Town of Lake Park Stormwater Masterplan

Task 5
Operations and Maintenance Program Review

Town of Lake Park, FL
Public Works Department

March 17, 2020

WRMA

TABLE OF CONTENTS

TABLE OF CONTENTS

List of Tables

List of Figures

Appendices

Section 1 Introduction

About Lake Park

The Town of Lake Park, Florida was originally founded as Kelsey City in1923, as the first zoned municipality in Florida. Located within Palm Beach County, South of North Palm Beach and North of Riviera Beach, the Town has a population of approximately 8,155 people as of the 2010 Census with a 2018 estimated population of 8,605. The Town contains 2.5 square miles of property, including 2.2 square miles of dry land. Approximately 0.18 square miles (7.2%) of the Town's area is located within the waters of the Lake Worth Lagoon (LWL). Located towards the Southwestern portion of the Town is the Lake Park Scrub Natural area, which includes approximately 0.13 square miles of preserved area.

The Town is composed of 0.70 square miles of high, medium and low intensity residential areas on the Town’s Eastern boundary and an industrial area to the West along 10th street and Dixie Highway. A downtown area lies along Park Avenue between 10th Street and 6th Street. The Town of Lake Park is located at 26°48′1″N 80°3′51″W (26.800389, -80.064237). **Figure 1-1** shows the Town of Lake Park boundary.

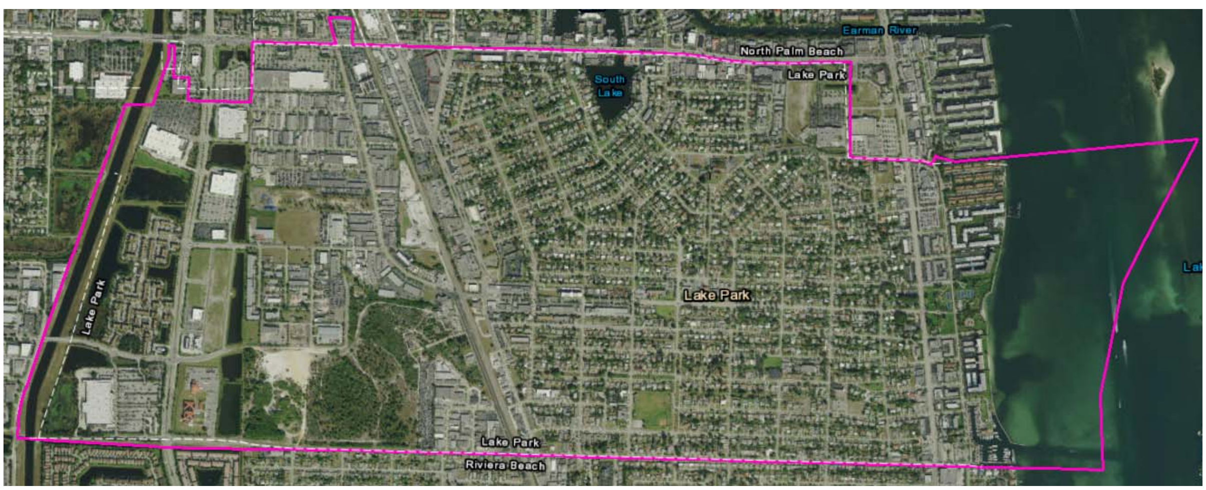

Figure 1-1 Town Limits of the Town of Lake Park, FL

Previous Stormwater Masterplan Updates

The development of Lake Park started in earnest in the 1950’s and by the 1980’s was considered fully developed. As development took place, public drainage facilities were installed sparsely throughout the Town. Drainage facilities on private property were installed as needed or per the requirements of the South Florida Water Management District and the Town's Land Development Code at the time they were constructed between 1950 until today. The Town’s current stormwater drainage system consist mostly of grassed swales within the Right of Way for conveyance of runoff to catch basins and underground pipes discharging through 10 major outfalls to the Intracoastal waterway and the C-17 Canal.

In 1980, the Town determined there was a need for a comprehensive storm drainage improvement program and a Comprehensive Plan for the Town was adopted in May 1980. Later, in 1986, a Stormwater Masterplan (SWMP) was prepared to develop a stormwater atlas of drainage facilities and to prioritize operations and maintenance activities. The Plan was updated in 1993 and again in 1996. Since the last drainage masterplan was updated, the failure rate of existing drainage infrastructure has accelerated. Additionally, development and climatic and environmental stressors pose a challenge to the existing system's capacity to handle storm events of medium to large magnitude. In 2018, the Town of Lake Park identified a need to again, update the stormwater masterplan in an effort to develop a roadmap for the management of stormwater townwide, and to identify programs and projects to repair and replace existing stormwater assets as well as to identify opportunities to implement new infrastructure and stormwater management strategies.

2019 Stormwater Master Plan Update Goals

The 2019 stormwater masterplan (SWMP) update is intended to provide the Town with a long-range stormwater management planning tool or "Road Map" that will allow for the rehabilitation of the existing drainage infrastructure over the next 25 years. The plan will examine the sewer condition data, mathematically-analyze the performance of the stormsewer and drainage swale infrastructure, conceptualize alternatives, make recommendations for rehabilitation, and develop a phased capital improvement plan for project implementation based on an analysis of current and projected funding sources (Annual Utility Revenues, Bonding, Grants, etc.).

To take advantage of advances in topographic, GIS, and GPS technologies which are now common in the management of public infrastructure asset management systems, the SWMP update will be data driven, utilizing the most recent available high quality data sources for topographic elevation and geo-spatial data. The high resolution topographic data, in combination with field data captured using dynamic GPS and traditional field surveys, the SWMP will be developed using state-of-the-art 2-Dimensional Hydrologic & Hydraulic (H&H) numerical models.

The SWMP update will also utilize Green Infrastructure planning approaches and Low Impact Development (LID) Best Management Practices (BMP's) for stormwater management. Green infrastructure methods include the use of bio-retention, rainwater harvesting and infiltration systems of varying size and configuration, in combination with traditional conveyance and end of pipe infrastructure.

The objective of LID will be to reduce the frequency with which the City's stormwater system releases runoff into the downstream end of pipe conveyance system and to the receiving water body of the Lake Worth Lagoon. The SMWP goal for Climate Change abatement will be to provide green infrastructure for 10% of the impervious surface area over the next 25 years, capable of capturing one inch of rain during storms. This objective if achieved, would not only reduce the total volume of runoff to be conveyed and treated at a lower cost, but also would offset the increase of rainfall intensity caused by climate change extreme events (i.e. A 3-year/one hour storm event today will likely be equivalent to a 5-year/one hour storm event in 20 years). **Figure 1-2** is an exhibit of the United States Army Corps of Engineers (USACE) Sea Level Rise (SLR) projection, which shows a 26 inch increase in mean sea level by 2060. The Town is currently planning and implementing new climate conscious development strategies through modifications to the Town's comprehensive plan as well as the Land Development Code.

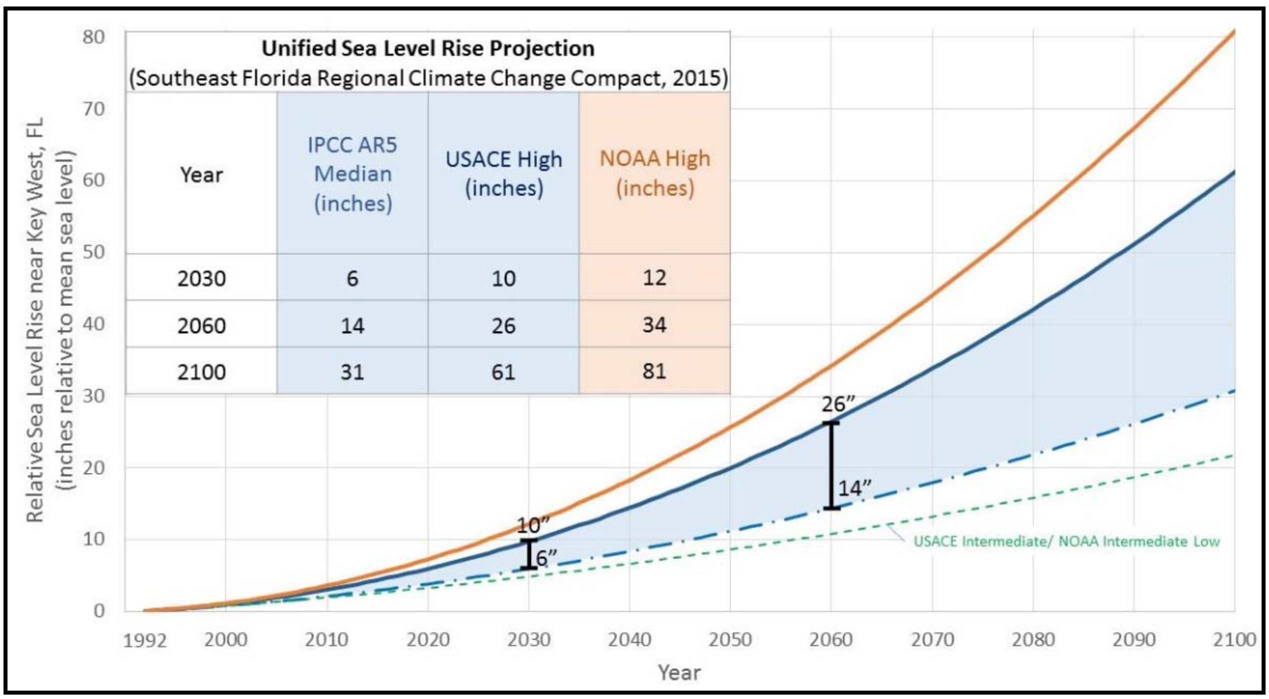

Figure 1-2 SE Florida Regional Climate Change Compact, 2015, Unified Sea Level Rise Projection

Stormwater Masterplan Tasks

As part of the development of the 2019 SWMP update, the Town has identified 10 activities, each which shall consider aspects of the Town's stormwater management infrastructure and flood control strategies, and their associated impact on the Town's financial health and economic development. This technical report represents the deliverable for Task 5.0 - Operations and Maintenance.

The updated 2020 Stormwater Masterplan includes the following activities:

Task 1.0	Data Collection And Management
Task 2.0	Community Rating System (Crs) Program Review
Task 3.0	Outreach And Communications
Task 4.0	Climate Change And Sea Level Rise Assessment
Task 5.0	***Operations And Maintenance (O&M) Program Review***
Task 6.0	Water Resources Engineering Modeling Science
Task 7.0	Project Management
Task 8.0	Alternatives Analysis
Task 9.0	Stormwater Utility Administration And Funding Sources
Task 10.0	Stormwater Master Plan Report

Section 2 Operations and Maintenance (O&M) Program Review

2.1 Organizational Structure, Mission & Equipment

Stormwater operations and maintenance is a function of the Public Works Department. The Town of Lake Park Public Works Department is organized into seven (7) Divisions to deliver the mission of maintaining the Town's roadways, buildings, fleet, grounds, parks and drainage infrastructure.

1. *Administration Division*: Supervises and provides support to staff, Coordinates consultants and vendors and provides contract oversight, Manages Capital Improvement Projects (CIP).
2. *Sanitation Division:* Serves businesses and residents with collection and disposal of garbage, trash, vegetation, and recycling pickup. It also provides garbage cans, recycling bins and dumpsters as needed.
3. *Grounds Maintenance Division*: Maintains the Town's 28 acres of parks, medians, easements, alleyways, building grounds and greenery, including grass, trees and shrubbery.
4. *Facilities Division:* Is responsible for building maintenance and repair, and assists other departments with special events and functions.
5. *Vehicle Division:* Services Town-owned vehicles and equipment.
6. *Streets and Roads Division*: Repairs and maintains the Town's streets, sidewalks, street signs and signals.
7. *Stormwater Division:* Repairs and maintains the Town's storm drains and related infrastructure.

The Stormwater Division is composed of the following Town staff and their roles:

- Richard Scherle, Public Works Director – Role: Assists with project management/procurement
- Michel Abdelmessih, Project Manager – Role: Manages stormwater projects
- John Wylie, Stormwater Infrastructure Manager – Role: Manages maintenance and operations
- Peter Mikes, Stormwater Technician – Role: Provides labor as needed

The Town is responsible for and committed to operating and maintaining a storm sewer network, comprised of swales and stormsewer pipes with a wide range of diameter and material, as well as other infrastructure such as storm inlets, manholes, and outfalls. **Figure 2-1** shows the extent of the drainage system.

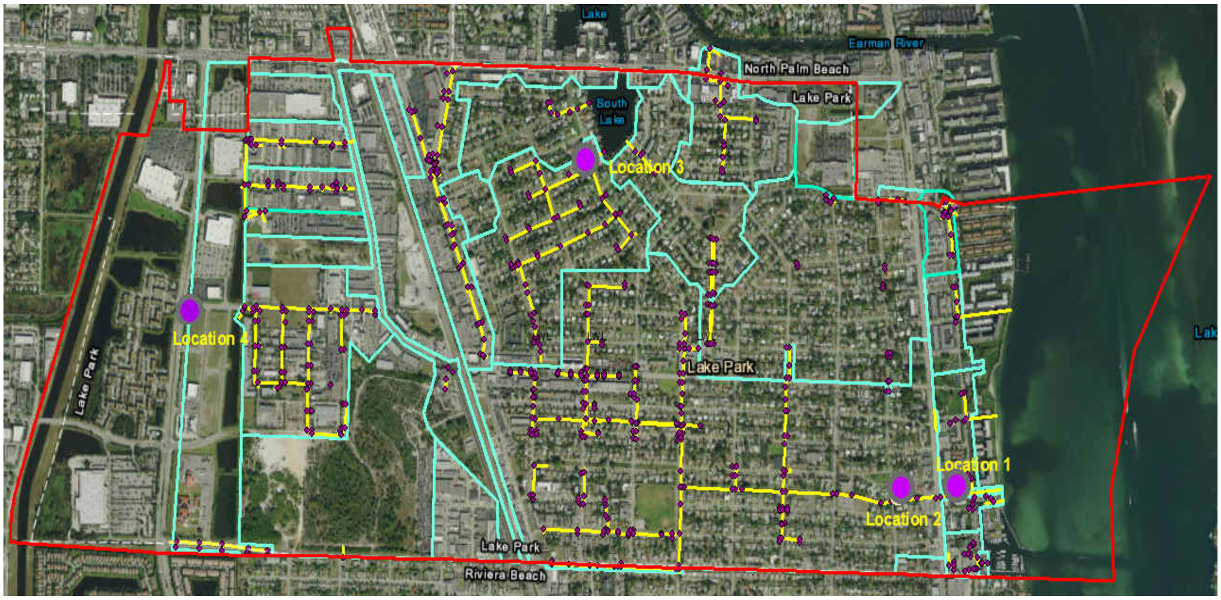

Figure 2-1 Town of Lake Park Stormwater/Drainage System by Basins

Table 2-1 presents a summary of the Town's stormwater asset geodatabase (as of August 2019 by CGA) by length, diameter, and material. As shown in **Table 2-1**, the Town's existing drainage system consists of approximately 10.6 miles of stormsewers and 589 structures, with drainage pipes ranging in size from 8-inch to 72-inch in diameter.

