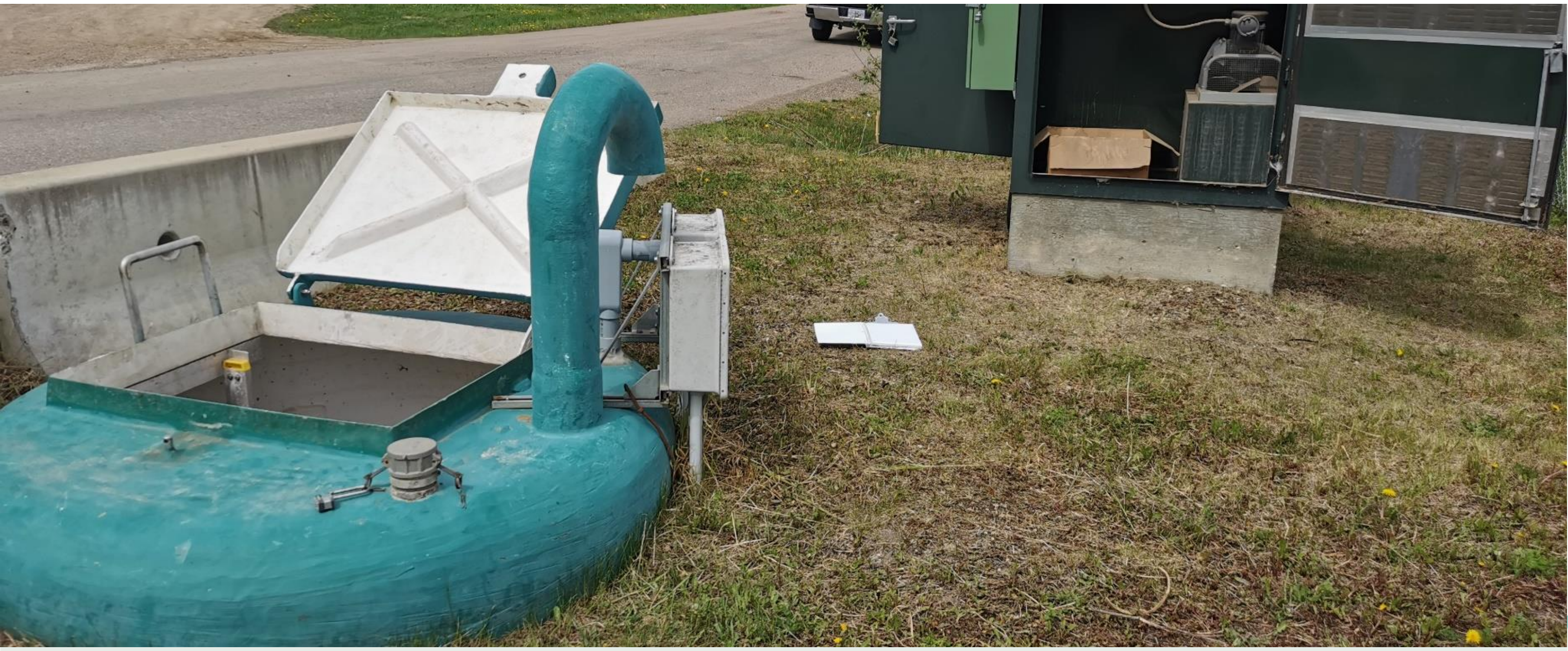

Peace River Regional District
Chilton Assessment

October 29, 2021 | Revision 0

Submitted to: Peace River Regional District
Prepared by: McElhanney Ltd.

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Our file: 3111-26522-00-CIV-RPT-001

Your Challenge.
Our Passion.

Our File: 3111-26522-00-CIV-RPT-001

October 29, 2021

Peace River Regional District
1981 Alaska Avenue
Dawson Creek, BC V1G 4H8

Peace River Regional District Chilton Assessments

McElhanney performed an inspection of the Chilton lift station to determine the condition and maintenance required to improve operations. The lift station pumps require frequent servicing, and the potential capacity of the lift station is negatively affected by some maintenance issues. Despite this, the lift station has adequate capacity for the community it serves; therefore, we recommend maintaining the current design operation and performing maintenance to prolong the service life of the lift station and to reduce the required future maintenance effort and cost. McElhanney recommends completing some preliminary repairs as soon as possible, with an estimated cost of $27,690, in order to improve the lift station's systems. There is also a need identified to study the upgrade to 3-phase power. Within the next 3 years, additional maintenance for the piping, pumps, and power supply will be required at consecutive phases, with an estimated cost of $111,500.

McElhanney performed CCTV inspection on approximately 1.2 kilometres of sanitary gravity sewer. We found that the gravity sewer was generally in fair condition, with an estimated 30+ years of service remaining. There are some repairs required to eliminate some sags in the sewer that may accelerate pipe deterioration and to replace existing cleanouts with manholes; the repairs required have an estimated cost of $123,500. Long-term, the pipes should be flushed and reinspected every 5 to 10 years to continuously monitor structural stability. Since replacing the pipe will occur at some point in the future, a precise cost cannot be provided; however, the 2021 replacement cost for the gravity sewer system is an estimated $928,800.

Sincerely,
McElhanney Ltd.

[redacted]

PERMIT TO PRACTICE
McElhanney Ltd.
PERMIT NUMBER: 1003299
Engineers and Geoscientists of BC

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1. Introduction

As part of its 2021 operations and maintenance plan, the Peace River Regional District (PRRD) contracted McElhanney Ltd. (McElhanney) to conduct a condition assessment of the Chilton subdivision sanitary sewer system, including the lift station and associated infrastructure. Located in the City of Dawson Creek (the City), the Chilton subdivision sanitary sewer system conveys flows through the City's system leading to their wastewater treatment facility. The goal of the assessment was to determine the current condition and remaining service life and to identify required system repairs and upgrades.

1.1. BACKGROUND

The Chilton subdivision was originally constructed in 2001, with approximately 1km of sanitary sewer main of 150mm to 200mm SDR35 PVC gravity main and a 100mm DR26 HDPE forcemain from the lift station to its outfall on 20th Street. A map of the area is provided in *Figure 1*.

Figure 1: Map of the Chilton Gravity Sanitary Sewer Network

The gravity main pipe is sloped at 1.5% to 2.5%. The sanitary sewer was generally constructed in the boulevard outside of the roadway, with an as-constructed cross-section as shown in *Figure 2.* Based on the as-built drawings, the pipe bedding was generally Class "B" bedding consisting of fine granular material (sand and gravel) above and below the pipe and compacted to 95% SPD.

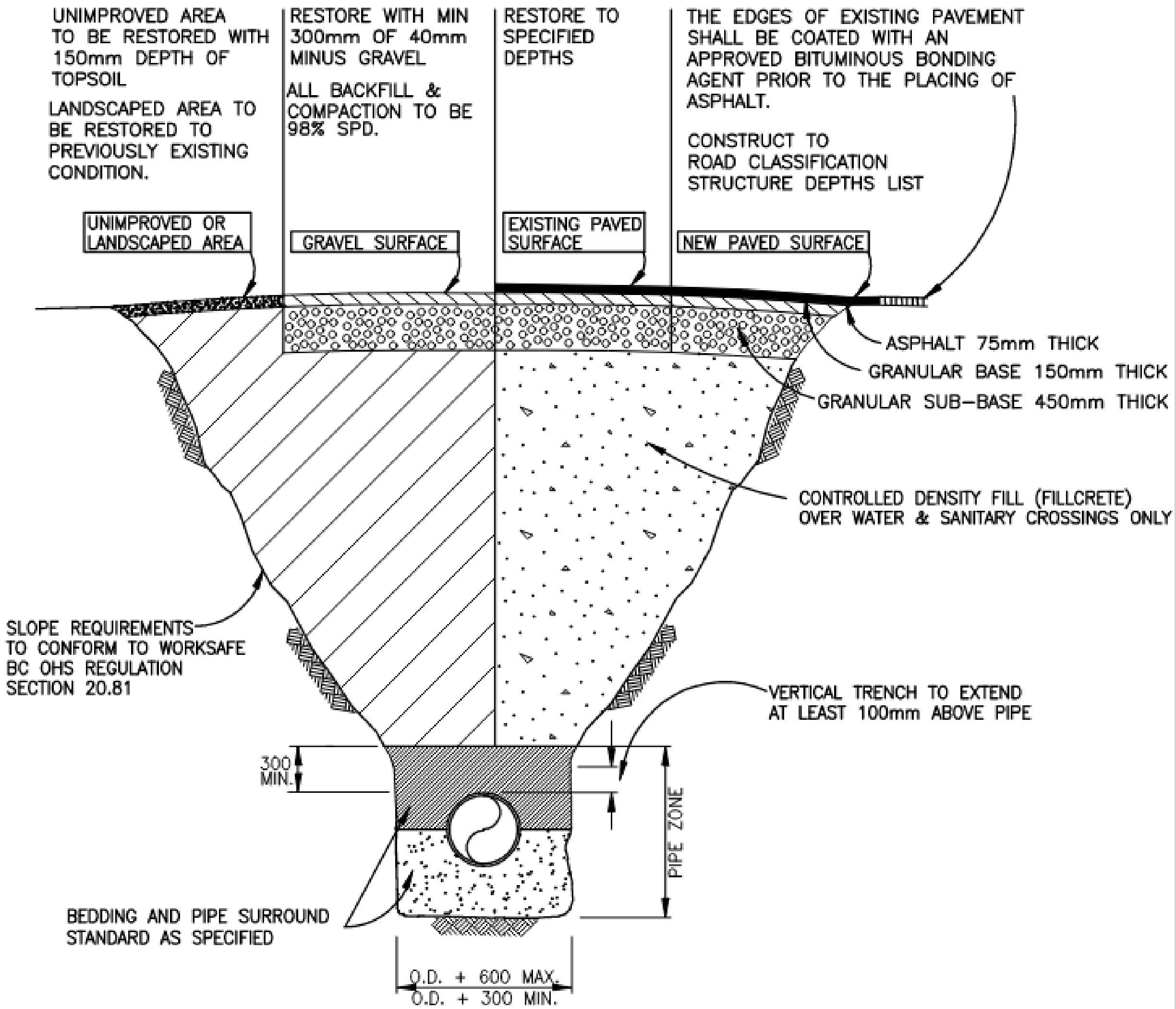

Figure 2: Typical Trench Detail for Chilton Subdivision Sewer Installation

2. Lift Station Assessment

The Chilton subdivision lift station (*Figure 3*), located along Patrick Drive, is fed by approximately 1180m of 200mm diameter PVC gravity sanitary pipe. It was commissioned in 2001 and lifts sanitary waste to a gravity manhole approximately 375m downstream on 20th Street via a 100mm DR 26 HDPE forcemain. There are no other services or connections between these two points. The lift station assessment summarizes the findings and recommendations for the infrastructure.

