A meeting was held in June 2021 to review the previously selected technology for both the Operational Technology (OT) network and control system equipment. Preferences for additional required OT network equipment and software and the system architecture conceptual design were also discussed.

1.2 Technical Memorandum Organization

This section describes the structure of the TM and the annotation for addressing the operational needs identified in TM-2 and recommended improvements.

1.2.1 Structure

TM-3 is organized into five sections, as described below:

- **Section 1: Introduction** summarizes the TM organization and the approach taken for the third phase of the Master Plan in preparation for TM-3.
- **Section 2: Previously Selected Technology** provides a summary of the various SCADA-related hardware and software platforms that the Sewer Utility has selected prior to or in parallel with the Master Plan and that will remain part of the Sewer Utility's core technological assets into the future.
- **Section 3: OT Network Architecture Technology and Software** describes the network architecture technology components and software products selected for

future Sewer Utility OT network improvements and software to support the SCADA-related assets. The section also provides a summary of the features of each of these components and software products as related to the Sewer Utility's system.

- **Section 4: PLC Hardware and Software** describes the Allen-Bradley CompactLogix 5380 controller and Compact 5000 input/output (I/O) platform components selected as the new Sewer Utility standard for wastewater treatment plant (WWTP) and remote pump station programmable logic controller (PLC) design and implementation. The section also provides a summary of the evaluation approach by which these PLC components were selected.
- **Section 5: References** lists the supporting source materials cited in TM-3.

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2 Previously Selected Technology

This section provides a summary of the various SCADA-related hardware and software platforms that the Sewer Utility has selected prior to or in parallel with the Master Plan and that will remain part of the Sewer Utility's core technological assets into the future. Technology selected in TM-3 will be combined with the Sewer Utility's previously selected technology to form a cohesive system.

2.1 Network Architecture

Previously selected network architecture technology is summarized in Table 2-1.

Table 2-1. Summary of previously selected network architecture technology

Manufacturer/ vendor	Product/model	Description	Application
Tempered Networks	Airwall system	Software-defined network (SDN) technology for implementing security policies, network segmentation, and encryption over wide-area networks (WANs). Platform consists of a cloud-hosted management portal (Airwall Conductor), cloud-hosted routing service (Airwall Relay), and hardware and software gateways (Airwall Gateways).	• Data exchange between Sewer Utility WWTPs • Remote access to Sewer Utility OT network for Sewer Utility staff • Remote access to Sewer Utility OT network for contractors
Verizon Wireless	Private network service, zero-tunnel configuration	4G Long-Term Evolution (LTE) cellular plan for machine-to-machine (M2M) applications. Communication restricted to customer mobile devices.	Remote pump station telemetry
Cradlepoint	IBR600C series cellular router	4G LTE cellular router	Remote pump station telemetry
VMWare	ESXi	Type 1 hypervisor for hosting virtual machines (VMs)	Central Kitsap Treatment Plant (CKTP) primary and secondary SCADA servers

2.2 Industrial Control System Hardware

Previously selected industrial control system (ICS) hardware technology is summarized in Table 2-2.

Table 2-2. Summary of previously selected ICS hardware technology

Manufacturer/ vendor	Product/model	Description	Application
Allen-Bradley	MicroLogix 1400	Compact controller with onboard I/O points, Ethernet port, and EtherNet/Internet Protocol (IP) and Distributed Network Protocol 3 (DNP3) communication capability	Remote pump station remote telemetry unit (RTU) controller

2.3 Industrial Control System Software

Previously selected ICS software technology is summarized in Table 2-3.

Table 2-3. Summary of previously selected ICS software technology

Manufacturer/ vendor	Product/model	Description	Application
AVEVA	System Platform 2020[a]	SCADA software platform for centralized management of SCADA human-machine interface (HMI) graphics and historical SCADA data. Includes communication drivers for integrating PLCs, network devices, and other ICS components. Also includes the individual AVEVA software components listed below.	• WWTP and remote pump station SCADA HMI screens • Redundant installation on servers residing at CKTP
AVEVA	InTouch HMI 2020[a]	Runtime and development software for SCADA HMI graphics.	• WWTP and remote pump station SCADA HMI screens • Runtime installations installed at WWTP operator SCADA personal computers (PCs) and workstations
AVEVA	Historian 2020[a]	SCADA data repository and management platform.	WWTP and remote pump station SCADA data
AVEVA	Historian Client 2020[a]	User interface for simplifying access to historical SCADA data and developing static and ad hoc trends.	• WWTP and remote pump station SCADA data • Installed at WWTP operator SCADA PCs and workstations
Rockwell Automation	Studio 5000 Logix Designer	PLC programming development environment	WWTP and remote pump station PLCs

a. Quality Controls Corporation (QCC) plans to update its ongoing System Platform 2017 implementation work for the Sewer Utility to System Platform 2020, the most current software offering.

2.4 Other Software Packages

Previously selected additional software packages are summarized in Table 2-4.

Table 2-4. Summary of previously selected additional software packages

Manufacturer/ vendor	Product/model	Description	Application
LLumin	LLumin	Computerized maintenance management system (CMMS)	Sewer Utility asset tracking and maintenance management
Hach	Water Information Management Solution (WIMS)	Laboratory information management system (LIMS)	• CKTP laboratory management • WWTP laboratory and SCADA data tracking and analysis

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3 OT Network Architecture Technology and Software

This section describes the network architecture technology components and software to support the SCADA-related assets. The section also provides a summary of the features of each of these components and software products as related to the Sewer Utility's system. The costing provided in this section is current as of the time of writing but may vary greatly depending on continuing supply chain issues.

3.1 Network Equipment Evaluation

In TM-2, Section 5.1.1, several requirements were identified for the Sewer Utility's OT network. These OT network requirements include the following:

- Secure and reliable connection between CKTP and the remote pump stations and WWTPs
- Remote access for instrumentation and controls (I&C) technicians via County-issued laptops
- Secure access to ICS data from business local-area network (LAN)

Several vendors of the industrial grade network equipment can meet the technical requirements. The following key attributes were considered for the selection of the Sewer Utility OT network equipment.

When selecting the modern OT network architecture technology components, the ability to integrate with the Sewer Utility's PLC hardware and software, relative costs, and minimal technical requirements are considered.

3.2 Managed Network Switches

Network equipment should be managed as a system and will ideally be consistent across manufacturer, product line, and vintage. Intermingling of network manufacturers, product lines, and vintages should be minimized. Network life cycle should be considered as part of facility planning.

Industrial-rated, panel-mounted switches like Allen-Bradley Stratix switches (Figure 3-1) should be used for control and I/O networks. Rack-mounted switches like the Cisco Catalyst 9000 switching family (Figure 3-2) should be used for SCADA and demilitarized zone (DMZ) networks.

3.2.1 Industrial Panel-Mounted Network Switches

Industrial panel-mounted network switches should support the following design features and protocols:

A. Support Ethernet 10/100/1000 megabits per second (Mbps)

B. Backbone (trunk) fiber ports shall be via small form-factor pluggable (SFP) modules

C. Provide as required (plus at least two spare) 10/100/1000 MBit/s port (twisted pair) at each Ethernet switch

D. Support Device Level Ring (DLR) topology

E. Support EtherNet/IP (Common Industrial Protocol [CIP]) protocol

F. Support Simple Network Management Protocol (SNMP) v3 and web-based management

G. Rapid Spanning Tree Protocol

H. Internet Group Management Protocol (IGMP) support for Internet Protocol (IP) multicast filtering to enable switches to automatically route messages only to appropriate ports

I. Check all received data for validity

   1. Discard invalid and defective frames or fragments

J. Monitor connected TP/TX line segments for short-circuit or interrupt using regular link test pulses in accordance with Institute of Electrical and Electronics Engineers (IEEE) 802.3

K. Monitor attached fiber-optic lines for open circuit conditions in accordance with IEEE 802.3

L. Dual redundant power supplies

M. Light-emitting diode (LED) status lights to indicate:

   1. Power: Supply voltage present
   2. Fault
   3. Port status

N. Environmental rating:

   1. Operating temperature: -40 degrees Fahrenheit (°F) to 140°F
   2. Humidity: 95 percent relative humidity, non-condensing

Figure 3-1. Allen-Bradley Stratix switch

Source: Rockwell Automation 2021b.

3.2.2 Cost

The costing for Allen-Bradley Stratix switches varies based on features such as the number of ports, managed or unmanaged, DLR connectivity, etc. Retail pricing for a few common Stratix switches that are typically used in PLC panels is shown in Table 3-1 for reference. Although unmanaged options are available for industrial panel-mounted switches they are not recommended. Each switch will need to be sized individually based on the network requirements for that panel.

Table 3-1. Allen-Bradley Stratix switches

Component	Component cost[a]
1783-BMS10CGN Stratix 5700 10-port managed switch	$3,032
1783-BMS06SA Stratix 5700 6-port managed switch	$1,352
1783-US5T Stratix 2000 unmanaged switch	$155

a. Retail cost information obtained from North Coast Electric website (North Coast Electric 2021a–c).

3.2.3 Rack-Mounted Switches (with Redundant Network Access)

Rack-mounted network switches should support the following design features and protocols:

A. Support Ethernet 10/100/1000 Mbps

B. Ethernet backbone uplink modules for connection to multimode and/or single-mode fiber via type LC connectors

C. Backbone (trunk) fiber ports shall be via SFP modules

D. Provide as required (plus at least two spare) 10/100/1000 MBit/s port (twisted pair) at each Ethernet switch

E. Support SNMP v3 and web-based management

F. Rapid Spanning Tree Protocol

G. IGMP support for IP multicast filtering to enable switches to automatically route messages only to appropriate ports

O. Check all received data for validity

    1. Discard invalid and defective frames or fragments

P. Monitor connected TP/TX line segments for short-circuit or interrupt using regular link test pulses in accordance with IEEE 802.3

H. Monitor attached fiber-optic lines for open circuit conditions in accordance with IEEE 802.3

I. Distance vector protocols:

    1. Routing Information Protocol (RIP)

    2. Border Gateway Protocol

    3. Rapid Spanning Tree Protocol

J. Link state protocols:

    1. Open Shortest Path First (OSPF)

K. Redundancy protocols:

    1. Hot Standby Router Protocol (HSRP)

L. Layer-3 LAN Base: support for static IP routing; support for Switched Virtual Interface (SVI)

M. Layer-3 IP base: RIP, EIGRP stub, OSPF for routed access, Policy-Based Routing (PBR), IPv4 and IPv6 EIGRP stub routing, IPv6 Unicast Reverse Path forwarding (uRPF), IPV6 PBR, Virtual Router Redundancy Protocol (VRRPv3), Policy Classification Engine, HSRP v6

N. Layer-3 IP services: OSPF, EIGRP, Border Gateway Protocol (BGP), Intermediate System to Intermediate System (IS-IS), Virtual Routing and Forwarding (VRF-lite)

O. Software support for IPv4 and IPv6 routing, multicast routing, modular quality of service (QoS), flexible netflow (FNF) and enhanced security features

P. Dual redundant power supplies

Q. LED status lights to indicate

4. Power: supply voltage present

5. Fault

6. Port status

R. Environmental rating:

3. Operating temperature: 32°F to 122°F

4. Humidity: 95 percent relative humidity, non-condensing

Figure 3-2. Cisco Catalyst 9000 family switch

Source: Cisco Systems 2021.

3.2.4 Cost

Like the Industrial panel-mounted switches, the costing for the Cisco Catalyst 9000 series varies based on features such as the number of ports, stackability, etc. Retail pricing for a few common Catalyst 9000 switches is shown in Table 3-2 for reference. Each switch will need to be sized individually based on the OT network requirements for that particular switch.

Table 3-2. Cisco Catalyst 9000 switches

Component	Component cost[a]
C9200-24P-E 24-port managed switch	$1,416
C9300-48P-A 48-port managed switch	$5,910

a. Retail cost information obtained from CDW 2021a–b.

3.3 Uninterrupted Power Supplies

Uninterrupted Power Supplies (UPS) should be used during a loss of power as a backup power source so that operators can be notified of a power loss and the SCADA system can temporarily maintain monitoring and control functions. The UPS can also help protect against potential damage to your equipment during power surges and spikes.

A tower style UPS like the APC SRT1500XLA should be used within the control panel. A rackmount UPS like APC SRT1500RMXLA-NC and additional rackmount external batteries like APC SRT48RMBP should be used inside the network rack to provide backup power for approximately 4 hours.

3.3.1 Control Panel Uninterrupted Power Supply

Uninterrupted power supplies should support the following design features:

A. Double Conversion, true online type

B. Tower type format

C. Waveform: Pure sine wave

D. Power factor correction

E. Provide enough time to notify operator of in pending power loss when UPS is exhausted

F. Frequency range: 45-65 HZ

G. Input protection: Fuse or Circuit Breaker

H. Output voltage regulation: ±1% online and ±2% on battery mode.

I. Battery: Sealed, lead-acid; maintenance free.

J. Three stage battery charging for prolonged battery life.

K. Battery over discharge protection.

L. Input power cord.

M. Output receptacles.

N. Efficiency:

   1. Normal mode, minimum: 89%.

   2. Efficiency mode, minimum: 95%.

   3. Battery mode, minimum: 83%.

O. Operating temperature: 32 to 104 DEGF.

P. Relative humidity: 5-95% non-condensing.

Q. Integral bypass to automatically bypass UPS on selected fault conditions.

R. Front panel indication of UPS status and alarm conditions.

   1. UPS Fault.

   2. UPS on battery.

   3. UPS is online and operating normally.

4. Battery low.

5. UPS in bypass.

S. Utilize network management card to enable remote annunciation of the following conditions.

1. UPS Fault.

2. UPS on battery.

3. UPS is online and operating normally.

4. Battery low.

5. UPS in Bypass

T. Agency Approvals:

1. Safety: UL 1778.

2. Emissions: FCC Part 15 (Class A).

Figure 3-3. APC Smart-UPS SRT 1500 Tower

Source: APC

3.3.2 Cost

The costs for both the UPS as well as the network management card to provide remote monitoring and control of the UPS are shown below in Table 3-3 for reference.

Table 3-3. APC Smart-UPS SRT 1500, UPS Network Management Card

Component	Component cost[a]
APC Smart-UPS SRT 1500VA, 120V, LCD, tower, 6x NEMA 5-15R outlets	$1,450
UPS Network Management Card 3 with Environmental Monitoring	$539

a. Retail cost information obtained from APC website (APC 2021a-b).

3.3.3 Rackmount Uninterrupted Power Supply

Uninterrupted power supplies should have the following design features:

A. Double Conversion, true online type

B. Network Rackmount type format

C. Waveform: Pure sine wave

D. Power factor correction

E. Minimum 4 hours power ride through of 100% of connected load without incoming power.

   1. Provide extended battery or batteries as necessary to achieve the specified battery run time.

F. Frequency range: 45-65 HZ

G. Input protection: Fuse or Circuit Breaker

H. Output voltage regulation: ±1% online and ±2% on battery mode.

I. Battery: Sealed, lead-acid; maintenance free.

J. Three stage battery charging for prolonged battery life.

K. Battery over discharge protection.

L. Input power cord.

M. Output receptacles.

N. Efficiency:

   1. Normal mode, minimum: 89%.

   2. Efficiency mode, minimum: 95%.

   3. Battery mode, minimum: 83%.

O. Operating temperature: 32 to 104 DEGF.

P. Relative humidity: 5-95% non-condensing.

Q. Integral bypass to automatically bypass UPS on selected fault conditions.

R. Front panel indication of UPS status and alarm conditions.

1. UPS Fault.
2. UPS on battery.
3. UPS is online and operating normally.
4. Battery low.
5. UPS in bypass.

S. Utilize network management card to enable remote annunciation of the following conditions.

1. UPS Fault.
2. UPS on battery.
3. UPS is online and operating normally.
4. Battery low.
5. UPS in Bypass

T. Agency Approvals:

1. Safety: UL 1778.
2. Emissions: FCC Part 15 (Class A).

Figure 3-4. APC Smart-UPS SRT 1500 Rackmount

Source: APC

Figure 3-5. APC Smart-UPS SRT Battery Pack

Source: APC

3.3.4 Cost

Unlike the tower UPS, the rackmount UPS is bundled with a network management card. Additional Battery Packs may be required to achieve necessary backup time. The battery packs are stackable up to 10 units to provide the necessary backup time. Retail prices for the UPS and the battery pack are shown in Table 3-4 below.

Table 3-4. APC Smart-UPS SRT 1500 Rackmount, APC Smart-UPS SRT Battery Pack

Component	Component cost[a]
APC Smart-UPS SRT 1500VA, 120V, LCD, rackmount, 2U, 6x NEMA 5-15R outlets, w/network card	$1,975
APC Smart-UPS SRT Battery Pack (1kVA & 1.5kVA) 48V, 594VAh, rackmount, 2U	$839

b. Retail cost information obtained from APC website (APC 2021c-d).

3.4 OT Cybersecurity and Disaster Recovery

This section describes OT cybersecurity and disaster recovery for the Sewer District, including OT access control, OT network monitoring and logging software, and cost.

3.4.1 OT Access Control

To manage users on the OT network, consider implementing Microsoft Active Directory Domain Server (AD DS). AD authenticates and authorizes all users and computers in the domain network, assigns and enforces security polices for all computers, provides authentication and authorization mechanisms, and establishes a framework to deploy other related services.

3.4.2 OT Network Monitoring and Logging Software

OT network traffic events should be logged and stored on a centralized server that has enough memory to allow personnel to monitor and troubleshoot network issues. SolarWinds Network Performance Monitor and Kiwi Syslog Sever platform provide centrally managed syslog messages, real-time alerts, storage, and report generation.

Network monitoring software should provide the following features:

A. Network mapping tool and SNMP scanner

B. Network monitoring software with alerts

C. Network Packet Analyzer and Capture (PCAP) tool

D. Network path analysis and uptime monitor

E. Infrastructure monitoring

The network monitoring system (NMS) on the local OT network shall be used to monitor the operation of OT system network hosts. Network hosts shall be scanned only after confirming with the vendor that the device can be safely scanned. For example, Allen-Bradley PLC-5 or SLC PLCs are known to be sensitive to scanning.

3.4.3 Cost

Retail pricing for the SolarWinds Network Performance Monitoring and Syslog server logging is shown in Table 3-5 for reference. The SolarWinds NPM SL250 perpetual license provides management of up to 250 elements, which will meet the current and anticipated future needs of the Sewer Utility's OT network.

Table 3-5. Network monitoring and logging software

Component	Component cost[a]
SolarWinds NPM SL250 perpetual license	$7,279
SolarWinds Kiwi Syslog Server	$319

a. Retail cost information obtained from SolarWinds 2021a–b.

3.5 Multifactor Authentication for HMI Software

Because of increasing cybersecurity risks, a zero-trust security model should be used when accessing the control system equipment, particularly from a remote location outside of the OT network. One additional layer of security that should be considered is multifactor authentication. It is recommended that all mobile devices connecting to the control network equipment should be protected with a multifactor authentication application. There are several multifactor authentication applications including DUO, which has a partnership with Cisco network for more integrated zero-trust security solutions. Most multifactor authentication costing is done on a monthly subscription basis per user at a cost of approximately $6 to $10 per user per month based on the features used.

3.6 Version Control and Backup Software for OT Systems

This section describes version control and backup software for OT systems, including version control software and secure offline storage and cost for each.

3.6.1 Version Control Software

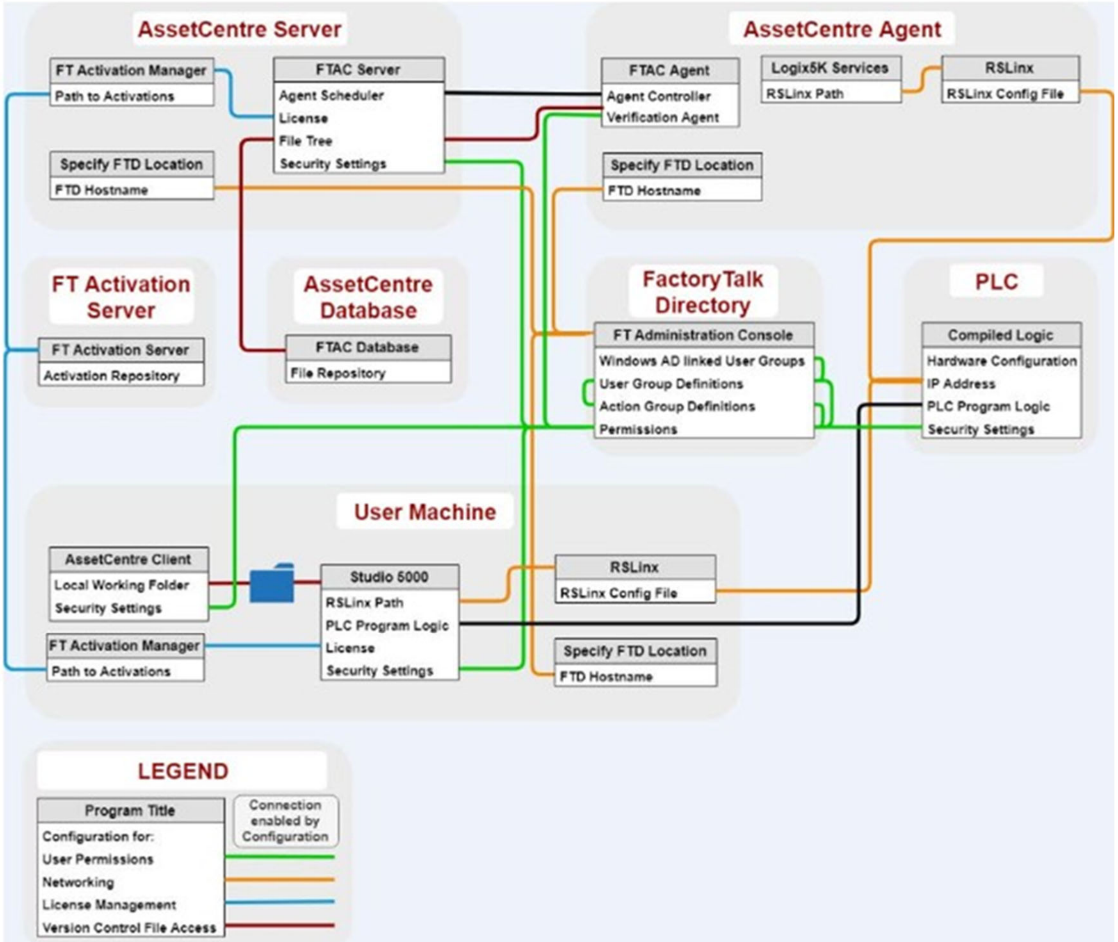
In a disaster response scenario, it is critical to have current configuration files for ICSs components (PLCs, operator panel, network switches, motor drives, etc.). Rockwell Software FactoryTalk (FT) Asset Centre provides a centralized tool for securing, managing, versioning, tracking, and reporting automation-related asset information across the entire Sewer Utility.

Rockwell Software FT AssetCentre is dedicated software for securing, managing, tracking, and documenting (versioning) the control system assets of the Sewer Utility.

FT AssetCentre will allow Sewer Utility staff to provide archive and disaster recovery for Allen-Bradley equipment, audit trails of programming changes, provide security on access to view and change production PLC code, and maintain controls assets along their useful life cycle. From a maintenance and troubleshooting standpoint FT AssetCentre has the capability to compare versions of Rockwell Software Studio5000 PLC code, which allows users to see programming changes quickly and easily between the two versions being compared. Also, FT AssetCentre can communicate directly with the Studio5000 Logix PLCs to retrieve scheduled backups and/or download the last known version to the processor itself, allowing all backups and version changes must be done automatically.

The graphic shown in Figure 3-6 shows the necessary requirements for the user permissions, network connections (and permissions), licensing, and version control. In the graphic the PLC represents all PLCs within the Sewer Utility's OT network and the user machine represents that field programming PCs. The FT AssetServer, FT Directory, and FT AssetCentre Agent are server PCs housed within the OT network.

Figure 3-6. Logical relationships of Rockwell software products required for FactoryTalk AssetCentre



Source: Rockwell Automation 2021c.

3.6.2 Version Control Software Cost

Retail pricing for Rockwell Software FT AssetCentre is shown in Table 3-6 for reference. Rockwell Software FT AssetCentre is available in two different formats: perpetual (ownership) and subscription. Perpetual licensing also has the option to pay a yearly support cost.

Table 3-6 highlights the costing associated with the two formats. Also, the Sewer Utility may elect to add the Archive Management of Change module, which would allow the formal approval (and documentation) of changes to be integrated within the FT AssetCentre software, rather than being done separately. Only one server and license is anticipated to be required for the Sewer Utility.

Table 3-6. Network monitoring and logging software

Component	Perpetual[a]	Subscription
FT AssetCentre one-time cost	$16,300/license	N/A
FT AssetCentre annual cost	$3,260/server/year	$6,600/server/year
Archive Management of Change module one-time cost	$6,000/license	N/A
Archive Management of Change module annual cost	$1,317/server/year	$2,439/server/year

a. Retail cost information obtained from Border States Electric 2021a–b.

3.6.3 Secure Offline Storage

In the event of a ransomware attack on the Sewer Utility control system, secure offline storage of Sewer Utility control system files (software licenses, configuration files, environmental compliance data, etc.) will be critical for the timely recovery of affected systems. The Sewer Utility should consider creating routine offline copies of ICS files. The Sewer Utility can either self-manage storage of physical media locally or use a company like Iron Mountain to store files at a secure off-site facility either in the cloud or with physical media.

3.6.4 Secure Offline Storage Cost

Table 3-7 shows the costing for offline storage via a tape drive and storage media for the backups. Alternatively, off-site storage via a service company like Iron Mountain requires a specific quote but is costed based on the number of virtual machines (VMs) being protected and gigabytes (GB) of data begin backed up. Payments for those services are generally done as a monthly or yearly service cost. An estimated yearly cost is shown in Table 3-8.

Table 3-7. LTO-7 tape drive and storage media

Component	Component cost[a]
HPE StoreEver LTO-7 Ultrium 15000 - tape drive - LTO Ultrium - SAS-2	$3,274
Quantum - LTO Ultrium 7 x 1 - 6 TB - storage media	$78

a. Retail cost information obtained from CDW 2021c–d.

Table 3-8. Off-site Storage Service

Component	Component cost[a]
Estimated yearly cost based on 5 VM and 10 GM/month of data	$896

a. Retail cost information obtained from Panoptics 2021.

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4 PLC Hardware and Software

This section describes the Allen-Bradley CompactLogix 5380 controller and Compact 5000 I/O platform components selected as the new Sewer Utility standard for WWTP and remote pump station PLC design and implementation. The section also provides a summary of the evaluation approach by which these PLC components were selected. The costing provided in this section is current as of the time of writing but may vary greatly depending on continuing supply chain issues.

4.1 Allen-Bradley CompactLogix 5380 Controller and Compact 5000 I/O Standard Components

The Allen-Bradley CompactLogix 5380 controller and Compact 5000 I/O platform comprise several component options and features that allow for flexibility in designing a PLC system that aligns with Sewer Utility preferences. The platform does not use a chassis and all modules are DIN-rail-mountable. This section documents the platform components that are recommended for the Sewer Utility to standardize on for future design and implementation projects. A summary table (Table 4-1) comprising the recommended platform components is provided in Section 4.1.6. An example of a PLC rack assembled from controller and I/O modules within this product line is provided in Figure 4-1.

Figure 4-1. Allen-Bradley CompactLogix 5380 controller with Compact 5000 I/O modules

Source: Rockwell Automation 2018a.

4.1.1 Controller

This section describes the controller module and recommended accessories of the Allen-Bradley CompactLogix 5380 PLC platform.

Controller Module

The Allen-Bradley CompactLogix 5380 controller family includes several controller modules that feature a range of capabilities in terms of user memory, local I/O module capacity, and supported EtherNet/IP connections. The retail cost for these controllers currently ranges from roughly $1,300 to $16,000 depending on the capabilities of the controller (North Coast Electric 2021d). Selecting a controller that is right-sized for the application can result in component cost savings and is recommended over a one-size-fits-all approach to controller module selection. A 5069-L320ER controller is depicted in Figure 4-2. This controller, for example, has 2 megabytes (MB) of user memory and supports up to 16 local I/O modules and 40 EtherNet/IP connections.

Figure 4-2. Allen-Bradley 5069-L320ER CompactLogix 5380 controller

Source: North Coast Electric 2021e.

All controller modules in the Allen-Bradley 5380 CompactLogix platform include two built-in 1 Gbps Ethernet ports. These ports can be configured for linear or DLR topologies where the ports share one IP address, or the ports can be configured with unique IP addresses to support network segmentation approaches. All controllers have a built-in Universal Serial Bus (USB) port for local programming, configuration, firmware updates, and online edits. Controllers also support Secure Digital (SD) memory cards for storing non-volatile memory.

Note, the CompactLogix 5380 controllers with part numbers ending in ERM, ERMK, and ERP include integrated motion and other advanced features that are not used in typical wastewater applications. The Sewer Utility is unlikely to leverage the additional functionality provided by these controllers, so investment in these higher-cost components is not recommended.

Controller Accessories

The Allen-Bradley 5380 CompactLogix controllers can be provided with spring clamp or screw clamp terminals for power connections, which must be ordered separately from the controller module. Either terminal kit would be suitable, but Sewer Utility staff are likely already familiar with screw clamp terminals based on the Sewer Utility’s existing ICS infrastructure. For this reason, the Allen-Bradley 5069-RTB64-SCREW power terminal kit is recommended.

An SD memory card is also recommended for non-volatile memory storage of application programming and data. A 2 GB SD memory card (part 1784-SD2) ships with each controller and should provide sufficient memory storage for most, if not all, Sewer Utility applications.

4.1.2 EtherNet/IP Adapter

This section describes the Allen-Bradley Compact 5000 I/O EtherNet/IP adapter recommended for the Sewer Utility.

EtherNet/IP Adapter

The Allen-Bradley Compact 5000 I/O platform includes two types of EtherNet/IP adapters that serve as communication modules for remote input/output (RIO) racks: the 5069-AENTR and 5069-AEN2TR. Both EtherNet/IP adapters facilitate high-speed data transfer between the connected Compact 5000 I/O modules within the RIO rack and one or more CompactLogix 5380 controllers (or other compatible controllers) on a shared EtherNet/IP network. Both EtherNet/IP adapters also include two built-in 1 Gbps Ethernet ports. These ports can be configured for linear or DLR topologies where the ports share one IP address, or a single port can be used to connect to a star network topology.

The most significant advantage that the 5069-AENTR has over the 5069-AEN2TR is some security features included in what Allen-Bradley refers to as Protected Mode. Among other things, these features are meant to reduce the attack surface of the device by preventing configuration changes, firmware updates, and remote resets from occurring once the adapter is exchanging I/O with a controller. While the 5069-AEN2TR does not support Protected Mode, the adapter has a four-character digital display that communicates status and fault messages, which can help with troubleshooting. The 5069-AEN2TR also supports SD memory cards for storing the adapter’s configuration in non-volatile memory. The latter feature allows for the adapter to automatically revert to its last saved configuration on power-up, which allows the device to automatically recover from loss or corruption of internal memory. While both EtherNet/IP adapters have advantages, the enhanced troubleshooting and resilience features of the 5069-AEN2TR are likely to be more beneficial to the Sewer Utility. For this reason, HDR Engineering, Inc. (HDR) recommends that the Sewer Utility standardize on the 5069-AEN2TR for future RIO racks (Figure 4-3).

Figure 4-3. Allen-Bradley 5069-AEN2TR Compact 5000 I/O EtherNet/IP adapter

Source: North Coast Electric 2021f.

EtherNet/IP Adapter Accessories

The Allen-Bradley 5069-AEN2TR EtherNet/IP adapter can be provided with spring clamp or screw clamp terminals for power connections, which, like the controller module, must be ordered separately from the EtherNet/IP adapter module. The power terminal kits used for the controller module are identical for the 5069-AEN2TR. As discussed for the controller module, HDR recommends that the Sewer Utility standardize on the Allen-Bradley 5069-RTB64-SCREW power terminal kit.

An SD memory card is also recommended for non-volatile memory storage of adapter configuration. A 1 GB SD memory card, the smallest available from Allen-Bradley, should provide ample memory storage for the adapter configuration.

4.1.3 Power Supply Considerations

The CompactLogix 5380 controller and Compact 5000 I/O platform does not include power supply modules like previous generations of the CompactLogix product line. Instead, the system requires the use of external power supplies that are wired to the power terminals on the CompactLogix 5380 controller or Compact 5000 I/O EtherNet/IP adapter. Power is distributed from the controller/adapter to the connected Compact 5000 I/O modules via a module (MOD) power bus. Similarly, power is distributed from the controller/adapter to the instrumentation with I/O connections to the Compact 5000 I/O modules via a sensor/actuator (SA) power bus. Both of these power buses reside at the rear of the controller/adapter and I/O modules and are made continuous by the interconnection of the modules.

Rockwell Automation recommends providing separate external power supplies for the MOD and SA power buses. This approach prevents a scenario where both power buses are lost because of the failure of a single component. The MOD power bus must be supplied with 24 volts direct current (VDC) power. While the SA power bus may be powered via 24 VDC or 120 volts alternating current (VAC), HDR recommends that the Sewer Utility standardize on 24 VDC for the SA power bus. According to National Fire Protection Association (NFPA) 70E: Standard for Electrical Safety in the Workplace, all voltages 50 volts (V) and greater are considered to present a shock hazard under most circumstances (NFPA 2021). In general, standardizing on the use of 24 VDC controls and power distribution, to the extent possible, within industrial control panels and for field instrumentation can reduce or eliminate shock hazards for personnel.

4.1.4 I/O Modules

This section describes the Allen-Bradley Compact 5000 I/O modules recommended for the Sewer Utility. To reduce shock hazards within industrial control panels and at field instrumentation, HDR recommends that the Sewer Utility standardize on 24 VDC control voltage for all I/O modules on future projects, when feasible. The I/O modules recommended in this section have been selected to conform with this 24 VDC control voltage standard.

Analog Input Module

HDR recommends that the Sewer Utility standardize on the Allen-Bradley 5069-IF8 module for analog inputs (Figure 4-4). This module supports current- and voltage-based two- and four-wire analog devices. A combination of these device types may be wired to the same module. Each module has eight available channels wired as differential inputs.

Figure 4-4. Allen-Bradley 5069-IF8 Compact 5000 I/O analog input module

Source: North Coast Electric 2021g.

Note, the Compact 5000 I/O platform also includes four-channel analog input modules that support thermocouple and resistance temperature detectors (RTDs) in addition to the two- and four-wire devices supported by the 5069-IF8 analog input module. However, unless thermocouples or RTDs are to be wired to the analog input module, the Sewer Utility would gain no benefit from using a module with fewer available channels.

Analog Output Module

HDR recommends that the Sewer Utility standardize on the Allen-Bradley 5069-OF8 module for analog outputs (Figure 4-5). This module supports current- or voltage-based analog outputs. Each module has eight available channels wired as differential outputs.

Figure 4-5. Allen-Bradley 5069-OF8 Compact 5000 I/O analog output module

Source: North Coast Electric 2021h.

Digital Input Module

HDR recommends that the Sewer Utility standardize on the Allen-Bradley 5069-IB16F module for digital inputs (Figure 4-6). This module has 16 available channels wired as sinking 24 VDC inputs.

Figure 4-6. Allen-Bradley 5069-IB16F Compact 5000 I/O digital input module

Source: North Coast Electric 2021i.

The 5069-IB16F is the high-speed variant of the 16-channel 24 VDC digital input modules available within the Compact 5000 I/O platform, which allows for connection of higher-speed frequency inputs for counter applications. A common application of counter applications in wastewater is for flow totalization where magmeter frequency outputs are monitored to determine total flows. Given that the high-speed variant of the digital input module retails for roughly $30 more than the standard digital input module, there is not likely to be considerable cost savings from only using the high-speed module for counter applications. Standardizing on two digital input module types would also require additional spare parts to be managed. For these reasons, HDR recommends that the Sewer Utility standardize on the 5069-IB16F for all digital input applications.

Digital Output Module

HDR recommends that the Sewer Utility standardize on the Allen-Bradley 5069-OB16 module for digital outputs (Figure 4-7). This module has 16 available channels wired as sourcing 24 VDC outputs.

Figure 4-7. Allen-Bradley 5069-OB16 Compact 5000 I/O digital output module

Source: North Coast Electric 2021j.

Unlike the previously discussed I/O modules, the 5069-OB16 module does not draw current from the SA power bus. Instead, wiring to an external power supply is required for the module, which allows for the digital output circuits to be isolated from the SA power bus used by other I/O modules.

I/O Module Accessories

The Allen-Bradley analog and digital I/O modules can be provided with spring clamp or screw clamp terminals for I/O connections. These terminal kits must be ordered separately from the modules. As discussed for the controller module, HDR recommends that the Sewer Utility standardize on the screw terminal kit variant, the Allen-Bradley 5069-RTB18-SCREW terminal kit.

4.1.5 End Cap

All CompactLogix 5380 controller and Compact 5000 I/O racks require installation of a 5069-ECR end cap on the right side of the rightmost module in the rack (see Figure 4-8). The end cap covers the exposed interconnections like the MOD and SA power buses on the rightmost module within the rack. Failure to install the end cap can result in equipment damage and risk of electric shock.

Figure 4-8. Allen-Bradley 5069-ECR CompactLogix 5380 and Compact 5000 I/O end cap

Source: EESCO 2021.

4.1.6 Recommended Standard Component Summary Table

The Allen-Bradley CompactLogix 5380 controller and Compact 5000 I/O platform components recommended for the Sewer Utility standard PLC and RIO components are summarized in Table 4-1.

Table 4-1. Allen-Bradley CompactLogix 5380 controller and Compact 5000 I/O platform standard components summary

Part number	Type	Description
5069-L3xxER	Controller	CompactLogix 5380 controller: sized per application
5069-RTB64-SCREW	Controller and EtherNet/IP adapter accessories	Screw clamp power terminal kit
1784-SD2	Controller accessories	SD memory card for application and data storage: 2 GB
5069-AEN2TR	EtherNet/IP adapter	Compact 5000 I/O EtherNet/IP adapter for RIO racks
1785-SD1	EtherNet/IP adapter accessories	SD memory card for configuration storage: 1 GB
5069-IF8	Analog input module	Analog input module: 8-channel, differential
5069-OF8	Analog output module	Analog output module: 8-channel, differential
5069-IB16F	Digital input module	Digital input module: 16-channel, high-speed, sinking
5069-OB16	Digital output module	Digital output module: 16-channel, sourcing
5069-RTB18-SCREW	I/O module accessories	Screw clamp terminal kit: 18-pin
5069-ECR	End cap	End cap: required on rightmost module in rack

4.2 PLC Programming Software

The Allen-Bradley CompactLogix 5380 controllers are configured and programmed with Rockwell Automation's Studio 5000 Logix Designer Application. This is the same software used to program the Sewer Utility's existing CompactLogix controllers from previous generations of the product line and HDR believes that the Sewer Utility already owns a license for the software. The CompactLogix 5380 controllers have minimum Logix Designer version requirements, which ranges from Version 28.00.00 to Version 29.00.00 for the controllers most suitable to the Sewer Utility's applications (Rockwell Automation 2020).

4.3 PLC Platform Evaluation

In TM-2, Section 6.1.1, several requirements were identified for the Sewer Utility's next PLC platform standard. These PLC platform requirements include the following:

- Support integration of an increasing number of Ethernet devices
- Compatible with existing PLC programming logic
- Actively supported by the manufacturer for the next 10 to 15 years
- Manufactured by Allen-Bradley to preserve the Sewer Utility's existing investment in standardizing on Allen-Bradley PLCs

Of the PLC platforms currently offered by Allen-Bradley, several controllers would meet the technical requirements. However, only two controller families are likely to satisfy the long-term active support requirements: ControlLogix 5580 and CompactLogix 5380. These controllers are compared in subsequent paragraphs.

Note, Allen-Bradley also offers a relatively new CompactLogix 5480 line of controllers that runs an instance of Windows 10 Internet of Things (IoT) Enterprise "in parallel" with the Logix control engine (Rockwell Automation 2021a). The intent of this offering is to allow advanced data processing and analytics to be shifted down from central servers to the device level. However, HDR has several concerns regarding the stability of the Windows 10 operating system, its fluctuating demands on device resources, and the high number of vulnerabilities that require frequent patches and updates from Microsoft. Long-term support of the Windows 10 operating system is also dubious, given that the extended support window for Windows 10 is currently slated to end on October 14, 2025 (Microsoft 2021). For these reasons, the CompactLogix 5480 product line was not considered as a viable candidate for the next Sewer Utility PLC platform standard.

4.3.1 Ease of Migration

Both the ControlLogix 5580 and CompactLogix 5380 controllers are made by the same manufacturer as the Sewer Utility's existing PLCs and share the same native industrial Ethernet communications protocol (EtherNet/IP) and programming environment as the existing CompactLogix PLCs. When it comes to the future migration of existing CompactLogix controllers, either platform would allow for relatively simple migration of existing programming logic and preservation of existing SCADA communication driver configuration.

The existing Allen-Bradley SLC 5/05 and MicroLogix 1500 PLCs that are recommended for near-term replacement are programmed via Rockwell Automation's RSLogix 500 software, which is a different programming environment from the Studio 5000 Logix Designer Application software used to program both the ControlLogix 5580 and CompactLogix 5380 controllers. The SLC 5/05 PLCs also use a different communication driver to establish data exchange with the Sewer Utility's AVEVA SCADA software. Because both candidate controllers share a common programming environment and require the same EtherNet/IP-based communication driver, neither controller has a distinct advantage when it comes to migrating the existing programming logic to the new platform and would both require transitioning to the communication driver currently used by the Sewer Utility's existing CompactLogix PLCs.

One significant benefit that the CompactLogix 5380 and Compact 5000 I/O platform has over the ControlLogix 5580 platform in terms of ease of migration is its form factor. The footprint of the CompactLogix 5380 and Compact 5000 I/O platform components is considerably smaller, which could reduce the amount of control panel modifications required for replacement of existing PLCs within existing enclosures. When it comes to SLC 5/05 PLC rack replacement, the CompactLogix 5380 and Compact 5000 I/O components could fit within the SLC 5/05 footprint with room to spare, assuming a one-for-one component replacement. The chassis required by the ControlLogix product line have a roughly identical footprint to those required by the SLC 500 product line. The difference in form factor will be more pronounced when it comes to replacement of the MicroLogix 1500 PLCs, which have a smaller footprint than either candidate platform. For these remote pump station control panel applications, the smaller footprint of the CompactLogix 5380 and Compact 5000 I/O components presents a significant advantage.

4.3.2 Capability

When determining modern controller requirements, programming application memory size (in megabytes) and maximum number of IP nodes supported are two significant metrics that are commonly considered. The former represents the available memory for the programming file and the data being handled, while the latter, in general terms, indicates how many IP devices the controller can communicate with. Table 4-2 includes a comparison of these metrics for the two Allen-Bradley controller families considered for the Sewer Utility. To provide some context for the comparison, the table also provides the actual memory used by the existing CKTP ultraviolet (UV) system PLC, which appears to have the largest memory usage of all PLCs in the Sewer Utility's inventory. For additional context, the table also includes an estimate of the maximum number of IP nodes that will need to communicate with any one PLC in the future Sewer Utility SCADA system. This estimate is based on the solids processing building (SPB) PLC (PLC 7105) and a scenario where the existing SPB motor control centers (MCCs) are upgraded with EtherNet/IP motor controllers and CKTP expansion adds loads to these MCCs. An allowance for 10 new Ethernet-capable instruments is also included in this estimation.

Table 4-2. Allen-Bradley CompactLogix 5380 and ControlLogix 5580 controller comparison

Controller family	Application memory size (MB)[a]	Max IP nodes supported[a]
CompactLogix 5380 standard controller	0.6–10.0	16–180
ControlLogix 5580 standard controller	3–40	100–300
Existing CKTP UV SCC 3100 controller memory used	~1.54	----
Estimated maximum IP nodes communicating to one controller in future Sewer Utility SCADA system	----	~75

a. Metrics obtained from Rockwell Automation literature (Rockwell Automation 2018b and Rockwell Automation 2019).