The prevalent diameter is the 15-inch pipe (29.8%), followed by 24-inch (16.5%) and 18-inch (14.5%). The prevalent pipe material is RCP (76.33%), followed by HDPE (17.31%) and CAP (3.55%). The CMP pipe, listed as "metal" in the database, accounts for 2.31% of the total length.

Curb, Gutter and Ditch Inlets account for 79.9% of all structures (471 out of 589). There are 107 manholes, 6 end walls and 5 null (unclassified) structures. The stormsewer system database indicates that 88.4% of the network is owned and operated by the Town of Lake Park, followed by 9.6% maintained by Palm Beach County along Old Dixie Highway, Northlake Boulevard, Tenth Street and Prosperity Farms Road. Private sewers account for 1.6% of the total pipe length. The CGA-acquired stormsewer system dataset was presented in ***Deliverable 1, Appendix A***.

Table 2-1 Stormwater Collection System Summary Breakdown

Pipe Diameter (in)	RCP (ft)	HDPE (ft)	CAP (ft)	Metal (ft)	PVC (ft)	Total (ft) (%)
8	-	-	48	-	238	**286 (0.51)**
10	-	36	-	-	-	**36 (0.064)**
12	451	927	251	16	39	**1,684 (3.0)**
15	12,889	3,163	597	119	-	**16,768 (29.8)**
18	5,229	2,851	75	-	-	**8,155 (14.5)**
24	7,095	1,713	54	391	-	**9,253 (16.5)**
30	7,893	559	-	172	-	**8,624 (15.3)**
34	729	-	-	-	-	**729 (1.3)**
36	4,367	482	520	603	-	**5,972 (10.6)**
42	545	-	54	-	-	**782 (1.4)**
48	1,305	-	237	-	-	**1,542 (2.7)**
54	894	-	-	-	-	**894 (1.6)**
60	1,516	-	-	-	-	**1,516 (2.7)**
72	-	-	162	-	-	**162 (0.29)**
Total Length (ft) (%)	**42,913 (76.33)**	**9731 (17.31)**	**1,998 (3.55)**	**1,301 (2.31)**	**277 (0.5)**	**56,220 ft or 10.65 miles**

Modern engineering practices employ the use of high density polyethylene (HDPE) pipe and reinforced concrete pipe (RCP), particularly in coastal environments. HDPE pipes often have a service life of approximately 75 years, and the material offers a high resistance to heat and aggressive media, among other qualities. RCP, which also has a long useful life, is durable and rigid, with high compressive strength compared to other building materials. RCP can also withstand a fair amount of tensile strength due to the steel reinforcement, is low in maintenance cost, and has a high level of resistance to saline environments. RCP of pipe is used mostly for road culvert crossings.

The Town has significant stormwater infrastructure that was installed since the 1920s, when VCP (Vitrified Clay Pipe) was commonly utilized. Interestingly, no VCP pipes were catalogued indicating that these pipes were in all likelihood replaced by CMP (1970’s and 1980’s), and by HDPE and RCP in the last decades.

Most of the system is RCP (76.3%) which greatly facilitates O&M activities and program renewal as this type of pipe is robust and durable. Additionally, the Town’s current Stormwater Atlas identifies 3,299 feet of CAP and CMP (5.86%). CMP is a modern pipe material but does not possess the long useful life of RCP, particularly when exposed to the saline environments present throughout eastern Town watersheds. Of these CAP/CMP linear assets, 1,123 feet are 36 inches in diameter and likely to be approaching the end of useful life and should be a priority for O&M inspection and planned pipe renewal.

The Stormwater O&M staff are deployed daily to perform scheduled activities, many of which are associated with NPDES MS4 permit compliance and are available 24 hours a day for emergency situations. Services provided by Stormwater O&M staff for MS4 permit compliance include, but are not limited to, the following:

- Litter control programs;
- Street sweeping;
- Completion of various flood control and retrofit projects;
- Controls and programs to minimize water resource impacts resulting from application of pesticides, herbicides, and fertilizer;
- Prevention and enforcement actions for illicit discharges;
- Staff training on spill response;
- Inventory and enforcement (as needed) for high risk facilities;
- Controls and actions for reducing impacts from runoff for construction sites; and
- Staff training regarding various methods to prevent non-point source pollution.

Additionally, the Stormwater O&M staff is also responsible for cleaning, condition assessments and repairs on an emergency basis. Further information regarding the Town's process for addressing non-planned repairs is provided the next section of this report.

In order to help meet its service commitments, the Stormwater Division staff has been provided with the following equipment to perform the assigned duties:

- 2009 Vac-Con Vacuum truck ;
- Tymco model 600 Street sweeper – new truck being manufactured;
- 2006 New Holland LS190 skid steer loader;
- ¾ ton Chevy pickup truck;
- 12' manhole ladder;
- 2000-watt generator w/ confined space ventilation;
- Miscellaneous electric power tools;
- Miscellaneous hand tools;

Based on the 2019 NPDES/MS4 Permit Annual Reporting Requirements, the following activities were completed by the Town's O&M staff for the year 2019:

- Percentage of storm drain line inspected: 3.66% (0.38 miles)
- Percentage of storm drain line cleaned: 10.05% (1.04 miles)
- Storm drain Structures Cleaned/Inspected: (42 of 409) 10.27%
- Footage of Exfiltration Structures Inspections: 101 Feet
- Percentage of Exfiltration Drain Structures Inspection Completed: 9 of 35 (25.71%)
- Grass Swales Structural Control Inspections: 35
- Linear Feet of Grass Swale Inspections: 6,731 Feet (1.27%)
- Number of Illicit Discharge and Improper Disposal Response: 4
- Annual Combined Total of Stormwater & Street Sweeping Debris Collection (Dry) : 78,300 Lbs
- Total Street Sweeping: 261 Miles
- Contractor Litter Collection Program Pick Up: 18.75 CY
- Town Litter Collection Program Pick Up: 276.6 CY
- Total Pounds of Phosphorus Removed (Dry): 28.27 Lbs
- Total Pounds of Nitrogen Removed (Dry): 44.08 Lbs
- Total Miles of Swale/Right of Way Improvements: 0.07 Miles
- Total Annual Pipe Replacement: 568 Feet (355' of 36" and 36' of 15" by Trenchless CIPP, 134' of 15" and 43' of 36" by RCP Open Cut Replacement)

2.2 Processes, Activities and Reporting

WRMA met with the Town's Stormwater O&M staff to discuss the process employed by the Town to operate and maintain the Town's stormwater assets. As part of the Town's MS4 permit conditions, the Stormwater O&M staff schedules the various activities associated with MS4 permit (as listed in the previous section) and documents the completion of the work through inspection forms, which are subsequently uploaded to a local supervisor's computer and annually reported to the FDEP NPDES/MS4 group program manager (North Palm Beach County Improvement District).

The town does not currently have the financial capacity to operate a Computerized Maintenance Management System (CMMS) for automated reporting to FDEP. A CMMS system, is a software package that maintains a computer database of information about an organization's maintenance operations.

The Stormwater O&M staff are also responsible for reacting to other, non-planned repairs on an as-needed basis. Below is an overview of the Town's process for non-planned inspections.

1. *Identification of Concern:* O&M crews are alerted of issues through customer service inquiries.
2. *Initial Evaluation of Concern*: O&M staff and/or other Town staff visit the site and evaluate areas of concern.
3. *Schedule Inspection*: Depending on complexity, either O&M staff perform inspections using previously applied Standard Operating Procedures (SOPs), or Public Works outsources inspection to on-call contractors.
4. *Inspection Performed:* NASSCO overall rating system currently used.
5. *Decision on Rehabilitation Methodology:* Repair methodology is selected by PW/O&M staff in consultation with engineer consultant and/or contractor.
6. *Rehabilitation Performed:* Pipes are typically repaired using CIPP or open-cut replacement:
    - In-house crews typically perform simpler repairs (i.e., point repairs on shallow small pipes)
    - Riskier or more complex projects requiring extensive dewatering are outsourced using an on-call contract.
7. *Documentation/Reporting:* Work completed by in-house crews or by an on-call contractor is documented on daily inspection forms and uploaded to the supervisor's computer system. Point repair or replacement O&M work plans are not currently stored digitally as the Town does not currently have a dedicated GIS Department (Any GIS generated plans are retained in the Contractor's or Consultant computers).

WRMA's review indicates that the Town O&M Division does not have or adhere to any specific stormwater/drainage system Standard Operating Procedures (SOP's), standards details, constructions methods and materials lists. Instead, the staff relies on the technical advice of the Consultant or Contractor assigned to the O&M task.

WRMA's review also found that the Town PW/O&M staff uses an annual contract solicitation to procure the services of a local contractor to perform the CCTV inspections, CIPP, and open cut pipe replacement. Although this is a competitive contract, there are no previous catalogued O&M activity pricing for basis of comparison and contract selection.

WRMA also reviewed drainage system maintenance activities to identify opportunities to maximize potential CRS Activity-540 credit points. The maximum credit for Activity-540 is 570 points. The Objective of this activity is to ensure that the community keeps its channels and storage basins clear of debris so that their flood carrying and storage capacity are maintained.

An area's drainage system consists of natural watercourses or channels, constructed storm drains and ditches, and detention/retention basins built to store high flows. When a drainage system loses a portion of its conveyance or storage capacity, overbank flooding occurs more frequently and flows reach higher elevations, potentially damaging nearby structures or causing increased channel erosion. If a community can answer "yes" to the following questions, it should be able to receive credit for this activity.

- Is there an annual inspection for at least some of the drainage system?
- Are inspections also conducted after major storms and in response to citizens' complaints?
- Are debris and other obstructions to flow or storage removed when they are found?
- Does the drainage maintenance program have written procedures?

WRMA has verified that these activities are already performed by the Town O&M Division and will leverage the implementation for CRS credits when a scheduled visit takes place later in the year 2020.

2.3 Recommended SOP's & Contracting Procurement Procedures for O&M Activities

WRMA has reviewed Standard Operating Procedures (SOP's) for stormwater system operation and maintenance applied by municipalities similar to the Town's size, location and resources, and compiled a list of SOP's that are recommended for adoption by the Town O&M Division. The SOP list is to be used as a resource and for adaptation for specific O&M issues, as each community is different and SOP's become final after successive/successful application. The SOP list is provided in **Appendix A.**

2.3.1 Stormwater Pipes

WRMA recommends the adaption of the Florida Department of Transportation (FDOT) pipe inspection criteria/methodology as a resource for implementing O&M stormwater drainage system inspections and repairs.

FDOT/Turnpike Authority Pipe Inspection and Repair Methodology

As the Town develops its stormwater program, it is critical that the specifications and project controls developed represent best practices and current industry standards. This section analyzes several Florida Department of Transportation (FDOT) documents that relate to stormwater pipeline inspection and construction standards. Since the FDOT operates stormwater systems throughout the State of Florida, the Department has a standardized approach and has optimized their program over the last several decades. This section looks at *Chapter 8.3 of the Construction Project Administration Manual (CPAM*), as well as *Section 5 and Section 430 of the FDOT standard specifications*. These sections will attempt to determine the applicability of these documents to the Town's stormwater program, and whether these procedures could be adopted and/or modified for use as guidelines for the Town's use. It is important to note that drainage pipes in service for more than 50 years are past their effective design life and would have a low likelihood of meeting any of the criteria below. The links for these documents are provided:

https://www.fdot.gov/construction/manuals/cpam/cpammanual.shtm

https://www.fdot.gov/programmanagement/implemented/specbooks/default.shtm

CPAM – Chapter 8.13 Construction Project Administration Manual

Chapter 8.13 of the FDOT's Construction Project Administration Manual contains a document entitled "Pipe Inspection, Evaluation, and Repair". The stated goal of Chapter 8.13 is "*to establish a standard procedure to ensure consistent review of all post installation pipe inspections associated with construction projects*". This document was written to address defects in newly installed drainage pipes, as opposed to repairing pipes that have been installed for several decades. It is unlikely that pipes in service for 50 years or more will pass any of the CPAM criteria.

Section 8.13.6.2 of the same document, addresses how to evaluate defects found in pipe inspection reports for newly installed pipe. It provides the following guidance relative to concrete pipe:

- **Cracking** – Cracks less than >0.01 inches in width and less than 12 inches in length;
- **Stains** – Not considered a defect unless associated with a crack in excess of certain tolerances;
- **Infiltration** – FDOT specifications require storm drains to be watertight to 5 psi;
- **Joint gaps** – FDOT specifications do not have joint gap tolerances for pipes other than concrete. Repair limited to hanging gaskets, joint damage, and infiltration.
- **Deflection** – Pipe with deflection greater than 5% must be replaced/repaired (note that most existing pipe would not meet this criteria)

The repair guidance states that proposed repair procedures should conform to the Pipe Repair Matrix (See **Figures 2-2 and 2-3**, Exhibits 5 and 6 for examples of repair to newly installed metal and concrete pipe). The FDOT does not allow hand application of grout for repair, only pressurized injection. Furthermore, the FDOT does not accept cured-in-place (CIPP) point repairs.

