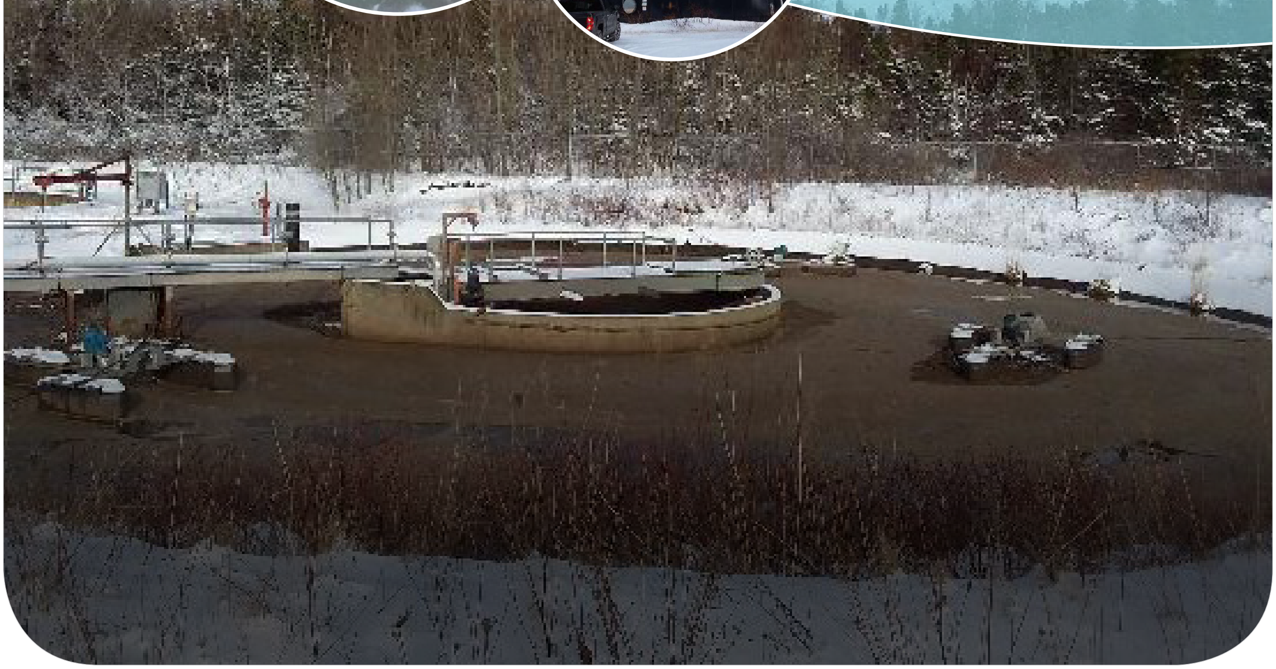
March 26, 2019

Municipality of the County of Inverness

Water and Wastewater Infrastructure Assessment and Recommendations

Final Report

Project # 18-8874



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Attention: Mr. Alan Benninger
Supervisor, Water & Wastewater Operations

Final Report - Water and Wastewater Infrastructure Assessment and Recommendations

Dillon Consulting Limited (Dillon) is pleased to submit our Final Report for the above noted project. This report includes an overview of the project scope, methodology and approach, results of the field investigation, condition and inventory assessment, details on the asset management tools and recommendations for investment over the next 10 years and beyond.

It has been a pleasure working with you on this interesting project, and we look forward to continuing our relationship in the future.

Sincerely,

DILLON CONSULTING LIMITED

James Sheppard, P.Eng.
Project Manager

Kyle MacIntyre, P.Eng.
Water/Wastewater Engineer

KRM:jes
Attachments

Our file: 18-8874-1000

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Executive Summary

The Municipality of the County of Inverness (MOCI) owns and operates municipal water and wastewater infrastructure in seven communities on Cape Breton Island, Nova Scotia. In order to assist in developing effective asset management practices, the MOCI retained Dillon Consulting to complete a condition and inventory assessment of linear and complex infrastructure across the Municipality. The project involved a desktop review of both linear and complex assets and a field program to evaluate the physical condition of the complex assets including 23 wastewater lift stations, 2 water booster stations, 7 wastewater treatment facilities and 9 water treatment facilities (2 of which were inactive or no longer in current use).

The project was extensively supported by MOCI operations' staff throughout the field program, which resulted in the development of asset management spreadsheets and a 10 year capital plan. The use of these tools will allow the MOCI to monitor and maintain the condition of its infrastructure in the future and make informed decisions on infrastructure expenditures.

Based on this study, the MOCI owns an estimated **$186 Million** of water and wastewater assets currently. **Table ES-1** compares the MOCI's complex/non-linear infrastructure condition ratings developed as an outcome of the current analysis to that of the 2016 Canadian Infrastructure Report Card (CIRC). **Table ES-2** provides a general description of the MOCI's infrastructure's condition.

Table ES – 1 Comparison to 2016 CIRC (Complex Assets)

Condition	2016 CIRC (Average across Water and Wastewater)	MOCI Condition Ratings
Very Good (1)	45.5%	6%
Good (2)	37.5%	19%
Fair (3)	26.5%	60%
Poor (4)	7.0%	15%
Very Poor/Critical (5)	1.5%	0%

This data is presented visually in **Figure 1-1**:

Figure 1-1 Asset Condition Comparison to 2016 CIRC

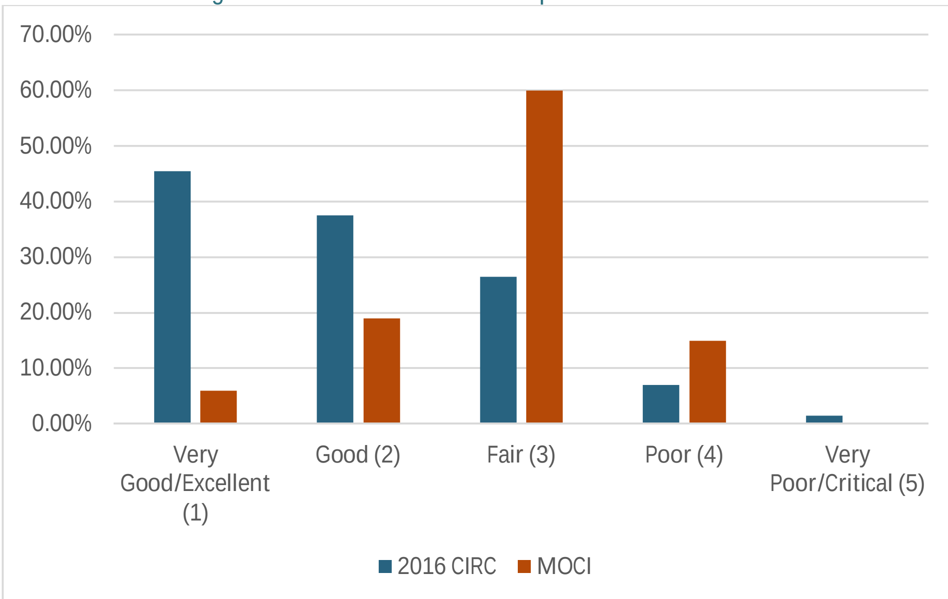

Table ES – 2 MOCI General Infrastructure Condition

Asset Type	General Condition
Watermain	Very Good (1)*
Gravity Sewer	Fair (3)*
Forcemain	Fair (3)
Complex Infrastructure (treatment plants, lift stations)	Fair (3)

* *significant percentage in Fair (3) – Very Poor (5) range*

Based on the results of the condition assessment, significant investments are recommended over the next 10 years in order to improve/maintain the current status of infrastructure and associated level of service to residents.

Table ES – 3 Recommended Annual Investments (all water/wastewater infrastructure)

Asset Type	Recommended Minimum Annual Investment (2016 CIRC)	General Guideline for Asset Planning	Recommended Minimum Annual Investment based on Condition Assessment
Water and Wastewater Infrastructure	1.65% of total asset value per year (approximately $3.0 M)	2 – 3% of total asset value per year (approximately $4.6 M)	5.56% of total asset value per year (approximately $10.3 M)

Table ES-4 provides an approximate breakdown of the current asset replacement value and estimated 10 year replacement cost by community.

Table ES – 4 Estimated Breakdown by Community

Community	Estimated Asset Replacement Value	Estimated 10 year Investment Cost	% of Total 10 Year Estimated Investment
Cheticamp	$19.8 M	$16.0 M	15.5%
Inverness	$48.5 M	$42.6 M	41.3%
Judique	$12.0 M	$4.1 M	4.0%
Mabou	$28.0 M	$6.0 M	5.8%
Port Hood	$30.4 M	$16.4 M	15.9%
Whycocomagh	$28.0 M	$7.7 M	7.5%
Port Hastings	$19.2 M	$10.3 M	10.0%
Total	$185.9 M	$103.1 M	100%

These estimates are based on the observed condition of current complex assets, age of linear infrastructure, desired replacement point to meet level of service standards and average life span of assets based on industry standards.

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1.0 Introduction

Dillon Consulting Limited (Dillon) was retained by the Municipality of the County of Inverness (MOCI) to complete a condition review of the municipal water and wastewater infrastructure in the seven communities within the MOCI. The key outcome of the project was to identify the current asset conditions, provide an inventory of the water and wastewater infrastructure assets owned and operated by the MOCI, and identify a 10 – year investment priority plan to complete any significant upgrades recommended for the facilities.

1.1 Background Information

The Municipality of the County of Inverness is located on Cape Breton Island, Nova Scotia. The MOCI has an approximate population of 14,021 residents (2018) and covers an approximate area of 3,831 square kilometers spanning the communities of Port Hastings to Meat Cove. Currently, the MOCI owns and operates seven water treatment facilities, six water distribution systems and seven wastewater treatment plants located in the following communities: Port Hastings, Judique, Port Hood, Mabou, Inverness, Whycocomagh, and Cheticamp. The community of Port Hastings currently purchases potable water from the Town of Port Hawkesbury water system; however, the Port Hastings distribution system is operated by the MOCI and is included in this report. **Table 1-1** details the estimated number of current connections in each of the communities.

Table 1-1 Estimated System Connections

Community	Estimated System Connections[1]	Percentage of MOCI
Port Hastings	105	3.6%
Judique	75	2.6%
Port Hood	300	10.2%
Mabou	160	5.5%
Inverness	1,500	51.4%
Whycocomagh	330	11.3%
Cheticamp	450	15.4%
TOTAL	**2,920**	**100%**

[1] *Provided by the MOCI*

1.2 Methodology

The following describes the key project steps undertaken to complete the project:

Initiation
- Project initiation meeting with MOCI's project team and Dillon personnel
- Introduction, review of work plan and scope, review proposed schedule, determine MOCI's main goals for the project, identify areas of concern
- Review available record and historic information

Workshop
- Workshop to discuss desktop study results and outline the data collection procedure
- Discussions with MOCI staff
- Determine level of detail to which assets would be inspected and data collected

Field Planning
- High level review of all sites/communities to be visited
- Approximate timing and duration at each site
- Coordination with MOCI staff

Field Program
- Collection of inventory and condition data as determined from the workshop
- Discussions with operations' staff to provide insight into existing infrastructure

Reporting
- Summarize data collected from the field program
- Develop annual capital investment plan spanning the next 10 years
- Summary sections outlining the state of the infrastructure
- Outline asset management tools

Presentation (April 2019)
- Presentation for council staff summarizing the methodology, field component, results and recommendation of the project.

1.2.1 Desktop Review

Available records were reviewed prior to the field program to obtain available background information on the water and wastewater linear systems and facilities. The MOCI's historical data was obtained from multiple sources during the background data collection process (e.g., the MCI-RFP-0918, available Record Drawings, Drawings of Nova Scotia Water Supply and Treatment Systems and system annual reports).

1.2.2 Workshop

A workshop was held with Municipal staff on January 4th, 2019 to review the results of the desktop study and discuss details related to the field program. The workshop discussed condition rating procedures, how asset values and overall conditions would be calculated and discussed the next steps in the project. Agreement was confirmed on the rating system for the infrastructure evaluation and prioritization.

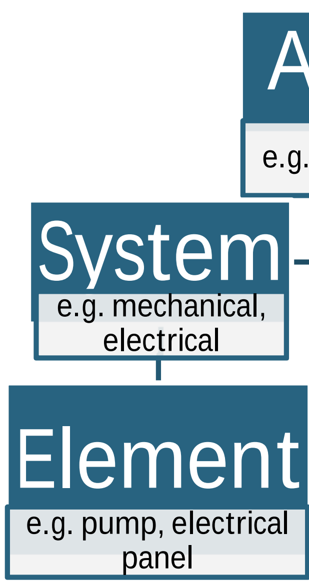
1.2.3 Field Program

Between January 7th and January 18th, 2019 site investigations of the seven communities were conducted by Dillon personnel with assistance from MOCI staff. During the site investigations the following items were completed:

- Condition assessment of accessible components by visual inspection at all lift stations, water treatment plants, and wastewater treatment plants;
- Attendance in weekly water/wastewater meetings with MOCI operations staff; and
- Interviews with both past and present MOCI operations staff to obtain an understanding of known infrastructure issues and conditions.

1.3 Nomenclature

There are several different approaches to asset management, and while most have similar methodologies and end results, the nomenclature used can often vary. For the purposes of this project every asset is defined as a collection of elements in an ordered hierarchy. In this manner the observable elements of an asset are grouped according to systems. The systems are logical representation of major features of the asset. For example, a lift station includes systems such as mechanical and electrical (among others). The electrical and mechanical systems include one or more elements with an observable condition. The asset hierarchy is summarized visually as follows:



2.0 Asset Inventory

This section provides a summary of the water and wastewater infrastructure inventory for the seven communities within the MOCI evaluated as part of this project. An overall illustration of the communities within the MOCI and their respective infrastructure can be found in Appendix B.

2.1 Types of Assets

Under this assessment the infrastructure asset portfolios were divided into two categories:

1. Linear including water mains and sanitary collection; and,
2. Complex including the non-linear treatment and conveyance facilities.

This division allows each group of assets to be individually evaluated and summarized, since the two have different sets of asset decay and expenditure attributes. Linear infrastructure is often “simpler” and contains relatively few components, while complex infrastructure is often larger and multi-disciplinary. These differences affect the way the asset condition changes over time, and the associated complexity in condition estimation and expenditure estimation related to asset replacement. The complex assets are not replaced in whole at an end-of-life date and instead receive ongoing replacement of individual elements.

The following subsections summarize the linear and complex infrastructure inventory obtained through records review and the site investigations conducted by MOCI staff and Dillon personnel.

2.2 Assumptions

During the records review process, missing data for the linear assets was encountered in all of the communities. In order to fully estimate the extent of water/wastewater distribution system in these communities (for both total inventory and costing exercises), assumptions were made by Dillon personnel. These assumptions were based on information provided by the RFP, discussions with former and current MOCI personnel and satellite images of the communities (e.g. Google Earth). These assumptions were discussed and validated with former and current MOCI personnel to the best of their abilities. **Table 2-1** describes the assumptions made during the data collection process.

Table 2-1 Linear Infrastructure Assumptions per Community

Community	Assumption for Unknown or Missing Information	
Cheticamp	• Forcemain is 100mm diameter (RFP); • Gravity Sewer is 200mm diameter (RFP);	• Watermain is 100mm diameter (former MOCI operator); • Collection system was installed in 1974 (RFP);
Inverness	• Forcemain is 100mm diameter (RFP); • Gravity Sewer is 200mm diameter (RFP);	• Watermain is 100mm diameter (former MOCI operator); • Collection system was installed in 1974 (RFP);
Judique	• Watermain materials (former MOCI operator); • Gravity Sewer is 200mm diameter;	• Watermain is 200mm diameter; • Collection system was installed in 1971 (RFP);
Mabou	• Collection system was installed in 1974 (RFP); • Unknown gravity sewer and watermain to be 200mm diameter;	
Whycocomagh	• Gravity Sewer is 200mm diameter; • Forcemain is 100mm diameter; • Collection system was installed in 1994 (RFP);	

2.2.1 Linear Infrastructure

Linear assets are those that contain only one primary component and are typically dispersed geographically over a large area, and include infrastructure such as roads, sidewalks and underground piping. The scope of this assignment included only underground piping (water distribution and wastewater collection). **Table 2-2** provides a summary of the length of linear infrastructure that was analyzed**. Table 2-3** to **Table 2-9** summarize the asset type and approximate length of pipe for the communities in this study. There were significant differences in overall length between the information provided at the start of the project in the RFP, and that collected during the background study and field assessments. Discussions with MOCI staff suggested that the actual field data and satellite measurements would be more accurate, however this should be confirmed in the future. To account for limited information in Port Hastings, placeholders were used to bring the overall linear lengths closer to that initially developed by the MOCI.

Table 2-2 Overall MOCI Linear Infrastructure Inventory for all Communities

Asset Type	Estimated Length (m)
Forcemain	10,722
Gravity Sewer	45,747
Watermain	71,333

Table 2-3 Cheticamp Linear Infrastructure Summary

Pipe	Estimated Length (m)
Forcemain	4,000
Gravity Sewer	3,095
Watermain	4,835

Table 2-4 Inverness Linear Infrastructure Summary

Pipe	Estimated Length (m)
Forcemain	433
Gravity Sewer Pipe	13,240
Watermain	18,087

Table 2-5 Judique Linear Infrastructure Summary

Pipe	Estimated Length (m)
Gravity Sewer Pipe	1,851
Watermain	2,914

Table 2-6 Mabou Linear Infrastructure Summary

Pipe	Estimated Length (m)
Forcemain	920
Gravity Sewer Pipe	7,151
Watermain	7,603

Table 2-7 Port Hastings Linear Infrastructure Summary

Pipe	Estimated Length (m)
Forcemain	3,450
Gravity Sewer Pipe	3,450
Watermain	6,900

Table 2-8 Port Hood Linear Infrastructure Summary

Pipe	Estimated Length (m)
Forcemain	619
Gravity Sewer Pipe	9,279
Watermain	12,087

Table 2-9 Whycocomagh Linear Infrastructure Summary

Pipe	Estimated Length (m)
Forcemain	1,300
Gravity Sewer	7,681
Watermain	18,907

The Inventory Asset Tool provides a full asset inventory, including the age, size/diameter, length and material of the linear systems. The reference location for each linear infrastructure segment is also provided.

2.2.2 Complex Infrastructure

Complex assets are those that contain a variety of components (e.g., mechanical, electrical, structural). For this assessment, four types of complex assets were analyzed: wastewater lift stations, water booster stations, wastewater treatment facilities and water treatment facilities. **Table 2-8** provides a summary of the complex infrastructure that was analyzed and the overall quantity in the study area. **Tables 2-9** to **2-15** summarize the complex infrastructure by community. There were two water treatment plants (Mabou and Port Hood) that are currently offline. While not operational, these assets due have capital value and could be placed back into service after any necessary upgrades are completed, and accordingly were included in the analysis. If these plants are to be decommissioned/demolished, their value may be removed from the annual investment costs. These two plants account for $5,840,000 of the 10-year capital cost plan.

Table 2-10 Complex Infrastructure Inventory (all communities)

Asset Type	Quantity
Wastewater Lift Stations	23
Water Booster Stations	2
Wastewater Treatment Facilities	7
Water Treatment Facilities	9 (7 active)
Water Storage Reservoirs	7
Total Number of Complex Assets	**48 (46 active)**

Table 2-11 Cheticamp Complex Infrastructure Inventory

Asset Type	Quantity
Wastewater Lift Stations	6
Water Booster Stations	0
Wastewater Treatment Facilities	1
Water Treatment Facilities	1
Water Storage Reservoirs	1

Table 2-12 Inverness Complex Infrastructure Inventory

Asset Type	Quantity
Wastewater Lift Stations	2
Water Booster Stations	1
Wastewater Treatment Facilities	1
Water Treatment Facilities	2
Water Storage Reservoirs	1

Table 2-13 Judique Complex Infrastructure Inventory

Asset Type	Quantity
Wastewater Lift Stations	0
Water Booster Stations	0
Wastewater Treatment Facilities	1
Water Treatment Facilities	1
Water Storage Reservoirs	1

Table 2-14 Mabou Complex Infrastructure Inventory

Asset Type	Quantity
Wastewater Lift Stations	2
Water Booster Stations	0
Wastewater Treatment Facilities	1
Water Treatment Facilities	2 (1 active)
Water Storage Reservoirs	1

Table 2-15 Port Hastings Complex Infrastructure Inventory

Asset Type	Quantity
Wastewater Lift Stations	3
Water Booster Stations	1
Wastewater Treatment Facilities	1
Water Treatment Facilities	0
Water Storage Reservoirs	1

Table 2-16 Port Hood Complex Infrastructure Inventory

Asset Type	Quantity
Wastewater Lift Stations	6
Water Booster Stations	0
Wastewater Treatment Facilities	1
Water Treatment Facilities	2 (1 active)
Water Storage Reservoirs	1

Table 2-17 Whycocomagh Complex Infrastructure Inventory

Asset Type	Quantity
Wastewater Lift Stations	4
Water Booster Stations	0
Wastewater Treatment Facilities	1
Water Treatment Facilities	1
Water Storage Reservoirs	1

The Asset Inventory Tool provides a full and detailed asset inventory, including the age, make, and other key information where available. The reference location for each complex infrastructure is also provided.

3.0 Condition Assessment Methodology

3.1 Introduction

Determining the condition of existing infrastructure is a critical step in asset management planning as it helps owners and operators estimate the remaining useful life of that asset, which helps inform decisions regarding upgrades, maintenance, replacement date and cost.

In general, the specific asset condition rating is the most valuable to a utility owner. However, it is difficult to assign a numerical rating to a lift station or treatment plant simply by looking at a facility and assigning a condition score. A defensible means of identifying the asset condition is to employ industry specialists to review the systems and elements of the asset and assign a condition rating based on the understood performance (e.g., the condition of a pump may be reasonably estimated by an engineer from a visual inspection and discussion with knowledgeable operators). The individual system/element conditions are weighted and a system condition score is calculated using the weighted average of the observed conditions. The systems are similarly weighted based on the workshop outcomes to ensure that the asset condition, or its "ability to perform" is based on a careful weighted average of the conditions of its systems. In this manner, a repeatable and defensible asset condition is calculated on the basis of field expertise applied to observable elements and weighted according to a system of metrics. Similarly, the asset condition is easily recomputed by revising the condition score associated with any system of the asset.

There are two general methods of performing condition assessments on municipal infrastructure:

1. Visually inspect the components to determine the condition (Visual Assessment); or
2. Assign a condition rating based on the age of the asset, and where that corresponds to its overall useful life (Model-Derived Assessment). This method is typically employed on infrastructure that is difficult to access (e.g. buried piping).

During this assessment, both Visual Assessment and Model-Derived Assessments were used. The visual assessment is used to provide a present-condition assessment of individual asset elements. A decay model is assigned to each element type to project the expected replacement intervention.

3.2 Systems

Nine systems were identified based on the range of infrastructure included in the assessment. These are:

1. Structural/building;
2. Electrical;
3. Mechanical;
4. Process equipment;

5. Site civil;
6. Instrumentation;
7. Environmental;
8. Performance; and,
9. Operability.

Numerical ratings were assigned to environmental, performance and operability with the intent to utilize these conditions as a qualitative assessment to supplement the physical condition. These three attributes provide operational knowledge and influence the asset condition, but do not influence replacement cost.

3.3 Condition Rating System

As shown in **Table 3-1,** the condition ratings used for this project are an industry standard that follows the five point scale utilized in the Canadian Infrastructure Report Card. A rating of 1 signifies infrastructure in very good or like-new condition, while a rating of 5 relates to very poor or failing infrastructure.

Table 3-1 Condition Ratings for Assets

Rating	Condition	Description
1	Very Good	Like new/physically sound and performing as intended.
2	Good	Minor superficial deterioration.
3	Fair	Showing deterioration and wear.
4	Poor	Major portion of the asset is deficient, functions but has major problems.
5	Very Poor	Physically unsound, unreliable and has reached or exceeded useful life.

Acknowledging that within different systems within an asset (e.g. structural, mechanical, electrical) are varied in the elements that make them up, additional detail was developed on how specific systems should be rated 1-5. This reference is provided in **Appendix A** and was used as a guide for visual inspection and assignment of condition ratings.

3.4 Condition Assessments

3.4.1 Field Assessments

From January 7th to January 18th, 2019, Dillon staff completed a field assessment of all complex water and wastewater infrastructure within the municipality. The scope of the assessment consisted of visiting every lift station and treatment plant, visually inspecting the site and assigning 1 – 5 ratings to each asset system based on the observations of the associated elements by trained water/wastewater professionals.

In order to maintain consistency across all surveys, a GIS based platform (Survey123) was used to collect field assessment data. Using this application to collect data at all sites ensured that the correct data was captured, information was uniform, and also allows the MOCI to keep track of all their assets using AcrGIS, including geographic location.

During the assessments Dillon staff were escorted around the various plants by operators, and would then complete a detailed condition assessment using the Survey123 application. Each piece of infrastructure (Linear, Lift Station, Water Treatment, Wastewater Treatment) had a specially built survey form that allowed specific data for each asset to be captured.

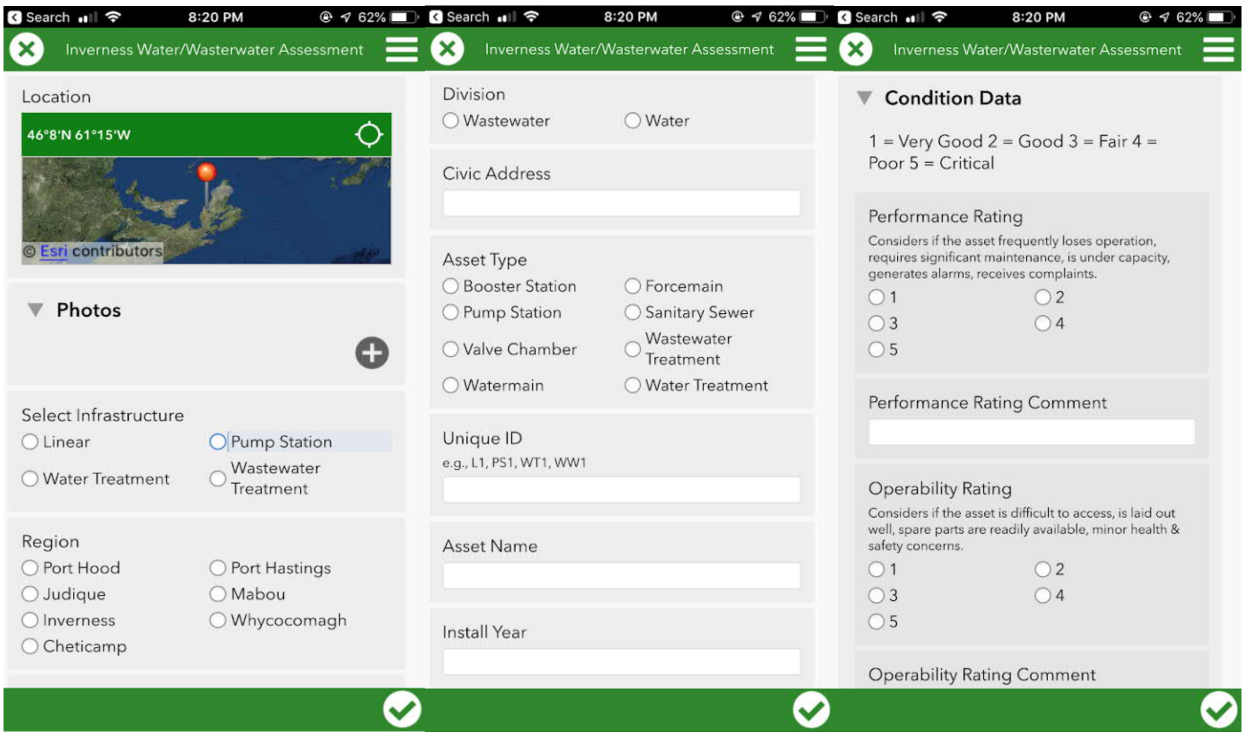


Figure 3-1 Data Collection Form

Operator input was also taken into account during the assessment. Dillon staff conducted interviews with both past and present operation and maintenance staff to gain as much information as possible on the systems. Past operator input was recommended by MOCI as past operations and maintenance staff have a vast amount of knowledge about of existing infrastructure. The flagged areas from the interviews were than examined during the site visits and captured in the field reports.