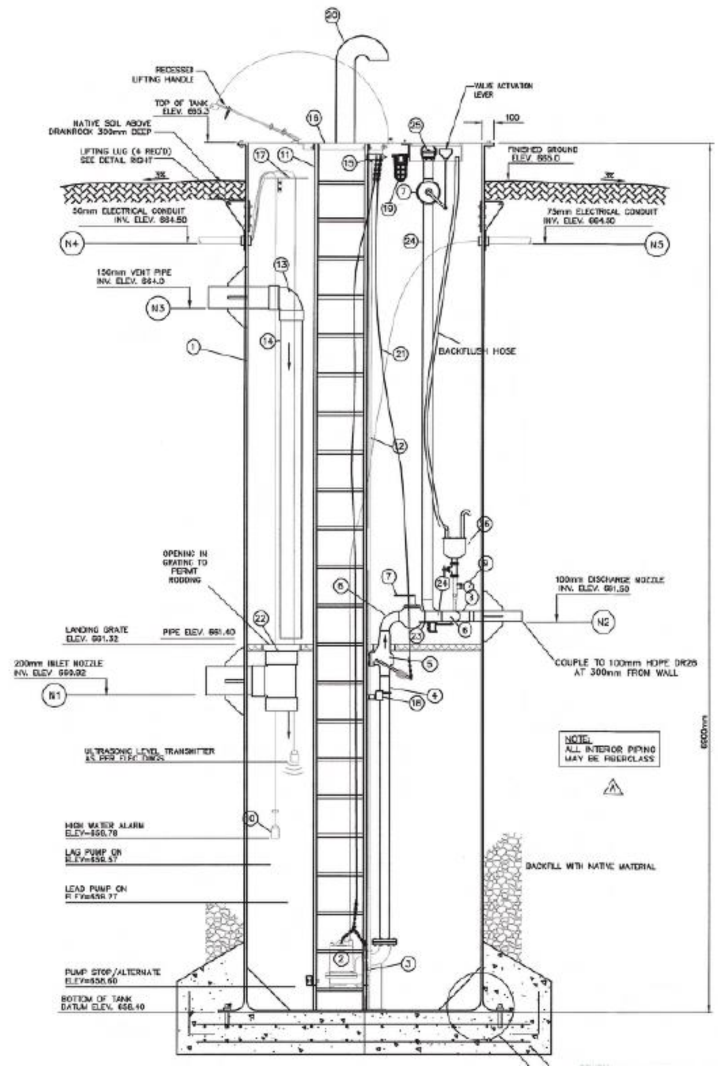

Figure 3: Chilton Lift Station General Arrangement

2.1. INSPECTION

McElhanney, along with PRRD representatives, conducted a site inspection from May 31 to June 2, 2021, to assess the existing conditions for the Chilton subdivision lift station. The site allows drive-up access, with jersey barriers positioned to protect the wet well and kiosk.

The inspection included a general visual inspection of all components, verification of installed pump type, and a drawdown test. The physical integrity of the lift station was found to be generally acceptable. The following sections will detail the findings for specific lift station components.

2.1.1. Wet Well

The wet well was found to be in good condition, without damage to the fibreglass surface. Operations staff reported no wet well leakage, nor was any observed during the inspection. Considerable rust was visible on the galvanized steel pipes and their flanges (*Figure 4*). The check valves, plug valves, and air release valve (*Figure 5*) within the wet well had no reported issues nor were any extraordinary observations reported by the staff.

Figure 4: Rusted Pipe and Flange in the Wet Well

EQUIPMENT SPECIFICATION

ITEM	DESCRIPTION
1.	1800mm DIA X 6900mm DEEP FIBERGLASS PUMP STATION C/W FIBERGLASS ENCAPSULATED STEEL ANTIFLOTATION COLLAR AND FIBREGLASS SUMP. (SEE DETAIL FOR DIMENSIONS)
2.	SUBMERSIBLE PUMP CAPABLE OF PUMPING 5.0 l/s @ 10.3m TDH. 2 FLYGT PUMPS, OR APPROVED EQUAL – 230/1/60 c/w CABLES.
3.	LIFT–OUT RAIL ASSEMBLY C/W 100mm THREADED DISCHARGE ELBOW. (EPOXY COATED)
4.	100mm VIC x FL SCH 40 STEEL SPOOL
5.	100mm VICTAULIC SWING CHECK VALVE C/W OUTSIDE LEVER AND WEIGHT
6.	100mm VICTAULIC SHORT RADIUS 90° ELBOW
7.	100mm VICTAULIC PLUG VALVE
8.	VICTAULIC CROSS – 75X100X100X100 mm
9.	12mm WELDOLET FITTING, SCH 40 STEEL PIPE, BALL VALVE AND NIPPLE FOR PRESSURE GAUGE – ALL THREADED. RANGE 0–30 PSI
10.	LEVEL CONTROL FLOAT (TYP.)
11.	ALUMINUM LADDER
12.	19mm DIA. SCH. 40 GALVANIZED GUIDE RAILS
13.	150mm SCH 40 PVC 90° ELBOW
14.	150mm SCH 40 PVC PIPE FOR VENTALATION FASTENED TO 23
15.	UPPER GUIDE RAIL SUPPORT
16.	STEEL STATION COVER FABRICATED FROM 9mm ASTM A-36 PLATE EPOXY COATED GREEN C/W ACCESS TO BOTH PUMPS.
17.	GALVANIZED FLOAT SUPPORT BRACKET
18.	INTERMEDIATE GUIDE RAIL SUPPORT (GALVANIZED)
19.	EXPLOSION PROOF 150 WATT CEILING MOUNTED LIGHT FIXTURE
20.	150mmø SCH. 40 STEEL GOOSENECK c/w 6mm OPENING GALVANIZED MESH SCREEN
21.	SS CABLE TO ACTIVATE CHECK VALVE LEVER FOR BACKFLUSHING
22.	200mm DR35 PVC TEE
23.	75 mm ALUMINUM ANGLE FOR DISCHARGE SUPPORT ACROSS ENTIRE TANK
24.	75mm VICTAULIC SPOOL TO FIT
25.	CAM–LOCK COUPLER 100mm HOSE CONNECTION WITH DUST CAP
26.	50mm AIR RELEASE VALVE C/W ISOLATION VALVE, THREADED

Figure 5: Lift Station Equipment List

It was observed that there is no inflow shutoff valve or outflow shutoff valve. Influent shutoff is useful for entry or inspection within the wet well; however, it is not recommended unless frequent work within the barrel is expected. In the event entry is required in the future, it is possible to utilize a temporary inflatable plug installed in the upstream manhole to gain access for a detailed inspection. This report notes the lack of isolation as a potential deficiency; however, long-term upgrade is not recommended based on limited reported issues with entry. The PRRD may consider the value of adding isolation valves at a later date if the station requires more cleaning or inspection than is currently the case.

The fixtures inside the barrel, such as the ladder, rails, grate, and chains, appeared to be in good condition and no damage was observed. The light bulb was broken; this is discussed in Electrical Control

Systems (*Section 2.2*). The hinge connection of the hatch door is loose and paint is spalling (*Figure 6*). Repair is necessary before the hatch door fails.

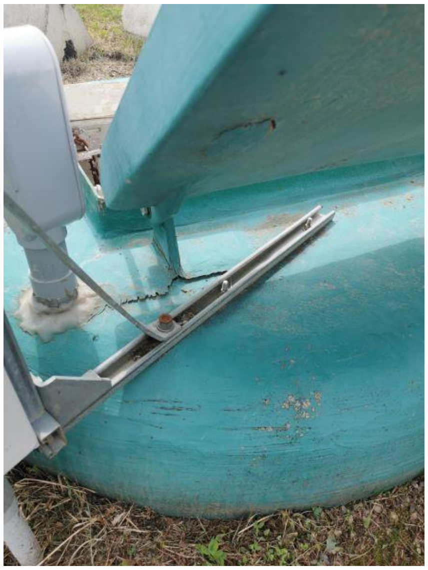

Figure 6: Anchor of Hatch Door Requires Tightening

2.1.2. Pumps

The Chilton subdivision lift station has two pumps installed with one operating and the other as a standby. During extremely high flows, both will work in unison. A shelf spare third pump is available to replace either installed pump for preventative maintenance or in the event of failure. PRRD staff informed McElhanney that one pump is removed for servicing every four (4) months; each pump runs for eight (8) consecutive months between servicing. Since commissioning in 2001, one additional pump was purchased for the lift station in 2019.

The review of the lift station documentation revealed that the installed pump is a Myers/Barnes; however, the record drawings from the contractor shows a Flygt pump (*Figure 7*). The O&M manuals are correct; thus, this is not likely to cause confusion. The documentation will be updated once the pumps are updated in 3 to 5 years; immediate changes are not recommended.

	ITEM	DESCRIPTION
	1.	1800mm DIA X 6900mm DEEP FIBERGLASS PUMP STATION C/W FIBERGLASS ENCAPSULATED STEEL ANTIFLOTATION COLLAR AND FIBREGLASS SUMP. (SEE DETAIL FOR DIMENSIONS)
A	2.	SUBMERSIBLE PUMP CAPABLE OF PUMPING 5.0 l/s @ 10.3m TDH. 2 FLYGT PUMPS, OR APPROVED EQUAL – 230/1/60 c/w CABLES.
	3.	LIFT–OUT RAIL ASSEMBLY C/W 100mm THREADED DISCHARGE ELBOW. (EPOXY COATED)
	4.	100mm VIC x FL SCH 40 STEEL SPOOL
	5.	100mm VICTAULIC SWING CHECK VALVE C/W OUTSIDE LEVER

Figure 7: Myers/Barnes Pump Installed

PRRD Operations staff informed McElhanney that the pumps require frequent service or repair due to solids entering the system. Two of the pumps were removed for repair in early July due to excessive solids (rags) entering the pumps. This resulted in issues starting the pumps and Operations reported that this is a common issue for this station. No issues were reported for any other mechanical components and fittings.

A recommendation from the lift station supplier (Engineered Pump Systems Ltd.) was to upgrade the drive power supply to 3-phase power and upgrade the pumps. Pumps running on 3-phase power have greater torque than the current single-phase pumping system. The lower torque pumps typically cannot overcome additional resistance caused by entrained solids. The pumps are within 5 years of their theoretical end of life. Upgrades to electrical to 3-phase power would limit the issue (if possible, which can be verified in an electrical supply study). If the pumps are replaced, the system controller would also be replaced and should include an hour meter.

The base of the lift station barrel is vacuum cleaned every six (6) months to remove debris and sediment and the station is inspected by PRRD staff approximately three (3) times per month or when a system alarm is triggered.

A drawdown test was conducted during the site inspection. The test revealed that the pumps are not performing to specification; the average flow rate was 5.5L/s, which is lower than expected based on the relevant pump curve (expected flow rate would be 9.5L/s). The pressure gauge (*Figure 5*, item 9) was removed prior to the inspection; therefore, a dead-head test was not conducted to confirm shut in pressure. It was noted that the gauge connection was severely corroded; thus, a gauge could not be connected.

The current pumping system is providing sufficient capacity for the area serviced. A theoretical analysis of the pump / forcemain performance based on PRRD record drawings and the pump curve shows a difference in actual performance compared to theoretical. This may be due to wear of the pump impeller, flow restriction in the forcemain or a combination of both.

To evaluate the pump, the Myers pump curve was used (*Figure 8*):

i. Point 1 is the design performance of the pump: 9.46L/s (150 USGPM) with design head at 12.2m (40ft).

ii. Point 2 shows the theoretical total head of 8.5m (28ft) required for the system as calculated using the Hazen-Williams equation according to the line record drawings based on the design flowrate: 9.46l/s (150 USGPM).

iii. Point 3 is the anticipated total head of 13.1m (43ft) of the pump according to the pump curve when pumping at the field recorded flowrate from the drawdown test: 5.5L/s (87 USGPM).

iv. Point 4 is the theoretical total head required by the system as calculated using the Hazen-Williams equation according to the line record drawings based on the flowrate obtained from the drawdown test: 5.5L/s (87 USGPM) with total head at 5.8m (19ft).