Exhibit 5. Pipe Repair Matrix for Metal

Pipe Type	Problem Noted	Acceptable Repair Methods
Metal Pipe	1. Coating has been damaged by welding fabrication or from excessive rough handling.	Pipe should be repaired using special paints and procedures as outlined in ASTM A 780
**There are several types of metal pipe listed in the Drainage Manual. They Include:		
1. Corrugated Aluminum Pipe (CAP)	2. Pipe damaged during normal handling which results in dents but no coating loss. The indentation cannot exceed the 5% deflection or can be no greater than 1 square foot or 10% of the diameter.	Saddle plates per the manufacturers recommendation covering the area of damage can be provided to cover the indentation and should be field welded to the pipe. Any damaged metallic coating shall be repaired according to ASTM A 780
2. Corrugated Steel Pipe (CSP)		
3. Corrugated Aluminized Steel Pipe (CASP)	3. Joint gaps, leaks, or gasket intrusion	1. Internal joint seals
4. Spiral Rib Aluminum Pipe (SRAP)		
5. Spiral Rib Steel Pipe		2. Concrete collars in accordance with Index 280 of the Department's Design Standards.
6. Spiral Rib Aluminized Steel Pipe (SRASP)		
		3. Pressure injection of an acceptable flexible chemical grout.
		4. Pipe lining with materials and methods found in Section 431 of the Department's Standards Specifications

Source: FDOT Office of Construction, 2017.

Figure 2-2 FDOT CPAM Chapter 8.13 Exhibit 5 - Pipe Repair Matrix for Metal

Exhibit 6. Pipe Repair Matrix for Concrete

Pipe Type	Problem Noted	Acceptable Repair Methods
Steel-Reinforced Concrete Pipe	1. Cracks	1. Seal cracks using pressurized injection an approved chemical grout of either acrylamide base gel, acrylic base gel, urethane base gel or urethane base flow
* Cracks that are 0.01 inches or greater in width and 12 inches or greater in length (ASTM C76) must be repaired or assessed by a Specialty engineer who can evaluate structural integrity, environmental conditions and the design service life of the culvert (AASHTO LRFD Chp. 27).		2. Pipe lining with materials and methods found in Section 431 of the Department's Standards Specifications
		3. Mechanical Repair Sleeve
	2. Spalling	Spalling will be remediated by cleaning and removing any loose materials, if possible, and then applying a Portland cement grout or rapid setting mortar cement or grout or epoxy resin to the affected area.
	3. Leaking Joints	1. Pipe lining with materials and methods found in Section 431 of the Department's Standards Specifications
		2. Internal Joint seals
		3. Pressure injection of an acceptable chemical grout.
		4. Concrete collars in accordance with Index 280 of the Department's Design Standards.
		5. Mechanical Repair Sleeve

Source: FDOT Office of Construction, 2017.

Figure 2-3 FDOT CPAM Chapter 8.13 Exhibit 6 - Pipe Repair Matrix for Concrete

The FDOT Repair Matrix is a guidance document and does not replace the specifications, proper installation or sound engineering judgment of the Town staff and/or Town consultants and contractors. The Repair Matrix can be an excellent reference applicable to the Town's stormwater program for new installations. However, applicability would be limited concerning the existing infrastructure.

Section 5 and Section 430 Standard Specifications

Section 5 addresses control of work and conformity with contract documents. It contains mostly administrative requirements such as shop drawing review procedures and how to evaluate claims. It is generally not applicable to the Town's stormwater program. Section 430 addresses the installation of new pipe culverts, including all of the tolerances and construction requirements for furnishing and installing drainage pipe. It should be noted that FDOT allows the use of both flexible and rigid pipe and have specific performance criteria for each pipe material.

Section 430 also covers approved materials as well as installation procedures. Section 430-4.8 addresses pipe inspection. Notable requirements of Section 430-4.8 include the following guidance on when to perform the inspection:

- For pipes installed under the roadway, inspection is to be done when the backfill reaches 3 feet above the pipe crown or upon completion of the stabilized sub-grade.
- For pipe installed within fills, including embankments confined by walls, inspection is to be conducted when compacted embankment reaches 3 feet above the pipe crown or the finished earthwork grade as specified in the plans.

Section 430-4.8 also states that for pipe 48 inches or less in diameter, the Contractor must provide the Engineer with a video DVD and report using low barrel distortion video equipment with laser profile technology, non-contact video micrometer and associated software. **Figure 2-4** shows Exhibit 7 below shows the required criteria for laser profiling. FDOT requires the following information as part of the report:

1. Actual recorded length and width measurements of all cracks within the pipe.
2. Actual recorded separation measurement of all pipe joints.
3. Pipe ovality report.
4. Deflection measurements and graphical diameter analysis report in terms of x and y axis.
5. Flat analysis report.
6. Representative diameter of the pipe.
7. Pipe deformation measurements, leaks, debris, or other damage or defects.
8. Deviation in pipe line and grade, joint gaps and joint misalignment.

As specifications are developed as part of this task order, the list mentioned above could be incorporated as part of the inspection requirements, depending on software requirements/needs that will be identified in future tasks.

Exhibit 7. Equipment Criteria

- A combination color CCTV pipeline survey system with a cable distance counter, laser profiling system, non-contact video micrometer and measurement software shall be used to perform a measurement survey of new or existing lines as directed by the Florida Department of Transportation. The equipment and software used must be tested and approved by a recognized independent testing group and includes a certified accuracy of 0.5% or better and a repeatability of 0.12% or better. References for the equipment calibration are ASTM E 691 and ASTM E 177.

- Equipment meeting or exceeding the calibration criteria and with the ability to perform specification requirements as defined in Section 430-4.8 and 430-4.8.1 of the Specifications will be acceptable for use on FDOT projects.

Source: FDOT Office of Construction, 2017.

Figure 2-4 Exhibit 7 from FDOT Office of Construction - Equipment Criteria of Pipe Inspection

Section 430-4.1 addresses leaking joints and states requirements for soil-tight joints and watertight joints. Cross drains, storm drains and side drains are required to be soil tight while gutter drains are required to be water-tight. The difference is the requirement that soil tight joints be tested at 2 psi while water-tight joints are tested to 5 psi. As alternative to repairing the leaking joint FDOT allows the option of showing that the hydrostatic head pressure on the pipe, based on water table data run exceeds the performance measurement for a soil tight or water tight joint.

Reinforced concrete pipe cracking criteria is covered under Section 449, which references ASTM C 76. FDOT also refers to Section 27 of the AASHTO LRFD Bridge Construction Specifications concerning cracking in concrete pipe, as it provides guidance on handling pipe crack issues. AASHTO Section 27.4.1 states that “Cracks in an installed precast concrete culvert that exceed 0.01 in. (.25 mm) width shall be appraised by the Engineer considering the structural integrity, environmental conditions and the design service life of the pipe."

Applicability of FDOT Documents

FDOT documents/standards as discussed have direct applicability to the Town’s program as it relates to concrete and CMP pipes, and should be referenced going forward. Although the FDOT documents do not specifically address all type of pipes, the inspection and repair guidelines and the Repair Matrix contain valuable information that the Town could apply during both acceptance of new construction as well as during rehabilitation projects.

2.3.2 Treatment Swales

Swales have been used for conveyance of stormwater along Town roads for decades. However, swales can also be used for stormwater treatment, especially as part of a BMP Treatment Train, when properly designed and maintained to provide retention and infiltration of stormwater. Swales are defined in Chapter 403.803(14), Florida Statutes, as follows:

Swale means a manmade trench which:

1. Has a top width to depth ratio of the cross-section equal to or greater than 6:1, or side slopes equal to or flatter than 3 feet horizontal to 1-foot vertical;
2. Contains contiguous areas of standing or flowing water only following a rainfall event;
3. Is planted with or has stabilized vegetation suitable for soil stabilization, stormwater treatment, and nutrient uptake, and;

4. Is designed to take into account the soil erodibility, soil percolation, slope, slope length, and drainage area so as to prevent erosion and reduce pollutant concentration of any discharge.

Swales are online retention systems and their treatment effectiveness is directly related to the amount of the annual stormwater volume that is infiltrated. Swales designed for stormwater treatment can be classified into two categories:

1. Swales with swale blocks or raised driveway culverts, or;
2. Swales without swale blocks or raised driveway culvert.

Inspections, Operation and Maintenance Requirements of Swales

Maintenance issues associated with swales are related to clogging of the porous soils which reduces or prevents infiltration thereby slowing recovery of the stormwater treatment volume and often resulting in standing water. Clogging can result from erosion and sedimentation and the resulting sealing of the bottom or side slope soils. It can also occur from excessive loading of oils and greases or from excessive algal or microorganism growth.

To determine if a swale is properly functioning or whether it needs maintenance requires that an inspection be done during and soon after a storm. The inspection should determine if the swale is recovering its storage volume within its permitted time frames, generally 24 to 72 hours after a storm. If this is not occurring and results in standing water, then the cause of clogging must be determined and appropriate actions undertaken beginning with those specified in the system's Operation and Maintenance:

(A) Inspection Items:

(1) Inspect swale for storage volume recovery within the permitted time, generally less than 72 hours. Failure to percolate the required treatment volumes indicates reduction of the infiltration rate and a need to restore system permeability

(2) Inspect and monitor sediment accumulation on the bottom of the swale or at inflows to prevent clogging of the swale or the inflow pipes.

(3) Inspect vegetation of bottom and side slopes to assure it is healthy, maintaining coverage, and that no erosion is occurring within the swale.

(4) Inspect the swale for potential mosquito breeding areas such as where standing water occurs after 72 hours or where cattails or other invasive vegetation becomes established.

(5) Inspect swale to determine if filling, excavation, construction of fences, or other objects are obstructing the surface water flow in the swales.

(6) Inspect the swale to determine if it has been damaged, whether by natural or human activities.

(B) Maintenance Activities As-Needed to Prolong Service:

(1) If needed, restore infiltration capability of the swale to assure it meets permitted requirements.

(2) Remove accumulated sediment from swale and inflow or outflows and dispose of properly. Please note that stormwater sediment disposal may be regulated under Chapter 62-701, F.A.C. Sediment removal should be done when the swale is dry and when the sediments are cracking.

(3) Remove trash and debris, especially from inflow or outflow structures, to prevent clogging or impeding flow.

(4) Maintain healthy vegetative cover to prevent erosion of the swale bottom or side slopes. Mow grass as needed and remove grass clippings to reduce nutrient loadings.

(5) Eliminate mosquito breeding habitats.

(6) Remove fences or other obstructions that may have been built in the swale system.

(7) Repair any damages to the swale system so that it meets permitted requirements.

2.4 Recommended Guidelines for O&M of Green Infrastructure-Based Drainage systems

The proposed Town of Lake Park Stormwater Masterplan update will be based on the application of Green Infrastructure Low Impact Development (GI/LID) Best Management Practices. The main goal of the SWMP update is integrating Best Management Practices (BMPs) in stormwater management Town-wide through new stormwater design standards, education and incentive programs for homeowners and developers who incorporate green infrastructure BMP elements into their properties and redevelopment plans. Example BMPs include green roofing, rainwater harvesting, infiltration systems in combination with traditional conveyance and end of pipe infrastructure. Rain water harvesting can be done on almost any scale, even up to providing low cost rain barrels to capture downspout runoff for residential and commercial property owners.

Low Impact Development (LID) is a planning and design approach that aims to mimic naturalized water balances. It combines infiltration, evaporation and transpiration while limiting runoff. The goal of LID is to reduce the frequency with which the Town's stormwater system releases runoff into the downstream end of pipe conveyance system. GI/LID BMP's include:

- Bioretention, biodetention, bioswales and rain gardens: These are vegetated systems at the ground level that allow stormwater to soak directly into the soil media. These systems restore evapo-transpiration and treat (clean) stormwater by filtering it as it flows through the engineered soil media.

- Pervious pavements: Allow stormwater runoff to infiltrate directly through the pavement layer into the underlying soils thus reducing the volume of stormwater runoff captured and conveyed through the drainage system. Permeable pavements can be used for low traffic roadways and driveways, parking lots and pedestrian walkways. Some of the most commercially successful systems include permeable interlocking pavers, grass pavers, pervious concrete, porous asphalt and recycled materials.
- Green roofs are vegetated roof systems that combine plants, engineered growing media, drainage layers and traditional waterproof roof membranes. They appear as rooftop gardens but in essence function to capture stormwater runoff that would otherwise be discharged through roof gutter letdowns.

2.4.1 Rain Gardens

Rain gardens are small retention basins that can be integrated into a site's landscaping. A rain garden is a shallow, constructed depression that is planted with deep-rooted Florida-Friendly plants. It is located in the landscape to receive runoff from hard surfaces such as a roof, a sidewalk, a driveway, or parking area. Rain gardens slow down the rush of water from these impervious surfaces, holds the water for a short period of time and allows it to naturally infiltrate into the ground.

Rain gardens have multiple functions. They recharge the local aquifer by increasing the amount of water that filters into the ground; reduce the amount of stormwater pollutants – fertilizer, pesticides, car oil, etc. – that enter nearby surface water bodies; provide habitat for birds, butterflies, and beneficial insects; and improve property value by adding curb appeal to the landscape. Rain gardens are a beautiful and colorful way for homeowners, businesses and municipalities to help ease stormwater pollution problems. A rain garden also conserves municipal water resources by reducing the need for potable water irrigation.

Maintenance of Raingardens

Like any other part of a landscape, weeding will be an ongoing maintenance issue for a rain garden. During the first year or two, as the plants fill-in and get established, hand-remove the weeds to prevent competition with desired plants and replenish the mulch as needed to maintain a 2"-3" layer over the soil. By the third year, the plants selected for the rain garden should be mature and will out-compete the weeds. However, occasional weeding of isolated patches may still be necessary.