While PLC memory usage will increase somewhat as the Sewer Utility acquires more data from Ethernet-capable devices in the future, it is not anticipated that the Sewer Utility will have applications that exceed the upper limit on the ControlLogix 5380 memory size range in the next 10 to 15 years. Nor is it anticipated that a single PLC within the Sewer Utility SCADA system will need to communicate with more IP nodes than the CompactLogix 5380 controllers can support within that time frame. Based on memory size and the number of IP nodes supported, the CompactLogix 5380 presents a more right-sized option for the Sewer Utility's needs.

Another consideration for modern controllers is Ethernet communication speed capabilities. Both the CompactLogix 5380 and ControlLogix 5580 controllers are capable of 1 Gbps Ethernet communications. ICSs are gradually migrating from 100 Mbps port speeds to support higher data communication rates at the controller and device level, and 1 Gbps is quickly becoming the new standard. Having controllers that support higher port speeds will allow the Sewer Utility to benefit from other proposed improvements to the Sewer Utility SCADA system network infrastructure and increase the likelihood that the controllers remain compatible with equipment that may be installed in the future.

One of the major advantages that the ControlLogix 5580 controllers have over the CompactLogix 5380 controllers is their support for controller redundancy. However, as identified in TM-2, controller redundancy is not a requirement for the Sewer Utility. While the ControlLogix 5580 controllers have some additional technical functionality and features, like hot-swappable I/O modules, these are not critical features that would present sufficient drivers to select an oversized controller on their merits alone.

4.3.3 Cost

In terms of cost, the CompactLogix 5380 controller and associated Compact 5000 I/O components are the clear choice over the ControlLogix product line. Retail pricing for components required for a single, hypothetical seven-slot PLC rack with similar I/O capabilities is provided in Table 4-3 for reference. Note, because of the difference in I/O module costs, the cost delta will become more pronounced as the number of I/O modules in the racks increases.

Table 4-3. Allen-Bradley CompactLogix 5380 and ControlLogix 5580 component cost comparison

Component	CompactLogix 5380/ Compact 5000 I/O component cost[a]	ControlLogix 5580/ ControlLogix I/O component cost[a]
7-slot chassis	Not required	$632
Rack power supply module (24 VDC)	Not required	$1,137
Controller module, 3 MB, support for at least 60 IP nodes	$5,586	$6,404
Analog input module, 8-channel	$867	$1,327
Analog output module, 8-channel	$1,520	$2,494
Digital input module, 16-channel, high-speed	$292	$616
Digital output module, 16-channel	$340	$689
Slot filler (quantity of 2)	Not required	$70
I/O module terminal blocks (quantity of 4)	$248	$384
Controller module terminal blocks	$34	Not required
End cap	$25	Not required
Total	**$8,912**	**$13,753**

a. Retail cost information obtained from North Coast Electric website (North Coast Electric 2021d).

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5 References

APC

2021a APC Smart-UPS SRT 1500VA, 120V, LCD, tower, 6x NEMA 5-15R outlets. https://www.apc.com/shop/us/en/products/APC-Smart-UPS-SRT-1500VA-120V-LCD-rackmount-w-kit-6x-NEMA-5-15R-outlets/P-SRT1500XLA. Viewed on December 1, 2021.

2021b UPS Network Management Card 3 with Environmental Monitoring. https://www.apc.com/shop/us/en/products/UPS-Network-Management-Card-3-with-Environmental-Monitoring/P-AP9641?Chat_CSC_ID=a50002. Viewed on December 1, 2021.

2021c APC Smart-UPS SRT 1500VA, 120V, LCD, rackmount, 2U, 6x NEMA 5-15R outlets, w/network card. https://www.apc.com/shop/us/en/products/APC-Smart-UPS-SRT-1500VA-120V-LCD-rackmount-2U-6x-NEMA-5-15R-outlets-w-network-card/P-SRT1500RMXLA-NC?Chat_CSC_ID=a50002. Viewed on December 1, 2021.

2021d APC Smart-UPS SRT Battery Pack (1kVA & 1.5kVA) 48V, 594VAh, rackmount, 2U. https://www.apc.com/shop/us/en/products/APC-Smart-UPS-SRT-Battery-Pack-1kVA-1-5kVA-48V-594VAh-rackmount-2U/P-SRT48RMBP?Chat_CSC_ID=a50002. Viewed on December 1, 2021.

Border States Electric

2021a FactoryTalk AssetCentre Perpetual and Subscription Costing. Obtained on August 27, 2021.

2021b FactoryTalk AssetCentre Archive Management of Change Module Perpetual and Subscription Costing. Obtained on August 27, 2021.

CDW

2021a Cisco Catalyst 9200 - Network Essentials - switch - 24 ports - smart - rack. https://www.cdw.com/product/cisco-catalyst-9200-network-essentials-switch-24-ports-smart-rack/5638586?pfm=srh. Viewed on August 14, 2021.

2021b Cisco Catalyst 9300 - Network Advantage - switch - 48 ports - managed – rack. https://www.cdw.com/product/cisco-catalyst-9300-network-advantage-switch-48-ports-managed-rac/4696725?pfm=srh. Viewed on August 14, 2021.

2021c HPE StoreEver LTO-7 Ultrium 15000 - tape drive - LTO Ultrium - SAS-2. https://www.cdw.com/product/hpe-storeever-lto-7-ultrium-15000-tape-drive-lto-ultrium-sas-2/4510331?pfm=srh. Viewed on September 8, 2021.

2021d Quantum - LTO Ultrium 7 x 1 - 6 TB - storage media. https://www.cdw.com/product/quantum-lto-ultrium-7-x-1-6-tb-storage-media/3936476?pfm=srh. Viewed on September 8, 2021.

Cisco Systems

2021 Cisco Catalyst 9000 Series. https://www.cisco.com/c/en/us/products/collateral/switches/catalyst-9000/nb-09-cat-9k-aag-cte-en.html. Viewed on September 5, 2021.

EESCO

2021 Allen-Bradley End Cap. https://buy.eescodist.com/Automation-and-Control/PLC-HMI-and-Logic-Devices/PLC-Components/PLC-End-Caps/ROCKWELL-AUTOMATION/End-

Cap-with-Adapter-Required-on-Right-Most-I-O-Module/5069-ECR/p/88950833414-1?dimId=1gn8j5m. Viewed on March 2, 2021.

Microsoft

2021 Microsoft Active Directory Server. https://docs.microsoft.com/en-us/troubleshoot/windows-server/identity/active-directory-overview. Viewed on September 3, 2021.

NFPA (National Fire Protection Association)

2021 NFPA 70E: Standard for Electrical Safety in the Workplace.

North Coast Electric

2021a Allen-Bradley 1783-BMS10CGN Stratix 5700 10-Port Managed Switch. https://www.northcoast.com/product/detail/911180/allen-bradley-rockwell-1783-bms10cgn. Viewed on September 8, 2021.

2021b Allen-Bradley 1783-BMS06SA Stratix 5700 6-Port Managed Switch. https://www.northcoast.com/product/detail/832979/allen-bradley-rockwell-1783-bms06sa. Viewed on September 8, 2021.

2021c Allen-Bradley 1783-US5T Stratix 2000 5-Port Unmanaged Switch. https://www.northcoast.com/product/detail/950131/allen-bradley-rockwell-1783-us5t. Viewed on September 8, 2021.

2021d Various component costs published online. https://www.northcoast.com. Viewed on March 1–2, 2021.

2021e *Allen-Bradley 5069-L320ER.* https://www.northcoast.com/product/detail/AB-CMX-5069-L320ER?s=1271268. Viewed on March 1, 2021.

2021f *Allen-Bradley 5069-AEN2TR.* https://www.northcoast.com/product/detail/AB-CMX-5069-AEN2TR?s=1271075. Viewed on March 2, 2021.

2021g *Allen-Bradley 5069-IF8.* https://www.northcoast.com/product/detail/AB-CMX-5069-IF8?s=1276577. Viewed on March 2, 2021.

2021h *Allen-Bradley 5069-OF8.* https://www.northcoast.com/product/detail/AB-CMX-5069-OF8?s=1276578. Viewed on March 2, 2021.

2021i *Allen-Bradley 5069-IB16F.* https://www.northcoast.com/product/detail/AB-CMX-5069-IB16F?s=1337024. Viewed on March 2, 2021.

2021j *Allen-Bradley 5069-OB16.* https://www.northcoast.com/product/detail/AB-CMX-5069-OB16?s=1271079. Viewed on March 2, 2021.

Panoptics

2021 Backup-as-a-Service. https://www.panoptics.com/services/datacenter-connectivity/backup-as-a-service/#section_5. Viewed on September 6, 2021.

Rockwell Automation

2018a *Migration Solutions: CompactLogix 1768-L4x Controller to CompactLogix 5380 Controller.* https://literature.rockwellautomation.com/idc/groups/literature/documents/pp/migrat-pp037_-en-e.pdf. November.

2018b *ControlLogix 5580 Controllers.* Publication 1756-PP001E-EN-P.

2019 *CompactLogix 5380 Controllers.* Publication 5069-PP003E-EN-P.

2020 *CompactLogix 5380 and Compact GuardLogix 5380 Controllers.* https://literature.rockwellautomation.com/idc/groups/literature/documents/um/5069-um001_-en-p.pdf. August.

2021a *CompactLogix 5480 Controllers.* https://www.rockwellautomation.com/en-us/products/hardware/allen-bradley/programmable-controllers/small-controllers/compactlogix-family/compactlogix-5480-controllers.html. Viewed on March 5, 2021.

2021b *Stratix 5400 Industrial Ethernet Switches.* https://www.rockwellautomation.com/en-us/products/hardware/allen-bradley/network-security-and-infrastructure/ethernet-networks/stratix-5400-industrial.html. Viewed on September 10, 2021.

2021c FactoryTalk AssetCentre Getting Results Guide. https://literature.rockwellautomation.com/idc/groups/literature/documents/gr/ftac-gr002_-en-e.pdf. Viewed on July 27, 2021.

SolarWinds Worldwide, LLC

2021a Network Performance Monitor. https://www.solarwinds.com/network-performance-monitor. Viewed on September 5, 2021.

2021b Kiwi Syslog Server. https://www.solarwinds.com/kiwi-syslog-server. Viewed on September 5, 2021.

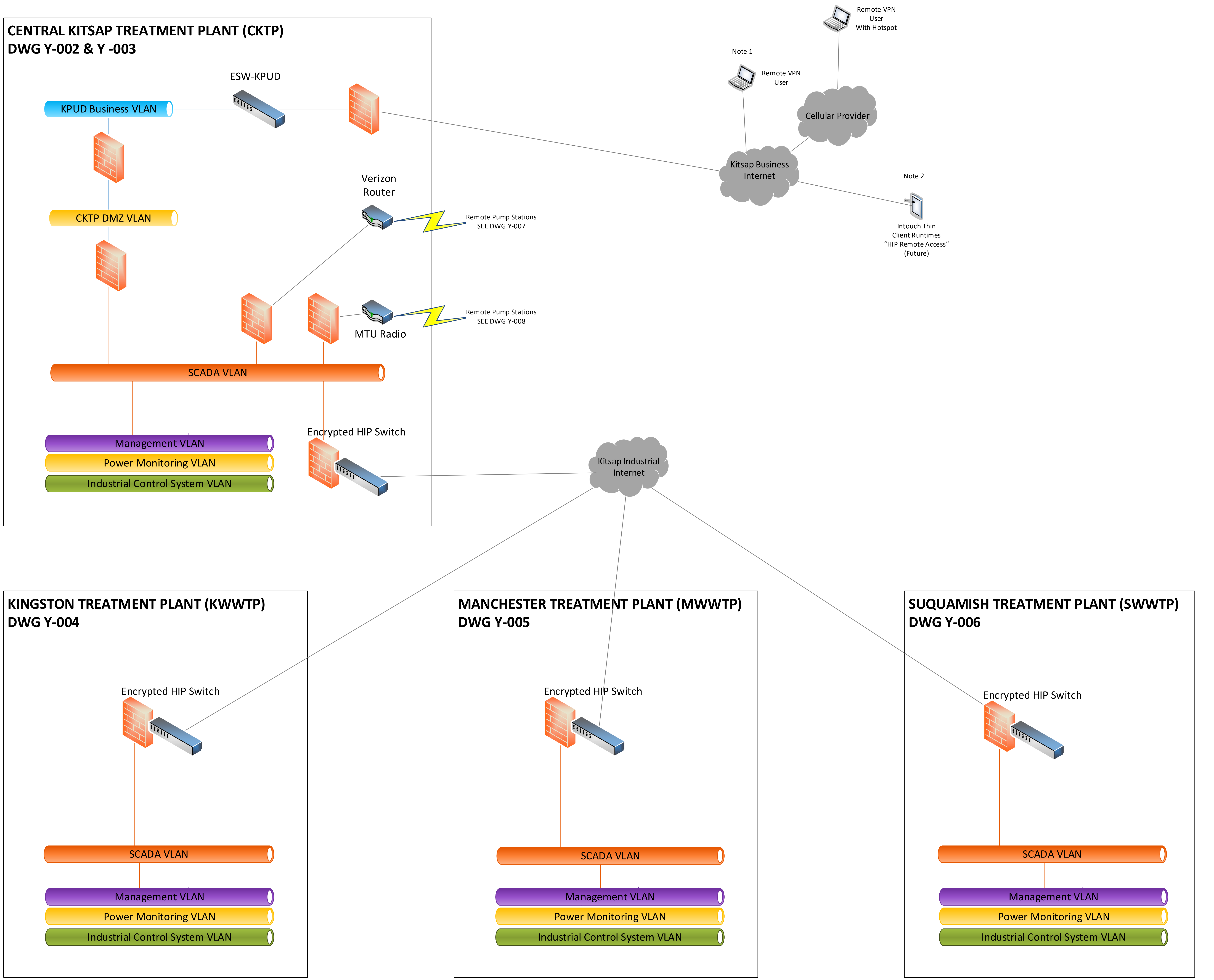
TM-4: System Architecture Conceptual Design

Sewer Utility SCADA Master Plan

Kitsap County Public Works
Sewer Utility Division

October 26, 2021

Notes:
1. All mobile wireless communications will use VPN for AAA (authentication, authorization, accounting) and encryption.
2. Tablets will be updated with Group Policy Objects from Active Directory. This excludes devices based on Android or IOS operating systems



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DRAWN BY — DATE
CHECKED BY — DATE

APPROVED BY — DATE
10231983
HDR PROJECT NUMBER — DATE
KC-205-20
CLIENT PROJECT NUMBER — DATE

Kitsap County Public Works
Sewer Utility Division
12351 Brownsville Highway NE
Poulsbo, WA 98370

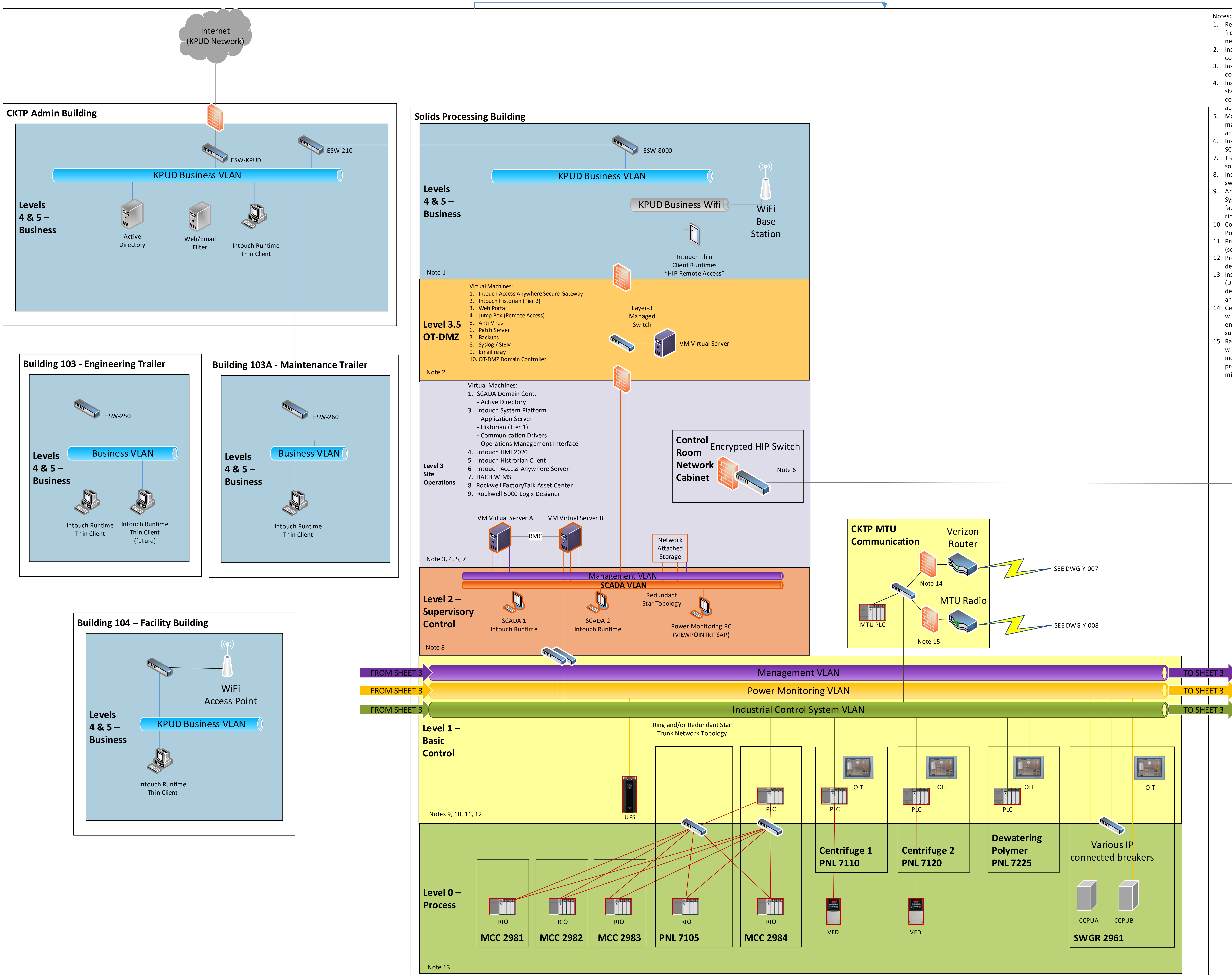
KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

SCALE: NONE

CONCEPT DIAGRAM
KITSAP SCADA OVERVIEW

DRAWING: Y-001

SHEET 1 OF 8



Notes:
1. Remote VPN access is to SCADA network from KDUP business network via the DMZ network.
2. Install a DMZ network with a domain controller.
3. Install a SCADA network with a domain controller.
4. Install a High Availability (HA) N+1 server stack with enough hardware (RAM and cores) to support all running software applications in the event one server fails.
5. Management VLAN to be connected to management ports on switches, servers and other hardware.
6. Install encrypted HIP switch for remote SCADA sites
7. Tier-1 Historian to be used as NTP time source for all related equipment.
8. Install HA stack of Layer 3 network switches.
9. Arrange and configure Industrial Control System (ICS) network switches with a fault tolerant trunk network either by ring or redundant star configuration.
10. Configure VLANs on the ICS (Control, Power Monitoring, and Management)
11. Provide UPS power to critical loads (severs, network switches, PLCs, RIO)
12. Provide redundant power circuits for HA devices.
13. Install a fault tolerant Device Level Ring (DLR) network between PLC and I/O devices (VFD, MCC, RIO) where possible and/or practical
14. Cellular communication to be protected with built-in firewall to include data encryption (256 bit preferred when supported, 128 bit minimum).
15. Radio communication to be protected with built-in or external firewall that includes data encryption (future: 256 bit preferred when supported, 128 bit minimum).

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KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

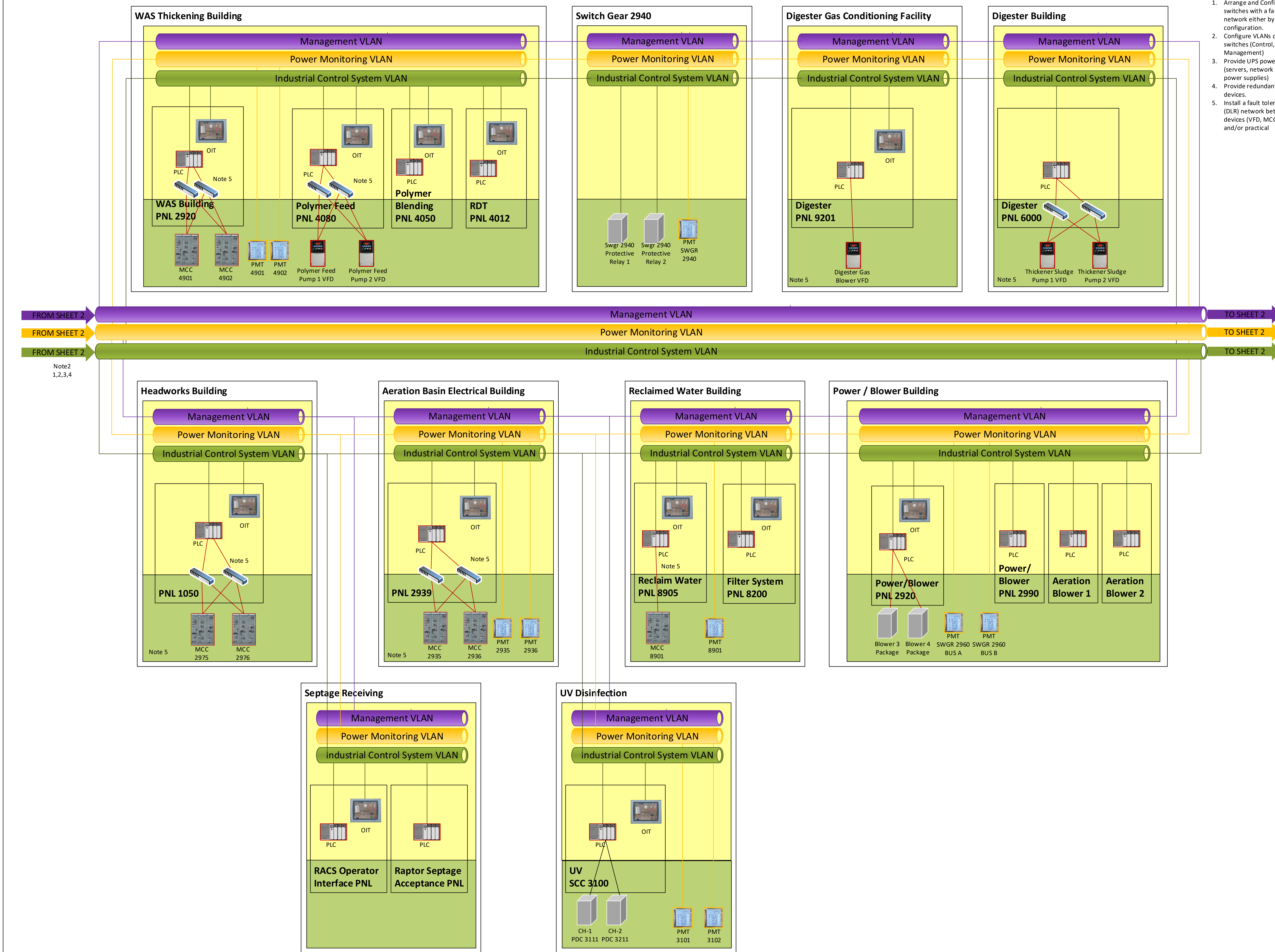
SCALE: NONE

CONCEPT DIAGRAM
CKTP ADMIN AND SOLID PROCESSING BUILDINGS

DRAWING: Y-002

SHEET 2 OF 8

Notes:
1. Arrange and Configure ICS network switches with a fault tolerant trunk network either by ring or redundant star configuration.
2. Configure VLANs on the ICS network switches (Control, Power Monitoring, and Management)
3. Provide UPS power to critical loads (servers, network switches, PLC & RIO power supplies)
4. Provide redundant power circuits for HA devices.
5. Install a fault tolerant Device Level Ring (DLR) network between PLC and I/O devices (VFD, MCC, RIO) where possible and/or practical



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KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

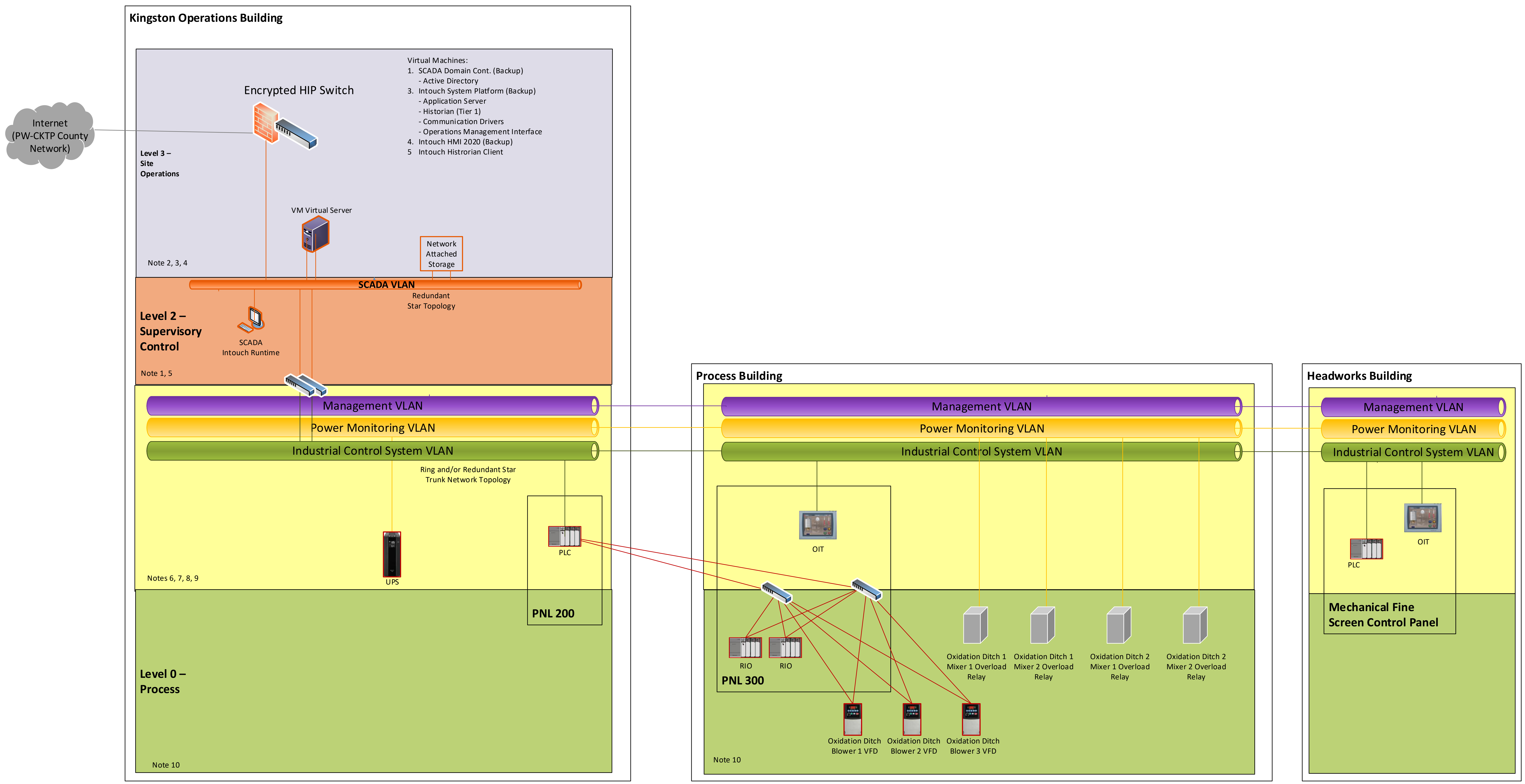
CONCEPT DIAGRAM
CKTP BALANCE OF PLANT

SCALE: NONE

DRAWING: Y-003

SHEET 3 OF 8

Notes:
1. Install a SCADA network with a backup domain controller.
2. Install a virtualized server with enough hardware (RAM and cores) to support all running software applications.
3. Install encrypted HIP switch for remote SCADA sites
4. Configure SCADA HMI and historian servers as backups in case of communication failure with the primary SCADA at CKTP.
5. Install High Availability (HA) pair of managed network switches.
6. Arrange and configure ICS network switches with a fault tolerant trunk network either by ring or redundant star configuration.
7. Configure VLANs on the ICS (Control, Power Monitoring, and Management)
8. Provide UPS power to critical loads (severs, network switches, PLCs, RIO)
9. Provide redundant power circuits for HA devices.
10. Install a fault tolerant Device Level Ring (DLR) network between PLC and I/O devices (VFD, MCC, RIO) where possible and/or practical.



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SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

CONCEPT DIAGRAM
KINGSTON WWTP

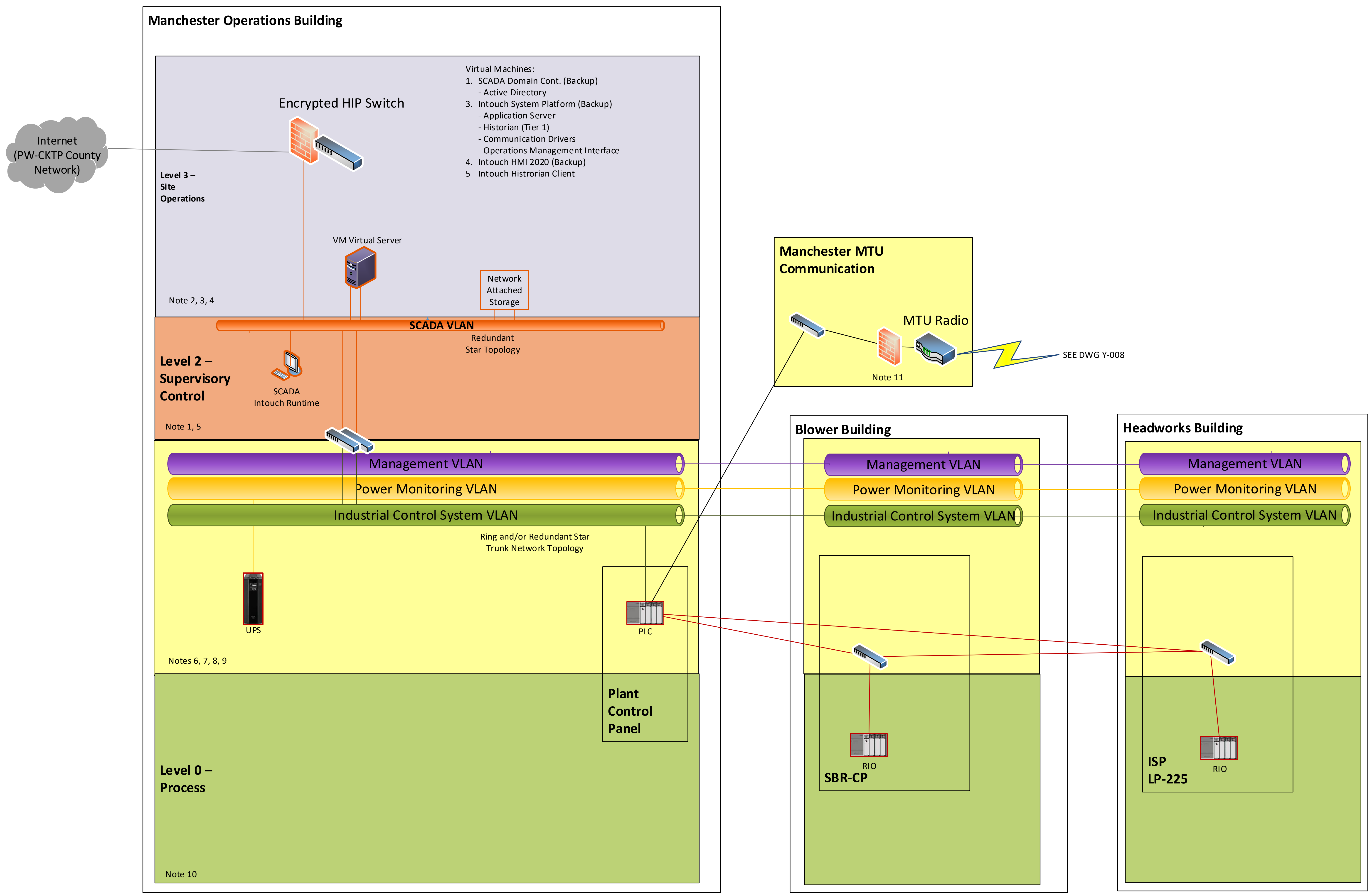
SCALE: NONE

DRAWING: Y-004

SHEET 4 OF 8

Notes:

1. Install a SCADA network with a backup domain controller.
2. Install a virtualized server with enough hardware (RAM and cores) to support all running software applications.
3. Install encrypted HIP switch for remote SCADA sites
4. Configure SCADA HMI and historian servers as backups in case of communication failure with the primary SCADA at CKTP.
5. Install High Availability (HA) pair of managed network switches.
6. Arrange and configure ICS network switches with a fault tolerant trunk network either by ring or redundant star configuration.
7. Configure VLANs on the ICS (Control, Power Monitoring, and Management)
8. Provide UPS power to critical loads (severs, network switches, PLCs, RIO)
9. Provide redundant power circuits for HA devices.
10. Install a fault tolerant Device Level Ring (DLR) network between PLC and I/O devices (VFD, MCC, RIO) where possible and/or practical
11. Radio communication to be protected with built-in or external firewall that includes data encryption (future: 256 bit preferred when supported, 128 bit minimum).



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KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

SCALE: NONE

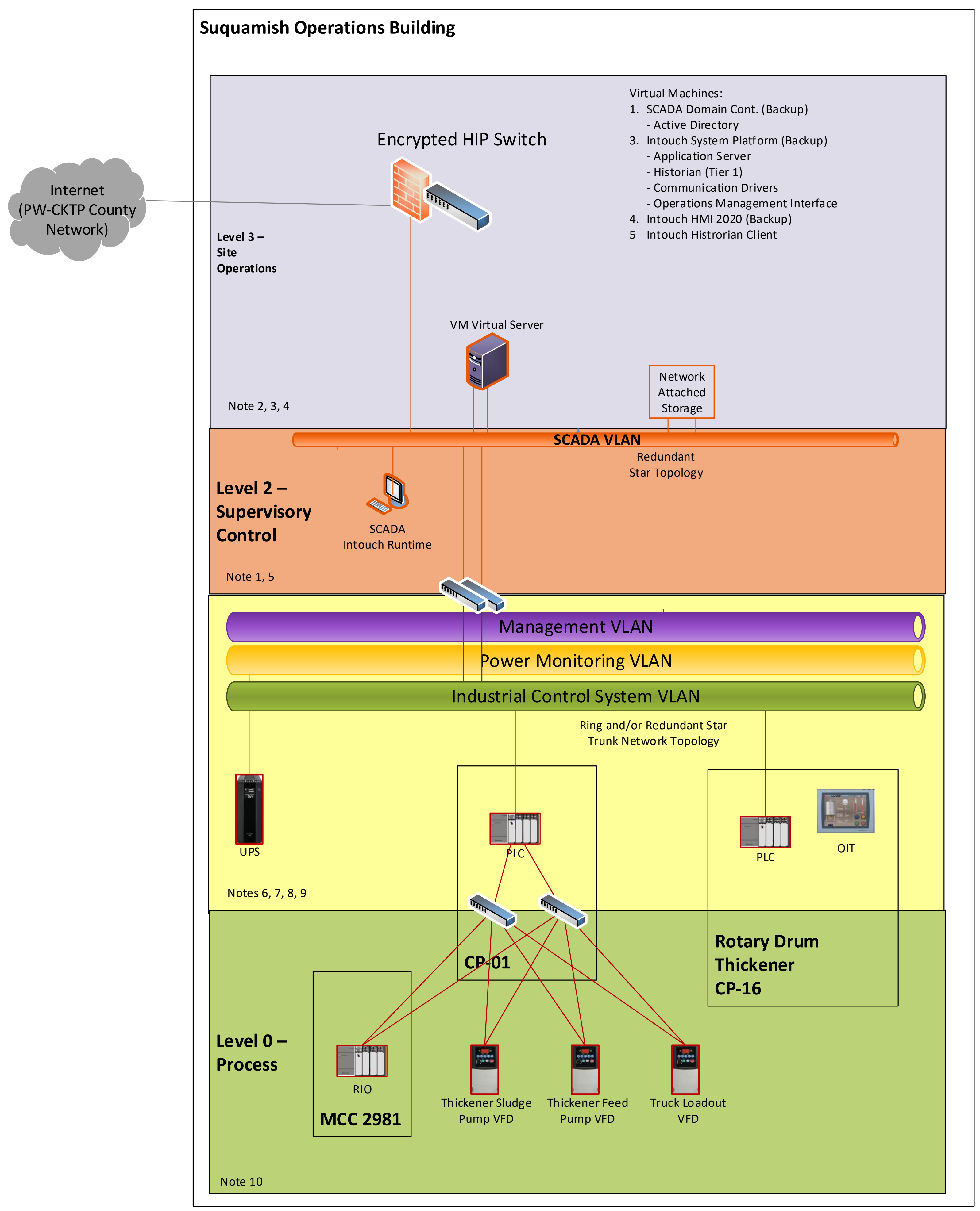
CONCEPT DIAGRAM
MANCHESTER WWTP

DRAWING: Y-005

SHEET 5 OF 8

Notes:

1. Install a SCADA network with a backup domain controller.
2. Install a virtualized server with enough hardware (RAM and cores) to support all running software applications.
3. Install encrypted HIP switch for remote SCADA sites
4. Configure SCADA HMI and historian servers as backups in case of communication failure with the primary SCADA at CKTP.
5. Install High Availability (HA) pair of managed network switches.
6. Arrange and configure ICS network switches with a fault tolerant trunk network either by ring or redundant star configuration.
7. Configure VLANs on the ICS (Control, Power Monitoring, and Management)
8. Provide UPS power to critical loads (severs, network switches, PLCs, RIO)
9. Provide redundant power circuits for HA devices.
10. Install a fault tolerant Device Level Ring (DLR) network between PLC and I/O devices (VFD, MCC, RIO) where possible and/or practical



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CONCEPT DIAGRAM
SUQUAMISH WWTP

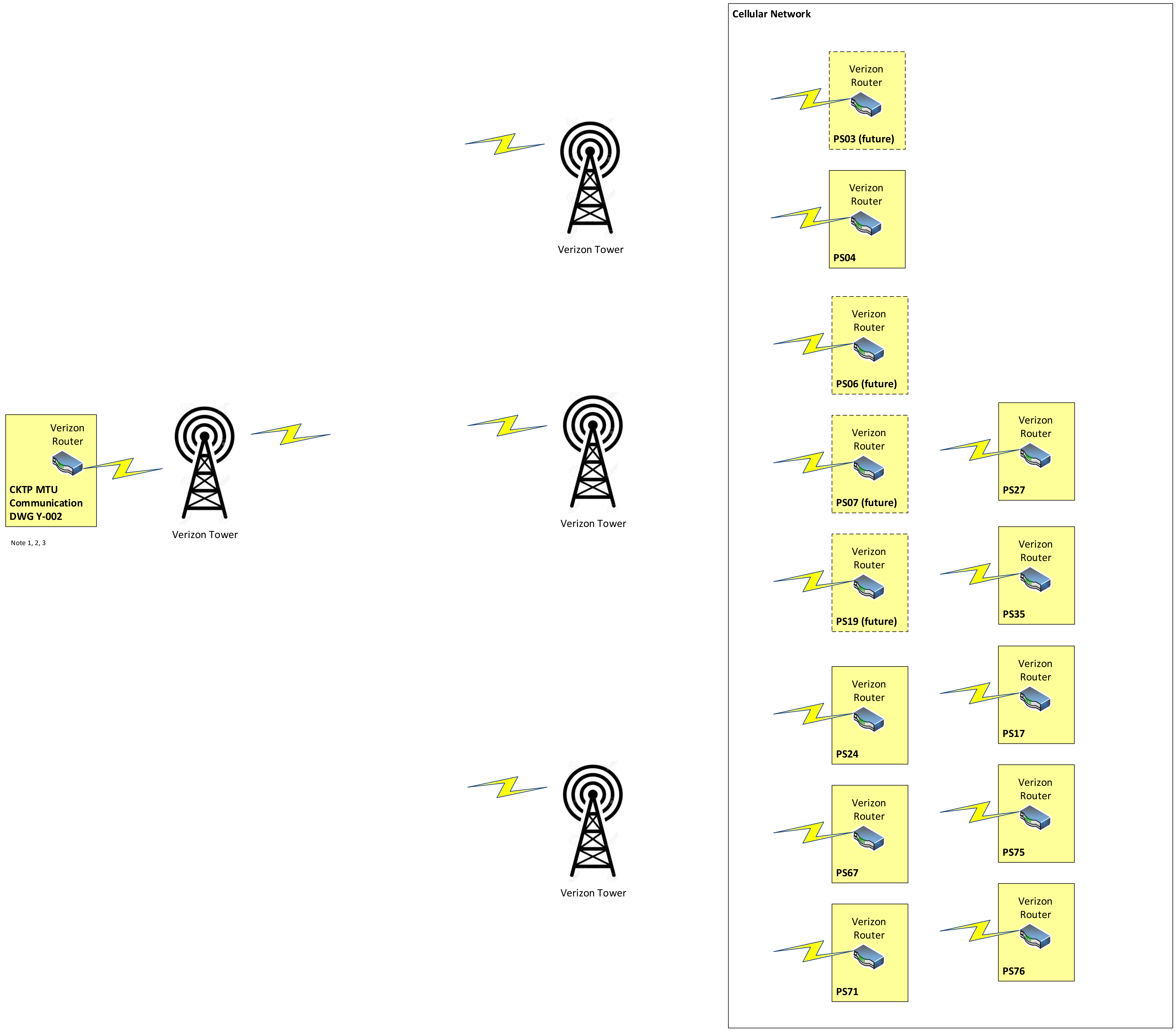
SCALE: NONE

DRAWING: Y-006

SHEET 6 OF 8

Notes:

1. Verizon Private LTE Machine to Machine Network
2. Cellular communication to be protected with either built-in firewall or an external security appliance.
3. Cellular communication to provide data encryption (256 bit preferred, 128 bit minimum).