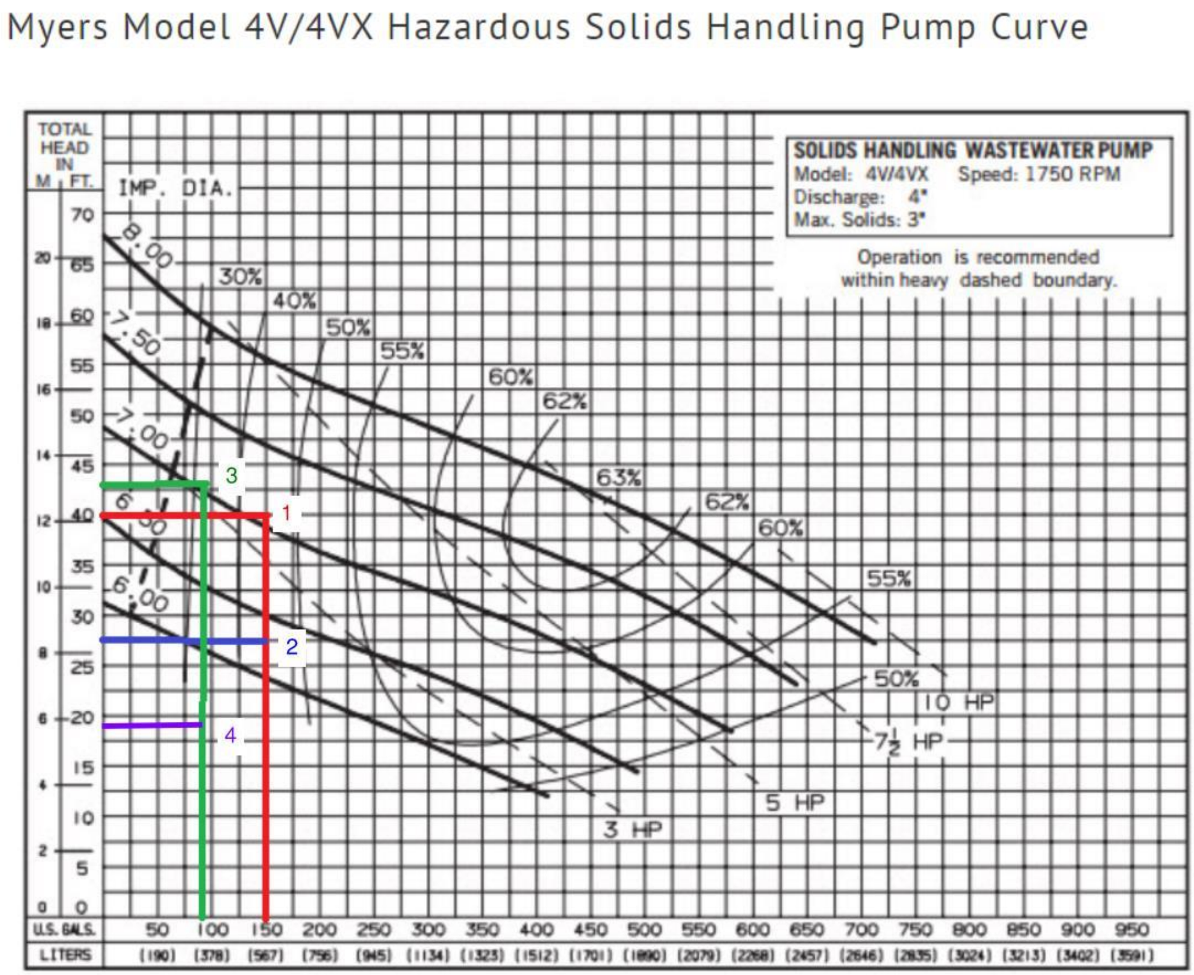

Figure 8: Pump Curve Comparison – Chilton Lift Station

The total pressure head gap between points 3 and 4 and the performance gap between points 1 and 4 could be caused by:

i. Increased roughness inside the pipe due to rust and spalling which increases flow restriction.

ii. Wear on the impeller (according to the PRRD staff who performed regular maintenance on the pump, the two original pump impellers had signs of significant wear and had been trimmed in the past).

iii. Sediment accumulation in the pipe, which would increase flow resistance and result in reduced flow area within the pipe (see *Section 3.3* for recommendations for on-going maintenance for the sewer pipe).

The above observations and analysis are presented primarily to address the observed system performance compared to the design information. The pumps are providing adequate service and upgrades to the electrical drive to limit stoppage during plugging appears to be the more pressing issue.

At the current flow rate, the water velocity in the outlet pipe is 0.63m/s; the recommended self-cleaning flow velocity is 1m/s. However, with smaller systems, having a larger diameter line is an acceptable approach as it is less vulnerable to plugging.

2.1.3. Additional Observations

On the morning of June 1, 2021, PRRD staff arrived on site and noticed the system alarm with the pump locked out due to over-heating. Further investigation revealed that one of the relay contacts had malfunctioned, burnt out the capacitor and prevented the pump from stopping at low liquid levels. The SCADA system alarm is monitored by City staff, who were sent the alarm at approximately 11 pm the previous day, but the information was not forwarded to the PRRD Operations staff for response.

Operations staff were able to replace the burnt capacitor and relay and no other issues were reported to McElhanney; therefore, this report assumes no further direct action for this item is required. However, communication protocols between the City and the PRRD should be addressed to ensure those directly involved with maintaining the lift station are alerted immediately to prevent any lag in addressing alarms.

2.2. ELECTRICAL CONTROL SYSTEMS

The lift station and pumps are controlled and automated by an electrical control unit, built approximately 3m north of the wet well. The unit is contained within a metal cabinet and is placed on a concrete base. The primary controls appear to be relay-based logic and were installed in 2001. A Programable Logic Control (PLC) was added for communications in 2009 but does not appear to replace the existing relay-based logic. A ventilation fan is also connected and controlled by a switch on the north side of the PLC unit.

At the time of field assessment, the LED display screen and alarms on the PLC panel were showing normal status for the pumps and liquid level. The pump starters appear to be in good condition. Manual control was used during drawdown tests and appeared to be functioning well.

The site pictures appear to show the conduit penetrations routed to external junction boxes containing EYS seals to prevent sewer gas escape. The wiring and connections in the external junction boxes are in good condition, with the power wiring clearly labelled. It was noted that the explosion-proof fixture (the light bulb) is damaged and is an immediate hazard (*Figure 9*). McElhanney recommends repair as soon as possible.

Figure 9: Damaged Explosion Proof Fixture (Light Bulb)

An unused residential grade ethernet switch was found lying at the base of the electrical cabinet (*Figure 10*). Decommissioned equipment should be removed to ensure staff do not think the system is operational.

Figure 10: Un-used Ethernet Switch

There appears to be a directional antenna installed on the wood pole with the incoming service and meter (*Figure 11*). This cable has been improperly installed and does not meet current electrical code. The antenna cabling should be replaced with a code-compliant installation.

Figure 11: Antenna and Improperly Installed Cable

McElhanney noticed that the running hours of the pump shown on the PLC panel were not updated when the service pump was switched. A pump log with updated running time after each switch would help determine the current condition and remaining life of the pumps. This will be reviewed in Recommendations (*Section 2.5)*.

2.3. ELECTRICAL POWER DISTRIBUTION SYSTEMS

The power breaker panel is located inside the cabinet next to the PCL panel (*Figure 12*). Federal Pioneer breakers are a known fire hazard and do not operate correctly under some conditions. This panel and all associated circuit breakers should be replaced with a currently available panelboard.

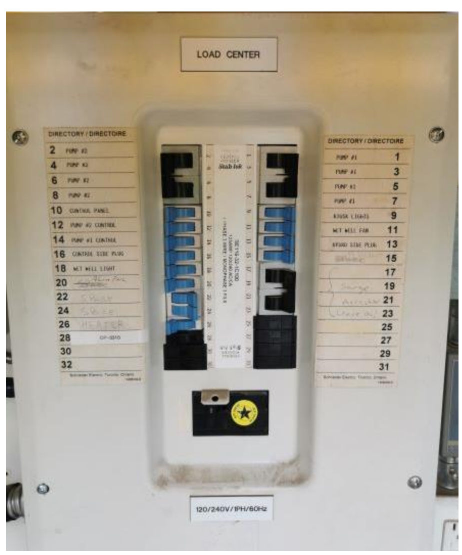

Figure 12: Electrical Panel with Federal Pioneer Breakers

On the west side of the cabinet, cable connections and junction boxes of the electrical components were mounted on the wall at the back of the control panels. At the bottom of the cabinet, a residential grade computer Uninterrupted Power Supply (UPS) is used for backup power (*Figure 13*). There is no monitoring of this UPS system, which could fail at any point. In addition, it may not provide proper equipment protection compared to a UPS suitable for this type of installation (i.e. Liebert GXT5 series or Eaton Powerware 9SX series). Replacement with a municipal quality UPS is recommended.

Figure 13: Residential Grade UPS

On the cabinet exterior, a manual transfer switch is installed with a pin and sleeve connector to allow connection to a portable generator. There is an overhead service coming to a wood pole with the service meter installed on it, which then transitions to underground to feed the manual transfer switch.

As described in *Section 2.1.3*, the capacitors in the power factor correction cabinet appear to have experienced catastrophic failure in the past and have been replaced (*Figure 14*). Based on the age of the facility and the previous capacitor failure, it is anticipated that another failure is likely. A surge protector should be installed to avoid re-occurrence.

Figure 14: Capacitor Cabinet with Burn Mark

2.4. AUXILIARY SYSTEMS

At the bottom of the cabinet on the back side of the control panels (west side), there is a plug-in ceramic heater used to maintain temperature in the cabinet (*Figure 15*). This is a fire hazard as the heater could be placed in front of flammable material or fall over. It should be replaced with a properly sized and installed heating unit.

Figure 15: Plug-in Ceramic Heater

2.5. SUMMARY & PROPOSED UPGRADES

Problems with the lift station electrical control components and pumps required frequent service and repairs and were not performing to the design. The capacity and safety of the lift station were negatively affected by the issues described above. Nevertheless, the flow demand from the community it serves has been met and there is no planned future expansion. Our recommendation is to maintain the current design operation and prolong the service life of the lift station and to reduce the required maintenance effort and cost.

2.5.1. Recommended Upgrades and Actions

To define a standard to prioritize the upgrade, we have utilized the following asset condition classification schema.

Table 1: Asset Condition Classification Schema

Classification	Definition
A Adequate	High level of confidence feature will perform well under operating conditions. Limited probability degraded conditions will impact service.
B Probably Adequate	Low level of confidence feature will perform well under operating conditions. System may not meet industry standards. Feature may require additional investigation to confirm adequacy. Low probability degraded condition will impact service.
C Probably Inadequate	Low level of confidence feature will meet current industry standards. Moderate probability degraded conditions will impact service.
D Inadequate	High level of confidence feature will not perform well under operating conditions. Signs of distress and deterioration. Deficiency in features serious enough to impact service. High probability degraded conditions will result in impact to service.
F Failed	Feature has failed.

Based on asset condition definitions listed above, *Table 2* assesses the upgrades recommended for 2021 and 2022.

Table 2: Recommended Scope of Work to be Completed in 2021-2022

Recommended Upgrade	Cost	Class	Priority	Rationale
Update SCADA programing/call out protocol	$5,000	D	High	Current SCADA system sends alarm signals to City staff who are to forward to PRRD staff. The delayed response is a high risk to lift station safety and jeopardizes robust service for the drainage area.
Replace damaged explosion-proof fixture	$1,500	F	High	Current light bulb is damaged. See *Section 2.2* and *Figure 9*.
Replace breaker panels	$5,000	C	Medium	Panels are not ideal for intended service and should be replaced. See *Section 2.3*.
Replace UPS	$3,000	C	Medium	Municipal infrastructure quality equipment should be used. See *Section 2.3*.
Install surge protector	$5,000	C	Medium	The PRRD has experienced power outrage many times in the past and the capacitor units appear to have experienced catastrophic failure in the past. Install a surge protector to significantly reduce the risk for connected electrical components. See *Section 2.3*.
Reinstall cabling for antenna	$500	D	High	Cable does not meet electrical standard. See *Section 2.2*.
Install a proper heating unit	$500	D	High	The current heater is a fire hazard. See *Section 2.4*.
Remove un-used ethernet switch	Nil	B	Medium	See *Section 2.4*.
Tighten hinge support of hatch door	$200	A	Low	See *Section 2.1.1*.
Reinstall Pressure Gauge	$600	A	Low	See *Section 2.1.2*.
Contingency (30%)	$6,390			
2021 Total	**$27,690**			

Table 3: Recommended Scope of Work to be Completed within Three (3) Years

Recommended Upgrade	Cost	Class	Priority	Rational
Replace steel piping, fittings, flanges, and valves	$32,250	B	Medium	Significant corrosion and spalling of paint on the surface and most parts; has reached the end of its design life according to ISC's guideline.
Replace two pumps that were purchased in 2001	$40,500	B	Medium	Two pumps purchased in 2001 will reach the end of their service life in 4 years according to ISC's guideline. In addition, plugging issues due to low torque can be improved if electrical study confirms power upgrade is possible
Upgrade power supply to a 3-phase power	$10,000	B	Medium	Upgraded power will limit pump plugging. See *Section 2.1.2*. Cost estimate does not include utility costs, which can vary significantly and will be determined with study as recommended in *Table 2*.
Install shut off valve for the pipe outlet	$3,000	B	Low	Not required for operation; improves station analytics.
Contingency (30%)	$25,725			
3+ Year Total	**$111,500**			

The cost items are quoted based on vendor pricing with an added allowance for installation.