3.5 Deterioration Curves Method

The condition of assets and infrastructure deteriorate over time due to a variety of reasons, and rarely in a straight line. As the condition degrades it typically becomes more difficult to maintain and declines in condition more rapidly. Previous experience and studies have indicated that a logarithmic decay curve is a sound representation of an asset's condition over the course of its operational life. An example of such curves used in the Asset Management Tool is shown **Figure 3-2**.

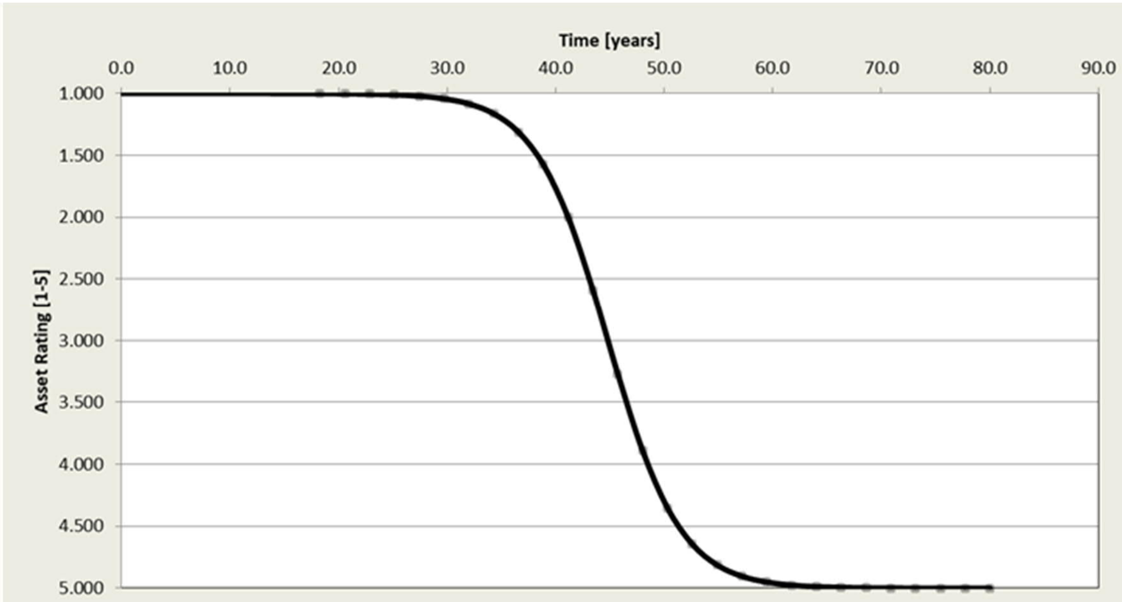


Figure 3-2 Deterioration Curve for PVC/HDPE Piping for Water and Wastewater Applications

As can be seen, when an asset is new it typically holds its "very good" condition for a period of time. At a certain point, it then begins to decay more rapidly before reaching a critical state, where it again holds relatively constant (as it is difficult to decay much more) before finally reaching the end of its useful life.

The asset decay curve follows a logistic regression. The Asset Management Tool implements a modified Richard's growth curve (also called the "generalized growth curve") which provides three parametric adjustments that dictate the shape of the decay curve between "new" and "critical" asymptotes and over the life span of the asset.

$$C(t) = C_{new} + \frac{C_{old} - C_{new}}{1 + Weight \times e^{-Growth(t-Delay)}}$$

The decay function estimates the condition (C) at any given age (t) between the condition asymptotes C_{new} and C_{old} using the adjustable parameters (Weight), (Growth), and (Delay). Together the three parameters determine the shape of the decay curve (Growth), the duration in like-new condition (Delay), and the longevity of the curve (Weight) and (Growth).

The deterioration curves were modeled using asset service life information obtained on expected and realized service lives of each component type. Information on asset lifespans was provided for previous projects by manufacturers, owners, operators, design engineers and other industry staff and has allowed decay curves to be created representing an approximated service life of important physical components.

The use of a decay curve permits a computational projection for the Asset Management Tool in determining condition thresholds. This is valuable for determining longevity, remaining life, and time to intervention (replacement or major upgrade) for infrastructure systems and components. The timing for replacement can be estimated from the condition decay curve by observing the difference between present condition ranking and the performance index.

3.6 Interventions

The intervention point (also sometimes referred to as "threshold of acceptability" or "performance index") is the state in which an asset requires to be replaced in order to avoid failure and potentially costly consequences. **Table 3-2** provides a summary of the Interventions for the water and wastewater infrastructure system and components that were evaluated in the condition assessment. When an asset's condition assessment surpasses its associated Intervention point, the asset should be replaced or undergo significant overhaul/repair. Based on industry standards and discussions with MOCI staff, an intervention of 90% was used for the linear assets, while 80 to 90% was used for the complex assets. The replacement intervention window may be placed at arbitrary locations along the decay curve and are generally based on experience with the specific asset portfolio, comfort with risk and desire for long term overall portfolio conditions.

If the intervention point is followed in practice, it will tend to drive the overall asset portfolio towards the selected points. The consequence is that annual reinvestment rates may tend to increase beyond practical limits. Later intervention points, particularly for structural assets, has been observed in some regions while others such as instrumentation may require more frequent replacement to modernize software and equipment at pace with service standards. The intervention point can be adjusted in the future by the MOCI based on experience, asset performance, budget allowances and risk tolerance.

Table 3-2 Intervention Points for All Assets

System/Asset	Intervention
Linear Assets	
Underground Piping (for all material)	4.5
Complex Assets	
Structural/Building	4.0
Electrical	4.5
Mechanical	4.5
Process Equipment	4.0
Site Civil	4.5
Instrumentation	4.0

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3.7 Forecasted Replacement Year

For complex infrastructure, the forecasted replacement year is calculated by assessing the individual condition ratings, and correlating the ratings to the deterioration curves to calculate the "current" age. The remaining life is then calculated by subtracting from the intervention point. The asset management tool will provide the condition of the asset, remaining life of the asset, forecasted replacement year and estimated replacement cost of the asset. The forecasted replacement year is a key tool for asset management as it identifies, based on current condition, when an asset should be considered for replacement.

For linear assets, the forecasted replacement year was calculated based on the estimated installation year of the asset and the intervention point.

3.8 Asset Weights

As there are nine systems that make up each complex asset, a weighted average calculation was completed for each asset. The average is computed using a condition weight and a value weight, these are based on the "importance" of the system. For example, the condition of the process equipment within a lift station is more critical than the condition of the site civil. Each system was assigned a condition and value weight on a scale of 1 to 10, based on the importance or criticality of that element to the functioning condition of the asset system. The given weights for the system is presented in **Table 3-3**.

Table 3-3 Condition and Value Weights

Systems	Condition Weight	Value Weight
Structural/Building	7.0	8.0
Electrical	5.0	5.0
Mechanical	5.0	5.0
Process Equipment	8.0	10.0
Site Civil	3.0	2.0
Instrumentation	6.0	4.0

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4.0 Condition Assessment Results

The following section presents the results of the condition assessment using the above methodology.

4.1 Linear Assets

4.1.1 Overall Linear Assets Rating

Underground infrastructure such as sanitary sewers, forcemains and watermains were assessed for condition using the model-derived assessment based on age. A summary of the results can be found in **Figures 4-1** and **4-2**. In general, the condition of the underground infrastructure in the seven communities is fair; the watermains were found to be in generally very good condition, the sanitary sewers were found to be in generally fair condition and the forcemains were found to be in generally fair condition. **Table 4-2** describes the general overall condition of the underground infrastructure in each community.

Figure 4-1 Condition of Linear Assets of All Communities

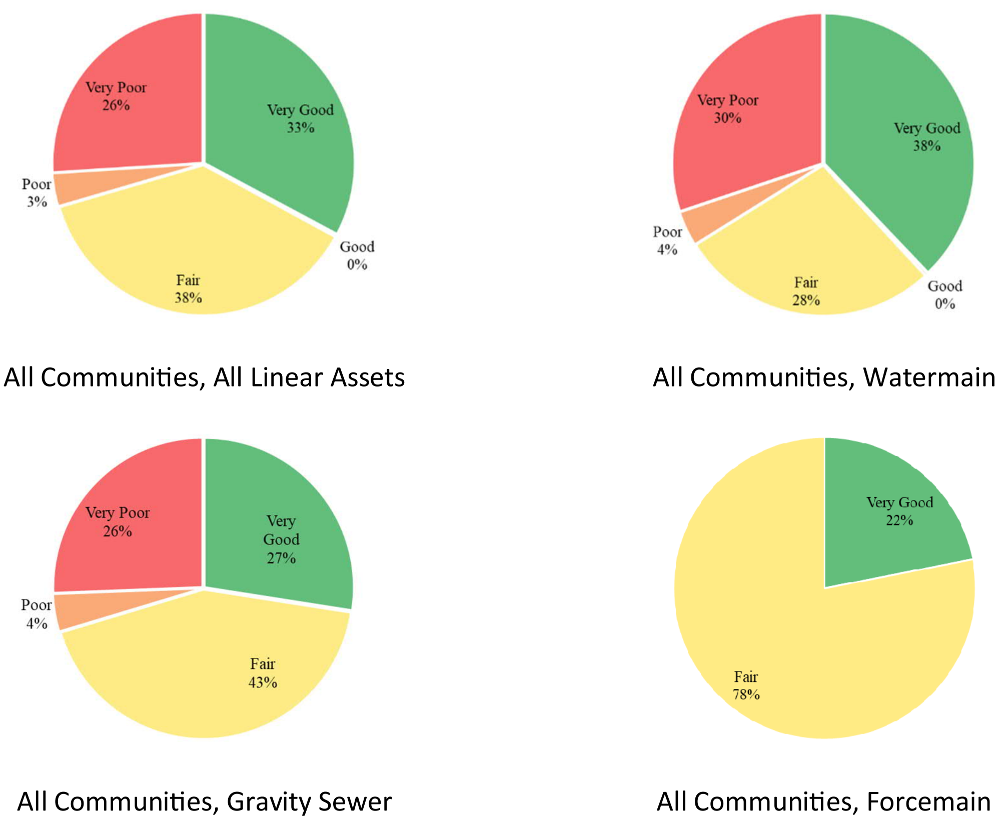


Figure 4-2 All Linear Asset Conditions by Community

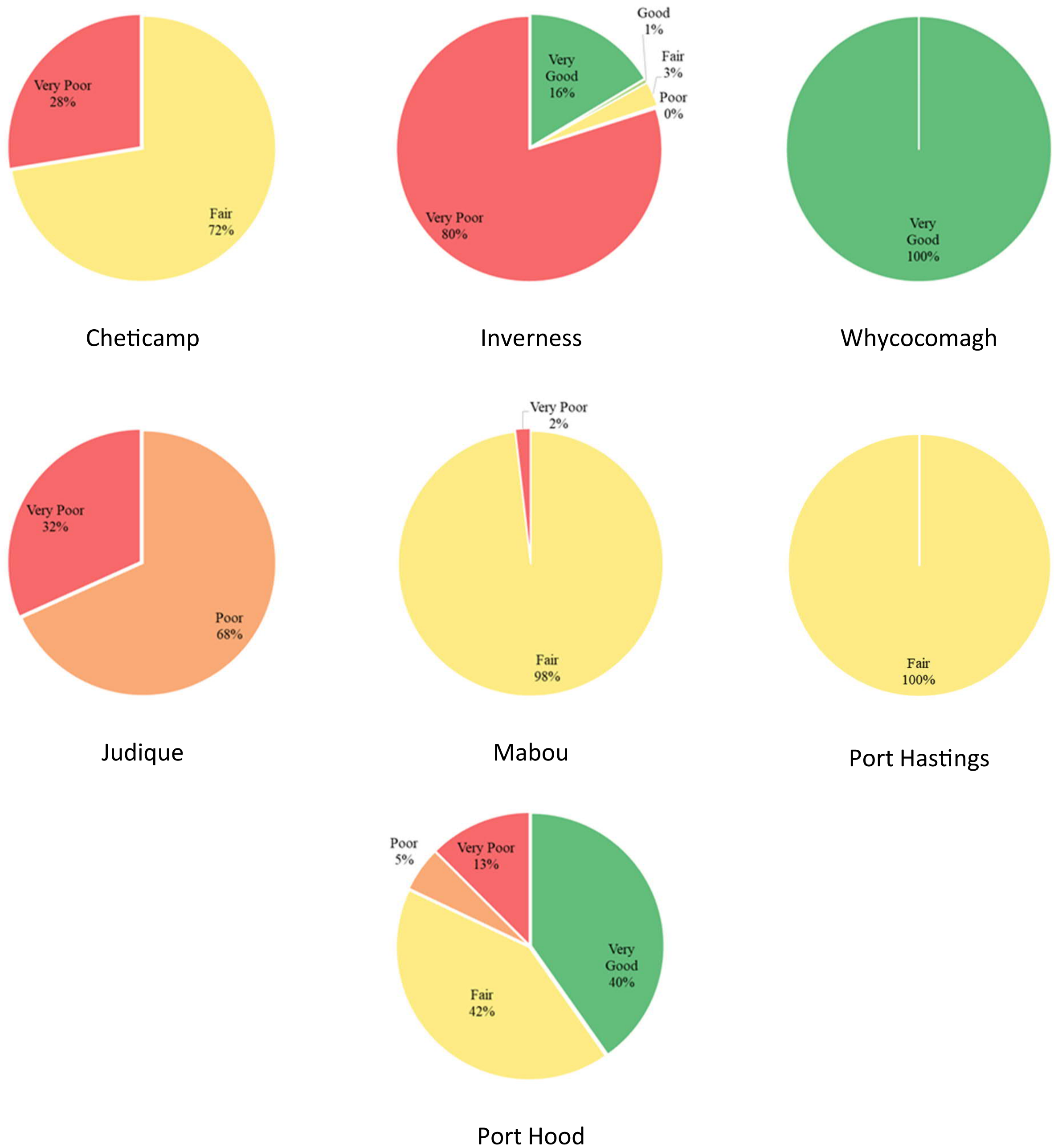


Table 4-1 General Condition of Linear Infrastructure in Each Community

Community	Median Condition
Cheticamp	Fair
Inverness	Very Poor
Judique	Poor
Mabou	Fair
Port Hastings	Fair
Port Hood	Fair
Whycocomagh	Very Good

4.1.2 Sanitary Sewer Pipes Assets

In general, the sanitary sewer condition in the Municipality was found to be fair. **Figure 4-3** details the overall sanitary sewer condition; **Figure 4-4** details a breakdown of the sanitary sewer condition by community.

Figure 4-3 Overall Sanitary Sewer Condition

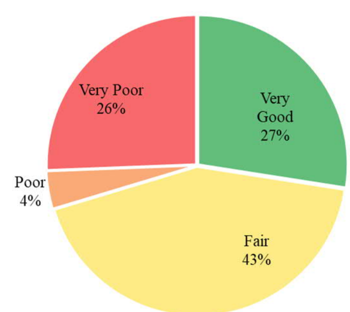
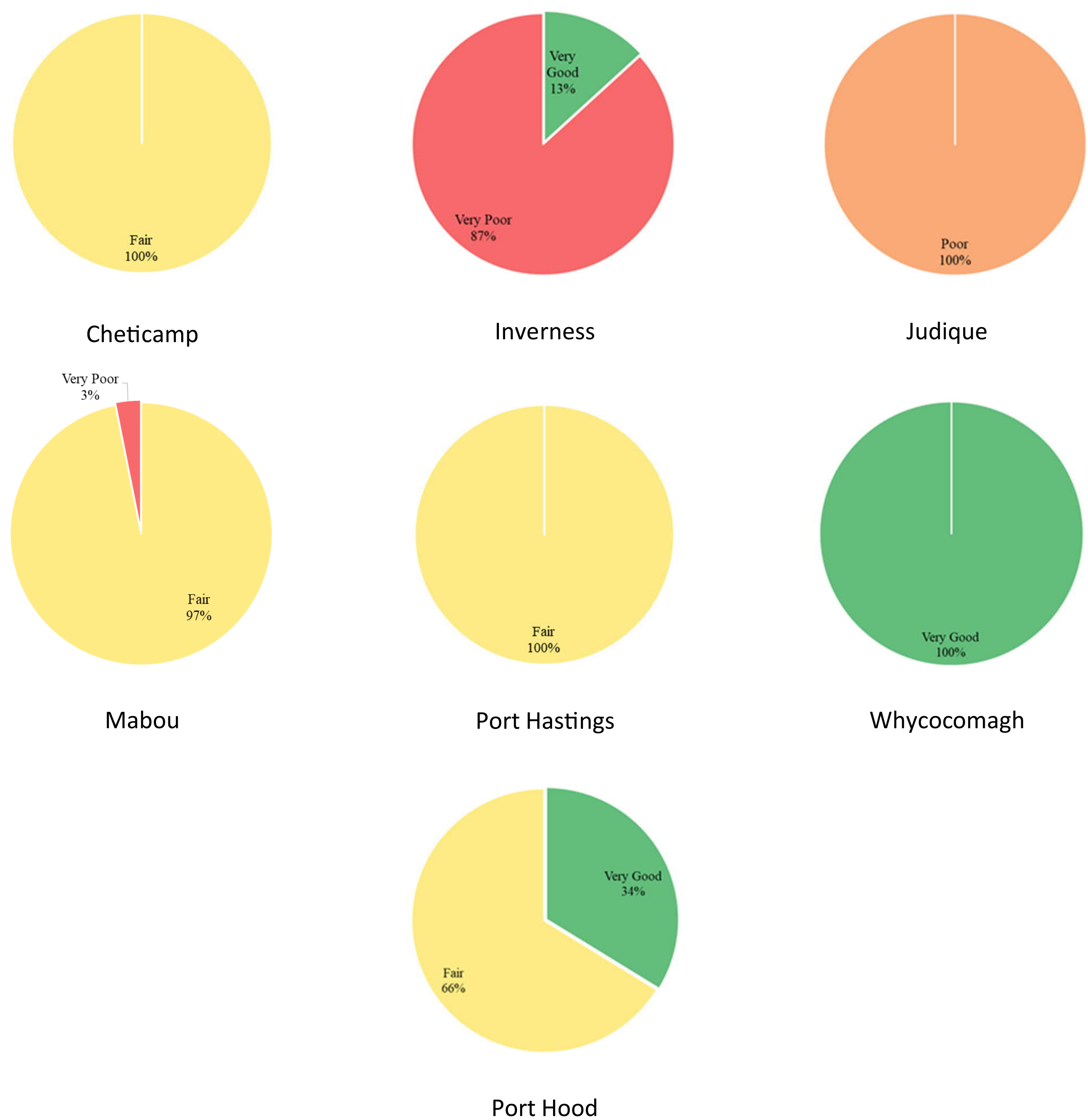


Figure 4-4 Condition of Sanitary Sewer by Community



4.1.3 Forcemains

The overall conditions of forcemains in the Municipality were found to be fair and is presented in Figure 4-5; the condition of the forcemains broken down by community can be found in Figure 4-6.

Figure 4-5 Overall Condition of Forcemains

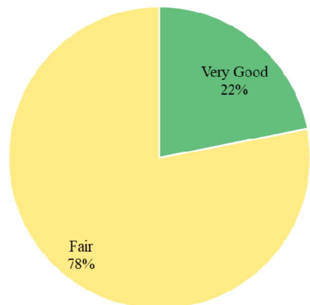
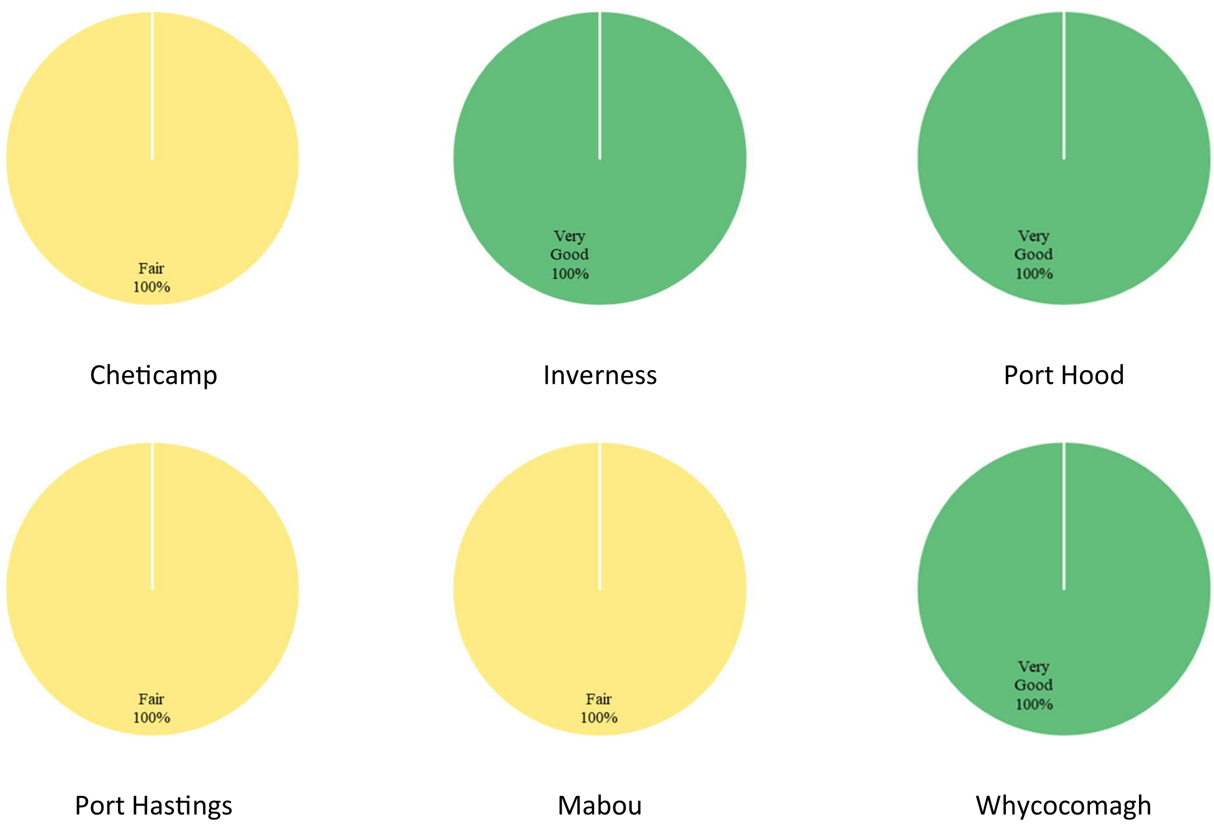


Figure 4-6 Condition of Forcemains by Community



4.1.4 Watermains

The general condition of the MOCI's watermains were found to be very good, however a significant portion were in the Very Poor to Poor range. The overall condition of the watermains can be found in **Figure 4-7**; the condition of the watermains broken down by community can be found in **Figure 4-8**. Although the condition of watermain in Whycocomagh is listed in general as "Very Good", it is reported that there is a major leak in the system which should be explored.

Figure 4-7 Overall Condition of Watermains

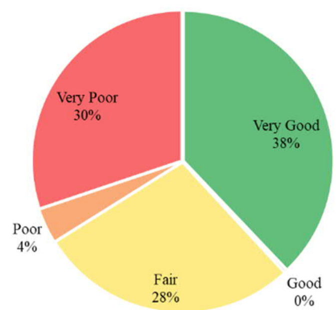
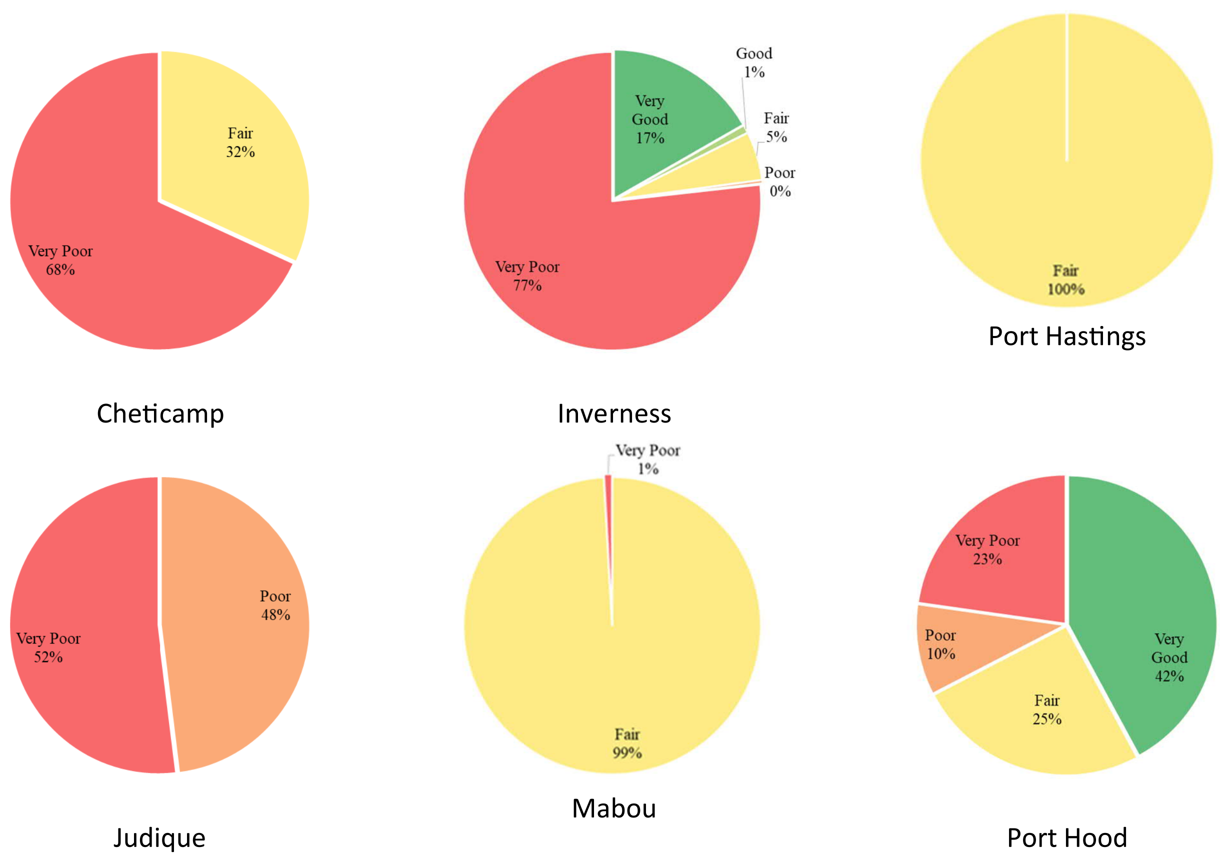
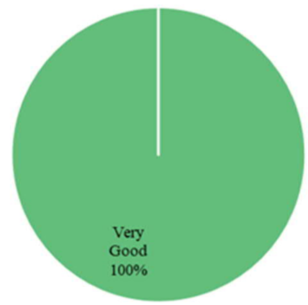


Figure 4-8 Condition of Watermain by Community





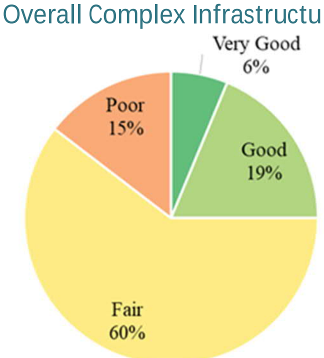
Whycocomagh

4.2 Complex Assets

4.2.1 Overall Complex Infrastructure Rating

The overall complex assets addressed include the water and wastewater treatment facilities, storage tanks, booster stations and lift stations throughout the seven communities in the MOCI. The overall condition of the complex infrastructure was found to be fair. **Figure 4-9** details the condition of the overall complex infrastructure in the municipality.

Figure 4-9 Overall Complex Infrastructure Condition



4.2.2 Lift Stations

The average rating for all lift station components in the MOCI is 2.8, suggesting that the systems are in generally in fair condition, showing signs of deterioration. **Figure 4-10** details the overall condition of the municipalities lift stations; **Table 4-2** presents a breakdown of the overall weighted condition rating for each lift station component and the average rating for each component.