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KITSAP COUNTY PUBLIC WORKS
SEWER UTILITY DIVISION
SEWER UTILITY SCADA MASTER PLAN

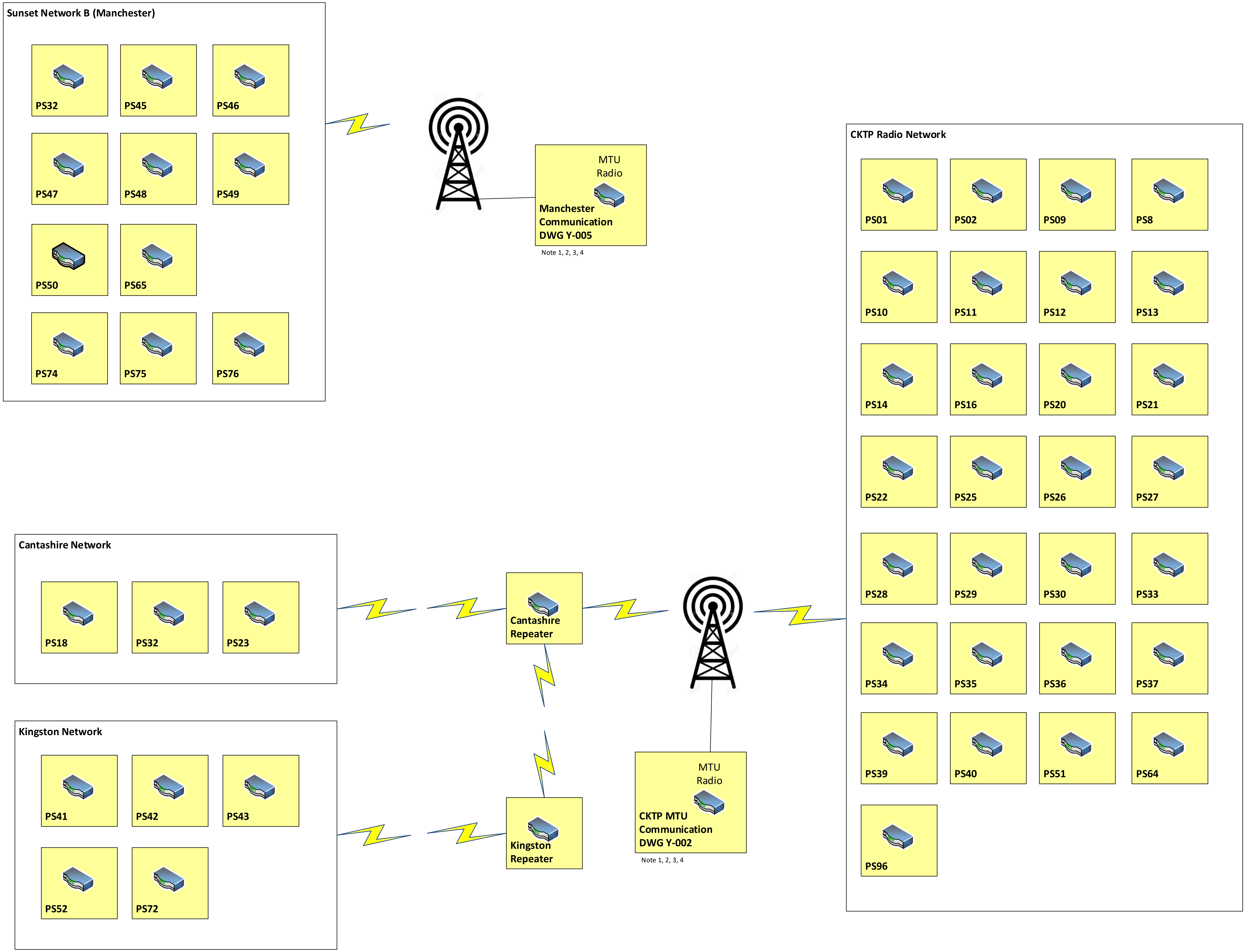
SCALE: NONE

CONCEPT DIAGRAM:
KITSAP CELLULAR NEWORK

DRAWING: Y-007

SHEET 7 OF 8

Notes:
1. Fixed Frequency Radio Network
2. VHF 173.3125 MHZ
3. Radio communication to be protected with either built-in firewall or an external security appliance.
4. Radio communication to provide data encryption (256 bit preferred, 128 bit minimum).



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SCALE: NONE

CONCEPT DIAGRAM:
MANCHESTER WWTP

DRAWING: Y-008

SHEET 8 OF 8

TM-5: Project Overview

Sewer Utility SCADA Master Plan

Kitsap County Public Works
Sewer Utility Division

May 23, 2022

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Kitsap County Public Works, Sewer Utility Division

Sewer Utility SCADA Master Plan

TM-5: Project Overview

May 23, 2022

Prepared by:

Brandon Erndt, PE

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I hereby certify that the technical memorandum was prepared under my direct supervision and that I am a duly registered Engineer under the laws of the State of Washington.

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Contents

Tables

Figures

Appendix

Abbreviations

CIP	Common Industrial Protocol
CKTP	Central Kitsap Treatment Plant
CMMS	Computerized maintenance management system
DLR	Device Level Ring
DMZ	Demilitarized zone
DS	Domain Server
EIGRP	Enhanced Interior Gateway Routing Protocol
FNF	Flexible netflow
FT	FactoryTalk
GB	Gigabyte(s)
HDR	HDR Engineering, Inc.
HIP	Host Identity Protocol
HMI	Human-machine interface
HPHMI	High Performance Human-Machine Interface
HRT	Hydraulic Retention Time
HSRP	Hot Standby Router Protocol
ICS	industrial control system
IEEE	Institute of Electrical and Electronics Engineers
IGMP	Internet Group Management Protocol
IP	Internet Protocol
IS	Intermediate System
KPUD	Kitsap Public Utility District
KWWTP	Kingscliff Waste Water Treatment Plant
LAN	Local-area network
LED	Light-emitting diode
LIMS	Laboratory information management system
LTE	Long-Term Evolution
MB	Megabyte(s)
MCC	Motor control center
N/A	Not applicable
NFPA	National Fire Protection Association
NMS	Network monitoring system
OSPF	Open Shortest Path First
OT	Operational Technology
OIT	Operator interface terminal
PBR	Policy-Based Routing
PC	Personal computer
PCAP	Network Packet Analyzer and Capture
PLC	Programmable logic controller
PS	Pump Station

QCC	Quality Controls Corporation
RIO	remote input/output
RIP	Routing Information Protocol
RTD	resistance temperature detector
RTU	remote telemetry unit
SA	sensor/actuator
SCADA	supervisory control and data acquisition
SD	Secure Digital
SDN	software-defined network
Sewer Utility	Public Works Sewer Utility Division
SFP	small form-factor pluggable
SNMP	Simple Network Management Protocol
SPB	solids processing building
SVI	Switched Virtual Interface
SWWTP	Shaoxing Wastewater Treatment Plant
TM	Technical Memorandum
TM-2	SCADA Use Cases and Operational Needs Technical Memorandum
TM-3	Technology Selection Technical Memorandum
TM-4	Sewer Utility SCADA Master Plan Technical Memorandum
TM-5	Project Overview SCADA Master Plan Technical Memorandum
TP/TX	Transport Protocol/Transmit
UPS	Uninterruptible Power Supply
USB	Universal Serial Bus
UV	ultraviolet
V	volt(s)
VAC	volt(s) alternating current
VDC	volt(s) direct current
VM	virtual machine
VRF	Virtual Routing and Forwarding
VRRP	Virtual Router Redundancy Protocol
WAN	wide-area network
WIMS	Water Information Management Solution
WWTP	wastewater treatment plant

1 Introduction

This *Project Overview SCADA Master Plan Technical Memorandum* (TM-5) documents the specific project descriptions, schedules, and cost breakdown for the Kitsap County (County) Public Works Sewer Utility Division (Sewer Utility) supervisory control and data acquisition (SCADA) system. This technical memorandum (TM) describes the current condition, arrangement, life-cycle state, and identified areas of risk identified in the *Existing System Overview Sewer Utility SCADA Master Plan Technical Memorandum* (TM-1). This technical memorandum also includes the evaluation approach by which these technological elements were selected based on the Sewer Utility's existing infrastructure and its future operational needs identified in the *SCADA Use Cases and Operational Needs Technical Memorandum* (TM-2). This technical memorandum includes the hardware and software platforms that were identified in the *Technology Selection Sewer Utility SCADA Master Plan* (TM-3) throughout the Kitsap County network drawn out in the *Concept Network Diagrams* (TM-4).

1.1 Approach

TM-5 completes the fifth phase of the *Sewer Utility SCADA Master Plan* (Master Plan), which is to provide project descriptions that include criticality, prerequisite projects, duration, and cost opinion. The projects have been organized into sections, Network Architecture, Hardware, Software, Documentation, and Other Software Packages. TM-5 will include a schedule which identifies the order of each project based on prioritization from Kitsap County.

1.2 Technical Memorandum Organization

This section describes the structure of the TM along with descriptions for each section.

1.2.1 Structure

TM-5 is organized into five sections, as described below:

- **Section 1: Introduction** summarizes the TM organization and the approach taken for the fifth phase of the Master Plan TM-5.
- **Section 2: Improvement Projects Segmentation** identifies the 5 main sections that each project was organized into.
- **Section 3: Overall Schedule** shows the overall project schedule that was developed based on project dependencies, budget, and project priority.
- **Section 4: Summary of Cost Opinions** includes the cost for each project and total cost for each fiscal year.

- **Section 5: Improvement Project Description** includes detailed project descriptions that include task schedule and cost breakdown.

2 Improvement Projects Segmentation

This section provides how each project has been organized according to type of project that is being implemented in each WWTP in Kitsap County. The projects have been separated into segments of Network Architecture, Hardware, Software, Documentation, and Other Software Packages.

2.1 Network Architecture

Projects within the Network Architecture section will be upgrading the current OT network within Kitsap County as well as implementing changes that will improve the overall network system design to meet the ICS standards.

Table 2-1. Projects List: Network Architecture Projects

Project ID	Facility	Project Name
NA-1	CKTP	Upgrade Central Kitsap Treatment Plant (CKTP) Control Room
NA-2	CKTP	Extend OT Network to County Public Works Annex Facility
NA-3	WWTPs and Remote Pump Stations	Remote Pump Station and WWTP Telemetry Improvements
NA-4	CKTP	CKTP OT Network Upgrades
NA-5	CKTP	Standardization to Managed Switches
NA-6	CKTP	ICS and OT Network Power Supply Improvements
NA-7	CKTP	DMZ and AVEVA InTouch Access Anywhere Implementation
NA-32	CKTP	Relocate Network Rack in Solids Processing Building

2.2 Hardware

Projects within the Hardware section will be upgrading or making changes to any hardware devices throughout Kitsap County WWTPs.

Table 2-2. Projects List: Hardware Projects

Project ID	Facility	Project Name
HW-8	WWTPs and Remote Pump Stations	Establish Sewer Utility PLC/OIT Platform Standard and Schedule Replacement of Select WWTP and Remote Pump Station PLCs/OITs
HW-9	WWTPs and Remote Pump Stations	Replace CKTP MCC DeviceNet Networks with Ethernet Capable Motor Controllers

HW-10	WWTPs and Remote Pump Stations	Develop a Formal Instrument Calibration and Maintenance Program
HW-11	CKTP	CKTP Digester Building PNL 6000 Relocation
HW-12	WWTPs and Remote Pump Stations	Include Integration of Composite Sampler Alarms and Monitoring with Replacement of Existing Samplers
HW-13	CKTP	Implement CKTP Instrumentation Improvements
HW-14	CKTP	Implement CKTP Automation Improvements
HW-15	KWWTP	Implement KWWTP Instrumentation Improvements
HW-16	KWWTP	Implement KWWTP Automation Improvements
HW-17	MWWTP	Implement MWWTP Instrumentation Improvements
HW-18	MWWTP	Implement MWWTP Automation Improvements
HW-19	SWWTP	Implement SWWTP Instrumentation Improvements
HW-20	SWWTP	Implement SWWTP Automation Improvements
HW-21	Remote Pump Stations	Implement Remote Pump Station Instrumentation Improvements
HW-22	Remote Pump Stations	Implement Remote Pump Station Automation Improvements

2.3 Software

Projects within the Software section will be upgrading or making changes to standalone HMI installations to AVEVA System Platform and the Historian.

Table 2-3. Projects List: Software Projects

Project ID	Facility	Project Name
SW-23	WWTPs	Upgrade WWTP Standalone SCADA HMI Installations to AVEVA System Platform with Managed InTouch Applications and Standardized Templates Based on HPHMI Concepts
SW-24	WWTPs and Remote Pump Stations	Implement an Alarm Management Program Based on ISA-18.2
SW-25	CKTP	Establish a Tiered Historian Implementation at CKTP
SW-26	WWTPs and Remote Pump Stations	Broaden the Data Set Archived by the Sewer utility Historian to Establish Foundations for More Comprehensive Process-and Asset-level Health and Performance Monitoring

2.4 Documentation

Projects within the Documentation section will be developing ICS Standards Document and the Control Strategy Document.

Table 2-4. Projects List: Documentation Projects

Project ID	Facility	Project Name
DC-27A	WWTPs and Remote Pump Stations	Develop ICS Standards - Hardware
DC-27B	WWTPs and Remote Pump Stations	Develop ICS Standards – Software and Governance
DC-28	WWTPs and Remote Pump Stations	Develop and Maintain Control Strategy Documentation

2.5 Other Software Packages

Projects within the Other Software Packages section will include implementing other software packages within Kitsap County. The Kitsap County will implement a laboratory information management system to automatically import historian data and analyze the trends. The county will also implement a Machine Interface server and utilize its ability to identify asset runtime thresholds, alarms, events, and analog set points that trigger a work order.

Table 2-5. Projects List: Other Software Package Projects

Project ID	Facility	Project Name
OS-29	CKTP	Complete Hach WIMS Implementation and Establish Data Exchange with AVEVA System Platform
OS-30	CKTP	Complete Asset Creation and Data Entry Required for LLumin Implementation, Establish Automatic Importing of Asset Runtimes, and Develop a Plan for Automating Work Order Generation
OS-31	WWTPs and Remote Pump Stations	Begin Leveraging the Sewer Utility's Power and Energy Data

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3 Overall Schedule

This section shows the overall cost project schedule that has been developed showing each project, utilizing the project dependencies outlined in each project description. The project schedule is based on a program start in fiscal year 2023 and with an anticipated completion in fiscal year 2029.

3.1 Projects in Fiscal Year 2023

Table 3-1. Projects in FY2023

Year	ID	Project	Cost	Duration
2023	DC-27A	Develop ICS Standards - Hardware	$154,000	4 months
2023	HW-8	Establish Sewer Utility PLC/OIT Platform Standard and Schedule Replacement of Select WWTP and Remote Pump Station PLCs/OITs	$5,000	2 months
2023	HW-10	Develop a Formal Instrument Calibration and Maintenance Program	$5,000	3 months
2023	NA-1	Upgrade Central Kitsap Treatment Plant (CKTP) Control Room	$5,000	12 months
2023	DC-28	Develop and Maintain Control Strategy Documentation	$167,000	18 months
2023	SW-23	Upgrade WWTP Standalone SCADA HMI Installations to AVEVA System Platform with Managed InTouch Applications and Standardized Templates Based on HPHMI Concepts	$0	0.05 months
		Total	**$336,000**	

3.2 Projects in Fiscal Year 2024

Table 3-2. Projects in FY2024

Year	ID	Project	Cost	Duration
2024	DC-27B	Develop ICS Standards – Software and Governance	$344,000	6 months
2024	NA-32	Relocate Network Rack in Solids Processing Building	$124,000	3 months
2024	NA-4	CKTP OT Network Upgrades	$213,000	6 months
2024	NA-2	Extend OT Network to County Public Works Annex Facility	$78,000	3 months
2024	NA-5	Standardization to Managed Switches	$136,000	2 months
		Total	**$895,000**	

3.3 Projects in Fiscal Year 2025

Table 3-3. Projects in FY2025

Year	ID	Project	Cost	Duration
2025	NA-6	ICS and OT Network Power Supply Improvements	$153,000	6 months
2025	SW-26	Broaden The Data Set Archived by the Sewer Utility Historian	$75,000	9 months
2025	HW-13	Implement CKTP Instrumentation Improvements	$184,000	18 months
2025	NA-3	Remote Pump Station and WWTP Telemetry Improvements	$264,000	24 months
2025	SW-24	Implement an Alarm Management Program Based on ISA-18.2	$54,000	6 months
2025	NA-7	DMZ and AVEVA InTouch Access Anywhere Implementation	$76,000	12 months
2025	HW-12	Include Integration of Composite Sampler Alarms and Monitoring with Replacement of Existing Samplers	$5,000	6 months
		Total	**$811,000**	

3.4 Projects in Fiscal Year 2026

Table 3-4. Projects in FY2026

Year	ID	Project	Cost	Duration
2026	HW-9	Replace CKTP MCC DeviceNet Networks w/ Ethernet Capable Motor Controllers	$94,000	9 months
2026	SW-25	Establish a Tiered Historian Implementation at CKTP	$89,000	3 months
2026	HW-14	Implement CKTP Automation Improvements	$154,000	12 months
2026	HW-15	Implement KWWTP Instrumentation Improvements	$105,000	6 months
2026	HW-17	Implement MWWTP Instrumentation Improvements	$173,000	12 months
		Total	**$615,000**	

3.5 Projects in Fiscal Year 2027

Table 3-5. Projects in FY2027

Year	ID	Project	Cost	Duration
2027	HW-16	Implement KWWTP Automation Improvements	$39,000	6 months

2027	HW-19	Implement SWWTP Instrumentation Improvements	$126,000	12 months
2027	HW-21	Implement Remote Pump Station Instrumentation Improvements	$202,000	6 months
2027	HW-18	Implement MWWTP Automation Improvements	$54,000	6 months
		Total	**$421,000**	

3.6 Projects in Fiscal Year 2028

Table 3-6. Projects in FY2028

Year	ID	Project	Cost	Duration
2028	HW-22	Implement Remote Pump Station Automation Improvements	$61,000	12 months
2028	HW-20	Implement SWWTP Automation Improvements	$48,000	6 months
2028	HW-11	CKTP Digester Building PNL 6000 and MCC Replacement	$80,000	12 months
2028	OS-31	Begin Leveraging the Sewer Utility's Power and Energy Data	$21,000	3 months
		Total	**$210,000**	

3.7 Projects in Fiscal Year 2029

Table 3-7. Projects in FY2029

Year	ID	Project	Cost	Duration
2029	OS-30	Complete Asset Creation and Data Entry Required for LLumin Implementation, Establish Automatic Importing of Asset Runtimes, and Develop a Plan for Automating Work Order Generation	$387,000	6 months
2029	OS-29	Complete Hach WIMS Implementation and Establish Data Exchange with AVEVA System Platform	$5,000	3 months
		Total	**$392,000**	

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4 Summary of Cost of Opinions

Budgetary opinions of probable costs were developed for each of the projects. These cost opinions were developed at a planning level of accuracy and include 10% labor contingency and 15% materials contingency.

4.1 Cost Breakdown for Each Fiscal year

Table 4-1. Cost Breakdown for each Fiscal Year

Allocation	FY2023 $ 336,000	FY2024 $ 895,000	FY2025 $ 811,000	FY2026 $ 615,000	FY2027 $ 421,000	FY2028 $210,000	FY2029 $392,000	Total $3,680,000
Hardware	$ 5,750	$ 189,480	$ 180,550	$ 236,900	$ 112,930	$ 57,500	$ -	
Software	$ -	$ 17,250	$ 9,775	$ 64,837	$ -	$ -	$ -	
Integration	$ 296,200	$ 587,800	$ 529,700	$ 239,800	$ 260,200	$ 128,700	$ 357,000	
Admin/QC/Misc .	$ 33,695	$ 99,480	$ 91,503	$ 74,155	$ 47,313	$ 23,620	$ 35,200	

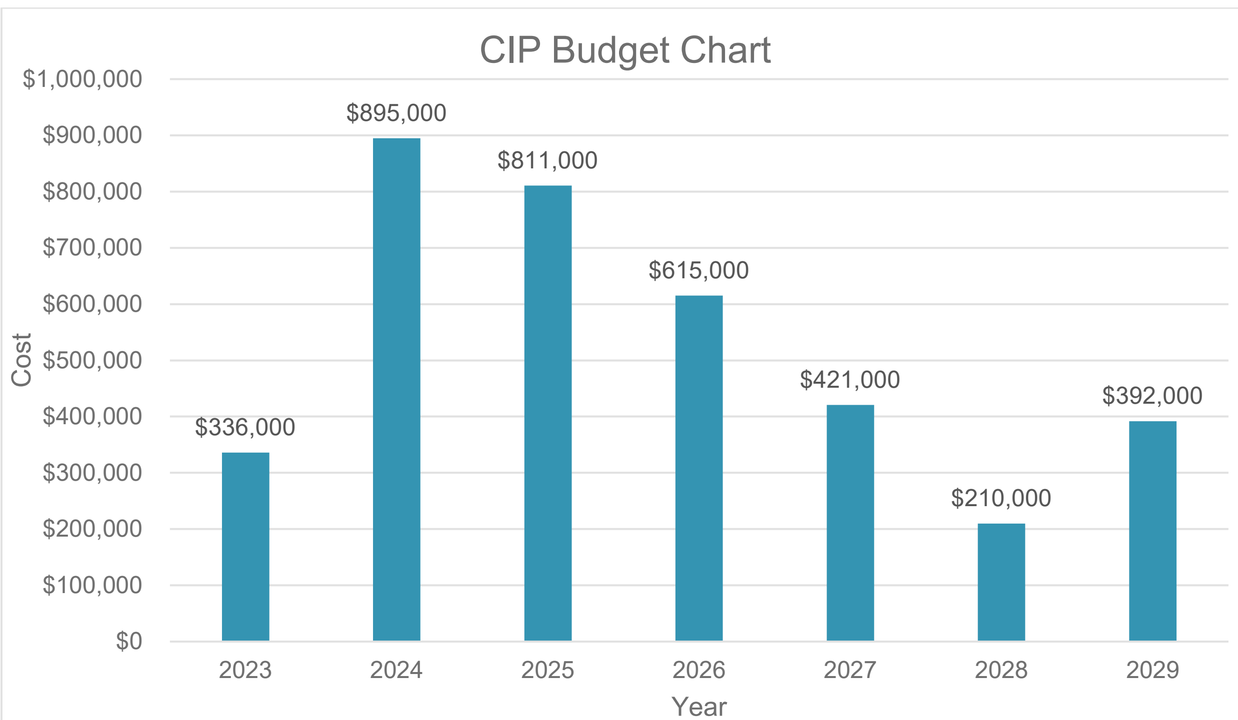

Figure 4-1. CIP Budget Chart

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5 Improvement Projects

This section includes detailed project descriptions for 33 projects. Each project description includes:

- Criticality
- Facilities
- Prerequisites
- Duration
- Description
- Impacted Stakeholders
- Cost Opinion

Table 5-1. Project List

ID	Project
Network Architecture	
NA-1	Upgrade Central Kitsap Treatment Plant (CKTP) Control Room
NA-2	Extend OT Network to County Public Works Annex Facility
NA-3	Remote Pump Station and WWTP Telemetry Improvements
NA-4	CKTP OT Network Upgrades
NA-5	Standardization to Managed Switches
NA-6	ICS and OT Network Power Supply Improvements
NA-7	DMZ and AVEVA InTouch Access Anywhere Implementation
NA-32	Relocate Network Rack in Solids Processing Building
Hardware	
HW-8	Establish Sewer Utility PLC/OIT Platform Standard and Schedule Replacement of Select WWTP and Remote Pump Station PLCs/OITs
HW-9	Replace CKTP MCC DeviceNet Networks with Ethernet Capable Motor Controllers
HW-10	Develop a Formal Instrument Calibration and Maintenance Program
HW-11	CKTP Digester Building PNL 6000 Relocation
HW-12	Include Integration of Composite Sampler Alarms and Monitoring with Replacement of Existing Samplers
HW-13	Implement CKTP Instrumentation Improvements
HW-14	Implement CKTP Automation Improvements
HW-15	Implement KWWTP Instrumentation Improvements
HW-16	Implement KWWTP Automation Improvements
HW-17	Implement MWWTP Instrumentation Improvements
HW-18	Implement MWWTP Automation Improvements
HW-19	Implement SWWTP Instrumentation Improvements
HW-20	Implement SWWTP Automation Improvements
HW-21	Implement Remote Pump Station Instrumentation Improvements
HW-22	Implement Remote Pump Station Automation Improvements
Software	

ID	Project
SW-23	Upgrade WWTP Standalone SCADA HMI Installations to AVEVA System Platform with Managed InTouch Applications and Standardized Templates Based on HPHMI Concepts
SW-24	Implement an Alarm Management Program Based on ISA-18.2
SW-25	Establish a Tiered Historian Implementation at CKTP
SW-26	Broaden the Data Set Archived by the Sewer utility Historian to Establish Foundations for More Comprehensive Process-and Asset-level Health and Performance Monitoring
Documentation	
DC-27A	Develop ICS Standards - Hardware
DC-27B	Develop ICS Standards – Software and Governance
DC-28	Develop and Maintain Control Strategy Documentation
Other Software Packages	
OS-29	Complete Hach WIMS Implementation and Establish Data Exchange with AVEVA System Platform
OS-30	Complete Asset Creation and Data Entry Required for LLumin Implementation, Establish Automatic Importing of Asset Runtimes, and Develop a Plan for Automating Work Order Generation
OS-31	Begin Leveraging the Sewer Utility’s Power and Energy Data

5.1 Network Architecture Projects

Project Name	Upgrade Central Kitsap Treatment Plant (CKTP) Control Room
Project ID	**NA-1**
Criticality	Medium
Facilities	▪ CKTP
Prerequisites	▪ DC-27A
Duration	12 Months
Description	This project will establish a central monitoring location at the CKTP for all pump stations and WWTPs. To do so, the existing control room in the Solids Processing Building (SPB) will be upgraded to a suitable centralized monitoring location to meet monitoring requirements. Large-format displays will be installed for static display of overview screens for the pump stations and WWTPs. The Large-format displays will also be used to display operator-selected screens to support group discussion and decision making. Two SCADA PCs will be installed with access to HMI screens, Historian clients, and data visualization and dashboarding software applications. Four monitors will be installed for each PC to enable simultaneous display of multiple software application screens. This project can be performed at the same time as the upgrades for the standalone SCADA HMI installations to AVEVA System Platform (SW-23). In the event of a power outage at CKTP, UPS and backup battery packs will be installed to provide a minimum of 4 hours of backup power for the control room workstations and displays. Backup power will also be installed for the network servers as well. It is assumed that AVEVA licensing is part of a separate project and not included in this costing.

Project Name	**Upgrade Central Kitsap Treatment Plant (CKTP) Control Room**		
	This project will be handled internally by the Sewer Utility. Project is currently underway - 4 27" monitors (duplicating construction building 103).		
Impacted Stakeholders	Operation Staff I&C Technician Public Works Management		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$5,000
	Administration/Quality Control	10%	-
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$5,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**Extend OT Network to County Public Works Annex Facility**		
Project ID	**NA-2**		
Criticality	Medium		
Facilities	▪ County Public Works Annex Facility		
Prerequisites	▪ None		
Duration	3 Months		
Description	The OT network will be extended to the County Public Works Annex Facility to establish a secondary monitoring location for its WWTPs and remote pump stations. A Host Identity Protocol Switch (HIP Switch) will be installed at this facility and a dedicated SCADA PC will be installed with the Sewer Utility's Tempered Network Airwall System deployment. This project will be tied into the backup database server project.		
Impacted Stakeholders	Operation Staff I&C Technician		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$21,850
	Software	-	$17,250
	Integration	-	$27,500
	Administration/Quality Control	10%	$6,660
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$78,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**Remote Pump Station and WWTP Telemetry Improvements**
Project ID	**NA-3**
Criticality	Medium
Facilities	▪ WWTPs and Remote Pump Stations
Prerequisites	▪ NA-4, NA-5, DC-27A, DC-27B
Duration	24 Months
Description	This project will upgrade the telemetry system is required for near-real-time monitoring and alarming for the remote pump stations. To accomplish this, the Sewer Utility will continue to work with Quality Controls Corporation to transition the remote pump stations to a cellular wide-area network (WAN). Before the transition, a site survey will take place to assess the signal strength of the Verizon Wireless Network at each pump station location. Due to unpredictable latency difficulties and increasing pump stations introduced to the WAN, 2 cellular routers will be placed at CKTP. This solution will mitigate latency issues as well as provide a layer of redundancy for the communication links between the remote pump station and CKTP. Along with the WAN implementation, the current very high frequency (VHF) licensed radios will be left as is in case cellular WAN communications are lost. To achieve near-real-time monitoring and alarming at the remote pump stations, DNP3 protocol will be utilized to incorporate a store-and-forward functionality. DNP3 protocol will be implemented in the existing Allen-Bradley Micrologix 1400 PLCs, which are located at the remote telemetry unit (RTU) panels at each pump station. A report-by-exception telemetry solution will be replacing the current round-robin polling to reduce the data exchange volume. This will be using the DNP3 protocol which will be implemented with the existing Micrologix 1400 PLCs as well. For the Sewer utility to assign accurate times to events and eliminate data loss, the existing MTU PLC will be replaced with a SCADA server at the CKTP to serve as a DNP3 master. Telemetry Server software, offered by AVEVA, will be integrated with the System platform offering, which will be easier to maintain than what is currently in place. To have accurate communication status and performance, the uptime percentage will be displayed at the HMI for the previous 24 hours and all history since the last manual reset. This will give the Sewer Utility staff the ability to configure the timer interval and number of consecutive unsuccessful polls that would initiate a loss of communications alarm from the HMI. In the event of an outage and to preserve alarm notifications, HIP switches will be provisioned with a cellular expansion module and a SIM card that will be activated on the Sewer Utility's cellular WAN.
Impacted Stakeholders	Operation Staff I&C Technician

Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$29,900
	Software	-	$9,775
	Integration	-	$195,800
	Administration/Quality Control	10%	$23,548
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$264,000**

Project Name	Remote Pump Station and WWTP Telemetry Improvements		
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**$1,600**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**CKTP OT Network Upgrades**		
Project ID	**NA-4**		
Criticality	High		
Facilities	▪ County Public Works Annex Facility (Solids Processing Building)		
Prerequisites	▪ DC-27B, NA-32		
Duration	6 Months		
Description	To consolidate the network infrastructure at CKTP, the rack-mounted servers and distribution switches for the OT network will be placed in one or more enclosed network racks within the SPB. The network racks will be sized for standard 19-inch equipment and have seismic testing certifying their suitability for installation in the seismic zone within CKTP. The rack cabinet enclosures will be wide enough to accommodate vertical cable management hardware on either side of the rack. The network racks will be placed in either the SPB Control room or in the ground floor of the SPB annex. The unmanaged switch, located in the SPB, will be replaced with a stacked Layer 3 distribution switch. This replacement will eliminate the single point of failure and establish routing capabilities at the OT network distribution layer. The two managed switches located in Panel 8580A, also located in SPB, will be replaced and the fiber-optic cable connections will be patched directly to the new Layer 3 distribution switches. The OT network HIP switches, located in the CKTP Administration and Laboratory building electrical rooms, will be relocated to the new network racks that will be placed in the SPB. For the relocation of these switches, a 1 GbE, multi-mode fiber-optic small form-factor pluggable (SFP) module will be inserted to the combination port on the KPUD Carrier Ethernet Switch where the existing Category Cable connection to the HIP switch is made. The SFP module will be patched to the existing fiber-optic patch panel mounted to the electrical room communications backboard to establish a connection to the SPB communications cabinet, using the existing fiber-optic cable between the two buildings. Afterwards, the Category cable along with the HIP switch, 24 VDC power supply components, and OT network switch mounted to the communications backboard will be removed. The UPS that is in the electrical room will be removed, instead UPS power will be provided to the KPUD Carrier Ethernet Switch located in the electrical room network rack. This will be done by installing a UPS in the existing electrical room network rack. This project will also include creating the Management, Power Monitoring, and Industrial Control System VLAN for the WWTPs after the managed switches have been installed. New IP address may also be configured to the OT network devices.		
Impacted Stakeholders	Operation Staff I&C Technician Sewer Utility IT staff		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$75,900
	Software	-	-
	Integration	-	$112,800
	Administration/Quality Control	10%	$18,870

Project Name	CKTP OT Network Upgrades		
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$213,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**Standardization to Managed Switches**		
Project ID	**NA-5**		
Criticality	High		
Facilities	▪ CKTP		
Prerequisites	▪ NA-32		
Duration	2 months		
Description	This project will standardize using managed access switches for the OT network. This will provide a uniform management interface for maintaining OT network access switches and reduce spare switch inventory requirements. The standardized switches will support Layer 2 management functionality for network segmentation, traffic filtering (IGMP), and implementation of cybersecurity controls. The switch will also have gigabit downlink ports to accommodate the gigabit port speeds of modern ICS devices. The standardized switches will replace the 5 current unmanaged switches that were mentioned in TM-1 at Table 2-1 (the unmanaged switches in the Vendor Package systems will not be replaced as part of this project). This project will establish redundant cable paths for critical OT network segments between building access switches at CKTP and the distribution switch stack located in the SPB. Depending on the costs, either a star topology or a ring topology network will be implemented. As redundant fiber-optic cables will be implemented, the project will utilize single-mode fiber-optic cables for communication links. Specifically, the fiber-optic cable between the CKTP administration, laboratory building electrical room, and SPB will be replaced with the single-mode fiber-optic cable. For costing, only minimal switch configuration such as disabling unused ports have been included.		
Impacted Stakeholders	Operation Staff I&C Technician		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$34,500
	Software	-	-
	Integration	-	$84,200
	Administration/Quality Control	10%	$11,870
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$136,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**ICS and OT Network Power Supply Improvements**		
Project ID	**NA-6**		
Criticality	High		
Facilities	▪ CKTP		
Prerequisites	▪ NA-4, DC-27B		
Duration	6 months		
Description	This project will include installing UPS power to the PLC panels throughout the WWTPs and Remote Pump Stations mentioned in TM-1 in Table 3-1. This standalone UPS approach will also be implemented for the Sewer Utility's PLC and RIO control panels that do not have backup power. The PLC control panels at CKTP will have a minimum backup power of 15 minutes, while the remote PLCs and RIO panels will have a backup power of up to 4 to 6 hours if space is available. Some existing panels will not have the space to support a UPS large enough to provide 6 hours of backup power. All UPS statuses, warnings, and alarms will be monitored by the SCADA system and integrated into the SCADA HMI screens, and alarm notification system. To meet this requirement, the UPSs will have Ethernet Communication options that can be integrated with the SCADA software, utilizing Ethernet protocols like Modbus Transmission Control Protocol. The Sewer Utility will standardize on carrying redundant power supplies to the ICS and OT network devices. All rack-mounted OT network switches, servers, and other network appliances will be standardized with dual onboard power supplies. Installation of the network rack-mounted UPS have been covered in the CKTP OT Network Upgrade project (NA-4).		
Impacted Stakeholders	I&C Technician		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$58,650
	Software	-	-
	Integration	-	$75,900
	Administration/Quality Control	10%	$13,455
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$153,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**DMZ and AVEVA InTouch Access Anywhere Implementation**		
Project ID	**NA-7**		
Criticality	Medium		
Facilities	▪ CKTP		
Prerequisites	▪ NA-1, NA-4, NA-6, DC-27A, DC-27B		
Duration	12 Months		
Description	This project will implement an industrial DMZ to handle data exchanges between the industrial and enterprise zones to provide a more secure method of data flow for the ICS assets. The network architecture will be established with a single entry to the industrial DMZ from the enterprise zone. The project will set up the Virtual Machine Server in the DMZ and implement AVEVA Intouch Access Anywhere for mobile access to the Sewer Utility's SCADA HMI Screens for the I&C technicians, third-party system integrators, and Sewer Utility Staff. Multi-factor authentication will be included during implementation for users to gain access to the industrial DMZ and will be handled by the County IS Department. This will require the users to access the industrial DMZ through the Sewer Utility business LAN via the VPN service maintained by the County IS department. The Sewer Utility will coordinate with the County IS department to make use of existing IT infrastructure and software licensing, such as Mobile Device Management (MDM) software, Operating System (OS) and Virtualization software (VMWare or Microsoft Hyper-V). The County IS Department will manage the implementation of the Firewall and switches for the DMZ. The County IS Department will also manage the implementation of the web portal, Jump Box (Remote Access), Anti-Virus, patch server, backups, Syslog/SIEM, Email relay, and OT-DMZ Domain Controller. It will be necessary to utilize HACH WIMS or another BI dashboard during the implementation of this project.		
Impacted Stakeholders	Operation Staff I&C Technician System Integrators County IS Department Sewer Utility IT Staff		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$17,250
	Software	-	-
	Integration	-	$47,300
	Administration/Quality Control	10%	$6,455
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$76,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	Relocate Network Rack in Solids Processing Building		
Project ID	NA-32		
Criticality	Medium		
Facilities	▪ County Public Works Annex Facility (Solids Processing Building)		
Prerequisites	▪ DC-27A, DC-27B		
Duration	3 Months		
Description	This project will include locating a secure area for the new network rack that will be in the Solids Processing Building. The new location must have the required space and access to run all required network cables to/from the network rack to support connection to all necessary OT network devices. The new location where the network rack will be placed must be climate assisted to support the associated hardware. To limit access to authorized personnel only, the network rack will be either locked or in a locked room.		
Impacted Stakeholders	Operation Staff I&C Technicians		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$57,500
	Software	-	-
	Integration	-	$55,000
	Administration/Quality Control	10%	$11,250
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$124,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

5.2 Hardware Projects

Project Name	**Establish Sewer Utility PLC/OIT Platform Standard and Schedule Replacement of Select WWTP and Remote Pump Station PLCs/OITs**		
Project ID	**HW-8**		
Criticality	Medium		
Facilities	▪ WWTPs and Remote Pump Stations		
Prerequisites	▪ DC-27A		
Duration	2 Months		
Description	Based on the current information of the life cycle of the existing PLCs and OITs, after the standards are created in project DC-27, the PLCs and OITs that need to be replaced will be prioritized by years in service, manufacturer support, and criticality of the application. No dedicated project is identified within this portfolio, but each PLC/OIT will be replaced as needed. This project will be handled internally by the Sewer Utility.		
Impacted Stakeholders	Operation Staff I&C Technicians		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$5,000
	Administration/Quality Control	10%	**-**
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$5,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**Replace CKTP MCC DeviceNet Networks with Ethernet Capable Motor Controllers**		
Project ID	**HW-9**		
Criticality	Medium		
Facilities	▪ WWTPs and Remote Pump Stations		
Prerequisites	▪ NA-4, DC-27A, DC-27B		
Duration	9 Months		
Description	This project will retrofit the existing MCC units in order to preserve the recently upgraded MCC units when eliminating the DeviceNet network. The PowerFlex 700 AC Drives will be upgraded with the 20-COMM-E EtherNet/IP adapter and the PowerFlex 753 AC Drives will be upgraded with the 20-750-ENETR EtherNet/IP option module to replace the existing DeviceNet adapters/modules. The Allen-Bradley E3 Plus electronic overlay relays will be replaced with the E300 electronic overlay relays or other viable replacements that are available during the time of DeviceNet network replacement work. The DeviceNet Starter Auxiliary components will also be replaced with I/O expansion modules compatible with the E300 relays. The size of the MCC units will have to be assessed as some hardwired signals are preferred (auto status and motor high temp alarm) and will require more control relays and additional field wiring. The PLC panels will need additional I/O modules and field terminal blocks to accommodate the new hardwired I/O. This will lead to additional RIO racks in the enclosures, subpanel replacement, and/or new control panels. Additional conduits and control wiring will be required in the electrical room to establish hardwired I/O connections between the MCC units and the control panels. With the additional hardwired I/O, the VFD communication adapters/modules and overload relays will require Ethernet connection to the OT network. The project will use Category 6 cable with 600V insulation for these connections. The existing PLC programs will be modified to realign with the hardwired I/O points and the EtherNet/IP data exchange. This project is considered an opportunity project by the county and can be rescheduled if necessary.		
Impacted Stakeholders	Operation Staff I&C Technicians System Integrators		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$49,450
	Software	-	-
	Integration	-	$31,900
	Administration/Quality Control	10%	$8,135
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$94,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to Appendix A for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**Develop a Formal Instrument Calibration and Maintenance Program**		
Project ID	**HW-10**		
Criticality	Medium		
Facilities	▪ WWTPs and Remote Pump Stations		
Prerequisites	▪ DC-27A		
Duration	3 Months		
Description	This project will develop a formal instrument calibration and maintenance program for its WWTPs and remote pump stations. The program will accomplish the following: • Determine the individuals responsible for scheduling calibration events, performing calibration procedures, maintaining program documentation, and reviewing calibration records to determine when additional corrective action is required. • Maintain an accurate inventory of installed instrumentation with manufacturer, model, and part number(s).The County may utilize the Hach WIMS system they plan to implement in Project OS-29. • Document instrument range, last calibration date, next calibration date, accuracy requirements, most recent calibrated zero and span settings for analog instruments, and most recent calibrated set point (rising or falling) and deadband settings for switches. • Document instrument-specific calibration procedures based on instrument manufacturer recommendations. Calibration procedures should include steps to test the instrument sensor (input), instrument 4–20 milliampere (mA) output or switch contact state, and instrument loop, including verification of correct value/state being displayed at the HMI or OIT. • Document ideal frequency of calibration activities based on manufacturer recommendations, field observations, instrument criticality, and past instrument performance. • Schedule calibration activities and ensure that they are performed and documented. • Maintain calibration records that document as-found settings, as-found test results, final calibration settings, final calibration test results, field observations, individual(s) who performed the calibration, and date of calibration This project will be handled internally by the Sewer Utility and is considered an opportunity project by the county and can be rescheduled if necessary.		
Impacted Stakeholders	Operation Staff I&C Technicians		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$5,000
	Administration/Quality Control	10%	-
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$5,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***

Project Name	Develop a Formal Instrument Calibration and Maintenance Program		
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to Appendix A for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**CKTP Digester Building PNL 6000 Relocation**		
Project ID	**HW-11**		
Criticality	Low		
Facilities	▪ CKTP		
Prerequisites	▪ NA-4, DC-27A, DC-27B		
Duration	12 Months		
Description	This project will relocate PNL 6000 or establish a replacement PLC control panel in a properly conditioned environment that is not classified as a hazardous-area classification. The MCC in the digester building is planned to be relocated due to the poor conditions in the current location but is being considered as part of the larger project and therefore not in the scope of this master plan so cost is not included. This project is considered an opportunity project by the county and can be rescheduled if necessary.		
Impacted Stakeholders	Operation Staff I&C Technicians System Integrators		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$57,500
	Software	-	-
	Integration	-	$11,000
	Administration/Quality Control	10%	$6,850
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$80,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to Appendix A for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	Implement CKTP Instrumentation Improvements
Project ID	HW-13
Criticality	Medium
Facilities	▪ CKTP
Prerequisites	▪ NA-4, DC-27A, DC-27B, DC-28
Duration	18 Months
Description	This project will perform an assessment of their Instrumentation equipment to determine the need for upgrades and replacement. The project will include the following: • Perform an alternatives analysis for implementing a direct means of plant effluent flow measurement to assess costs and feasibility of available options. • Provide additional analytical probes and, potentially, aeration flowmeters per recommendations from a separate BNR optimization task in the Sewer Utility facility planning program. • Install a flowmeter on the plant wastewater pump station discharge line to obtain a return flow measurement to upstream of the primary diversion channel. A magmeter could be installed in a new meter vault downstream from the valve vault potentially since there is no adequate room in the existing wastewater pump station valve vault. • Install a flowmeter on the primary sludge line to GBTs to monitor primary sludge flow from the primary sludge pumps. • Install a flowmeter on the scum line to GBTs to monitor primary and secondary scum flow from the scum pumps. • Install a flowmeter on the mixed liquor line from the mixed liquor distribution channel foam wasting sump to monitor mixed liquor flow to the digesters. • Install flowmeters on the thickened sludge lines from the GBTs to the thickened sludge blending tank to monitor individual thickened sludge flows from each GBT. • Install a flowmeter on the thickened sludge line from the hauled sludge receiving station to the thickened sludge blending tank to monitor hauled sludge flows received from remote WWTPs. • Install flowmeters on the digested sludge lines from the digesters to the centrifuges to monitor individual digested sludge flows from each digester. • During next septage receiving station upgrade, ensure that the replacement vendor package system includes incoming septage flow monitoring. • Service or replace the lower explosive limit (LEL) transmitter on the headworks odor control fan ductwork. • Service or replace the chlorine residual and turbidity analyzers associated with the reclaimed water system. • Service or replace the thermal dispersion flowmeter installed on the aeration line for the aerated grit tank 1 stage 2 diffuser. • Install suspended solids probes in the aeration basins and WAS pump discharge line to support automated calculation of hydraulically determined solids retention time. If installation is infeasible, a probe could be installed on

	the RAS pumps discharge line with the assumption that the suspended solids profile would be the same. This project is considered an opportunity project by the county and can be rescheduled if necessary.		
Impacted Stakeholders	Operation Staff I&C Technicians System Integrators		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$74,750
	Software	-	-
	Integration	-	$88,000
	Administration/Quality Control	10%	$16,275
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$184,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to Appendix A for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**Include Integration of Composite Sampler Alarms and Monitoring with Replacement of Existing Samplers**		
Project ID	**HW-12**		
Criticality	Medium		
Facilities	▪ WWTPs and Remote Pump Stations		
Prerequisites	▪ SW-24, DC-27A, DC-27B		
Duration	6 Months		
Description	This project will integrate the composite samplers and will monitor sampler alarms and statuses at SCADA. The Sewer Utility will need to communicate the SCADA requirements to the vendors so that the appropriate hardwired and communication options can be integrated. The Sewer Utility has received quotes for the samplers from vendors and are currently evaluating them, so sampler costs were not included. This project will be handled internally by the Sewer Utility and this project is considered an opportunity project by the county and can be rescheduled if necessary.		
Impacted Stakeholders	Operation Staff I&C Technicians		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$5,000
	Administration/Quality Control	10%	**-**
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$5,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to Appendix A for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	Implement CKTP Automation Improvements
Project ID	**HW-14**
Criticality	Medium
Facilities	▪ CKTP
Prerequisites	▪ NA-4, HW-13, DC-27A, DC-27B, DC-28
Duration	12 Months
Description	This project will perform an assessment of their Automation equipment to determine the need for upgrades and replacement. The project will include the following: • Develop a SCADA HMI screen to monitor the comprehensive liquid stream flow balance for the plant along with the hydraulic retention time values for tanks basins, and clarifiers. • Develop a SCADA HMI screen for monitoring the comprehensive solid stream flow balance for the plant along with detention time values for GBTs, digesters, and the thickened sludge blending tank. • Provide PLC programming and SCADA HMI modifications to restore automated control of the BNR process per recommendations from the separate BNR optimization task in the Sewer Utility facility planning program. • Develop a SCADA HMI screen to provide operators with situational awareness for the load shedding and emergency load sequencing during planned and unplanned transitions between utility and standby generator power. • Replace the headworks odor control biofilter sprinkler control panel and associated instrumentation to restore automated control of the biofilter sprinklers/soaker hose. The Sewer Utility will allow the SCADA manual controls to be implemented as an optional override of the sprinkler control panel to allow operations staff to manually initiate and schedule timer-based watering of the biofilter from SCADA HMIs. • Provide PLC programming modifications to establish a low-level shutdown interlock for the thickened sludge blending tank circulation pump and digester feed pumps based on tank level transmitter measurement to support elimination of the thickened sludge blending tank low level switch. The Sewer Utility will also replace the low-level switch. • Establish monitoring of high torque warning and high-high torque shutdown conditions at SCADA for its primary clarifiers. This project is considered an opportunity project by the county and can be rescheduled if necessary.
Impacted Stakeholders	Operation Staff I&C Technicians System Integrators