Pump replacement will require investigation of the availability and practicality of providing 3-phase power. If power upgrade is not viable, the pump upgrade may require additional electrical upgrades to improve reliability by increasing pump torque. Conducting this study is outside the scope of this project but is recommended before upgrading the pumps.

3. CCTV Inspection Assessment

This section summarizes the findings and recommendations for the gravity sanitary sewer main of the Chilton subdivision based on CCTV inspection. The analysis will assist the PRRD with determining current condition, identifying required repairs, estimating remaining service life, providing a cost estimate for repairs that are required immediately, and estimating replacement costs for the whole system in 2021 funds.

3.1. METHODOLOGY

McElhanney contracted Northern Lites Technologies to inspect each section of sanitary sewer in the Chilton subdivision. The pipe segments were flushed when necessary and video was recorded using a CCTV camera mounted on a remote operated tractor. The operator stopped the camera and noted defects based on the National Association of Sewer Service Companies (NASSCO) defect codes during the inspection. When surveys needed to be abandoned due to water levels or other obstructions, an attempt was made to send the camera to that spot from the opposite direction. The collected videos were then watched, verified, and scored according to the NASSCO Pipeline Assessment Certification Program (PACP) rating guidelines.

The pipe segments were analyzed using the NASSCO PACP Condition Grading System and a score associated with each defect was identified. The scores range from 1 to 5, with 5 being the most severe; separate scoring is completed for structural defects as well as operational and maintenance defects. The full table can be seen in *Appendix B*.

The PACP Quick Scoring method has four (4) digits and represents the two most severe defects and their number of occurrences. For example, a PACP Quick Score of 3224 identifies that the segment of pipe has two (2) grade 3 defects and four (4) grade 2 defects. Using such a system allows quick identification of pipe segments that may require closer scrutiny.

The Index Rating method takes a sum of all the defect scores and divides it by the number of defects, essentially calculating an average defect score for a given segment of pipe. This method is to be applied with caution, as a severe defect can be diluted by many less severe defects; hence, the two rating systems are used in conjunction to allow the review to focus on pipe segments that may need closer scrutiny.

The pipe rating system used is in accordance with the NASSCO Pipeline Assessment and Certification Program, Version 6.0.1, dated November 2010. Refer to *Appendix C* for an excerpt from the PACP training manual that describes the rating methods described above. Also included are two pages taken from the PACP training manual that briefly describe the reasons for CCTV inspection, the information provided by CCTV inspection data, reasons for standardization in CCTV inspection reporting and the origin of condition codes.

Manholes were assessed using a remote camera suspended from a tripod that was capable of taking 3D scans of manhole interiors. The camera was lowered to different heights and a 360° view of the manhole was then compiled at each depth. From these 3D views, the manholes were assessed using the NASSCO MACP system. The MACP system collects information on the manhole and is divided into Level 1 and Level 2 assessments. Level 1 MACP assessments gather information for a general condition assessment with observations and helps to determine whether a more comprehensive inspection (Level 2) is required. If a Level 2 inspection is warranted, the MACP uses coded defect ratings similar to the NASSCO PACP rating system.

3.2. NASSCO PIPE AND MANHOLE ANALYSIS

The following sections provide a summary of the defects for each of the branches assessed. Identified in the sections below are the segments of the sewer with a pipe defect severity of 4 or higher as well as other problematic segments. Defects of a lower severity are associated with minor infiltration or deposits in the main, which would be addressed by flushing.

3.2.1. Pipe Segments CCTV Inspection

The Chilton segment of the CCTV assessment generally had PVC sanitary sewer main in good structural condition. In general, laterals were installed using manufactured connections, with services typically being in good condition. A few pipes exhibited problems with large sags in the pipe grade, indicated by changes in the water level with stagnant water pooling. Several other pipes showed signs of less significant sags, with sections of water pooling to about 20% of the pipe area.

Some segments in this area had encrustation, intruding saddles, and settled gravels but, unless otherwise noted, maintained minimum 80% pipe cross-section. Below is a summary of each segment; details can be found in *Appendix B*.

- SMH-01 to SMH-02, 200mm PVC: Pipe in good condition, no defects of note.
- SMH-02 to SMH-03; 200mm PVC: Survey abandoned due to underwater camera with pipe 80% to 100% full of water (with dry sections before and after) indicating large sags in the pipe grade as seen in *Figure 16*.

Figure 16: Sags in Pipe Grade Causing Standing Water between SMH-02 and SMH-03

- SMH-03 to SMH-04; 200mm PVC: Several intruding service leads, including an intruding saddle causing the CCTV investigation to be abandoned, as seen in *Figure 17.* The saddle appears to be installed correctly, but the service is intruding enough to require abandoning the survey and approach from the downstream manhole There is also a moderate severity infiltration leak and attached deposits at the interface of manhole SMH-04 and the sewer main.

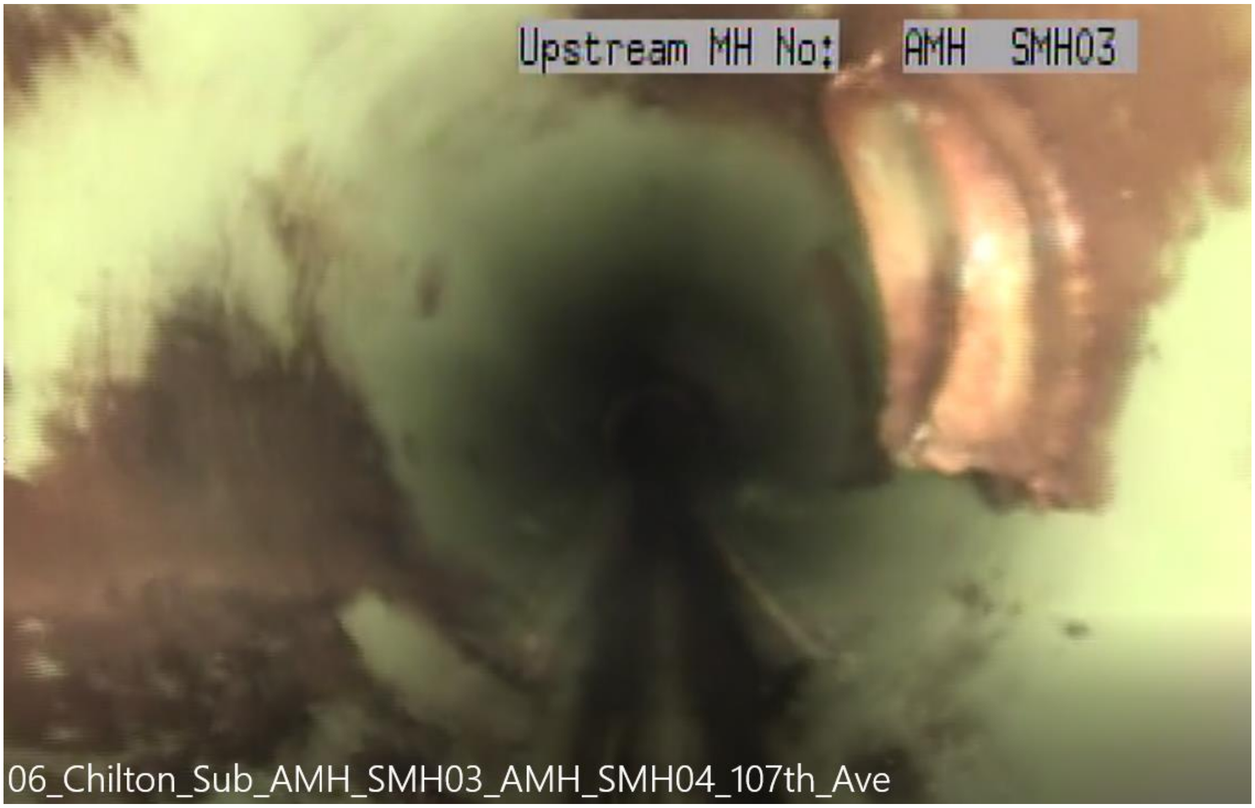

Figure 17: Intruding Service Caused CCTV Inspection to be Abandoned; Service Installed Correctly and Not Defective

- SMH-04 to SMH-05; 200mm PVC: Moderate severity infiltration leak at interface of SMH-05 and the sewer main. Some sections of increased water level to approximately 20%, indicating minor sags in the pipe grade.
- SMH-05 to SMH-06, 200mm PVC: Pipe in fair condition, with one section of increased water level to approximately 20% at a service location, indicating a minor sag in the pipe grade.
- SMH-06 to SMH-07, 200mm PVC: Pipe in good condition, no defects of note.
- SMH-07 to SMH-09; 150mm PVC: Several instances of underwater camera with pipe 80% full of water (with dry sections before and after) indicating large sags in the pipe grade.
- SMH-09 to SMH-08, 150mm PVC: Pipe is in fair condition. Some sections of increased water level to approximately 20%, indicating minor sags in the pipe grade. Pipe was unable to be surveyed beyond the first cleanout as the pipe was not accessible due to bends in the pipe mainline as seen in *Figure 18*.

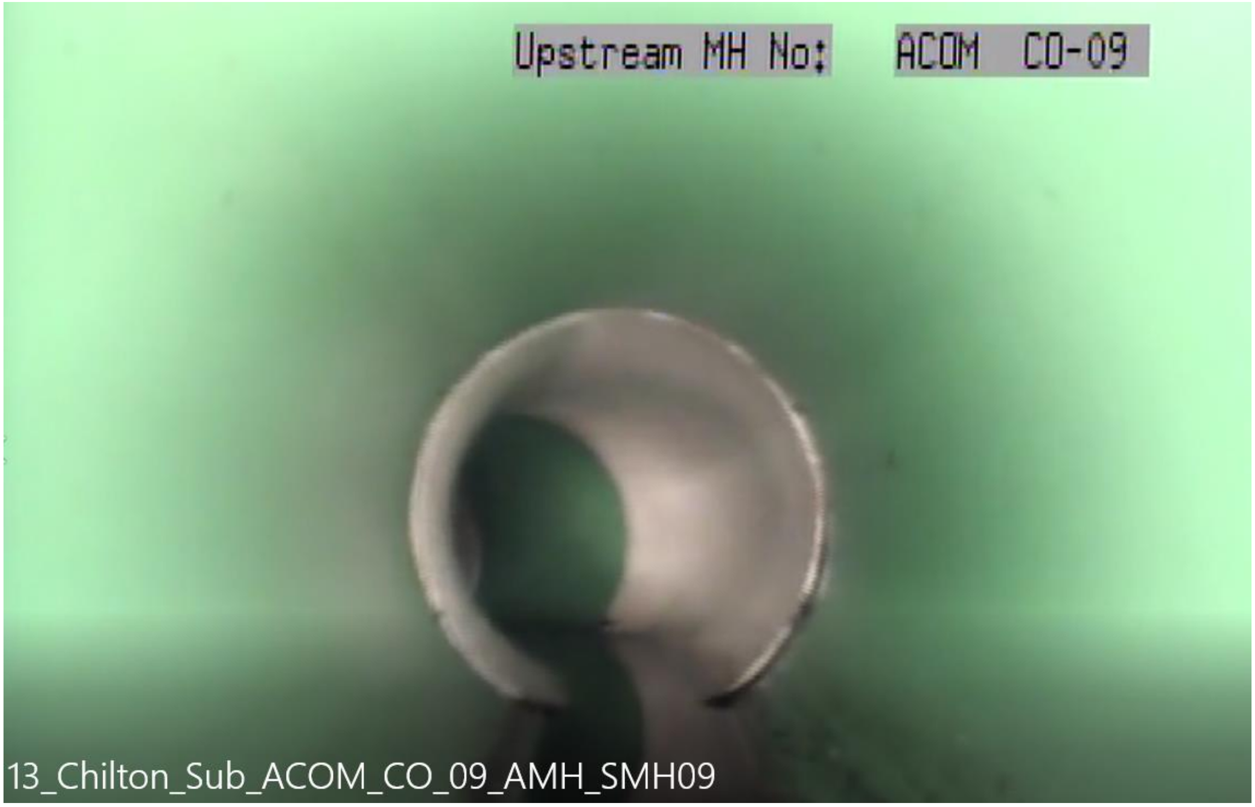

Figure 18: Bends in Pipe in Mainline Prevented CCTV Camera Survey

- SMH-07 to Lift Station: Large amount of debris obstructing inspection of the pipe, as seen in *Figure 19*. Survey abandoned shortly beyond SMH-07.