Figure 4-10 Overall Condition of Lift Stations

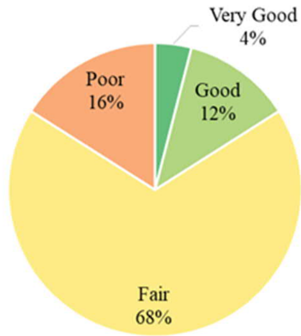


Table 4-2 Lift Station Condition Rating Summary

System	Total LS Condition Ratings					Mean Condition Rating	Condition Grade
	1	2	3	4	5		
Performance	1	6	2	13	3	3.4	Fair
Operability	1	12	10	1	1	2.6	Fair
Structural/Building	1	10	10	2	2	2.8	Fair
Electrical	1	11	9	1	3	2.8	Fair
Mechanical	1	11	7	6	0	2.7	Fair
Process Equipment	1	8	1	12	3	3.3	Fair
Site Civil	1	17	4	2	1	2.4	Fair
Instrumentation	1	8	11	2	3	2.9	Fair
Environmental	2	17	4	2	0	2.2	Fair

4.2.3 Wastewater Treatment Plants

The average rating for all wastewater treatment plants components in the MOCI is 2.6, suggesting that the systems are generally in fair to good condition, and that some assets perform as intended but show signs of deterioration. **Figure 4-11** shows the overall condition of wastewater treatment plants; **Table 4-3** presents a breakdown of the overall weighted condition rating for each wastewater treatment plant component and the average rating for each component.

Figure 4-11 Overall Condition of Wastewater Treatment Plants

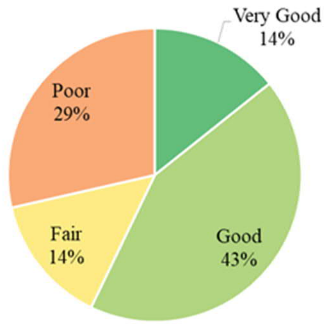


Table 4-3 Wastewater Treatment Plant Condition Rating Summary

System	Total WWT Condition Ratings					Mean Condition Rating	Condition Grade
	1	2	3	4	5		
Performance	1	3	0	2	1	2.6	Fair
Operability	1	3	1	1	1	2.7	Fair
Structural/Building	1	3	0	2	1	2.9	Fair
Electrical	1	3	2	0	1	2.6	Fair
Mechanical	1	4	1	1	0	2.3	Fair
Process Equipment	1	3	1	2	0	2.6	Fair
Site Civil	0	4	3	0	0	2.4	Fair
Instrumentation	1	3	1	1	1	2.7	Fair
Environmental	1	3	2	1	0	2.4	Fair

4.2.4 Water Treatment Plants

The average rating for all water treatment plants components in the MOCI is 2.3, suggesting that the components are in generally in good to fair condition, meaning some assets perform as intended and show minor of deterioration. **Figure 4-12** shows the overall condition of the Municipality's water treatment plants; **Table 4-4** presents a breakdown of the overall weighted condition rating for each waste treatment plant component and the average rating for each component.

Figure 4-12 Overall Condition of Water Treatment Plants

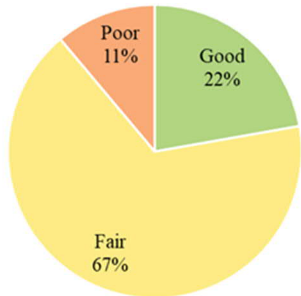


Table 4-4 Water Treatment Plant Condition Rating Summary

System	Total WT Condition Ratings					Mean Condition Rating	Condition Grade
	1	2	3	4	5		
Performance	1	5	1	0	1	2.4	Fair
Operability	1	5	2	0	1	2.4	Fair
Structural/Building	1	5	2	2	0	2.5	Fair
Electrical	2	5	2	1	0	2.2	Fair
Mechanical	1	4	2	2	1	2.8	Fair
Process Equipment	1	4	2	0	1	2.5	Fair
Site Civil	1	6	3	0	0	2.2	Fair
Instrumentation	1	5	2	0	0	2.1	Good
Environmental	5	4	0	0	0	1.4	Good

4.2.5 Water Storage Tanks

The average rating for all water storage tank components in the MOCI is 2.2, suggesting that the components are in generally in fair condition, meaning some assets perform as intended and show minor of deterioration. **Figure 4-13** shows the overall condition of the Municipality's water storage tanks; **Table 4-5** presents a breakdown of the overall weighted condition rating for each storage tank component and the average rating for each component.

Figure 4-13 Overall Condition of Water Storage Tanks

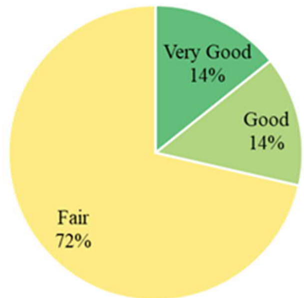


Table 4-5 Water Storage Tank Condition Rating Summary

System	Total ST Condition Ratings					Overall Condition Rating	Condition Grade
	1	2	3	4	5		
Performance	1	2	1	3	0	2.9	Fair
Structural/Building	1	1	2	3	0	3.0	Fair
Electrical	1	4	2	0	0	2.1	Good
Site Civil	1	6	0	0	0	1.9	Good
Instrumentation	1	4	1	1	0	2.3	Fair
Environmental	7	0	0	0	0	1.0	Very Good

5.0 Risk Management

The first step towards implementing a risk management strategy within asset management plans is to identify assets that are necessary to attain the expected level of service within a given community. In addition, high value or "core" assets should be considered a priority as their potential loss could have significant financial, environmental and social repercussions.

Risks are the results of a negative event occurring at an asset resulting in a negative consequence. The following equation was used as the framework to analyze risks:

Risk = Probability x Consequence

In the context of asset management, probability was compared to the overall asset condition rating, as an asset in worse condition has a higher probability of failure. Consequence was calculated by summing the hazards associated with asset failure. The following sections outline the basis in which the risk assessment was completed for the MOCI.

5.1 Hazards Analyzed

A triple bottom line approach was used to estimate the potential risks should an asset fail. This approach looks at three key elements of risk:

- Public health (the public/residents of the MOCI);
- Environmental (the environment and downstream ecosystems); and
- Financial (the economic cost, be it in remediation, repair or potential litigation).

As each asset was evaluated, Dillon staff would answer a yes/no question if there was an obvious risk to any of the three frameworks.

5.2 High and Core Value Assets

In addition to the triple bottom line, high value or “core” assets were identified. These assets are considered as key infrastructure pieces to the MOCI that may result in public or environmental health issues should they fail. These pieces of infrastructure were identified by factors such as the size of the area that is serviced by the asset, adjacent environments, and repair requirements.

6.0 Cost Analysis

6.1 Introduction

The model is used to estimate the financial expenditure by projecting interventions in time and allocating a cost value to the intervention. This cost approach can be used as either a high level estimation or as a unit-quantity approach. The model is intended to provide an accurate reflection of long-term budgeting projection costs across the asset portfolio.

The replacement cost for each asset is estimated by scaling the direct replacement value for all systems with a cost element associated with it. The total replacement value is calculated as the sum of these costs. To accurately capture the current replacement cost of current assets, recent tender pricing on similar projects (e.g. Mabou WWTP and Judique Reservoir) were used to calibrate the estimates.

Consideration should be given to the accuracy and intent behind the cost estimates prepared for the analysis; they are designed to provide a holistic order of magnitude of the estimated overall value for the infrastructure across all portfolios, and not detailed or even “class D” cost estimates. Wherever possible they were based on actual project costing, but detailed and itemized cost estimates should always be completed on a project-specific basis. Historically, the impact of short-term funding programs has dramatically increased construction costs in previous years due to contractor availability. This should be considered when projects are being evaluated as they can have a significant impact on project feasibility.

6.2 Replacement Cost Model

The current high level replacement value for all complex and linear assets was estimated in 2019 dollars and excludes tax. The linear assets were calculated using a typical unit cost of each type of pipe material and pipe size. The complex assets were determine using engineering estimates for each facility. All costs are inclusive of engineering design fees and contingencies, but are exclusive of applicable taxes. These replacement costs consider only the value of the infrastructure currently in-place, and do not account for expansions or modifications to equipment, processes or technology.

6.2.1 Linear Infrastructure

The total estimated replacement cost for the linear infrastructure is approximately **$113 Million**. The replacement costs include an engineering/contingency of 25%; further details can be found in **Table 6-1**.

Table 6-1 Estimated Replacement Cost of Linear Infrastructure by Region

Region	Watermain	Gravity Sewer	Forcemain	Total Estimated Replacement Cost (2019)
Cheticamp	$4,540,000	$2,620,000	$2,880,000	$10,040,000
Inverness	$20,080,000	$13,600,000	$330,000	$34,010,000
Judique	$2,990,000	$1,570,000	$0	$4,560,000
Mabou	$6,130,000	$6,130,000	$670,000	$12,930,000
Port Hood	$10,570,000	$7,830,000	$470,000	$18,870,000
Whycocomagh	$15,010,000	$6,490,000	$940,000	$22,440,000
Port Hasting	$5,610,000	$2,920,000	$2,480,000	$11,010,000
Total Cost	**$64,930,000**	**$41,160,000**	**$7,770,000**	**$113,860,000**

6.2.2 Complex Infrastructure

The estimated replacement cost for all the complex assets is approximately **$72.3 Million**. The replacement costs include an engineering/contingency of 35%, further details can be found in **Table 6-2**.

Table 6-2 Estimated Replacement Cost of Complex Assets by Region

Asset Type	Lift Stations	Wastewater Treatment Plants	Water Treatment Plants	Storage Tanks	Total Estimated Replacement Cost (2019)
Cheticamp	$3,230,000	$3,920,000	$1,290,000	$1,350,000	$9,790,000
Inverness	$1,350,000	$4,050,000	$7,110,000	$2,030,000	$14,540,000
Judique	$0	$4,090,000	$1,970,000	$1,350,000	$7,410,000
Mabou	$2,320,000	$6,820,000	$4,560,000	$1,350,000	$15,050,000
Port Hood	$3,230,000	$3,290,000	$3,680,000	$1,350,000	$11,550,000
Whycocomagh	$1,840,000	$400,000	$2,100,000	$1,350,000	$5,690,000
Port Hastings	$1,850,000	$5,100,000	N/A	$1,350,000	$8,300,000
Total Cost	**$13,820,000**	**$27,670,000**	**$20,710,000**	**$10,130,000**	**$72,330,000**

6.3 Capital Investment Plan

The capital investment plan has been prepared based on the results from the condition assessment and replacement cost values. The plan examines the next 10 years and the anticipated investments for both linear and complex assets. As intervention points are estimated using the current condition and estimated remaining life, a number of factors can influence the actual replacement year and accordingly something forecasted, for example in year 7, may occur earlier or later. All costs are in current 2019 Canadian dollars and exclusive of HST. These rates are intended to account for re-investments into infrastructure and in addition to a municipality's operational budgets for a given system.

6.3.1 Canadian Infrastructure Report Card Recommendations

The 2016 CIRC identified that the overall condition, based on nationwide investment levels, is declining across all lines of infrastructure. To address this negative trend, the report recommended average annual reinvestment rates as a percentage of overall asset value. The intent is to improve the overall condition of assets over time. These recommended minimum rates are presented in **Table 6-3**.

Table 6-3 CIRC Recommended Investment Rates

Asset Type	Recommended Minimum Annual Reinvestment Rate	Minimum Recommended Annual Reinvestment Based on Current Infrastructure Replacement Cost
Wastewater (linear)	1.0 – 1.3%	$560,000
Wastewater (non-linear)	1.7 – 2.5%	$870,000
Water (linear)	1.0 – 1.5%	$810,000
Water (non-linear)	1.7 – 2.5%	$650,000
	TOTAL	**$2,890,000**

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However, the general condition of MOCI water and wastewater infrastructure was assessed to be, on average, in worse condition than that nationally. This suggests that MOCI's annual reinvestment rate will be larger for the foreseeable future in order to prevent an overall decline in infrastructure condition.

6.3.2 10 Year Capital Plan

6.3.2.1 Linear Infrastructure

There is a large investment forecasted for linear infrastructure in 2019, which is presented in **Figure 6-1**, the estimated total investment over the next 10 years for linear infrastructure is approximately **$37 Million**. This suggest that a large portion of linear infrastructure is at, or has exceeded, its useful life.

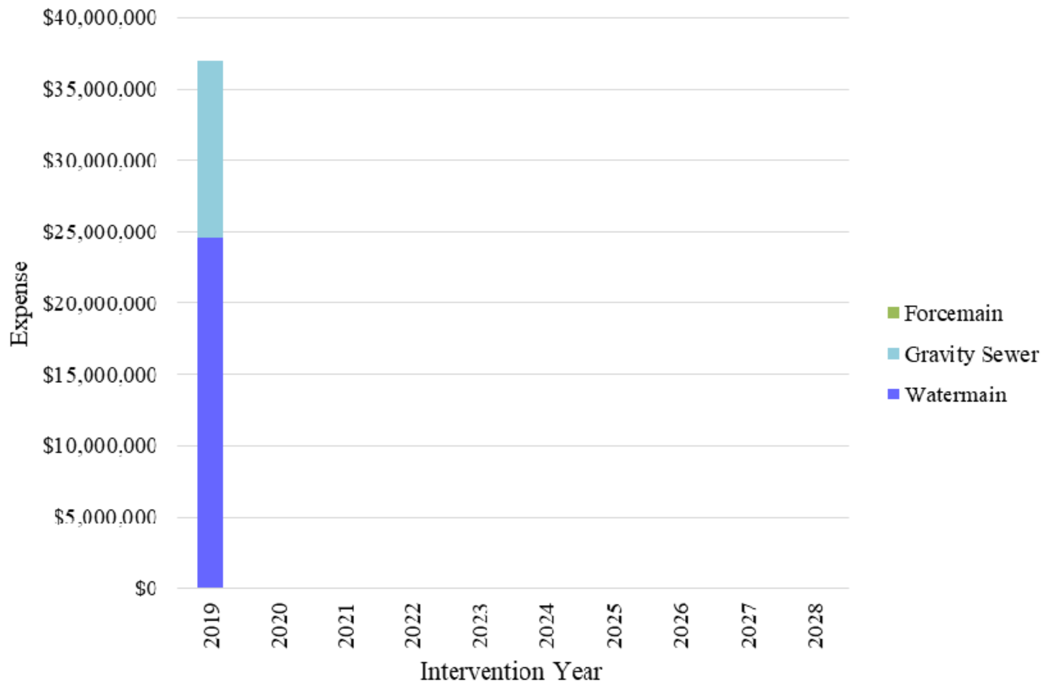

Figure 6-1 Forecasted Investment for Linear Infrastructure (10year)

The forecasted replacement cost can be distributed across 10 years to replace the piping in poor condition. It is recommended to complete a visual condition assessment of the linear infrastructure that is in poor to very poor condition in order to prioritize a replacement schedule. If detailed visual assessments are completed on linear assets and the physical condition is observed to be "worse" or "better" than the condition based on age alone, the asset tools can be adjusted to reflect this actual condition and the associated interventions adjusted automatically.

If this cost was distributed over the next 10 years, the estimated investment would be **$3.7 Million per year**. The breakdown for each asset type is presented in **Table 6-4**.

Table 6-4 Linear Infrastructure Investment (10 year) – All Communities

Asset Type	Total Investment Cost in 2019 Dollars	Average Investment per Year
Watermain	$24,590,000	$2,459,000
Gravity Sewer	$12,410,000	$1,241,000
Forcemain	$0	$0
Total Estimated Investment	**$37,000,000**	**$3,700,000**

6.3.2.2 Complex Infrastructure

The 10 year forecasted investment for complex infrastructure is **$66.4 Million**. The estimated replacement cost by asset type is presented in **Figure 6-2**. There are some years that do not have an associated cost, suggesting that an intervention is not anticipated to be required that year. However, best practices suggest annual capital projects be initiated to mitigate individual year spikes in investment requirements. The average annual investment over the next 10 years is estimated to be **$6.64 Million per year** for complex infrastructure.

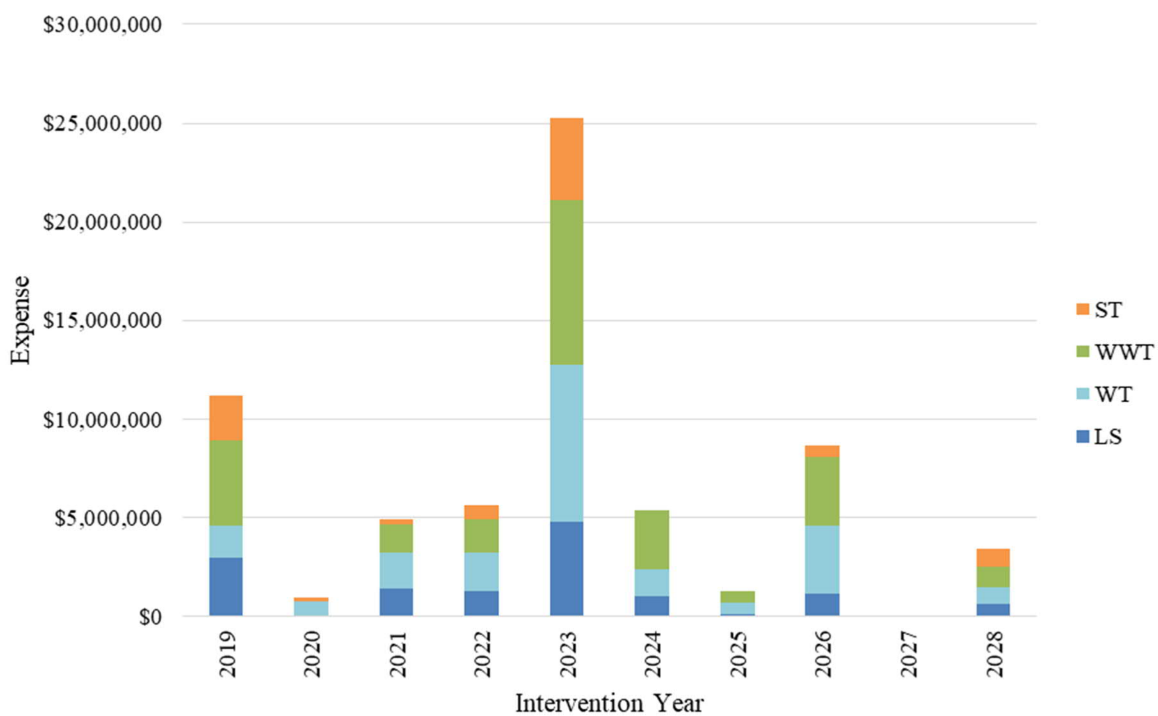

Figure 6-2 Forecasted Investment for Complex Infrastructure

7.0 Recommended Upgrade Priority

7.1 Priority Upgrades

Based on the condition ratings developed during the field assessment and the hazard assessment, **Table 7-1** lists the high priority upgrades for complex infrastructure; all estimated costs are in 2019 Canadian dollars. **Appendix C** provides more detail related to each item, along with Medium and Low priority upgrades. Those identified as "High" should be completed immediately in the near future, while "Medium" and "Low" in the shorter – longer term respectively. All estimates are in 2019 dollars and exclusive of applicable taxes.

Table 7-1 High Priority Upgrades (Complex Infrastructure)

Asset	Recommended Upgrade	Estimated Cost
Judique WWTP	Replace plant	$2,900,400
Judique WTP	Complete detailed structural assessment of Judique dam	$57,500
Inverness WWTP	Replace plant	$4,700,000
Whycocomagh WWTP	Replace plant	$4,900,000
Cheticamp LS5	Replace one submersible pump	$18,000
Whycocomagh WTP	Identify and repair major leaks in distribution system	$70,800
Inverness WTP	Fix leaking storage tank	$60,000
Inverness WTP	Water exploration/well setup	$350,000
Judique WTP	Operational improvements to DAF	$60,000
Judique WTP	Program filters to automatically backwash	$12,000
Judique WTP	Install plant ventilation	$90,000
Judique WTP	Water exploration/well setup	$350,000
Cheticamp LS4	Replace 40 HP generator and diesel fuel tank	$97,750
Port Hood LS3	Replace one submersible pump	$17,250
Mabou WTP	Water exploration/well setup	$350,000
Port Hood	Water exploration/well setup	$350,000

Within the spreadsheet, the risks identified are in the event of asset failure; they do not necessarily imply that there is an immediate risk to the public, environment or financial. However, based on the current condition the Municipality should review these in detail.

Table 7-2 and **7-3** lists the high priority replacements for linear infrastructure; there were no identified high priority replacements for forcemains due to estimated age of current assets, however this should be confirmed with visual inspections. As detailed street locations was not known for some of these assets, generic descriptions were used where possible and it can be assumed that general improvements to the linear infrastructure in that region should be anticipated.

Table 7-2 High Priority Upgrades (Watermains)

Region	Description	Estimated Cost
Inverness	Maple Street	$98,000
Inverness	Central Avenue	$1,580,000
Inverness	Varniers Lane	$48,000
Inverness	Various Streets	$8,000,000
Judique	Route 19	$430,000
Judique	Various Streets	$705,000
Mabou	Ceilidh Trail	$50,000
Port Hood	Various Streets	$373,000
All Communities	Curb stop annual replacement program (5% of total per year)	$292,000/year[1]

[1] *Assumes projects completed as standalone replacements (full mobilization/excavation)*

Table 7-3 High Priority Upgrades (Gravity Sewer)

Region	Description	Estimated Cost
Inverness	Broad Cove Road	$1,100,000
Port Hastings	Manhole Downstream LS #1 (frozen MH in rotary)	$20,000
Inverness	Beach Road	$265,000
Inverness	Central Avenue	$235,000
Inverness	Mine Road	$170,000
Inverness	Cabot Links	$95,000
Inverness	Various Streets	$5,320,000
Mabou	Main Road	$170,000
Mabou	SW Ridge Road	$540,000

Table 7-4 details the high priority upgrades and installations for site civil infrastructure. **Table 7-5** lists the infrastructures that performs poorly, as described by MOCI personnel and the associated repair costs.

Table 7-4 High Priority Upgrades (Site Civil)

Region	Recommended Upgrade	Estimated Cost
Inverness WWTP	Fencing	$17,250
Cheticamp WWTP	Fencing	$2,300
Judique WWTP	Fencing	$1,150
Mabou WTP	Guard Rail Installation	$11,500
Port Hood	Install Perimeter Fencing	$23,000

Table 7-5 Poor Performing Infrastructure

Region	Recommended Upgrade	Estimated Cost
Port Hood	Expose and Heat Trace line to Pressure Transducer (Water Storage Tank)	$17,250
Whycocomagh	Identify and repair major leaks in distribution system	$75,000
All Communities	Fire Hydrant Replacement	$8,500/hydrant[1]
Judique	Possibly replace or rehabilitate dam	Requires further assessment
Mabou	Decommission old WTP	$200,000
Whycocomagh	Re-route wet well vents at LS 1,2, and 4	$1,500 per LS
Whycocomagh	Replace panel at LS4	$11,500
Cheticamp	One or more pumps out of service (LS1)	$17,250
Cheticamp	One or more pumps out of service (LS2)	$17,250
Cheticamp	One or more pumps out of service (LS3)	$23,000
Cheticamp	One or more pumps out of service (LS6)	$17,250
Mabou	Install new station (LS1)	$115,000
Mabou	Install new station (LS2)	$115,000
Port Hastings	One or more pumps out of service (LS2)	$17,250
Port Hood	One or more pumps out of service (LS1)	$17,250
Port Hood	One or more pumps out of service (LS2)	$17,250
Port Hood	Replace station (LS4)	$230,000
Port Hood	One or more pumps out of service (LS5)	$17,250
Port Hood	One or more pumps out of service (LS6)	$17,250
Whycocomagh	One or more pumps out of service (LS3)	$23,000

[1] *Assumes projects completed as standalone replacements (full mobilization/excavation)*

7.2 Assets Recommended for Further Investigation

During the course of the field program some assets were identified as those that should be analyzed further. The majority of these were either inaccessible or outside the scope of the project.

Table 7-6 Recommended Further Investigations

Asset	Rationale
Judique Dam	While outside the scope of the project, during the field assessments staff attempted to visually inspect the dam but were limited due to snow cover and access. Operator input suggested that the dam is in poor condition and could present a major risk to the downstream environment as well as the community's water supply. A detailed structural and condition assessment should be completed in the immediate future.
Inverness and Port Hastings water storage reservoirs	During the field assessments the reservoirs appeared to have been leaking out of their seams. As this could present a significant risk (both to the adjacent environment and the community's water supply) they should be investigated and repaired immediately.
Cheticamp wellheads	During the field program the wellheads were inaccessible. It was reported that the status/presence of a chlorination system is unknown and should be investigated immediately.
Cheticamp water reservoir	It was reported that the roof on the tower experiences repetitive failures. The cause of this failure is assumed to be due to wind, but should be investigated in detail and a permanent solution implemented.
Pre-purchased lift stations	It is reported that two self-priming wastewater lift stations were purchased in previous years and are currently in storage at the equipment manufacturer's warehouse in Truro, NS. While the current age and condition of these units is unknown, the option of replacing certain lift stations with them should be investigated.

Appendix A

Condition Rating Methodology

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Rating Scale		System								
Grade	**Condition**	**Structural/Building**	**Mechanical**	**Electrical**	**Process Equipment**	**Site Civil**	**Instrumentation**	**Environmental**	**Performance**	**Operability**
1	Very Good	Building structure is physically sound. Well maintained and secure weatherproof structure.	Equipment is physically sound and performing as designed/intended.	No abnormalities and resembles brand new.	Equipment is brand new or well-maintained with no defects.	Acess to the site is ideal. Security features (lighting, fencing, cameras, etc.) are as expected for such a facility. Suitable space for parking and asset maintenance. No observable drainage issues.	Instrumentation is fully functional and well maintained. No defects.	No obvious risk to flooding. No obsverable odours or noise issues at the site. Adjacent and downstream environment does not appear to be sensitive in the event of overflows or asset failure.	Little or no maintenance required, asset never experiences downtime. Very infrequent alarms, and system is operating below its rated capacity.	Asset is easily accessible with a service truck, and does not require any special equipment to access. Asset is generally laid out well, with no confined spaces. Operators describe it as one of their ideal sites.
2	Good	Stucture is performing as intended. Some maintenance needed to prevent initial stages of decay or dereliction.	Minor signs of equipment deterioration such as minor vibrations, looseness, misalignment, slight leaks. Protective coating and enclosure still functioning.	Minor signs of deterioration. Requires infrequent/minor repairs, but does not affect performance or its ability to properly function.	Equipment may not be the current generation/model manufactured, but is in good shape and all replacement components are available from the supplier.	Access to the site is not a significant issue. Security features are present and operable, but show some signs of wear. Minor drainage issues that do not impact accessibility or operation.	No deterioration on fittings or displays that impacts safety, strength or appearance. Minor wear and tear but no impacts on operation. All replacement components are still available.	-	-	-
3	Fair	Showing deterioration, with some components physically deficient. Structure appearance affected by minor cracking, staining, peeling, paintwork or minor leakage.	Obvious signs of deterioration. Minor failures with increasing corrosion of metal components, bearings and or gland	Showing signs of deterioration, which is beginning to effect the safety, efficiency and operation of the system.	Showing signs of deterioration. Equipment may not be compatible with the current standard (obsolete design, no longer manufactured) but spare parts are available.	Acess to the site has some limitations, with space for only 1 service vehicle. Most security features are present, but some are either missing or inoperable. There are signs of some drainage issues.	Instruments show signs of deterioration. May not be compatible with current standards (obsolete design or no longer manufactured), but spare parts are available.	Visual signs or operator input imply a low-moderate risk of flooding. Some odours and noises, but generally limited to the immediate surroundings. Immediately adjacent environment does not appear sensitive, but such an environment exists downstream.	Routine maintenace required, but with infrequent downtime. Asset gives off routine alarms or requires routing operator visits. System is operating at our around its rated capacity.	Asset is accessible, but not ideal. Traffic control required to work on some parts of the site. Site layout is fair, but there are some areas that are difficult to access or service.
4	Poor	Major portion of the structure is physically deficient. Structure is still operating as intended, but showing signs of stability loss or deformation. Potential problems include lekage, rotting woodwork and decayed brickwork.	Significant leaks, vibration, looseness, misalignment or out of balance. Parts and components function but require significant maintenance to remain operational.	The performance and serviceaility is becoming a maintenance issue. System is functioning, but significant maintenance is required.	Asset functions, but with frequent problems and significant defects. Difficult/impossible to maintain spare parts, or costs/lead times are excessive.	Access to the site is fairly limited. Little-no dedicated parking, and obvious drainage issues. Most of the security features are either not present or not functional.	Instruments function, but have frequent problems due to significant defects. Requires constant and frequent maintenance. Difficult to obtain spare parts.	-	-	-
5	Critical	Physically unsound. Serious structural problems having a deteremental efect on the performance of the building.	Unreliable with frequet breadowns and adverse impacts on performance. Equipment now incurring excessive maintenance.	High risk of breakdowns with a serious impact on system safety, efficiency and operation. The remaining life is exceeded and excessive maintenance is required.	Asset has surpassed its useful life. If a serious failure occurs, a complete replacement is required.	Access to the site is a nightmare, with no parking (or parking impacts adjacent traffic). No security features (fencing, cameras, lighting, etc.) present, and standing water/drainage issues are evident.	Asset is past the end of its useful life, and no replacment or spare parts are available. Significant signs of wear and tear. Measurements cannot be trusted due to inaccuracies.	Asset appears to be in a floodplain, or his recent issues of flooding. Foul odours/loud noises are evident as you approach the site, and the adjacent environment is sensitive.	Asset requires frequent and major maintenance. Significant downtime due to failing equipment. Asset operates above its rated capacity or does not meet design requirements.	Asset is very difficult to access, and traffic control is always required. Several confined spaces, and site layout is very poor.