If plants that are all low-growing are selected, like ground covers and spreading perennials, an easy way to keep them maintained would be to mow the dead plant material once a year. This will stimulate growth and help to deter weeds. This may only be feasible if the mower blade can be raised to a height of 6 inches or more. If not, a string trimmer, weed-eater or pruning shears shall be used to cut the plants back to about 6 or 8 inches tall. Evergreen plants, such as ornamental grasses, should be pruned selectively or cut back at the end of the growing season and once the risk of frost/freeze has passed.

Mulch should be replenished as needed to maintain a 2" – 3" layer over the soil. Some grasses, will need to be cut back in the spring . Spent blooms and seed heads should be removed on an as-needed basis. This will help to maintain aesthetics in the garden. Certain plants, like lilies and irises, may need to be divided after a few growing seasons.

2.4.2 Biofiltration Systems (Biodetention/Bioretention)

Biofiltration systems are designed primarily as BMPs for addressing stormwater quality. Although biofiltration systems will provide some attenuation of peak flows, they will most likely not provide sufficient storage capacity to meet Town water quantity control criteria. Biofiltration systems use the chemical, biological, and physical properties of plants, microbes, and soils or engineered media (BAM) to remove stormwater pollutants. Treating stormwater by biofiltration can be very effective due to the variety of chemical, physical, and biological removal mechanisms.

Biofilters may be especially useful in highly urban areas where land for wet detention systems is scarce and soils are inappropriate for retention systems. Biofilters may be especially useful in highly urban areas where land for retention or wet detention systems is scarce and soils are inappropriate for retention systems. For example, roof runoff can be effectively detained and treated in containerized biofilters such as a planter box. Parking lot runoff can be routed into shallow depressed landscape islands with curb cuts or into biofilters integrated into the landscaping adjacent to the parking lot.

Biofiltration systems are suitable for many types of development, from single-family residential to high-density commercial projects. Because the shape and sizing of systems are relatively flexible, the systems can be incorporated into many landscaped designs. These systems can be used near impervious areas such as within roadway medians, parking lot islands, or planter boxes. Biofiltration systems are also well suited for treating runoff from pervious areas, such as recreational fields, golf courses, or landscaped areas. Biofiltration systems may also be used to treat roof runoff, in which case they could be installed with all or a part of the system above ground. If biofiltration systems are installed above ground, the same fundamental design requirements would have to be met as with in-ground biofiltration systems and the biofiltration system would have to discharge through an under-drain system. Biofiltration systems are not suitable for regional stormwater control.

There are many opportunities for biofiltration systems and many configurations making them highly applicable to urbanized areas undergoing redevelopment or for retrofitting existing urban areas to reduce pollutant loading. The major components of a biofiltration system include:

- Pretreatment area (optional) – sediment and trash pre-treatment BMPs, vegetated buffers, or swales commonly used;
- Ponding area – typically limited to a depth of 6 to 12 inches;
- Ground cover layer and plants – 2 to 6 inches of top soil planted with Florida-friendly plants;
- Planting/filtration media – Varies depending on purpose (porosity vs. filtration);
- Inlet and outlet controls – non-erosive inflows and underdrain outflow.

As is customary with green infrastructure principles, numerous biofiltration systems distributed throughout a catchment instead of a single large stormwater basin help facilitate treatment near the source. This can reduce total land needed for stormwater management and reduce project costs. Although any one treatment area may be small, the cumulative effect of multiple systems can be significant.

Operation and Maintenance of Biofiltration Systems

Maintenance Access

Access to the biofiltration system must be provided at all times for inspection, maintenance, and landscaping upkeep. There must be sufficient space around the biofiltration system to allow accumulated surface sediments to be removed and possibly for underdrains to be cleaned out or replaced if they should fail infiltration tests or inspection. To facilitate maintenance of the underdrain system, capped and sealed inspection and cleanout ports that extend to the surface of the ground must be provided at the following locations for each drainage pipe at a minimum: The beginning and end of each run of pipe, at every 50 feet or every bend of greater than 45 or more degrees, whichever is shorter.

Safety Features

Due to their shallow ponding depth, biofiltration systems generally do not require any special safety features such as fencing. Railings or a grate can be used to address safety concerns if the area is designed with vertical walls.

Pre-Treatment Area

The main purpose of the pre-treatment area is to temporarily store runoff and allow coarse solids to settle, thereby reducing the amount of sediments which could be introduced into the filter media of the main bioretention. Remove accumulated sediment, debris, and trash from the pre-treatment chamber once a year.

Ponding

After a major storm, if the water has not drained within 72 hours (48 hours for rain gardens), the source of clogging should be identified and corrected. Silts and sediments should be removed from the surface of the bed as specified in the subsequent sections of this procedure

Landscaping

Landscaping enhances the performance and function of biofiltration systems. Selecting plant material based on hydrologic conditions in the basin and aesthetics will improve plant survival, public acceptance, and overall treatment efficiency. Native or Florida-Friendly plants shall be selected. All landscaping recommendations should be considered before storm flows are conveyed to the biofiltration system:

- The unpaved contributing area should be well vegetated to minimize erosion and sediment inputs to the biofiltration system;
- Where feasible, a pre-filter vegetative strip or vegetative swale should be installed;
- If used, trees should be spaced 12 to 15 feet apart depending on the type;
- Plants should be placed at irregular intervals;
- If woody vegetation is used, it should be placed along the banks and edges of the biofiltration system, not in the direct flow path;
- Only species well adapted to the regional climate should be used;
- Species planted in well-drained media should tolerate short-term ponding as well as periods of low soil moisture;
- Plants in the vicinity of the underdrains shall not have extensive root systems that can damage the underdrains;

Routine Inspections

The operation and maintenance entity must conduct regular inspections of the biofiltration system immediately after a rainfall to ensure it is operating as permitted. At a minimum, an inspection should occur in the spring, before the rainy season begins in June, and during the rainy season. At a minimum the following should be inspected:

- Inspect inflow/outflow points for any clogging;
- Inspect prefilter strip vegetated buffer/grass swale and ponding area for erosion or gullying;
- Inspect trees and shrubs to evaluate their health;
- Inspect the underdrain system to ensure it is not clogged.

Erosion Control

Inspect flow entrances, stagnant water, erosion control stones, and surface overflow areas periodically. Replace soil, plant material, and/or mulch in areas where erosion has occurred, and fill void, if any, in erosion control soil. Erosion problems should not occur with proper design except during extreme weather events. If erosion problems do occur, the flow volumes from the contributing drainage area and bioretention size should be re-addressed by stormwater design consultants. If sediment is deposited in the bioretention facility, immediately determine the source, remove excess deposits, and correct the problem.

Weeding

A bioretention facility, like any other garden, needs annual spring weeding of unwanted plants materials. Mulching helps to reduce weed growth and retain moisture in the soil.

Maintenance

Any problems identified during the routine inspection must be corrected as soon as possible. To ensure the system is properly maintained and to continue to receive stormwater treatment credits, the operation and maintenance entity must:

- Prune and weed to keep any structures clear;
- Maintain/mow the vegetated buffer, prefilter strip or swale at least twice during the growing season and remove clippings from the flow path;
- If used, replace mulch where needed when erosion is evident;
- Remove trash and debris as needed;
- If used, replace mulch over the entire area every 2 to 3 years;
- Remove sediment from inflow system and outflow system, including underdrains, as needed. Flush underdrains as needed to maintain their flow capacity;
- Stabilize any upstream erosion as needed;
- Remove and replace any dead or severely damaged vegetation;

Recertification Inspection and Testing

If privately owned, the operation and maintenance entity is required to provide for the inspection of the entire stormwater management system by a Landscape Architect or Florida registered professional to assure that the system is properly operated and maintained. The inspections shall be performed 18 months after operation is authorized by both the Town and every 18 months thereafter. The report is due to the Town within 30 days of the date of inspection. Testing must include the following:

- The planting soils pH must be tested at least once every 3 years. Planting soils pH must appropriate for the plants used in the system;
- Biofiltration systems that include infiltration components require that a double-ring infiltration test be performed every 3 years at up to three locations in the bottom of the basin to confirm design infiltration rates. If two out of three tests are below the design criteria or the average rate of the three tests is below the design criteria, the mulch layer and surficial soil layer must be restored. Core aeration or cultivating of non-vegetated areas may be sufficient to ensure adequate filtration.

Additional reference technical literature for operation and maintenance of Biofiltration systems is provided in **Appendix B**

The Following is an example of a Biofiltration Maintenance Frequency Checklist:

BMP Location	
Date/Time	
Maintenance Staff Names:	
Maintenance Contractor Name:	

Figure 2-5 BMP O&M Frequency Checklist Header Form

Inspection Item	Frequency of Inspection	Inspection Requirements	Remedial Action
Bioretention Basin	Seasonally and after a major storm		
Dewatering		Facility must dewater within 48 hours of rainfall. Noticeable odors, stained water on the filter surface or at the outlet, or the presence of algae or aquatic vegetation are indicators of anaerobic conditions, and inadequate dewatering of the facility or at the outlet, or the presence of algae or aquatic vegetation are indicators of anaerobic conditions, and inadequate dewatering of the facility.	The top three inches of soil should be removed and replaced with soil material as per plan specifications. Follow up inspections must confirm adequate dewatering. If the facility does not function as intended after the above action, the entire filter and underdrain system may need maintenance. MDE approval may be necessary.
Mulch Layer		Check mulch for adequate cover, sediment accumulation, or discoloration.	Replace and remove old mulch and excess sediments. Provide adequate mulch cover according to approved design.
Vegetative Surfaces	Monthly		
Plant Composition and Health		Compare plant composition with approved plans. Check for invasive species or weeds. Check for dead or dying vegetation.	Remove and replace plants in accordance with plan specifications.
Vegetative Cover and Erosion		Check for evidence of erosion, runoff channelizing, or bare spots.	Re-seed or re-plant in accordance with approved landscaping plans. Re-grading may be required when concentrated flow causes rills or gullying through the facility.

Figure 2-6 BMP O&M Frequency Checklist Form Section 1

Inspection Item	Frequency of Inspection	Inspection Requirements	Remedial Action
Debris and Trash Cleanout	Monthly		
		Check that the facility is clean of trash and debris. Inlets, outlets, and contributing areas around the facility must be checked.	Trash and debris must be disposed of in an acceptable manner according to current regulations after separating out recyclable material at the time of collection.
Structural Components	Annually		
		Check for evidence of structural deterioration, spalling, or cracking. Inlet and outlet structures must be in good condition.	Repair to good condition according to specifications on the approved plans.
Inlets/Outlets	Seasonally and after a major storm		
		Check for evidence of erosion, rills, or gullying.	Stabilize all eroded areas and grade to provide stable conveyance.
		Riprap outlet must be maintained in good functional condition.	Repair according to approved plan.
Pretreatment Chamber/ Forebays	Seasonally and after a major storm		
Sediment Accumulation		Check for sediment accumulation in the forebay.	When the forebay depth is less than half the proposed design, sediment must be removed and the forebay restored according to the approved design.
Sand Layer		Check sand for staining and sediment accumulation	Replace first three inches of sand layer with sand materials per plan specifications.
Gravel Diaphragm		Check gravel diaphragm for sediment accumulation and evidence of erosion	Stabilize or replace gravel according to plan specifications.
Grass Channel Conveyance Systems	Seasonally and after a major storm		

Figure 2-7 BMP O&M Frequency Checklist Form Section 2

Inspection Item	Frequency of Inspection	Inspection Requirements	Remedial Action
		Check for erosion, flow blockages, and stable conveyance	Stabilize and grade according to approved plan.
Overall Function of the Facility	Annually		
		Check that flow splitters are functioning as designed and that bypass is operating as designed	Construction must be in accordance with approved plans.

Inspector's Observations:

Figure 2-8 BMP O&M Frequency Checklist Form Section 3

The Following is an example of a BMP Inspection Form:

BMP Location	
Date/Time	
Inspector(s) Name	

Figure 2-9 BMP Inspection Header Form

		Date						
Frequency	Drainage System Feature	√	√	√	√	Problem	Conditions to Check For	Maintenance Activities and Conditions That Should Exist
B	Ponding Area					Cracks in concrete pre-treatment chamber	Cracks wider than ½ inch or maintenance/inspection personnel determine that the pre-treatment chamber is not structurally sound	Repair pre-treatment chamber so that it meets design specifications and is structurally sound.
Q	Ponding Area					Sediment or debris accumulation in pre-treatment chamber	Accumulation of sediment or debris in pre-treatment chamber	Remove excess sediment or debris. Identify and control the sediment source, if feasible. Facility should be free of material. May contain standing water.
B	Ponding Area					Curb cut inlet via surface flow	Clogged with debris	Remove debris
B	Conveyance channel					Cracks in channel	Cracks wider than ½ inch	Repair the cracks
A	Conveyance channel					Channel grates missing or broken	Any cast iron channel grates missing or broken	Replace broken or missing grates with new grate

Figure 2-10 BMP Inspection Form Section 1

B	Ponding Area					Inlet/outlet pipe failure	Pipe is damaged	Repair/replace
B	Ponding Area					Inlet/outlet pipe failure	Pipe is clogged.	Remove roots or debris
B	Ponding Area					Inlet/outlet	Sediment, debris or trash	Remove sediment, debris or trash
B	Bioretention Basin					Trash, debris in bioretention area	Trash and debris	Remove trash and debris
B	Bioretention Basin					Missing riprap at weir	Missing riprap stones	Replace missing riprap stones
B	Bioretention Basin					Rills or gulley	Rills or gulley around riprap	Fill in rills or gulley with soil and mulch
S	Bioretention Basin					Bioretention soil	Water remains in the basin 48 hours or longer after the end of a storm.	Remove upper 2 to 3 inches of soil and replace with imported bioretention soil. Identify sources of clogging and correct. If problems still persists, ensure that under drain is not clogged. If necessary, clear under drain after removing existing plants, mulch, bioretention soil, and ground recharge layer etc. in consultation of professional engineer.
S	Vegetation					Mulch	Bare spots (without much cover) are present or mulch covers less than 3 inches or mulch is discolored	Replenish mulch to cover bare spots and augment to minimum depth.
M	Vegetation					Weeds/Invasive species	Weeds & invasive species are present	Remove and dispose of weed & invasive species. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality.