Figure 19: Debris Blocking Sewer Main Leading to Chilton Lift Station

Table 4 provides an overview of pipe conditions and the PACP ratings for the surveys conducted.

Table 4: NASSCO PACP Pipe Segment Rating and Index

Upstream MH	Downstream MH	PACP Quick (Structural)	PACP Quick (O&M)	Structural Index	O&M Index	Overall Index	Rating per m	Defects per m
SMH-01	**SMH-02**	1100	2311	1	1.75	1.6	0.113	0.071
SMH-02	**SMH-03**	1100	2700	1	2	1.875	0.126	0.067
SMH-03	**SMH-04**	1100	4131	1	2.5	2.29	0.139	0.061
SMH-04	**SMH-05**	1100	2600	1	2	1.86	0.131	0.071
SMH-05	**SMH-06**	0000	2400	0	2	2	0.072	0.036
SMH-06	**SMH-07**	0000	2400	0	2	2	0.074	0.037
SMH-09	**SMH-07**	0000	4400	0	4	4	0.178	0.045
SMH-09	**SMH-08**	0000	2100	0	2	2	0.027	0.013
SMH-07	**LIFT STATION**	0000	5100	0	5	5	5.000	1.000

3.2.1. Manhole 3D Scan Inspection

The Chilton manhole assessment indicated that the manholes were generally in good condition. The manholes are all precast manufactured concrete with aluminum stepladder rungs, manufactured benching, and cast-iron manhole covers. Manholes of this type installed to specifications are expected to have a lifespan of 50+ years but can last for significantly longer in low corrosivity environments.

Several manholes exhibited some minor infiltration, typical of all manholes, and a few exhibited some encrustation around the manhole benching and manhole base. All assessments were completed to NASSCO MACP Level 1 standards. Below is a summary of each manhole; details can be found in *Appendix B*.

- SMH-01, 1050mm concrete manhole: Manhole in good condition. Some minor infiltration staining and encrustation near the manhole base joint, as seen in *Figure 20*.

Figure 20: Some Minor Infiltration Staining and Encrustation in SMH-01

- SMH-02, 1050mm concrete manhole: Manhole in good condition. Some minor infiltration staining.
- SMH-03, 1050mm concrete manhole: Manhole in good condition. Some minor infiltration staining.
- SMH-04, 1050mm concrete manhole: Manhole in good condition. Some minor infiltration staining, and the pipe interfaces are exhibiting some minor infiltration

- SMH-05, 1050mm concrete manhole: Manhole in good condition. Some minor infiltration staining and encrustation near the manhole base joint, and the pipe interfaces are exhibiting some minor infiltration
- SMH-06, 1050mm concrete manhole: Manhole in good condition. Some minor infiltration staining.
- SMH-07, 1050mm concrete manhole: Manhole in good condition. Some minor infiltration staining.
- SMH-09, 1050mm concrete manhole: Manhole in good condition. Some minor infiltration staining.
- SMH-08, 1050mm concrete manhole: Manhole in good condition.

3.3. RECOMMENDATIONS

The following recommended repairs are based on the NASSCO PACP rating and industry best practices. Areas of sag greater that 50% in the mainline of the pipe should be repaired, when possible, as it is difficult to remotely inspect the issue and causes of the sag. In addition, the stagnant water can lead to flow and odour problems and may be a sign of other problems like collapsed pipe and in-washing trench material.

McElhanney recommends the following:

- Continuing the monitoring and maintenance program, with flushing every 5 years (or more often as required) and reinspection and assessment every 10 years.
- Replacement of the SMH-07 to SMH-09 segment and reconnection of services. This segment is exhibiting three sagged sections with water levels over 50%, with point repairs expected to be similar to the cost of full replacement.
- Locating and replacing the segments of pipe exhibiting sagging between SMH-02 and SMH-03. This work could be performed as point repairs to the system with disturbance only required in the vicinity of the repair. This may require work to reconnect service connections at the new grade if services are located at the underwater sections.
- The pipe segment between SMH-04 to SMH-05, SMH-05 to SMH-06 and SMH-09 to SMH-08 should be monitored for signs of increasing sags along the line of the pipe. The existing sags are minor and will not impact the flow capacity of the pipe, but additional issues may occur if the sags increase.
- Cleaning and repairing the interface of SMH-04 and SMH-05 and the sewer mains to repair infiltration.
- Installing new overbuild manholes between SMH-09 and SMH-08 to replace the existing cleanouts. Typically, cleanouts are not acceptable for use along a mainline as they can prevent maintenance and inspection. While the sewer main services only a few lots along this run, manholes are preferred for operational purposes.
- Flushing of the pipe segment SMH-07 to the lift station.

3.4. COST ESTIMATE

The system has defects that require attention but the system, as a whole, is in fair condition, with an estimated lifespan of another 30+ years with proper maintenance. All costs are listed as 2021 dollars with a 30% contingency. *Table 5* provides an overview of the repairs, on-going maintenance, replacement costs, and the estimated lifespan for each asset.

Table 5: Cost Estimate for Chilton Sanitary Sewer Repairs, Maintenance, and Replacement

Asset		Cost of Current Repairs Required	Cost of Maintenance (Yearly)	Cost of Replacement	Estimated Lifespan (Years)
PIPES	**SMH-01 to SMH-02**	$0	$200	$56,800	55
	SMH-02 to SMH-03	$15,000	$200	$95,200	55
	SMH03 to SMH-04	$0	$200	$92,000	55
	SMH04 to SMH-05	$0	$200	$79,200	55
	SMH05 to SMH-06	$0	$200	$88,800	55
	SMH-06 to SMH-07	$0	$200	$86,400	55
	SMH-09 to SMH-07	$72,000	$200	$72,000	55
	SMH-08 to SMH-09	$0	$200	$151,200	55
	SMH-07 to LIFT	$4,000	$200	$75,200	55
MANHOLES	**SMH-01**	$500	$100	$12,000	30
	SMH-02	$500	$100	$12,000	30
	SMH-03	$500	$100	$12,000	30
	SMH-04	$2,500	$100	$12,000	30
	SMH-05	$2,500	$100	$12,000	30
	SMH-06	$500	$100	$12,000	30
	SMH-07	$500	$100	$12,000	30
	SMH-09	$500	$100	$12,000	30
	SMH-08	$500	$100	$12,000	30
	SMH-09-CO1	$12,000	$100	$12,000	30
	SMH-09-CO2	$12,000	$100	$12,000	30

3.4.1. Repairs

Pipes

McElhanney recommends replacement of one section of sewer (SMH09 to SMH-07) and point repairs on sagging areas of the sewers to MMCD standards, including new sections of PVC SDR35 sanitary sewer installed with new bedding and repair couplings. While repairs are carried out, the subgrade should be inspected for suitability and removed if unsuitable or if deleterious materials are found, as soft ground may be the cause of the pipe sags. Once repaired, the pipes should be re-inspected. McElhanney also recommends flushing of sewer segment SMH-07 to the lift station.

Estimated Cost of Repairs: $91,000

Manholes

McElhanney recommends replacing the cleanouts along the line with manholes. McElhanney also recommends cleaning all manholes to clear encrustation. Once complete, perform concrete patching as required, with special attention paid to SMH-04 and SMH-05 and pipe interfaces.

McElhanney also recommends replacing the existing cleanouts along the mainline between SMH-09 and SMH-08 with new manholes to facilitate operations and maintenance.

Estimated Cost: $32,500

3.4.2. On-going Maintenance

Pipes

Flushing and reinspecting every 5 to 10 years to watch for signs of pipe failure is recommended. Pipes showing signs of early failure (cracking, root intrusion, additional sagging) should be repaired as necessary until full replacement is warranted. Pricing assumes that the entire system is cleaned and inspected together. Individual segments inspected more frequently would lead to a higher overall maintenance cost.

Estimated Cost: $200 per segment per year with an expected $20,000 total per inspection and flushing cycle.

Manholes

Cleaning and reinspecting every 5 to 10 years to watch for signs of structural failure is recommended. Manholes showing signs of early failure (cracking, root intrusion, major encrustation) should be repaired as necessary until full replacement is warranted.

Estimated Cost: $100 per manhole per year with a total expected spend of $11,000 total every inspection cycle.

3.4.3. Replacement

Once replacement is warranted, the entire gravity system should be removed and replaced. Services should be scoped as the replacement takes place, with deficient services being replaced and transferred at property line. Replacement is usually required when the cost of on-going repairs becomes too high or when the pipes begin to exhibit excessive structural failures in the NASSCO PACP ratings system. Full replacement is not warranted at this time. The system condition is consistent with the age of the assets. The system should be expected to last 30+ years with proper maintenance and repairs

Estimated Total Replacement Costs: $928,800

Appendix A

Statement of Limitations

Statement of Limitations

Use of this Report. This report was prepared by McElhanney Ltd. ("McElhanney") for the particular site, design objective, development and purpose (the "Project") described in this report and for the exclusive use of the client identified in this report (the "Client"). The data, interpretations and recommendations pertain to the Project and are not applicable to any other project or site location and this report may not be reproduced, used or relied upon, in whole or in part, by a party other than the Client, without the prior written consent of McElhanney. The Client may provide copies of this report to its affiliates, contractors, subcontractors and regulatory authorities for use in relation to and in connection with the Project provided that any reliance, unauthorized use, and/or decisions made based on the information contained within this report are at the sole risk of such parties. McElhanney will not be responsible for the use of this report on projects other than the Project, where this report or the contents hereof have been modified without McElhanney's consent, to the extent that the content is in the nature of an opinion, and if the report is preliminary or draft. This is a technical report and is not a legal representation or interpretation of laws, rules, regulations, or policies of governmental agencies.

Standard of Care and Disclaimer of Warranties. This report was prepared with the degree of care, skill, and diligence as would reasonably be expected from a qualified member of the same profession, providing a similar report for similar projects, and under similar circumstances, and in accordance with generally accepted engineering and scientific judgments, principles and practices. McElhanney expressly disclaims any and all warranties in connection with this report.