Appendix B

Community Infrastructure Maps

MUNICIPALITY OF THE
COUNTY OF INVERNESS
WATER & WASTEWATER
INFRASTRUCTURE ASSESSMENT
INVERNESS COUNTY, NS

COMMUNITY LOCATIONS
FIGURE 1

COUNTY LINES
COMMUNITY LOCATION

File Location:
c:\projectwise\working directory\projects 2018\50tlr\dms61507\188874-05-03-fig 1.dwg
February, 07, 2019 3:40 PM

MAP/DRAWING INFORMATION
Google Earth Pro.

CREATED BY: TLR
CHECKED BY: KRM
DESIGNED BY: KRM

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SCALE 1:300,000 KILOMETRES

W N S E

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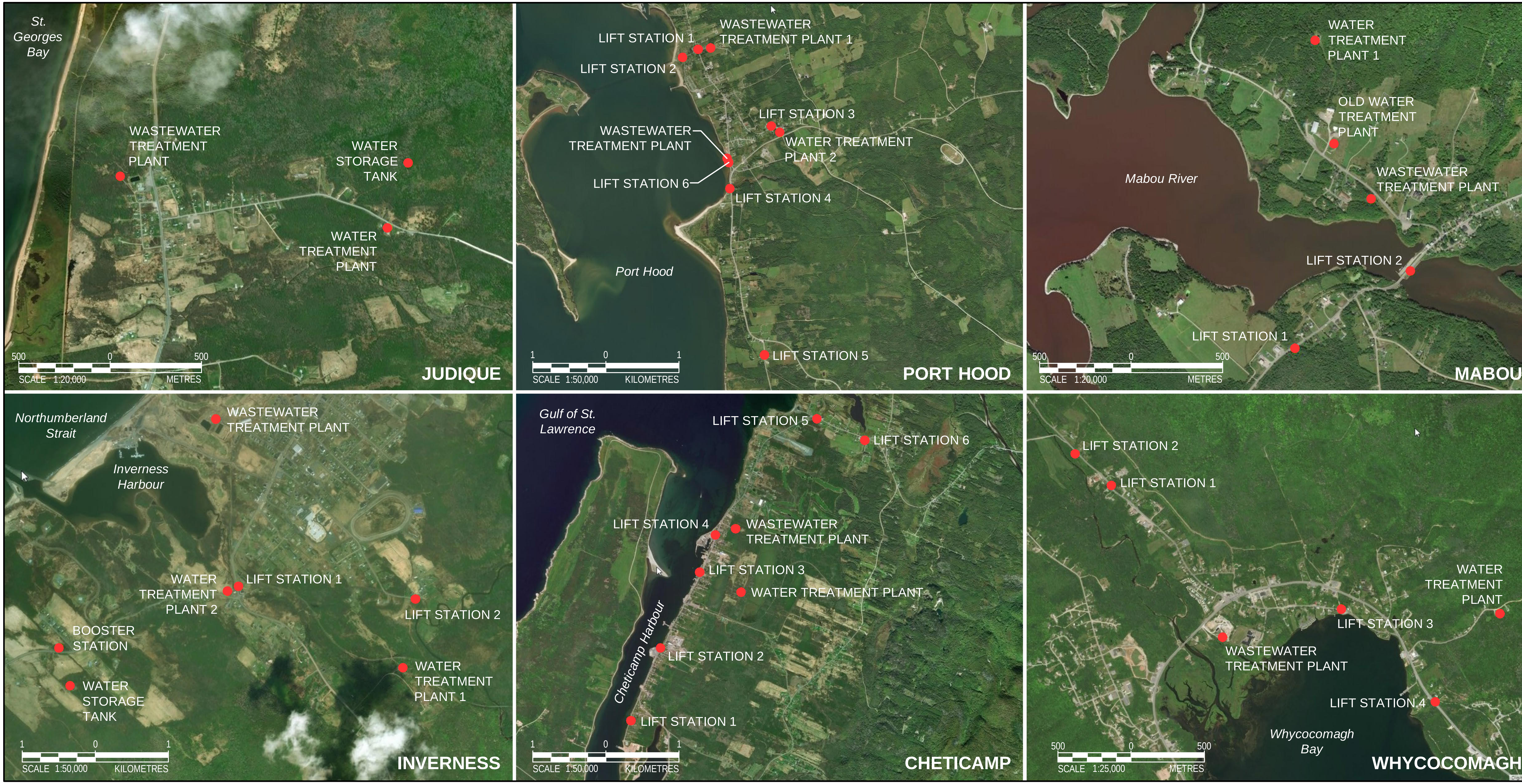
CONSULTING

NOTE:
INFRASTRUCTURE LOCATIONS ARE APPROXIMATE ONLY.

PROJECT: 18-8874

DATE: FEBRUARY 2019



MUNICIPALITY OF THE COUNTY OF INVERNESS

WATER & WASTEWATER INFRASTRUCTURE ASSESSMENT

INVERNESS COUNTY, NS

COMMUNITY WATER & WASTEWATER INFRASTRUCTURE PLANS

FIGURE 2

● WATER/WASTEWATER INFRASTRUCTURE

File Location:
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February, 07, 2019 3:22 PM

MAP/DRAWING INFORMATION
Dillon Consulting Limited site visit and Survey123 for ArcGIS (Esri, © OpenStreetMap contributors, HERE, Garmin, FAO, USGS, AAFC, NRCan).

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DESIGNED BY: KRM

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NOTE:
INFRASTRUCTURE LOCATIONS ARE APPROXIMATE ONLY.

PROJECT: 18-8874

DATE: FEBRUARY 2019

MUNICIPALITY OF THE
COUNTY OF INVERNESS
WATER & WASTEWATER
INFRASTRUCTURE ASSESSMENT
INVERNESS COUNTY, NS

COMMUNITY WATER & WASTEWATER
INFRASTRUCTURE PLANS
FIGURE 3

● WATER/WASTEWATER INFRASTRUCTURE

File Location:
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NOTE:
INFRASTRUCTURE LOCATIONS ARE APPROXIMATE ONLY.

PROJECT: 18-8874

DATE: FEBRUARY 2019

Appendix C

Recommended Upgrades

Region	Asset	Recommended Upgrade	Weighted Asset Rating	Core Asset	Risk to Public Health	Risk to Environmental Health	Economic Risk	Hazard Score	Risk Score	Importance	Ranking	Total Estimated Cost	Costing Comments
Judique	Judique WWTP	Replace plant	4.49	Yes	Yes	Yes	Yes	4	17.96	High	1	$ 2,900,400.00	Assumes SBR technology at same site
Judique	Judique WTP	Complete detailed structural assessment of Judique dam	3.91	Yes	Yes	Yes	Yes	4	15.64	High	2	$ 57,500.00	Assessment only
Inverness	Inverness WWTP	Replace plant	3.52	Yes	Yes	Yes	Yes	4	14.08	High	3	$ 4,700,000.50	Assumes SBR technology at same site
Whycocomagh	Whycocomagh WWTP	Replace plant	3.18	Yes	Yes	Yes	Yes	4	12.72	High	4	$ 4,900,000.60	Based on current plant design
Cheticamp	Cheticamp LS5	Replace one submersible pump	3.01	Yes	Yes	Yes	Yes	4	12.04	High	5	$ 18,000.00	
Judique	Water Supply	Water exploration/Well Setup	4	Yes	Yes	No	Yes	3	12	High	6	$ 420,000.00	Assumes the entire process from exploration to a well field protection study and designation
Whycocomagh	Whycocomagh WTP	Identify and repair major leaks in distribution system	4	Yes	Yes	No	Yes	3	12	High	7	$ 70,800.00	
Inverness	Inverness Water Storage Tank	Fix leaking storage tank	4	Yes	Yes	No	Yes	3	12	High	8	$ 60,000.00	Tank may still be under warranty
Inverness	Inverness Water Storage Tank	Install Site Fencing	4	Yes	Yes	No	Yes	3	12	High	9	$ 11,500.00	
Inverness	Inverness WWTP	Fencing Upgrades	4	Yes	Yes	No	Yes	3	12	High	10	$ 17,250.00	
Port Hood	Port Hood WWTP	Install perimeter fencing	4	Yes	Yes	No	Yes	3	12	Medium	11	$ 23,000.00	
Judique	Judique WTP	Operational improvements to DAF	3.91	Yes	Yes	No	Yes	3	11.73	High	12	$ 60,000.00	Miscellaneous valve, piping and controls upgrades
Judique	Judique WTP	Program filters to automatically backwash	3.91	Yes	Yes	No	Yes	3	11.73	High	13	$ 12,000.00	
Judique	Judique WTP	Install plant ventilation	3.91	Yes	Yes	No	Yes	3	11.73	High	14	$ 90,000.00	
Cheticamp	Cheticamp LS4	Replace 40 HP generator and diesel fuel tank	2.69	Yes	Yes	Yes	Yes	4	10.76	High	15	$ 97,750.00	New Genset about 40 HP and Tank
Port Hood	Port Hood LS3	Replace one submersible pump	3.55	No	Yes	Yes	Yes	3	10.65	High	16	$ 17,250.00	
Cheticamp	Cheticamp WWTP	Fix Fencing	3.5	Yes	Yes	No	Yes	3	10.5	Medium	17	$ 2,300.00	
Port Hood	Port Hood LS1	Replace one submersible pump	3.29	No	Yes	Yes	Yes	3	9.87	Medium	18	$ 17,250.00	
Port Hood	Port Hood LS4	Replace station	3.29	Yes	No	Yes	Yes	3	9.87	Medium	19	$ 230,000.00	
Port Hood	Port Hood LS4	Install EYS seals on conduit	3.29	Yes	Yes	No	Yes	3	9.87	Medium	20	$ 1,725.00	
Whycocomagh	Whycocomagh LS3	Replace one self-priming pump (20 HP)	3.27	Yes	No	Yes	Yes	3	9.81	Medium	21	$ 23,000.00	
Whycocomagh	Whycocomagh LS3	Install EYS seals on conduit	3.27	Yes	Yes	No	Yes	3	9.81	Medium	22	$ 1,725.00	
Mabou	Mabou LS2	Replace station with one currently on order (Sansom)	4.82	No	Yes	No	Yes	2	9.64	Medium	23	$ 115,000.00	Installation only. Assumes station paid for
Mabou	Mabou WTP1	Install interlock for chlorine pump failure	3.2	Yes	Yes	No	Yes	3	9.6	Medium	24	$ 8,625.00	
Mabou	Mabou WTP1	Program filters to automatically backwash	3.2	Yes	Yes	No	Yes	3	9.6	Medium	25	$ 11,500.00	
Whycocomagh	Whycocomagh WWTP	Repair inoperable blower	3.18	Yes	No	Yes	Yes	3	9.54	Medium	26	$ 17,250.00	
Whycocomagh	Whycocomagh WWTP	Repair digester equipment	3.18	Yes	No	Yes	Yes	3	9.54	Medium	27	$ 40,250.00	
Port Hood	Port Hood WTP1	Complete detailed video inspection of well	3.1	Yes	Yes	No	Yes	3	9.3	Medium	28	$ 1,725.00	
Port Hood	Port Hood LS5	Replace one self-priming pump	3.08	No	Yes	Yes	Yes	3	9.24	Medium	29	$ 17,250.00	
Cheticamp	Cheticamp LS5	Install EYS seals on conduit to control panel and inspect panel	3.01	Yes	Yes	No	Yes	3	9.03	Medium	30	$ 4,025.00	Sewage odour in control panel
Inverness	Water Supply	Water exploration/Well Setup	3	Yes	Yes	No	Yes	3	9	High	31	$ 420,000.00	Assumes the entire process from exploration to a well field protection study and designation
Port Hood	Water Supply	Water exploration/Well Setup	3	Yes	Yes	No	Yes	3	9	High	32	$ 420,000.00	Assumes the entire process from exploration to a well field protection study and designation
Judique	Judique WWTP	Fencing Upgrades	3	Yes	Yes	No	Yes	3	9	Medium	33	$ 1,150.00	Assumes SBR technology at same site
Cheticamp	Cheticamp LS2	Replace one self-priming pump	2.89	Yes	No	Yes	Yes	3	8.67	Medium	34	$ 17,250.00	
Cheticamp	Cheticamp LS2	Install EYS seals on conduit	2.89	Yes	Yes	No	Yes	3	8.67	Medium	35	$ 1,725.00	
Whycocomagh	Whycocomagh WTP	Install interlock for chlorine pump failure	2.81	Yes	Yes	No	Yes	3	8.43	Medium	36	$ 8,625.00	
Port Hastings	Port Hastings LS2	Replace one self-priming pump	2.75	Yes	Yes	No	Yes	3	8.25	Medium	37	$ 17,250.00	
Port Hastings	Port Hastings LS2	Install EYS seals on conduit	2.75	Yes	Yes	No	Yes	3	8.25	Medium	38	$ 1,725.00	
Mabou	Mabou LS1	Replace entire station with new one they have in Truro	4.1	No	Yes	Yes	Yes	2	8.2	Medium	39	$ 115,000.00	Installation only. Assumes station paid for
Port Hastings	Port Hastings LS1	Replace one self-priming pump	2.73	Yes	No	Yes	Yes	3	8.19	Medium	40	$ 17,250.00	
Port Hastings	Port Hastings LS1	Install EYS seals on conduit	2.73	Yes	Yes	No	Yes	3	8.19	Medium	41	$ 1,725.00	
Cheticamp	Cheticamp LS4	Install EYS seals on conduit	2.69	Yes	Yes	No	Yes	3	8.07	Medium	42	$ 1,725.00	
Mabou	Mabou WTP1	Install guard rail on access road	4	Yes	Yes	No	No	2	8	Medium	43	$ 11,500.00	
Mabou	Mabou Old Water Treatment Plant	Decommission building	4	No	Yes	No	Yes	2	8	Low	44	$ 230,000.00	Remove building and re-route piping
All	All Assets	Upgrade all door locks to a master key	4	Yes	No	No	Yes	2	8	High	45	$ 51,750.00	
Cheticamp	Cheticamp LS6	Replace one self-priming pump (7.5 HP)	3.98	No	No	Yes	Yes	2	7.96	Medium	46	$ 17,250.00	
Cheticamp	Cheticamp LS6	Replace level indicator in wet well	3.98	No	Yes	No	Yes	2	7.96	Medium	47	$ 5,750.00	
Cheticamp	Cheticamp LS6	Install EYS seals on conduit	3.98	No	Yes	No	Yes	2	7.96	Medium	48	$ 1,725.00	
Port Hood	Port Hood LS6	Replace one self-priming pump	2.64	Yes	No	Yes	Yes	3	7.92	Medium	49	$ 17,250.00	
Port Hood	Port Hood LS6	Install EYS seals on conduit	2.64	Yes	Yes	No	Yes	3	7.92	Medium	50	$ 1,725.00	
Judique	Judique WTP	Complete groundwater supply investigation program	3.91	Yes	No	No	Yes	2	7.82	Medium	51	$ 300,000.00	
Judique	Judique WTP	Replace grating and stairs around DAF	3.91	Yes	Yes	No	No	2	7.82	Medium	52	$ 30,000.00	
Port Hood	Port Hood LS3	Install EYS seals on conduit	3.55	No	Yes	No	Yes	2	7.1	Medium	53	$ 1,725.00	
Inverness	Inverness WWTP	Replace digester piping	3.52	Yes	Yes	No	No	2	7.04	Medium	54	$ 57,500.00	
Inverness	Inverness WWTP	Replace UV lamps	3.52	Yes	No	Yes	No	2	7.04	Medium	55	$ 11,500.00	
Inverness	Inverness WWTP	Install timer on digester pumps	3.52	Yes	No	Yes	No	2	7.04	Medium	56	$ 5,750.00	
Inverness	Inverness WWTP	Repair leaking blower piping	3.52	Yes	No	Yes	No	2	7.04	Medium	57	$ 11,500.00	
Inverness	Inverness Booster Station	Replace building envelope	2.32	Yes	Yes	No	Yes	3	6.96	Medium	58	$ 360,000.00	
Inverness	Inverness WTP1	Install interlock for chlorine pump failure	2.31	Yes	Yes	No	Yes	3	6.93	Medium	59	$ 8,625.00	
Cheticamp	Cheticamp LS3	Replace one submersible pump and rail	3.38	No	No	Yes	Yes	2	6.76	Medium	60	$ 23,000.00	
Cheticamp	Cheticamp LS3	Install EYS seals on conduit to control panel	3.38	No	Yes	No	Yes	2	6.76	Medium	61	$ 1,725.00	
Port Hood	Port Hood WTP2	Install interlock for chlorine pump failure	2.24	Yes	Yes	No	Yes	3	6.72	Medium	62	$ 8,625.00	
Port Hood	Port Hood LS1	Install EYS seals on conduit	3.29	No	Yes	No	Yes	2	6.58	Medium	63	$ 1,725.00	
Mabou	Mabou WTP1	Calibrate analyzers	3.2	Yes	Yes	No	No	2	6.4	Medium	64	$ 8,625.00	
Cheticamp	Cheticamp WTP	Fix storage tank roof	2.1	Yes	Yes	No	Yes	3	6.3	Medium	65	$ 30,000.00	
Cheticamp	Cheticamp WTP	Install interlock for chlorine pump failure	2.1	Yes	Yes	No	Yes	3	6.3	Medium	66	$ 8,625.00	
Port Hood	Port Hood WTP1	Replace filter media	3.1	Yes	Yes	No	No	2	6.2	Medium	67	$ 11,500.00	
Port Hood	Port Hood LS5	Install EYS seals on conduit	3.08	No	Yes	No	Yes	2	6.16	Medium	68	$ 1,725.00	
Port Hastings	Port Hastings booster station	Install interlock for chlorine pump failure	2.01	Yes	Yes	No	Yes	3	6.03	Medium	69	$ 8,625.00	
Port Hastings	Port Hastings booster station	Install interlock on booster pump for chlorine feed	2.01	Yes	Yes	No	Yes	3	6.03	Medium	70	$ 5,750.00	
Port Hood	Port Hood LS2	Replace one self-priming pump	3.01	No	No	Yes	Yes	2	6.02	Medium	71	$ 17,250.00	
Port Hood	Port Hood LS2	Install EYS seals on conduit	3.01	No	Yes	No	Yes	2	6.02	Medium	72	$ 1,725.00	
Mabou	Water Supply	Water exploration/Well Setup	2	Yes	Yes	No	Yes	3	6	High	73	$ 420,000.00	Assumes the entire process from exploration to a well field protection study and designation
Port Hood	Port Hood Water Storage Tank	Expose and Heat Trace Line to Pressure Transducer	3	Yes	No	No	Yes	2	6	High	74	$ 17,250.00	
Inverness	Inverness WTP2	Install interlock for chlorine pump failure	1.94	Yes	Yes	No	Yes	3	5.82	Medium	75	$ 8,625.00	
Whycocomagh	Whycocomagh WTP	Calibrate analyzers	2.81	Yes	Yes	No	No	2	5.62	Medium	76	$ 8,625.00	
Whycocomagh	Whycocomagh WTP	Repair unit heaters/HVAC system	2.81	#N/A	No	No	Yes	1	2.81	Medium	77	$ 51,750.00	Replace unit heaters, repair ventilation system
Whycocomagh	Whycocomagh LS4	Install EYS seals on conduit	2.66	No	Yes	No	Yes	2	5.32	Medium	78	$ 1,725.00	
Whycocomagh	Whycocomagh LS1	Relocate Wet Well Vent	2.64	Yes	No	No	Yes	2	5.28	Medium	79	$ 575.00	
Whycocomagh	Whycocomagh LS1	Install EYS seals on conduit	2.64	No	Yes	No	Yes	2	5.28	Medium	80	$ 1,725.00	
Whycocomagh	Whycocomagh LS2	Install EYS seals on conduit	2.36	No	Yes	No	Yes	2	4.72	Medium	81	$ 1,725.00	

Region	Asset	Recommended Upgrade	Weighted Asset Rating	Core Asset	Risk to Public Health	Risk to Environmental Health	Economic Risk	Hazard Score	Risk Score	Importance	Ranking	Total Estimated Cost	Costing Comments
Inverness	Inverness WTP1	Calibrate analyzers	2.31	Yes	Yes	No	No	2	4.62	Medium	82	$ 8,625.00	
Inverness	Inverness WTP1	Program filters to automatically backwash	2.31	Yes	Yes	No	No	2	4.62	Medium	83	$ 12,000.00	
Port Hood	Port Hood WTP2	Calibrate analyzers	2.24	Yes	Yes	No	No	2	4.48	Medium	84	$ 8,625.00	
Cheticamp	Cheticamp LS1	Install EYS seals on conduit	2.15	No	Yes	No	Yes	2	4.3	Medium	85	$ 1,725.00	
Cheticamp	Cheticamp WTP	Calibrate analyzers	2.1	Yes	Yes	No	No	2	4.2	Medium	86	$ 8,625.00	
Port Hood	Port Hood WWTP	Calibrate DO/TSS analyzer	2.08	Yes	Yes	No	No	2	4.16	Medium	87	$ 2,875.00	
Inverness	Inverness LS1	Install EYS seals on conduit	2.02	No	Yes	No	Yes	2	4.04	Medium	88	$ 1,725.00	
Cheticamp	Cheticamp WWTP	Replace drying beds dewatering bags	2.01	Yes	No	No	Yes	2	4.02	Medium	89	$ 410,550.00	
Cheticamp	Cheticamp LS6	Replace wetwell hatch	3.98	No	Yes	No	No	1	3.98	Medium	90	$ 5,750.00	
Inverness	Inverness WTP2	Calibrate analyzers	1.94	Yes	Yes	No	No	2	3.88	Medium	91	$ 8,625.00	
Inverness	Inverness WTP2	Program filters to automatically backwash	1.94	Yes	Yes	No	No	2	3.88	Medium	92	$ 12,000.00	
Port Hood	Port Hood LS3	Replace wetwell hatch	3.55	No	Yes	No	No	1	3.55	Medium	93	$ 5,750.00	
Inverness	Inverness WWTP	Install perimeter fencing	3.52	Yes	No	No	No	1	3.52	Medium	94	$ 23,000.00	
Inverness	Inverness WWTP	Replace building exterior envelope	3.52	Yes	No	No	No	1	3.52	Medium	95	$ 345,000.00	Low working around operating system
Inverness	Inverness WWTP	Program flow meter to totalize flow	3.52	Yes	No	No	No	1	3.52	Medium	96	$ 5,750.00	
Cheticamp	Cheticamp LS3	Replace wetwell hatch	3.38	No	Yes	No	No	1	3.38	Medium	97	$ 5,750.00	
Port Hood	Port Hood LS4	Replace wetwell hatch	3.29	Yes	No	No	No	1	3.29	Medium	98	$ 5,750.00	
Port Hood	Port Hood LS1	Replace wetwell hatch	3.29	No	Yes	No	No	1	3.29	Medium	99	$ 5,750.00	
Whycocomagh	Whycocomagh LS3	Replace wetwell hatch	3.27	Yes	No	No	No	1	3.27	Medium	100	$ 5,750.00	
Mabou	Mabou WTP1	Replace hot water heater	3.2	Yes	No	No	No	1	3.2	Medium	101	$ 5,750.00	
Whycocomagh	Whycocomagh WWTP	Replace flow meter wiring	3.18	Yes	No	No	No	1	3.18	Medium	102	$ 5,750.00	
Whycocomagh	Whycocomagh WWTP	Replace doors	3.18	Yes	No	No	No	1	3.18	Medium	103	$ 3,450.00	
Port Hood	Port Hood LS5	Replace wetwell hatch	3.08	No	Yes	No	No	1	3.08	Medium	104	$ 5,750.00	
Cheticamp	Cheticamp LS5	Replace wetwell hatch	3.01	Yes	No	No	No	1	3.01	Medium	105	$ 5,750.00	
Port Hood	Port Hood LS2	Replace wetwell hatch	3.01	No	Yes	No	No	1	3.01	Medium	106	$ 5,750.00	
Cheticamp	Cheticamp LS2	Replace wetwell hatch	2.89	Yes	No	No	No	1	2.89	Medium	107	$ 5,750.00	
Port Hastings	Port Hastings LS2	Replace wetwell hatch	2.75	Yes	No	No	No	1	2.75	Medium	108	$ 5,750.00	
Port Hastings	Port Hastings LS1	Replace wetwell hatch	2.73	Yes	No	No	No	1	2.73	Medium	109	$ 5,750.00	
Cheticamp	Cheticamp LS4	Replace wetwell hatch	2.69	Yes	No	No	No	1	2.69	Medium	110	$ 5,750.00	
Whycocomagh	Whycocomagh LS4	Relocate Wet Well Vent	2.66	No	No	No	Yes	1	2.66	Medium	111	$ 575.00	
Whycocomagh	Whycocomagh LS4	Replace Panel	2.66	No	No	No	Yes	1	2.66	Medium	112	$ 11,500.00	
Whycocomagh	Whycocomagh LS4	Replace wetwell hatch	2.66	No	Yes	No	No	1	2.66	Medium	113	$ 5,750.00	
Port Hood	Port Hood LS6	Replace wetwell hatch	2.64	Yes	No	No	No	1	2.64	Medium	114	$ 5,750.00	
Whycocomagh	Whycocomagh LS1	Replace wetwell hatch	2.64	Yes	No	No	No	1	2.64	Medium	115	$ 5,750.00	
Whycocomagh	Whycocomagh LS2	Relocate Wet Well Vent	2.36	No	No	No	Yes	1	2.36	Medium	116	$ 575.00	
Whycocomagh	Whycocomagh LS2	Replace wetwell hatch	2.36	Yes	No	No	No	1	2.36	Low	117	$ 5,750.00	
Cheticamp	Cheticamp LS1	Replace wetwell hatch	2.15	No	Yes	No	No	1	2.15	Low	118	$ 5,750.00	
Inverness	Inverness LS1	Replace wetwell hatch	2.02	No	Yes	No	No	1	2.02	Low	119	$ 5,750.00	
Inverness	Inverness WTP2	Replace doors	1.94	Yes	No	No	No	1	1.94	Low	120	$ 4,600.00	
Inverness	Inverness WTP2	Fix broken lights outside building	1.94	Yes	No	No	No	1	1.94	Low	121	$ 575.00	

Appendix D

Asset Management Tool User's Guide

MUNICIPALITY OF THE COUNTY OF INVERNESS

Water and Wastewater Infrastructure Assessment

Asset Analysis Tool User Manual

March 2019 – 18-8874

Table of Contents

DILLON CONSULTING

1.0 Introduction

Asset Management is the process of planning the expenditures required to maintain an acceptable level of service within a portfolio of tangible items. The decision making process associated with management includes the definition of level of service, the identification of assets and portfolios, and fiscal funding mechanisms. These decisions are supported by robust and defensible evaluation of asset condition, the change in condition over time as it relates to service, and the expenditure required to mitigate asset decay. In this context, the following document outlines the means for calculating asset condition and expenditure through repeatable processes guided by engineering best practices.