Figure 2-11 BMP Inspection Form Section 2

M	Vegetation					Trees and shrubs	Standing dead vegetation is present.	Remove standing dead.
A	Aesthetics					Grass/vegetation	Less than 75% of planted vegetation is healthy with a generally good appearance.	Take appropriate maintenance actions. (e.g., remove/replace plants, amend soil, etc.)
B	Pest Control					Mosquitoes	Standing water remains in the basin for more than three days following storms.	Identify the cause of the standing water and take appropriate actions to address the problem (see Bioretention Soil above)
A	Pest Control					Rodents	Rodent holes are present near the facility.	Fill and compact soil around the holes And report to BSW.
Observations:								

Overall condition of facility (acceptable or unacceptable):	
Dates any maintenance must be completed by:	

(M) Monthly from November to April
(A) Annually, once in late summer (preferable September)
(S) After any major storm (use 1-inch in 24 hours as a guideline
(B) Biannually (spring and fall)
(Q) Quarterly

Figure 2-12 BMP Inspection Form Section 3

2.4.3 Pervious Pavement

Pervious pavement systems can be used for many impervious applications (i.e. sidewalks, driveways, on-street parking) but they primarily are used in parking lots, especially the parking stalls. Typically, pervious pavements are used in areas with low-traffic volume, low truck traffic, and low number of turning areas. To address these concerns, pervious pavements often are integrated with traditional impervious pavements such as within a parking lot where the parking stalls are pervious pavements. The designer must consider the limitations of the pervious pavement system application in determining its proper application. In addition, the designer must consider various site conditions and potential challenges including:

a) Poorly draining soils such as those with shallow Seasonal High Ground Water Tables (SHGWTs), shallow confining units (i.e., clays/hardpans), organic mucks, etc.

b) In areas subject to high traffic volumes, regardless of wheel loads. It is recommended that:

1. The number of vehicles using a pervious pavement parking stall should not exceed one hundred (100) vehicles per day for most pervious pavement systems.

2. Traditional Class I concrete, brick pavers or an appropriate asphalt section should be used in areas subject to high traffic volumes such as the primary driving areas within a parking lot.

c) Regardless of wheel loads, pervious pavement should not be used on areas of frequent turning movements (public roadways, drive thru lanes, around gas pumps, adjacent to dumpster pads, driveway entrances, etc.). It is recommended that traditional Class I concrete, brick pavers or an appropriate asphalt section be used in these areas.

d) If pervious pavement is proposed for areas with heavy wheel loads or other non-recommended conditions, then the applicant shall be required to use alternate methods of pavement design. This may include using imported (hydraulically clean) soils, structural/permeable geo-fabrics, thicker pervious pavement sections, etc. above the parent soil. Hydraulically clean soils will be defined as those that are free of materials (clays, organics, etc.) that will impede the soil's saturated vertical and horizontal hydraulic conductivity.

e) Pervious pavements shall not be used in areas with high potential for hazardous material spills that could seep into the underlying ground water. Examples of these areas include (but are not limited to) gas stations, auto maintenance facilities, auto parts stores that are subject to on-site installation of hazardous materials by customers/store personnel, chemical plants, etc.

f) Pervious pavements may not be appropriate in areas with high levels of wind-blown sediment since these could increase maintenance.

g) Certain pervious pavement systems may create the potential for tripping hazards that needs to be considered when designing areas used by pedestrians or the handicapped.

h) Any underground treatment systems should not be located directly under pervious pavement.

Figure 2-13 shows a typical pervious pavement cross section.

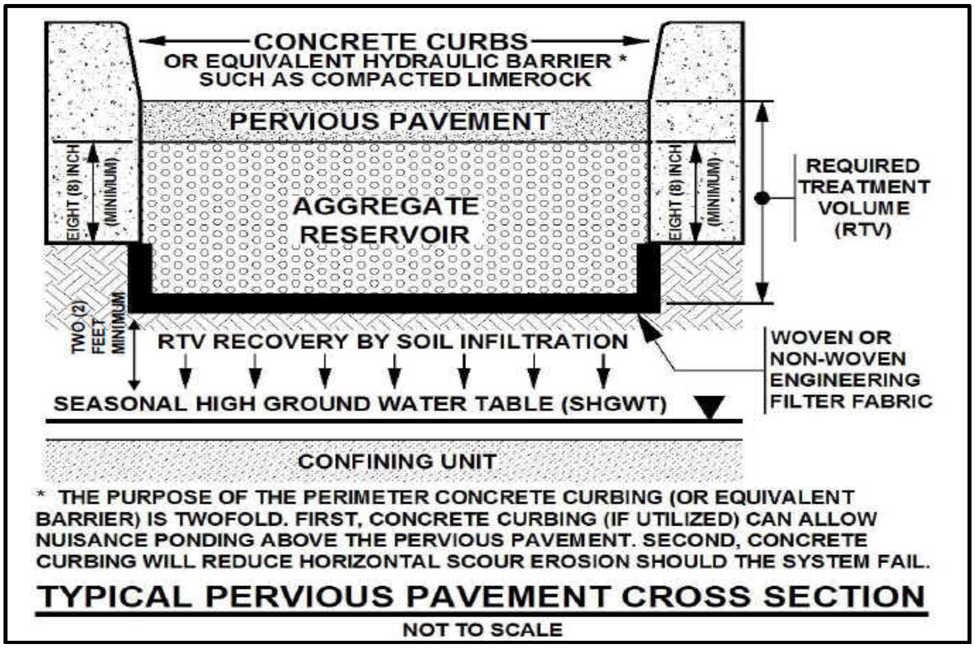

Figure 2-13 Typical Pervious Pavement Cross Section (Pinellas County)

Inspection, Operation and Maintenance of Pervious Pavements

Maintenance issues associated with pervious pavements are related to clogging of the porous surfaces which reduces or prevents infiltration thereby slowing recovery of the stormwater treatment volume and often resulting in standing water. To determine if the pervious pavement is properly functioning or whether it needs maintenance requires that either an inspection be within 72 hours of a storm and that the "ERIK" devices be used to test the infiltration rate as specified below.

a) Inspection Items:

1. Inspect pervious pavement for storage volume recovery within the permitted time, generally less than 72 hours. Determine if nuisance flooding is occurring in those areas of the parking lot that were designed to flood if the pervious pavement was failing. Nuisance flooding indicates that the required treatment volume is not infiltrating because of a reduction of the infiltration rate and a need to restore system permeability.
2. Use the ERIK infiltrometers at least once every two (2) years to test if the vertical hydraulic conductivity is less than 2.0 inches per hour or is less than the permitted design percolation rate in any of the required ERIK infiltrometers. If any of the ERIK infiltrometers have rates less than the permitted rate, maintenance activities shall be undertaken to restore the permeability of the pervious pavement. The results of the ERIK infiltrometer testing shall be submitted to the County if requested.

3. Inspect all edge constraints and overflow areas to determine if any erosion is occurring and repair as needed.

b) Maintenance Activities As-Needed to Prolong Service:

1. Vacuum sweeping will be conducted annually and whenever the vertical hydraulic conductivity is less than 2.0 inches per hour or is less than the permitted design percolation rate in any of the required ERIK infiltrometers. Vacuum sweeping will be done on an as-needed basis on pervious pavements located in areas that are subject to wind transported soils (near sand dunes or other coastal areas) or other conditions where excessive soil or other debris deposition is expected to occur (from adjacent landscaping mulch and leaf litter, from areas with high leaf fall, fugitive sands and lime rock fines from adjacent construction sites, etc.).
2. A remediation plan shall be submitted to the County should vacuum sweeping fail to improve the vertical hydraulic conductivity to a rate greater than 2.0 inches per hour, or equal to or greater than the permitted design percolation rate, or resolve the nuisance ponding. The remediation plan shall be prepared and submitted to the County for review and approval.
3. Repair erosion near edge constraints or overflows and assure that the contributing drainage area is stabilized and not a source of sediments.

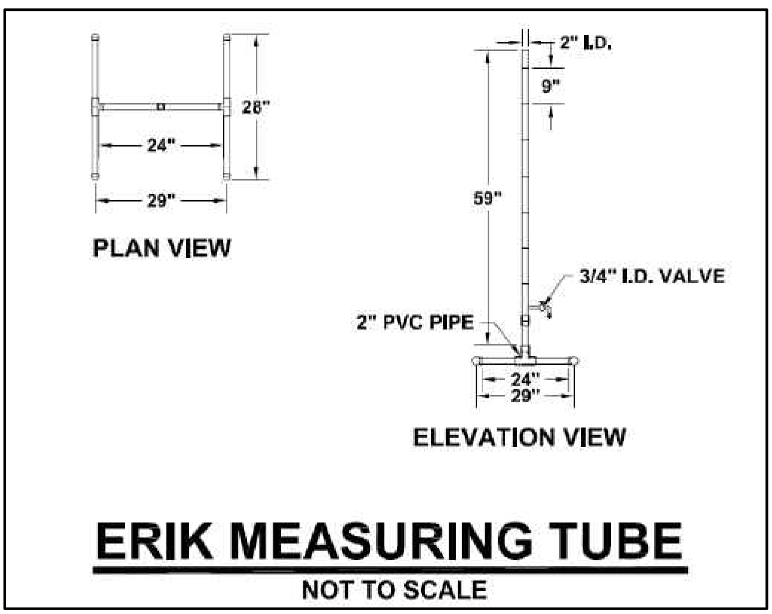

Figure 2-14 Example of ERIK Measuring Tube

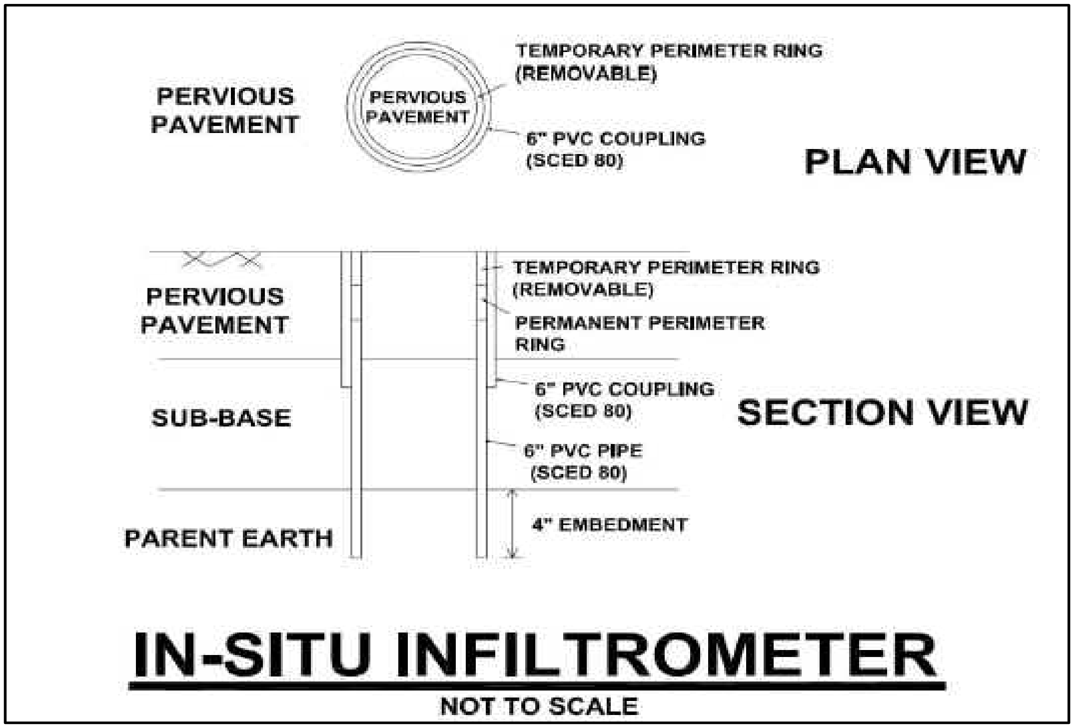

Figure 2-15 Plan and Section View of ERIK In-Situ Infiltrometer

2.4.4 Greenroofs / Cistern Systems

A greenroof/cistern stormwater treatment system is a vegetated roof followed by storage in a cistern for the filtrate that is reused for irrigation. A greenroof/cistern system is a retention BMP and its effectiveness is directly related to the annual volume of roof runoff that is captured, retained, and reused. The filtrate from the greenroof is collected in a cistern or other appropriate storage container or, if the greenroof is part of a BMP Treatment Train, the filtrate may be discharged to a downstream BMP such as a wet detention pond.

The cistern is sized for a specific amount of filtrate and receives no other runoff water. Other pond storage must also provide capacity to detain a specified quantity of filtrate. The retained water is used to irrigate the roof. Irrigation must be provided to maintain the plants. A back up source of water for irrigation is necessary. Excess filtrate and excess runoff can be discharged to other stormwater treatment systems, infiltrated into the ground, or used for irrigation or other non-potable purposes. The greenroof/cistern system functions to attenuate, evaporate, and lower the volume of discharge and pollutant load coming from the roof surface. Greenroof systems have been shown to assist in stormwater management by attenuating hydrographs, neutralizing acid rain, reducing volume of discharge, and reducing the annual mass of pollutants discharged.

Concentrations of pollutants discharged from a greenroof with pollution control media have been shown to be approximately the same as would be anticipated from a conventional roof. Thus, the concentration and mass must be managed. If no pollution control media are used, greenroof concentrations are greater than those from conventional roofs. In addition, with fertilization of the plants, increased nutrients are expected and storage for the filtrate is required.