Information from Client and Third Parties. McElhanney has relied in good faith on information provided by the Client and third parties noted in this report and has assumed such information to be accurate, complete, reliable, non-fringing, and fit for the intended purpose without independent verification. McElhanney accepts no responsibility for any deficiency, misstatements or inaccuracy contained in this report as a result of omissions or errors in information provided by third parties or for omissions, misstatements or fraudulent acts of persons interviewed.

Effect of Changes. All evaluations and conclusions stated in this report are based on facts, observations, site-specific details, legislation and regulations as they existed at the time of the site assessment and report preparation. Some conditions are subject to change over time and the Client recognizes that the passage of time, natural occurrences, and direct or indirect human intervention at or near the site may substantially alter such evaluations and conclusions. Construction activities can significantly alter soil, rock and other geologic conditions on the site. McElhanney should be requested to re-evaluate the conclusions of this report and to provide amendments as required prior to any reliance upon the information presented herein upon any of the following events: a) any changes (or possible changes) as to the site, purpose, or development plans upon which this report was based, b) any changes to applicable laws subsequent to the issuance of the report, c) new information is discovered in the future during site excavations, construction, building demolition or other activities, or d) additional subsurface assessments or testing conducted by others.

Independent Judgments. McElhanney will not be responsible for the independent conclusions, interpretations, interpolations and/or decisions of the Client, or others, who may come into possession of this report, or any part thereof. This restriction of liability includes decisions made to purchase, finance or sell land or with respect to public offerings for the sale of securities.

Construction Cost Estimates. This construction cost estimate has been prepared using the design and technical information currently available, and without the benefit of Geotechnical, Environmental, and Archaeological information. Furthermore, McElhanney cannot predict the competitive environment, weather or other unforeseen conditions that will prevail at the time that contractors will prepare their bids. The cost estimate is therefore subject to factors over which McElhanney has no control, and McElhanney does not guarantee or warranty the accuracy of such estimate.

Appendix B

Pipe Condition Tables

File: 3111-26522-00CIV-RPT-001 Chilton CCTV Table

Date: October 29, 2021

Pipe Segment	U/S MH#	D/S MH#	Pipe Size (mm)	Material	Length (m)	Grade (%)	Report #	Report Date	Video #	Station	Defect								Structural Rating	O&M Rating	# of Structural Defects Count	# of O&M Defects Count	Total Number of Defects	Structural Rating Index	O&M Rating Index	Overall Index
											Group	Descriptor	Modifier	Defect	Defect (Input)	Continuous (Match Codes)	Numeral Mod	Percent/Count								
1	SMH 01	SMH 02	200	PVC	70.5	-	3.1113E+10	Jun-21	01 Chilton Sub AMH SMH01 AMH SMHO2	0	Access Points	Manhole		AMH			0		0	0	0	0	5	1.0	1.8	1.6
										0	Miscellaneous	Water Level		MWL	5		0		0	0	0	0				
										14.5	Tap	Saddle	Intruding	TSI			OM Percent	<=10	0	2	0	1				
										27.5	Tap	Saddle	-	TS			0		0	0	0	0				
										27.5	Tap	Saddle	Defective	TSD			0		0	2	0	1				
										30.5	Tap	Saddle	Intruding	TSI			OM Percent	<=10	0	2	0	1				
										39	Joint	Separated (open) Medium		JSM			0		1	1	1	1				
										39	Infiltration	Stain		IS			0		0	0	0	0				
										49.1	Miscellaneous	Water Level		MWL			0		0	0	0	0				
										69.7	Tap	Saddle	Intruding	TSI			OM Percent		0	0	0	0				
										70.5	Access Points	Manhole		AMH			0		0	0	0	0				
										Total									**1**	**7**	**1**	**4**				
										Quick									**1100**	**2311**						
2	SMH 02	SMH 03	200	PVC	118.6	-	3.1113E+10	Jun-21	02 Chilton Sub AMH SMH02 SSM AMH SMH03 mp4	0	Access Points	Manhole		AMH			0		0	0	0	0	8	1.0	2.0	1.9
3					23.5	-	3.1113E+10	Jun-21	03 Chilton Sub AMH SMH02 AMH SMH03 1	0	Miscellaneous	Water Level		MWL	5		0		0	0	0	0				
4					37.4	-	3.1113E+10	Jun-21	04 Chilton Sub AMH SMH02 AMH SMH03	0	Infiltration	Stain		IS			0		0	0	0	0				
					Combined video data					15.3	Joint	Separated (open) Medium		JSM			0		1	0	1	0				
										15.3	Infiltration	Stain		IS			0		0	0	0	0				
										18.3	Tap	Saddle	Intruding	TSI			OM Percent	<=10	0	2	0	1				
										20	Deposits	Deposits Settled	Other	DSZ			OM Percent	<=10	0	2	0	1				
										24.4	Tap	Saddle	Defective	TSD			0		0	2	0	1				
										45.1	Tap	Saddle	Activity	TSA			0		0	0	0	0				
										56.6	Miscellaneous	Water Level		MWL			0		0	0	0	0				
										57.4	Tap	Saddle	Intruding	TSI			OM Percent	<=10	0	2	0	1				
										57.8	Tap	Saddle	Intruding	TSI			OM Percent	<=10	0	2	0	1				
										57.8	Miscellaneous	Survey Abandoned		MSA			0		0	0	0	0				
										58.2	Miscellaneous	Survey Abandoned		MSA			0		0	0	0	0				
										59	Miscellaneous	Water Level		MWL	5		0		0	0	0	0				
										59	Infiltration	Stain		IS			0		0	0	0	0				
										59	Tap	Saddle	Defective	TSD			0		0	2	0	1				
										107.8	Tap	Saddle	Intruding	TSI			OM Percent	<=10	0	2	0	1				
										118.6	Access Points	Manhole		AMH			0		0	0	0	0				
										Total									**1**	**14**	**1**	**7**				
										Quick									**1100**	**2700**						
5	SMH 03	SMH 04	200	PVC	115.4	-	3.1113E+10	Jun-21	05 Chilton Sub AMH SMH03 AMH SMH04	0	Access Points	Manhole		AMH			0		0	0	0	0	7	1.0	2.5	2.3
6										0	Miscellaneous	Water Level		MWL	5		0		0	0	0	0				
										49.9	Tap	Saddle	Intruding	TSI			OM Percent	<=10	0	2	0	1				
										53.8	Tap	Saddle	Intruding	TSI			OM Percent	<=10	0	2	0	1				
										80	Tap	Saddle	Intruding	TSI			OM Percent	<=10	0	2	0	1				
										89.5	Tap	Saddle	Intruding	TSI			OM Percent	<=10	0	2	0	1				
										98.7	Joint	Separated (open) Medium		JSM			0		1	0	1	0				
										98.7	Infiltration	Stain		IS			0		0	0	0	0				
										106	Tap	Saddle	Intruding	TSI			OM Percent	<=20	0	3	0	1				
										106	Miscellaneous	Survey Abandoned		MSA			0		0	0	0	0				
										115.4	Infiltration	Runner		IR			0		0	4	0	1				
										115.4	Access Points	Manhole		AMH			0		0	0	0	0				
										Total									**1**	**15**	**1**	**6**				
										Quick									**1100**	**4131**						
7	SMH 04	SMH 05	200	PVC	99.2	-	3.1113E+10	Jun-21	07 Chilton Sub AMH SMH04 AMH smh05	0	Access Points	Manhole		AMH			0		0	0	0	0	7	1.0	2.0	1.9
8					39.9	-	3.1113E+10	Jun-21	08 Chilton Sub AMH SMH04 AMH smh05 107th Ave	0	Miscellaneous	Water Level		MWL	5		0		0	0	0	0				
										1.6	Tap	Saddle	Intruding	TSI			OM Percent	<=10	0	2	0	1				
										1.9	Miscellaneous	Water Level		MWL			0		0	0	0	0				
										4.7	Miscellaneous	Water Level		MWL			0		0	0	0	0				
										28.2	Tap	Saddle	Intruding	TSI			OM Percent	<=10	0	2	0	1				
										45.4	Tap	Saddle	Intruding	TSI			OM Percent	<=10	0	2	0	1				
										59.9	Tap	Saddle	Intruding	TSI			OM Percent	<=10	0	2	0	1				
										60.9	Miscellaneous	Survey Abandoned		MSA			0		0	0	0	0				
										60.9	Tap	Saddle	Intruding	TSI			OM Percent	<=10	0	2	0	1				
										71.4	Joint	Separated (open) Medium		JSM			0		1	0	1	0				
										88.6	Tap	Saddle	Intruding	TSI			OM Percent	<=10	0	2	0	1				
										95.9	Miscellaneous	Water Level		MWL	5		0		0	0	0	0				
										99.2	Access Points	Manhole		AMH			0		0	0	0	0				
										Total									**1**	**12**	**1**	**6**				
										Quick									**1100**	**2600**						

9	SMH 05	SMH 06	200	PVC	111.5	-	3.1113E+10	Jun-21	09 Chilton Sub AMH smh05 AMH SMH06	0	Access Points	Manhole		AMH		0		0	0	0	0	4	**0.0**	**2.0**	**2.0**
										0	Miscellaneous	Water Level		MWL	5	0		0	0	0	0				
										42.3	Tap	Saddle	Intruding	TSI		OM Percent	<=10	0	2	0	1				
										42.9	Tap	Saddle	Intruding	TSI		OM Percent	<=10	0	2	0	1				
										70.1	Tap	Saddle	Intruding	TSI		OM Percent	<=10	0	2	0	1				
										70.1	Miscellaneous	Water Level		MWL		0		0	0	0	0				
										107.7	Tap	Saddle	Intruding	TSI		OM Percent	<=10	0	2	0	1				
										111.5	Access Points	Manhole		AMH		0		0	0	0	0				
										Total								**0**	**8**	**0**	**4**				
										Quick								**0000**	**2400**						
10	SMH 06	SMH 07	200	PVC	108.3	-	3.1113E+10	Jun-21	10 Chilton Sub AMH SMH06 AMH SMH07	0	Access Points	Manhole		AMH		0		0	0	0	0	4	**0.0**	**2.0**	**2.0**
										0	Miscellaneous	Water Level		MWL	5	0		0	0	0	0				
										20.2	Tap	Saddle	Intruding	TSI		OM Percent	<=10	0	2	0	1				
										24.6	Tap	Saddle	Intruding	TSI		OM Percent	<=10	0	2	0	1				
										57.4	Tap	Saddle	Intruding	TSI		OM Percent	<=10	0	2	0	1				
										57.8	Tap	Saddle	Intruding	TSI		OM Percent	<=10	0	2	0	1				
										108.3	Access Points	Manhole		AMH		0		0	0	0	0				
										Total								**0**	**8**	**0**	**4**				
										Quick								**0000**	**2400**						
11	SMH 09	SMH 07	150	PVC	89.8	-	3.1113E+10	Jun-21	11 Chilton Sub AMH SMH09 AMH SMH07	0	Access Points	Manhole		AMH		0		0	0	0	0	4	**0.0**	**4.0**	**4.0**
										0	Miscellaneous	Water Level		MWL	5	0		0	0	0	0				
										12.6	Miscellaneous	Water Level		MWL		0		0	0	0	0				
										14	Miscellaneous	Water Level		MWL		0		0	0	0	0				
										30.4	Miscellaneous	Water Level		MWL		0		0	0	0	0				
										30.4	Line	Down		LD		OM Degree	>20	0	4	0	1				
										31.9	Miscellaneous	Camera Underwater		MCU		0		0	4	0	1				
										32.6	Tap	Saddle	-	TS		0		0	0	0	0				
										41.5	Miscellaneous	Camera Underwater		MCU		0		0	4	0	1				
										43.2	Miscellaneous	Water Level		MWL		0		0	0	0	0				
										43.2	Line	Up		LU		OM Degree	>20	0	4	0	1				
										46.1	Miscellaneous	Water Level		MWL		0		0	0	0	0				
										89.8	Access Points	Manhole		AMH		0		0	0	0	0				
										Total								**0**	**16**	**0**	**4**				
										Quick								**0000**	**4400**						
12	SMH 07	LIFT STATION	200	PVC	1	-	3.1113E+10	Jun-21	12 Chilton Sub AMH SMH07 AMH LS	0	Access Points	Manhole		AMH		0		0	0	0	0	1	**0.0**	**5.0**	**5.0**
										0	Miscellaneous	Water Level		MWL	5	0		0	0	0	0				
										1.4	Deposits	Deposits Settled	Gravel	DSGV		OM Percent	>30	0	5	0	1				
										1	Miscellaneous	Survey Abandoned		MSA		0		0	0	0	0				
										Total								**0**	**5**	**0**	**1**				
										Quick								**0000**	**5100**						

Appendix C

NASSCO PACP Rating Guidelines

PACP© Condition Grading System

The Pipeline Assessment and Certification Program (PACP) developed by NASSCO provides a mechanism for creating reliable descriptions of pipe conditions. NASSCO has also developed a system based on the PACP codes to assign a condition rating to pipelines. Requirements of the grading system were as follows:

1. Like the PACP, the grading system should be direct and objective.
2. Provide the ability to qualitatively identify differences in pipe condition between one inspection and subsequent inspections, and to prioritize based on the significance of the defects different pipe segments.