Cost Opinion*	CAPITAL COSTS	%	COST OPINION*
	Hardware	-	$86,825
	Software	-	-
	Integration	-	$48,400
	Administration/Quality Control	10%	$13,523

Project Name	**Implement CKTP Automation Improvements**		
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$154,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to Appendix A for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**Implement KWWTP Instrumentation Improvements**		
Project ID	**HW-15**		
Criticality	Medium		
Facilities	▪ KWWTP		
Prerequisites	▪ NA-4, DC-27A, DC-27B, DC-28		
Duration	6 Months		
Description	This project will perform an assessment of their Instrumentation equipment at KWWTP to determine the need for upgrades. The project will include the following: • Install a flowmeter for the thickened sludge storage tank truck loadout station. • Install a flowmeter on the biofilter sump pump station discharge line to monitor biofilter drainage flow to the oxidation ditches. • Install a flowmeter on the process building sump pump station discharge line to monitor return flow to the headworks. • Install a flowmeter on the W2 line downstream from the hydropneumatic tank to monitor W2 flow to plant processes. • Install a flowmeter on the secondary scum pump discharge line to monitor secondary scum flow to the WAS/TWAS tanks. • Install suspended solids probes in the oxidation ditches and WAS line at KWWTP based on the outcome of suspended solids probe and hydraulically determined SRT calculation performance at CKTP. This project is considered an opportunity project by the county and can be rescheduled if necessary.		
Impacted Stakeholders	Operation Staff I&C Technicians		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$36,225
	Software	-	-
	Integration	-	$55,000
	Administration/Quality Control	10%	$9,123
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$105,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to Appendix A for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	Implement KWWTP Automation Improvements		
Project ID	**HW-16**		
Criticality	Medium		
Facilities	▪ KWWTP		
Prerequisites	▪ NA-4, NA-7, HW-15, DC-27A, DC-27B, DC28		
Duration	6 Months		
Description	This project will perform an assessment of their Automation equipment at KWWTP to determine the need for upgrades and replacement. The project will include the following: • Develop a SCADA HMI screen for monitoring the comprehensive liquid stream flow balance for the plant along with HRT values for tanks, oxidation ditches, and clarifiers. • Develop a SCADA HMI screen for monitoring the comprehensive solid stream flow balance for the plant along with detention time values for WAS and TWAS tanks. • With favorable results from the suspended solids probes and hydraulically determined SRT calculations at CKTP, The Sewer Utility will develop PLC programming and SCADA HMI modifications to monitor mixed liquor suspended solids and WAS suspended solids and to calculate hydraulically determined SRT at KWWTP. This project is considered an opportunity project by the county and can be rescheduled if necessary.		
Impacted Stakeholders	Operation Staff I&C Technicians System Integrators		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$35,200
	Administration/Quality Control	10%	$3,520
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$39,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to Appendix A for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**Implement MWWTP Instrumentation Improvements**		
Project ID	**HW-17**		
Criticality	Medium		
Facilities	▪ MWWTP		
Prerequisites	▪ NA-4, DC-27A, DC-27B, DC28		
Duration	12 Months		
Description	This project will perform an assessment of their Instrumentation equipment at MWWTP to determine the need for upgrades and replacement. The project will include the following: • Install a flowmeter for the thickened sludge storage tank truck loadout station. • Evaluate the installation of an ultrasonic or radar level instrument at the existing Parshall flume downstream from the grit chamber to obtain this flow measurement. • Replace the magmeter on the sludge line feeding the GBT. • Install a flowmeter on the odor control blowdown sump discharge line to the headworks to monitor blowdown return from odor control. • Install a flowmeter on the W2 line downstream from the hydropneumatic tank to monitor W2 flow to plant processes. • Service or replace the flowmeter on the W3 line to restore monitoring of W3 flow to plant processes. • Install a flowmeter on the in-plant pump station discharge line to obtain return flow measurement to the headworks. • Install a flowmeter on the WAS line from the RAS pump station to the WAS tanks to monitor WAS flow. • Install a flowmeter on the secondary scum pump discharge line to monitor secondary scum flow to the WAS/TWAS tanks. • Consider installation of suspended solids probes in the aeration basins and WAS line at MWWTP based on the outcome of the suspended solids probe and hydraulically determined SRT calculation performance at CKTP. • Install analytical probes in the aeration basins to monitor the BNR process as part of the plant upgrade to adapt to new TN limits. • Install a level transmitter for the sodium hypochlorite tank and install local indication of tank level at the location from which the tank is filled. • Service or replace non-functional combustible gas-monitoring equipment in the sludge pumping gallery, headworks odor control system, and WAS tanks. This project is considered an opportunity project by the county and can be rescheduled if necessary.		
Impacted Stakeholders	Operation Staff		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$64,400
	Software	-	-
	Integration	-	$88,000

Project Name	Implement MWWTP Instrumentation Improvements		
	Administration/Quality Control	10%	$15,240
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$173,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to Appendix A for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	Implement MWWTP Automation Improvements		
Project ID	**HW-18**		
Criticality	Medium		
Facilities	▪ MWWTP		
Prerequisites	▪ NA-4, NA-7, HW-17, DC-27A, DC-27B, DC-28		
Duration	6 Months		
Description	This project will perform an assessment of their Automation equipment at MWWTP to determine the need for upgrades and replacement. The project will include the following: • Develop a SCADA HMI screen for monitoring the comprehensive liquid stream flow balance for the plant along with HRT values for tanks, basins, and clarifiers. • Develop a SCADA HMI screen for monitoring the comprehensive solid stream flow balance for the plant along with detention time values for the WAS and TWAS tanks. • With favorable results from the suspended solids probes and hydraulically determined SRT calculations at CKTP, the Sewer Utility will develop PLC programming and SCADA HMI modifications to monitor mixed liquor suspended solids and WAS suspended solids and to calculate hydraulically determined SRT at MWWTP. • Develop PLC programming and SCADA HMI screen modifications to allow operations staff to schedule and adjust aeration blower operation time sequence from SCADA HMIs. • Install an electrically actuated isolation valve on the WAS line to the WAS tanks to enable SCADA control of the sludge wasting process. PLC programming and SCADA HMI screen modifications will be developed to add functionality for operations staff to manually open and close the valve from SCADA. • Wire a fault signal from the mixing channel blower motor starter to the discrete input at the LP-225 RIO rack in the headworks building and provide PLC programming and SCADA HMI screen modification to integrate the fault alarm. This project is considered an opportunity project by the county and can be rescheduled if necessary.		
Impacted Stakeholders	Operation Staff I&C Technicians		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$49,000
	Administration/Quality Control	10%	$4,900
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$54,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

***Refer to Appendix A for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.**

Project Name	**Implement SWWTP Instrumentation Improvements**		
Project ID	**HW-19**		
Criticality	Medium		
Facilities	▪ SWWTP		
Prerequisites	▪ NA-4, DC-27A, DC-27B, DC-28		
Duration	12 Months		
Description	This project will perform an assessment of their Instrumentation equipment at SWWTP to determine the need for upgrades and replacement. The project will include the following: • Service or replace the combustible gas monitoring equipment in the process building upper floor process room. • Install a flowmeter for the thickened sludge storage tank truck loadout station. • Verify calibration of the thickened sludge storage tank level transmitter. After calibrating, record a series of measured level values versus actual tank level during two or three tank loadout operations. If accuracy and repeatability of level measurement are unacceptable, install a radar level transmitter to replace the pressure-based level transmitter currently installed in a non-ideal location on the pump suction line. Record drawings indicate that a spare 6-inch nozzle was provided on the tank for a future instrument, which could be used for installation of the radar level transmitter. • Install a radar level transmitter for monitoring and control of sludge storage tank level with a level switch that can provide a high level interlock and alarm. • Install DO probes in the SBRs. Depending on the outcome of ongoing facility planning, the Sewer Utility should consider additional analytical probes to facilitate improved monitoring and control of the BNR process. • Replace the damaged thermal dispersion flow switch on the RDT spray water supply line. • Consider the installation of suspended solids probes in the SBRs and WAS line at SWWTP based on the outcome of the suspended solids probe and hydraulically determined SRT calculation performance at CKTP. • Install a flowmeter on the discharge line from the drain collection pump station to monitor return flow to the headworks equipment. • Install a flowmeter on the W3 line downstream from the reclaimed water pumps to monitor W3 flow to plant processes. • Service or replace the process building fire alarm system (will need information on the square footage and feet of building to provide accurate cost estimate). This project is considered an opportunity project by the county and can be rescheduled if necessary.		
Impacted Stakeholders	Operation Staff I&C Technicians		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$43,700

Project Name	**Implement SWWTP Instrumentation Improvements**		
	Software	-	-
	Integration	-	$66,000
	Administration/Quality Control	10%	$10,970
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$126,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**Implement SWWTP Automation Improvements**
Project ID	**HW-20**
Criticality	Medium
Facilities	▪ SWWTP
Prerequisites	▪ NA-4, NA-7, HW-19, DC-27A, DC-27B, DC-28
Duration	6 Months
Description	This project will perform an assessment of their Automation equipment at SWWTP to determine the need for upgrades and replacement. The project will include the following: • Develop a SCADA HMI screen for monitoring the comprehensive liquid stream flow balance for the plant along with HRT values for SBRs and tanks. • Develop a SCADA HMI screen for monitoring the comprehensive solid stream flow balance for the plant along with detention time values for the sludge storage tank. • Service or replace the effluent flow control valve to restore its ability to maintain positions from SCADA-issued commands. This will have to be done a shutdown and the Sewer Utility will utilize this shutdown to complete other upgrades as well. This project is considered an opportunity project by the county and can be rescheduled if necessary.
Impacted Stakeholders	Operation Staff I&C Technicians

Cost Opinion*

CAPITAL COSTS	%	COST OPINION*
Hardware	-	-
Software	-	-
Integration	-	$44,000
Administration/Quality Control	10%	$4,400
MISC Expenses	-	-
TOTAL CAPITAL COSTS	**-**	**$48,000**
ANNUAL O&M COSTS	**%**	**COST OPINION***
TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**Implement Remote Pump Station Instrumentation Improvements**		
Project ID	**HW-21**		
Criticality	Medium		
Facilities	▪ Remote Pump Stations		
Prerequisites	▪ NA-4, DC-27A, DC-27B, DC-28		
Duration	6 Months		
Description	This project will perform an assessment of their Instrumentation equipment at their remote pump stations to determine the need for upgrades and replacement. The project will include the following: • Install pressure transmitters on remote pump station force mains and monitor force main pressures. 12 pressure transmitters will be installed in the pump stations with PLC's installed already (reference table 3-1 in TM-1). • Service or replace the combustible gas monitoring equipment at the PS-24 wet well. • Replace PS-24 wet well level transducer and transmitter, which has been in service for about 20 years. With the replacement of the level transducer, a submergence shield will also be implemented. If the Sewer Utility is unable to replace the level transducer, then the current level transducer will be recalibrated and serviced. • Install a level transmitter for the PS-71 BIOXIDE storage tank. • Service or replace the combustible-gas monitoring equipment at the PS-71 wet well. This project is considered an opportunity project by the county and can be rescheduled if necessary.		
Impacted Stakeholders	Operation Staff I&C Technician		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	$69,230
	Software	-	-
	Integration	-	$110,000
	Administration/Quality Control	10%	$17,923
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$202,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**Implement Remote Pump Station Automation Improvements**
Project ID	**HW-22**
Criticality	Medium
Facilities	▪ Remote Pump Stations
Prerequisites	▪ NA-4, NA-7, HW-21, DC-27A, DC-27B, DC-28
Duration	12 Months
Description	This project will perform an assessment of their Automation equipment at their remote pump stations to determine the need for upgrades and replacement. The project will include the following: • Develop SCADA HMI screens to provide a summary-level, process flow diagram depiction of the conveyance system associated with each WWTP. The summary conveyance system screens will display pump running status, flow, force main pressure, and indication of whether an alarm is active for each pump station. • Implement time-to-overflow monitoring for its critical (or all) pump stations. • Modify the existing PLC programming logic to favor energy efficient operating points while within normal level range in the wet well for pump stations with VFDs that are monitoring pump power and flow. • Review the hardwired relay logic and PLC programming for the existing pump controls to confirm the as-implemented conditions, which will contribute to the pump short cycling occurring at the pump station. After review of existing controls and near-real-time pump station data, the Sewer Utility will implement the appropriate control improvements to reduce or eliminate pump short cycling at the station to increase the useful service life of the equipment. • Upgrade the control system at PS-34. The control system upgrade would include replacement of the existing control panel with a PLC-based control panel and an OIT for improved local monitoring and control functionality. • Evaluate the remote alarm reset functionality for select remote pump station alarms. Remote reset capability will likely require additional hardwiring at the remote pump station, in addition to PLC programming and SCADA HMI screen modifications. This project is considered an opportunity project by the county and can be rescheduled if necessary.
Impacted Stakeholders	Operation Staff I&C Technicians

Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$55,000
	Administration/Quality Control	10%	$5,500
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$61,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

5.3 Software Projects

Project Name	Upgrade WWTP Standalone SCADA HMI Installations to AVEVA System Platform with Managed InTouch Applications and Standardized Templates Based on HPHMI Concepts
Project ID	**SW-23**
Criticality	Medium
Facilities	▪ WWTPs
Prerequisites	▪ None
Duration	N/A
Description	This project will utilize the AVEVA systems platform on the servers within the CKTP OT Network. The Sewer Utility and QCC are already in the process of converting the standalone InTouch HMI applications, which will help towards the SCADA HMI screen development and management. Once the ICS Standards (DC-27) are complete, the new standards will be implemented to the System Platform upgraded HMI screens for all WWTPs and Remote Pump Stations. The upgrades will be implemented to the already existing InTouch screens and will require graphical adjustments. Workshops will be held to determine the visual and functional requirements of the future SCADA HMI screens. During these workshops, the Sewer Utility stakeholders will be involved to confirm the final implementation meets the Sewer Utility's needs. The Project already funded and will be completed by end of FY2022.
Impacted Stakeholders	Operation Staff I&C Technician

Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$0
	Administration/Quality Control	10%	$0
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$0**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

	Implement an Alarm Management Program Based on ISA-18.2		
Project ID	**SW-24**		
Criticality	High		
Facilities	▪ WWTPs and Pump Stations		
Prerequisites	▪ NA-1, NA-4, DC-27A, DC-27B		
Duration	6 Months		
Description	This project will implement an alarm management program based on ISA-18.2. The Sewer Utility will continue developing its alarm management program in parallel with or prior to other ICS automation programming efforts. The alarm management program will address the following deficiencies: • Lots of activity from the same alarm during CKTP Wonderware Implementation. • No means of shelving nuisance alarms or alarms associated with known issues. • HMI screens do not provide alarm priority information and do not have any means to filter out alarms by priority. • Root-cause analysis and alarm suppression functionality have not been developed for HMI screens • HMI screens do not have troubleshooting text prompt or decisions tree aids to help operation staff react to alarm conditions • Alarm summary and alarm history screens at SWWTP do not automatically display current alarm information. • Monitored alarms should include PLC faults and communication errors so that Sewer Utility staff are alerted when PLCs and RIO racks are experiencing performance issues • Monitored alarms should include signal out-of-range alarms for all analog signals so that Sewer Utility staff are notified when current-based signals fall outside of the 4–20 mA range The data related to the ICS alarms will be captured in the historian or another database environment and be made available to users on the Sewer Utility Business LAN. Third-party alarm management software or dashboards will be used to develop visualizations and reports that will help manage alarms and help with responsiveness.		
Impacted Stakeholders	Operation Staff I&C Technician		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$49,500
	Administration/Quality Control	10%	$4,950
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$54,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

***Refer to Appendix A for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.**

Project Name	Establish a Tiered Historian Implementation at CKTP
Project ID	SW-25
Criticality	Medium
Facilities	▪ CKTP
Prerequisites	▪ NA-2, NA-7, DC-27A, DC-27B
Duration	3 Months
Description	This project will establish a central historian at CKTP to consolidate ICS data received from the Sewer Utility WWTPs and remote pump stations. Embedded trends would display data that have been received from the central historian. The AVEVA Historian Client software will be implemented to access the historian data and facilitate development of static and ad hoc trends from the PCs on the OT network but cost has not been included because it is not within the scope of the master plan. To prevent loss of data received from the plants during an outage, store-and-forward functionality will be implemented. A “Tier 2” historian will be established on the Sewer Utility Business LAN at CKTP to provide access to the historian data for users. The “Tier 1” Historian will push data through the DMZ to the “Tier 2” Historian and the one-way nature of this data flow and limited open port requirements will simplify industrial DMZ firewall configuration, improve OT network security controls, and significantly reduce the network traffic traversing the industrial DMZ firewall. Any additional Firewall configuration during the historian implementation in the DMZ will be managed by the County IS Department.
Impacted Stakeholders	Operation Staff I&C Technician
Cost Opinion*	

CAPITAL COSTS	%	COST OPINION*
Hardware	-	-
Software	-	$64,837
Integration	-	$16,500
Administration/Quality Control	10%	$8,134
MISC Expenses	-	-
TOTAL CAPITAL COSTS	**-**	**$89,000**
ANNUAL O&M COSTS	**%**	**COST OPINION***
TOTAL ANNUAL COSTS**	**-**	**$10,938**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	Broaden the Data Set Archived by the Sewer utility Historian to Establish Foundations for More Comprehensive Process-and Asset-level Health and Performance Monitoring
Project ID	SW-26
Criticality	Medium
Facilities	▪ WWTPs and Pump Stations
Prerequisites	▪ NA-4, DC-27B, DC-28
Duration	9 Months
Description	This project will audit the parameters that are being monitored and configure the site Tier 1 historian to historize the parameters of interest.

Project Name	**Broaden the Data Set Archived by the Sewer utility Historian to Establish Foundations for More Comprehensive Process-and Asset-level Health and Performance Monitoring**		
	The project will also include the following in the historian: • In Auto Status • Close/Open Commands • Position Commands • Start/Stop Commands • Speed Commands • Set Point Commands • Energy Consumption Status • Power Data Status • Fail/Fault Alarm • Networked Equipment alarms and warnings • Actuator Torque Status • Pump Suction and Discharge Pressure Status • Liquid Stream and Solid Stream Low and Flow Totalization Status To monitor and record the above parameters, the PLC program, filed wiring, and Ethernet Device configuration will need to be investigated. No hardware costing for any required updates has been included in this cost.		
Impacted Stakeholders	Operation Staff I&C Technicians		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$68,200
	Administration/Quality Control	10%	$6,820
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$75,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

5.4 Documentation Projects

Project Name	Develop ICS Standards - Hardware
Project ID	DC-27A
Criticality	Medium
Facilities	▪ WWTPs and Pump Stations
Prerequisites	▪ None
Duration	4 Months
Description	This project will develop PLC, HMI, and control panel standards. The ICS control and telemetry panel hardware standards will include guidelines and template drawings that specify hardware component requirements; general control panel interior and exterior layouts; power distribution methodology; and fabrication, testing, and installation requirements for new ICS control and telemetry panels at Sewer Utility WWTPs and pump stations. The standards would also document network device configuration and hardening requirements for Ethernet switches, cellular gateways, and other network components to be installed within these panels. Anticipated standards to be created are: SCADA Control Panel Std SCADA Instrument and Vendor Communication Std SCADA Network Design and Hardware Std SCADA Equipment Procurement Std
Impacted Stakeholders	Operation Staff
Cost Opinion*	

CAPITAL COSTS	%	COST OPINION*
Hardware	-	$5,750
Software	-	-
Integration	-	$129,400
Administration/Quality Control	10%	$13,515
MISC Expenses	-	$5,000
TOTAL CAPITAL COSTS	**-**	**$154,000**
ANNUAL O&M COSTS	**%**	**COST OPINION***
TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

Project Name	**Develop ICS Standards – Software and Governance**
Project ID	**DC-27B**
Criticality	Medium
Facilities	▪ WWTPs and Pump Stations
Prerequisites	▪ DC-27A
Duration	6 Months
Description	This project will develop PLC, HMI, and control panel standards. The PLC standard will include information like preferred PLC programming project file organization; appropriate level of annotation; tagging conventions; use of tag descriptions; program and routine naming conventions; use of ladder logic and function block diagram; and standard AOIs, UDTs, and subroutines that are to be used for common applications throughout the Sewer Utility ICS infrastructure.' The HMI graphics standard will include guidelines with screenshots and programming files that specify requirements and standard programming objects for graphics development and configuration work associated with AVEVA System Platform. Once the ICS Standards Documentation are created, which will contain PLC Programming standards, HMI graphics standards, and ICS control and telemetry panel hardware standards, it will be managed by a standards committee. The members of the committee will be technically qualified and be willing to participate in maintaining the standards. There will also be an ICS standards manager who will enforce the development of the standards and will oversee revising the document when necessary. The standards manager will also be responsible for maintaining version control of the document and make sure that the contractors have the most updated version available so that they may meet the requirements. With the standards being created, the Sewer Utility will establish an appropriate method for Operators to electronically log daily notes, observations, and activities. The Sewer Utility will compile relevant P&IDs from past projects into consolidated sets for each WWTP and Pump Station. Then they will be reviewed to the actual infrastructure so that the P&IDs can be updated. After the sets are compared to the current infrastructure, they will be compiled into the eO&M SharePoint site. The Sewer Utility will then develop and maintain the network architecture diagrams for the four WWTPs (physical and logical). They will also develop and maintain an asset inventory for the OT Network devices. The fiber-optic patch panel schedules and the information about the fiber-optic cables and patch panels will also be maintains. The tagging convention for the panels and cables will be standardized and noted on the ICS standard documentation. The project will utilize a software platform to implement a dashboarding and data visualization functionality for analyzing data. The project will first select a software solution and then begin developing the ability to create dashboards and visualizations in-house. Staff will need to be trained first and preliminary dashboards will need to be created. As in-house skills develop over time, the

Project Name	Develop ICS Standards – Software and Governance		
	dashboards and visualizations will become more technical and have more impact in process control and utility management. Once the standards are created remote access via tablets will be available for reference. Anticipated standards to be created are: SCADA Application Programming Std for PLCs HMI Software and Architecture Std SCADA Application Programming Std for HMI SCADA Data Historization and Archiving Std SCADA Cybersecurity and Network Monitoring Std SCADA Software Management and Revision Control Std Staff Roles and Skills Development Std		
Impacted Stakeholders	Operation Staff		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$308,300
	Administration/Quality Control	10%	$30,830
	MISC Expenses	-	$5,000
	TOTAL CAPITAL COSTS	**-**	**$344,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

	Develop and Maintain Control Strategy Documentation		
Project ID	**DC-28**		
Criticality	High		
Facilities	▪ WWTPs and Pump Stations		
Prerequisites	▪ DC-27A		
Duration	18 Months		
Description	This project will develop and maintain control strategies to document how WWTP, pump station process, and equipment are controlled locally and with SCADA. The control strategies will be used to evaluate performance based on data that has been obtained through SCADA. Once the control strategy document is created, the document will be available on the County electronic operation and maintenance SharePoint site for the Sewer utility Staff. The control strategy will be updated and managed so that it remains current and accurate.		
Impacted Stakeholders	Operation Staff		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$151,800
	Administration/Quality Control	10%	$15,180
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$167,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

5.5 Other Software Package Projects

	Complete Hach WIMS Implementation and Establish Data Exchange with AVEVA System Platform		
Project ID	**OS-29**		
Criticality	Low		
Facilities	▪ CKTP		
Prerequisites	▪ NA-4, NA-7, SW-25, DC-27A, DC-27B, OS-30		
Duration	3 Months		
Description	This project will use Hach WIMS for its laboratory information management system (LIMS) software. The Sewer utility will have its current SCADA system automatically import data into the new Hach WIMS. Once the exchange between Hach WIMS and the Sewer utility Historian is established, the staff will have the ability to select specific SCADA tags and date ranges for ad hoc data imports and trend analysis within Hach WIMS. The sever that the Hach WIMS software will be located is on the business LAN and will be configured with the “Tier 2” historian. In the meantime, the Hach WIMS server will be deployed on the CKTP OT network while the Industrial DMZ is being implemented. The Project is considered an opportunity project by the county and can be rescheduled if necessary.		
Impacted Stakeholders	Operation Staff I&C Technicians		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$5,000
	Administration/Quality Control	10%	-
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$5,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

	Complete Asset Creation and Data Entry Required for LLumin Implementation, Establish Automatic Importing of Asset Runtimes, and Develop a Plan for Automating Work Order Generation		
Project ID	**OS-30**		
Criticality	Low		
Facilities	▪ CKTP		
Prerequisites	▪ NA-4, NA-7, HW-21 SW-25, DC-27A, DC-27B		
Duration	6 Months		
Description	Once the Sewer Utility completes some configurations and data entry work for the assets, this project will establish automatic importing of asset runtimes from the Sewer Utility Historian. The Sewer Utility will be configured with the "Tier 2" historian within the business LAN. The LLumin Machine Interface Server will be implemented as an on-premise solution, running as a Windows service. The project will utilize the software's ability to support asset specific, rule-based generation of work orders to identify asset runtime thresholds, alarms, events, and analog set points that trigger a work order within the LLumin system. Initially, a small sample of assets will be implemented first to see the efficacy of the work order automation. Once favorable results are seen, the project will develop a schedule to implement this system to the remainder assets. If alarm or event based work order generation on a near-real-time basis is required, The LLumin's Machine Interface server software will need to communicate with AVEVA System Platform. To do this, the project will need to relocate the LLumin Machine Interface Server software to the CKTP OT Network or industrial DMZ. First, the Sewer utility will start with the data exchange between LLumin and the "Tier 2" historian and then expand the LLumin system after the Sewer utility's CMMS program is developed. The County IS Department will install, develop, and maintain the Llumin software so no license costs have been included. Cartagraph will also be integrated with the implementation of this project. This project is considered an opportunity project by the county and can be rescheduled if necessary.		
Impacted Stakeholders	Operation Staff I&C Technicians		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$352,000
	Administration/Quality Control	10%	$35,200
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$387,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**-**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

	Begin Leveraging the Sewer Utility's Power and Energy Data		
Project ID	**OS-31**		
Criticality	Low		
Facilities	▪ WWTPs and Pump Stations		
Prerequisites	▪ NA-4, SW-23, DC-27A, DC-27B		
Duration	3 Months		
Description	This project will begin recording historical power and energy data from installed power monitors and network-capable motor controllers. This will require the install of network cabling to establish communication with the power monitors. For the Ethernet-capable power monitors that are not communicating with the PLC, communication will have to established between the power monitors and the AVEVA SCADA software. This information will be used to evaluate the existing infrastructure's capacity to accept additional electrical loads and to assess when harmonic distortion is approaching unacceptable levels. The Sewer Utility will transition away from the existing GE Enervista Viewpoint Monitoring software in the CKTP SPB control room and utilize the AVEVA System Platform to monitor and record the Sewer Utility's power and energy data. The project will install Ethernet-capable power monitors at all major electrical distribution buses as the equipment is replaced/upgraded in the future and has not been included in the cost. When installing future motor controllers, the Sewer Utility will make sure that they will be provided with Ethernet communication so that power and energy data can be monitored and recorded. When determining energy-based metrics the Sewer utility will use KPIs for evaluating its operations and then leverage KPIs to establish baselines at each of its WWTPs and remote pump stations. The baselines will be established from 1 years' worth of data to account for seasonal variation. The project will utilize data analytics and visualization software to track and monitor energy-based KPIs. Once sufficient baseline energy data is provided, they will be reviewed to identify processes and equipment where energy efficiency measures are likely to yield benefits. A formal energy audit will take place and then targeted goals will be set as part of a separate project.		
Impacted Stakeholders	Operation Staff I&C Technicians		
Cost Opinion*	**CAPITAL COSTS**	**%**	**COST OPINION***
	Hardware	-	-
	Software	-	-
	Integration	-	$18,700
	Administration/Quality Control	10%	$1,870
	MISC Expenses	-	-
	TOTAL CAPITAL COSTS	**-**	**$21,000**
	ANNUAL O&M COSTS	**%**	**COST OPINION***
	TOTAL ANNUAL COSTS**	**-**	**0**

*Refer to **Appendix A** for more information on the cost opinion approach. Totals and subtotals are rounded up to the nearest $1,000.

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Appendix A – Cost Estimate

NA-1					
Upgrade Central Kitsap Treatment Plant (CKTP) Control Room					
Hardware Items	**Qty**	**Unit Prices**	**Extended**		
	0	$ -	$ -		
Hardware Subtotal			$ -		
Software Items					
	0	$ -	$ -		
Software Subtotal			$ -		
Totals	0	$ -	$ -		
Installation/ Configuration	**Qty**	**Unit Price**	**Extended**		
Sewer Utility will handle internally	1	$ 5,000	$ 5,000		
			Subtotal Configuration, Programming and Startup		*$ 5,000*
			Contingency	10%	
			Total Configuration, Programming and Startup		
			Subtotal Hardware Costs		*$ -*
			Contingency	*15%*	*$ -*
			Hardware Total		***$ -***
			Subtotal Software Costs		*$ -*
			Contingency	*15%*	*$ -*
			Software Total		***$ -***
			Total Hardware and Software Costs		***$ -***
Admin/QC				10%	$ -
Misc Expenses					
			Total		***$ -***

NA-2			
Extend OT Network to County Public Works Annex Facility			
Hardware Items	**Qty**	**Unit Prices**	**Extended**
Workstations (Testing)	1	$ 5,000	$ 5,000
Large Screen Monitors (Training)	2	$ 2,000	$ 4,000
HIP Switch	1	$ 10,000	$ 10,000
Hardware Subtotal			$ 19,000
Software Items			
Lic: Workstations (1)	1	$ 15,000	$ 15,000
Software Subtotal			$ 15,000
Totals	5	$ 32,000	$ 34,000

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**		
HMI/Historian	1	$ 10,000	$ 10,000		
Firewall Installation / Configuration	1	$ 5,000	$ 5,000		
Workstation Installation / Configuration	1	$ 10,000	$ 10,000		
Subtotal Configuration, Programming and Startup					*$ 25,000*
Contingency				10%	*$ 2,500*
Total Configuration, Programming and Startup					***$ 27,500***
Subtotal Hardware Costs					*$ 19,000*
Contingency				*15%*	*$ 2,850*
Hardware Total					***$ 21,850***
Subtotal Software Costs					*$ 15,000*
Contingency				*15%*	*$ 2,250*
Software Total					***$ 17,250***
Total Hardware and Software Costs					**$ 39,100**

Admin/QC	10%	$ 6,660
Misc Expenses		$ 5,000
Total		**$ 78,000**

NA-3

Remote Pump Station and WWTP Telemetry Improvements

Hardware Items	Qty	Unit Prices	Extended	
Cellular Router for Verizon	2	$ 500	$ 1,000	
Server	1	$ 15,000	$ 15,000	
Switch	1	$ 10,000	$ 10,000	
Hardware Subtotal			$ 26,000	
Software Items				
Lic: AVEVA Telemetry Server Software	1	$ 8,500	$ 8,500	
Software Subtotal			$ 8,500	
Totals	5	$ 34,000	$ 34,500	
Installation/ Configuration	**Qty**	**Unit Price**	**Extended**	
Server Installation / Configuration	1	$ 10,000	$ 10,000	
Firewall Installation / Configuration	2	$ 5,000	$ 10,000	
Cellular Radio Configuration and Testing	61	$ 2,000	$ 122,000	
HMI/Historian	1	$ 10,000	$ 10,000	
PLC Programing	1	$ 6,000	$ 6,000	
Cellular Site Survey	1	$ 20,000	$ 20,000	
Subtotal Configuration, Programming and Startup				*$ 178,000*
Contingency			10%	*$ 17,800*
Total Configuration, Programming and Startup				***$ 195,800***
Subtotal Hardware Costs				*$ 26,000*
Contingency			*15%*	*$ 3,900*
Hardware Total				***$ 29,900***
Subtotal Software Costs				*$ 8,500*
Contingency			*15%*	*$ 1,275*
Software Total				***$ 9,775***
Total Hardware and Software Costs				**$ 39,675**
Admin/QC			10%	$ 23,548
Misc Expenses				$ 5,000
Total				**$ 264,000**

Annual AVEVA Telemetry Server Support Cost $1,600

# of pump stations

NA-4

CKTP OT Network Upgrades

Hardware Items	**Qty**	**Unit Prices**	**Extended**
Network Rack	1	$ 15,000	$ 15,000
Switch (Managed)	3	$ 15,000	$ 45,000
UPS	1	$ 4,000	$ 4,000
SFP Module	1	$ 2,000	$ 2,000
Hardware Subtotal			$ 66,000
Software Items			
Software Subtotal			$ -
Totals	6	$ 36,000	$ 15,000

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**
Switch Installation / Configuration	3	$ 2,000	$ 6,000
Fiber Installation	1	$ 66,500	$ 66,500
OT Network Device Communication updates	1	$ 30,000	$ 30,000

Subtotal Configuration, Programming and Startup		*$ 102,500*
Contingency	10%	*$ 10,300*
Total Configuration, Programming and Startup		***$ 112,800***
Subtotal Hardware Costs		*$ 66,000*
Contingency	*15%*	*$ 9,900*
Hardware Total		***$ 75,900***
Subtotal Software Costs		*$ -*
Contingency	*15%*	*$ -*
Software Total		***$ -***
Total Hardware and Software Costs		**$ 75,900**
Admin/QC	10%	$ 18,870
Misc Expenses		$ 5,000
Total		**$ 213,000**

Fiber $18.00 per foot without conduit or interduct or $33.25 with conduit.
Cost is including 2,000 feet for Fiber with Conduit

NA-5				
Standardization to Managed Switches				
Hardware Items	**Qty**	**Unit Prices**	**Extended**	
Switch (Managed)	5	$ 6,000	$ 30,000	
Hardware Subtotal			$ 30,000	
Software Items				
Software Subtotal			$ -	
Totals	5	$ 6,000	$ 30,000	
Installation/ Configuration	**Qty**	**Unit Price**	**Extended**	
Fiber Installation	1	$ 66,500	$ 66,500	
Switch Installation / Configuration	5	$ 2,000	$ 10,000	
Subtotal Configuration, Programming and Startup				*$ 76,500*
Contingency			10%	*$ 7,700*
Total Configuration, Programming and Startup				***$ 84,200***
Subtotal Hardware Costs				*$ 30,000*
Contingency			*15%*	*$ 4,500*
Hardware Total				***$ 34,500***
Subtotal Software Costs				*$ -*
Contingency			*15%*	*$ -*
Software Total				***$ -***
Total Hardware and Software Costs				**$ 34,500**
Admin/QC			10%	$ 11,870
Misc Expenses				$ 5,000
Total				**$ 136,000**

Fiber $18.00 per foot without conduit or interduct or $33.25 with conduit.
Cost is including 2,000 feet for Fiber with Conduit

NA-6				
ICS and OT Network Power Supply Improvements				

Hardware Items	**Qty**	**Unit Prices**	**Extended**
UPS Compact Tower	51	$ 1,000	$ 51,000
Hardware Subtotal			$ 51,000
Software Items			
Software Subtotal			$ -
Totals	51	$ 1,000	$ 51,000

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**		
PLC Programing	1	$ 8,000	$ 8,000		
HMI Configuration	1	$ 10,000	$ 10,000		
UPS Install	51	$ 1,000	$ 51,000		
Subtotal Configuration, Programming and Startup					*$ 69,000*
Contingency				10%	*$ 6,900*
Total Configuration, Programming and Startup					***$ 75,900***
Subtotal Hardware Costs					*$ 51,000*
Contingency				*15%*	*$ 7,650*
Hardware Total					***$ 58,650***
Subtotal Software Costs					*$ -*
Contingency				*15%*	*$ -*
Software Total					***$ -***
Total Hardware and Software Costs					**$ 58,650**

Admin/QC	10%	$ 13,455
Misc Expenses		$ 5,000
Total		**$ 153,000**

NA-7

DMZ and AVEVA InTouch Access Anywhere Implementation

Hardware Items	Qty	Unit Prices	Extended
Server	1	$ 15,000	$ 15,000
Hardware Subtotal			$ 15,000
Software Items			
	1	$ -	$ -
Software Subtotal			$ -
Totals	2	$ 15,000	$ 15,000

Installation/ Configuration	Qty	Unit Price	Extended		
Server Installation / Configuration	1	$ 20,000	$ 20,000		
AVEVA InTouch Access Anywhere Configuration	1	$ 5,000	$ 5,000		
Coordination with County IS Department	1	$ 18,000	$ 18,000		
Subtotal Configuration, Programming and Startup					*$ 43,000*
Contingency				10%	*$ 4,300*
Total Configuration, Programming and Startup					***$ 47,300***
Subtotal Hardware Costs					*$ 15,000*
Contingency				*15%*	*$ 2,250*
Hardware Total					***$ 17,250***
Subtotal Software Costs					*$ -*
Contingency				*15%*	*$ -*
Software Total					***$ -***
Total Hardware and Software Costs					**$ 17,250**

Admin/QC	10%	$ 6,455
Misc Expenses		$ 5,000
Total		**$ 76,000**

3 weeks * $150 per hour

HW-8				
Establish Sewer Utility PLC/OIT Platform Standard and Schedule Replacement of Select WWTP and Remote Pump Station PLCs/OITs				
Hardware Items	**Qty**	**Unit Prices**	**Extended**	
	0	$ -	$ -	
Hardware Subtotal			$ -	
Software Items				
	0	$ -	$ -	
Software Subtotal			$ -	
Totals	0	$ -	$ -	
Installation/ Configuration	**Qty**	**Unit Price**	**Extended**	
Prioritize PLCs and OITs for End of Life Replacement (will handled internally)	1	$ 5,000	$ 5,000	
Subtotal Configuration, Programming and Startup				*$ 5,000*
Contingency			10%	
Total Configuration, Programming and Startup				
Subtotal Hardware Costs				*$ -*
Contingency			*15%*	*$ -*
Hardware Total				***$ -***
Subtotal Software Costs				*$ -*
Contingency			*15%*	*$ -*
Software Total				***$ -***
Total Hardware and Software Costs				**$ -**
Admin/QC			10%	$ -
Misc Expenses				
Total				**$ -**

HW-9					
Replace CKTP MCC DeviceNet Networks w/ Ethernet Capable Motor Controllers					
Hardware Items	**Qty**	**Unit Prices**	**Extended**		
Ethernet/IP Adapter/Module	19	$ 1,000	$ 19,000		
E300 Electronic Overlay Relays	4	$ 1,000	$ 4,000		
Miscelaneous PLC I/O Module	1	$ 20,000	$ 20,000		
Hardware Subtotal			$ 43,000		
Software Items					
Software Subtotal			$ -		
Totals	24	$ 22,000	$ 43,000		
Installation/ Configuration	**Qty**	**Unit Price**	**Extended**		
PLC Programing	1	$ 6,000	$ 6,000		
Communication Module Retrofit	23	$ 500	$ 11,500		
EtherNet Wiring Allowance	23	$ 500	$ 11,500		
Subtotal Configuration, Programming and Startup					*$ 29,000*
Contingency				10%	*$ 2,900*
Total Configuration, Programming and Startup					***$ 31,900***
Subtotal Hardware Costs					*$ 43,000*
Contingency				*15%*	*$ 6,450*
Hardware Total					***$ 49,450***
Subtotal Software Costs					*$ -*
Contingency				*15%*	*$ -*
Software Total					***$ -***
Total Hardware and Software Costs					**$ 49,450**
Admin/QC				10%	$ 8,135
Misc Expenses					$ 5,000
Total					**$ 94,000**

HW-10

Develop a Formal Instrument Calibration and Maintenance Program

Hardware Items	**Qty**	**Unit Prices**	**Extended**		
	0	$ -	$ -		
Hardware Subtotal			$ -		
Software Items					
	0	$ -	$ -		
Software Subtotal			$ -		
Totals	0	$ -	$ -		

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**		
Creation of Program for Maintenance and Calibration (will handle internally)	1	$ 5,000	$ 5,000		
			Subtotal Configuration, Programming and Startup		*$ 5,000*
			Contingency	10%	
			Total Configuration, Programming and Startup		
			Subtotal Hardware Costs		*$ -*
			Contingency	*15%*	*$ -*
			Hardware Total		***$ -***
			Subtotal Software Costs		*$ -*
			Contingency	*15%*	*$ -*
			Software Total		***$ -***
			Total Hardware and Software Costs		**$ -**

Admin/QC	10%	$ -
Misc Expenses		$ -
	Total	**$ -**

HW-11					
CKTP Digester Building PNL 6000 and MCC Replacement					
Hardware Items	**Qty**	**Unit Prices**	**Extended**		
PLC Panel	$ 1	$ 50,000	$ 50,000		
Hardware Subtotal			$ 50,000		
Software Items					
Software Subtotal			$ -		
Totals	1	$ 50,000	$ 50,000		
Installation/ Configuration	**Qty**	**Unit Price**	**Extended**		
Miscellaneous Field Wiring	1	$ 10,000	$ 10,000		
			Subtotal Configuration, Programming and Startup		*$ 10,000*
			Contingency	10%	*$ 1,000*
			Total Configuration, Programming and Startup		***$ 11,000***
			Subtotal Hardware Costs		*$ 50,000*
			Contingency	*15%*	*$ 7,500*
			Hardware Total		***$ 57,500***
			Subtotal Software Costs		*$ -*
			Contingency	*15%*	*$ -*
			Software Total		***$ -***
			Total Hardware and Software Costs		**$ 57,500**
Admin/QC				10%	$ 6,850
Misc Expenses					$ 5,000
			Total		**$ 80,000**

HW-12					
Include Integration of Composite Sampler Alarms and Monitoring with Replacement of Existing Samplers					
Hardware Items	**Qty**	**Unit Prices**	**Extended**		
	0	$ -	$ -		
Hardware Subtotal			$ -		
Software Items					
	0	$ -	$ -		
Software Subtotal			$ -		
Totals	0	$ -	$ -		
Installation/ Configuration	**Qty**	**Unit Price**	**Extended**		
Sewer Utility will handle internally	1	$ 5,000	$ 5,000		
			Subtotal Configuration, Programming and Startup		*$ 5,000*
			Contingency	10%	
			Total Configuration, Programming and Startup		
			Subtotal Hardware Costs		*$ -*
			Contingency	*15%*	*$ -*
			Hardware Total		***$ -***
			Subtotal Software Costs		*$ -*
			Contingency	*15%*	*$ -*
			Software Total		***$ -***
			Total Hardware and Software Costs		***$ -***
Admin/QC				10%	$ -
Misc Expenses					
			Total		***$ -***