Classification of Greenroof Surfaces

There are two types of greenroofs. An extensive greenroof is one where the root zone (pollution control layer and growth media layer) is less than 6 inches in depth. Whereas intensive greenroofs have root zones greater than or equal to 6 inches and are typically intended for public or private access. There are two distinct functions for greenroofs, one is passive and the other is active. Passive greenroofs are intended only for maintenance access and typically require less maintenance, while an active roof is used for public and private access. Greenroofs can be built on any type of roof deck with a minimum slope of one inch per foot if there is adequate structural support provided. Accordingly, as part of the application, a structural engineer must certify that the roof can safely handle the weight load of the greenroof.

Construction Requirements

To assure proper construction of the greenroof/cistern system the following construction procedures are required:

- Construct the greenroof in accordance with permitted design plans and specifications;
- Be sure that all greenroof waterproofing components are properly installed before placing any of the media on the greenroof;
- Be sure all equipment and plants are properly sited per design drawings and installed properly;
- Construct the irrigation system in accordance with all permitted design specifications and irrigation system design standards;
- Assure that all irrigation components are properly sited and that irrigation spray heads are working properly and not spraying irrigation water onto impervious areas.

Inspections, Operation and Maintenance of Greenroofs

Maintenance issues associated with greenroof/cistern systems are related to the health of the plants, the drainage capabilities of the system, and proper functioning of the irrigation system.

Greenroof/cistern systems must be inspected annually by the operation and maintenance entity to determine if it is operating as designed and permitted. Reports documenting the results of annual inspections shall be filed with the Town every three years.

a) Inspection Items:

1. Inspect operation of the greenroof/cistern system to assure that rainfall is flowing properly through the greenroof and into the cistern;
2. Inspect the plants on the greenroof to assure they are healthy and growing. Assure plants are covering at least 80% of the surface area of the greenroof and that plant species not on the approved plant list are not becoming established;
3. If an intensive greenroof, inspect it for damage by foot traffic or other human uses of the greenroof;
4. Inspect the operation of the pumping system and the irrigation system to assure they are working properly.

b) Maintenance Activities As-Needed to Prolong Service:

1. Repair any components of the greenroof drainage system which are not functioning properly and restore proper flow of stormwater or filtrate;
2. Maintain the plants on the greenroof on an as needed basis to assure healthy growth and meet the required 80% coverage of the greenroof. Weeding to remove plants not on the approved design plant list will be needed on a regular basis. Whenever plant coverage is less than 80%, new plants shall be established as soon as possible;
3. Repair any damage to the greenroof by foot traffic or other human uses;
4. Repair or replace any damaged components of the pumping and irrigation system as needed for proper operation.

c) Record keeping

The owner/operator of a greenroof/cistern system must keep a maintenance log of activities that is available at any time for inspection or recertification purposes. The log will include records related to the use of the filtrate water for irrigation to demonstrate that the permitted nutrient load reduction is being achieved. A flow meter to measure the quantity and day/time of irrigation is required. Visual observations of the success of plant growth and cover, including photo documentation is also required. The maintenance log shall include the following:

1. Irrigation volume measured using a flow meter specifying the day and amount;
2. Cistern overflow volumes and makeup water volumes;
3. Observations of the irrigation system operation, maintenance, and a list of parts that were replaced;
4. Pruning and weeding times and dates to maintain plant health and 80% coverage;
5. A list of dead, dying, or damaged plants that are removed and replaced;
6. Maintenance of roof mechanical equipment;
7. Dates on which the greenroof was inspected and maintenance activities conducted, and
8. Dates on which fertilizer, pesticide, or compost was added and the amounts used.

2.4.5 Rainfall Interceptor Trees

Interceptor trees are those trees used in urban land uses adjacent to impervious surfaces as part of the stormwater treatment system to reduce runoff volume and pollution from the area. Trees intercept storm water and retain a significant volume of the captured water on their leaves and branches allowing for evaporation and providing runoff reduction benefits. For example, a large oak tree can intercept and retain more than 500 to 1,000 gallons of rainfall in a given year. While the most effective Interceptor Trees are large canopied evergreen trees, deciduous trees can also provide a benefit. Interceptor trees are an important component of urban reforestation and therefore also help to reduce the heat island effect.

Applicability and Siting Considerations

1. Soils: Drainage and soil type must support selected tree species. Must have sufficient soil volume to allow a tree to grow to its mature size. In general, a large-sized tree (16 inches diameter) needs at least 1,000 cubic feet of uncompacted soil.

2. Location: Locate within an impervious surface (such as within landscape islands within parking lots or tree planters within plazas) or within 15 feet of an impervious surface (as close as practical depending on the tree species). Alternatively, the location is consistent with the requirements for Street Trees in the Town’s Community Development Standards.

3. Other structures: Maintain appropriate distance from infrastructure and structures that could be damaged by roots and avoid overhead power lines, underground utilities, septic systems, sidewalks, curbs, patios, etc.

4. Advantages: Interceptor trees reduce the volume of rainfall that land on impervious surfaces and become stormwater. This helps to reduce the total stormwater volume and the stormwater pollutant loading entering the storm drain system and can reduce the size of downstream stormwater systems. Interceptor trees also provide for enhanced aesthetic value, provides shade to cool pavement and reduces surface runoff temperatures, aids in removal of air pollutants and noise reduction, and provides potential LEED Credits.

Design Criteria

1. *Site applicability:* For residential development on private property, interceptor tree credit can only be used at sites larger than 5,000 square feet. For all sites including right-of-way with over 1,000 square feet of impervious surface to manage, no more than 10 percent of the impervious area can be mitigated through the use of trees.

2. *New tree sizing:* New trees on private property must be at least 2.0 caliper inches at the time of planting, and new coniferous trees must be at least 10 feet tall to receive credit. The size of the tree should require at least a 10 to 15-gallon container.

3. New tree setbacks: New trees shall be planted within 15 feet of impervious surfaces such that their canopy covers impervious surface areas. Siting of trees shall ensure that the root system is not harmed by proximity to impervious surfaces. Trees must be spaced such that the crowns do not overlap at maturity.

4. *Existing tree sizing and setbacks:* Credit also applies to existing trees kept on a site if the trunk is within 15 feet of impervious surfaces and are at least 4.0-inch caliper or larger. Caliper is the diameter of the tree measured at breast height.

5. *Tree selection:* The trees selected shall be Florida-friendly suitable species for the site conditions and the design intent. The Town of Lake Park may require a certified arborist's report to verify suitable tree selection and preservation.

6. *Planting sites:* Ideal planting sites within a development are those that create interception opportunities around impervious surfaces. These include areas along pathways, roads, islands and median strips, and parking lot interiors and perimeters. It is important to evaluate and record the conditions, such as soil type, soil pH, soil compaction, and the hydrology of proposed planting sites to

ensure they are suitable for planting. These evaluations provide a basis for species selection and determination of the need for any special site preparation techniques. A minimum of 1,000 cubic feet of uncompacted, rootable soil volume must be provided per tree. In planting arrangements that allow for shared rooting space amongst multiple trees, a minimum of 1,000 cubic feet of rootable soil volume must be provided for each tree. Rootable soil volume must be within 3 feet of the surface. Site characteristics determine what tree species will flourish there and whether any of the conditions, such as soils, can be improved through the addition of compost or other amendments.

Planting trees at development sites requires prudent species selection, a maintenance plan, and careful planning to avoid impacts from nearby infrastructure, runoff, vehicles or other urban elements.

7. *Trees Along Streets and in Parking Lots*. When considering a location for planting, clear lines of sight must be provided, as well as safe travel surfaces, and overhead clearance for pedestrians and vehicles. Also, ensure enough future soil volume for healthy tree growth. At least two cubic feet of useable soil per square foot of average mature tree canopy is required. (Useable soil must be uncompacted and may not be covered by impervious material). Having at least a 6-foot wide planting strip or locating sidewalks between the trees and street allows more rooting space for trees in adjacent property.

   Select tree species that are drought tolerant, can grow in poor or compacted soils, and are tolerant to typical urban pollutants (oil and grease, metals, and chlorides). Additionally, select species that do not produce excessive fruits, nuts, or leaf litter, that have fall color, spring flowers or some other aesthetic benefit, and can be limbed up to 6 feet to provide pedestrian and vehicle traffic underneath. The Cooperative Extension Service and the Florida Yards Program can provide guidance on preferred street tree species.

8. *Planting Techniques*. Prepare a hole no deeper than the root ball or mass but two to three times wider than the spread of the root ball or mass. The majority of the roots on a newly planted tree will develop in the top 12 inches of soil and spread out laterally. Proper handling during planting is essential to avoid prolonged transplant shock and ensure a healthy future for new trees and shrubs. Trees should always be handled by the root ball or container, never by the trunk.

9. *Post-Planting Tree Protection*. Once the tree has been properly planted, 2 to 4 inches of organic mulch must be spread over the soil surface out to the drip line of the tree. If planting a cluster of

trees, mulch the entire planting area. Slow-decomposing organic mulches, such as shredded bark, compost, leaf mulch, or wood chips provide many added benefits for trees. Mulch that contains a combination of chips, leaves, bark, and twigs is ideal for reforestation sites. Grass clippings and sawdust are not recommended as mulches because they decompose rapidly and require frequent application, resulting in reduced benefits.

For well-drained sites up to 4 inches of mulch may be applied, and for poorly drained sites a thinner layer of mulch should be applied. Mulch should never be more than 4 inches deep or applied right next to the tree trunk; however, a common sight in many landscaped areas is the ―mulch volcano. This over-mulching technique can cause oxygen and moisture-level problems, and decay of the living bark at the base of the tree. A mulch-free area, 2- to 3-inches wide at the base of the tree, must be provided to avoid moist bark conditions and prevent decay (ISA, 2003a).

Construction considerations

1. New trees
   - Do not allow soil in planter areas to be compacted during construction;
   - Do not allow soil in planter areas to become contaminated with construction related materials such as lime or limestone gravel, concrete, sheetrock, or paint;
   - Install irrigation system according to proper specifications;
   - When installing lawn around trees, install the grass no closer than 24 inches from the trunk;
   - Install protective fencing if construction is ongoing, to avoid damage to new trees;
   - Mulch with hardwood chips 4”-6” installed depth (2”-3” settled depth);
   - Do not use pressure treated stakes. Do not stake into or through the root ball. Stakes should be set perpendicular to the prevailing wind. Stakes should be cut off 1”-2” above the highest tree tie.
2. Existing trees
   - Proposed development plans and specifications must clearly state protection procedures for trees that are to be preserved;
   - Existing trees must be protected during construction as required by Section 138-3654, Tree Protection and Relocation. High-visibility construction fencing must be set at the outer limit of the critical root zone. The fence must prevent equipment traffic and storage under the trees. Excavation within this zone should be accomplished by hand, and roots 1/2" and larger should be preserved. It is recommended that pruning of the branches or roots be completed by, or under the supervision of, an arborist.

- Soil compaction under trees must be avoided;
- Ensure that trees that receive irrigation continue to be watered during and after construction.

Interceptor Tree Inspection Requirements

An initial inspection by a qualified professional (ISA certified arborist) must be done to ensure the tree has been planted, watered, and protected correctly with locations flagged if appropriate. For newly planted trees, transplant shock is common and causes stress on a new tree. For this reason, newly planted trees must be inspected more frequently than established trees. The time it takes for a tree to become established varies with the size at planting, species, stock, and site conditions, but generally, trees should be inspected every few months during the first 3 years after planting, to identify problems and implement repairs or modify maintenance strategies.

After the first 3 years, annual inspections are sufficient to check for problems. Trees must also be inspected after major storm events for any damage that may have occurred. The inspection should take only a few minutes per tree, but prompt action on any problems encountered results in healthier, stronger trees. Inspections should include an assessment of overall tree health, an assessment of survival rate of the species planted, cause of mortality, if maintenance is required, insect or disease problems, tree protection adjustment, and weed control condition.

Interceptor Tree Maintenance Requirements

Water newly planted trees regularly (at least once a week) during the first growing season. Water trees less frequently (about once a month) during the next two growing seasons. After three growing seasons, water trees only during drought. The exact watering frequency will vary for each tree and site.

A general horticultural rule of thumb is that trees need 1 inch of rainfall per week during the growing season. Water trees deeply and slowly near the roots. Light, frequent watering of the entire plant can actually encourage roots to grow at the surface. Soaker hoses and drip irrigation work best for deep watering of trees. It is recommended that slow leak watering bags or tree buckets are installed to make watering easier and more effective. Continue watering until mid-fall, tapering off during lower temperatures.

Pruning is usually not needed for newly planted trees but may be beneficial for tree structure and safety purposes. If necessary, prune only dead, diseased, broken or crossing branches at planting. As the tree grows, lower branches may be pruned to provide clearance above the ground, or to remove dead or damaged limbs. Trees that are removed or die should be replaced with similar species, or all water quality benefits will be lost. The property owner is responsible for all costs associated with the replacement of interceptor trees.

2.5 O&M Stormwater Rehabilitation Practices Review

WRMA has performed a review of the Town's repair and replacement rehabilitation program including review of the process for acquisition of stormwater system condition assessment (CCTV) data.

2.5.1 Introduction

Part of WRMA's scope of work under Task 5 is to develop condition assessment data acquisition and technical requirements for use as part of Town of Lake Park stormwater condition assessment and rehabilitation program. The primary objective of establishing technical requirements is that they are standardized so that the process and quality of the output, regardless of whether the Town or a contractor completes the inspections, results in an inspection outcome that is the same. In order for this to be achieved, the following is required:

- Standardized inspection process and condition rating scale;
- Explicit technical requirements for inspection equipment and software;
- Explicit requirements for data acquisition and reporting;
- Quality control program requirements for inspection acceptance.

The following sections outline the overarching objective for a linear infrastructure condition assessment program including a recommended standard for achieving the objective, a review of condition assessment technology options, and recommended inspection technical requirements to achieve the program objective. In addition, a tiered inspection approach is provided with linkage to a decision logic for the Town to employ different levels and methods of inspection.