Many other approaches to sewer pipe grading have been used in the United States as well as in other parts of the World. These approaches generally use some type of defect grading that is then used to calculate an overall pipe rating.

It is problematic to develop a single pipe segment rating that fully describes all of the important aspects of a pipe. Therefore the PACP Condition Grading System uses more than one method of rating pipe segment condition including a rating that considers the number of total defects within the pipe segment and a rating that considers the most severe defects within the pipe segment.

The PACP Condition Grading System only considers internal pipe conditions obtained from TV inspection. While other factors such as pipe material, depth, soils, and surface conditions also affect pipe survivability, those factors have not been included in the PACP Condition Grading System. The PACP Condition Grading System should be used only as a tool for screening pipe segment inspections, allowing the User to quickly determine which pipe segments have significant defects. It is expected that as the PACP further develops the PACP Condition Grading System will expand to include other factors.

The PACP Condition Grading System provides condition ratings for Structural Defects and Operation and Maintenance Defects.

Approach

Using the PACP Code Matrix, Each PACP defect code is assigned a condition grade of from 1 to 5. Grades are assigned based on the significance of the defect, extent of damage, percentage of flow capacity restriction, or the amount of wall loss due to deterioration.

The PACP Condition Grading System alone is inadequate for determining if a pipe segment should be rehabilitated or replaced. Many other factors in addition to the internal condition of the segment should be considered. The fact that a segment has significant Grade 4 or Grade 5 defects does not necessarily mean the pipe segment should be immediately rehabilitated. Recent experience by PACP Users has shown that pipe segments with serious defects such as hinge failures may remain largely unchanged for many decades if no deterioration factors such as surcharging, roots, or groundwater are present.

What is needed is improved estimates of remaining life or mean time before failure that are based on close monitoring of pipe segments over time. Once we know how much change occurs in pipe segments we can better understand the relationship between defects, deterioration factors, and pipe segment life expectancy. PACP continues to be an excellent tool for benchmarking pipe condition between one inspection and subsequent inspections of the same pipe.

Grades are assigned for two categories, Structural, and O&M defects.
Grades are as follows;
5 - Most significant defect grade
4 – Significant
3 – Moderate defect grade
2 – Minor to Moderate
1 –Minor defect grade

The PACP Condition Grading System results are entirely dependent on the quality of the PACP defect coding. Errors in the coding will directly result in errors in the Grading. All utilities, engineers, and contractors should make sure the data they are using was coded by experienced technicians who have successfully demonstrated their competence through a formal or informal apprenticeship program. PACP data from inexperienced technicians should be checked and corrected as needed. Errors found in coding should be corrected and the errors brought to the attention of the technician.

Grading of Continuous Defects

The PACP continuous defect feature is used to denote where long portions of a sewer pipe are affected by the same defect, without the User having to repetitively enter point defects. However to develop a grade for the pipe segment, a mechanism is needed to translate a continuous defect into an equivalent number of point defects.

The equivalent number (quantity) of "uninterrupted" and "joint repeating" continuous defects is calculated by dividing the length of the continuous defect by 5. Example, a 6-meter long continuous defect, grade 3, should equate to four Grade 3 defects. Fractions are rounded to the nearest whole number.

Pipe Ratings

The pipe rating is based on the number of occurrences for each condition grade. Ratings are calculated separately for **Structural Defects** and **O&M Defects**. Several ways of expressing pipe segment condition are used by the PACP Condition Grading System as follows.

Segment Grade Scores - Each pipe segment will have a Segment Grade Score for each of the five grades. The number of occurrences of each pipe grade is multiplied by the pipe grade to calculate the segment grade score. Example, six Grade 5 defects would be 6 times 5 and equates to a Segment Grade 5 Score of 30. If a pipe segment had no defects of a particular grade, then the Segment Grade Score for that grade would be 0.

Overall Pipe Rating –The five Segment Grade Scores are added together to calculate the **Overall Pipe Rating. Structural Pipe Ratings** are calculated using only Structural Defect grades, while **O&M Pipe Ratings** are calculated using only O&M Defect grades.

PACP Quick Rating – The PACP Quick Rating is a shorthand way of expressing the number of occurrences for the two highest severity grades. The PACP Quick Rating is a four character score as follows:

1. The first character is the highest severity grade occurring along the pipe length.
2. The second character is the total number of occurrences of the highest severity grade. If the total number exceeds 9, then alphabetic characters are used as follows- 10 to 14 – A; 15 to 19 – B; 20 to 24 – C; etc.
3. The third character is the next highest severity grade occurring along the pipe length.
4. The fourth character is the total number of the second highest severity grade occurrences, derived as in item 2 above.

For Example

4B27

This immediately shows that no grade 5 defects or grade 3 defects, however 15 to 19 grade 4 defects and seven grade 2 defects were found.

Another Example

3224

Two grade 3 defects and four grade 2 defects, however no grade 5 or grade 4 defects were found.

If a pipe segment only has defects of one grade, the first two characters are the grade and the quantity of defects, and the last two characters are 00 (denoting no other defect grades). A pipe segment with no defects would have a Quick Score of 0000 (all zeros).

The PACP Quick Rating provides the ability to summarize the number and severity of defects found within a pipe segment. As with the Pipe Rating, Quick Structural Ratings are calculated using only Structural Defect Grades, and Quick O&M Ratings are calculated using only O&M Defect Grades.

The Quick Rating is an excellent screening tool to determine which pipe segments require closer scrutiny. If a pipe has not defects greater than Grade 1 or 2, then the pipe segment probably does not need any further investigation.

Pipe Ratings Index – This is an indicator of the distribution of defect severity. The Pipe Ratings Index is calculated by dividing the Pipe Rating by the number of defects. For example, the Structural Pipe Ratings Index would be the Structural Pipe Rating divided by the number of structural defects. Pipe Ratings Indexes are calculated for Structural, O&M, and Overall. A pipe segment with a Pipe Rating of zero (0) would have a Pipe Rating Index of zero (0).

Summary

The following procedures are used to calculate pipe segment ratings using the PACP Condition Grading System:

1. Determine the number of occurrences for each condition grade within the pipe segment. Calculate separately for Structural Defect Grades and O&M Defect Grades.
2. Calculate the Segment Grade Score by multiplying the number of occurrences by the respective grade 1 through 5. Calculate the Structural Segment Grade Score and the O&M Segment Grade Score separately, and then add together for the Overall Segment Grade Score.
3. Calculate the Pipe Rating for the pipe segment by adding the Segment Grade Scores. Add all five Structural Segment Grade Scores for the Structural Pipe Rating, and add all five O&M Segment Grade Scores for the O&M Pipe Rating. Add all five Overall Segment Grade Scores for the Overall Pipe Rating.
4. Determine the PACP Quick Rating by calculating the number of occurrences of the two highest severity grades.

5. Calculate the Pipe Ratings Index by dividing the Pipe Rating by the number of defects. If the pipe has no defects, the Pipe Ratings Index is zero.
6. Verify the PACP defect data used in accurate. The grading is a direct calculation from the defect data, and coding errors will be reflected in grading errors.

NASSCO PACP Condition Grading System
Code Matrix

Family	Group	Descriptor	Modifier	Code	Structural Grade	O&M Grade
Structural	Crack (C)	Circumferential (C)		CC	1	
		Longitudinal (L)		CL	2	
		Multiple (M)		CM	3	
		Hinge (CH2)		CH2	4	
		Hinge (CH3)		CH3	5	
		Hinge (CH4)		CH4	5	
		Spiral (S)		CS	2	
Structural	Fracture (F)	Circumferential (C)		FC	2	
		Longitudinal (L)		FL	3	
		Multiple (M)		FM	4	
		Hinge (H2)		FH2	4	
		Hinge (H3)		FH3	5	
		Hinge (H4)		FH4	5	
		Spiral (S)		FS	3	
Structural	Pipe Failures (Silent)	Broken (B)		B	1 clock pos - 3, 2 clock pos - 4, >=3 clock pos - 5	
		Broken (B)	Soil Visible (SV)	BSV	5	
		Broken (B)	Void Visible (V V)	BVV	5	
		Hole (H)		H	1 clock pos - 3, 2 clock pos - 4, >= 3 clock pos - 5	
		Hole (H)	Soil Visible (SV)	HSV	5	
		Hole (H)	Void Visible (V V)	HVV	5	
Structural	Collapse (X)	Pipe (P)		XP	5	
		Brick (B)		XB	5	
Structural	Deformed (D)	(Pipe)		D	<=10% - 4,>10% - 5	
		(Brick)	Horizontally (H)	DH	5	
		(Brick)	Vertically (V)	DV	5	
Structural	Joint (J)	Offset (displaced) (O)	Med (M)	JOM	1	
			Large (L)	JOL	2	
		Separated (open) (S)	Med (M)	JSM	1	
			Large (L)	JSL	2	
		Angular (A)	Med (M)	JAM	1	
			Large (L)	JAL	2	
Structural	Surface Damage Chemical (S)	Roughness Increased (RI)	C	SRIC	1	
		Surface Spalling (SS)	C	SSSC	2	
		Aggregate Visible (AV)	C	SAVC	3	
		Aggregate Projecting (AP)	C	SAPC	3	
		Aggregate Missing (AM)	C	SAMC	4	

NASSCO PACP Condition Grading System
Code Matrix

Family	Group	Descriptor	Modifier	Code	Structural Grade	O&M Grade
		Reinforcement Visible (RV)	C	SRVC	5	
		Reinforcement Projecting (RP)	C	SRPC	3	
		Reinforcement Corroded (RC)	C	SRCC	5	
		Missing Wall (MW)	C	SMWC	5	
		Other (Z)	C	SZC		
Structural	Surface Damage Mechanical (M)	Roughness Increased (RI)	M	SRIM	1	
		Surface Spalling (SS)	M	SSSM	2	
		Aggregate Visible (AV)	M	SAVM	3	
		Aggregate Projecting (AP)	M	SAPM	3	
		Aggregate Missing (AM)	M	SAMM	4	
		Reinforcement Visible (RV)	M	SRVM	5	
		Reinforcement Projecting (RP)	M	SRPM	3	
		Reinforcement Corroded (RC)	M	SRCM	5	
		Missing Wall (MW)	M	SMWM	5	
		Other (Z)	M	SZM	N/A	
Structural	Surface Damage Not Evident (Z)	Roughness Increased (RI)	Z	SRIZ	1	
		Surface Spalling (SS)	Z	SSSZ	2	
		Aggregate Visible (AV)	Z	SAVZ	3	
		Aggregate Projecting (AP)	Z	SAPZ	3	
		Aggregate Missing (AM)	Z	SAMZ	4	
		Reinforcement Visible (RV)	Z	SRVZ	5	
		Reinforcement Projecting (RP)	Z	SRPZ	3	
		Reinforcement Corroded (RC)	Z	SRCZ	5	
		Missing Wall (MW)	Z	SMWZ	5	
		Other (Z)	Z	SZZ	N/A	
Structural	Surface Damage (Metal Pipes)	Corrosion (CP)		SCP	3	
Structural	Lining Features (LF)	Detached (D)		LFD	3	
		Defective End (DE)		LFDE	3	
		Blistered (B)		LFB	3	
		Service Cut Shifted (CS)		LFCS	3	
		Abandoned Connection (AC)		LFAC		
		Overcut Service (OC)		LFOC	3	
		Undercut Service (UC)		LFUC	3	
		Buckled (BK)		LFBK	3	
		Annular Space (AS)		LFAS	3	
		Bulges (BU)		LFBU	3	
		Discoloration (DC)		LFDC	3	
		Delamination (DL)		LFDL	3	
		Pinholes (PH)		LFPH	3	
		Resin Slug (RS)		LFRS	3	
		Wrinkled (W)		LFW	3	
		Other (Z)		LFZ	N/A	
Structural	Weld Failure (WF)	Circumferential (C)		WFC	2	
		Longitudinal (L)		WFL	2	