The Asset Management Tools were built using Microsoft Excel programs which allows the user to input, store and manipulate data to output information such as:

- Forecast individual asset condition over their useful life;
- Plan intervention dates for asset replacement; and
- Examine detailed inventories of water and wastewater assets.

The asset management tools consist of three Microsoft Excel documents created for the water and wastewater infrastructure as follows:

1. An Asset Inventory;
2. Asset Analysis of Complex Assets;
3. Asset Analysis of Linear Assets.

The three tools provide different functions from each other. The inventory tool is a compilation of the data provided to Dillon and/or observed through the field assessments for the individual assets. As an inventory, this tool is intended as a look-up reference and does not provide analysis in support of capital decisions. The analysis tools are divided according to asset portfolio. The linear assets analysis includes condition and expenditure calculations for buried infrastructure such as water mains and sewers. In contrast, the complex assets tool provides condition and expenditure analysis for facilities such as treatment plants and lift stations. The complex assets are distinguished from linear assets due to the presence of systems and elements that experience condition decay at different rates within the asset and require a more sophisticated expenditure projection.

This guide is intended to provide a high level user-manual, allowing someone to utilize the tool, customize data and develop reporting. It is not meant to be an instructional guide on asset management or design. For more information regarding the terminology, processes, and data used in these tools, refer to the full report.

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2.0 Asset Inventory

The asset inventory is an Excel workbook that stores asset information for linear assets, lift stations, water treatment facilities, wastewater treatment facilities, and water storage tanks.

The "MASTER" worksheet holds all the information for all the assets, while the other four worksheets provide a breakdown based on asset type. For example if an asset is added in the Water Treatment worksheet, it will also have to be added in the Master worksheet as well. This asset would also have to be added to the Complex asset analysis tool.

The asset inventory is an important workbook as it contains a lot of data that is not stored in the analysis workbooks. Information not directly relevant for asset decay and expenditure—such as treatment type, pump sizes, building sizes, etc.—are contained in this sheet. This workbook features the ability to sort and filter based on many different parameters. An example of this is shown in **Figure 1.**

Region	Select Infrastructure	Division	Civic Address	Asset Type	Asset Name	Unique ID	Install Year	Last Major Upgrade	Process/Technology	Source Water	# of Wells
Cheticamp	Water Treatment	Water	Off of Barren Road by water tower	Water Treatment	Cheticamp WTP	C-WT1	1970	2008	None	Groundwater (Secure)	3
Inverness	Water Treatment	Water	15450 Ceilidh Trail	Water Treatment	Inverness WTP1	I-WT1	2002	2017	Filtration	Groundwater (Secure)	2
Inverness	Water Treatment	Water	31 Broad Cove Banks Road	Water Treatment	Inverness WTP2	I-WT2	2008	2008	Filtration	Groundwater (Secure)	1

Figure 1 - Example of Asset Inventory Sheet

It is important to keep this workbook updated when new information is discovered or assets are constructed/decommissioned. This will help in the future by providing an up-to-date cross reference of the Municipal assets. This workbook is not linked to the analysis tools and may require revision of the asset analysis tools as assets are added or removed.

3.0 Asset Analysis of Complex Assets

3.1 Overview

The process of asset analysis for complex assets is based on a configurable and parametric template that performs the following basic functions:

- Describe the hierarchical structure of each asset, its systems, and components;
- Calculate the decay of each observed component;
- Calculate the intervention (replacement) date for each component; and,
- Apply an expenditure for each intervention.

The analysis engine consists of the decay and expenditure calculations based on the most readily available condition and capital value data. The analysis of complex assets (lift stations and treatment plants) is completed using actual observed asset conditions from field inspections. However, the asset replacement value is generally based on the overall asset and not each component (which may number hundreds of elements for a given asset). Consequently a system of weighted averages are employed to calculate the condition of the asset systems and the asset overall. Conversely the replacement value of each component is based on proportioning the asset value by system, and then by components within a system. When a replacement is identified an expenditure equal to the proportioned component value is applied to the forecast year.

The following sections provide a summary of how the workbook is laid out, how to input additional data into the workbook and how to modify the analysis parameters based on actual asset management performance feedback. The complex asset analysis tool is colour coded for easier navigation by the user. The colour coding is described in **Figure 2** below.

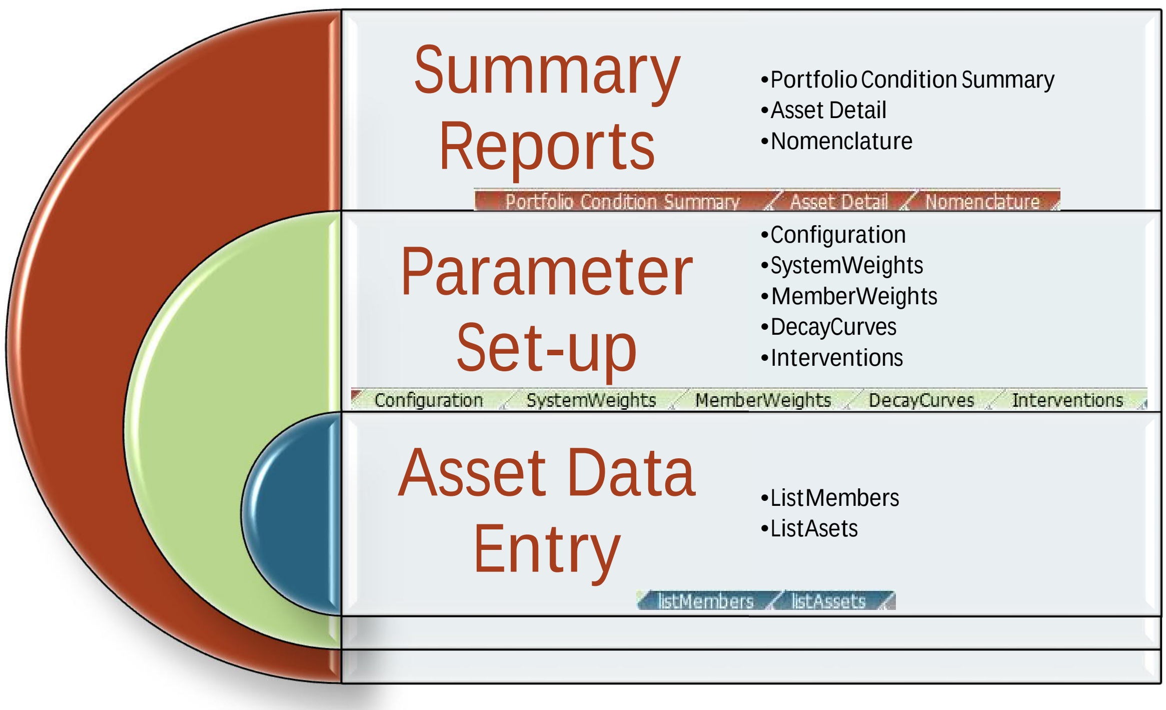


Figure 2: Complex Asset Analysis Worksheet Colour Coding Summary

3.2 Summary Reports Worksheets

The summary worksheets are highlighted in **"red"**. These worksheets provide a summary of the asset condition analysis. The summary reports are intended to be the most used portion of the tool, presenting the user with the outcome of the asset analysis and a means to interrogate the data. These worksheets are presented on the left-most portion of the workbook and are discussed first to provide the user with some context for the detailed technical components of the analysis tool.

3.2.1 Portfolio Condition Summary

The Portfolio Condition Summary worksheet provides an overview of all assets in the system. This at-a-glance report provides:

- Overall condition for all assets in the portfolio
- Distribution of asset grades
- Best and worst assets
- Asset system conditions
- Capital expenditure projections

The summary results are presented as an overall assessment of the asset portfolio condition with summary statistics representing the range of condition ratings and proportion of assets ranked according to condition grade (refer to sidebar: *Asset Conditions and Grades*). The overview graphics provide at-a-glance summary of the condition of the portfolio as well as key insights.

Asset Conditions and Grades

Asset conditions are calculated using weighted average of all observed elements within an asset system. The resulting asset condition score is a weighted average of the system conditions. The analysis provides condition scores by asset and by asset systems.

For ease of use, the user defines descriptive grades associated with the condition scores within the tool. The default condition grades are aligned with typical five-bin conditions from very good to poor. The reports present both the condition score as well as the resulting grade for the assets.

A five-point condition system is typically as follows (the tool will allow the use of arbitrary grade names and score values, refer to Section 3.3.1 starting on page 9):

- Very Good: 1
- Good : 2
- Fair: 3
- Poor: 4
- Very Poor: 5

Additional summary detail include the ten assets with the highest and lowest overall condition rating, the asset systems condition grade histogram, and summary statistics. Asset conditions are calculated based on the observed conditions, dates of observations, the desired base date, decay curves, and configured weights that proportion the relative "importance" of components and systems. These parameters are intended to be refined over time based on continuous feedback and are discussed in later sections.

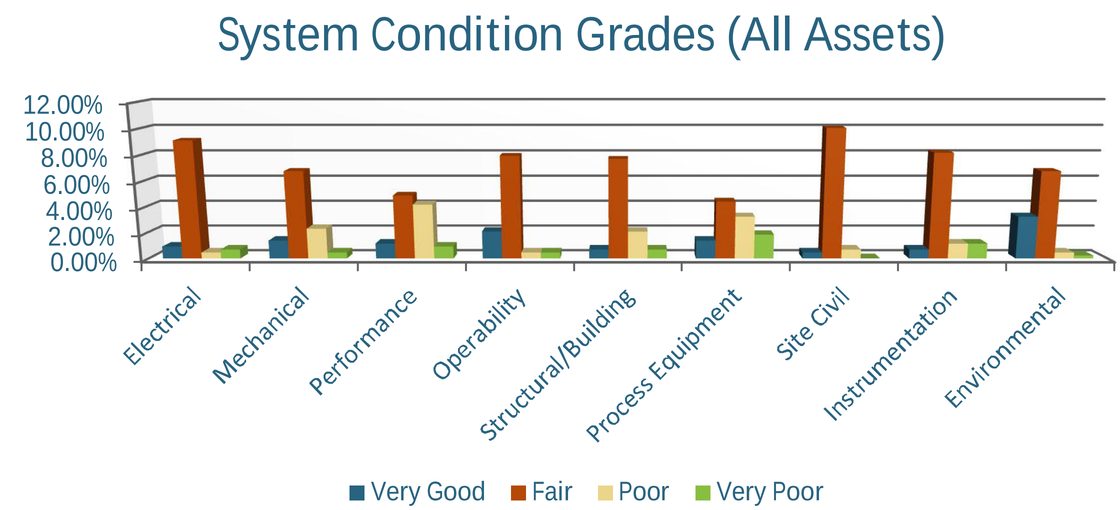
Caution!

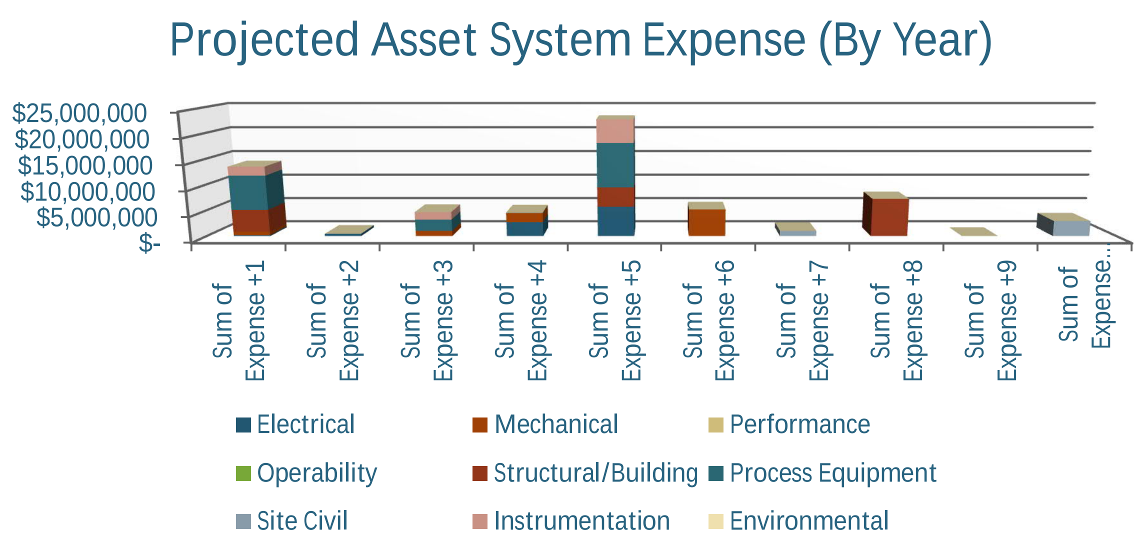
The asset analysis workbook updates all calculations when the report worksheet is opened. Allow this process to complete before interrupting with the mouse or keyboard.

Interrupting the calculation will result in inaccurate reports. Re-opining the report will allow the tool to recalculate.

This report also provides the projected

expense summary over the analysis period, including summary statistics such as overall portfolio value, average annual expenditure, and capital reinvestment rate as an annual percentage of the portfolio value. These key fiscal metrics are intended to provide future planning basis for return on capital versus overall portfolio performance condition. This report is not user-interactive. The analysis tool will re-calculate the summary results each time the report worksheet is opened to ensure the output is fresh. All "present condition" calculations are based on the base date as configured by the user (refer to **Section 3.3.1**).





3.2.2 Asset Detail

The Asset Detail worksheet displays an in-depth analysis of individual assets and is **user-interactive**. Only one asset is presented in the detail report. Information includes:

- Asset tombstone information
- Asset age and replacement value
- Projected expenditures over the analysis period
- Average expenditure and capital reinvestment rate projections
- Condition of the asset systems and observed members according to "grade"
- Projection of the next intervention for all observed asset members

The asset can be selected by the dropdown list in the grey "Asset ID" list. The interaction is summarized in **Figure 3**.

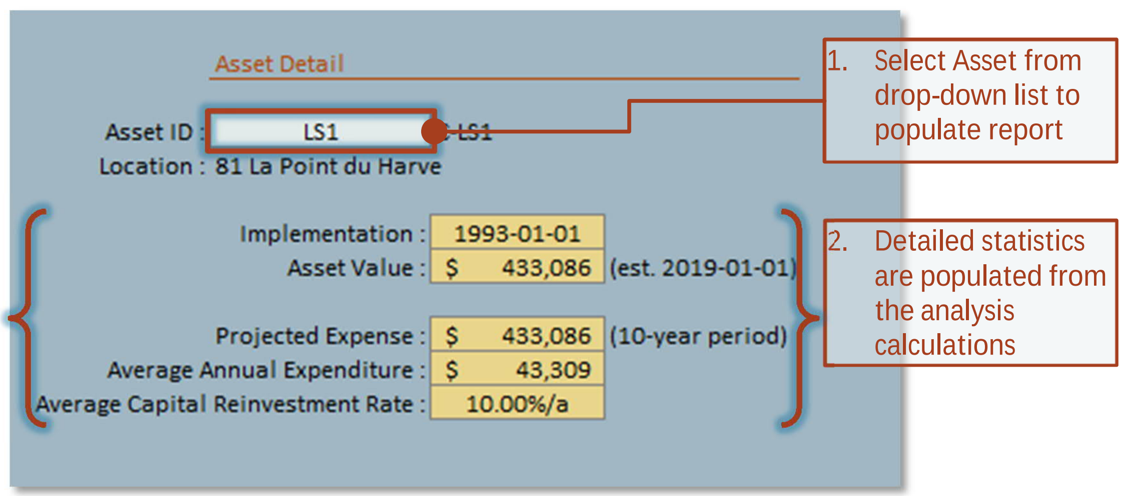


Figure 3: Asset Detail Report Interaction

The projected expenses and asset condition data are summarized according to the analysis calculations. The condition data are presented according to the defined "grades" for comparison to other assets and to the metrics in the portfolio summary report. Using condition "grades" also allows the planner to compare asset condition performance to other portfolios that may employ a different numeric grading system, such as linear infrastructure, facilities, or non-tangible assets such as related services.

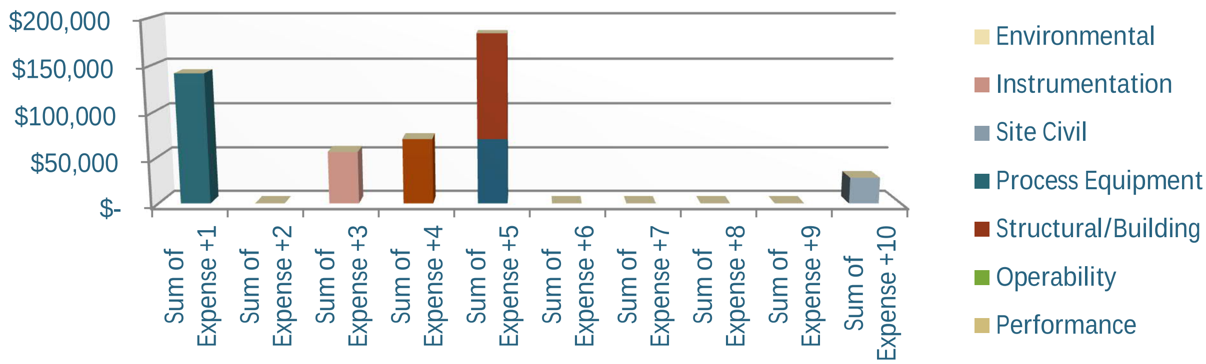


Figure 4: Sample Asset Detail Expense Projection, Year over Year with System Breakdown

The projected intervention year for asset members are summarized for all observed members in a bar chart (refer to example in **Figure 5** on page 8). The analysis calculations are limited to the designated period; however, the "next intervention" is based on the member condition, the projected decay, and the desired intervention threshold. (Refer to sidebar: *Asset Decay and Intervention*.) Consequently these projections may exceed the analysis window to provide insight into long-lived components. The projection does not present recurring interventions within the analysis calculation, only the next intervention.

The projected next intervention for all observed asset members are presented in a bar chart summary with a time-line axis for comparison. This chart may be used to identify the ultimate "end of life" for the asset, particularly where major structural components may dictate the effective longevity of the asset. A sample intervention summary chart is presented in **Figure 5** below.

Asset Decay and Intervention

The change in asset conditions are calculated using a decay curve based on a three-parameter logistic regression. The curve follows a typical ageing pattern of like new period, performance degradation period, and end-of-life zone. The decision to change the asset member condition through investment is the intervention window.

The intervention window defines the zone on the decay curve where investment in the asset member will cause a rebound in its condition score. A typical intervention includes replacement, which may occur when the member reaches 90% of its longevity (e.g., a condition score of 4.5 out of 5). The condition rebound in the case of replacement is a 100% recover to "like new" condition (e.g., a condition score of 1).

All decay curves and interventions are configured by the user as described in Section 3.3.4 and Section 3.3.5. The decay and intervention system is applied to asset members as described in Section 3.3.3. The asset decay and expenditure calculation system is entirely parametric and may be adjusted over time based on actual performance feedback.

Caution!

The asset analysis workbook updates all calculations when the report worksheet is opened. Allow this process to complete before interrupting with the mouse or keyboard.

Interrupting the calculation will result in inaccurate reports. Re-opining the report will allow the tool to recalculate.

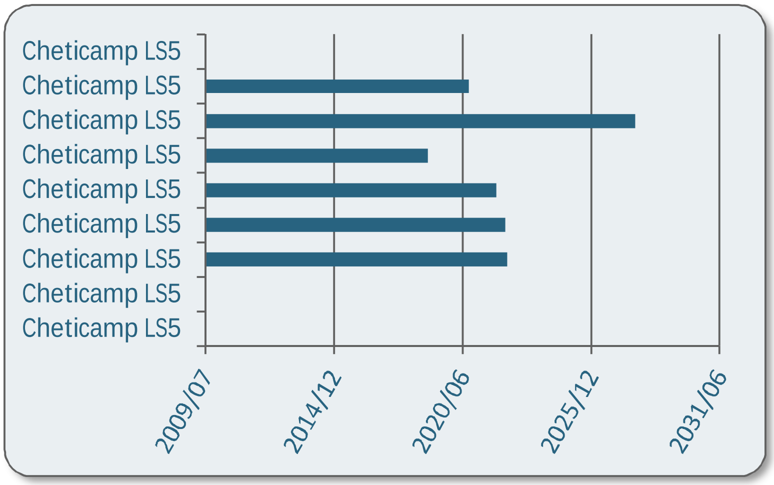


Figure 5: Sample Asset Detail "Next Intervention" Projections

More information regarding the intervention for a given asset member can be seen by selecting the member from the grey "Next Intervention For" dropdown list. As summarized below.

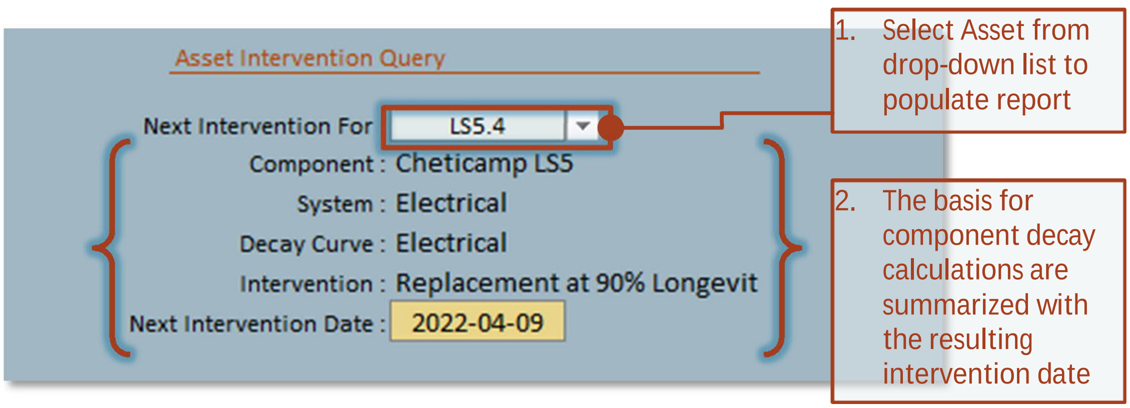


Figure 6: Asset Detail Report "Next Intervention" Interaction

The asset detail report also provides the raw summary data for the asset interventions and conditions. These data are presented in tabular format.

3.2.3 Nomenclature

The Nomenclature worksheet describes the hierarchy of components the make up an asset. This is an information worksheet. The data presented here is for convenience.

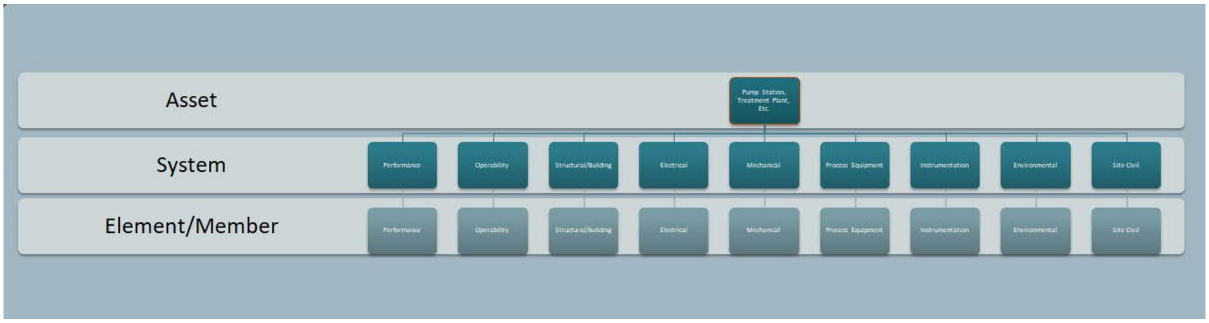


Figure 7: Asset Structure Hierarchy Nomenclature

3.3 Parameter Set-Up Worksheets

The set up worksheets are highlighted in **"light green"**. These worksheets are used to define the asset structure, to configure the system of proportioning and weighted averaging, to define decay curves and interventions, and to set-up basic calculation parameters including the base date for projections and condition scoring and grading. The parametric configuration of the entire analysis platform is achieved through the careful configuration of these sheets. Modifications to the unerlying analysis may be achieved through ongoing planning feedback and adjustment. The user must ensure that the green set-up worksheets are configured before adding data in the blue worksheets.

3.3.1 Configuration

This worksheet contains the basic calculation assumptions for the asset analysis including:

- Condition rank range (numeric)
- Condition grading range (descriptive grade mapping to condition rank)
- Base date for calculation (e.g., "year zero")
- Inflation rate for projecting asset value as of base date

Together these parameters influence the presentation of the condition information.

The condition rank section identifies what numerical values will correspond with new and old objects. The range of values used here will influence the resulting calculations. The rank must be aligned with the asset condition evaluation procedures. It is typical to use a five-bin approach to asset condition grading, consequently a rank from 1 to 5 is appropriate. In some asset portfolios it is common to use condition rank from 1 (new) to 5 (end of life). Any numeric range may be used provided it has meaning for the domain experts providing condition assessment. The condition rank is used in the logistic decay calculations. These calculations are asymptotic, meaning they approach a value but do not reach it. Therefore an epsilon value is used to ensure that the logistic decay calculations will extend slightly beyond the condition rank values. These asymptotes are calculated by the analysis tool based on the condition rank and epsilon values entered by the user as shown in **Figure 8** below.

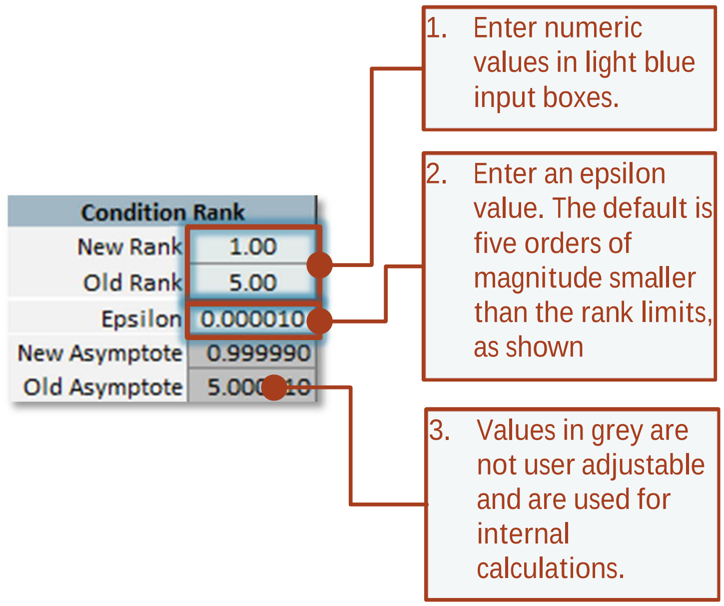


Figure 8: Configuring Asset Decay Condition Rank

The condition grade system is defined after establishing the condition rank. The decay curve projections will result in decimal numbers rather than whole numbers. In the field, condition scores are most often established on the basis of whole numbers such as the list below that correspond with *The Canadian Infrastructure Report Card*:

- Very Good: Score "1"
- Good: Score "2"
- Fair: Score "3"
- Poor: Score "4"
- Very Poor: Score "5"

In order to reflect the intent behind the definitions of Very Good or Very Poor, it is necessary to define the range of decimal values that will correspond to the grades. A review of the decay curve shape and its relationship between condition rank and performance longevity is valuable in defining the condition grade ranges. In general the condition grading defines the mapping between calculated condition and condition grade as it relates to performance. The table is adjusted by the user on this worksheet as shown below.