2.5.2 Objective of a Linear Infrastructure Condition Assessment Program

The objective of a linear infrastructure condition assessment program should be to provide a standardized and consistent process for assessing the condition of assets to support an organization's decision making process related to asset rehabilitation and replacement (R&R) and maintenance requirements, allowing for a risk-informed prioritization of those activities across all of an organization's assets.

Standardization in a condition assessment program is critical for the following reasons:

- Assessments are the same across all assets;
- Assessment process is consistent regardless of inspector;
- Ability to detect changes in condition over time;
- Avoids effort to develop organization or project specific standards;
- Provide options to utilize data from different software that use the same standard.

The National Association of Sewer Service Companies (NASSCO) has implemented the Pipeline Assessment & Certification Program (PACP) and the Manhole Assessment and Certification Program (MACP) to provide a standardized and consistent method to document linear infrastructure asset condition. NASSCO's coding system focuses primarily on structural and operations and maintenance (O&M) issues, and less on rehabilitation materials and defects. NASSCO is the industry standard for pipe and manhole inspections, and multiple vendors have developed hardware and software products that meet NASSCO standards.

For NASSCO PACP and MACP inspections, observation codes are defined for each observation noted during an inspection. These codes are categorized into thirteen different structural defects groups (e.g. fracture or break), six different O&M groups (e.g., roots or obstructions), four construction features groups (e.g., service lateral connections, manholes, bends), and miscellaneous features (e.g., water mark readings). The CCTV operator codes additional information as appropriate to categorize the defect or observation, such as: the length of defects (e.g., 20-foot long crack), the sizes and locations (e.g., hole from 12 o'clock to 6 o'clock), and the percent blockage (e.g., roots blocking 50 percent of the pipe). Due to the wide range of codes available, the CCTV operator can be very specific about the type of defect observed which in turn can be used to develop detailed mapping and condition assessments.

Appendix C provides a summary chart for the NASSCO PACP structural defects, O&M issues, and construction feature codes.

The Town has already been using the NASSCO PACP/MACP on all condition assessment work to date. Using one coding system for all Town and contract staff would make it easier to transfer data into one source database in the future and provide an equal interpretation of data among all users. This would also allow the Town to review condition and risk across different asset classes through the same process and criterion. With NASSCO being the more widely accepted standard, new staff or new contractors will be more familiar with its terminology and practices, thereby allowing the Town efficiency in implementation of its program over time. As such, it is recommended that the Town standardize its condition assessment program on the NASSCO PACP/MACP system for the linear stormwater assets to achieve the objective.

2.5.3 Other Condition Assessment Methods

As a result of this lack of standardization for storm sewer assessments there have been multiple systems developed at the state and federal level. Most of these assessment systems have been developed for very specific objectives and application based on a specific need (i.e., metal pipes only or culverts only), and are not comprehensive to cover all asset classes and/or scenarios that may exist within a municipal storm sewer system. At the state level, several departments of transportation (DOTs) have developed storm sewer assessment systems. Florida DOT has developed an assessment system for storm sewers, but this system focuses on the evaluation of newly constructed pipe for construction acceptance, not pipe that has been in place for decades.

2.5.4 Condition Assessment Technology Options

There are many different technologies for condition assessment of linear infrastructure in use by public agencies and contractors. The purpose of this section is to generally describe the types of technologies available, where they are best suited based on the application and recommend an inspection approach and decision logic for the implementation of each inspection tier.

Closed Circuit Television (CCTV)

Conventional CCTV

Conventional CCTV technology uses a video camera with lighting to provide a visual inspection of the inside condition of a pipe. The CCTV camera movement through a pipe varies in complexity from simple pushrod cameras to complex remote-controlled robot crawlers. The level of optical control on the camera also varies in complexity. The ability to pan, tilt, and zoom is the industry standard for CCTV inspection technology; this ability allows the operator to gain a full circumferential view of the pipe. Typical data obtained from CCTV inspection includes identification of:

- Sediment, debris, roots, etc;
- Pipe sags and deflection;
- Offset joints;
- Pipe breaks, voids, fractures, and cracks;
- Leaks and intrusions;
- Location and condition of service connections;

- Pipe material.

CCTV technology is limited in that it can only provide a visual representation of the inside surface of a pipe above the waterline. In addition, the assessment is dependent on operator interpretation, picture quality, and water level. Even with these limitations, CCTV is one of the most cost-effective technologies for completing a condition assessment.

Subaqueous CCTV

Subaqueous CCTV provides the inspection of a pipe below the waterline or for fully submerged pipes. There are a number of companies that provide technology to provide subaqueous CCTV equipment, ranging from remotely operated vehicle (ROV) to conventional tethered systems, both as an equipment purchase option for the Town and as contractor inspection services. The core functionality of this technology should be the same as conventional CCTV. For partially full pipes, a multi-phase inspection approach would be required to fully inspect the pipe, including the use of subaqueous CCTV to inspect below the waterline and a conventional CCTV on a float to inspect above the waterline.

In addition, with subaqueous CCTV technology, it is likely that the inspection would have to be completed in two separate processes. One to collect the inspection data and one for the coding of this data into a direct entry software package complaint with the NASSCO system. Upon discussion with several firms there is no apparent NASSCO direct entry software that supports the type of hardware necessary to complete a subaqueous inspection. The NASSCO scoring could be completed during the actual inspection but would likely be hard copy with a post-processing to enter into a NASSCO compliant software program.

Typically, the costs associated with subaqueous CCTV can be more than 2.0 times greater per foot of inspection than conventional CCTV inspections. Subaqueous CCTV inspections are a specialty inspection and there are fewer contractors with the technology and competency to complete this type of inspection than conventional CCTV inspections. The primary considerations can be attributed to dewatering and bypass pumping for conventional CCTV and the process to generate a NASSCO compliant score with a subaqueous CCTV system. **Table 2-2** outlines a summary comparison of conventional CCTV and subaqueous CCTV of factors that would impact the application and cost of each CCTV technology.

Table 2-2 Comparison of Conventional and Subaqueous CCTV Inspection Methods

Convention CCTV	Subaqueous CCTV
Industry Standard Approach	Specialty Inspection
Numerous Contractors Available	Limited Contractors
Equipment directly linked to NASSCO Compliant direct entry software	No linkage (at this time) to NASSCO compliant direct entry software (requires post processing)
May require pipeline/structure cleaning	May require pipeline/structure cleaning
May require dewatering and/or bypass pumping to maintain water levels below 20% full pipe	May require multi-technology approach for partially full pipe
	Quality of image will be dependent on water color and suspended sediment levels

Zoom Camera

The use of a zoom camera is a common method used for manhole/inlet inspections and preliminary pipe inspections. The zoom camera is placed at the end of a pole and allows the inspector to view upstream and downstream segments of a pipeline from an entry point, such as a stormwater manhole or inlet. With the appropriate equipment, these inspections can provide an indication of the sewer environment from the perspective of the manhole/inlet invert, including the physical condition, construction quality of the joints and manhole/inlet connections, and other visual inspection (debris, etc.). It mainly provides a preview of pipe condition, but observations can be used to prioritize individual assets for cleaning and/or CCTV inspections.

The use of a zoom camera does not provide detailed information along the entire pipe length from manhole to manhole. Generally speaking, pole mounted zoom cameras are limited to a maximum of approximately 35-foot deep manholes and require water levels in the pipe to be less than 30 percent full to make observations.

Laser Profiling

Laser profiling can provide very accurate shape and condition data for the internal wall of a pipe being inspected. These systems are typically utilized to report pipeline deflection, deformation, ovality, and changes in cross sectional area. Laser profilers may also be used to estimate wall deterioration (loss of thickness of the pipe wall). The hardware included with the camera or attached to the camera projects a ring of laser light onto the internal surface of the pipe. The laser image is captured in the field of view of the CCTV inspection camera, while it moves through the pipeline being inspected. Once all the laser images are captured and recorded, companion software uses the laser images captured in the inspection and builds a digital profile of the pipe wall that was inspected.

The costs associated with laser profiling can be 1.5 or 2.0 times greater per foot of inspection than conventional CCTV inspections. Therefore, this technology is typically reserved for collecting information on pipes that are planned for rehabilitation, especially for large diameter pipe or deep pipe, or for pipes with known physical condition issues which require rehabilitation. The laser profiling provides information, as detailed above, that conventional CCTV cannot and therefore allows an engineer to make the most informed decision on rehabilitation techniques and the potential pipe defects that may create issues during construction of the rehabilitation technique.

Sonar

Sonar is typically provided as part of a multi-sensor technology; with CCTV and laser profiling capabilities and can used in fully submerged or partially submerged pipes or structures. Multi-frequency sonar measurements are used to calculate sediment depth and pipe obstructions, as well as identify deflections and offsets in the pipe profile. Sonar will not reveal the presence of fractures, cracks, or corrosion. Metallic pipes, including corrugated metal pipe (CMP), are subject to corrosion and sonar methods are not able to detect and quantify the nature and extent of corrosion. Therefore, sonar has limited application for the inspection of metallic pipe.

For pipes that are partially full, a multi-sensor technology could be used for the inspection, such as a CCTV combined with high resolution sonar. NASSCO has standards for CCTV and sonar equipment use so the application of using both for the survey is consistent with the NASSCO system. The sonar could be used as a screening for non-metallic pipes to determine if further investigation is required.

2.5.5 Cleaning Requirements

Typically, before a condition assessment is completed; pipes and structures are cleared of sediment, debris, and roots. At a minimum, an acceptable level of sediment in a pipe is no more than 10 to 20 percent of the pipe diameter and does not block the advance of the inspection equipment. In many cases, there are defects or debris in a pipe that require the CCTV operator to set up a reverse inspection from the alternative flow direction of the pipe. This is a common inspection technique to overcome unknown issues that exist inside pipes.

There are numerous methods to clean sewer lines, but they fall into two general categories: mechanical and hydraulic. The most common techniques for each are as follows:

- Mechanical
  - Rodding – primary application is small diameter pipe;
  - Bucket machine – typically a cylindrical drive with jaws that can pull debris from a pipe or structure.
- Hydraulic
  - Jetting – high velocity Town water used to wash sediment from a pipe, most efficient for smaller diameter low flow pipes;
  - Typically used in parallel with a vacuum truck to remove sediment and debris from a downstream point.

As pipe diameters get larger and sediment levels are greater, there will be a need for multiple technologies to clean the pipes, and likely more intensive mechanical operations will be required to remove the sediment or large debris.

2.5.6 Dewatering and Bypass Requirements

If the water level in a pipe is greater than 10 to 20 percent of the pipe diameter, the pipe and/or structure will require dewatering to complete a comprehensive inspection using conventional CCTV. This operation is typically completed using an upstream pipe plug to stop flow from entering the reach of pipe to be inspected. For the Town, a high groundwater table and open stormwater system may require an upstream and downstream plug, as a pipe's typical condition under these circumstances may be partially or fully submerged, with a pump to dewater the pipe reach to be inspected. In addition, bypass pumping may be required if the upstream segment of pipe surcharges and has the potential to cause surface flooding.

Recommended Tiered Inspection Approach

The methods for inspection of linear infrastructure assets are typically performed in a tiered approach, as a process to manage costs and to obtain information in a logical sequence needed to make appropriate R&R and/or O&M decisions. It is recommended that the Town implement such a tiered approach to maximize its investment in condition assessment activities. The following bullets outline the recommended tiered approach and associated inspection technology:

- **Tier 1 – Preliminary Inspection**
  - This a screening level inspection and does not result in a condition rating, just a general qualitative condition opinion (structural and O&M) for the prioritization of assets for Tier 2 inspections.

  - Inspection Technology:
    - Zoom camera
    - Subaqueous CCTV

- **Tier 2 – Condition Assessment**
  - This inspection provides detailed visual inspection over the entire length of an asset, producing a structural and O&M condition rating. The data from this level of inspection can be used to define the limits of the more intensive Tier 3 inspections and the data from this inspection maybe sufficient to make decisions on the most viable rehabilitation technique for pipes that require R&R.

  - Inspection Technology
    - CCTV: Conventional or Subaqueous

      The decision of which CCTV technology to use will be dependent on pipe water level conditions and the cost associated with a specialty inspection using subaqueous CCTV equipment versus potentially having to dewater a pipe segment to use conventional CCTV equipment.

      Depending on the water level in a pipe, especially if greater than 10-20 percent full over the entire pipe length, a multi-sensor technology (CCTV and sonar) is recommended at a minimum to capture the debris level below the waterline.
    - Zoom camera (for manholes/inlet only)
    - Visual inspection: Large culverts, that are not submerged, can be inspected by a manned entry.
- **Tier 3 – Inspection to Support Engineering Design Activities**
  - These inspections result in detailed data inputs for engineering analyses to define the appropriate rehabilitation technique.
  - Inspection Technology:
  - Multi-sensor technology including:
    - CCTV
    - Laser profiling
    - Sonar

It should be noted there are many advanced technologies that fall into this category (i.e. laser diode measurement tools, sidewall scanning).