NASSCO PACP Condition Grading System
Code Matrix

Family	Group	Descriptor	Modifier	Code	Structural Grade	O&M Grade
		Multiple (M)		WFM	3	
		Spiral (S)		WFS	2	
Structural	Point Repair (RP)	Localized Pipeliner (L)		RPL		
		Localized Pipeliner (L)	Defective (D)	RPLD	4	
		Patch Repair (P)		RPP		
		Patch Repair (P)	Defective (D)	RPPD	4	
		Pipe Replaced (R)		RPR		
		Pipe Replaced (R)	Defective (D)	RPRD	4	
		Other (Z)		RPZ		
		Other (Z)	Defective (D)	RPZD		
Structural	Brickwork (Silent)	Displaced (DB)		DB	3	
		Missing (MB)		MB	4	
		Dropped Invert (DI)		DI	5	
		Missing Mortar	Small	MMS	2	
			Medium	MMM	3	
			Large	MML	3	
O&M	Deposits (D)	Deposits Attached (DA)	Encrustation (E)	DAE		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
			Grease (G)	DAGS		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
			Ragging (R)	DAR		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
			Other (Z)	DAZ		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Deposits Settled (DS)	Hard/Compacted (C)	DSC		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
			Fine silt/sand (F)	DSF		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
			Gravel (G)	DSGV		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
			Other (Z)	DSZ		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Deposits Ingress (DN)	Fine silt/sand (F)	DNF		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
			Gravel (GV)	DNGV		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5

NASSCO PACP Condition Grading System
Code Matrix

Family	Group	Descriptor	Modifier	Code	Structural Grade	O&M Grade
			Other (Z)	DNZ		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
O&M	Roots (R)	Fine (F)	Barrel (B)	RFB		2
			Lateral (L)	RFL		1
			Connecfion (C)	RFC		1
	Roots (R) at a Joint		N/A	RFJ	in software with a J	1
		Tap (T)	Barrel (B)	RTB		3
			Lateral (L)	RTL		2
			Connecfion (C)	RTC		2
	Roots (R) at a Joint		N/A	RTJ		2
		Medium (M)	Barrel (B)	RMB		4
			Lateral (L)	RML		3
			Connecfion (C)	RMC		3
	Roots (R) at a Joint		N/A	RMJ		3
		Ball (B)	Barrel (B)	RBB		5
			Lateral (L)	RBL		4
			Connecfion (C)	RBC		4
	Roots (R) at a Joint		N/A	RBJ		4
O&M	Infiltration (I)	Weeper (W)		IW		2
		Dripper (D)		ID		3
		Runner (R)		IR		4
		Gusher (G)		IG		5
		Stain (S)		IS		
O&M	Obstacles/Obstructions (OB)	Brick or Masonry (B)		OBB		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Pipe Material in Invert (M)		OBM		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Object Intruding Thru Wall (I)		OBI		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Object Wedged in Joint (J)		OBJ		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Object Thru Connection (C)		OBC		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		External Pipe or Cable In Sewer (P)		OBP		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Built Into Structure (S)		OBS		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5

NASSCO PACP Condition Grading System
Code Matrix

Family	Group	Descriptor	Modifier	Code	Structural Grade	O&M Grade
		Construction Debris (N)		OBN		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Rocks (R)		OBR		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Other Objects (Z)		OBZ		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
O&M	Vermin (V)	Rat (R)		VR		2
		Cockroach (C)		VC		1
		Other (Z)		VZ		1
O&M	Grout Test and Seal (G)	Grout Test Pass (GTP)				
			Joint (J)	GTPJ		
			Lateral (L)	GTPL		
		Grout Test Fail (GTF)				
			Joint (J)	GTFJ		
			Lateral (L)	GTFL		
		Grout Test Unable to Test (GTU)				
			Joint (J)	GTUJ		
			Lateral (L)	GTUL		
		Grout at a Location (not a joint) (GRT)		GRT		
Construction Features	Tap (T)	Factory Made (F)		TF		
			Capped (C)	TFC		
			Abandoned (B)	TFB		
			Defective (D)	TFD		2
			Intruding (I)	TFI		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
			Activity (A)	TFA		
		Break-In/Hammer (B)		TB		
			Capped (C)	TBC		2
			Abandoned (B)	TBB		
			Defective (D)	TBD		3
			Intruding (I)	TBI		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
			Activity (A)	TBA		
		Saddle (S)		TS		
			Capped (C)	TSC		
			Abandoned (B)	TSB		

NASSCO PACP Condition Grading System
Code Matrix

Family	Group	Descriptor	Modifier	Code	Structural Grade	O&M Grade
			Defective (D)	TSD		2
			Intruding (I)	TSI		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
			Activity (A)	TSA		
		Rehabilitated (R)		TR		
			Defective (D)	TRD		2
			Intruding (I)	TRI		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
Construction Features	Intruding Seal Material (IS)			IS		
		Sealing Ring (SR)		ISSR		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
			Hanging (H)	ISSRH		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
			Broken (B)	ISSRB		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Loose, Poorly Fitting (SRL)		ISSRL		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Grout (GT)		ISGT		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
		Other (Z)		ISZ		<=10% - 2, <=20% - 3, <=30% - 4, >30% - 5
Construction Features	Line (L)	Left (L)		LL		<=10 Deg - 1, <=20 Deg 2, >20 Deg - 4
		Left/Up (LU)		LLU		<=10 Deg - 1, <=20 Deg 2, >20 Deg - 4
		Left/Down (LD)		LLD		<=10 Deg - 1, <=20 Deg 2, >20 Deg - 4
		Right (R)		LR		<=10 Deg - 1, <=20 Deg 2, >20 Deg - 4

NASSCO PACP Condition Grading System
Code Matrix

Family	Group	Descriptor	Modifier	Code	Structural Grade	O&M Grade
		Right/Up (RU)		LRU		<=10 Deg - 1, <=20 Deg 2, >20 Deg - 4
		Right/Down (RD)		LRD		<=10 Deg - 1, <=20 Deg 2, >20 Deg - 4
		Up (U)		LU		<=10 Deg - 1, <=20 Deg 2, >20 Deg - 4
		Down (D)		LD		<=10 Deg - 1, <=20 Deg 2, >20 Deg - 4
Construction	Access Points (A)					
		Cleanout (CO)		ACO		
			Mainline (M)	ACOM		
			Property (P)	ACOP		
			House (H)	ACOH		
		Discharge Point (DP)		ADP		
		Junction Box (JB)		AJB		
		Meter (M)		AM		
		Manhole (MH)		AMH		
		Other Special Chamber (OC)		AOC		
		Tee Connection (TC)		ATC		
		WW Access Device (WA)		AWA		
		Wet Well (WW)		AWW		
		Catch Basin (CB)		ACB		
		End of Pipe (EP)		AEP		
Other	Miscellaneous (M)	Camera Underwater (CU)		MCU		4
		Dimension/Diam/Shape Change (SC)		MSC		
		General Observation (GO)		MGO		
		General Photograph (GP)		MGP		
		Material Change (MC)		MMC		
		Lining Change (LC)		MLC		
		Pipe Joint Length Change (JL)		MJL		
		Survey Abandoned (SA)		MSA		
		Water Level (WL)		MWL		
			Sag (S)	MWLS	<=30% - 2, <=50% - 3, >50% - 4	
		Water Mark (WM)		MWM		>=50% 4, >=75% 5
		Dye Test (Y)		MY		
			Visible (V)	MYV		5
			Not Visible (N)	MYN		3

Reasons for TV Inspection

We televise sewers for many different purposes, some of those purposes are:

- **Routine Operational Requirements** – Pro-active inspection to identify potential failures and for planning routine Operation and Management (O&M) and renovation programs.
- **Troubleshooting** – Investigation of problem incidents to select remedial action.
- **Compliance with Mandated Programs** – Inspection and data collection to support programs such as Capacity, Management, Operations and Maintenance (C-MOM) and Administrative Orders (AOs), Governmental Accounting Standards Board statement 34 (GASB-34), and Consent Decrees.
- **Acceptance Testing** – Inspection of new or renewed sewers to insure that construction met specifications and to document as-built conditions.
- **Infiltration/Inflow (I/I) or Capital Improvement Program (CIP) Projects** – Examples of the type projects normally conducted by specialty firms or engineering consultants.

Regardless of what purpose we televise sewers, it is important that TV inspection data is collected thoroughly and consistently. This approach insures better and more comprehensive data is collected, and will provide opportunities for a single TV inspection to serve multiple purposes. While obtaining a limited amount of information may meet the immediate data needs, it also means the information obtained as part of a comprehensive PACP inspection will not be available for other possible requirements in the future.

What We Need from TV Inspection Data

The basic information we need from TV inspection is as follows:

- Record and archive all descriptive data using standard procedures and data format
- Develop a condition rating for each line
- Provide follow-up recommendations
- Display results on a map
- Establish benchmarks to compare with future inspections of same line

Standardizing on the PACP codes as well as integration with other components of the PACP will meet the above objectives.

Why Standardization is Important

Some the benefits of standardization are as follows:

- Allows for more effort to be placed on consistency of data and utilization of data rather than development of utility-specific or project-specific standards
- Provides the capability of benchmarking sewers within a single utility as well as from one geographical area of the US to another
- Ability to detect change due to deterioration over time
- Provides better opportunities for integrating data from different software programs
- Improved confidence in the description of pipe conditions will provide cost savings during renewal
- Advances the professionalism of the TV inspection industry

Origin of Condition Codes

WRc first drafted the Manual of Sewer Condition Classification (MSCC) in 1980 for use in the United Kingdom. At that time, consistent assessment of sewer condition was needed in order to fairly set sewer rates charged to consumers by the private utility companies that operated throughout the UK, and those codes are now the mandated standard. The MSCC was most recently updated by WRc in 2004 (MSCC Fourth Edition) and are used extensively throughout the world. Other WRc-based coding systems have been implemented throughout the world including Australia, New Zealand, Southeast Asia, and Europe.

The PACP codes were developed by NASSCO and the Water Research Centre (WRc) in 2002. Prior to the development of the PACP, no standard TV inspection codes or procedures existed in the United States. While many agencies and engineering firms in the US used adaptations of the WRc codes, no single standard existed, nor was a standard training and certification program available.

Those familiar with the WRc codes will find the PACP codes very similar. Terminology has been changed to reflect terms used in the United States. Codes have been added to describe conditions found in renewed pipes and point repairs. The ability to describe pipe corrosion has been greatly improved. Coding of Operational and Maintenance problems in general has been improved. Codes have been added to describe observations and defects that otherwise would be noted in the remarks or comment section.

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