HW-13				
Implement CKTP Instrumentation Improvements				
		Unit		
Hardware Items	**Qty**	**Prices**	**Extended**	
Flowmeter 4" Pipe(Magmeter)	2	$ 3,500	$ 7,000	
Flowmeter 6" Pipe(Magmeter)	5	$ 4,000	$ 20,000	
Flowmeter 8" Pipe(Magmeter)	2	$ 4,500	$ 9,000	
Thermal Dispersion Flowmeter	1	$ 2,500	$ 2,500	
Chlorine Residual Analyzer	1	$ 2,500	$ 2,500	
Turbidity Analyzer	1	$ 3,000	$ 3,000	
Lower Explosive Limit Transmitter	1	$ 5,000	$ 5,000	
Suspended Solids Probe	2	$ 8,000	$ 16,000	
Hardware Subtotal			$ 65,000	
Software Items				
Software Subtotal			$ -	
Totals	15	$ 33,000	$ 65,000	
Installation/ Configuration	**Qty**	**Unit Price**	**Extended**	
Installation of instruments	13	$ 5,000	$ 65,000	
PLC Programming	1	$ 10,000	$ 10,000	
HMI Configuration	1	$ 5,000	$ 5,000	
Subtotal Configuration, Programming and Startup				*$ 80,000*
Contingency			10%	*$ 8,000*
Total Configuration, Programming and Startup				***$ 88,000***
Subtotal Hardware Costs				*$ 65,000*
Contingency			*15%*	*$ 9,750*
Hardware Total				***$ 74,750***
Subtotal Software Costs				*$ -*
Contingency			*15%*	*$ -*
Software Total				***$ -***
Total Hardware and Software Costs				**$ 74,750**
Admin/QC			10%	$ 16,275
Misc Expenses				$ 5,000
Total				**$ 184,000**

HW-14

Implement CKTP Automation Improvements

Hardware Items	Qty	Unit Prices	Extended
PLC Panel	1	$ 50,000	$ 50,000
Associated Odor Control Instrumentation	1	$ 25,000	$ 25,000
Low Level Switch	1	$ 500	$ 500
Hardware Subtotal			$ 75,500
Software Items			
Software Subtotal			$ -
Totals	3	$ 75,500	$ 75,500

Installation/ Configuration	Qty	Unit Price	Extended
PLC Programing	2	$ 12,000	$ 24,000
HMI Configuration	4	$ 5,000	$ 20,000

Subtotal Configuration, Programming and Startup		*$ 44,000*
Contingency	10%	*$ 4,400*
Total Configuration, Programming and Startup		***$ 48,400***
Subtotal Hardware Costs		*$ 75,500*
Contingency	*15%*	*$ 11,325*
Hardware Total		***$ 86,825***
Subtotal Software Costs		*$ -*
Contingency	*15%*	*$ -*
Software Total		***$ -***
Total Hardware and Software Costs		**$ 86,825**
Admin/QC	10%	$ 13,523
Misc Expenses		$ 5,000
Total		**$ 154,000**

HW-15					
Implement KWWTP Instrumentation Improvements					
Hardware Items	**Qty**	**Unit Prices**	**Extended**		
Flowmeter 2" Pipe(Magmeter)	2	$ 2,500	$ 5,000		
Flowmeter 3" Pipe(Magmeter)	1	$ 3,000	$ 3,000		
Flowmeter 4" Pipe(Magmeter)	1	$ 3,500	$ 3,500		
Flowmeter 6" Pipe(Magmeter)	1	$ 4,000	$ 4,000		
Suspended Solids Probe	2	$ 8,000	$ 16,000		
Hardware Subtotal			$ 31,500		
Software Items					
Software Subtotal			$ -		
Totals	7	$ 21,000	$ 31,500		
Installation/ Configuration	**Qty**	**Unit Price**	**Extended**		
Installation of instruments	7	$ 5,000	$ 35,000		
PLC Programming	1	$ 10,000	$ 10,000		
HMI Configuration	1	$ 5,000	$ 5,000		
Subtotal Configuration, Programming and Startup					*$ 50,000*
Contingency				10%	*$ 5,000*
Total Configuration, Programming and Startup					***$ 55,000***
Subtotal Hardware Costs					*$ 31,500*
Contingency				*15%*	*$ 4,725*
Hardware Total					***$ 36,225***
Subtotal Software Costs					*$ -*
Contingency				*15%*	*$ -*
Software Total					***$ -***
Total Hardware and Software Costs					**$ 36,225**
Admin/QC				10%	$ 9,123
Misc Expenses					$ 5,000
Total					**$ 105,000**

HW-16

Implement KWWTP Automation Improvements

Hardware Items	Qty	Unit Prices	Extended
	0	$ -	$ -
Hardware Subtotal			$ -
Software Items			
Software Subtotal			$ -
Totals	0	$ -	$ -

Installation/ Configuration	Qty	Unit Price	Extended
PLC Programing	2	$ 6,000	$ 12,000
HMI Configuration	4	$ 5,000	$ 20,000

Subtotal Configuration, Programming and Startup		*$ 32,000*
Contingency	10%	*$ 3,200*
Total Configuration, Programming and Startup		***$ 35,200***
Subtotal Hardware Costs		*$ -*
Contingency	*15%*	*$ -*
Hardware Total		***$ -***
Subtotal Software Costs		*$ -*
Contingency	*15%*	*$ -*
Software Total		***$ -***
Total Hardware and Software Costs		***$ -***

Admin/QC	10%	$ 3,520
Misc Expenses		
Total		**$ 39,000**

HW-17			
Implement MWWTP Instrumentation Improvements			
Hardware Items	**Qty**	**Unit Prices**	**Extended**
Flowmeter 2" Pipe(Magmeter)	1	$ 2,500	$ 2,500
Flowmeter 3" Pipe(Magmeter)	4	$ 3,000	$ 12,000
Flowmeter 4" Pipe(Magmeter)	1	$ 3,500	$ 3,500
Flowmeter 6" Pipe(Magmeter)	1	$ 4,000	$ 4,000
Level Transmitter	1	$ 3,000	$ 3,000
Lower Explosive Limit Transmitter	3	$ 5,000	$ 15,000
Suspended Solids Probe	2	$ 8,000	$ 16,000
Hardware Subtotal			$ 56,000
Software Items			
Software Subtotal			$ -
Totals	13	$ 29,000	$ 56,000

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**
Installation of instruments	13	$ 5,000	$ 65,000
PLC Programming	1	$ 10,000	$ 10,000
HMI Configuration	1	$ 5,000	$ 5,000

Subtotal Configuration, Programming and Startup		*$ 80,000*
Contingency	10%	*$ 8,000*
Total Configuration, Programming and Startup		***$ 88,000***
Subtotal Hardware Costs		*$ 56,000*
Contingency	*15%*	*$ 8,400*
Hardware Total		***$ 64,400***
Subtotal Software Costs		*$ -*
Contingency	*15%*	*$ -*
Software Total		***$ -***
Total Hardware and Software Costs		**$ 64,400**

Admin/QC	10%	$ 15,240
Misc Expenses		$ 5,000
	Total	**$ 173,000**

HW-18					
Implement MWWTP Automation Improvements					
Hardware Items	**Qty**	**Unit Prices**	**Extended**		
	0	$ -	$ -		
Hardware Subtotal			$ -		
Software Items					
Software Subtotal			$ -		
Totals	0	$ -	$ -		
Installation/ Configuration	**Qty**	**Unit Price**	**Extended**		
PLC Programing	4	$ 6,000	$ 24,000		
HMI Configuration	4	$ 5,000	$ 20,000		
Wiring a Fault Signal from Starter to IO panel	1	$ 500	$ 500		
				Subtotal Configuration, Programming and Startup	*$ 44,500*
			Contingency	10%	*$ 4,500*
				Total Configuration, Programming and Startup	***$ 49,000***
				Subtotal Hardware Costs	*$ -*
			Contingency	*15%*	*$ -*
				Hardware Total	***$ -***
				Subtotal Software Costs	*$ -*
			Contingency	*15%*	*$ -*
				Software Total	***$ -***
				Total Hardware and Software Costs	***$ -***
Admin/QC				10%	$ 4,900
Misc Expenses					
				Total	**$ 54,000**

HW-19

Implement SWWTP Instrumentation Improvements

Hardware Items	Qty	Unit Prices	Extended
Flowmeter 3" Pipe(Magmeter)	2	$ 3,000	$ 6,000
Flowmeter 6" Pipe(Magmeter)	1	$ 4,000	$ 4,000
Level Transmitter	1	$ 3,000	$ 3,000
Lower Explosive Limit Transmitter	1	$ 5,000	$ 5,000
Suspended Solids Probe	2	$ 8,000	$ 16,000
DO Probes	2	$ 2,000	$ 4,000
Hardware Subtotal			$ 38,000
Software Items			
Software Subtotal			$ -
Totals	9	$ 25,000	$ 38,000

Installation/ Configuration	Qty	Unit Price	Extended
Installation of instruments	9	$ 5,000	$ 45,000
PLC Programming	1	$ 10,000	$ 10,000
HMI Configuration	1	$ 5,000	$ 5,000

Subtotal Configuration, Programming and Startup		*$ 60,000*
Contingency	10%	*$ 6,000*
Total Configuration, Programming and Startup		***$ 66,000***
Subtotal Hardware Costs		*$ 38,000*
Contingency	*15%*	*$ 5,700*
Hardware Total		***$ 43,700***
Subtotal Software Costs		*$ -*
Contingency	*15%*	*$ -*
Software Total		***$ -***
Total Hardware and Software Costs		**$ 43,700**

Admin/QC	10%	$ 10,970
Misc Expenses		$ 5,000
Total		**$ 126,000**

HW-20				
Implement SWWTP Automation Improvements				
Hardware Items	**Qty**	**Unit Prices**	**Extended**	
	0	$ -	$ -	
Hardware Subtotal			$ -	
Software Items				
Software Subtotal			$ -	
Totals	0	$ -	$ -	
Installation/ Configuration	**Qty**	**Unit Price**	**Extended**	
PLC Programing	4	$ 6,000	$ 24,000	
HMI Configuration	2	$ 5,000	$ 10,000	
High Discharge Pressure Troubleshooting	1	$ 6,000	$ 6,000	
Subtotal Configuration, Programming and Startup				*$ 40,000*
Contingency			10%	*$ 4,000*
Total Configuration, Programming and Startup				***$ 44,000***
Subtotal Hardware Costs				*$ -*
Contingency			*15%*	*$ -*
Hardware Total				***$ -***
Subtotal Software Costs				*$ -*
Contingency			*15%*	*$ -*
Software Total				***$ -***
Total Hardware and Software Costs				***$ -***
Admin/QC			10%	$ 4,400
Misc Expenses				
Total				**$ 48,000**

HW-21

Implement Remote Pump Station Instrumentation Improvements

Hardware Items		Qty	Unit Prices	Extended
Pressure Transmitter		12	$ 3,600	$ 43,200
Level Transmitter		2	$ 3,000	$ 6,000
Level Transducer		1	$ 1,000	$ 1,000
Lower Explosive Limit Transmitter		2	$ 5,000	$ 10,000
	Hardware Subtotal			$ 60,200
Software Items				
	Software Subtotal			$ -
	Totals	17	$ 12,600	$ 60,200

Installation/ Configuration	Qty	Unit Price	Extended
Installation of instruments	17	$ 5,000	$ 85,000
PLC Programming	1	$ 10,000	$ 10,000
HMI Configuration	1	$ 5,000	$ 5,000

Subtotal Configuration, Programming and Startup		*$ 100,000*
Contingency	10%	*$ 10,000*
Total Configuration, Programming and Startup		***$ 110,000***
Subtotal Hardware Costs		*$ 60,200*
Contingency	*15%*	*$ 9,030*
Hardware Total		***$ 69,230***
Subtotal Software Costs		*$ -*
Contingency	*15%*	*$ -*
Software Total		***$ -***
Total Hardware and Software Costs		**$ 69,230**

Admin/QC	10%	$ 17,923
Misc Expenses		$ 5,000
Total		**$ 202,000**

HW-22					
Implement Remote Pump Station Automation Improvements					
Hardware Items	**Qty**	**Unit Prices**	**Extended**		
	0	$ -	$ -		
Hardware Subtotal			$ -		
Software Items					
Software Subtotal			$ -		
Totals	0	$ -	$ -		
Installation/ Configuration	**Qty**	**Unit Price**	**Extended**		
PLC Programing	5	$ 6,000	$ 30,000		
HMI Configuration	4	$ 5,000	$ 20,000		
Subtotal Configuration, Programming and Startup					*$ 50,000*
Contingency				10%	*$ 5,000*
Total Configuration, Programming and Startup					***$ 55,000***
Subtotal Hardware Costs					*$ -*
Contingency				*15%*	*$ -*
Hardware Total					***$ -***
Subtotal Software Costs					*$ -*
Contingency				*15%*	*$ -*
Software Total					***$ -***
Total Hardware and Software Costs					**$ -**
Admin/QC				10%	$ 5,500
Misc Expenses					
Subtotal					**$ 61,000**

SW-23

Upgrade WWTP Standalone SCADA HMI Installations to AVEVA System Platform with Managed InTouch Applications and Standardized Templates Based on HPHMI Concepts

Hardware Items		Qty	Unit Prices	Extended
		0	$ -	$ -
	Hardware Subtotal			$ -
Software Items				
		0	$ -	$ -
	Software Subtotal			$ -
	Totals	0	$ -	$ -

Installation/ Configuration	Qty	Unit Price	Extended

Subtotal Configuration, Programming and Startup		$ -
Contingency	10%	
Total Configuration, Programming and Startup		
Subtotal Hardware Costs		$ -
Contingency	*15%*	$ -
Hardware Total		**$ -**
Subtotal Software Costs		$ -
Contingency	*15%*	$ -
Software Total		**$ -**
Total Hardware and Software Costs		**$ -**

Admin/QC	10%	$ -
Misc Expenses		
Funded and in Progress	***Total***	**$ -**

WWTP = 1 PLC/week *150
REMOTE = 4 PLC/week *150

SW-24

Implement an Alarm Management Program Based on ISA-18.2

Hardware Items	**Qty**	**Unit Prices**	**Extended**
	0	$ -	$ -
Hardware Subtotal			$ -
Software Items			
	0	$ -	$ -
Software Subtotal			$ -
Totals	0	$ -	$ -

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**
Workshops to Review Current Alarm Classifications	1	$ 5,000	$ 5,000
HMI/Historian Configuration	1	$ 40,000	$ 40,000

Subtotal Configuration, Programming and Startup		*$ 45,000*
Contingency	10%	*$ 4,500*
Total Configuration, Programming and Startup		***$ 49,500***
Subtotal Hardware Costs		*$ -*
Contingency	*15%*	*$ -*
Hardware Total		***$ -***
Subtotal Software Costs		*$ -*
Contingency	*15%*	*$ -*
Software Total		***$ -***
Total Hardware and Software Costs		***$ -***

Admin/QC	10%	$ 4,950
Misc Expenses		
Total		**$ 54,000**

SW-25

Establish a Tiered Historian Implementation at CKTP

Hardware Items	**Qty**	**Unit Prices**	**Extended**
	0	$ -	$ -
Hardware Subtotal			$ -
Software Items			
Enterprise Historian License (25,000 tags)	1	$ 53,000	$ 53,000
2 Additional Historian Web Client License	2	$ 1,690	$ 3,380
Software Subtotal			$ 56,380
Totals	1	$ 53,000	$ 56,380

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**		
Workshops to determine data to go to Tier 2 Historian	1	$ 5,000	$ 5,000		
Historian Configuration	1	$ 10,000	$ 10,000		
Subtotal Configuration, Programming and Startup					*$ 15,000*
Contingency				10%	*$ 1,500*
Total Configuration, Programming and Startup					***$ 16,500***
Subtotal Hardware Costs					*$ -*
Contingency				*15%*	*$ -*
Hardware Total					***$ -***
Subtotal Software Costs					*$ 56,380*
Contingency				*15%*	*$ 8,457*
Software Total					***$ 64,837***
Total Hardware and Software Costs					**$ 64,837**
Admin/QC				10%	$ 8,134
Misc Expenses					$ -
Total					**$ 89,000**

Annual Cost for Enterprise Historian License	$10,600
Annual cost for 2 Historian Web Client Licenses	$338
Total	$10,938

SW-26					
Broaden The Data Set Archived by the Sewer Utility Historian					
Hardware Items	**Qty**	**Unit Prices**	**Extended**		
	0	$ -	$ -		
Hardware Subtotal			$ -		
Software Items					
	0	$ -	$ -		
Software Subtotal			$ -		
Totals	0	$ -	$ -		
Installation/ Configuration	**Qty**	**Unit Price**	**Extended**		
Site/PLC Program Investigation of current available signals	1	$ 27,000	$ 27,000		
Workshops to select parameters from findings	1	$ 5,000	$ 5,000		
Historian Configuration	4	$ 7,500	$ 30,000		
Subtotal Configuration, Programming and Startup					*$ 62,000*
Contingency				10%	*$ 6,200*
Total Configuration, Programming and Startup					***$ 68,200***
Subtotal Hardware Costs					*$ -*
Contingency				*15%*	*$ -*
Hardware Total					***$ -***
Subtotal Software Costs					*$ -*
Contingency				*15%*	*$ -*
Software Total					***$ -***
Total Hardware and Software Costs					***$ -***
Admin/QC				10%	$ 6,820
Misc Expenses					$ -
Total					**$ 75,000**

(1 PLC/day for 4.5 weeks (*40hrs))*150= Cost

DC-27A

Develop ICS Standards (Hardware)

Hardware Items	**Qty**	**Unit Prices**	**Extended**
Tablets	5	$ 1,000	$ 5,000
Hardware Subtotal			$ 5,000
Software Items			
	0	$ -	$ -
Software Subtotal			$ -
Totals	5	$ 1,000	$ 5,000

Installation/ Configuration	**Qty**	**Unit Price**	A **Extended**
SCADA Control Panel Std	1	$ 34,996	$ 34,996
SCADA Instrument and Vendor Communication Std	1	$ 28,116	$ 28,116
SCADA Network Design and Hardware Std	1	$ 30,300	$ 30,300
SCADA Equipment Procurement Std	1	$ 24,188	$ 24,188

Subtotal Configuration, Programming and Startup		*$ 117,600*
Contingency	10%	*$ 11,800*
Total Configuration, Programming and Startup		***$ 129,400***
Subtotal Hardware Costs		*$ 5,000*
Contingency	*15%*	*$ 750*
Hardware Total		***$ 5,750***
Subtotal Software Costs		*$ -*
Contingency	*15%*	*$ -*
Software Total		***$ -***
Total Hardware and Software Costs		**$ 5,750**

Admin/QC	10%	$ 13,515
Misc Expenses		$ 5,000
Total		**$ 154,000**

DC-27B			
Develop ICS Standards and Governance Documents			
Hardware Items	**Qty**	**Unit Prices**	**Extended**
Hardware Subtotal			$ -
Software Items			
	0	$ -	$ -
Software Subtotal			$ -
Totals	0	$ -	$ -

Installation/ Configuration	**Qty**	**Unit Price**	A **Extended**
SCADA Application Programming Std for PLCs	1	$ 70,924	$ 70,924
HMI Software and Architecture Std	1	$ 19,774	$ 19,774
SCADA Application Programming Std for HMI	1	$ 67,624	$ 67,624
SCADA Data Historization and Archiving Std	1	$ 30,140	$ 30,140
SCADA Cybersecurity and Network Monitoring Std	1	$ 35,868	$ 35,868
SCADA Software Management and Revision Control Std	1	$ 31,068	$ 31,068
Staff Roles and Skills Development Std	1	$ 24,796	$ 24,796

Subtotal Configuration, Programming and Startup		*$ 280,200*
Contingency	10%	*$ 28,100*
Total Configuration, Programming and Startup		***$ 308,300***
Subtotal Hardware Costs		*$ -*
Contingency	*15%*	*$ -*
Hardware Total		***$ -***
Subtotal Software Costs		*$ -*
Contingency	*15%*	*$ -*
Software Total		***$ -***
Total Hardware and Software Costs		***$ -***

Admin/QC	10%	$ 30,830
Misc Expenses		$ 5,000
Total		**$ 344,000**

DC-28

Develop and Maintain Control Strategy Documentation

Hardware Items	Qty	Unit Prices	Extended
	0	$ -	$ -
Hardware Subtotal			$ -
Software Items			
	0	$ -	$ -
Software Subtotal			$ -
Totals	0	$ -	$ -

Installation/ Configuration	Qty	Unit Price	Extended		
Process Assessments for the WWTPs/Pumpstations	1	$ 138,000	$ 138,000		
Workshops to review findings	4	$ 5,000	$ 20,000		
Finalize Control Strategies for WWTPs and Pump stations	1	$ 30,000	$ 30,000		
Subtotal Configuration, Programming and Startup					*$ 138,000*
Contingency				10%	*$ 13,800*
Total Configuration, Programming and Startup					***$ 151,800***
Subtotal Hardware Costs					*$ -*
Contingency				*15%*	*$ -*
Hardware Total					***$ -***
Subtotal Software Costs					*$ -*
Contingency				*15%*	*$ -*
Software Total					***$ -***
Total Hardware and Software Costs					***$ -***

Admin/QC	10%	$ 15,180
Misc Expenses		
Total		**$ 167,000**

(1 PLC/week for (23PLCs) (*40hrs))*150= Cost

OS-29

Complete Hach WIMS Implementation and Establish Data Exchange with AVEVA System Platform

Hardware Items		**Qty**	**Unit Prices**	**Extended**
		0	$ -	$ -
	Hardware Subtotal			$ -
Software Items				
		0	$ -	$ -
	Software Subtotal			$ -
	Totals	0	$ -	$ -

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**
Sewer Utility will handle internally	1	$ 5,000	$ 5,000

Subtotal Configuration, Programming and Startup		*$ 5,000*
Contingency	10%	
Total Configuration, Programming and Startup		
Subtotal Hardware Costs		*$ -*
Contingency	*15%*	*$ -*
Hardware Total		***$ -***
Subtotal Software Costs		*$ -*
Contingency	*15%*	*$ -*
Software Total		***$ -***
Total Hardware and Software Costs		***$ -***

Admin/QC	10%	$ -
Misc Expenses		
Total		***$ -***

2 weeks (40hr)*150 = Cost

OS-30

Complete Asset Creation and Data Entry Required for LLumin Implementation, Establish Automatic Importing of Asset Runtimes, and Develop a Plan for Automating Work Order Generation

Hardware Items	**Qty**	**Unit Prices**	**Extended**
	0	$ -	$ -
Hardware Subtotal			$ -
Software Items			
Software Subtotal			$ -
Totals	0	$ -	$ -

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**		
Workshops to determine Data	2	$ 5,000	$ 10,000		
Pilot Project connecting Tier 2 Historian to Llumin	1	$ 24,000	$ 24,000		
Add additional Data from Tier 2 historian to Llumin	1	$ 12,000	$ 12,000		
Establish connection from Llumin to AVEVA System Platform	1	$ 24,000	$ 24,000		
Integration with Cartagraph	1	$ 250,000	$ 250,000		
Subtotal Configuration, Programming and Startup					*$ 320,000*
Contingency				10%	*$ 32,000*
Total Configuration, Programming and Startup					***$ 352,000***
Subtotal Hardware Costs					*$ -*
Contingency				*15%*	*$ -*
Hardware Total					***$ -***
Subtotal Software Costs					*$ -*
Contingency				*15%*	*$ -*
Software Total					***$ -***
Total Hardware and Software Costs					***$ -***
Admin/QC				10%	$ 35,200
Misc Expenses					
Total					**$ 387,000**

4 weeks (40hr)*150 = Cost

OS-31					
Begin Leveraging the Sewer Utility's Power and Energy Data					
Hardware Items	**Qty**	**Unit Prices**	**Extended**		
		$ -	$ -		
Hardware Subtotal			$ -		
Software Items					
		$ -	$ -		
Software Subtotal			$ -		
Totals	0	$ -	$ -		
Installation/ Configuration	**Qty**	**Unit Price**	**Extended**		
Integrate existing PQMs to AVEVA System Platform	11	$ 1,000	$ 11,000		
Workshops/Develop KPI Dashboard	1	$ 6,000	$ 6,000		
Subtotal Configuration, Programming and Startup				$	*17,000*
Contingency			*10%*	$	*1,700*
Total Configuration, Programming and Startup				***$***	***18,700***
Subtotal Hardware Costs				$	-
Contingency			*15%*	$	-
Hardware Total				***$***	**-**
Subtotal Software Costs				$	-
Contingency			*15%*	$	-
Software Total				***$***	**-**
Total Hardware and Software Costs				***$***	**-**
Admin/QC			10%	$	1,870
Misc Expenses					
Total				***$***	**21,000**

NA-32

Relocate Network Rack in Solids Processing Building

Hardware Items		**Qty**	**Unit Prices**	**Extended**
PLC Panel	$	1	$ 50,000	$ 50,000
Hardware Subtotal				$ 50,000
Software Items				
		0	$ -	$ -
Software Subtotal				$ -
Totals		1	$ 50,000	$ 50,000

Installation/ Configuration	**Qty**	**Unit Price**	**Extended**
Building Assessment and Engineering a room (HVAC and cabling)	1	$ 50,000	$ 50,000

Subtotal Configuration, Programming and Startup		$	*50,000*
Contingency	10%	$	*5,000*
Total Configuration, Programming and Startup		***$***	***55,000***
Subtotal Hardware Costs		$	*50,000*
Contingency	*15%*	$	*7,500*
Hardware Total		***$***	***57,500***
Subtotal Software Costs		$	-
Contingency	*15%*	$	-
Software Total		***$***	**-**
Total Hardware and Software Costs		**$**	**57,500**

Admin/QC	10%	$	11,250
Misc Expenses			
Total		**$**	**124,000**

B

Appendix B – Schedule

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ID		Task Mode	Task Name	Duration	Start	Finish	Predecessors
1			**SCADA Master Plan**	**1745 days**	**Mon 1/9/23**	**Fri 9/14/29**	
2			**Quick Wins & Immediate Needs**	**1565 days**	**Mon 1/9/23**	**Fri 1/5/29**	
3			DC-27A SCADA Standards - Hardware	4 mons	Mon 1/9/23	Fri 4/28/23	
4			HW-8 Prioritize PLC & OIT for EOL replacement	2 mons	Mon 5/1/23	Fri 6/23/23	3
5			HW-10 Develop Instrument Cal and Maint Program	3 mons	Tue 6/6/23	Mon 8/28/23	3
6			NA-1 Upgrade CKTP Control Room	12 mons	Mon 5/1/23	Fri 3/29/24	3
7			DC-28 Control Strategy Documentation	18 mons	Tue 6/6/23	Mon 10/21/24	3
8			SW-23 WWTP Standalone to AVEVA SP Managed Intouch Apps	0.05 mons	Mon 1/9/23	Mon 1/9/23	
9			**Near Term Improvement**	**1305 days**	**Mon 1/8/24**	**Fri 1/5/29**	
10			DC-27B SCADA Standards - Software/Governance	6 mons	Mon 1/8/24	Fri 6/21/24	3
11			NA-32 Relocate Network Rack in Solids Processing Building	3 mons	Mon 6/24/24	Fri 9/13/24	3,10
12			NA-4 CKTP OT Network Upgrades	6 mons	Mon 9/16/24	Fri 2/28/25	10,11
13			NA-2 Extend OT Network to PW Annex	3 mons	Mon 8/5/24	Fri 10/25/24	
14			NA-5 Standardization to Managed Switches	2 mons	Mon 9/16/24	Fri 11/8/24	11
15			NA-6 ICS and OT Network PS Improvements	6 mons	Mon 3/3/25	Fri 8/15/25	12,10
16			SW-26 Broaden Data Set at CKTP Tier 1 Historian	9 mons	Mon 3/3/25	Fri 11/7/25	7,12,10
17			HW-13 CKTP Instrumentation Improvements	18 mons	Mon 3/3/25	Fri 7/17/26	7,12,3,10
18			NA-3 Remote PS and WWTP Telementry Improvements	24 mons	Mon 5/26/25	Fri 3/26/27	3,12,14,10
19			SW-24 Alarm Management Program Based on ISA 18.2	6 mons	Mon 6/2/25	Fri 11/14/25	3,12,6,10
20			NA-7 DMZ and AVEVA Intouch Access Anywhere Imp	12 mons	Mon 8/18/25	Fri 7/17/26	3,12,15,6,10
21			HW-12 Integrate Sampler A&M for New Samplers	6 mons	Mon 11/17/25	Fri 5/1/26	19,3,10

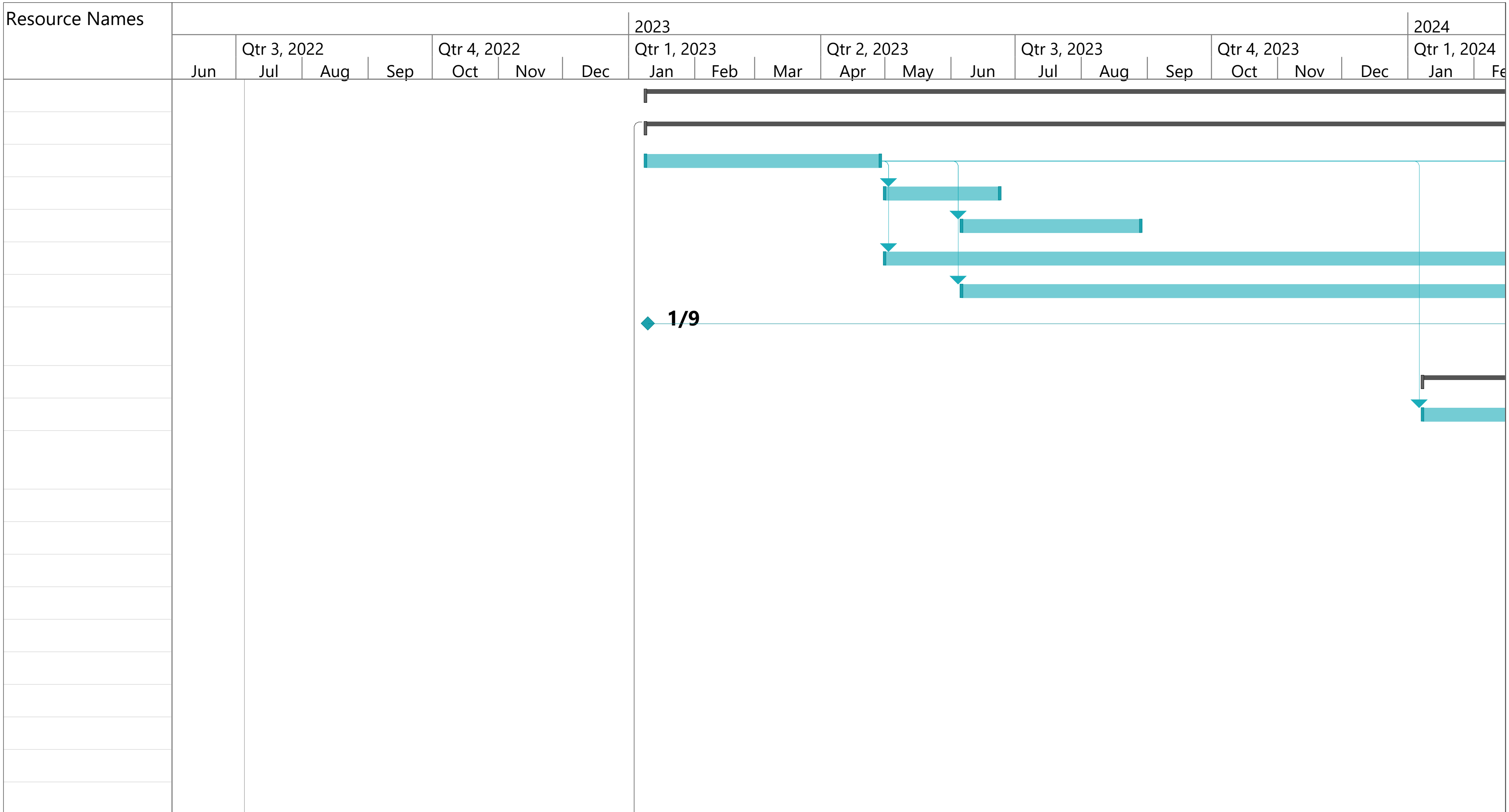
Project: SCADA Master Plan Pro
Date: Mon 5/23/22

Task	Inactive Summary	External Tasks
Split	Manual Task	External Milestone
Milestone	Duration-only	Deadline
Summary	Manual Summary Rollup	Progress
Project Summary	Manual Summary	Manual Progress
Inactive Task	Start-only	
Inactive Milestone	Finish-only	

ID		Task Mode	Task Name	Duration	Start	Finish	Predecessors
22			HW-9 Replace CKTP MCC DeviceNet	9 mons	Mon 1/5/26	Fri 9/11/26	12,3,10
23			SW-25 Tiered Historian at CKTP	3 mons	Mon 7/20/26	Fri 10/9/26	3,20,13,10
24			HW-14 CKTP Automation Improvements	12 mons	Mon 7/20/26	Fri 6/18/27	3,12,7,17,10
25			HW-15 KWWTP Instrumentation Improvements	6 mons	Mon 7/20/26	Fri 1/1/27	3,12,7,10
26			HW-17 MWWTP Instrumentation Improvements	12 mons	Mon 8/10/26	Fri 7/9/27	3,12,7,10
27			HW-16 KWWTP Automation Improvments	6 mons	Mon 1/4/27	Fri 6/18/27	3,12,20,7,25,10
28			HW-19 SWWTP Instrumentation Improvements	12 mons	Mon 2/8/27	Fri 1/7/28	3,12,7,10
29			HW-21 Remote PS Intrumentation Improvements	6 mons	Mon 4/12/27	Fri 9/24/27	3,12,7,10
30			HW-18 MWWTP Automation Improvements	6 mons	Mon 7/12/27	Fri 12/24/27	3,12,20,7,10,26
31			HW-22 Remote PS Automation Improvements	12 mons	Tue 1/11/28	Mon 12/11/28	3,12,20,7,10,29
32			HW-20 SWWTP Automation Improvements	6 mons	Mon 1/24/28	Fri 7/7/28	3,12,20,7,10,28
33			HW-11 CKTP Digester Bldg PNL 6000 Replacement	12 mons	Mon 2/7/28	Fri 1/5/29	3,12,10
34			OS-31 Power and Energy Data Integration to SCADA	3 mons	Mon 3/20/28	Fri 6/9/28	3,12,8,10
35			**Long Term Improvement**	**180 days**	**Mon 1/8/29**	**Fri 9/14/29**	**2SS+60 mons**
36			OS-30 Llumin integration with Tier 2 Historian/System Platform	6 mons	Mon 1/8/29	Fri 6/22/29	3,12,20,23,29,10
37			OS-29 Hach WIMS Implementation Data Exchange with AVEVA SP	3 mons	Mon 6/25/29	Fri 9/14/29	3,12,20,23,36,10

Project: SCADA Master Plan Pro
Date: Mon 5/23/22

Task	Inactive Summary	External Tasks
Split	Manual Task	External Milestone
Milestone	Duration-only	Deadline
Summary	Manual Summary Rollup	Progress
Project Summary	Manual Summary	Manual Progress
Inactive Task	Start-only	
Inactive Milestone	Finish-only	



Project: SCADA Master Plan Pro
Date: Mon 5/23/22

Task	Inactive Summary	External Tasks
Split	Manual Task	External Milestone
Milestone	Duration-only	Deadline
Summary	Manual Summary Rollup	Progress
Project Summary	Manual Summary	Manual Progress
Inactive Task	Start-only	
Inactive Milestone	Finish-only	

Resource Names	2023								2024
	Qtr 3, 2022	Qtr 4, 2022	Qtr 1, 2023	Qtr 2, 2023	Qtr 3, 2023	Qtr 4, 2023	Qtr 1, 2024		

Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Fe

Project: SCADA Master Plan Pro
Date: Mon 5/23/22

Task	Inactive Summary	External Tasks
Split	Manual Task	External Milestone
Milestone	Duration-only	Deadline
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Inactive Task	Start-only	
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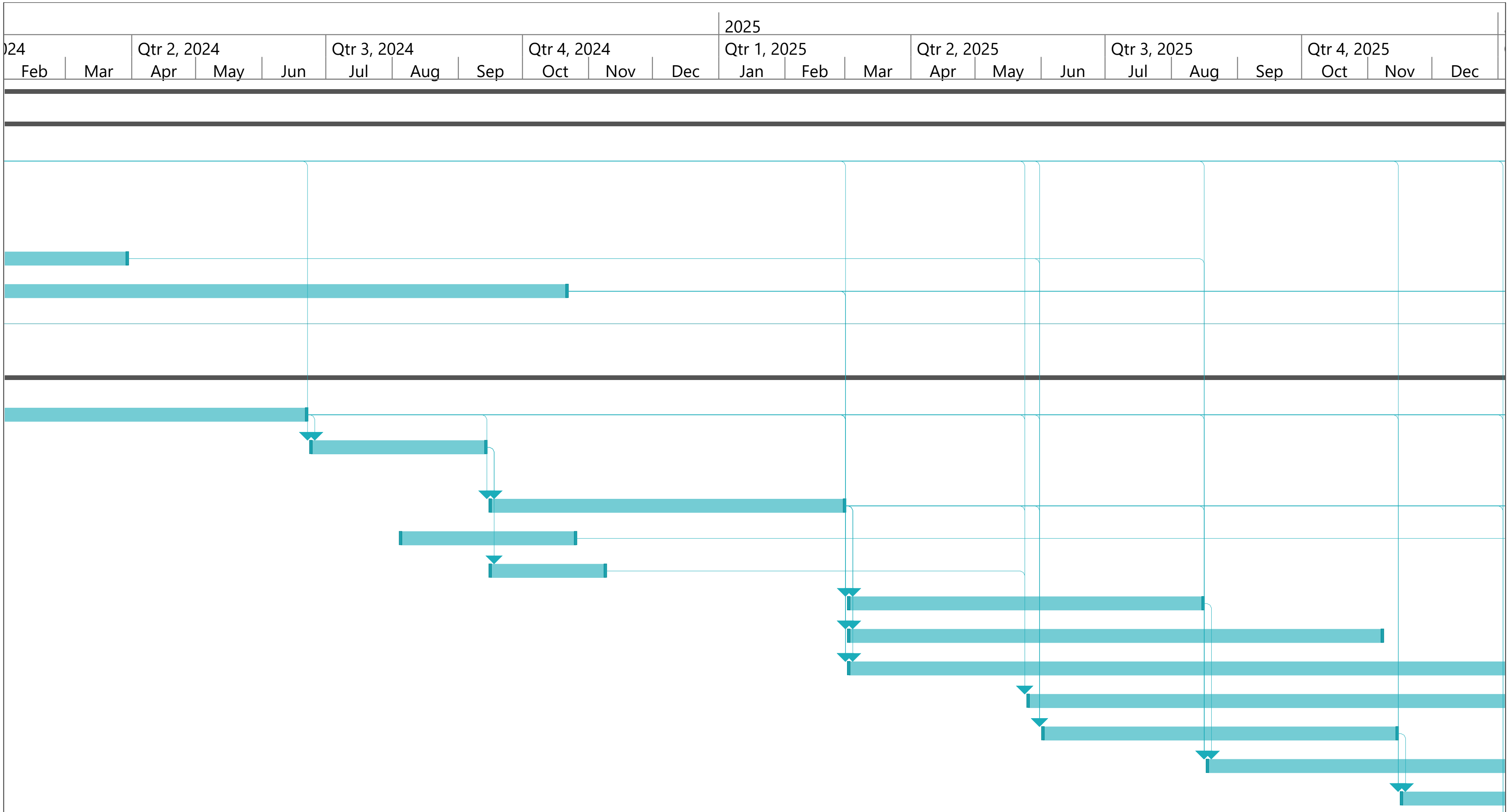

Project: SCADA Master Plan Pro
Date: Mon 5/23/22

Task	Inactive Summary	External Tasks
Split	Manual Task	External Milestone
Milestone	Duration-only	Deadline
Summary	Manual Summary Rollup	Progress
Project Summary	Manual Summary	Manual Progress
Inactive Task	Start-only	
Inactive Milestone	Finish-only	

2024											2025												
)24		Qtr 2, 2024			Qtr 3, 2024			Qtr 4, 2024			Qtr 1, 2025			Qtr 2, 2025			Qtr 3, 2025			Qtr 4, 2025			
Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	

Project: SCADA Master Plan Pro
Date: Mon 5/23/22

Task	Inactive Summary	External Tasks
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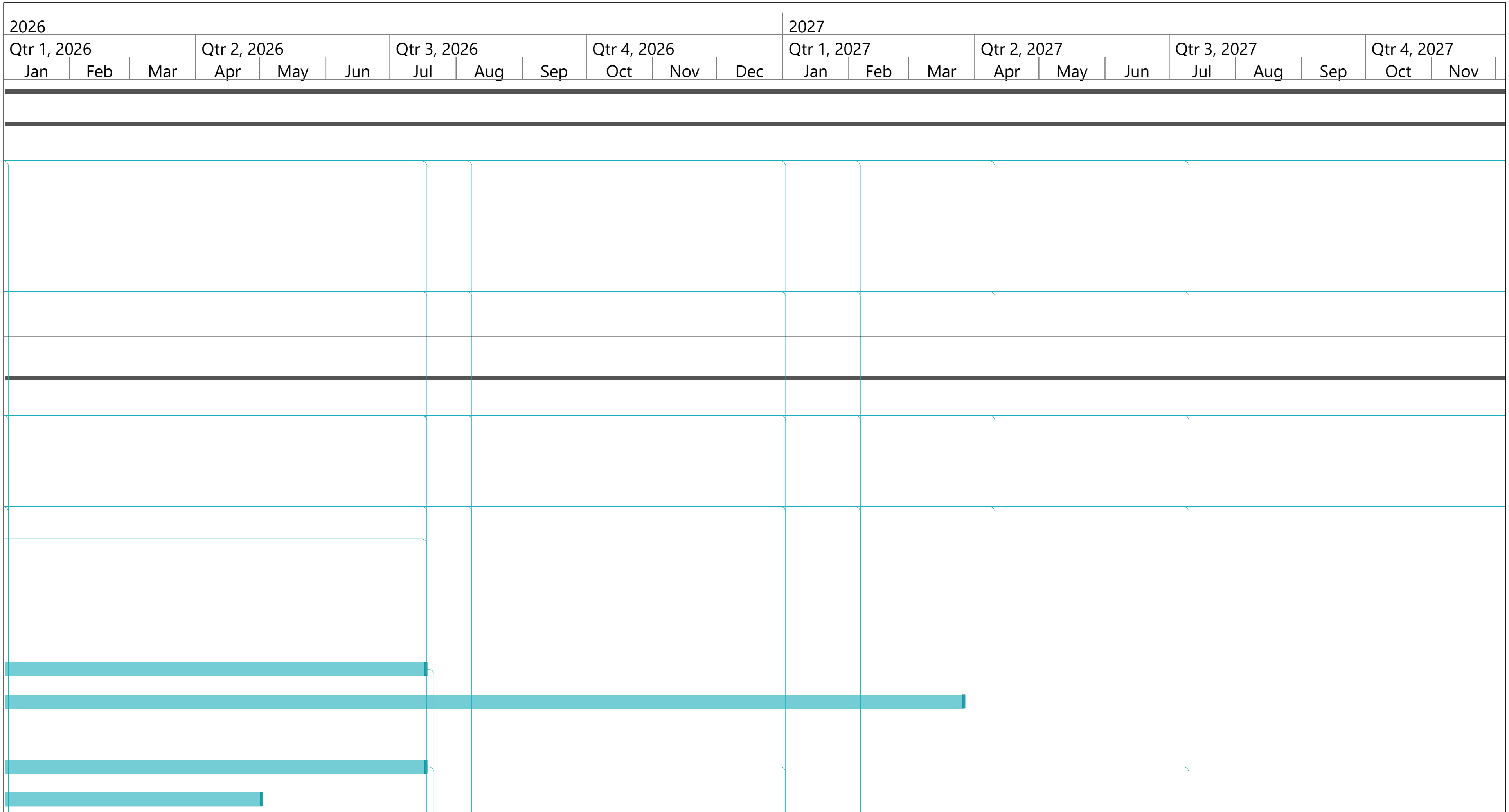