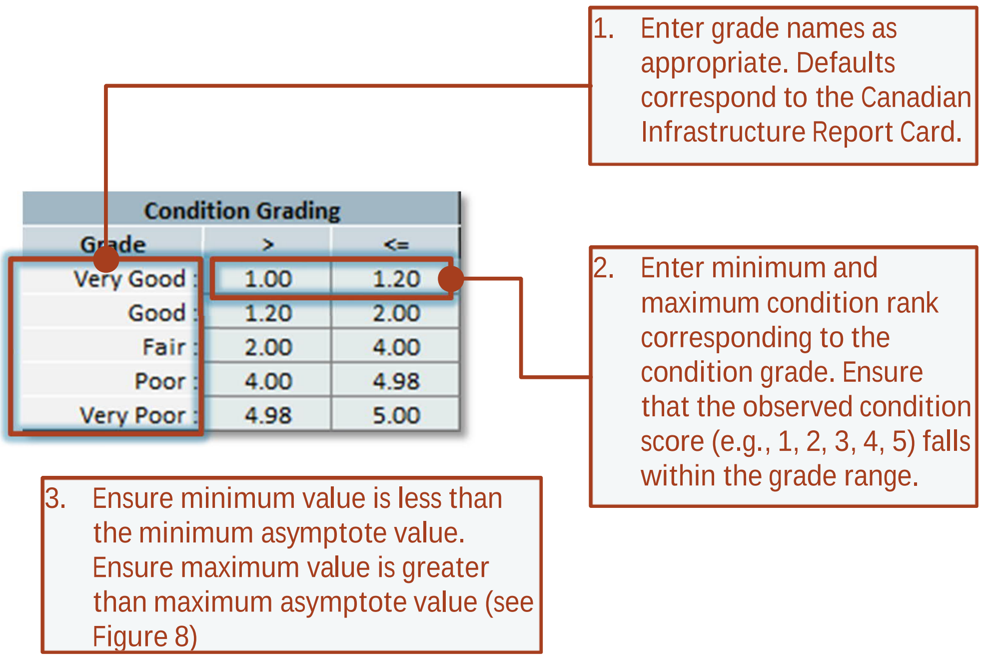


Figure 9: Configuring Asset Condition Grade Ranges

In certain circumstances it may be desirable to omit an asset grade from reporting, such as an asset that does not decay, that is not in its active life cycle (e.g., has not been implemented), or for other reporting reasons. This may be achieved either through creating a “blank” grade name, or, more effectively, by omitting a condition rank from the grading table. For instance, the condition grade table may start with a minimum value that is greater than the minimum asymptote. In the example above, this will result in asset components that are superior to “Very Good” omitted from condition grade reporting. Conversely, a maximum grade score that is less than the asymptote maximum could result in very old assets in the example above from being reported. This could be interpreted in the example above as assets that are beyond reinvestment life and perhaps considered redundant although still within the portfolio inventory. (It would be important to ensure that the intervention definition also omits the affected range to prevent expenditures on the redundant asset.)

The final configuration component is to define the base date for the analysis projection. This date is the starting time for projection and will be referenced as the “present” date within the analysis. The choice of date is defined by the user and could be past, present, or future. One alternative is to set the time for the first day of the next fiscal year. The related parameter “Inflation Rate” is used to estimate the replacement value for each asset at the base date (see **Section 3.4.1** starting on page 23 for more information regarding asset data entry and replacement values). All expenditure projections are based on values as at the base date. Inflation is not applied to projected expenditures. The user inputs are provided in light blue input boxes as shown in **Figure 10** below.

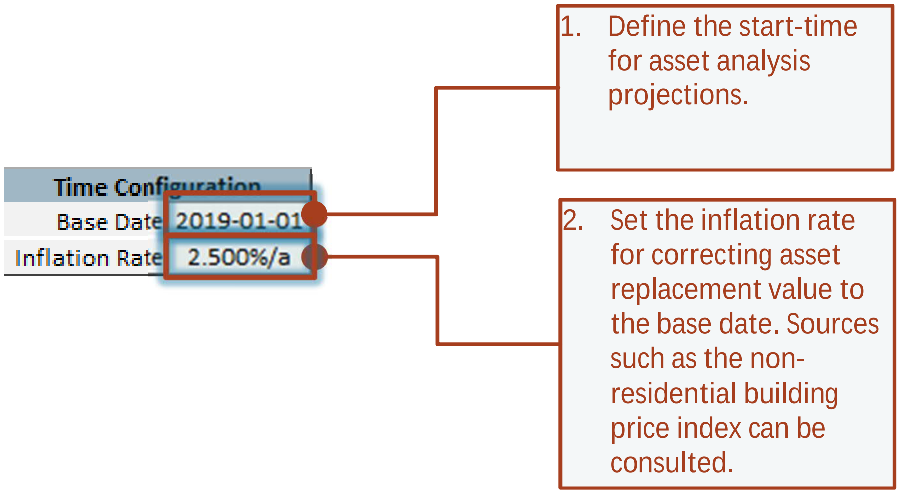


Figure 10: Configuring Projection Start Time and Asset Value Correction

3.3.2 System Weights

Asset hierarchy consists of the asset as a collection of systems, and each system is a collection of members. The number of systems, the proportioning of asset value among systems, and the proportioning of condition rank between systems is configured in this worksheet.

The number of asset systems is defined by creating a system identifier and defining its weights. The number of systems is determined by the user. In general, the number of systems should be limited to as few as possible to limit complexity within the analysis platform, yet provide sufficient differentiation of asset members to provide a narrative explanation of condition and expenditure. For example, in a trivial asset such as a water main, the systems may be limited to pipes and appurtenances. In complex facilities the systems may be divided by major construction divisions such as civil and structural, architectural, electrical, and process and building mechanical. In fleet portfolios the systems may be divided by chassis, drive train, body, and electrical. The definition of systems should provide the user with predictive power that reports expenditure and condition on tangible outcomes.

A new system can be added to the list by clicking the “+” button in the record control area. Records that have not been used may be trimmed by clicking the “-“ button in the record control area. The workbook will automatically cull unused records during calculation and when the worksheet is activated. Records that have a blank ID field are considered unused.

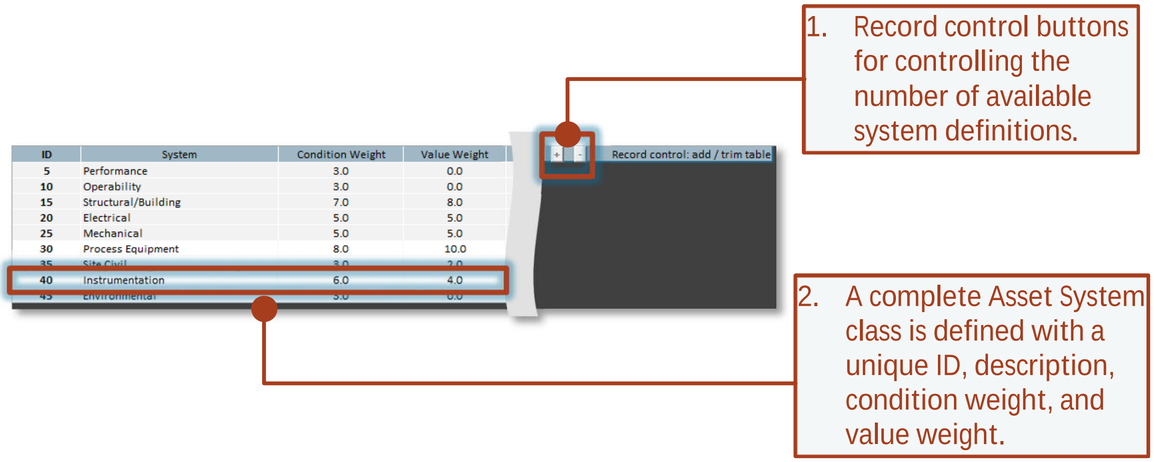


Figure 11: Asset Systems Record Control

The Asset System class is described with a unique identification code. The code may be numeric (as in the examples shown) or it may include letters and punctuation. Spaces should be avoided for clarity. The identification code should be short but meaningful. Many tables within the analysis tool refer to identification codes or allow the user to make choices from the available identification codes. For example, a system identification code could refer to the asset portfolio, such as WW for wastewater treatment, then to the structural system such as: “WW.St”. The choice of identification is determined by the user. The analysis tool will enforce unique values for the ID field.

Condition Rank and Weighted Averages

Individual condition rank values are combined together to form the condition of the collective group. The calculation is a weighted average of the observed conditions and the weight associated with the observation class or type. For example, the condition rank of each system with observed elements are combined in a weighted average to calculate the overall asset condition rank. The same method is used to collect the individual element conditions into a weighted average condition rank for the respective systems. For example, where the condition rank vales are “C” and the associated weights are “W”:

$$Overall\ Condition = \frac{C_A \cdot W_{Class,A} + C_B \cdot W_{Class\ B}}{W_{Class,A} + W_{Class,B}}$$

The weighted average calculation does not require a specific number of observations. Consequently the user is free to choose how many asset observations to record for each asset system, or none at all.

The condition weight is used to roll up the overall condition rank of the system within the context of the asset total condition rank. (Refer to sidebar: *Condition Rank and Weighted Averages*.) For instance, the condition of the asset depends on the condition of the systems that are present. In turn, the condition of each system is based on the conditions of the observed elements in the system. The analysis does not require that all systems have elements with condition observations. This means that the Asset System class is defined but not required for all assets. For example in a pumping station portfolio some assets may have elements belonging to an architectural asset system while other assets such as simple lift stations may not have superstructures. These assets may be part of the same analysis workbook because of the flexibility of the weighted average calculation. The individual asset element condition observations are responsible for calculating the asset system condition, and in turn the overall asset condition.

The Asset System class includes a **Condition Weight** field for calculating the weighted average of the system condition ranks. A weight of zero will cause the system to be omitted from condition ranking within the asset. This is useful for systems that are important for expenditure estimation but not relevant for the performance of the asset. The Asset System class also includes a **Value Weight** field that is used to proportion the capital replacement value of the asset onto each of its systems. Using a value of zero in this field will prevent expenditures from calculating on all related asset elements associated with the system. This may be useful for capturing non-tangible systems such as environmental or social factors associated with the performance condition of the asset. The configuration of an Asset System class is summarized in **Figure 12** below.

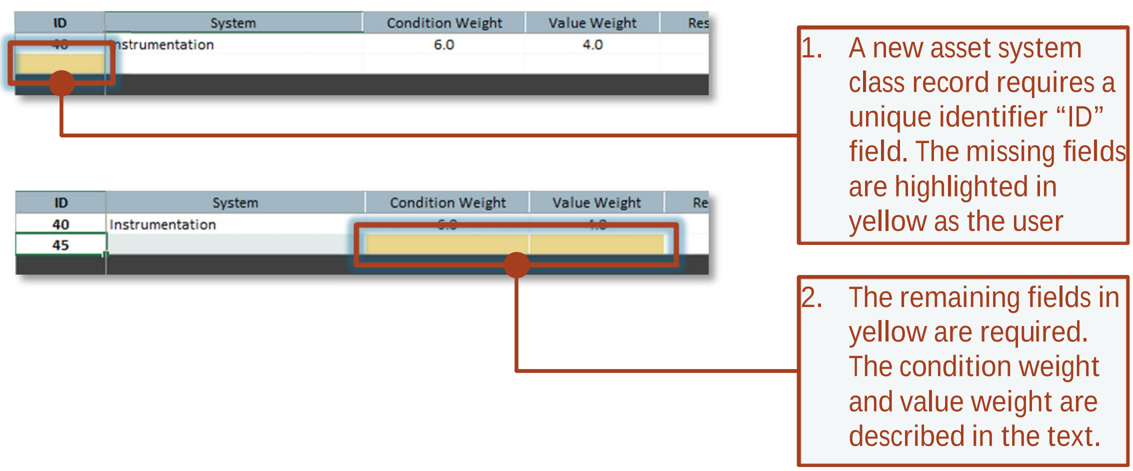


Figure 12: Configuring Asset System Class Fields

3.3.3 Member Weights

The asset hierarchy tree ends with the asset members. Members are the observed elements of each asset. These elements are grouped into systems (as described in Section 3.3.2) that in turn define each asset. Observations of asset condition are captured into one of the defined Asset Member classes. The Asset Member class defines the relationship between the system, the decay, and interventions. Consequently the number of fields that must be defined include:

- Unique Asset Member identifier
- System ID
- Decay Curve ID
- Intervention ID

Each Asset Member class is provided with a descriptive name to differentiate and describe the condition observations that will belong to the member class. For example, a submersible pump may employ a different decay curve from an ANSI pump and will require two different Asset Member classes using different decay curves. Typically at least one Asset Member class will be defined for each Asset System to enable condition observations and expenditures to be associated with a system. If a system does not include a member class, then the user is advised to eliminate the system from the analysis. The relationship between the Asset Member class configured on this worksheet, and the configuration of **Asset Systems** (Section 3.3.2), **Decay Curves** (Section 3.3.4), and **Interventions** (Section 3.3.5) is summarized in **Figure 13** below. The condition data is recorded as asset elements and associated with a single Asset and Asset Member.

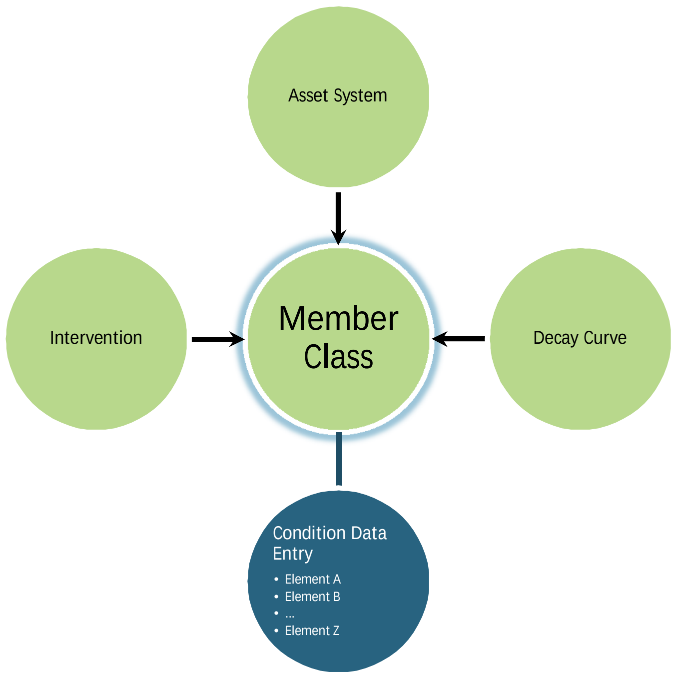


Figure 13: Asset Member Relationship to Configured Parameters and Observed Data

The configuration of Asset Member class records is similar to configuring the Asset Systems additional required fields to make the required associations with systems, decay, and interventions.

A new member class can be added to the list by clicking the "+" button in the record control area. Records that have not been used may be trimmed by clicking the "-" button in the record control area. The workbook will automatically cull unused records during calculation and when the worksheet is activated. Records that have a blank ID field are considered unused.

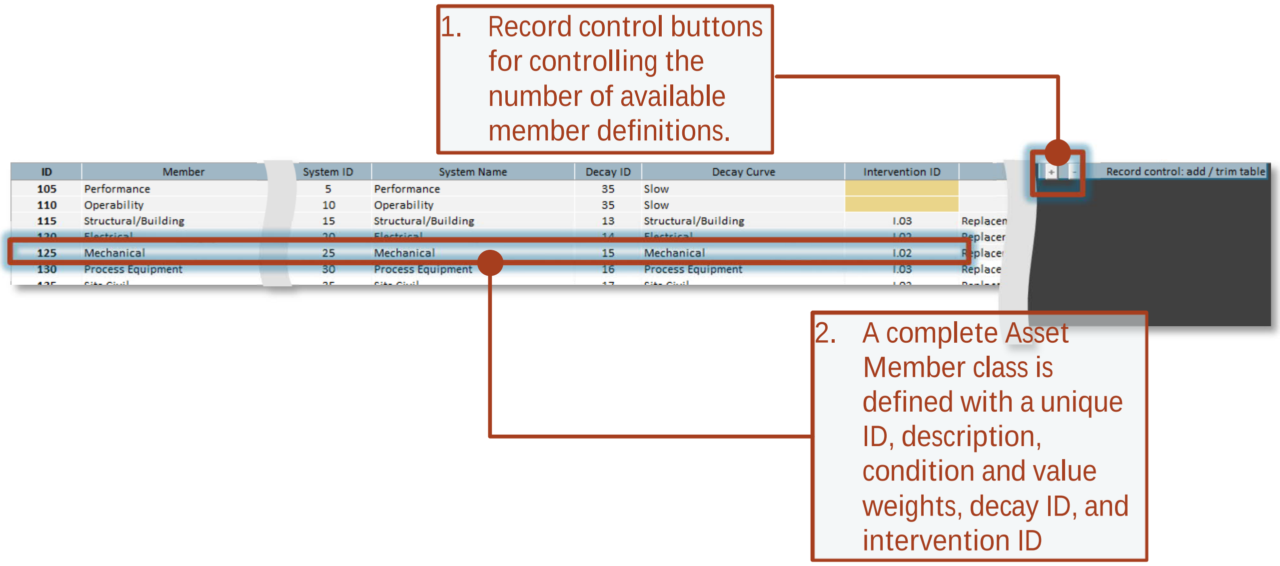


Figure 14: Asset Members Record Control

The Asset Member class is described with a unique identification code. The code may be numeric (as in the examples shown) or it may include letters and punctuation. Spaces should be avoided for clarity. The identification code should be short but meaningful. Many tables within the analysis tool refer to identification codes or allow the user to make choices from the available identification codes. For example, a member identification code could refer to the asset portfolio, such as WW for wastewater treatment, then to the structural system such as "St", and finally to the member type such as foundation "Fd" for a unique identification string of "WW.St.Fd". The choice of identification is determined by the user. The analysis tool will enforce unique values for the ID field.

The member condition weight and value weight work in precisely the same manner as in the Asset System class definitions. Refer to Section 3.3.2 for a complete discussion of the weights. Lastly the complete member definition is associated with a decay curve and an intervention. The unique identifiers for the decay and intervention definitions are selected by the user from the available options defined separately. See Section 3.3.4 for a review of Decay Curves and Section 3.3.5 for a review of Interventions. It is recommended to configure these items before creating the Asset Members.

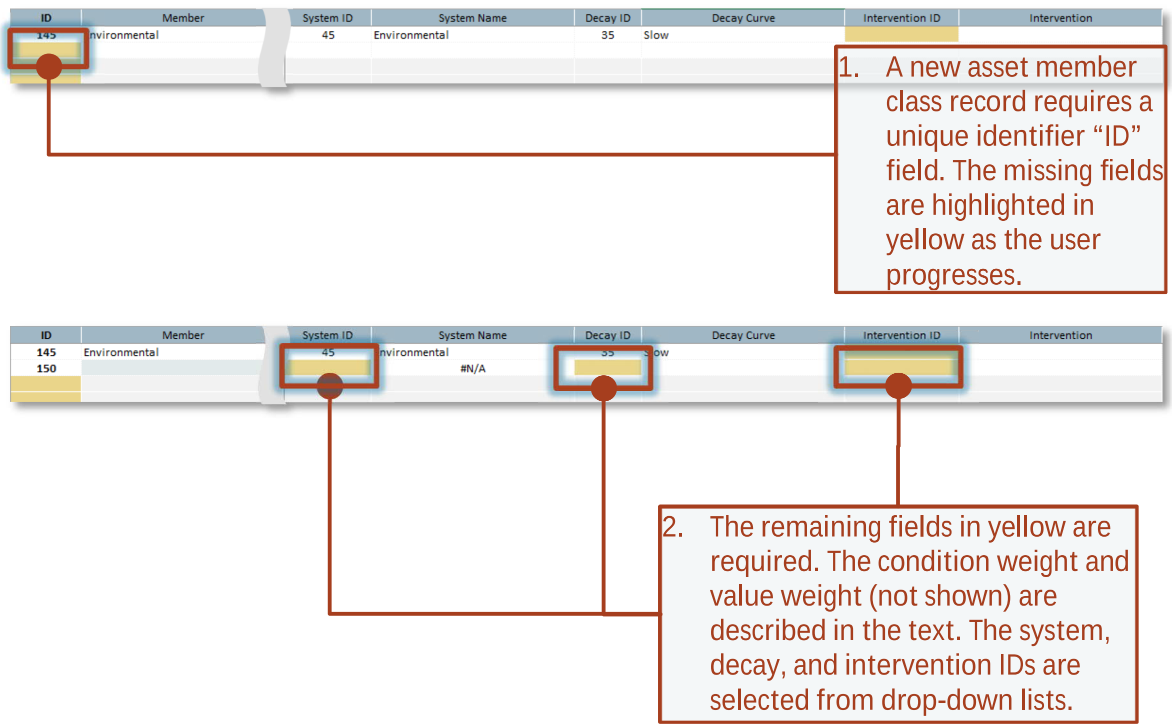


Figure 15: Configuring Asset Member Class Fields

3.3.4 Decay Curves

Example: Decay Curve Limits vs. Condition

The survey team is instructed to use a five-degree condition assessment for each asset element to be recorded. The condition method will follow the Canadian Infrastructure Report Card, with grades of Very Good represented by a score of 1, Good = 2, Fair = 3, Poor = 4, and Very Poor = 5. As a result, the condition rank limits will be from 1 to 5. In order for the decay curve function to provide a full range of values the limits of the function must be set such that all condition rank values are within the function asymptotes. A small value (ε) is subtracted from the minimum condition rank to define the minimum decay curve limit. Similarly (ε) is added to the maximum condition rank to define the function maximum asymptote. The condition grade system will be defined to ensure that all values from the decay curve calculation will be assigned a grade; therefore, Epsilon is subtracted or added to the limits of the grade range.

The principle behind asset management is the projection of change in condition with respect to time. The condition describes the performance of the asset and time describes the performance longevity. Relating these two concepts is the decay curve function. The analysis platform employs a generalized logistic function, also known as a three-parameter Richard's Growth Curve. The function defines a classic "S" shape with a plateau at the "like new" condition, a decline, and a heel at the end of life. This function operates between two asymptotes[1]. The asymptotic nature of the decay curve function is beneficial and can be used to relate a condition to age, or a known age to a condition.

[1] An asymptote is a minimum or maximum value that a numeric function will approach but will not reach.

It is important to understand the requirement that the decay curve limits (i.e., the New Rank and Old Rank) must be slightly outside the observed conditions recorded during field visits. Similarly the condition grade ranges must be outside the decay curve limits to ensure that all calculated condition values are assigned a grade description. The relationship between rank, decay, and grade are summarized graphically in Figure 16. (Refer to sidebar: *Example: Decay Curve Limits vs. Condition*.) The condition rank and condition grade values are configured in the **Configuration** worksheet as described in Section 3.3.1 starting on page 9. The decay curve asymptotes are called "New Rank" and "Old Rank". These values default to the calculated limits described in the figure. The user may change these values as desired for each decay curve; however, it is **recommended that all decay curves use the same "New Rank" and "Old Rank"** values to ensure that all calculated conditions have the same meaning between assets, systems, and member elements. In some circumstances it may be desirable to use decay curves with different asymptotes. In these circumstances the analysis tool will allow the user to define alternative limits as desired, but the interpretation of the resulting calculations will be for the user to determine. The direction of the condition values may be reversed, such that large values represent "Like New" while small values represent "End of Life".

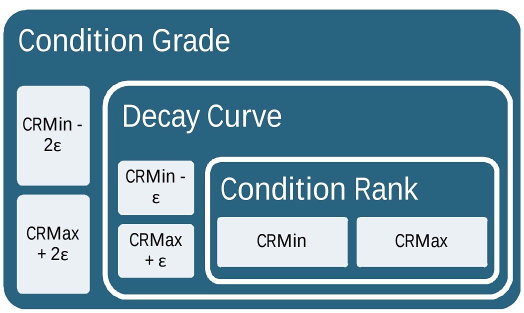


Figure 16: Numeric Relationship Between Condition Grade, Decay Curve, and Condition Rank

A new decay curve can be added to the list by clicking the "+" button in the record control area. Records that have not been used may be trimmed by clicking the "-" button in the record control area. The workbook will automatically cull unused records during calculation and when the worksheet is activated. Records that have a blank ID field are considered unused.

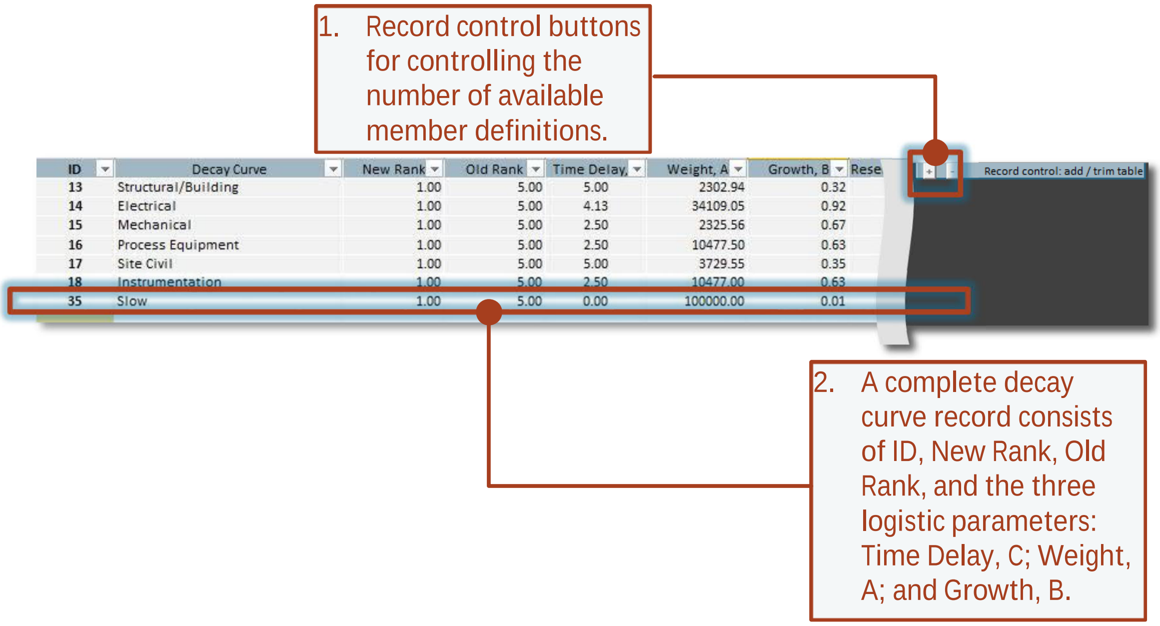


Figure 17: Decay Curve Record Control

The Decay Curve record is described with a unique identification code. The code may be numeric (as in the examples shown) or it may include letters and punctuation. Spaces should be avoided for clarity. The identification code should be short but meaningful. Many tables within the analysis tool refer to identification codes or allow the user to make choices from the available identification codes. For example, a decay curve code could refer to the tangible item (structure, machine, electrical, etc), the environmental (dry, indoor, corrosive), or any other relevant distinguishing feature of the curve and its intended purpose. Decay curves based purely on a desired longevity, such as 5-year, 10-year, 75-year may be employed and applied to various member classes as needed. The choice of identification is determined by the user. The analysis tool will enforce unique values for the ID field.

The logistic function parameters define the shape of the decay curve. Generally, the parameters have the following effect:

- Weight (parameter A): Defines the duration, interacts with growth to define slope of the curve.
- Growth (parameter B): Defines the slope, interacts with weight to define duration.
- Time Delay (parameter C): Defines the duration that the element remains in "Like New" condition.

The decay curve parameters are calculated with the assistance of a separate regression analysis tool. The decay curves pre-populated in the analysis tool have been developed through the input of industry experts including manufacturers, suppliers, and engineers. It is possible to approximate unchanging condition decay through exaggeration of the Weight and Growth parameters to simulate systems that change over periods several orders of magnitude longer than the analysis period (e.g., weight values in excess of 100000 with growth values less than 0.01). These have been used with qualitative asset members such as ease of maintenance opinions that may be used to contribute to asset condition rank.

A sample decay curve is shown in **Figure 18** below . This curve uses asymptotes between 1 and 5, as shown in the example for decay curve ID 14. The decay demonstrates a period of approximately four years in like new condition before the deterioration starts, followed by progressive performance condition decay through year 17 before reaching the critical failure area through to year 23.

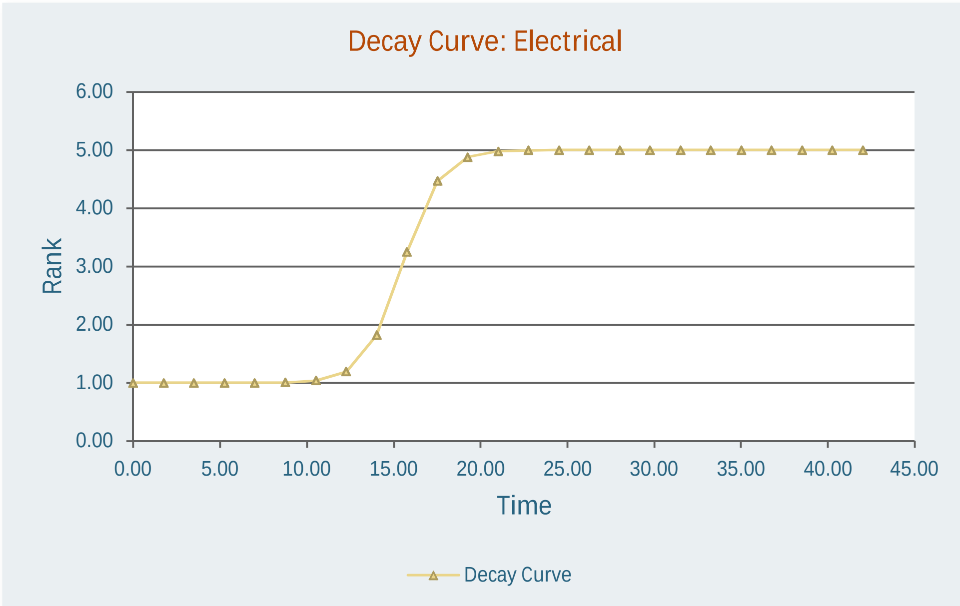


Figure 18: Sample Decay Curve

Each of the decay curves may be examined by the user with the assistance of the curve viewer tool within the worksheet. The user may select any of the decay curves to observe the relationship between condition rank and performance longevity. This interaction is summarized in **Figure 19**.

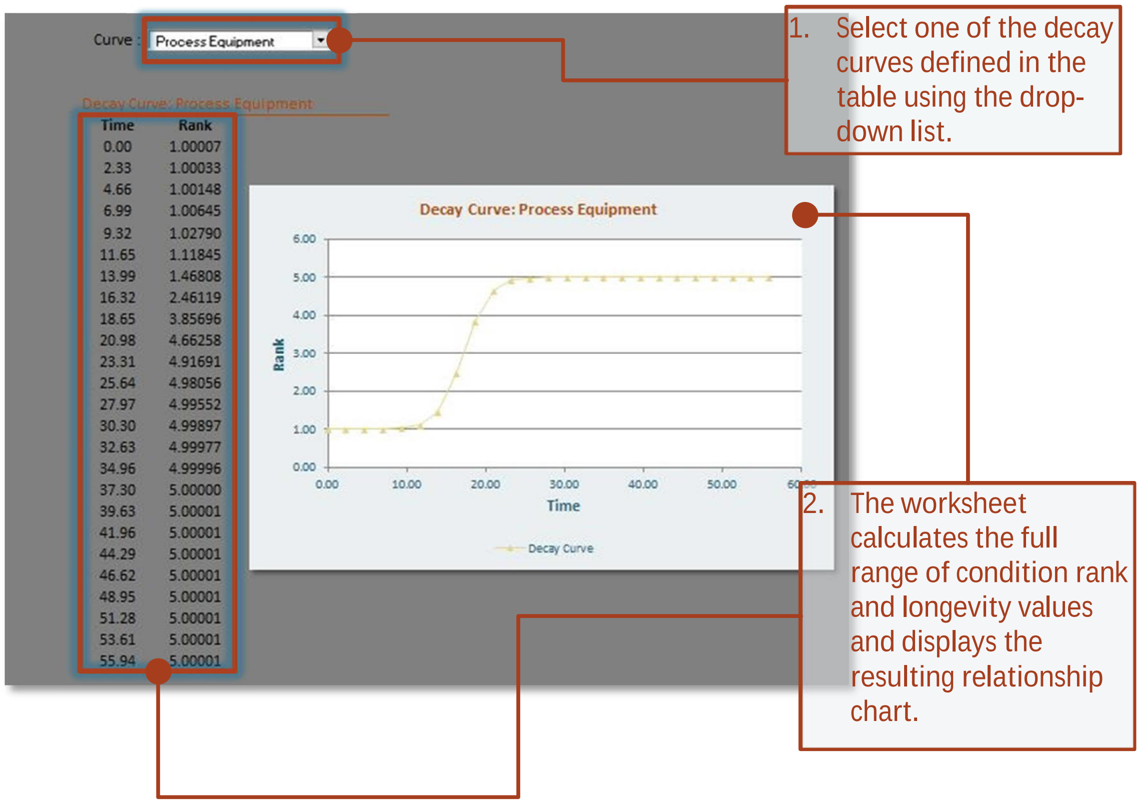


Figure 19: Decay Curve Inspector Tool

3.3.5 Interventions

An intervention is a behaviour that affects change on an asset condition through an expenditure. The intervention describes what happens to the asset member and when it may happen. The basic configuration of an intervention is a condition rank window (not before and not after), and the improvement to the condition as a consequence of the intervention. The most basic intervention is a replacement that occurs as the asset member reaches end of life, resulting in the full replacement value expenditure, and a full rebound of the condition rank to like new status. Interventions are applied to decay curves to determine at what condition an expenditure will occur. Interventions and decay curves are combined in the Asset Member class definitions as described in Section 3.3.3.

A new intervention can be added to the list by clicking the “+” button in the record control area. Records that have not been used may be trimmed by clicking the “-“ button in the record control area. The workbook will automatically cull unused records during calculation and when the worksheet is activated. Records that have a blank ID field are considered unused.

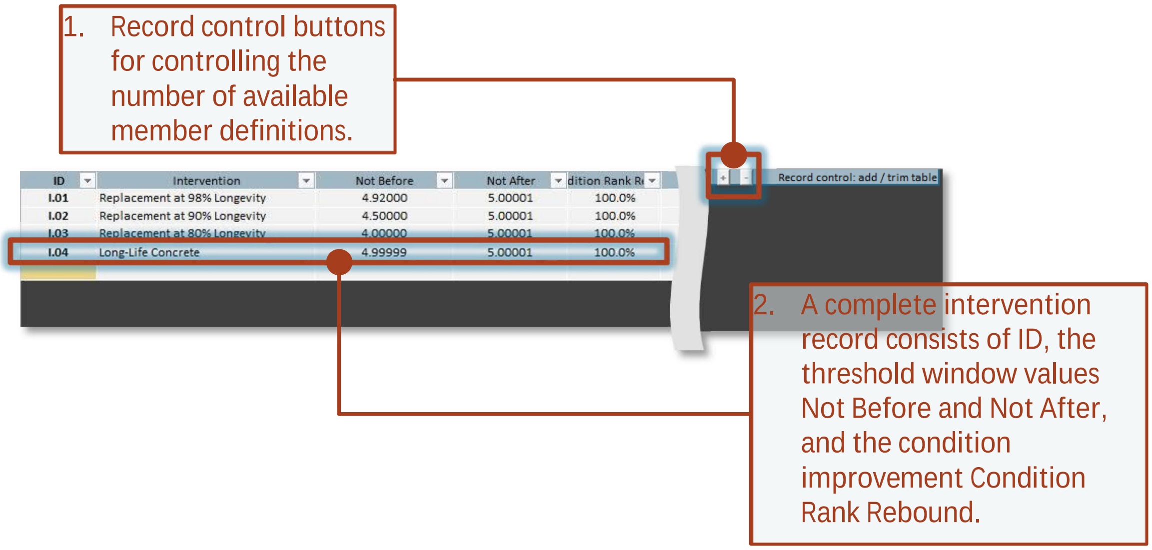


Figure 20: Intervention Record Control

The Intervention record is described with a unique identification code. The code may be numeric or it may include letters and punctuation. Spaces should be avoided for clarity. The identification code should be short but meaningful. Many tables within the analysis tool refer to identification codes or allow the user to make choices from the available identification codes. For example, an intervention code could refer to the overall life span before intervention (e.g., 98% of longevity for a replacement), or it may describe the nature of the intervention. Interventions curves representing replacement at 90% or 99% of ultimate longevity may be called “I.90” or “I.99” respectively. The choice of identification is determined by the user. The analysis tool will enforce unique values for the ID field.

The final three fields of an intervention are the condition rank threshold window defined by “Not Before” and “Not After”, and the “Condition Rank Rebound”. The analysis calculation identifies the change in the condition rank for the year according to the decay curve and compares the result with the intervention assigned through the member class. If the resulting condition rank is between the “Not Before” and “Not After” condition rank values for the intervention, then the analysis will identify the intervention as required for the year. The calculated condition rank for the year is reversed by the proportion determined by the “Condition Rank Rebound” field for the intervention. The resulting calculated condition rank is the projected final condition for the asset member in the year. Where a replacement intervention is identified, the replacement value for the asset member (as proportioned using the value weight system) is assigned to the expense for the forecast year. The sequence is summarized in **Figure 21**:

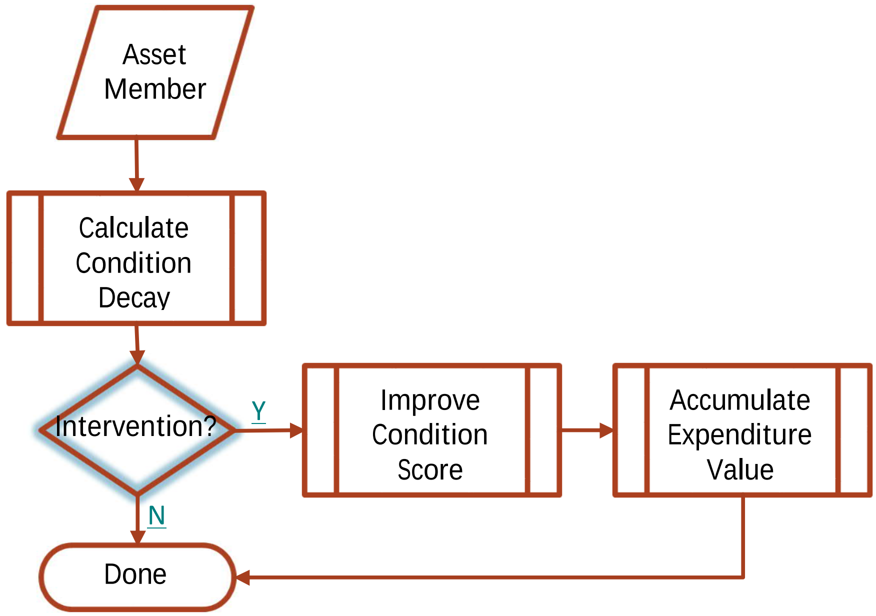


Figure 21: Intervention Calculation Flowchart for Each Asset Member for Each Projection Year

It is important to observe that it is the responsibility of the user to ensure that the intervention threshold window includes the required condition range for intervention. If the “Not After” value fails to overlap the decay curve asymptote, then the intervention may fail to be observed as intended. For a replacement intervention, the user is advised to ensure that the “Not After” value is superior to the asymptote value equal to old age. The default value ensures that interventions will match end of life conditions.

3.4 Input Worksheets

The analysis tool calculates asset condition and expenditure according to the rules and parameters configured by the user in the green worksheets. The calculations act upon the asset data entered on the input worksheets. The worksheets that are highlighted in **“dark blue”** are to input the data corresponding to the assets.

3.4.1 ListAssets

The analysis tool includes two data entry worksheets that divide the portfolio data into the asset list, and the asset members list. The first worksheet is the assets list, which must be populated before asset member observations may be configured for the assets. Each asset record is a group of systems with members and is the main unit of portfolio management. The assets in a portfolio should belong to a group defined by similar function, similar role, similar value, and similar decay. The policy decisions used to group assets into portfolios is outside the scope of this document. The asset analysis platform does not dictate any limitations to the number or type of asset and leaves the policy and interpretation up to the user. One means of limiting the asset portfolio is to divide assets by functional planning group such that the resulting condition and expenditure projections are valuable to the planning group for budget and performance assessments. The asset data includes important information required by the calculations as summarized in **Table 1** below:

Table 1: Asset Record Field Description

Asset Record Field	Description	Required
ID	Unique asset identification used for cross-referencing. This may be a GIS ID or other tag (see text)	Yes
Name	Asset name that will appear in reporting	Optional
Location	Geographic information related to the asset such as street address	No
Category	User information that may be used in user-created reports	No
Implement	Date of construction or overall "like new" condition date such as major overhaul. For age-based asset projections this is the base date of the asset	Yes
Retire	Date of asset retirement (calculations of condition and expenditure halt)	No
Replacement Value	Capital cost for asset replacement (includes indirect costs as appropriate)	Yes
Value Estimate Date	Date of capital replacement value estimation for inflation to present date	Yes

A new asset record can be added to the list by clicking the "+" button in the record control area. Records that have not been used may be trimmed by clicking the "-" button in the record control area. The workbook will automatically cull unused records during calculation and when the worksheet is activated. Records that have a blank ID field are considered unused.

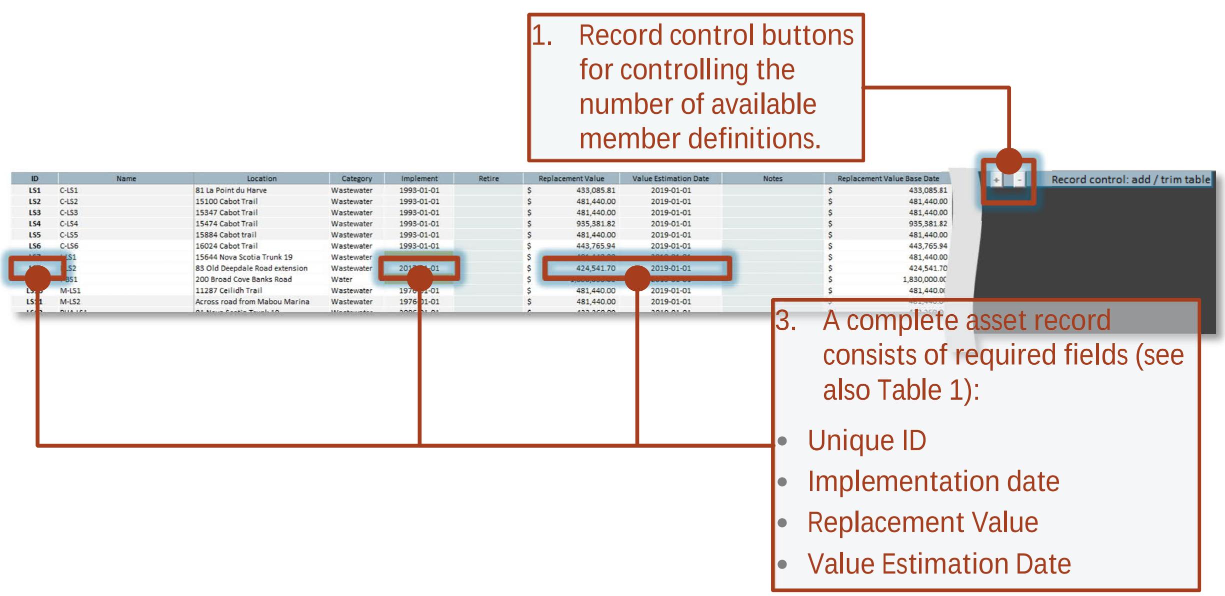


Figure 22: Asset Record Control

The asset unique identifier field may be coordinated with external data sources such as geospatial databases (e.g., GIS) or other inventory systems. The results of the asset analysis platform may be cross referenced and integrated with these external data sources and used in external reporting. The configuration of these systems and reports is outside the context of this manual. The asset record unique ID must be defined in this worksheet before it is accessible for report results and asset member data entry. If the unique ID is modified on this worksheet then the user is responsible for correcting the asset ID on other worksheets as appropriate, including the members data entry sheet.

The asset implementation date **Implement** is required for the age-based asset condition fallback calculation method. It is assumed that the asset was in “like new” condition at the implementation date. Consequently the date may be the original purchase or construction date, or the last major overhaul date or major rehabilitation. It is best practice to ensure that this date is provided for all assets. Where the date is unknown or not available, then all asset members belonging to the affected asset must have complete condition data as described in **Section 0** starting on page 26.

The **replacement value** is a known capital value for the whole asset. This value may include indirect costs such as markups, construction mobilization, design, and management costs. The asset analysis platform uses the capital replacement value for projecting all expenses related to the portfolio. Including indirect costs in the asset replacement value is equivalent to ensuring that these costs are carried forward into the expenditure projections. Asset replacement values may omit indirect costs and include only the direct purchase costs. In this scenario the expenditure projections will be based on direct costs only. It is best practice to ensure that one method is used for all assets. Asset replacement value data may be calculated using an external tool, based on insurance valuation, or other method. The replacement value is **not equivalent** to book value subjected to depreciation effects. The **Value Estimate Date** is the time-value of the capital replacement amount. The analysis tool will inflate the replacement value from the Value Estimate Date to the analysis Base Date as defined by the user in the Configure worksheet. See **Section 3.3.1** starting on page 9 for more details.

3.4.2 ListMembers

The asset members data records are the fundamental unit of calculation upon which all condition and expenditure projections are made. The data provided on this worksheet connects the elements of every asset to the decay and expenditure parameters configured on other worksheets. Asset members may be modified, added, and removed following ongoing activities within the portfolio. The asset analysis platform does not limit the minimum or maximum number of asset member records for each asset. The key assumption of the analysis is that each member record represents an aspect of the asset that exists. It is not required to create an asset member record for each asset, nor for each asset system; this is contrary to the flexibility of the weighted averaging method employed in the calculations. (Refer to sidebar: *Choosing a Policy for Member Record Detail: Practical Considerations*.) The asset data includes important information required by the calculations as summarized in **Table 2**:

Choosing a Policy for Member Record Detail: Practical Considerations

All asset member records are entered within the ListMembers worksheet. The total number of records is not limited by the analysis tool except as dictated by software limits such as total number of table rows. The practical limits to calculation of complex data within the software suggest that a reasonable limit to the number of member records will benefit the speed of the overall analysis. Limiting the data burden is achieved through decisions made in policy and interpretation:

- Set **portfolio limits** to divide assets into useful reporting groups, such as by business unit and class (e.g., sewage pumping stations).
- Maintain asset **inventory details separate from asset analysis** and coordinate by asset ID for reporting inventory and condition/expenditure in external tools. The asset analysis does not benefit from detailed inventory data, only the key fields are required.
- Establish limits to data collection by deciding up-front which inventory items may be assessed together and which should include separate observations. This is achieved through a **condition assessment policy**.

It is acceptable in some circumstances to use one asset member observation to reflect a group of components in inventory while using distinct observation records for significant asset components. Developing a record management policy should consider the predictive power of the record, specifically the importance to system condition rank and the proportion of capital value reflected in the record. For example, each pump in a lift station may require individual observations while all process piping may be collected into a single observation without sacrificing predictive strength.

Table 2: Asset Member Record Field Description

Asset Member Record Field	Description	Required
ID	Unique asset member identification used for cross-referencing. This may be a GIS ID, SCADA tag, inventory tag, or other classifier (see text)	Yes
Name	Asset member name that will appear in reporting used to distinguish observations	Optional
Implement	Date of construction or overall "like new" condition date such as major overhaul, replacement, or purchase. This field is not required unless it is different from the asset implementation date	Optional
Retire	Date of asset retirement (calculations of condition and expenditure halt)	No
Condition Rank	Observed condition rank reflecting asset member performance as determined by a domain expert	Yes
Condition Date	Date of condition rank observation, used for decay projection	Yes
Notes	Optional user notes field for	No

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Asset Member Record Field	Description	Required
	record-keeping purposes (e.g., data source, field observation or rationale for condition rank)	
Asset ID	Unique asset identification selected from the list of defined assets	Yes
Asset Name	The asset name as recorded on the assets data entry worksheet	Automatic
Member ID	Unique asset member class identification selected from the list of configured asset member classes	Yes
Member Type	The asset member class name as defined in the configuration worksheet	Automatic

A new asset member record can be added to the list by clicking the "+" button in the record control area. Records that have not been used may be trimmed by clicking the "-" button in the record control area. The workbook will automatically cull unused records during calculation and when the worksheet is activated. Records that have a blank ID field are considered unused.

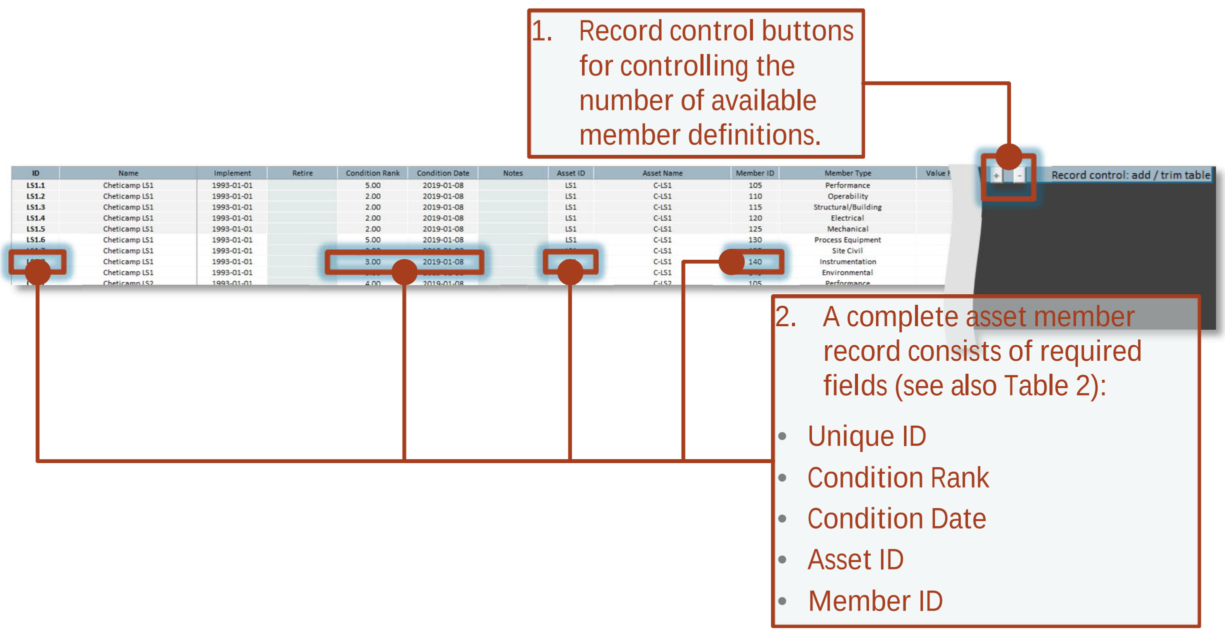


Figure 23: Asset Member Record Control

The asset member unique identifier field may be coordinated with external data sources such as geospatial databases (e.g., GIS), SCADA tag, or other inventory systems. The results of the asset analysis platform may be cross referenced and integrated with these external data sources and used in external reporting. The configuration of these systems and reports is outside the context of this manual. The asset member record unique ID must be defined in this worksheet before it is accessible for report results. Any changes to the asset ID or asset member class ID will require the user to update the affected data records on this sheet to ensure that the asset member data references the correct asset and member configuration.

The asset member implementation date **Implement** is required for the age-based condition fallback calculation method. It is assumed that the asset was in "like new" condition at the implementation date. Consequently the date may be the original purchase or construction date, or the last major overhaul date or major rehabilitation. It is not necessary to provide an implementation date for every asset member if the implementation is the same as the overall asset. It is only beneficial when the age of the member is known to be significantly different from the asset in circumstances where a condition observation is not available or not possible. It is common for new analysis workbooks to include asset members with unknown condition for which the condition rank field is blank. In this event an age-based fallback method is used to estimate the last known condition and project present and future conditions (refer to **Figure 24**).

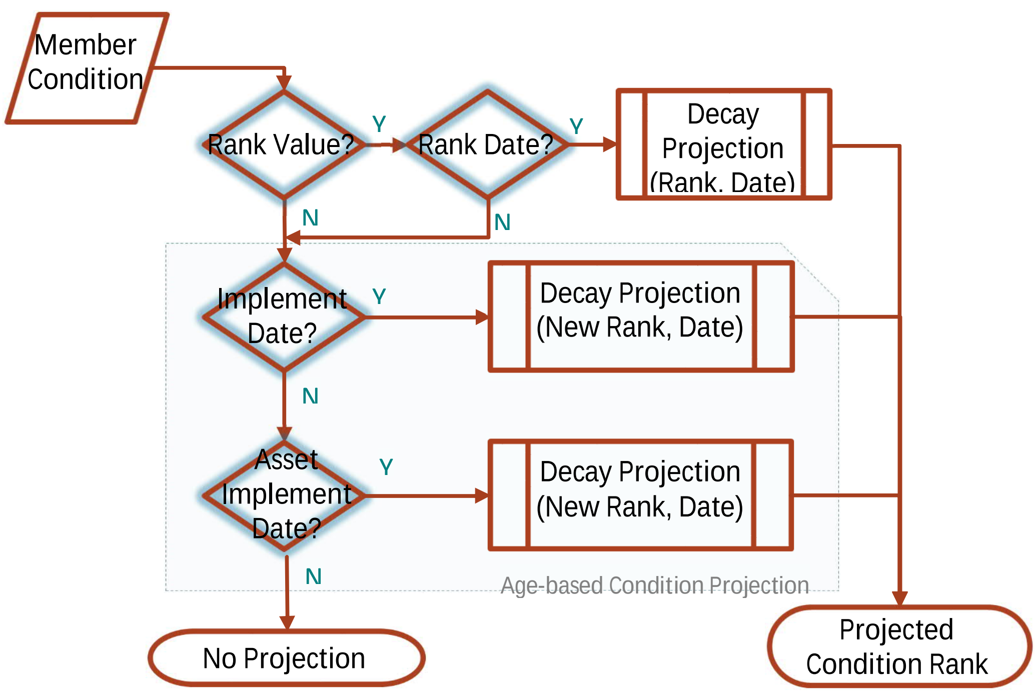
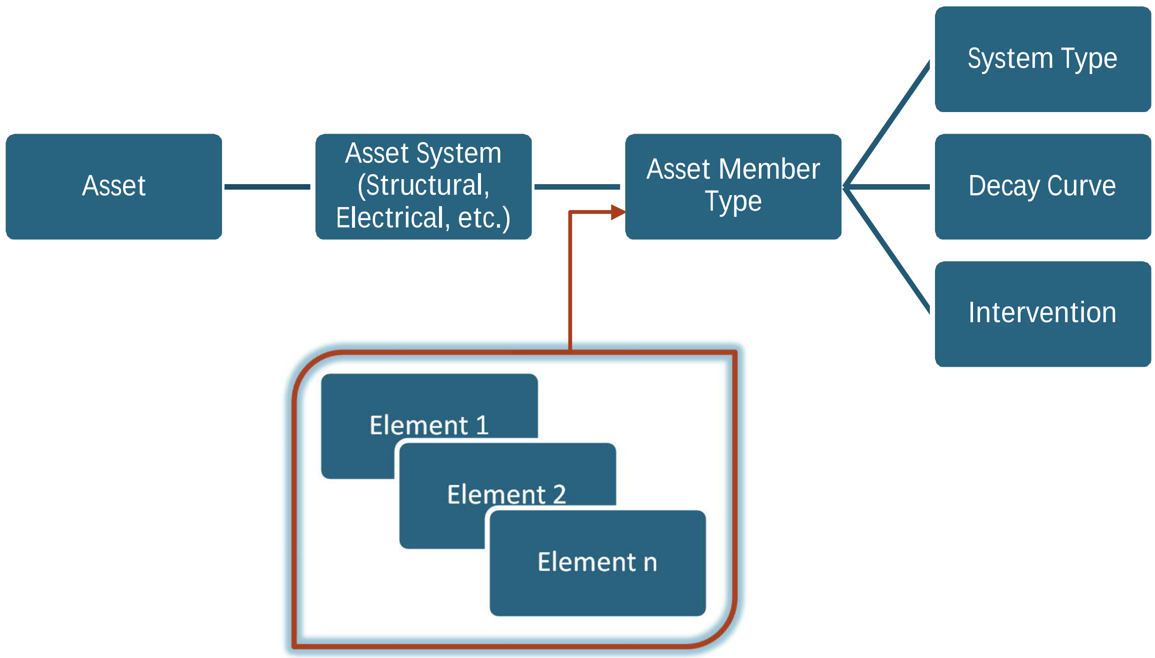


Figure 24: Member Condition Rank Projection - Observation vs. Age-Based Decision Tree

3.5 Adding a Complex Asset

Every complex asset is composed of members that belong to systems (structural, electrical, mechanical, etc.). The condition assessment for each of these members determines the condition of the asset, and the projected expenditures associated with the asset. Below is a figure showing a hierarchy of the main components that determine an assets condition, and interventions associated with expenditures. The analysis of complex assets requires configuration of the asset hierarchy and decay systems and asset data entry.