Project: SCADA Master Plan Pro
Date: Mon 5/23/22

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Split	Manual Task	External Milestone
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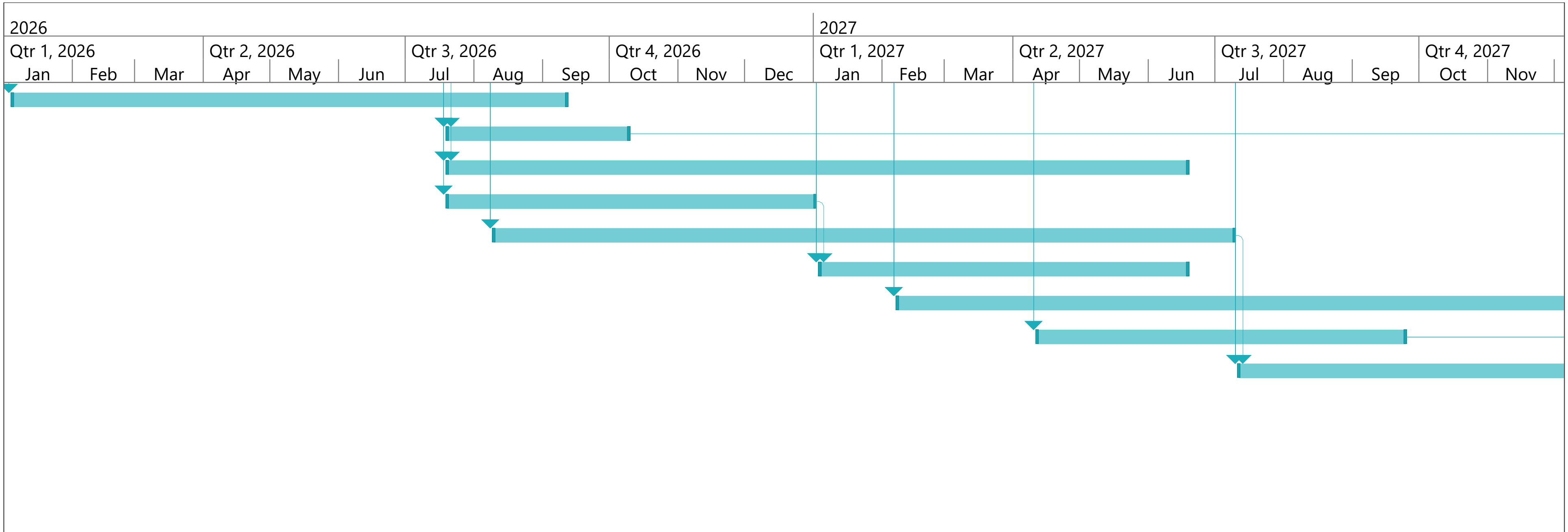

Project: SCADA Master Plan Pro
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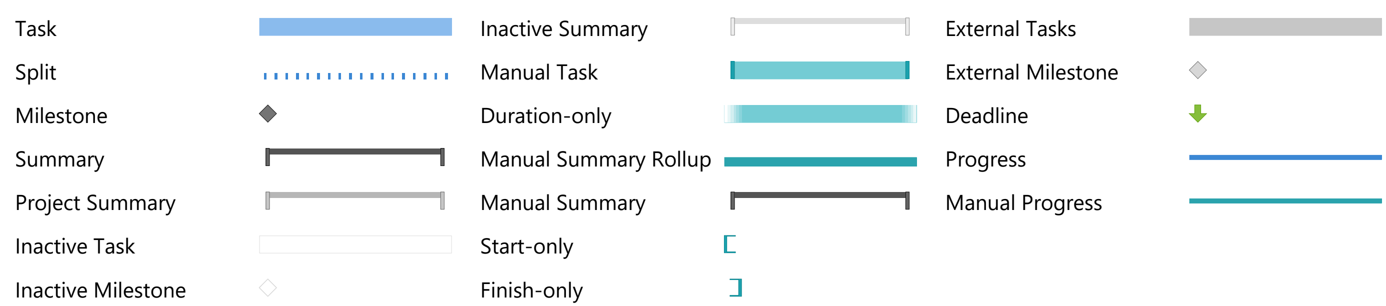

Project: SCADA Master Plan Pro
Date: Mon 5/23/22

Task	Inactive Summary	External Tasks
Split	Manual Task	External Milestone
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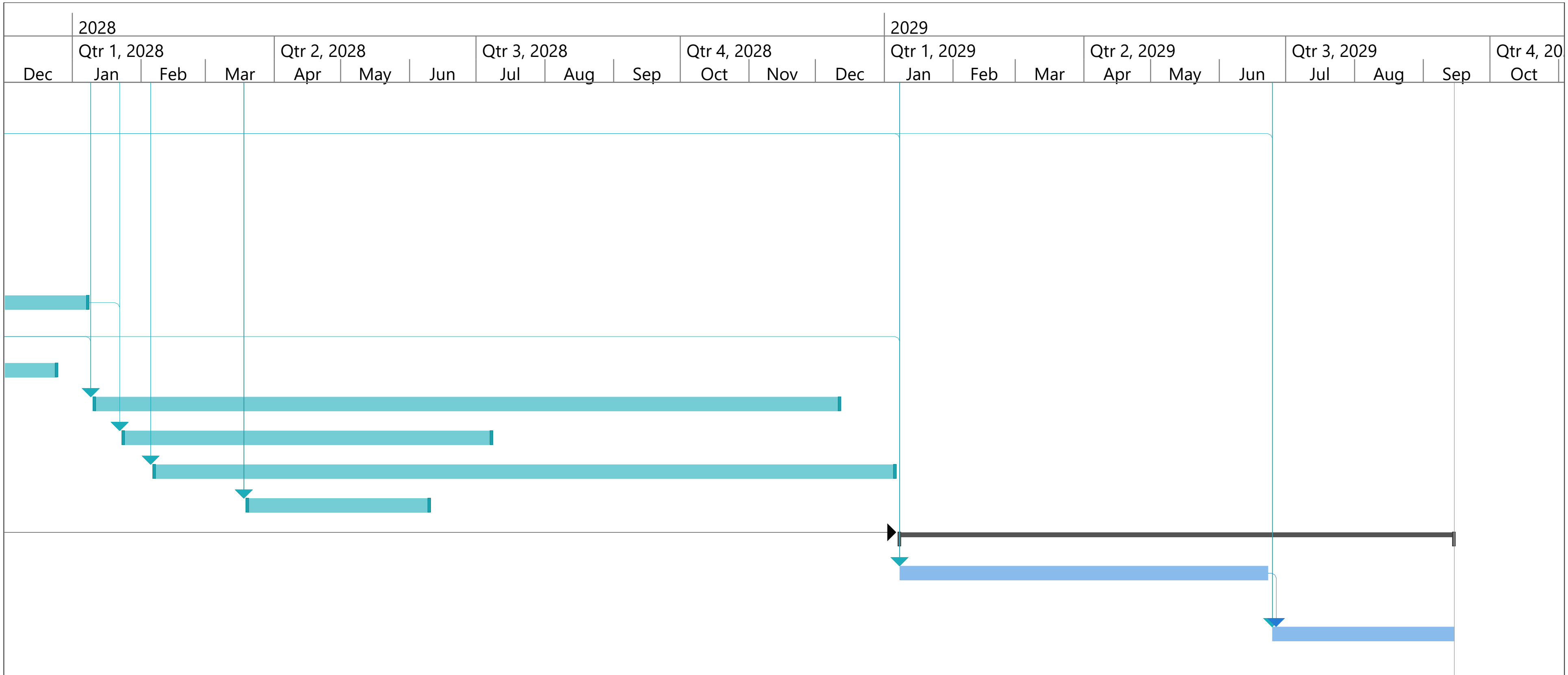


Project: SCADA Master Plan Pro
Date: Mon 5/23/22

Task		Inactive Summary		External Tasks	
Split		Manual Task		External Milestone	
Milestone		Duration-only		Deadline	
Summary		Manual Summary Rollup		Progress	
Project Summary		Manual Summary		Manual Progress	
Inactive Task		Start-only			
Inactive Milestone		Finish-only			

APPENDIX G
VISUAL HYDRAULICS
SUMMARY REPORT

Visual Hydraulics Summary Report - Hydraulic Analysis

Project: **Manchester_Existing.vhf**
Company: **Consor**
Date: **10/23/2024**

Current flow conditions

Forward Flow =	1.84 mgd
Return I Flow =	0.28 mgd
Return II Flow =	-----
Return III Flow =	-----

Section Description	Water Surface Elevation
Starting water surface elevation	**14.14**
Eff_Pipe	**14.82**

Channel shape = Circular
Manning's 'n' = 0.013
Channel length = 4 ft
Channel width/diameter = 1.5 ft
Flow = 1.84 mgd
Downstream channel invert = 13.9
Channel slope = 0.05 ft/ft
Channel side slope = not applicable
Area of flow = 0.56 ft^2
Hydraulic radius = 0.294
Normal depth = 0.36 ft
Critical depth = 0.65 ft
Depth downstream = 0.65 ft
Bend loss = 0.07 ft
Depth upstream = 0.72 ft
Velocity = 3.88 ft/s
Flow profile = Steep

Eff_Pipe_Opening **14.89**

Opening type = circular orifice
Opening diameter/width = 18 in
Opening height = not applicable
Invert = 14
Number of openings = 1

Section Description	Water Surface Elevation
Flow through opening(s) = 1.84 mgd Total area of opening(s) = 1 ft^2 Velocity through opening(s) = 2.86 ft/s Flow behavior = orifice, downstream control Orifice loss = 0.06 ft Downstream water level = 14.82 Upstream water level = 14.89	
Eff_Box	**14.89**
Channel shape = Rectangular Manning's 'n' = 0.013 Channel length = 3.33 ft Channel width/diameter = 3.33 ft Flow = 1.84 mgd Downstream channel invert = 13.5 Channel slope = 0 ft/ft Channel side slope = not applicable Area of flow = 4.62 ft^2 Hydraulic radius = 0.757 Normal depth = infinite Critical depth = 0.28 ft Depth downstream = 1.39 ft Bend loss = 0 ft Depth upstream = 1.39 ft Velocity = 0.62 ft/s Flow profile = Horizontal	
Eff_Flume	**19.75**
Flume invert = 18.5 Flume throat width = 0.5 ft Flow through flume = 1.84 mgd Flume 'm' value = 2 Flume 'e' value = 1.58 Head through flume = 1.25 ft	
UV_Eff_Weir	**20.31**
Weir invert (top of weir) = 20.22 Weir length = 34 ft Weir 'C' coefficient = 3.33 Flow over weir = 1.84 mgd Weir submergence = unsubmerged Head over weir = 0.09 ft	
UV Banks	**20.36**
Theory used = Kirschmer Rack/screen invert = 18.8	

Section Description	Water Surface Elevation
Rack/screen width = 2.5 ft Flow through rack = 1.84 mgd Bar width = 1 in Bar spacing = 2 in Bar shape = Rectangular Angle of inclination = 90 degrees Downstream depth = 1.5 ft Approach velocity = 0.73 ft/s Rack/screen head loss = 0.06 ft	
UV_Channel Channel shape = Rectangular Manning's 'n' = 0.013 Channel length = 35 ft Channel width/diameter = 2.5 ft Flow = 1.84 mgd Downstream channel invert = 18.8 Channel slope = 0 ft/ft Channel side slope = not applicable Area of flow = 3.91 ft^2 Hydraulic radius = 0.694 Normal depth = infinite Critical depth = 0.34 ft Depth downstream = 1.56 ft Bend loss = 0 ft Depth upstream = 1.56 ft Velocity = 0.73 ft/s Flow profile = Horizontal	**20.36**
Clarifiers_Common_Eff Pipe shape = Circular Diameter = 12 in Length = 38.5 ft Flow = 1.84 mgd Friction method = Manning's Equation Friction factor = 0.013 Total fitting K value = 1.2 Pipe area = 0.79 ft² Pipe hydraulic radius = 0.25 Age factor = 1 Solids factor = 1 Velocity = 3.62 ft/s Friction loss = 0.24 ft Fitting loss = 0.24 ft Total loss = 0.49 ft	**20.85**
Calrifier_Eff	

Section Description	**Water Surface Elevation**
Clarifier_1_Pipe	**21.75**

Pipe shape = Circular
Diameter = 12 in
Length = 34 ft
Flow = 1.84 mgd
Friction method = Manning's Equation
Friction factor = 0.013
Total fitting K value = 3.34
Pipe area = 0.79 ft²
Pipe hydraulic radius = 0.25
Age factor = 1
Solids factor = 1
Velocity = 3.62 ft/s
Friction loss = 0.22 ft
Fitting loss = 0.68 ft
Total loss = 0.9 ft

Clarifier_2_Pipe	**Off-line**
Clarifier 2 Launder	**Off-line**
Clarifier 2 weir	**Off-line**
Splitter box to Clarifier 2	**Off-line**
Splitter box weir to clarifier 2	**Off-line**
Clarifier 1 Launder	**21.83**

Launder invert = 19.17
Launder length = 51.83 ft
Launder width = 0.7 ft
Launder slope = 0.014 ft/ft
Flow through launder = 1.84 mgd
Critical depth = 0.8 ft
Downstream depth = 2.58 ft
Upstream depth = 1.94 ft

Clarifier 1 weir	**21.84**

Invert of V notch = 20.75
Angle of V notch = 90 degrees
Number of notches = 199
Total flow over weir = 1.84 mgd
Weir submergence = fully submerged
Head over weir = 1.09 ft

Splitter box to Clarifier 1	**22.39**

Pipe shape = Circular

Section Description	Water Surface Elevation
Diameter = 14 in	
Length = 63 ft	
Flow = 2.12 mgd	
Friction method = Manning's Equation	
Friction factor = 0.013	
Total fitting K value = 2.15	
Pipe area = 1.07 ft²	
Pipe hydraulic radius = 0.292	
Age factor = 1	
Solids factor = 1	
Velocity = 3.07 ft/s	
Friction loss = 0.23 ft	
Fitting loss = 0.31 ft	
Total loss = 0.55 ft	
Splitter box weir to clarifier 1	**23.09**
Weir invert (top of weir) = 22.25	
Weir length = 1.5 ft	
Weir 'C' coefficient = 3	
Flow over weir = 2.12 mgd	
Weir submergence = partially submerged	
Head over weir = 0.84 ft	
Flow_Splitter_Box	**23.09**
User defined loss for flow split = 0 ft	
Total flow through flow split = 2.12 mgd	
16in_ML_Pipe	**23.56**
Pipe shape = Circular	
Diameter = 16 in	
Length = 100 ft	
Flow = 2.12 mgd	
Friction method = Manning's Equation	
Friction factor = 0.013	
Total fitting K value = 3.3	
Pipe area = 1.4 ft²	
Pipe hydraulic radius = 0.333	
Age factor = 1	
Solids factor = 1	
Velocity = 2.35 ft/s	
Friction loss = 0.18 ft	
Fitting loss = 0.28 ft	
Total loss = 0.46 ft	
10in_ML_Pipe	**24.12**
Pipe shape = Circular	
Diameter = 10 in	

Section Description	Water Surface Elevation

Length = 20 ft
Flow = 2.12 mgd
Friction method = Manning's Equation
Friction factor = 0.013
Total fitting K value = 0.2
Pipe area = 0.55 ft²
Pipe hydraulic radius = 0.208
Age factor = 1
Solids factor = 1
Velocity = 6.01 ft/s
Friction loss = 0.45 ft
Fitting loss = 0.11 ft
Total loss = 0.56 ft

Basin 1 Eff Pipe **24.71**

Pipe shape = Circular
Diameter = 10 in
Length = 38 ft
Flow = 1.06 mgd
Friction method = Manning's Equation
Friction factor = 0.013
Total fitting K value = 2.75
Pipe area = 0.55 ft²
Pipe hydraulic radius = 0.208
Age factor = 1
Solids factor = 1
Velocity = 3.01 ft/s
Friction loss = 0.21 ft
Fitting loss = 0.39 ft
Total loss = 0.6 ft

Basin 1 Eff Weir1 **24.73**

Weir invert (top of weir) = 23.75
Weir length = 8 ft
Weir 'C' coefficient = 3.33
Flow over weir = 1.06 mgd
Weir submergence = fully submerged
Head over weir = 0.98 ft

Aeration Basin 1 **24.74**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 48 ft
Channel width/diameter = 23 ft
Flow = 1.06 mgd
Downstream channel invert = 8.6

Section Description | **Water Surface Elevation**

Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 371.09 ft^2
Hydraulic radius = 6.714
Normal depth = infinite
Critical depth = 0.05 ft
Depth downstream = 16.13 ft
Bend loss = 0 ft
Depth upstream = 16.14 ft
Velocity = 0 ft/s
Flow profile = Horizontal

Basin 1 Inf_Pipe | **25.1**

Pipe shape = Circular
Diameter = 12 in
Length = 90 ft
Flow = 1.06 mgd
Friction method = Manning's Equation
Friction factor = 0.013
Total fitting K value = 2.65
Pipe area = 0.79 ft^2
Pipe hydraulic radius = 0.25
Age factor = 1
Solids factor = 1
Velocity = 2.09 ft/s
Friction loss = 0.19 ft
Fitting loss = 0.18 ft
Total loss = 0.37 ft

Basin 1 Weir | **26.7**

Weir invert (top of weir) = 26
Number of contracted sides = 2
Weir length = 1 ft
Flow over weir = 1.06 mgd
Submergence = unsubmerged
Head over weir = 0.7 ft

Basin 2 Eff Pipe | **24.6**

Pipe shape = Circular
Diameter = 10 in
Length = 12 ft
Flow = 1.06 mgd
Friction method = Manning's Equation
Friction factor = 0.013
Total fitting K value = 3
Pipe area = 0.55 ft^2
Pipe hydraulic radius = 0.208

Section Description	Water Surface Elevation
Age factor = 1 Solids factor = 1 Velocity = 3.01 ft/s Friction loss = 0.07 ft Fitting loss = 0.42 ft Total loss = 0.49 ft	
Basin 2 Eff Weir2	**24.62**
Weir invert (top of weir) = 23.75 Weir length = 8 ft Weir 'C' coefficient = 3.33 Flow over weir = 1.06 mgd Weir submergence = fully submerged Head over weir = 0.87 ft	
Aeration Basin 2	**24.63**
Channel shape = Rectangular Manning's 'n' = 0.013 Channel length = 48 ft Channel width/diameter = 23 ft Flow = 1.06 mgd Downstream channel invert = 8.6 Channel slope = 0 ft/ft Channel side slope = not applicable Area of flow = 368.56 ft^2 Hydraulic radius = 6.695 Normal depth = infinite Critical depth = 0.05 ft Depth downstream = 16.02 ft Bend loss = 0 ft Depth upstream = 16.03 ft Velocity = 0 ft/s Flow profile = Horizontal	
Basin 2 Inf_Pipe	**25.18**
Pipe shape = Circular Diameter = 12 in Length = 164 ft Flow = 1.06 mgd Friction method = Manning's Equation Friction factor = 0.013 Total fitting K value = 3.15 Pipe area = 0.79 ft² Pipe hydraulic radius = 0.25 Age factor = 1 Solids factor = 1 Velocity = 2.09 ft/s	

Section Description	Water Surface Elevation
Friction loss = 0.35 ft	
Fitting loss = 0.21 ft	
Total loss = 0.56 ft	
Basin 2 Weir	**26.7**
Weir invert (top of weir) = 26	
Number of contracted sides = 2	
Weir length = 1 ft	
Flow over weir = 1.06 mgd	
Submergence = unsubmerged	
Head over weir = 0.7 ft	
Headorks_ML_Split	**26.7**
User defined loss for flow split = 0 ft	
Total flow through flow split = 2.12 mgd	
ML_Channel	**26.7**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 23 ft	
Channel width/diameter = 3 ft	
Flow = 2.12 mgd	
Downstream channel invert = 21.77	
Channel slope = 0 ft/ft	
Channel side slope = not applicable	
Area of flow = 14.79 ft^2	
Hydraulic radius = 1.15	
Normal depth = infinite	
Critical depth = 0.33 ft	
Depth downstream = 4.93 ft	
Bend loss = 0 ft	
Depth upstream = 4.93 ft	
Velocity = 0.22 ft/s	
Flow profile = Horizontal	
Parshall Flume	**27.92**
Flume invert = 27.75	
Flume throat width = 12 ft	
Flow through flume = 1.84 mgd	
Flume 'm' value = 46.756	
Flume 'e' value = 1.6	
Head through flume = 0.17 ft	
Flume_Inf	**27.93**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 5 ft	

Section Description	Water Surface Elevation
Channel width/diameter = 3 ft Flow = 1.84 mgd Downstream channel invert = 26.75 Channel slope = 0 ft/ft Channel side slope = not applicable Area of flow = 3.52 ft^2 Hydraulic radius = 0.659 Normal depth = infinite Critical depth = 0.3 ft Depth downstream = 1.17 ft Bend loss = 0 ft Depth upstream = 1.18 ft Velocity = 0.81 ft/s Flow profile = Horizontal	
Grit Chamber	**28.64**
2nd degree polynomial Flow = 1.84 mgd Overall head loss = 0.71 ft	
Grit_Inf	**28.68**
Channel shape = Rectangular Manning's 'n' = 0.013 Channel length = 20 ft Channel width/diameter = 1.25 ft Flow = 1.84 mgd Downstream channel invert = 27.75 Channel slope = 0 ft/ft Channel side slope = not applicable Area of flow = 1.14 ft^2 Hydraulic radius = 0.371 Normal depth = infinite Critical depth = 0.54 ft Depth downstream = 0.89 ft Bend loss = 0 ft Depth upstream = 0.93 ft Velocity = 2.56 ft/s Flow profile = Horizontal	
Screen Eff	**28.69**
Channel shape = Rectangular Manning's 'n' = 0.013 Channel length = 5 ft Channel width/diameter = 3 ft Flow = 1.84 mgd Downstream channel invert = 27.75 Channel slope = 0 ft/ft	

Section Description	Water Surface Elevation

Channel side slope = not applicable
Area of flow = 2.81 ft^2
Hydraulic radius = 0.576
Normal depth = infinite
Critical depth = 0.3 ft
Depth downstream = 0.93 ft
Bend loss = 0.01 ft
Depth upstream = 0.94 ft
Velocity = 1.01 ft/s
Flow profile = Horizontal

Screen Combine

Mech_Screen_Eff **29**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 8 ft
Channel width/diameter = 2 ft
Flow = 1.84 mgd
Downstream channel invert = 28.5
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 0.9 ft^2
Hydraulic radius = 0.31
Normal depth = infinite
Critical depth = 0.4 ft
Depth downstream = 0.4 ft
Bend loss = 0 ft
Depth upstream = 0.5 ft
Velocity = 3.58 ft/s
Flow profile = Horizontal

Manual_Screen_Eff **29.07**

Channel shape = Rectangular
Manning's 'n' = 0.013
Channel length = 12 ft
Channel width/diameter = 1.75 ft
Flow = 1.84 mgd
Downstream channel invert = 28.5
Channel slope = 0 ft/ft
Channel side slope = not applicable
Area of flow = 0.88 ft^2
Hydraulic radius = 0.319
Normal depth = infinite
Critical depth = 0.44 ft
Depth downstream = 0.44 ft
Bend loss = 0 ft

Section Description	**Water Surface Elevation**
Depth upstream = 0.57 ft	
Velocity = 3.74 ft/s	
Flow profile = Horizontal	
Manual Screen	**29.41**
Theory used = Kirschmer	
Rack/screen invert = 28.5	
Rack/screen width = 1.75 ft	
Flow through rack = 1.84 mgd	
Bar width = 0.38 in	
Bar spacing = 1.38 in	
Bar shape = Rectangular	
Angle of inclination = 60 degrees	
Downstream depth = 0.57 ft	
Approach velocity = 1.8 ft/s	
Rack/screen head loss = 0.33 ft	
Manual_Screen_Inf	**29.41**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 5 ft	
Channel width/diameter = 1.75 ft	
Flow = 1.84 mgd	
Downstream channel invert = 28.5	
Channel slope = 0 ft/ft	
Channel side slope = not applicable	
Area of flow = 1.59 ft^2	
Hydraulic radius = 0.445	
Normal depth = infinite	
Critical depth = 0.44 ft	
Depth downstream = 0.91 ft	
Bend loss = 0 ft	
Depth upstream = 0.91 ft	
Velocity = 1.8 ft/s	
Flow profile = Horizontal	
Mech Screen	**29.6**
2nd degree polynomial	
Flow = 1.84 mgd	
Overall head loss = 0.6 ft	
Mech_Screen_Inf	**29.6**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 5 ft	
Channel width/diameter = 2 ft	
Flow = 1.84 mgd	

Section Description	Water Surface Elevation
Downstream channel invert = 28.5	
Channel slope = 0 ft/ft	
Channel side slope = not applicable	
Area of flow = 2.2 ft^2	
Hydraulic radius = 0.524	
Normal depth = infinite	
Critical depth = 0.4 ft	
Depth downstream = 1.1 ft	
Bend loss = 0 ft	
Depth upstream = 1.1 ft	
Velocity = 1.29 ft/s	
Flow profile = Horizontal	
Screen Split	**29.6**
User defined loss for flow split = 0 ft	
Total flow through flow split = 3.68 mgd	
Inlet Trough	**29.61**
Channel shape = Rectangular	
Manning's 'n' = 0.013	
Channel length = 2.66 ft	
Channel width/diameter = 4.75 ft	
Flow = 1.84 mgd	
Downstream channel invert = 27	
Channel slope = 0 ft/ft	
Channel side slope = not applicable	
Area of flow = 12.37 ft^2	
Hydraulic radius = 1.242	
Normal depth = infinite	
Critical depth = 0.22 ft	
Depth downstream = 2.6 ft	
Bend loss = 0 ft	
Depth upstream = 2.61 ft	
Velocity = 0.23 ft/s	
Flow profile = Horizontal	
8 in RS pipe to inlet trough	**33.94**
Pipe shape = Circular	
Diameter = 8 in	
Length = 57 ft	
Flow = 1.84 mgd	
Friction method = Manning's Equation	
Friction factor = 0.013	
Total fitting K value = 1.15	
Pipe area = 0.35 ft^2	
Pipe hydraulic radius = 0.167	
Age factor = 1	

Section Description	Water Surface Elevation

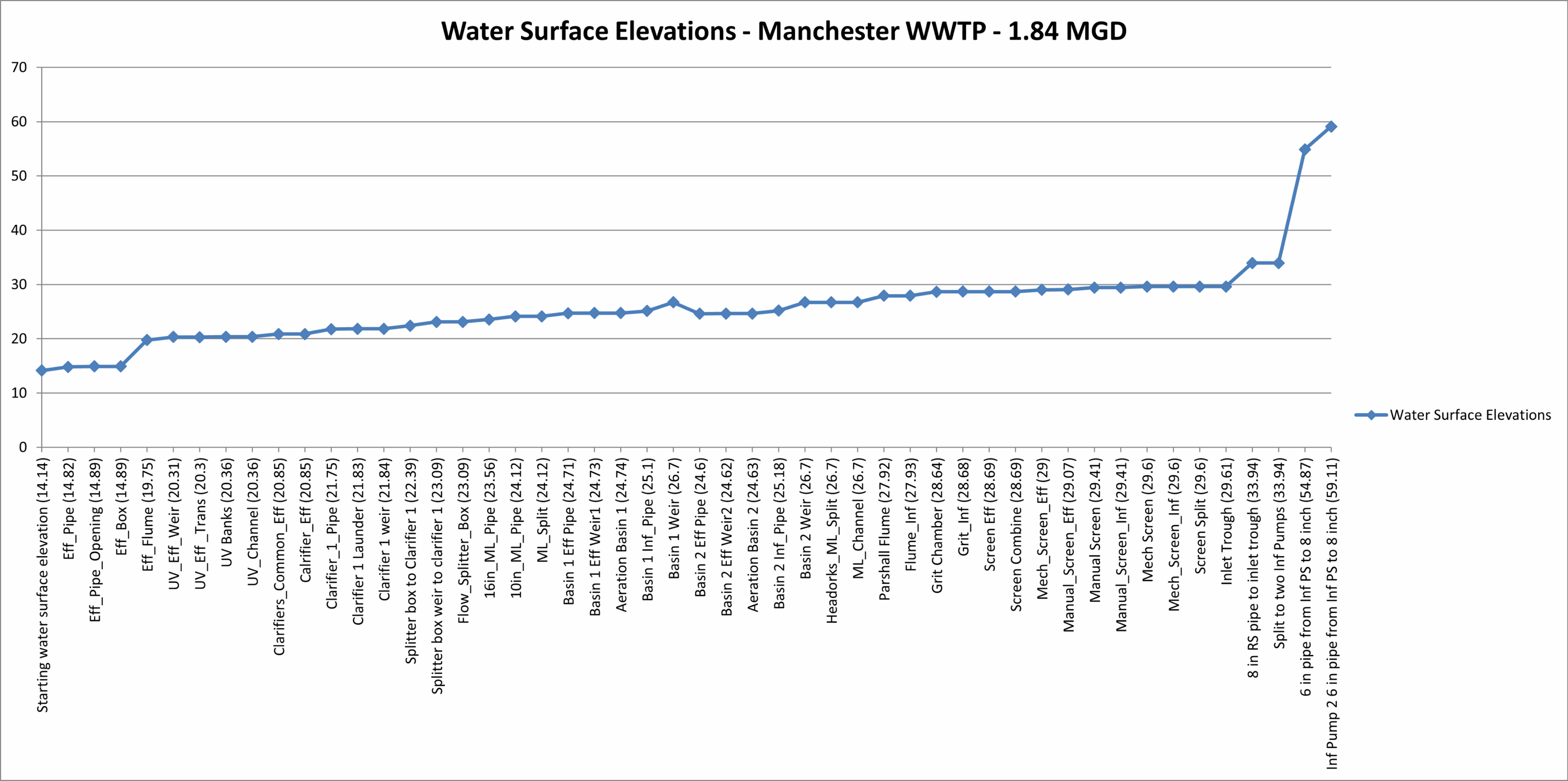
Solids factor = 1
Velocity = 8.15 ft/s
Friction loss = 3.15 ft
Fitting loss = 1.19 ft
Total loss = 4.34 ft

6 in pipe from Inf PS to 8 inch — **54.87**

Pipe shape = Circular
Diameter = 6 in
Length = 32 ft
Flow = 1.84 mgd
Friction method = Manning's Equation
Friction factor = 0.013
Total fitting K value = 3.9
Pipe area = 0.2 ft²
Pipe hydraulic radius = 0.125
Age factor = 1
Solids factor = 1
Velocity = 14.5 ft/s
Friction loss = 8.2 ft
Fitting loss = 12.73 ft
Total loss = 20.93 ft

Inf Pump 2 6 in pipe from Inf PS to 8 inch — **59.11**

Pipe shape = Circular
Diameter = 6 in
Length = 32 ft
Flow = 1.84 mgd
Friction method = Manning's Equation
Friction factor = 0.013
Total fitting K value = 5.2
Pipe area = 0.2 ft²
Pipe hydraulic radius = 0.125
Age factor = 1
Solids factor = 1
Velocity = 14.5 ft/s
Friction loss = 8.2 ft
Fitting loss = 16.97 ft
Total loss = 25.17 ft


Water Surface Elevations - Manchester WWTP - 1.84 MGD
70
60
50
40
30
20
10
0
Starting water surface elevation (14.14)
Eff_Pipe (14.82)
Eff_Pipe_Opening (14.89)
Eff_Box (14.89)
Eff_Flume (19.75)
UV_Eff_Weir (20.31)
UV_Eff_Trans (20.3)
UV Banks (20.36)
UV_Channel (20.36)
Clarifiers_Common_Eff (20.85)
Calrifier_Eff (20.85)
Clarifier_1_Pipe (21.75)
Clarifier 1 Launder (21.83)
Clarifier 1 weir (21.84)
Splitter box to Clarifier 1 (22.39)
Splitter box weir to clarifier 1 (23.09)
Flow_Splitter_Box (23.09)
16in_ML_Pipe (23.56)
10in_ML_Pipe (24.12)
ML_Split (24.12)
Basin 1 Eff Pipe (24.71)
Basin 1 Eff Weir1 (24.73)
Aeration Basin 1 (24.74)
Basin 1 Inf_Pipe (25.1)
Basin 1 Weir (26.7)
Basin 2 Eff Pipe (24.6)
Basin 2 Eff Weir2 (24.62)
Aeration Basin 2 (24.63)
Basin 2 Inf_Pipe (25.18)
Basin 2 Weir (26.7)
Headorks_ML_Split (26.7)
ML_Channel (26.7)
Parshall Flume (27.92)
Flume_Inf (27.93)
Grit Chamber (28.64)
Grit_Inf (28.68)
Screen Eff (28.69)
Screen Combine (28.69)
Mech_Screen_Eff (29)
Manual_Screen_Eff (29.07)
Manual Screen (29.41)
Manual_Screen_Inf (29.41)
Mech Screen (29.6)
Mech_Screen_Inf (29.6)
Screen Split (29.6)
Inlet Trough (29.61)
8 in RS pipe to inlet trough (33.94)
Split to two Inf Pumps (33.94)
6 in pipe from Inf PS to 8 inch (54.87)
Inf Pump 2 6 in pipe from Inf PS to 8 inch (59.11)
Water Surface Elevations

APPENDIX H
2014 SEWER FACILITIES
STRATEGY PLAN, CHAPTER 5

Chapter 5 Conveyance System Evaluation and Modeling

The existing sewage conveyance system of the Manchester Limited Area of More Intense Rural Development (LAMIRD) was modeled to identify potential future infrastructure needs. Conveyance system modeling was utilized to analyze the existing facilities and evaluate their capacity and effectiveness to convey flows generated by the current and the projected future population. The projected populations and their distributions were the basis for establishing future system requirements.

The following sections describe the hydraulic modeling approach used for the Plan.

5.1 Modeling and Analysis Approach

Modeling was performed to evaluate existing pump stations and conveyance facilities under the current and projected population and related flow scenarios. Recommended system improvements and sizing of future pump stations and force mains were based on system deficiencies found during the modeling analysis and also on system needs identified by Kitsap County staff.

The MIKE Urban hydraulic model developed by the Danish Hydraulic Institute (DHI) was selected for use in modeling the conveyance system. MIKE Urban release 2009 is a fully-dynamic model utilizing DHI's proprietary hydraulic engine and is designed specifically for modeling urban sanitary and combined sewers systems. The current version operates interactively with ArcGIS (ArcMap).

5.2 Model Input Parameters

The MIKE Urban model relies on user generated as well as automatically generated parameters to perform a range of calculations for various flow scenarios. Conveyance system details such as daily flow patterns, peaking factors, and infrastructure characteristics are input by the user and used by the model in conjunction with sewage flow information to provide simulation of the system under existing and future conditions. Infrastructure characteristics include pipe diameters and inverts, manhole locations and rim elevations, and pump station parameters. Automatically generated data, such as pipe slope, friction losses, and pump head-discharge relationships rely on user input along with model-based algorithms.

5.2.1 Daily Flow Pattern

A diurnal curve represents the variation in flow over time as a fraction of the average daily flow. A diurnal curve factors the average 24-hour flow, typically on an hourly basis, providing a multiplier for each time component of the analysis. The average of all the multipliers must equal 1.0, so that the model produces the correct amount of flow. A diurnal curve, based on measured hourly flow rates was developed to represent a typical daily flow rate pattern for the LAMIRD. A second diurnal curve was developed to vary peak day flow over the 24-hours simulation. The diurnal curves are included in Appendix C.

5.2.2 Existing Facilities

Existing facilities must be modeled and evaluated as a basis for development of future system needs. As part of this process, the existing collection and conveyance system is inventoried; physical properties of the infrastructure are tabulated; parcel-based flow projections are generated; sewerage basins are defined; and the sewered properties are identified and input into the hydraulic model. Kitsap county staff provided maintenance information that was used as a condition assessment for the existing collection and conveyance system. After a model run is initiated, flows are generated and loaded into manholes throughout the model and sewage is "conveyed" through the modeled collection system. Flow patterns and results are calibrated against known flow data to validate the model.

5.2.2.1 Infrastructure

Kitsap County maintains a database of sewer mapping in Graphical Information Systems (GIS) format. The database contains a very complete and comprehensive data set which includes elevations of rims and inverts of manholes, manhole and pipe numbering, pipe diameters and materials, and documentation of pipe conditions. Pumping facilities information stored in the database includes details of the pump station wet or dry well, known operational characteristics based on facilities tests, pump curves and motor controls (constant speed vs variable speed).

Conveyance system piping is defined as either force mains or gravity pipes. The database of physical attributes of the existing conveyance facilities was incorporated into the MIKE Urban modeling software to create a base model. The model uses these attributes and supplemental data, such as pump curves, to identify friction factors, head losses, and pumping capacities under a range of flows to simulate the system to evaluate the system capabilities and limitations.

5.2.2.2 Delineation of Existing Pump Station Basins

Delineation of the sanitary sewer drainage basins that serve existing pump stations is shown on Figure 5-1. The drainage basins illustrated on Figure 5-1 were incorporated into the model to define the area that contributes to each pump station.

5.2.2.3 Loading of Existing Flows

One of the key elements in developing a sanitary sewer system model is the method used to tell the model the quantity of flows and the location where they enter the system. This is referred to as "loading" the model. In this case, flow loading was based on parcel-level population/sewer user data. The "Sewer Permits" data set from the County GIS was utilized to define and distribute flow loading from each sewered parcel to the appropriate node in the model; a node typically represents a manhole in the conveyance system.

The "Sewer Permits" data set identified the number of ERUs that were attributed to each parcel, both for residential and non-residential users. Prior to loading the model, the data set was manually prepared so that the model could make use of the parcel-based data. Each ERU in the dataset was converted to an 'equivalent population'. Historical sewage flow data was used to estimate the annual average flow (AAF) for the LAMIRD of 85 gallons of sewage per capita per day (gpcd).

The flow loading for each parcel was calculated in the model by applying the AAF of 85 gallons per day to the equivalent population assigned to each sewered parcel. The loading from each parcel was generally distributed to the node representing the manhole physically closest to that parcel within the defined pump station drainage basin. In a few cases, the physically closest manhole to a basin was not necessarily the most appropriate for loading due to factors such as topography. For these cases, the loading is graphically reassigned to a more appropriate manhole using editing tools available with the software. The flow loading process is partially automated using an application developed by DHI specifically for this project in which sewer "catchments" were delineated around each manhole and parcel "centroids" located within each catchment contributed their resultant flow to the associated manhole.

5.2.2.4 Model Calibration

Existing condition model pump simulation was calibrated at each pump station by evaluating the modeled pump output of discharge pressure, or total dynamic head (TDH) vs. discharge and comparing simulated pump discharge to the design operating point. The design operating point and associated pump curve were determined from pump manufacturers and design data. Simulated pump discharge and manufacturer's pump curves were plotted together to illustrate how simulated pump output correlates with manufacturer's data. Adjustments were made iteratively to pump parameters in the model to obtain the closest correlation.

The total volume generated in the model was verified against actual historical daily Manchester SewageTreatment Plant (MTP) flow volume data for AAF and average design flow (ADF) per capita. Actual average values for a five year period were compared to model flow results. The total flow results were within 1 percent of the actual values. Since this difference was considered insignificant, the model was not adjusted.

5.2.2.5 Model Execution for Existing Conditions

The MIKE Urban model is a continuous simulation model which allows flows to be dynamically routed through the system over time, as opposed to a single event model that performs an instantaneous analysis for a single point in time. In this case, the model was run to represent a period of 24 hours. The daily flow totals produced by the population are introduced to and routed through the system over a typical 24-hour period based on the diurnal curve discussed in the previous section.

The initial model runs were based on the AAF which is a dry weather flow, with additional runs modified to represent wet weather flow. Wet weather, or peak day flow, was simulated by applying a factor of 4.71 to the AAF. The development of this factor was discussed in Chapter 4.

5.2.2.6 Existing Conditions Results

Results of the existing conditions model run indicated no areas where problems could occur during a period of peak day flow. In general, problem areas are where the flow depth in manholes exceeds 50 percent of manhole depth and these problem areas were not observed in the existing conditions model run.

5.2.3 Future Sewage Conveyance System Facilities

Once the model of the existing infrastructure was completed and calibrated, future conditions are represented conceptually by loading the model with sewage flows predicted to be generated by future populations. Once the future flows are generated, the infrastructure requirements to convey the future flows to the MTP are identified and tabulated. The results of this analysis are presented in the following sections, with modeling data provided in Appendix C.

5.2.3.1 Delineation of Potential Future Pump Station Basins

The future flow loading on the existing facilities was estimated from unsewered areas of the LAMIRD. The basins were delineated based on topography, as either an area that could flow strictly by gravity to an existing pump station (e.g., Basin F may be sewered by gravity flow into the Pump Station F-1 collection system) or an area where a pump station is required to convey flow into the existing system.

For currently unsewered basins requiring pumping, a hypothetical pump station was located at a topographical low point in the basin. Again, based on topography as well as the most convenient flow routing, flows from the pump stations were typically routed directly to the nearest gravity sewer manhole. The representation of future pump stations is not intended to establish the exact location of future facilities, rather, they are provided as a means to approximate the future system requirements on a more global level. Specific locations are identified to tally flows at a reasonable location in order to approximate pump station sizes for evaluating the system. More specific location and hydraulic information must be developed during the final design process for each pump station.

Future basin delineations and future pump station locations may (and will likely) vary from those presented in this analysis. In some basins or areas within basins, alternative conveyance systems may be more appropriate than traditional pumping stations. The nature of each facility is not evaluated here, but could include grinder pumps and small diameter conveyance pipe (individual pumps), vacuum systems (good for shorelines) or septic tank effluent pump (STEP) systems.

5.2.3.2 Loading Build-Out Flows

Flow projections were developed for the future conditions, similar to the flow estimates for the existing condition. Parcel-based ERUs were assigned to the unserved and developable parcels within the LAMIRD in accordance with the Kitsap County Department of Community Development population allocations and Land Capacity Analysis as described in Chapter 2. ERUs were converted to equivalent populations and entered into the model assigned to their respective parcels. For the future condition, the AAF was set at 85 gpcd. Similar to loading for existing flows, the AAF was factored by 3.76 to obtain peak day flow.

Because no actual collection facilities currently exist in future basins, flow loading could not be assigned to local infrastructure. Rather, the sewage flows from the future basins were generally assigned into the existing system at the nearest available entry point (manhole or pump station).

5.3 Model Execution and Analysis Results

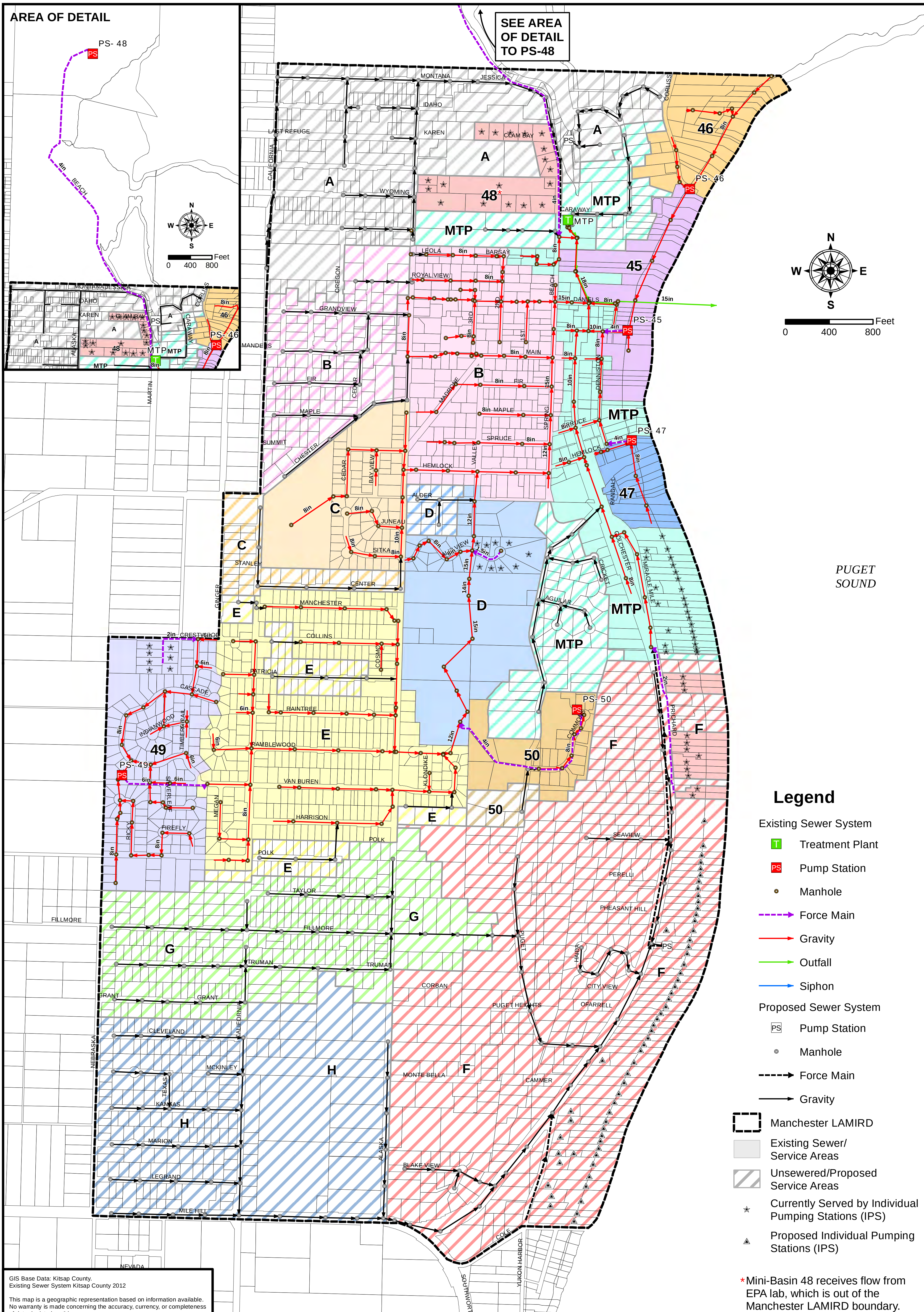
The modeling effort and data set described above were developed to determine the infrastructure requirements to provide adequate sewer service to the projected build-out population within the LAMIRD as defined in Chapter 2.

An initial review of existing pump stations is included in Chapter 3 which summarizes the hydraulic capacity of each station. That evaluation was expanded as part of the analysis to model projected future flows to each station and to determine if the existing capacity was adequate for future flows or if expansion of the pump station may be necessary.

The effects of the future flows (2019, 2030, and build-out) on the conveyance system were analyzed by applying the peak hour peaking factor of 3.76 to the existing facilities model with the future flow loading, as listed in Table 4-9. Modeled results through build-outdo not indicate any locations where the existing conveyance facilities do not have adequate capacity to accommodate the increased flows. As such, no improvements were made to the modeled system to accommodate future flows.

5.3.1 Future New Conveyance Facilities to Accommodate Build-Out Projected Flows

Future new conveyance facilities for areas that are currently unsewered are sized according to the modeled build-out flow requirements and the calculated total dynamic head for each facility. Using these variables, force main sizes and pump station horsepower were determined. The estimated capacities of future new pump stations are presented in Chapter 6. The conceptual locations of future force mains and gravity sewers are presented in Figures 6-1 and 6-2.



P:\Mapping\Maps_Generated\KitsapCounty\Projects\12-10274.00\009\maps\Fig 5-1 Mini Basins 11x17.mxd 10/2/2014 ctolentino

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MINI-BASINS MAP

MANCHESTER SEWER FACILITIES STRATEGY PLAN
Kitsap County
October 2014

Figure

5-1

APPENDIX I

OPPCS

Kitsap County General Sewer Plans
Manchester Basin

Gravity Pipeline and Force Main from PS-A1 in Basin A (Beach Drive)

Project Summary

• Install approximately 840 LF of gravity pipeline in Basin A in Beach Drive between Jessica Way and proposed PS-A1
• Install Approximately 980 LF of force main from PS-A1

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 40,000	$ 40,000
2	Traffic Control	1	LS	$ 30,000	$ 30,000
3	Dewatering	1	LS	$ 9,000	$ 9,000
4	SWPPP & BMPs	1	LS	$ 2,000	$ 2,000
5	Sewer Bypass	1	LS	$ 9,000	$ 9,000
6	Open Trench New 8-inch Pipe (SDR 35 PS46)	840	LF	$ 150	$ 126,000
7	6-inch Side Sewer Replacement	300	LF	$ 180	$ 54,000
8	4-inch Force Main Sewer	980	LF	$ 129	$ 125,937
9	Shoring and Trench Safety	1	LS	$ 4,000	$ 4,000
10	Imported Trench Backfill	600	TON	$ 25	$ 15,000
11	Manhole 48-inch diameter	1	EA	$ 15,000	$ 15,000
12	HMA for Trench Patch (CSBC and CSTC Incidental)	200	TON	$ 210	$ 42,000
13	Cleanup & Site Restoration	1	LS	$ 10,000	$ 10,000
	SUBTOTAL				$ 481,937
	Contingency (Approximately 50%)				$ 241,000
	Sales Tax (9.2%)				$ 66,510
	CONSTRUCTION SUBTOTAL				$ 790,000
	Design Services Engineering and Allied Costs (25%)				$ 198,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 198,000
	TOTAL (ROUNDED)				**$ 1,200,000**

Consor's construction cost ("estimate") is in dollars valued as of the date of this estimate. This estimate is an opinion of probable cost based on information available at the time of its development in June 2023. Final costs will depend on

• Actual field conditions • Actual material and labor costs • Market conditions for construction • Regulatory factors • Final project scope
• Method of implementation • Schedule (time to completion, time of commencement, speed of excecution, and • Other variables

This estimate is based on our perception, which is based on experience and research, yet nevertheless, an assessment, of current conditions at the project location. This estimate reflects our professional opinion of current costs and is subject to change as the project design evolves. Consor has no control over, nor can it forecast variences in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work, or of determining prices, of the impact of competitive bidding or market conditions, practices, or bidding strategies. Consor neither warrants nor guarentees that proposals, bids, or actual construction costs will reflect the costs presented, which are for illustrative purposes only.

Kitsap County General Sewer Plans
Manchester Basin

Manchester WWTP Influent Pump Station Rehabilitation

Project Summary

- Replace electrical, instrumentation, and control equipment
- Install new wet well hatch with fall prevention net

Item	Description	Quantity	Unit	Unit Cost	Total
1	Pumpstation Rehabilitation*	1	LS	$ 1,030,000	$ 1,030,000
	SUBTOTAL				$ 1,030,000
	Contingency (Approximately 50%)				Included in estimate
	Sales Tax (9.2%)				Included in estimate
	CONSTRUCTION SUBTOTAL				$ 1,030,000
	Design Services Engineering and Allied Costs (25%)				Included in estimate
	Construction Services and Allied Costs (25%, assumes full CM)				Included in estimate
	TOTAL (ROUNDED)				**$ 1,030,000**

Consor's construction cost ("estimate") is in dollars valued as of the date of this estimate. This estimate is an opinion of probable cost based on information available at the time of its development in June 2023. Final costs will depend on

• Actual field conditions • Actual material and labor costs • Market conditions for construction • Regulatory factors • Final project scope
• Method of implementation • Schedule (time to completion, time of commencement, speed of excecution, and • Other variables

This estimate is based on our perception, which is based on experience and research, yet nevertheless, an assessment, of current conditions at the project location. This estimate reflects our professional opinion of current costs and is subject to change as the project design evolves. Consor has no control over, nor can it forecast variences in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work, or of determining prices, of the impact of competitive bidding or market conditions, practices, or bidding strategies. Consor neither warrants nor guarentees that proposals, bids, or actual construction costs will reflect the costs presented, which are for illustrative purposes only.

Kitsap County General Sewer Plans
Manchester Basin

Rehabilitate Pump Station 48

Project Summary

- Rehabilitate PS-48 which is projected to reach the end of its design life before 2033.
- Replace mechanical components
- Replace pumps
- Replace electrical, instrumentation, and control equipment
- Install new equipment canopy/ shelters
- Install new flow meter vaults
- Install new generator sets with weather/ acoustical enclosures.

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mob/Demob	1	LS	$ 95,000	$ 95,000
2	Traffic Control	1	LS	$ 19,000	$ 19,000
3	TESC	1	LS	$ 9,200	$ 9,200
4	Dewatering	1	LS	$ 63,000	$ 63,000
5	Sheeting, Shoring, and Bracing	1	LS	$ 7,000	$ 7,000
6	48" Manhole Type 1	1	EA	$ 9,000	$ 9,000
7	Valve & Meter Vaults	1	LS	$ 62,000	$ 62,000
8	Rehabilitate Existing Wet Well	1	LS	$ 47,000	$ 47,000
9	Pumps	2	EA	$ 79,500	$ 159,000
10	Valves and Piping - Wetwell & Valve Vault	1	LS	$ 70,000	$ 70,000
11	Yard Piping	1	LS	$ 17,000	$ 17,000
12	Generator w/ Level 2 Sound Attenuating Enclosure	1	LS	$ 75,000	$ 75,000
13	Electrical, Instrumentation, and Controls	1	LS	$ 300,000	$ 300,000
14	Fencing	160	LF	$ 40	$ 6,400
15	Clearing and Grubbing	1	LS	$ 4,000	$ 4,000
16	Temporary Bypass Pumping	1	LS	$ 50,000	$ 50,000
17	Site Restoration	1	LS	$ 23,000	$ 23,000
18	Canopy	1	LS	$ 25,000	$ 25,000
	SUBTOTAL				$ 1,040,600
	Contingency (Approximately 50%)				$ 521,000
	Sales Tax (9.2%)				$ 143,667
	CONSTRUCTION SUBTOTAL				$ 1,706,000
	Design Services Engineering and Allied Costs (25%)				$ 426,500
	Construction Services and Allied Costs (25%, assumes full CM)				$ 426,500
	TOTAL (ROUNDED)				**$ 2,600,000**
	CIP-M-CC-OM-4 PROJECT TOTAL (ROUNDED)				**$ 6,200,000**

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Kitsap County General Sewer Plans
Manchester Basin

Rehabilitate Pump Station 49

Project Summary

- Rehabilitate PS-49 which is projected to reach the end of its design life before 2033.
- Replace mechanical components
- Replace pumps
- Replace electrical, instrumentation, and control equipment
- Install new equipment canopy/ shelters
- Install new flow meter vaults
- Install new generator sets with weather/ acoustical enclosures.

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mob/Demob	1	LS	$ 64,000	$ 64,000
2	Traffic Control	1	LS	$ 13,000	$ 13,000
3	TESC	1	LS	$ 6,000	$ 6,000
4	Dewatering	1	LS	$ 20,000	$ 20,000
5	Sheeting, Shoring, and Bracing	1	LS	$ 20,000	$ 20,000
6	Rehabilitate Existing Wet Well	1	LS	$ 47,000	$ 47,000
7	Valve & Meter Vaults	1	LS	$ 62,000	$ 62,000
8	Pumps	2	EA	$ 75,000	$ 150,000
9	Valves and Piping - Wetwell & Valve Vault	1	LS	$ 25,000	$ 25,000
10	Yard Piping	1	LS	$ 7,000	$ 7,000
11	Generator w/ Level 2 Sound Attenuating Enclosure	1	LS	$ 40,000	$ 40,000
12	Electrical, Instrumentation, and Controls	1	LS	$ 198,000	$ 198,000
13	Canopy	1	LS	$ 21,000	$ 21,000
14	Fencing	80	LF	$ 40	$ 3,200
15	Clearing and Grubbing	1	LS	$ 1,000	$ 1,000
16	Temporary Bypass Pumping	8	WK	$ 2,000	$ 16,000
17	Site Restoration	1	LS	$ 13,000	$ 13,000
	SUBTOTAL				$ 706,200
	Contingency (Approximately 50%)				$ 354,000
	Sales Tax (9.2%)				$ 97,538
	CONSTRUCTION SUBTOTAL				$ 1,158,000
	Design Services Engineering and Allied Costs (25%)				$ 289,500
	Construction Services and Allied Costs (25%, assumes full CM)				$ 289,500
	TOTAL (ROUNDED)				**$ 1,800,000**

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Kitsap County General Sewer Plans
Manchester Basin

Rehabilitate Pump Station 50

Project Summary

- Rehabilitate PS-50 which is projected to reach the end of its design life before 2033.
- Replace mechanical components
- Replace pumps
- Replace electrical, instrumentation, and control equipment
- Install new equipment canopy/ shelters
- Install new flow meter vaults
- Install new generator sets with weather/ acoustical enclosures.

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mob/Demob	1	LS	$ 64,000	$ 64,000
2	Traffic Control	1	LS	$ 13,000	$ 13,000
3	TESC	1	LS	$ 6,000	$ 6,000
4	Dewatering	1	LS	$ 20,000	$ 20,000
5	Sheeting, Shoring, and Bracing	1	LS	$ 20,000	$ 20,000
6	Rehabilitate Existing Wet Well	1	LS	$ 47,000	$ 47,000
7	Valve & Meter Vaults	1	LS	$ 62,000	$ 62,000
8	Pumps	2	EA	$ 75,000	$ 150,000
9	Valves and Piping - Wetwell & Valve Vault	1	LS	$ 25,000	$ 25,000
10	Yard Piping	1	LS	$ 7,000	$ 7,000
11	Generator w/ Level 2 Sound Attenuating Enclosure	1	LS	$ 40,000	$ 40,000
12	Electrical, Instrumentation, and Controls	1	LS	$ 198,000	$ 198,000
13	Canopy	1	LS	$ 21,000	$ 21,000
14	Fencing	80	LF	$ 40	$ 3,200
15	Clearing and Grubbing	1	LS	$ 1,000	$ 1,000
16	Temporary Bypass Pumping	8	WK	$ 2,000	$ 16,000
17	Site Restoration	1	LS	$ 13,000	$ 13,000
	SUBTOTAL				$ 706,200
	Contingency (Approximately 50%)				$ 354,000
	Sales Tax (9.2%)				$ 97,538
	CONSTRUCTION SUBTOTAL				$ 1,158,000
	Design Services Engineering and Allied Costs (25%)				$ 289,500
	Construction Services and Allied Costs (25%, assumes full CM)				$ 289,500
	TOTAL (ROUNDED)				**$ 1,800,000**

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Kitsap County General Sewer Plans
Manchester Basin

Gravity Pipeline Expansion in Basin A

Project Summary

- Install approximately 9,550 LF of gravity sewer in Basin A to expand sewer service to currently unsewered areas.
- Project will include installation of new gravity sewer pipe, manholes, and side sewer connections

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 340,000	$ 340,000
2	Traffic Control	1	LS	$ 210,000	$ 210,000
3	Dewatering	1	LS	$ 84,000	$ 84,000
4	SWPPP & BMPs	1	LS	$ 20,000	$ 20,000
5	Sewer Bypass	1	LS	$ 96,000	$ 96,000
6	Open Trench New 8-inch Pipe (SDR 35 PS46)	9,550	LF	$ 150	$ 1,432,500
7	6-inch Side Sewer Replacement	2,900	LF	$ 180	$ 522,000
8	Shoring and Trench Safety	1	LS	$ 39,000	$ 39,000
9	Imported Trench Backfill	6,900	TON	$ 25	$ 172,500
10	Manhole 48-inch diameter	7	EA	$ 15,000	$ 105,000
11	HMA for Trench Patch (CSBC and CSTC Incidental)	2,600	TON	$ 210	$ 546,000
12	Grind and Overlay, Channelization*	1	EST	$ 1,100,000	$ 1,100,000
13	Cleanup & Site Restoration	1	LS	$ 120,000	$ 120,000
	SUBTOTAL				$ 4,787,000
	Contingency (Approximately 50%)				$ 2,394,000
	Sales Tax (9.2%)				$ 660,652
	CONSTRUCTION SUBTOTAL				$ 7,842,000
	Design Services Engineering and Allied Costs (25%)				$ 1,961,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 1,961,000
	TOTAL (ROUNDED)				**$ 11,800,000**

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Kitsap County General Sewer Plans
Manchester Basin

Gravity Main Expansion in Basin B

Project Summary

- Install approximately 6,410 LF of gravity sewer in Basin B to expand sewer service to currently unsewered areas.
- Project will include installation of new gravity sewer pipe, manholes, and side sewer connections

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 240,000	$ 240,000
2	Traffic Control	1	LS	$ 150,000	$ 150,000
3	Dewatering	1	LS	$ 59,000	$ 59,000
4	SWPPP & BMPs	1	LS	$ 13,000	$ 13,000
5	Sewer Bypass	1	LS	$ 65,000	$ 65,000
6	Open Trench New 8-inch Pipe (SDR 35 PS46)	6,410	LF	$ 150	$ 961,500
7	6-inch Side Sewer Replacement	2,000	LF	$ 180	$ 360,000
8	Shoring and Trench Safety	1	LS	$ 26,000	$ 26,000
9	Imported Trench Backfill	4,700	TON	$ 25	$ 117,500
10	Manhole 48-inch diameter	7	EA	$ 15,000	$ 105,000
11	HMA for Trench Patch (CSBC and CSTC Incidental)	1,800	TON	$ 210	$ 378,000
12	Grind and Overlay, Channelization*	1	EST	$ 800,000	$ 800,000
13	Cleanup & Site Restoration	1	LS	$ 80,000	$ 80,000
	SUBTOTAL				$ 3,355,000
	Contingency (Approximately 50%)				$ 1,678,000
	Sales Tax (9.2%)				$ 463,036
	CONSTRUCTION SUBTOTAL				$ 5,497,000
	Design Services Engineering and Allied Costs (25%)				$ 1,375,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 1,375,000
	TOTAL (ROUNDED)				**$ 8,300,000**

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Kitsap County General Sewer Plans
Manchester Basin

Gravity Main Expansion in Basin C

Project Summary

• Install approximately 2,280 LF of gravity sewer in Basin C to expand sewer service to currently unsewered areas.
• Project will include installation of new gravity sewer pipe, manholes, and side sewer connections

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 100,000	$ 100,000
2	Traffic Control	1	LS	$ 60,000	$ 60,000
3	Dewatering	1	LS	$ 23,000	$ 23,000
4	SWPPP & BMPs	1	LS	$ 5,000	$ 5,000
5	Sewer Bypass	1	LS	$ 23,000	$ 23,000
6	Open Trench New 8-inch Pipe (SDR 35 PS46)	2,280	LF	$ 150	$ 342,000
7	6-inch Side Sewer Replacement	700	LF	$ 180	$ 126,000
8	Shoring and Trench Safety	1	LS	$ 10,000	$ 10,000
9	Imported Trench Backfill	1,700	TON	$ 25	$ 42,500
10	Manhole 48-inch diameter	7	EA	$ 15,000	$ 105,000
11	HMA for Trench Patch (CSBC and CSTC Incidental)	700	TON	$ 210	$ 147,000
12	Grind and Overlay, Channelization*	1	EST	$ 300,000	$ 300,000
13	Cleanup & Site Restoration	1	LS	$ 30,000	$ 30,000
	SUBTOTAL				$ 1,313,500
	Contingency (Approximately 50%)				$ 657,000
	Sales Tax (9.2%)				$ 181,286
	CONSTRUCTION SUBTOTAL				$ 2,152,000
	Design Services Engineering and Allied Costs (25%)				$ 538,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 538,000
	TOTAL (ROUNDED)				**$ 3,300,000**

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Kitsap County General Sewer Plans
Manchester Basin

Gravity Main Expansion in Basin D

Project Summary

- Install approximately 720 LF of gravity sewer in Basin D to expand sewer service to currently unsewered areas.
- Project will include installation of new gravity sewer pipe, manholes, and side sewer connections

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 40,000	$ 40,000
2	Traffic Control	1	LS	$ 30,000	$ 30,000
3	Dewatering	1	LS	$ 10,000	$ 10,000
4	SWPPP & BMPs	1	LS	$ 2,000	$ 2,000
5	Sewer Bypass	1	LS	$ 8,000	$ 8,000
6	Open Trench New 8-inch Pipe (SDR 35 PS46)	720	LF	$ 150	$ 108,000
7	6-inch Side Sewer Replacement	300	LF	$ 180	$ 54,000
8	Shoring and Trench Safety	1	LS	$ 3,000	$ 3,000
9	Imported Trench Backfill	600	TON	$ 25	$ 15,000
10	Manhole 48-inch diameter	7	EA	$ 15,000	$ 105,000
11	HMA for Trench Patch (CSBC and CSTC Incidental)	300	TON	$ 210	$ 63,000
12	Grind and Overlay, Channelization*	1	EST	$ 100,000	$ 100,000
13	Cleanup & Site Restoration	1	LS	$ 10,000	$ 10,000
	SUBTOTAL				$ 548,000
	Contingency (Approximately 50%)				$ 274,000
	Sales Tax (9.2%)				$ 75,624
	CONSTRUCTION SUBTOTAL				$ 898,000
	Design Services Engineering and Allied Costs (25%)				$ 225,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 225,000
	TOTAL (ROUNDED)				**$ 1,400,000**

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Kitsap County General Sewer Plans
Manchester Basin

Gravity Main Expansion in Basin E

Project Summary

• Install approximately 3,210 LF of gravity sewer in Basin E to expand sewer service to currently unsewered areas.
• Project will include installation of new gravity sewer pipe, manholes, and side sewer connections

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 130,000	$ 130,000
2	Traffic Control	1	LS	$ 80,000	$ 80,000
3	Dewatering	1	LS	$ 31,000	$ 31,000
4	SWPPP & BMPs	1	LS	$ 7,000	$ 7,000
5	Sewer Bypass	1	LS	$ 33,000	$ 33,000
6	Open Trench New 8-inch Pipe (SDR 35 PS46)	3,210	LF	$ 150	$ 481,500
7	6-inch Side Sewer Replacement	1,000	LF	$ 180	$ 180,000
8	Shoring and Trench Safety	1	LS	$ 13,000	$ 13,000
9	Imported Trench Backfill	2,400	TON	$ 25	$ 60,000
10	Manhole 48-inch diameter	7	EA	$ 15,000	$ 105,000
11	HMA for Trench Patch (CSBC and CSTC Incidental)	900	TON	$ 210	$ 189,000
12	Grind and Overlay, Channelization*	1	EST	$ 400,000	$ 400,000
13	Cleanup & Site Restoration	1	LS	$ 40,000	$ 40,000
	SUBTOTAL				$ 1,749,500
	Contingency (Approximately 50%)				$ 875,000
	Sales Tax (9.2%)				$ 241,454
	CONSTRUCTION SUBTOTAL				$ 2,866,000
	Design Services Engineering and Allied Costs (25%)				$ 717,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 717,000
	TOTAL (ROUNDED)				**$ 4,300,000**

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Kitsap County General Sewer Plans
Manchester Basin

Gravity Main Expansion in Basin F

Project Summary

• Install approximately 7,540 LF of gravity sewer in Basin F to expand sewer service to currently unsewered areas.
• Project will include installation of new gravity sewer pipe, manholes, and side sewer connections

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 270,000	$ 270,000
2	Traffic Control	1	LS	$ 170,000	$ 170,000
3	Dewatering	1	LS	$ 67,000	$ 67,000
4	SWPPP & BMPs	1	LS	$ 16,000	$ 16,000
5	Sewer Bypass	1	LS	$ 76,000	$ 76,000
6	Open Trench New 8-inch Pipe (SDR 35 PS46)	7,540	LF	$ 150	$ 1,131,000
7	6-inch Side Sewer Replacement	2,300	LF	$ 180	$ 414,000
8	Shoring and Trench Safety	1	LS	$ 31,000	$ 31,000
9	Imported Trench Backfill	5,500	TON	$ 25	$ 137,500
10	Manhole 48-inch diameter	7	EA	$ 15,000	$ 105,000
11	HMA for Trench Patch (CSBC and CSTC Incidental)	2,100	TON	$ 210	$ 441,000
12	Grind and Overlay, Channelization*	1	EST	$ 900,000	$ 900,000
13	Cleanup & Site Restoration	1	LS	$ 90,000	$ 90,000
	SUBTOTAL				$ 3,848,500
	Contingency (Approximately 50%)				$ 1,925,000
	Sales Tax (9.2%)				$ 531,162
	CONSTRUCTION SUBTOTAL				$ 6,305,000
	Design Services Engineering and Allied Costs (25%)				$ 1,577,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 1,577,000
	TOTAL (ROUNDED)				**$ 9,500,000**

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Kitsap County General Sewer Plans
Manchester Basin

Gravity Main Expansion in Basin G

Project Summary

• Install approximately 9,790 LF of gravity sewer in Basin G to expand sewer service to currently unsewered areas.
• Project will include installation of new gravity sewer pipe, manholes, and side sewer connections

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 350,000	$ 350,000
2	Traffic Control	1	LS	$ 220,000	$ 220,000
3	Dewatering	1	LS	$ 87,000	$ 87,000
4	SWPPP & BMPs	1	LS	$ 20,000	$ 20,000
5	Sewer Bypass	1	LS	$ 98,000	$ 98,000
6	Open Trench New 8-inch Pipe (SDR 35 PS46)	9,790	LF	$ 150	$ 1,468,500
7	6-inch Side Sewer Replacement	3,000	LF	$ 180	$ 540,000
8	Shoring and Trench Safety	1	LS	$ 40,000	$ 40,000
9	Imported Trench Backfill	7,100	TON	$ 25	$ 177,500
10	Manhole 48-inch diameter	7	EA	$ 15,000	$ 105,000
11	HMA for Trench Patch (CSBC and CSTC Incidental)	2,700	TON	$ 210	$ 567,000
12	Grind and Overlay, Channelization*	1	EST	$ 1,200,000	$ 1,200,000
13	Cleanup & Site Restoration	1	LS	$ 120,000	$ 120,000
	SUBTOTAL				$ 4,993,000
	Contingency (Approximately 50%)				$ 2,497,000
	Sales Tax (9.2%)				$ 689,080
	CONSTRUCTION SUBTOTAL				$ 8,180,000
	Design Services Engineering and Allied Costs (25%)				$ 2,045,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 2,045,000
	TOTAL (ROUNDED)				**$ 12,300,000**

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Kitsap County General Sewer Plans
Manchester Basin

Gravity Main Expansion in Basin H

Project Summary

- Install approximately 11,390 LF of gravity sewer in Basin H to expand sewer service to currently unsewered areas.
- Project will include installation of new gravity sewer pipe, manholes, and side sewer connections

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 400,000	$ 400,000
2	Traffic Control	1	LS	$ 250,000	$ 250,000
3	Dewatering	1	LS	$ 99,000	$ 99,000
4	SWPPP & BMPs	1	LS	$ 23,000	$ 23,000
5	Sewer Bypass	1	LS	$ 114,000	$ 114,000
6	Open Trench New 8-inch Pipe (SDR 35 PS46)	11,390	LF	$ 150	$ 1,708,500
7	6-inch Side Sewer Replacement	3,500	LF	$ 180	$ 630,000
8	Shoring and Trench Safety	1	LS	$ 46,000	$ 46,000
9	Imported Trench Backfill	8,200	TON	$ 25	$ 205,000
10	Manhole 48-inch diameter	7	EA	$ 15,000	$ 105,000
11	HMA for Trench Patch (CSBC and CSTC Incidental)	3,200	TON	$ 210	$ 672,000
12	Grind and Overlay, Channelization*	1	EST	$ 1,300,000	$ 1,300,000
13	Cleanup & Site Restoration	1	LS	$ 140,000	$ 140,000
	SUBTOTAL				$ 5,692,500
	Contingency (Approximately 50%)				$ 2,847,000
	Sales Tax (9.2%)				$ 785,634
	CONSTRUCTION SUBTOTAL				$ 9,326,000
	Design Services Engineering and Allied Costs (25%)				$ 2,332,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 2,332,000
	TOTAL (ROUNDED)				**$ 14,000,000**

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Kitsap County General Sewer Plans
Manchester Basin

Gravity Main Expansion in Basin 50

Project Summary

• Install approximately 480 LF of gravity sewer in Basin 50 to expand sewer service to currently unsewered areas.
• Project will include installation of new gravity sewer pipe, manholes, and side sewer connections

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 40,000	$ 40,000
2	Traffic Control	1	LS	$ 20,000	$ 20,000
3	Dewatering	1	LS	$ 8,000	$ 8,000
4	SWPPP & BMPs	1	LS	$ 1,000	$ 1,000
5	Sewer Bypass	1	LS	$ 5,000	$ 5,000
6	Open Trench New 8-inch Pipe (SDR 35 PS46)	480	LF	$ 150	$ 72,000
7	6-inch Side Sewer Replacement	200	LF	$ 180	$ 36,000
8	Shoring and Trench Safety	1	LS	$ 2,000	$ 2,000
9	Imported Trench Backfill	400	TON	$ 25	$ 10,000
10	Manhole 48-inch diameter	7	EA	$ 15,000	$ 105,000
11	HMA for Trench Patch (CSBC and CSTC Incidental)	200	TON	$ 210	$ 42,000
12	Grind and Overlay, Channelization*	1	EST	$ 100,000	$ 100,000
13	Cleanup & Site Restoration	1	LS	$ 10,000	$ 10,000
	SUBTOTAL				$ 451,000
	Contingency (Approximately 50%)				$ 226,000
	Sales Tax (9.2%)				$ 62,284
	CONSTRUCTION SUBTOTAL				$ 740,000
	Design Services Engineering and Allied Costs (25%)				$ 185,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 185,000
	TOTAL (ROUNDED)				**$ 1,200,000**

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Kitsap County General Sewer Plans
Manchester Basin

Gravity Main Expansion in Basin WWTP

Project Summary

- Install approximately 5,310 LF of gravity sewer in Basin WWTP to expand sewer service to currently unsewered areas.
- Project will include installation of new gravity sewer pipe, manholes, and side sewer connections

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 200,000	$ 200,000
2	Traffic Control	1	LS	$ 130,000	$ 130,000
3	Dewatering	1	LS	$ 50,000	$ 50,000
4	SWPPP & BMPs	1	LS	$ 11,000	$ 11,000
5	Sewer Bypass	1	LS	$ 54,000	$ 54,000
6	Open Trench New 8-inch Pipe (SDR 35 PS46)	5,310	LF	$ 150	$ 796,500
7	6-inch Side Sewer Replacement	1,600	LF	$ 180	$ 288,000
8	Shoring and Trench Safety	1	LS	$ 22,000	$ 22,000
9	Imported Trench Backfill	3,900	TON	$ 25	$ 97,500
10	Manhole 48-inch diameter	7	EA	$ 15,000	$ 105,000
11	HMA for Trench Patch (CSBC and CSTC Incidental)	1,500	TON	$ 210	$ 315,000
12	Grind and Overlay, Channelization*	1	EST	$ 700,000	$ 700,000
13	Cleanup & Site Restoration	1	LS	$ 70,000	$ 70,000
	SUBTOTAL				$ 2,839,000
	Contingency (Approximately 50%)				$ 1,420,000
	Sales Tax (9.2%)				$ 391,828
	CONSTRUCTION SUBTOTAL				$ 4,651,000
	Design Services Engineering and Allied Costs (25%)				$ 1,163,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 1,163,000
	TOTAL (ROUNDED)				**$ 7,000,000**

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Kitsap County General Sewer Plans
Manchester Basin

Install Pump Station A1

Project Summary

- Theoretical pump station that would allow for future development in Basin A.
- More specific location and hydraulic information must be developed during the final design process for this pump station.

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mob/Demob	1	LS	$ 64,000	$ 64,000
2	Traffic Control	1	LS	$ 13,000	$ 13,000
3	TESC	1	LS	$ 6,200	$ 6,200
4	Dewatering	1	LS	$ 20,000	$ 20,000
5	Sheeting, Shoring, and Bracing	1	LS	$ 20,000	$ 20,000
6	8-foot Diameter Wet Well	1	LS	$ 116,000	$ 116,000
7	Valve Vault	1	LS	$ 10,000	$ 10,000
8	Pumps	2	EA	$ 75,000	$ 150,000
9	Valves and Piping - Wetwell & Valve Vault	1	LS	$ 25,000	$ 25,000
10	Yard Piping	1	LS	$ 7,000	$ 7,000
11	Generator w/ Level 2 Sound Attenuating Enclosure	1	LS	$ 40,000	$ 40,000
12	Electrical, Instrumentation, and Controls	1	LS	$ 198,000	$ 198,000
13	Canopy	1	LS	$ 21,000	$ 21,000
14	Fencing	80	LF	$ 40	$ 3,200
15	Clearing and Grubbing	1	LS	$ 1,000	$ 1,000
16	Site Restoration	1	LS	$ 13,000	$ 13,000
	SUBTOTAL				$ 707,400
	Contingency (Approximately 50%)				$ 354,000
	Sales Tax (9.2%)				$ 97,649
	CONSTRUCTION SUBTOTAL				$ 1,160,000
	Design Services Engineering and Allied Costs (25%)				$ 290,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 290,000
	TOTAL (ROUNDED)				**$ 1,800,000**

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Kitsap County General Sewer Plans
Manchester Basin

Annual Pipe Replacement

Project Summary

- Annual program to replace aging and deficient pipes not identified in other capital improvement projects
- Assumes that half of one percent of the pipe in the Manchester basin would be replaced each year

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization / Demobilization	1	LS	$ 30,000	$ 30,000
2	Traffic Control	1	LS	$ 20,000	$ 20,000
3	Dewatering	1	LS	$ 7,000	$ 7,000
4	SWPPP & BMPs	1	LS	$ 1,000	$ 1,000
5	Sewer Bypass	1	LS	$ 4,000	$ 4,000
6	Open Trench New 8-inch Pipe (SDR 35 PS46)	320	LF	$ 150	$ 48,000
7	6-inch Side Sewer Replacement	100	LF	$ 180	$ 18,000
8	Shoring and Trench Safety	1	LS	$ 2,000	$ 2,000
9	Imported Trench Backfill	300	TON	$ 25	$ 7,500
10	Manhole 48-inch diameter	7	EA	$ 15,000	$ 105,000
11	HMA for Trench Patch (CSBC and CSTC Incidental)	100	TON	$ 210	$ 21,000
12	Grind and Overlay, Channelization*	1	EST	$ 100,000	$ 100,000
13	Cleanup & Site Restoration	1	LS	$ 10,000	$ 10,000
	SUBTOTAL				$ 373,500
	Contingency (Approximately 50%)				$ 187,000
	Sales Tax (9.2%)				$ 51,566
	CONSTRUCTION SUBTOTAL				$ 613,000
	Design Services Engineering and Allied Costs (25%)				$ 154,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 154,000
	TOTAL (ROUNDED)				**$ 1,000,000**
	14 - YEAR TOTAL (ROUNDED)				**$ 14,000,000**

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Kitsap County General Sewer Plans
Manchester Basin

Upsize 10” Mixed Liquor Pipe and 12” Plant Effluent Pipes

Project Summary

• Replace existing mixed liquor and plant effluent pipes with larger pipes to increase hydraulic capacity

Item	Description	Quantity	Unit	Unit Cost	Total
1	Upsize 10” Mixed Liquor Pipe and 12” Plant Effluent Pipes	152	LF	$ 325	$ 49,400
	SUBTOTAL				$ 49,400
	Contingency (50%)				$ 25,000
	Sales Tax (9.2%)				$ 6,845
	CONSTRUCTION SUBTOTAL				$ 82,000
	Design Services Engineering and Allied Costs (25%)				$ 20,500
	Construction Services and Allied Costs (25%, assumes full CM)				$ 20,500
	TOTAL PROJECT COST (ROUNDED)				**$ 200,000**

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Kitsap County General Sewer Plans
Manchester Basin

Aeration System Optimization

Project Summary

- Project will improve TIN monitoring and control to ensure effluent TIN can be consistently reduced to below 10 mg/L
- Replace jet aeration system with fine bubble diffusers
- Replace existing blowers with variable speed blowers
- Install dissolved oxygen and ammonia and nitrogen monitoring probes

Item	Description	Quantity	Unit	Unit Cost	Total
1	Basin Preparation	2208	SF	$ 10	$ 22,080
2	Existing Jet Aeration Demolition	1	LS	$ 9,600	$ 9,600
3	Existing Blowers Demolition	1	LS	$ 3,000	$ 3,000
4	Diffuser Assembly	1	LS	$ 97,500	$ 97,500
5	Mechanical Piping - 8" SCH 80 (Air piping)	246	LF	$ 92	$ 22,706
6	Mechanical Piping - 8" SCH 80 (Blower piping)	130	LF	$ 92	$ 11,999
7	Blowers	3	EA	$ 26,000	$ 78,000
8	Blower Duct Modifications	1	LS	$ 10,000	$ 10,000
9	Airflow Control Valves and Flow Meter	2	LS	$ 16,250	$ 32,500
10	Blower FVDs	3	EA	$ 10,400	$ 31,200
11	On-line DO and Ammonia/Nitrate Probes	4	EA	$ 13,260	$ 53,040
12	EI&C Allowance	1	LS	$ 53,061	$ 53,061
	SUBTOTAL				$ 424,686
	Contingency (50%)				$ 213,000
	Sales Tax (9.2%)				$ 58,667
	CONSTRUCTION SUBTOTAL				$ 697,000
	Design Services Engineering and Allied Costs (25%)				$ 174,250
	Construction Services and Allied Costs (25%, assumes full CM)				$ 174,250
	TOTAL PROJECT COST (ROUNDED)				**$ 1,100,000**

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Kitsap County General Sewer Plans
Manchester Basin

Replace WWTP ATS

Project Summary					
• Replace obsolete automatic transfer switch					
Item	**Description**	**Quantity**	**Unit**	**Unit Cost**	**Total**
1	Replace WWTP ATS	1	LS	$ 75,000	$ 75,000
	SUBTOTAL				$ 75,000
	Contingency (50%)				$ 38,000
	Sales Tax (9.2%)				$ 10,396
	CONSTRUCTION SUBTOTAL				$ 124,000
	Design Services Engineering and Allied Costs (25%)				$ 31,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 31,000
	TOTAL PROJECT COST (ROUNDED)				**$ 200,000**

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Kitsap County General Sewer Plans
Manchester Basin

Replace Odor Control System

Project Summary

• Replace odor control system with activated carbon filter

Item	Description	Quantity	Unit	Unit Cost	Total
1	Existing Chemical Scrubber Demolition	1	LS	$ 3,000	$ 3,000
2	New Activated Carbon System	1	LS	$ 156,000	$ 156,000
3	New Concrete Pad	122	SF	$ 65	$ 7,898
4	Blower Duct Modifications	1	LS	$ 10,000	$ 10,000
5	EI&C Allowance	1	LS	$ 53,069	$ 53,069
	SUBTOTAL				$ 229,967
	Contingency (50%)				$ 115,000
	Sales Tax (9.2%)				$ 31,737
	CONSTRUCTION SUBTOTAL				$ 377,000
	Design Services Engineering and Allied Costs (25%)				$ 94,250
	Construction Services and Allied Costs (25%, assumes full CM)				$ 94,250
	TOTAL PROJECT COST (ROUNDED)				**$ 600,000**

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Kitsap County General Sewer Plans

Replace UV System

Project Summary

• Replace obsolete UV system with new, more advanced model to reduce operating costs and O&M requirements

Item	Description	Quantity	Unit	Unit Cost	Total
1	Stainless steel channel reduction baffle	1	LS	$ 6,500	$ 6,500
2	Existing UV3000B Demolition	1	LS	$ 3,000	$ 3,000
3	New UV3000+ System	1	LS	$ 273,000	$ 273,000
4	UV Transmittance Probe	1	LS	$ 36,660	$ 36,660
5	EI&C Allowance	1	LS	$ 93,798	$ 93,798
	SUBTOTAL				$ 412,958
	Contingency (50%)				$ 207,000
	Sales Tax (9.2%)				$ 57,036
	CONSTRUCTION SUBTOTAL				$ 677,000
	Design Services Engineering and Allied Costs (25%)				$ 169,250
	Construction Services and Allied Costs (25%, assumes full CM)				$ 169,250
	TOTAL PROJECT COST (ROUNDED)				**$ 1,100,000**

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Kitsap County General Sewer Plans
Manchester Basin

Replace Clarifier Drives

Project Summary					
• Replace clarifier drives, collection mechanisms, walkways, platforms, and weirs					
Item	**Description**	**Quantity**	**Unit**	**Unit Cost**	**Total**
1	Replace Clarifier Drives	1	LS	$ 195,000	$ 195,000
	SUBTOTAL				$ 195,000
	Contingency (50%)				$ 98,000
	Sales Tax (9.2%)				$ 26,956
	CONSTRUCTION SUBTOTAL				$ 320,000
	Design Services Engineering and Allied Costs (25%)				$ 80,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 80,000
	TOTAL PROJECT COST (ROUNDED)				**$ 500,000**

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Kitsap County General Sewer Plans
Manchester Basin

Replace WWTP Electrical Service, Main Power Distribution, and MCC					
Project Summary					
• Replace electrical service, main power distribution, and MCC					
Item	**Description**	**Quantity**	**Unit**	**Unit Cost**	**Total**
1	Replace WWTP Electrical Service, Main Power Distribution, and MCC	1	LS	$ 130,000	$ 130,000
	SUBTOTAL				$ 130,000
	Contingency (50%)				$ 65,000
	Sales Tax (9.2%)				$ 17,940
	CONSTRUCTION SUBTOTAL				$ 213,000
	Design Services Engineering and Allied Costs (25%)				$ 53,250
	Construction Services and Allied Costs (25%, assumes full CM)				$ 53,250
	TOTAL PROJECT COST (ROUNDED)				**$ 400,000**

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Kitsap County General Sewer Plans
Manchester Basin

Fine Screen Replacement

Project Summary

• Replace fine screen with new fine screen

Item	Description	Quantity	Unit	Unit Cost	Total
1	Fine Screen Replacement	1	LS	$ 260,000	$ 260,000
2	Channel Modifications	1	LS	$ 8,000	$ 8,000
3	E&IC Modifications	1	LS	$ 24,000	$ 24,000
	SUBTOTAL				$ 292,000
	Contingency (50%)				$ 146,000
	Sales Tax (9.2%)				$ 40,296
	CONSTRUCTION SUBTOTAL				$ 479,000
	Design Services Engineering and Allied Costs (25%)				$ 119,750
	Construction Services and Allied Costs (25%, assumes full CM)				$ 119,750
	TOTAL PROJECT COST (ROUNDED)				**$ 800,000**

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Kitsap County General Sewer Plans
Manchester Basin

Grit Chamber, Pump, Cyclone, and Classifier Replacement

Project Summary

• Replace grit chamber, grit pump, cyclone, and classifier

Item	Description	Quantity	Unit	Unit Cost	Total
1	Grit Chamber, Pump, Cyclone, and Classifier Replacement	1	LS	$ 260,000	$ 260,000
	SUBTOTAL				$ 260,000
	Contingency (50%)				$ 130,000
	Sales Tax (9.2%)				$ 35,880
	CONSTRUCTION SUBTOTAL				$ 426,000
	Design Services Engineering and Allied Costs (25%)				$ 106,500
	Construction Services and Allied Costs (25%, assumes full CM)				$ 106,500
	TOTAL PROJECT COST (ROUNDED)				**$ 700,000**

Consor's construction cost ("estimate") is in dollars valued as of the date of this estimate. This estimate is an opinion of probable cost based on information available at the time of its development in June 2023. Final costs will depend on

• Actual field conditions • Actual material and labor costs • Market conditions for construction • Regulatory factors • Final project scope
• Method of implementation • Schedule (time to completion, time of commencement, speed of excecution, and • Other variables

This estimate is based on our perception, which is based on experience and research, yet nevertheless, an assessment, of current conditions at the project location. This estimate reflects our professional opinion of current costs and is subject to change as the project design evolves. Consor has no control over, nor can it forecast variences in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work, or of determining prices, of the impact of competitive bidding or market conditions, practices, or bidding strategies. Consor neither warrants nor guarentees that proposals, bids, or actual construction costs will reflect the costs presented, which are for illustrative purposes only.