Adding complex asset data and related configuration might follow the steps outlined below.

1. Navigate to the "ListAssets" tab;
2. Click the "Add Records" button;
3. Fill out columns A through I for the new asset;
    - **A - ID** – Asset ID
    - **B - Name** – Asset Name
    - **C - Location** – Asset Location
    - **D - Category** – Water or Wastewater
    - **E - Implement** - Date that the asset was installed
    - **F - Retire** – Date that the asset will be retired, if applicable
    - **G - Replacement Value** – Cost to replace an identical asset in the year listed in column **H**
    - **H - Value Estimation Date** – Year that the replacement value (column G) was estimated
    - **I - Notes** – Specific notes on the asset
4. Navigate to the "ListMembers" tab;
5. Click the "Add Records" button;
6. Fill out columns A through H, and J for the applicable asset members;
    - **A - ID** – Member ID, use "Asset ID" followed by ".#" for each asset member
    - **B - Name** – Full Asset Name

- **C - Implement** - Date that the asset was installed
- **D - Retire** – Date that the asset will be retired, if applicable
- **E - Condition Rank** – Actual condition rating of the member on the date listed in column **F**
- **F - Condition Date** – Date of the condition assessment for the member
- **G - Notes** – Specific notes on the member
- **H - Asset ID** – Select from dropdown list
- **J - Member ID** – Select from dropdown list
  - Pre-Set Members
    - **105** – Performance
    - **110** – Operability
    - **115** – Structural/Building
    - **120** – Electrical
    - **125** – Mechanical
    - **130** – Process Equipment
    - **135** – Site Civil
    - **140** – Instrumentation
    - **145** – Environmental
  - If a new member is required
    1. Navigate to "SystemWeights" tab
    2. Select "Add Records" button
    3. Fill out columns A through D
       - **A - ID** – System ID number
       - **B - System** – System description
       - **C - Condition Weight** – Condition weight of system
       - **D - Value Weight** – Value weight of system
    4. Navigate to "MemberWeights" tab
    5. Select "Add Records"
    6. Fill out columns A through E, G, and I
       - **A - ID** – Member ID number
       - **B - Member** – Member Description
       - **C - Condition Weight** – Condition weight of member
       - **D - Value Weight** – Value weight of member
       - **E - System ID** – Select from dropdown list
       - **G - Decay ID** – Select from dropdown list

- Pre-Set Decay Curves
  - **13** - Structural/Building
  - **14** - Electrical
  - **15** - Mechanical
  - **16** - Process Equipment
  - **17** - Site Civil
  - **18** - Instrumentation
  - **35** - Slow
- **I** – **Intervention ID** – Select from dropdown list
  - Pre-Set Interventions
    - **I.01** – Replacement at 98% longevity
    - **I.02** – Replacement at 90% longevity
    - **I.03** – Replacement at 80% longevity
    - **I.04** – Replacement at 99.99% Longevity
  - Adding a New Intervention
    - Navigate to "Interventions" tab
    - Select "Add Records" button
    - Fill out columns A through E
      - **A** – **ID** – Intervention ID number
      - **B** – **Intervention** – Description
      - **C** – **Not Before** – Condition ranking that an intervention will take place
      - **D** – **Not After** – Drag row to auto-fill
      - **E** – **Condition Rank Rebound** – Determines what asset condition the intervention brings the asset to

4.0 Asset Analysis of Linear Assets

The linear asset analysis tool contains three main types of worksheets, as outlined in **Figure 25.** This tool is used for calculating the expected life cycle of linear assets, as well as capital cost planning to upgrade the assets. One of the limitations of the linear analysis workbook is that it will only perform a single intervention on an asset, so the life cycle costing of the asset is only projected for the expected life of the asset.

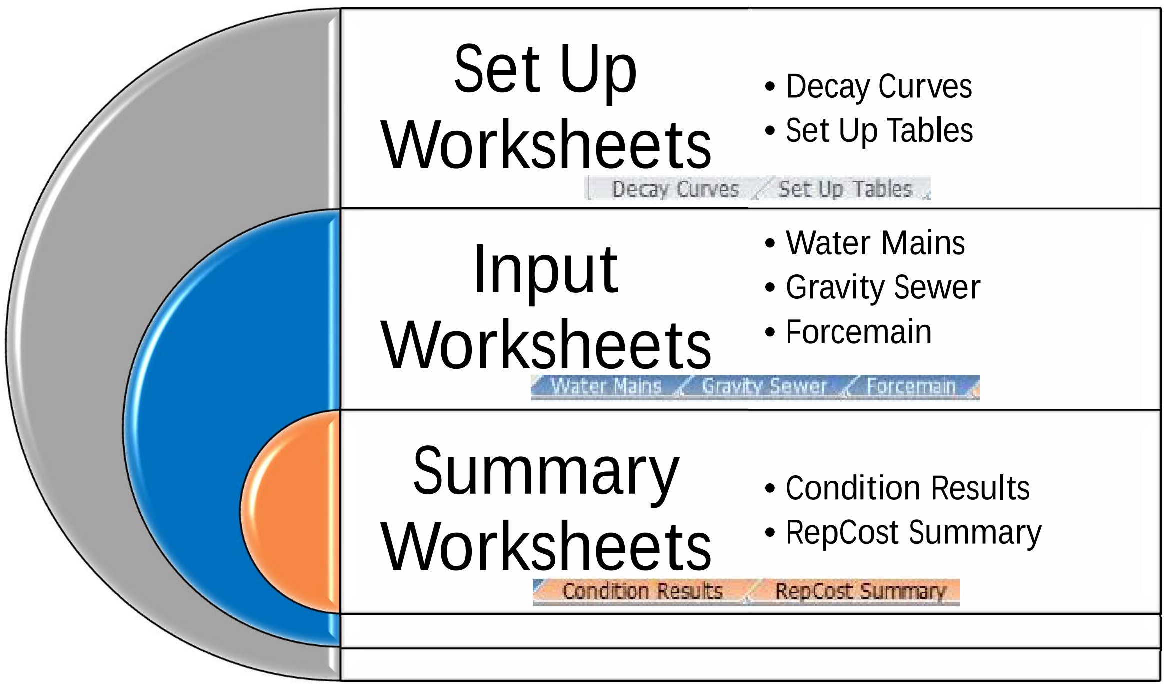


Figure 25 - Linear Asset Analysis Workbook

4.1 Set Up Worksheets

The set up worksheets are highlighted in **"light grey"**. These worksheets are used to organize the data according to the type of assets that will be inputted into the sheet.

4.1.1 Decay Curves

This worksheet contains the decay curve information for all linear infrastructure.

Richard's Growth Curve (3-Parameter Logistic Curve)

$$Y = min + \frac{max - min}{1 + Ae^{-B(t-C)}}$$

Condition Ranking Range: 1 to 5

Underground Piping		
Polyvinyl Chloride	2	60
High Density Polyethylene	2	60
Reinforced Concrete Pipe	3	60
Asbestos Concrete	4	50
Concrete (Non-Reinforced)	4	50
Ductile Iron	5	40
Cast Iron	5	40
Galvanized Pipe	5	40
Corrugated Metal Pipe	6	70

	PVC/HDPE	Reinforced Concrete	Asbestos Concrete	Pipe - DI or CI	Terra Cotta
t [years]	$Y = Min + Range / (1 + A e^{(-B(t-C))})$	$Y = Min + Range / (1 + A e^{(-B(t-C))})$	$Y = Min + Range / (1 + A e^{(-B(t-C))})$	$Y = Min + Range / (1 + A e^{(-B(t-C))})$	$Y = Min + Range / (1 + A e^{(-B(t-C))})$
0.00	0.9990064	0.99944	0.9990040	0.9990022	1.00561692
1.00	0.9990086	0.99957	0.9990058	0.9990036	1.00660333
2.00	0.9990115	0.99974	0.9990085	0.9990059	1.00773648
3.00	0.9990155	0.99995	0.9990125	0.9990097	1.00903807
4.00	0.9990209	1.00022	0.9990182	0.9990158	1.01053302
5.00	0.9990281	1.00057	0.9990266	0.9990258	1.01224987
6.00	0.9990378	1.00103	0.9990388	0.9990422	1.01422132
7.00	0.9990508	1.00161	0.9990566	0.9990688	1.01648482
8.00	0.9990683	1.00236	0.9990827	0.9991123	1.01908321
9.00	0.9990918	1.00333	0.9991207	0.9991833	1.02206552
10.00	0.9991235	1.00457	0.9991762	0.9992992	1.02548774
11.00	0.9991661	1.00617	0.9992573	0.9994882	1.02941384
12.00	0.9992233	1.00823	0.9993757	0.9997967	1.03391676
13.00	0.9993003	1.01088	0.9995485	1.0002999	1.03907963
14.00	0.9994039	1.01428	0.9998008	1.0011209	1.04499705
15.00	0.9995431	1.01866	1.0001692	1.0024600	1.05177647
16.00	0.9997303	1.02428	1.0007069	1.0046434	1.05953981
17.00	0.9999820	1.03150	1.0014917	1.0082014	1.06842505
18.00	1.0003204	1.04076	1.0026372	1.0139942	1.07858800
19.00	1.0007755	1.05261	1.0043085	1.0234116	1.09020418
20.00	1.0013872	1.06777	1.0067463	1.0386848	1.10347060
21.00	1.0022096	1.08713	1.0103004	1.0633591	1.11860771
22.00	1.0033150	1.11177	1.0154785	1.1029722	1.13586106
23.00	1.0048004	1.14306	1.0230150	1.1659332	1.15550283
24.00	1.0067963	1.18261	1.0339682	1.2644240	1.17783306

Lookup X	PVC/HDPE	Reinforced Concrete	Asbestos Concrete	Pipe- DI or CI	Terra Cotta
$Y = Min + Range / (1 + A e^{(-B(t-C))})$					
0.1000000000	65	56	50	40	61
0.9990085880	64	55	49	39	60
0.9990115489	63	54	49	39	59
0.9990155304	62	54	48	38	58
0.9990208847	61	53	47	38	57
0.9990280849	60	52	46	37	56
0.9990377674	59	51	45	36	55
0.9990507880	58	50	44	36	54
0.9990682975	57	50	43	35	53
0.9990918433	56	49	42	34	52
0.9991235063	55	49	41	33	51
0.9991660848	54	48	40	33	50
0.9992233412	53	47	39	32	49
0.9993003349	52	46	38	32	48
0.9994038683	51	46	38	32	47
0.9995430877	50	45	37	31	46
0.9997302893	49	44	36	31	45
0.9999820032	48	43	36	30	44
1.0003204483	47	43	35	30	43
1.0007754861	46	42	34	29	42
1.0013872403	45	41	33	29	41
1.0022096087	44	40	32	28	40
1.0033149650	43	39	31	28	39
1.0048004423	42	38	31	28	38
1.0067963150	41	38	30	27	37

Decay Curves | Set Up Tables | Water Mains | Gravity Sewer | Forcemain | Condition Results | RepCost Summary | Sheet1

4.1.2 Set Up Tables

Update or fill in the set up worksheet with the correct information. The set up worksheet is used as the main modification platform for all components. Any costing information, intervention indices or condition information entered in this sheet will be used to populate the linear results for costing and for the condition assessment. This sheet should be updated or changed where required.

Materials	Useful Life	Intervention		Unit Cost	Unit	Cost Factor
Underground Piping (i.e., Water and Sewer)						
Polyvinyl Chloride	60	4	80%	Dependent on Diameter		1
Reinforced Concrete Pipe	60	4	80%	Dependent on Diameter		1.25
Concrete (Non-Reinforced)	50	4	80%	Dependent on Diameter		1.25
Asbestos Concrete	60	4	80%	Dependent on Diameter		1.25
Ductile Iron	40	4	80%	Dependent on Diameter		1.5
Cast Iron	40	4	80%	Dependent on Diameter		1.5
Corrugated Metal Pipe	70	4	80%	Dependent on Diameter		1.75
High Density Polyethylene	60	4	80%	Dependent on Diameter		1
Galvanized Pipe	40	4	80%	Dependent on Diameter		1.5

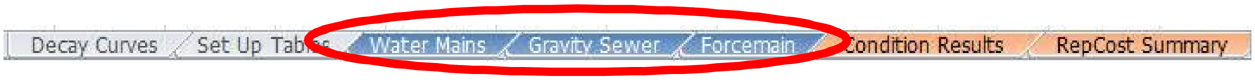
Diameter (mm)	Unit Cost ($/m)
0.1	$200
100	$250
150	$350
200	$400
250	$500
300	$600
350	$700
400	$800
450	$900
500	$1,000
550	$1,050
600	$1,100
650	$1,150
700	$1,200
750	$1,250
800	$1,300
850	$1,350
900	$1,400
1000	$1,500
1050	$1,550
1100	$1,600

Condition Rating Scale

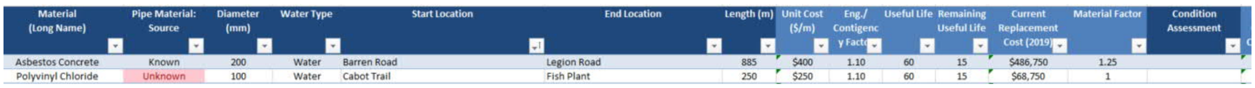
Condition Number	Condition Definition
0	Excellent
1	Excellent
1.2	Excellent
1.2999	Good
2	Good
2.099	Fair
3	Fair
3.9999	Poor
4.98	Poor
4.989	Very Poor
5	Very Poor

4.2 Input Worksheets

The tabs that are highlighted in **"blue"** (i.e. Water Main, Gravity Sewer and Forcemain) are the main sheets that require users to input information.



Within each sheet, there are columns that the user has to input data and others that are populated using the inputted data, set up tables and decay curves. The cells that are in **"dark blue"** are the cells that information has to be inputted by the user, the cells in **"light blue"** are the calculated cell and should not be changed by the user.



Material (Long Name)	Pipe Material: Source	Diameter (mm)	Water Type	Start Location	End Location	Length (m)	Unit Cost ($/m)	Eng./ Contigency Facto	Useful Life	Remaining Useful Life	Current Replacement Cost (2019)	Material Factor	Condition Assessment
Asbestos Concrete	Known	200	Water	Barren Road	Legion Road	885	$400	1.10	60	15	$486,750	1.25	
Polyvinyl Chloride	Unknown	100	Water	Cabot Trail	Fish Plant	250	$250	1.10	60	15	$68,750	1	

The condition of an asset can be calculated two ways:

1) Using decay curves; or
2) By visual condition assessments.

The user has the ability to either input a condition in the **"dark blue"** column labelled *Condition Assessment* or to leave it blank and let the tool output an *Expected Condition Assessment*. If a condition assessment was input by the user, this will override the expected condition thus making the "Actual Condition Ranking" the visual condition assessment.

4.3 Summary Worksheets

A summary of both the condition and cost results are outputted in the worksheets highlighted in **"orange"**.

These worksheets include pivot tables that are used to summarize the results from the data worksheets. These can be modified to output the information that the user want to analyze.

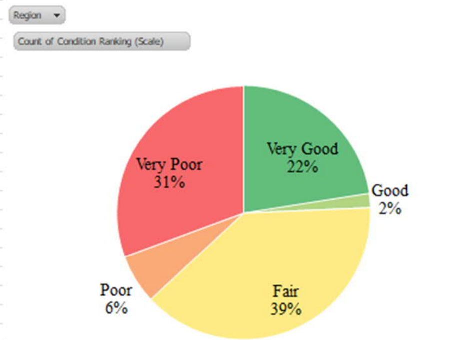
4.3.1 Condition Results

This worksheet contains only the condition results of the linear infrastructure. The condition results are broken down by the type of infrastructure (watermain, gravity sewer, and forcemain) and can be viewed by region using the "Region" drop down list.

Watermain

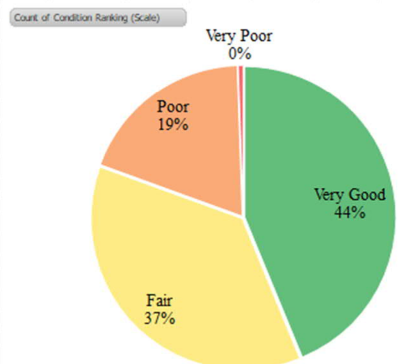
Region (All)

Row Labels	Count of Condition Ranking (Scale)
Very Good	25
Good	2
Fair	43
Poor	7
Very Poor	34
Grand Total	**111**



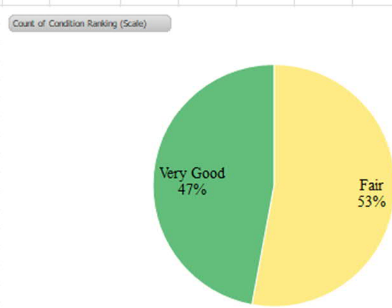
Gravity Sewer

Row Labels	Count of Condition Ranking (Scale)
Very Good	81
Fair	68
Poor	35
Very Poor	1
Grand Total	**185**



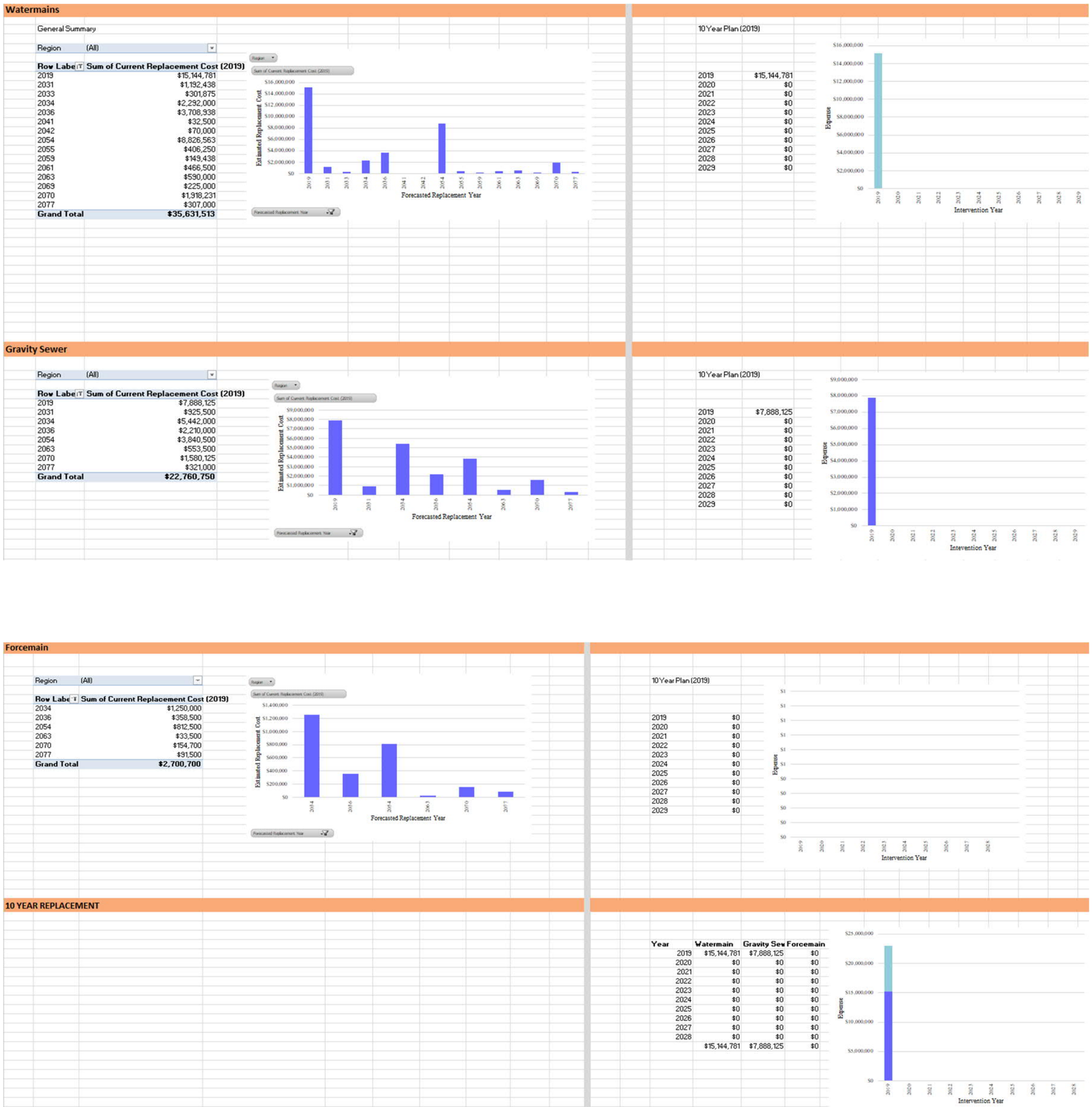
Forcemain

Row Labels	Count of Condition Ranking (Scale)
Fair	9
Very Good	8
Grand Total	**17**



4.3.2 RepCost Summary

This worksheet contains the projected replacement costs for the linear infrastructure. The forcasted replacement year graph displays the estimated capital cost to replace all linear infrastructure in the system. Similar to the Condition Results sheet, the replacement costs are broken down by the type of infrastructure (watermain, gravity sewer, and forcemain) and can be viewed by region using the "Region" drop down list.



Watermains

General Summary

Region (All)

Row Labels	Sum of Current Replacement Cost (2019)
2019	$15,144,781
2031	$1,192,438
2033	$301,875
2034	$2,292,000
2036	$3,708,938
2041	$32,500
2042	$70,000
2054	$8,826,563
2055	$406,250
2059	$149,438
2061	$466,500
2063	$590,000
2069	$225,000
2070	$1,918,231
2077	$307,000
Grand Total	$35,631,513

10 Year Plan (2019)

2019	$15,144,781
2020	$0
2021	$0
2022	$0
2023	$0
2024	$0
2025	$0
2026	$0
2027	$0
2028	$0
2029	$0

Gravity Sewer

Region (All)

Row Labels	Sum of Current Replacement Cost (2019)
2019	$7,888,125
2031	$925,500
2034	$5,442,000
2036	$2,210,000
2054	$3,840,500
2063	$553,500
2070	$1,580,125
2077	$321,000
Grand Total	$22,760,750

10 Year Plan (2019)

2019	$7,888,125
2020	$0
2021	$0
2022	$0
2023	$0
2024	$0
2025	$0
2026	$0
2027	$0
2028	$0
2029	$0

Forcemain

Region (All)

Row Labels	Sum of Current Replacement Cost (2019)
2034	$1,250,000
2036	$358,500
2054	$812,500
2063	$33,500
2070	$154,700
2077	$91,500
Grand Total	$2,700,700

10 Year Plan (2019)

2019	$0
2020	$0
2021	$0
2022	$0
2023	$0
2024	$0
2025	$0
2026	$0
2027	$0
2028	$0
2029	$0

10 YEAR REPLACEMENT

Year	Watermain	Gravity Sewer	Forcemain
2019	$15,144,781	$7,888,125	$0
2020	$0	$0	$0
2021	$0	$0	$0
2022	$0	$0	$0
2023	$0	$0	$0
2024	$0	$0	$0
2025	$0	$0	$0
2026	$0	$0	$0
2027	$0	$0	$0
2028	$0	$0	$0
	$15,144,781	$7,888,125	$0

References

- Request for Proposals
  - MCI-RFP-0918
- Record Drawings
  - Harbourview Sewer and Water Project – Project 08-34
    - Sheets 10 to 100, 210, 300
  - Maple Street/Old Deepdale Road Sewer Extensions – Waterline Replacement – Project 16-05
    - Sheets 05, 10 to 30
  - Port Hawkesbury – Port Hastings Sewage Treatment Plant, Port Hastings Water Distribution & Sewage Collection Phase 1-D
    - Sheets 10 to 270, 271, 272, 280 to 320
  - Cheticamp Wastewater Treatment Facility Upgrade Project 2014
    - Specification
  - Mabou Sewerage and Water System – Job 346 & 409
    - Sheets 3 to 12
- Drawings
  - The Community of Inverness, Nova Scotia Water Supply and Treatment System
    - Sheets 2-1, 2-1, 4-1 to 4-6
- Reports
  - Pre-Design Report for Harbourview Sewer and Water Project 08-34 (December 2008)
  - Inverness Public Water System – System Assessment Report (May 2013)
  - Judique Wastewater Treatment Plant System Assessment Report – Final Report (January 2018)
  - Mabou Public Water System – System Assessment Report (April 2013)
  - Port Hastings Public Water System – System Assessment Report (March 2013)
  - Port Hood Public Water System – System Assessment Report (April 2013)
  - 2015 Wastewater Annual Reports
    - Cheticamp Sewage Treatment Facility
    - Inverness Sewage Treatment Facility
    - Port Hood Sewage Treatment Facility
    - Whycocomagh Sewage Treatment Facility
  - 2016 Wastewater Annual Reports
    - Cheticamp Sewage Treatment Facility
    - Inverness Sewage Treatment Facility
    - Port Hood Sewage Treatment Facility
    - Whycocomagh Sewage Treatment Facility

    - Mabou Sewage Treatment Facility
    - Judique Sewage Treatment Facility
- 2017 Wastewater Annual Reports
    - Cheticamp Sewage Treatment Facility
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    - Whycocomagh Sewage Treatment Facility
- 2015 Water Annual Reports
    - Inverness County Water Systems - Annual Report 2015 (2016-04-26) R1
    - Inverness Water System - NSE Annual Report, 2015 (2016-05-16)
    - Judique Water System - NSE Annual Report, 2015 (2016-05-16)
    - Mabou Water System - NSE Annual Report (2016-05-16)
    - Port Hastings Water System - NSE Annual Report, 2015 (2016-05-16)
    - Port Hood Water System - NSE Annual Report, 2015 (2016-05-16)
    - Revised Port Hood Sheet January 2015
    - Whycocomagh Water System - NSE Annual Report, 2015 (2016-05-16)
- 2016 Water Annual Reports
    - Inverness Water System - NSE An. Report for 2016 (2017-04-30) Revised
    - Judique Water System - NSE An. Report for 2016 (2017-04-30) Revised
    - Mabou Water System - NSE An. Report for 2016 (2017-04-30) Revised
    - Port Hastings Water System - NSE An. Report for 2016 (2017-04-30) Revised
    - Port Hood Water System - NSE An. Report for 2016 (2017-04-30) Revised
    - Whycocomagh Water System - NSE An. Report for 2016 (2017-04-30) Revised
- 2017 Water Annual Reports
    - Inverness Water System Report
    - Judique Water System Report
    - Mabou Water System Report
    - Port Hastings Water System Report
    - Port Hood Water System Report
    - Whycocomagh Water System Report
- Whycocomagh Wastewater Treatment Plant – Pre-Design Study – Revised Draft Report (October 2017)
- Whycocomagh Public Water System – System Assessment Report (March 2013)
- Whycocomagh Wastewater Treatment Plant – System Assessment Report – Final Report (September 2017)

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