Kitsap County General Sewer Plans
Manchester Basin

consor

Replace Thickening Equipment

Project Summary					
• Replace existing gravity belt thickener with new sludge thickening system					
Item	**Description**	**Quantity**	**Unit**	**Unit Cost**	**Total**
1	Replace Thickening Equipment	1	LS	$ 266,500	$ 266,500
	SUBTOTAL				$ 266,500
	Contingency (50%)				$ 134,000
	Sales Tax (9.2%)				$ 36,846
	CONSTRUCTION SUBTOTAL				$ 438,000
	Design Services Engineering and Allied Costs (25%)				$ 109,500
	Construction Services and Allied Costs (25%, assumes full CM)				$ 109,500
	TOTAL PROJECT COST (ROUNDED)				**$ 700,000**

Consor's construction cost ("estimate") is in dollars valued as of the date of this estimate. This estimate is an opinion of probable cost based on information available at the time of its development in June 2023. Final costs will depend on

• Actual field conditions • Actual material and labor costs • Market conditions for construction • Regulatory factors • Final project scope
• Method of implementation • Schedule (time to completion, time of commencement, speed of excecution, and • Other variables

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Kitsap County General Sewer Plans
Manchester Basin

Replace Sludge Tank Blowers and Sludge Pumps

Project Summary

• Replace sludge tank blowers and pumps

Item	Description	Quantity	Unit	Unit Cost	Total
1	Replace Sludge Tank Blowers and Sludge Pumps	1	LS	$ 158,000	$ 158,000
	SUBTOTAL				$ 158,000
	Contingency (50%)				$ 79,000
	Sales Tax (9.2%)				$ 21,804
	CONSTRUCTION SUBTOTAL				$ 259,000
	Design Services Engineering and Allied Costs (25%)				$ 64,750
	Construction Services and Allied Costs (25%, assumes full CM)				$ 64,750
	TOTAL PROJECT COST (ROUNDED)				**$ 400,000**

Consor's construction cost ("estimate") is in dollars valued as of the date of this estimate. This estimate is an opinion of probable cost based on information available at the time of its development in June 2023. Final costs will depend on

• Actual field conditions • Actual material and labor costs • Market conditions for construction • Regulatory factors • Final project scope
• Method of implementation • Schedule (time to completion, time of commencement, speed of excecution, and • Other variables

This estimate is based on our perception, which is based on experience and research, yet nevertheless, an assessment, of current conditions at the project location. This estimate reflects our professional opinion of current costs and is subject to change as the project design evolves. Consor has no control over, nor can it forecast variences in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work, or of determining prices, of the impact of competitive bidding or market conditions, practices, or bidding strategies. Consor neither warrants nor guarentees that proposals, bids, or actual construction costs will reflect the costs presented, which are for illustrative purposes only.

Kitsap County General Sewer Plans
Manchester Basin

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Biological Nutrient Removal - MLE Process

Project Summary

• Convert the existing aeration basins to a biological nutrient removal system by adding baffles to implement the Modified Ludzack-Ettinger process.
• Project is expected to reduce effluent TIN to approximately 5 mg/L

Item	Description	Quantity	Unit	Unit Cost	Total
1	Basin Preparation	2208	SF	$ 10	$ 22,080
2	FRP Walls	1.39	CY	$ 49,451	$ 68,737
3	Existing Jet Aeration Demolition	1	LS	$ 9,600	$ 9,600
4	Existing Blowers Demolition	1	LS	$ 3,000	$ 3,000
5	Mixers - Submersible	4	EA	$ 14,300	$ 57,200
6	Diffuser Assembly (Include Dropleg, mainfold, air distributors, and supports/anchors)	1	LS	$ 97,500	$ 97,500
7	MLR Pumps	2	EA	$ 27,300	$ 54,600
8	Mechanical Piping - 8" SCH 80 (Air piping)	246	LF	$ 92	$ 22,706
9	Mechanical Piping - 18" SCH 80 (MLR piping)	86.4	LF	$ 237	$ 20,442
10	Mechanical Piping - 8" SCH 80 (Blower piping)	130		$ 92	$ 11,999
11	Blowers	3	EA	$ 26,000	$ 78,000
12	Blower Duct Modifications	1	LS	$ 10,000	$ 10,000
13	Airflow Control Valves and Flow Meter	6	LS	$ 16,250	$ 97,500
14	Blower FVDs	3	EA	$ 10,400	$ 31,200
15	On-line DO and Ammonia/Nitrate Probes	8	EA	$ 13,260	$ 106,080
16	EI&C Allowance	1	LS	$ 92,509	$ 92,509
	SUBTOTAL				$ 783,153
	Contingency (50%)				$ 392,000
	Sales Tax (9.2%)				$ 108,114
	CONSTRUCTION SUBTOTAL				$ 1,284,000
	Design Services Engineering and Allied Costs (25%)				$ 321,000
	Construction Services and Allied Costs (25%, assumes full CM)				$ 321,000
	TOTAL PROJECT COST (ROUNDED)				**$ 1,930,000**

Consor's construction cost ("estimate") is in dollars valued as of the date of this estimate. This estimate is an opinion of probable cost based on information available at the time of its development in June 2023. Final costs will depend on

• Actual field conditions • Actual material and labor costs • Market conditions for construction • Regulatory factors • Final project scope
• Method of implementation • Schedule (time to completion, time of commencement, speed of excecution, and • Other variables

This estimate is based on our perception, which is based on experience and research, yet nevertheless, an assessment, of current conditions at the project location. This estimate reflects our professional opinion of current costs and is subject to change as the project design evolves. Consor has no control over, nor can it forecast variences in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work, or of determining prices, of the impact of competitive bidding or market conditions, practices, or bidding strategies. Consor neither warrants nor guarentees that proposals, bids, or actual construction costs will reflect the costs presented, which are for illustrative purposes only.

Kitsap County General Sewer Plans
Manchester Basin

Biological Nutrient Removal - Bardenpho Process

Project Summary

- A new aeration basin will be constructed to convert the secondary treatment system to the Bardenpho process and will provide post-anoxic and post-aerobic zones downstream of the existing aeration basins.
- Project can be implemented if needed after or in conjunction with CIP-M-WWTP-CAP-13 to further reduce effluent TIN to approximately 3 mg/L.

Item	Description	Quantity	Unit	Unit Cost	Total
1	Excavation	900	CY	$ 60	$ 53,973
2	Backfill	135	SF	$ 63	$ 8,501
3	Dewatering	1	LS	$ 200,000	$ 200,000
4	FRP Walls	0.69	CY	$ 53,572	$ 36,964
5	Aeration Basin	1012	SF	$ 300	$ 303,600
6	Mixers - Submersible	2	EA	$ 14,300	$ 28,600
7	Diffuser Assembly (Include Dropleg, mainfold, air distributors, and supports/anchors)	1	LS	$ 48,750	$ 48,750
8	Mechanical Piping - 8" SCH 80 (Air piping)	146	LF	$ 92	$ 13,476
9	Blowers	1	EA	$ 26,000	$ 26,000
10	Airflow Control Valves and Flow Meter	2	EA	$ 16,250	$ 32,500
11	Blower FVDs	1	EA	$ 10,400	$ 10,400
12	On-line DO and Ammonia/Nitrate Probes	2	EA	$ 13,260	$ 26,520
13	EI&C Allowance	1	LS	$ 29,865	$ 29,865
	SUBTOTAL				$ 819,150
	Contingency (50%)				$ 410,000
	Sales Tax (9.2%)				$ 113,082
	CONSTRUCTION SUBTOTAL				$ 1,343,000
	Design Services Engineering and Allied Costs (25%)				$ 335,750
	Construction Services and Allied Costs (25%, assumes full CM)				$ 335,750
	TOTAL PROJECT COST (ROUNDED)				**$ 2,020,000**

Consor's construction cost ("estimate") is in dollars valued as of the date of this estimate. This estimate is an opinion of probable cost based on information available at the time of its development in June 2023. Final costs will depend on

• Actual field conditions • Actual material and labor costs • Market conditions for construction • Regulatory factors • Final project scope
• Method of implementation • Schedule (time to completion, time of commencement, speed of excecution, and • Other variables

This estimate is based on our perception, which is based on experience and research, yet nevertheless, an assessment, of current conditions at the project location. This estimate reflects our professional opinion of current costs and is subject to change as the project design evolves. Consor has no control over, nor can it forecast variences in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work, or of determining prices, of the impact of competitive bidding or market conditions, practices, or bidding strategies. Consor neither warrants nor guerantees that proposals, bids, or actual construction costs will reflect the costs presented, which are for illustrative purposes only.

APPENDIX J
SUMMARY OF STATE OF WASHINGTON GRANT AND LOAN PROGRAMS FOR DRINKING WATER AND WASTEWATER CAPITAL PROJECTS

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Funding Programs for Drinking Water and Wastewater Projects

Updated 9-17-2024

Type of Program	Pages
Planning/ Pre-Construction	2 - 6
Pre-Construction Only	7 - 8
Construction	9 - 16
Emergency	17 - 19

You can find the latest version of this document at http://www.infrafunding.wa.gov/resources.html

Please contact Amie Smith at amie.smith@commerce.wa.gov if you would like to update your program information

PLANNING **Programs**	**Eligible Projects**	**Eligible Applicants**	**Funding Available**	**How To Apply**
DWSRF Drinking Water State Revolving Fund Planning and Engineering Loans Department of Health	Preparation of planning documents, engineering reports, construction documents, permits, cultural reports, environmental reports. Potential for grant subsidy for disadvantaged communities or those with high affordability rates.	Group A (private and publicly-owned) community and not-for-profit non-community water systems, but not federal or state-owned systems. Small systems serving fewer than 10,000 people.	Loan: $500,000 maximum per jurisdiction 0% annual interest rate 2% loan service fee 2-year time of performance 10-year repayment period	On-line applications accepted year-round until funding exhausted. Approximately $3 million available to award each year. **Contact:** Jocelyne Gray 564-669-4893 Jocelyne.gray@doh.wa.gov For information and forms visit: http://www.doh.wa.gov/DWSRF
DWSRF Drinking Water State Revolving Fund Consolidation Grant Department of Health	Development of a feasibility study, engineering evaluation, design of a infrastructure project to consolidated one or more Group A water systems	Group A not-for-profit community water system, county, city, public utility district, or water district in Washington State Tribal systems are eligible provided the project is not receiving other national set-aside funding for the project.	Grant: Up to $50,000 per project Minimum of $10,000 2-year time of performance	Online applications accepted year round until funding exhausted. **Contact:** Jocelyne Gray 564-669-4893 Jocelyne.gray@doh.wa.gov For information and forms visit: http://www.doh.wa.gov/DWSRF
DWSRF Drinking Water State Revolving Fund Lead Service Line Inventory Loan Department of Health	Develop lead service line inventory. Can include creating or updating a planning document. There is principal forgiveness for disadvantaged communities.	Group A (private and publicly-owned) community and not-for-profit non-community water systems, but not federal or state-owned systems.	Loan: Minimum $25,000 No maximum 0% annual interest rate 2% loan service fee 2-year time of performance 10-year repayment period First come, first served based on application submittal date.	Online applications available and accepted October 1 through November 30, 2024. **Contact:** Jocelyne Gray 564-669-4893 Jocelyne.gray@doh.wa.gov For information and forms visit: http://www.doh.wa.gov/DWSRF

PLANNING Programs	**Eligible Projects**	**Eligible Applicants**	**Funding Available**	**How To Apply**
DWSRF Drinking Water State Revolving Fund Drinking Water System Rehabilitation and Consolidation Grant Department of Health	Rehabilitation Planning and design of infrastructure to bring system into compliance. Restructuring, Consolidation, Receivership Planning Preconstruction to bring the water system into compliance. Purchase cost of the water system to be acquired. Establishment of a water program for any receiving city, town, or county.	Rehabilitation Group A water systems serving less than 10,000 people under a DOH compliance order. Restructuring, Consolidation, Receivership Group A publicly owned water system (city, town, county, public utility district, or water/sewer district), an approved Satellite Management Agency, or approved receiver.	Grant: Maximum $1.25 million 4-year time of performance	By invite only. **Contact:** Jocelyne Gray 564-669-4893 Jocelyne.gray@doh.wa.gov For information and forms visit: http://www.doh.wa.gov/DWSRF
SOURCE WATER PROTECTION GRANT PROGRAM Department of Health	Source water protection studies (watershed, hydrogeologic, feasibility studies). Eligible activities can lead to reducing the risk of contamination of a system's drinking water sources(s), or they can evaluate or build resiliency for a public water supply. They must contribute to better protecting one or more public water supply sources.	Non-profit Group A water systems. Local governments proposing a regional project. Project must be reasonably expected to provide long-term benefit to drinking water quality or quantity.	Grants: Funding is dependent upon project needs, but typically does not exceed $30,000.	Applications accepted anytime; grants awarded on a funds available basis. **Contact:** Deborah Johnson 253-433-4054 Deborah.Johnson@doh.wa.gov http://www.doh.wa.gov/CommunityandEnvironment/DrinkingWater/SourceWater/SourceWaterProtection.aspx Grant guidelines https://www.doh.wa.gov/Portals/1/Documents/Pubs/331-552.pdf

PLANNING Programs	**Eligible Projects**	**Eligible Applicants**	**Funding Available**	**How To Apply**
ECOLOGY: WATER QUALITY COMBINED FUNDING PROGRAM State Water Pollution Control Revolving Fund (SRF) Centennial Clean Water Fund Stormwater Financial Assistance Program (SFAP) Department of Ecology	Planning projects associated with publicly-owned wastewater and stormwater facilities. The integrated program also funds planning and implementation of nonpoint source pollution control activities.	Counties, cities, towns, conservation districts, or other political subdivision, municipal or quasi-municipal corporations, and federally recognized tribes	Loan: $10,000,000 reserved for preconstruction statewide Interest rates (SFY 2025) • 6-20 year loans: 1.2% • 1-5 year loans: 0.6% Preconstruction set-aside (Distressed Communities) 50% forgivable principal loan and 50% loan	Applications due October 15, 2024. **Contact:** Eliza Keeley 360-628-1976 Eliza.keeley@ecy.wa.gov https://ecology.wa.gov/About-us/How-we-operate/Grants-loans/Find-a-grant-or-loan/Water-Quality-grants-and-loans
RD PRE-DEVELOPMENT PLANNING GRANTS (PPG) U.S. Dept. of Agriculture Rural Development – Rural Utilities Service – Water and Waste Disposal Direct Loans and Grants	Water and/or sewer planning; environmental work; and other work to assist in developing an application for infrastructure improvements.	Low-income, small communities and systems serving areas under 10,000 population. Population determined by U.S. Census 2020. Income determined by the American Community Survey 2017-2021 (5-year).	Planning grant to assist in paying costs associated with developing a complete application for RD funding for a proposed project. Maximum $60,000 grant. Requires minimum 25% match.	Applications accepted year-round, on a fund-available basis. **Contact:** Koni Reynolds 360-704-7737 koni.reynolds@usda.gov http://www.rd.usda.gov/wa
RD 'SEARCH' GRANTS: SPECIAL EVALUATION ASSISTANCE FOR RURAL COMMUNITIES U.S. Dept. of Agriculture Rural Development – Rural Utilities Service – Water and Waste Disposal Direct Loans and Grants	Water and/or sewer planning; environmental work; and other work to assist in developing an application for infrastructure improvements.	Low-income, small communities and systems serving areas under 2,500 population. Population determined by U.S. Census 2020. Income determined by the American Community Survey 2017-2021 (5-year).	Maximum $30,000 grant. No match required.	Applications accepted year-round, on a fund-available basis. **Contact: :** Koni Reynolds 360-704-7737 koni.reynolds@usda.gov http://www.rd.usda.gov/wa

PLANNING **Programs**	**Eligible Projects**	**Eligible Applicants**	**Funding Available**	**How To Apply**
CERB PLANNING AND FEASIBILITY GRANTS Community Economic Revitalization Board – Project-Specific Planning Program	Project-specific feasibility and pre-development studies that advance community economic development goals for industrial sector business development.	Eligible statewide Counties, cities, towns, port districts, special districts. Federally recognized tribes Municipal corporations, quasi-municipal corporations w/ economic development purposes.	Grant: Up to $100,000 per project. Requires 20% (of total project cost) matching funds CERB is authority for funding approvals.	Applications accepted year-round. The Board meets six times a year. **Contact:** Janea Stark 360-252-0812 janea.stark@commerce.wa.gov
RCAC Rural Community Assistance Corporation Feasibility and Pre-Development Loans	Water, wastewater, stormwater, and solid waste planning; environmental work; and other work to assist in developing an application for infrastructure improvements.	Non-profit organizations, public agencies, tribes, and low-income rural communities with a 50,000 population or less, or 10,000 or less if proposed permanent financing is through USDA Rural Development.	Typically up to $50,000 for feasibility loan. Typically up to $350,000 for pre-development loan. Typically up to a 1-year term. 5.5% interest rate. 1% loan fee.	Applications accepted anytime. **Contact**: Jessica Scott 719-458-5460 jscott@rcac.org Applications available online at http://www.rcac.org/lending/environmental-loans/
Economic Development Administration (EDA) United States Department of Commerce **EDA Public Works & Economic Adjustment Assistance Program:** Planning, Feasibility Studies, Preliminary Engineering Reports, Environmental Consultation for distressed and disaster communities.	Drinking water infrastructure; including pre-distribution conveyance, withdrawal/harvest (i.e. well extraction), storage facilities, treatment and distribution. Waste water infrastructure; including conveyance, treatment facilities, discharge infrastructure and water recycling.	Indian Tribes; state, county, city, or other political subdivisions of a state; institutions of higher education; public or private non-profit organizations or associations acting in cooperation with officials of a political subdivision of a State	Grants: EDA investment share up to $500,000 Cost sharing required from applicant Standard grant rate of 50% of total project cost and up to 80%. ○ Up to 100% for Tribal Nations	Submit application through EDA Grants Management Experience “EDGE” Home (eda.gov) **Contact:** J. Wesley Cochran Economic Development Representative (206) 561-6646 jcochran@eda.gov

PLANNING **Programs**	**Eligible Projects**	**Eligible Applicants**	**Funding Available**	**How To Apply**
Public Works Board WA Department of Commerce Pre-construction program	Capital facilities planning (including small water system management plans, wastewater facility plans, transportation elements, etc.) Roads, streets and bridges, domestic water, sanitary sewer, stormwater, and solid waste/recycling/organics facilities.	Counties, cities, special purpose districts, and quasi-municipal organizations that meet certain requirements. Ineligible applicants: school districts, port districts, and tribes, per statute.	Pre-construction awarded quarterly until funds are exhausted. Up $1,000,000 per project. FY25 interest rate: 0.86%. 5 year loan term. Maximum award per jurisdiction per biennium across all PWB funding programs: $10 million Awards are typically 100% loans, but partial grant funding may be awarded to communities meeting Distressed or Severely Distressed criteria.	**Contact:** Sheila Richardson 564-999-1927 Sheila.richardson@commerce.wa.gov Check the Public Works Board website periodically at http://www.pwb.wa.gov to obtain the latest information on program details or to contact Public Works Board staff.

PRECONSTRUCTION ONLY Programs	Eligible Projects	Eligible Applicants	Funding Available	How To Apply
ECOLOGY: WATER QUALITY COMBINED FUNDING PROGRAM State Water Pollution Control Revolving Fund (SRF) Centennial Clean Water Fund Stormwater Financial Assistance Program (SFAP)	Design projects associated with publicly-owned wastewater and stormwater facilities. The integrated program also funds planning and implementation of nonpoint source pollution control activities.	Counties, cities, towns, conservation districts, or other political subdivision, municipal or quasi-municipal corporations, and federally recognized tribes. Stormwater Financial Assistance Program (SFAP) is limited to cities, counties, and public ports.	Loan: $10,000,000 reserved for preconstruction statewide Interest rates (SFY 2025) • 6-20 year loans: 1.2% • 1-5 year loans: 0.6% Preconstruction set-aside (Distressed Communities) 50% forgivable principal loan and 50% loan	Applications due October 15, 2024. A cost effectiveness analysis must be complete at the time of application. **Contact:** Eliza Keeley 360-628-1976 Eliza.keeley@ecy.wa.gov https://ecology.wa.gov/About-us/How-we-operate/Grants-loans/Find-a-grant-or-loan/Water-Quality-grants-and-loans
Public Works Board PWB PRE-CON WA Department of Commerce Pre-Construction Program	Pre-construction activities to bring projects to a higher degree of readiness that prepare a specific project for construction. Roads, streets and bridges, domestic water, sanitary sewer, stormwater, and solid waste/recycling/organics facilities.	Counties, cities, special purpose districts, and quasi-municipal organizations that meet certain requirements. Ineligible applicants: school districts, port districts, and tribes, per statute.	Pre-construction awarded quarterly until funds are exhausted. Up $1,000,000 per project. FY25 interest rate: 0.86%. 5 year loan term. Maximum award per jurisdiction per biennium across all PWB funding programs: $10 million Awards are typically 100% loans, but partial grant funding may be awarded to communities meeting Distressed or Severely Distressed criteria.	**Contact:** Sheila Richardson 564-999-1927 Sheila.richardson@commerce.wa.gov Check the Public Works Board website periodically at http://www.pwb.wa.gov to obtain the latest information on program details or to contact Public Works Board staff.

PRECONSTRUCTION ONLY Programs	**Eligible Projects**	**Eligible Applicants**	**Funding Available**	**How To Apply**
RCAC Rural Community Assistance Corporation Feasibility and Pre-Development Loans	Water, wastewater, stormwater, or solid waste planning; environmental work; and other work to assist in developing an application for infrastructure improvements.	Non-profit organizations, public agencies, tribes, and low-income rural communities with a 50,000 population or less, or 10,000 or less if proposed permanent financing is through USDA Rural Development.	Typically up to $50,000 for feasibility loan. Typically up to $350,000 for pre-development loan. Typically a 1-year term. 5.5% interest rate. 1% loan fee.	Applications accepted anytime. **Contact**: Jessica Scott 719-458-5460 jscott@rcac.org Applications available online at http://www.rcac.org/lending/environmental-loans/
Economic Development Administration (EDA) United States Department of Commerce **EDA Public Works & Economic Adjustment Assistance Program:** Design and/or Construction for distressed and disaster communities.	Drinking water infrastructure; including pre-distribution conveyance, withdrawal/harvest (i.e. well extraction), storage facilities, treatment and distribution. Waste water infrastructure; including conveyance, treatment facilities, discharge infrastructure and water recycling.	Indian Tribes; state, county, city, or other political subdivisions of a state; institutions of higher education; public or private non-profit organizations or associations acting in cooperation with officials of a political subdivision of a State.	Grants: EDA investment share up to $500,000 Cost sharing required from applicant Standard grant rate is 50% of total project cost, and up to 80%. ○ Up to 100% for Tribal Nations	Submit application through EDA Grants Management Experience “EDGE” Home (eda.gov) **Contact:** J. Wesley Cochran Economic Development Representative (206) 561-6646 jcochran@eda.gov

CONSTRUCTION AND DESIGN/CONSTRUCTION Programs	Eligible Projects	Eligible Applicants	Funding Available	How To Apply
DWSRF Drinking Water State Revolving Fund Construction Loan Program Department of Health	Drinking water system infrastructure projects aimed at increasing public health protection. There is principal forgiveness for disadvantaged communities.	Group A (private and publicly-owned) community and not-for-profit non-community water systems, but not federal or state-owned systems. Tribal systems are eligible provided the project is not receiving other national set-aside funding for the project.	Loan: Maximum $15 million per jurisdiction. 2.25% annual interest rate (Final rate is set September 1, 2024). 1.0% loan service fee (water systems receiving subsidy are not subject to loan fees). 4-year time of performance, encouraged 2-year time of performance Loan repayment period: 20 years or life of the project, whichever is less. No local match required.	Online applications available and accepted year-round. Applications due November 30, 2024. **Contact:** Jocelyne Gray 564-669-4893 Jocelyne.gray@doh.wa.gov For information and forms visit: http://www.doh.wa.gov/DWSRF
DWSRF Drinking Water State Revolving Fund Lead Service Line (LSL) Replacement Loan Department of Health	Lead service line replacement. Galvanized service lines to be replaced per Lead and Copper Rule. Service water meters older than 1986 lead ban, as part of LSL replacement. There is principal forgiveness for disadvantaged communities.	Group A (private and publicly-owned) community and not-for-profit non-community water systems, but not federal or state-owned systems. Tribal systems are eligible provided the project is not receiving other national set-aside funding for the project.	Loan: Minimum $25,000 No maximum 2.25% annual interest rate (Final rate is set September 1, 2024). 1% loan service fee (water systems receiving subsidy are not subject to loan fees) 4-year time of performance, encouraged 2-year time of performance 20-year repayment period	Online applications available and accepted October 1 year-round. Applications due November 30, 2024. **Contact:** Jocelyne Gray 564-669-4893 Jocelyne.gray@doh.wa.gov For information and forms visit: http://www.doh.wa.gov/DWSRF

CONSTRUCTION AND DESIGN/CONSTRUCTION Programs	Eligible Projects	Eligible Applicants	Funding Available	How To Apply
DWSRF Drinking Water State Revolving Fund Drinking Water System Rehabilitation and Consolidation Grant **Department of Health**	Rehabilitation Construction of infrastructure to bring water system into compliance. Restructuring, Consolidation, Receivership Planning Construction of infrastructure to bring water system into compliance.	Rehabilitation Group A water systems serving less than 10,000 people under a DOH compliance order. Restructuring, Consolidation, Receivership Group A publicly owned water system (city, town, county, public utility district, or water/sewer district), an approved Satellite Management Agency, or approved receiver.	Grant: Maximum $1.25 million 4-year time of performance	By invite only. **Contact:** Jocelyne Gray 564-669-4893 Jocelyne.gray@doh.wa.gov For information and forms visit: http://www.doh.wa.gov/DWSRF
ECOLOGY: Water Quality Combined Funding Program State Water Pollution Control Revolving Fund (SRF) Centennial Clean Water Fund Stormwater Financial Assistance Program (SFAP)	Construction projects associated with publicly-owned wastewater and stormwater facilities. The integrated program also funds planning and implementation of nonpoint source pollution control activities.	Counties, cities, towns, conservation districts, or other political subdivision, municipal or quasi-municipal corporations, and federally recognized tribes. Stormwater Financial Assistance Program (SFAP) is limited to cities, counties, and public ports. Hardship Assistance Jurisdictions listed above with a service area population of 25,000 or less.	Loan: $200,000,000 available statewide. Interest rates (SFY 2025) • 21-30 year loans: 1.6% • 6-20 year loans: 1.2% • 1-5 year loans: 0.6% Hardship assistance for the construction of wastewater treatment facilities may be available in the form of a reduced interest rate, and up to $5,000,000 grant or loan forgiveness. SFAP grant maximum award per jurisdiction: $10,000,000, with a required 15% match, with match reduced to 5% for hardship.	Applications due October 15, 2024. A cost effectiveness analysis must be complete at the time of application. **Contact:** Eliza Keeley 360-628-1976 Eliza.keeley@ecy.wa.gov https://ecology.wa.gov/About-us/How-we-operate/Grants-loans/Find-a-grant-or-loan/Water-Quality-grants-and-loans

CONSTRUCTION AND DESIGN/CONSTRUCTION Programs	**Eligible Projects**	**Eligible Applicants**	**Funding Available**	**How To Apply**
PWB Public Works Board Construction Program	New construction, replacement, and repair of existing infrastructure for roads, streets and bridges, domestic water, sanitary sewer, stormwater, and solid waste/recycling/organics.	Counties, cities, special purpose districts, and quasi-municipal organizations. Ineligible applicants: school districts, port districts, and tribes, per statute.	FY26 Cycle: Pending appropriation FY25 interest rate: 1.71%. Loan term 20 years. Maximum award per jurisdiction per biennium across all PWB funding programs: $10 million Maximum project award: $10 million per jurisdiction per biennium. Awards are typically 100% loans, but partial grant funding may be awarded to communities meeting Distressed criteria. Construction is a competitive program with two cycles per biennium.	Typically opens in Spring Contact: Sheila Richardson 564-999-1927 Sheila.richardson@commerce.wa.gov Check the Public Works Board website periodically at http://www.pwb.wa.gov to obtain the latest information on program details or to contact Public Works Board staff.

CONSTRUCTION AND DESIGN/CONSTRUCTION Programs	**Eligible Projects**	**Eligible Applicants**	**Funding Available**	**How To Apply**
RD U.S. Dept. of Agriculture Rural Development - Rural Utilities Service Water and Waste Disposal Direct Loans and Grants	Pre-construction and construction associated with building, repairing, or improving drinking water, wastewater, solid waste, and stormwater facilities.	Cities, towns, and other public bodies, tribes and private non-profit corporations serving rural areas with populations under 10,000. Population determined by U.S. Census 2020. Income determined by the American Community Survey 2017-2021 (5-year).	Loans; Grants in some cases Interest rates change quarterly; contact staff for latest interest rates. Up to 40-year loan term. No pre-payment penalty.	Applications accepted year-round on a fund-available basis. **Contact: :** Koni Reynolds 360-704-7737 koni.reynolds@usda.gov http://www.rd.usda.gov/wa
CERB Community Economic Revitalization Board Construction Program	Public facility projects required by private sector expansion and job creation. Projects must support significant job creation or significant private investment in the state. Bridges, roads and railroad spurs, domestic and industrial water, sanitary and storm sewers. Electricity, natural gas and telecommunications General purpose industrial buildings, port facilities. Acquisition, construction, repair, reconstruction, replacement, rehabilitation	Counties, cities, towns, port districts, special districts Federally-recognized tribes Municipal and quasi-municipal corporations with economic development purposes.	Maximum grant amounts: $2,000,000 for construction projects. $500,000 for housing rehabilitation programs. $250,000 for microenterprise assistance programs.	Applications accepted year-round. The Board meets six times a year. **Contact:** Janea Stark 360-252-0812 janea.stark@commerce.wa.gov

CONSTRUCTION AND DESIGN/CONSTRUCTION Programs	**Eligible Projects**	**Eligible Applicants**	**Funding Available**	**How To Apply**
CDBG-GP Community Development Block Grant General Purpose Grants	Design and construction of community facility, wastewater, drinking water, stormwater and street/sidewalk projects. Infrastructure in support of affordable housing.	Projects must principally benefit low- to moderate-income people in non-entitlement cities and counties. List and map of local governments served by state CDBG program	Maximum grant amounts: $2,000,000 for construction projects. $500,000 for housing rehabilitation programs. $250,000 for microenterprise assistance programs.	Applications accepted year-round on a fund-available basis. **Contact:** Jon Galow 509-847-5021 Jon.galow@commerce.wa.gov Visit www.commerce.wa.gov/cdbg for more information.
RCAC Rural Community Assistance Corporation Intermediate Term Loan	Water, wastewater, solid waste and stormwater facilities that primarily serve low-income rural communities.	Non-profit organizations, public agencies, tribes, and low-income rural communities with a 50,000 population or less.	Typically up to $3 million with commitment letter for permanent financing Security in permanent loan letter of conditions Term matches construction period. 5.5% interest rate 1.125% loan fee	Applications accepted anytime. **Contact**: Jessica Scott 719-458-5460 jscott@rcac.org Applications available online at http://www.rcac.org/lending/environmental-loans/
RCAC Rural Community Assistance Corporation Construction Loans	Water, wastewater, solid waste and stormwater facilities that primarily serve low-income rural communities. Can include pre-development costs.	Non-profit organizations, public agencies, tribes, and low-income rural communities with a 50,000 population or less, or 10,000 populations or less if using USDA Rural Development financing as the takeout.	2023-2025 solicitation closed 9/25/2024 Longstanding program will likely be offered in the 2025-2027 biennium. Minimum match requirements will apply. Other State funds cannot be used as match.	Applications accepted anytime. **Contact**: Jessica Scott 719-458-5460 jscott@rcac.org Applications available online at http://www.rcac.org/lending/environmental-loans/

CONSTRUCTION AND DESIGN/CONSTRUCTION Programs	Eligible Projects	Eligible Applicants	Funding Available	How To Apply
Energy Retrofits for Public Buildings Program: Energy Efficiency Grant Washington State Department of Commerce	Retrofit projects that reduce energy consumption (electricity, gas, water, etc.) and operational costs on existing facilities and related projects owned by an eligible applicant. Projects must utilize devices that do not require fossil fuels whenever possible.	Washington State public entities, such as cities, towns, local agencies, public higher education institutions, school districts, federally recognized tribal governments, and state agencies. Some percentage of funds are reserved for projects in small towns or cities with populations of 5,000 or fewer. Priority given to applicants who have not received funding previously, certain priority communities.	2023-25 solicitation closed 09/25/2024. Longstanding program will likely be offered in the 2025-27 biennium. Minimum match requirements will apply. Other State funds cannot be used as match.	**Contact:** Kristen Kalbrener 360-515-8112 energyretrofits@commerce.wa.gov For more information: https://www.commerce.wa.gov/growing-the-economy/energy/energy-efficiency-and-solar-grants/
Energy Efficiency and Conservation Block Grant Washington State Department of Commerce	Energy audits and energy conservation planning projects including financing, infrastructure, public education	Local governments (cities, counties, federally-recognized tribes) Priority for disadvantaged communities	Funding for the current biennium is depleted. Visit our website to sign up for updates. Future funding anticipated in Late Spring 2025.	**Contact:** Kristen Kalbrener 360-515-8112 energyretrofits@commerce.wa.gov
Energy Retrofits for Public Buildings: Solar Grants Washington State Department of Commerce	Purchase and installation of grid-tied solar photovoltaic (electric) arrays net metered with existing facilities owned by public entities. Additional points for 'Made in Washington' components.	Washington State public entities, such as cities, towns, local agencies, public higher education institutions, school districts, federally recognized tribal governments, and state agencies. See above.	Funding for the current biennium is depleted. Visit our website to sign up for updates. Future funding anticipated in Late Spring 2025.	**Contact:** EPICgrants@commerce.wa.gov **Visit:** https://www.commerce.wa.gov/growing-the-economy/energy/epic/clean-energy-grant-programs/ for more information.

CONSTRUCTION AND DESIGN/CONSTRUCTION Programs	Eligible Projects	Eligible Applicants	Funding Available	How To Apply
Solar plus Storage for Resilient Communities Washington State Department of Commerce	The Solar plus Storage program funds solar and battery back-up power so community buildings can provide essential services when the power goes out, including both planning and installation grants.	Local governments, State governments, Tribal governments and their affiliates, Non-profit organizations and Retail electric utilities.	Funding for the current biennium is depleted. Visit our website to sign up for updates. Future funding anticipated in Late Spring 2025.	**Contact:** EPICgrants@commerce.wa.gov **Visit:** **https://www.commerce.wa.gov/growing-the-economy/energy/epic/clean-energy-grant-programs**
Dual Use Solar **Washington State Department of Commerce**	Constructions or planning projects that will lead to the creation of mixed use solar installation. Projects should including, but are not limited to, combining solar with: animal grazing, beekeeping, pollinator habitat, or other colocation uses.	Local governments, State governments, Tribal governments and their affiliates, Non-profit organizations, for-profit organizations, and Retail electric utilities.	Grants: EDA investment share up to $5,000,000. Cost sharing required from applicant Standard grant rate is 50% of total project cost, and up to 80%. Up to 100% for Tribal Nations	**Contact:** EPICgrants@commerce.wa.gov **Visit:** **https://www.commerce.wa.gov/growing-the-economy/energy/epic/clean-energy-grant-programs/**

CONSTRUCTION AND DESIGN/CONSTRUCTION Programs	Eligible Projects	Eligible Applicants	Funding Available	How To Apply
Economic Development Administration (EDA) United States Department of Commerce **EDA Public Works & Economic Adjustment Assistance Program:** Design and/or Construction for distressed and disaster communities.	Drinking water infrastructure; including pre-distribution conveyance, withdrawal/ harvest (i.e. well extraction), storage facilities, treatment and distribution. Waste water infrastructure; including conveyance, treatment facilities, discharge infrastructure, water recycling.	Indian Tribes; state, county, city, or other political subdivisions of a state; institutions of higher education; public or private non-profit organizations or associations acting in cooperation with officials of a political subdivision of a State.	Loans may not exceed $200,000 or 75% of the total project cost, whichever is less. Applicants given credit for documented project costs prior to receiving the loan. Interest rates at the lower of the poverty or market interest rate as published by USDA RD RUS, with a minimum of 3% at time of closing. Maximum repayment period is 10 years. Additional ranking points for a shorter repayment period. The repayment period cannot exceed the useful life of the facilities.	Submit application through EDA Grants Management Experience "EDGE" Home (eda.gov) **Contact:** J. Wesley Cochran Economic Development Representative (206) 561-6646 jcochran@eda.gov
RURAL WATER REVOLVING LOAN FUND	Short-term costs incurred for replacement equipment, small scale extension of services, or other small capital projects that are not a part of regular operations and maintenance for drinking water and wastewater projects.	Public entities, including municipalities, counties, special purpose districts, Native American Tribes, and corporations not operated for profit, including cooperatives, with up to 10,000 population and rural areas with no population limits.	$55.5 million in total funds available in 2023-2025 biennium. $19.4 million specifically reserved for jurisdictions with a population of less than 150,000. $2,000,000 maximum award. Funds available as both grants and deferred loans.	Applications accepted anytime. **Contact**: Tracey Hunter Evergreen Rural Water of WA 360-462-9287 thunter@erwow.org Download application online: http://nrwa.org/initiatives/revolving-loan-fund/
Connecting Housing to Infrastructure Program (CHIP) Washington State Department of Commerce	Housing projects with at least 25% of units affordable for at least 25 years. Funding goes toward water, sewer, and stormwater infrastructure improvements for eligible projects, as well as toward system development charges and impact fees, which are waived to encourage affordable housing.	Cities, counties, and utility districts located in a jurisdiction which has a dedicated sales tax for affordable housing. The local jurisdiction will sponsor/ partner with a housing developer on the project.	$55.5 million in total funds available in 2023-2025 biennium. $19.4 million specifically reserved for jurisdictions with a population of less than 150,000. $2,000,000 maximum award. Funds available as both grants and deferred loans.	Contact: Mischa Venables 360-725-3088 Mischa.venables@commerce.wa.gov Visit www.commerce.wa.gov/CHIP

EMERGENCY Programs	Eligible Projects	Eligible Applicants	Funding Available	How To Apply
ECOLOGY Water Quality Emergency Clean Water State Revolving Funding Program	Projects that may result from a natural disaster or an immediate and emergent threat to public health due to water quality issues resulting from unforeseen or unavoidable circumstances. Water quality-related projects considered to be an environmental emergency that meets the WAC 173-98-030(27)5 definition and has received a Declaration of Emergency from the local Government.	Only available to public bodies serving a population of 10,000 or less. Counties, cities, and towns, federally recognized tribes, water and sewer districts, irrigation districts, conservation districts, local health jurisdictions, port districts, quasi-municipal corporations, Washington State institutions of higher education	Loan: $5,000,000 maximum Interest rates (SFY25): 10-year loan, 0.0-1.6%	Available year round. Contact: Eliza Keeley 360-628-1976 Eliza.keeley@ecy.wa.gov https://ecology.wa.gov/About-us/How-we-operate/Grants-loans/Find-a-grant-or-loan/Water-Quality-grants-and-loans

EMERGENCY Programs	Eligible Projects	Eligible Applicants	Funding Available	How To Apply
RD – ECWAG U.S. Dept. of Agriculture Rural Development Emergency Community Water Assistance Grants	Domestic water projects needing emergency repairs due to an incident such as: a drought; earthquake; flood; chemical spill; fire; etc. A significant decline in quantity or quality of potable water supply that was caused by an emergency.	Public bodies, tribes and private non-profit corporations serving rural areas with populations under 10,000. Population determined by U.S. Census 2020. Income determined by the American Community Survey 2017-2021 (5-year).	Grant; pending availability of funds. Water transmission line grants up to $150,000 to construct water line extensions, repair breaks or leaks in existing water distribution lines, and address related maintenance to replenish the water supply. Water source grants up to $1,000,000 for the construction of new wells, reservoirs, transmission lines, treatment plants, and/or other sources of water (water source up to and including the treatment plant).	Applications accepted year-round on a fund-available basis. **Contact:** Koni Reynolds 360-704-7737 koni.reynolds@usda.gov http://www.rd.usda.gov/wa
DWSRF Department of Health – Drinking Water State Revolving Fund Emergency Loan Program Department of Health	Will financially assist eligible communities experiencing the loss of critical drinking water services or facilities due to an emergency.	Publicly or privately owned (not-for-profit) Group A community water systems with a population of fewer than 10,000. Transient or non-transient non-community public water systems owned by a non-profit organization. Non-profit non-community water systems must submit tax-exempt documentation. Tribal systems are eligible provided the project is not receiving other national set-aside funding for the project.	Loan: Interest rate: 0%, no subsidy available Loan fee: 1.5% Loan term: 10 years $500,000 maximum award per jurisdiction. Time of performance: 2 years from contract execution to project completion date. Repayment commencing first October after contract execution.	To be considered for an emergency loan, an applicant must submit a completed emergency application package to the department. **Contact:** Jocelyne Gray 564-669-4893 Jocelyne.gray@doh.wa.gov For information and forms visit: http://www.doh.wa.gov/DWSRF

EMERGENCY Programs	Eligible Projects	Eligible Applicants	Funding Available	How To Apply
RURAL WATER REVOLVING LOAN FUND Disaster area emergency loans	Contact staff for more information on emergency loans.	Public entities, including municipalities, counties, special purpose districts, Native American Tribes, and corporations not operated for profit, including cooperatives, with up to 10,000 population and rural areas with no population limits.	90-day, no interest, disaster area emergency loans with immediate turn-around. Download application online: http://nrwa.org/initiatives/revolving-loan-fund/	Applications accepted anytime. **Contact**: Tracey Hunter Evergreen Rural Water of WA 360-462-9287 thunter@erwow.org
HAZARD MITIGATION GRANT PROGRAM FEMA/WA Emergency Management Division	Disaster risk-reduction projects and planning after a disaster declaration in the state.	Any state, tribe, county, or local jurisdiction (incl., special purpose districts) that has a current FEMA-approved hazard mitigation plan.	Varies depending on the level of disaster, but projects only need to compete at the state level. Local jurisdiction cost-share: 12.5%	Applications will be opened after a disaster declaration. **Contact**: Tim Cook State Hazard Mitigation Officer 253-512-7072 Tim.cook@mil.wa.gov
PUBLIC ASSISTANCE PROGRAM FEMA/WA Emergency Management Division	Construction, repair to, and restoration of publicly owned facilities damaged during a disaster. Debris-removal, life-saving measures, and restoration of public infrastructure.	State, tribes, counties, and local jurisdictions directly affected by the disaster.	Varies depending on the level of disaster and total damage caused.	Applications are opened after disaster declaration. **Contact:** Gary Urbas Public Assistance Project Manager 253-512-7402 Gary.urbas@mil.wa.gov
WASHINGTON STATE DEPARTMENT OF COMMERCE ERR - Emergency Rapid Response	Projects that provide continuity of essential community services/ lifelines that become diminished during an emergency and recovery assistance after an emergency event. Projects that restore service for a limited duration or through a temporary measure. These funds are not designated for long term recovery costs associated with the full re-establishment of lifeline services.	Tribes and local governments	Grant; pending availability of funds $5,000,000- $6,000,000 Period of performance state fiscal year July-June	Applications accepted year-round until funding exhausted. $5.5 to 6 million available to award each year. **Contact:** Nicole Patrick 206-713-6997 Nicole.patrick@commerce.wa.gov For information and application visit: EmergencyRapidResponse or https://deptofcommerce.box.com/s/skmab4hq3l4z55jazzc7qlsmbrsgermv