2.5.7 Asset Inspection Decision Logic

Figure 2-16 provides a recommended decision logic diagram to standardize the Town's decision process related to the application of the tiered inspection approach and determining which inspection technology to leverage. This logic diagram takes into account local conditions for the Town, specifically related to stormwater pipes that have high water levels due to the high groundwater table and tidal influences and is laid out with the objective to achieve a NASSCO complaint inspection. A larger version of the Decision Logic Chart is provided in **Appendix C.**

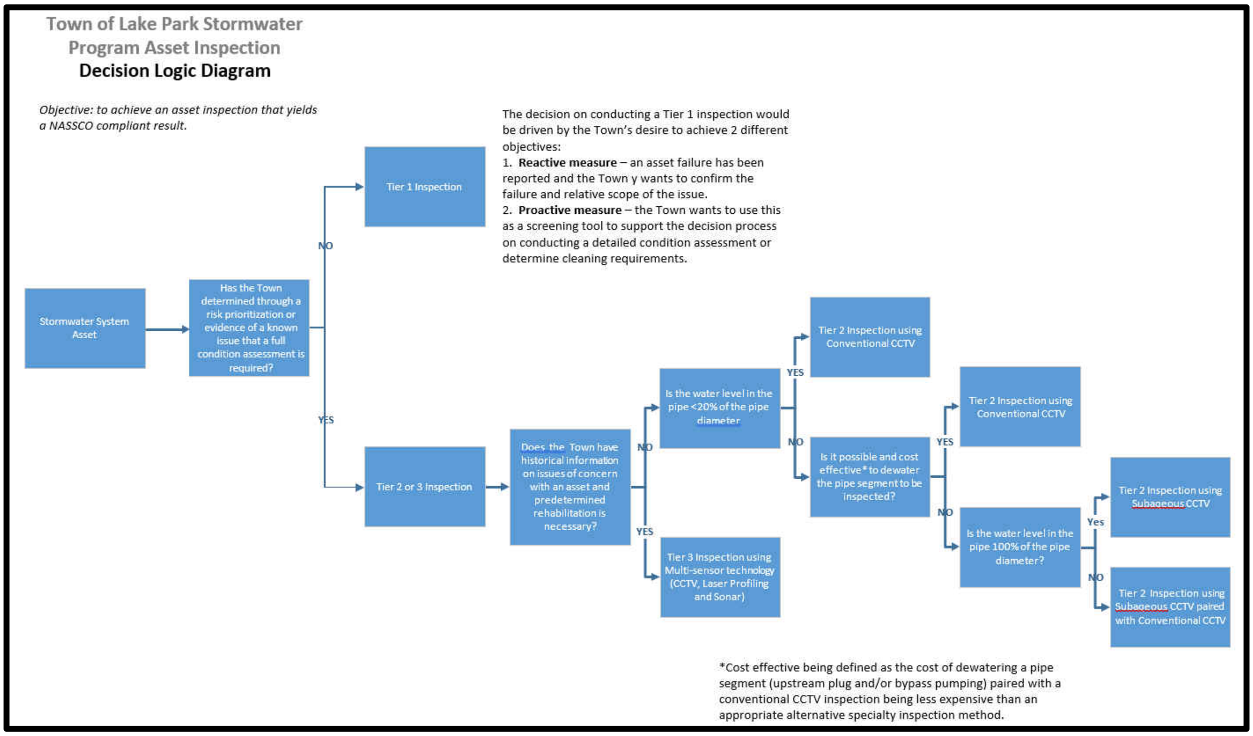

Figure 2-16 Condition Assessment Decision Logic Chart

2.5.8 Asset Inspection Work Management

A computerized maintenance management system (CMMS) is an essential part of a municipality's procedures required to manage, maintain, and operate their facilities, assets, and equipment. In regard to condition assessment, a CMMS supports the management of the business process workflow related to the initiation, completion and tracking of condition assessment activities. The Town currently does not have a CMMS. The following CMMS are prevalent in the industry and provide an interface and connectivity to GIS data: Cartegraph, Townworks, Infor10 EAM, LuTown, Maintenance Connection, Maximo, and VUEWorks. Integration of GIS data has become an important CMMS function to manage and visualize spatially distributed linear assets.

2.5.9 Inspection Equipment and Software Minimum Requirements

The following sections outline the inspection equipment, software and data reporting technical requirements the Town should consider for any inspections to be completed on stormwater assets.

EQUIPMENT REQUIREMENTS

CCTV Cameras for Pipe and Structure Inspections

The following are recommended minimum requirements for conventional and subaqueous CCTV cameras for the completion of pipe and structure inspections:

General Set-Up

- Television monitor;
- Computers for storing electronic data;
- Cables suitable for wet environments;
- Power source;
- Remote reading footage counter:
    - Accuracy: two-tenths of a foot over length of section being inspected
    - Marking on cable should not be allowed
- Calibration: each day prior to setup;

Camera

- Recording format: color, digital;
- High resolution video and still images;
    - NTSC at 470 H lines of resolution or 720 × 576 pixels
- 65-degree viewing angle, minimum, and either automatic or remote focus and iris controls;
- Operative in 100 percent humidity conditions;
    - For subaqueous CCTV fully submerged conditions
- Mount on appropriate transport system, sized for each pipe diameter;
- Equip with tag line suitable for pulling camera backwards;
- Focal Distance: Adjustable through range from six inches to infinity;
- Equip with winch, power winch, optic cable, powered rewind, or other devices used to move camera through pipe;
- Nationally Recognized Testing Laboratory (NRTL) certification for suitability in hazardous environment use.

Camera Lighting

- Minimize reflection;
- Ability to achieve proper balance of tint and brightness;
- Lighting quality to provide clear, in-focus picture of entire inside periphery of pipe;

Inspection Images

- Continuous view;
- Distance measured along reach (tape counter footage);
- Recording should include on the periphery of screen: starting location ID, ending location ID and distance from starting point;

Camera for Manhole/Inlet Inspections

The following are recommended minimum requirements for a digital camera used for the completion of manhole/inlet inspections:

- Minimum of 7.2-megapixel imaging;
- Minimum 3x optical zoom;
- Optical vibration reduction image stabilization;
- 3.0-inch high resolution LCD;
- Adjusts up to ISO 1600 in low light;

Zoom Camera for Inspections

The following are recommended minimum requirements for a zoom camera used for the completion of inspections:

- Camera should produce a color video image;
- The image sensor should be a Color Hyper-Had CCD with expanded sensitivity to view down a minimum diameter of six-inch pipelines and have a minimum viewing range of 50-foot to 150-foot with bright pipe sidewall detail;
- The camera should have a zoom feature of 18:1 optical and a digital zoom of 12 times for a total of 216:1;
- Camera should have a minimum lux rating no greater than seven;
- The camera should have a single button that allows for shutter speed to go beyond 1/60th of a second and react automatically to changing dark environments for viewing in large or far dark areas;
- Camera should have ability for auto and manual focus and maximum time for auto focus to resolve a subject is 1/2 second;

- System illumination should be provided by HID (High Intensity Discharge) lighting with a maximum reflector angle of 6 degree for far viewing and maximum of 13.5 degree for close viewing. (4100cp at 13-degree beam, 13000cp at 6 degree beam) and lamps operate at a minimum color temperature of 4,300 Kelvin and up to 5500 Kelvin to provide for bright and contrast lighting at far distances;
- Camera construction should include all solid-state circuitry designed to withstand shocks and vibrations;
- The camera housing should be made of clear anodized aluminum designed for damp and underwater environments with an operating temperature range of 0º to 120º F;
- Distance between center lens of camera and center point on lighting to be no greater than 62 mm or 2 4/10-inch in order to guarantee acceptable video images in small pipes and at longer distances in larger pipes;
- Distances between center point of dual narrow beam lamps to be no greater than 40 mm or 1 6/10-inch;
- Camera should be rated at 4.5 bar / 150-foot of water;
- Camera should have air valve for purge and pressurization of electronic components to prevent fogging of lens when there is a change in temperature;
- Front camera housing should be able to be removed without tools for easy maintenance and camera module upgrade;
- Front light housings should be able to be removed without tools for easy lamp beam selection change out and field maintenance;
- Camera should have ability to easily tilt while pole is extended via a three-inch aluminum tilt-bar secured to the rear camera housing cap;
- All camera and lighting wires should be housed within the camera housing;
- System must have quick-connect camera head feature where camera head attaches to pole via waterproof connector and two stainless thumb screws;
- Camera should be supported and be able to tilt via two side arms that have 1/3-inch diameter solid stainless-steel journals;
- Camera head with lighting must have ability to fit into a 5.5-inch diameter opening, providing access in six-inch risers and having viewing capability in six-inch pipelines;
- Camera should be able to straight tilt a maximum of 234 degrees;
- Camera should have tilt locking screw for times when camera tilt must be in a fixed position;
- Camera window should be made of scratch resistant sapphire crystal.

Control Box And Belt For Zoom Camera

- The control belt should contain a 95-watt hour rechargeable battery pack;
- System control box should have a single joystick to control zoom, focus and auto focus;
- Backward and forward should control tele and macro zoom while left and right will control far and near manual focus;
- Depressing the joystick in the center should engage auto focus;
- The control belt should contain controls for zoom, manual/auto focus, on/off switch single or double lamps, main power and shutter speed override;
- The size of the control box should be no greater than 5 1/8-inch x 2-inch x 6-inch;
- Control belt should have adjustments for different waist sizes;
- An automatic battery charger should be included;
- Control box switches/controls should be backlit rocker style and joystick;
- Control box should have splash proof switches and connectors;
- Control box should have input and output connectors on its bottom side;
- BNC video out, military spec locking connector with keyway for main control cable;
- Control box should have camera control software chip that can be upgraded in the field;
- Control box should have 3-pin XLR secured connector for 12V DC power input;
- Control belt should have provisions to quickly adhere or remove battery packs via a velcro strip;
- Control box shall have colored (green, orange, red) LED indicator to let operator know condition of should charge.

System Hardware For Pole Camera

- A telescoping pole adjustable from 6 to 18 feet should be included to permit placement of the camera into a variety of areas;
- Pole diameter should be large enough to internally house the camera connector and cable;
- A 38-foot video/camera control cable should be integrated inside the pole;
- Cable is externally armored with crush proof steel to prevent damage or tangling of cable;
- A pouch with neck strap shall be provided to house the video storage equipment, spare parts and instruction manual;
- Tool bag should be supplied with necessary maintenance tools and supplies;
- System should have ability to work with fiberglass 24-foot pole, Kevlar reinforced pole or add 6-foot extension section to standard pole;

- System positioning should be calibrated and have adjustable pole mounted standoff/ stabilization capability via a three-foot aluminum rod to assist viewing dropped lines, centering camera in different diameter lines and to assist with stabilizing and dampening image movement from manhole or basin bottom;
- Standoff should be calibrated with markings that correspond to centering camera in six 60-inch lines;
- Standoff should have spring loaded foot to allow for a minimum of three-inch of travel for the camera to properly center the camera to maximize viewing results;
- Stabilization system should have ability to add different spring tensions that correspond with different camera and lighting configurations;
- Should be able to attach a sump stabilizer to stabilize rod according to calibrated centering lines for environments that are filled with soft sediment;
- System should have provisions for hard side shipping and storage case for pole, camera head and standoff;
- System should have options for direct connection to 12V car power supply and an 110V AC to 12V DC adapter.

2.5.10 Software Requirement

The primary requirement for any CCTV software system should be certified to be compatible with the NASSCO PACP and MACP coding system and be able to integrate the Town's GIS data. This should be the requirement for any contractor completing inspections for the Town.

2.5.11 Date and Reporting Requirement

Data Acquisition Requirements

The following are recommended data acquisition requirements (inspection execution) for pipeline inspections:

- Mandatory fields according to PACP format standards and valid codes, including additional mandatory project-specific codes, include:
  - Surveyor's name (1)
  - PACP certificate No. (1a)
  - System owner (2)
  - Pipe segment reference (7) – use GIS ID
  - Date (8)
  - Time (9)

- Location (street number and name) (10)
- Location details (11)
- Upstream manhole number (only those provided in Town's GIS database) (12)
- Upstream rim to invert elevation (13)
- Upstream rim to grade (15)
- Downstream manhole number (only those provided in OWNER's approved database) (16)
- Downstream rim to invert elevation (17)
- Downstream rim to grade (19)
- Use of sewer (i.e., sanitary, storm, or other) (20)
- Direction (of survey - reverse or downstream only) (21)
- Height (diameter of round pipe, or height of other shape) (23)
- Width (not used for round pipe, or width of other shape) (24)
- Shape (25)
- Material (26)
- Lining method (if available) (27)
- Total length of pipe (from drawings/GIS data, center of manhole upstream to
- center of manhole downstream) (29)
- Total length surveyed (from inspection edge of upstream manhole to edge of downstream manhole) (30)
- Tape/media number (unique number for every inspection e.g. date - # or 110206-1 or 110206-2) (33)
- Pre-cleaning (36)
- Purpose (of survey) (34)
- Additional Information (complete for "other" codes used in previous fields) (39)
  - For example – pipe or structure surcharging

- Mandatory fields according to MACP format standards and valid codes, including additional mandatory project-specific codes include:

  Header fields according to MACP format standards and valid codes:

  - Surveyed by – level 1/ level 2
  - PACP certificate No. – level 1/ level 2
  - System owner – level 1/ level 2
  - Sheet number – level 1/ level 2
  - Date – level 1/ level 2

- Time – level 1/ level 2
- Street name and number – level 1/ level 2
- Town name (where work is being performed, use county name if not within Town limits) – level 1 or 2
- Location details – level 1/ level 2
- Manhole number (only those approved by local agency) – level 1/ level 2
- Rim to invert elevation (outgoing) – level 1/ level 2
- Grade to invert (outgoing) – level 1/ level 2
- Rim to grade (outgoing) – level 1/ level 2
- Manhole use – level 1/ level 2
- Media label – level 1/ level 2
- Purpose – level 1/ level 2
- Pre-cleaning – level 2
- Location code – level 1/ level 2
- Surface type – level 1/ level 2
- Access type – level 1/ level 2
- Inspection status – level 1/ level 2
- Evidence of surcharge – level 1/ level 2
- Inspection level – level 1/ level 2

- Manhole component observation fields

  Manhole component defect form – valid coding using MACP codes

  - MACP Level 1 inspections are a basic condition assessment that primarily results in the completion of the header fields and the manhole component observation fields. The Level 1 inspection can be completed without any equipment or manned entry. A Level 1 inspection will provide an indication if a Level 2 inspection is necessary.
  - MACP Level 2 inspections gather more detailed information, than a Level 1, on the condition of the manhole; the manhole component defect form is required for this inspection. A Level 2 inspection requires manned entry or camera.

- Video Recording:
  - Voiceover should be used to document operational issues only, equipment issues, or other pertinent information to describe an interruption in image.

- Camera should be on an axis with the centerline of pipe.
- Continuous footage reading should be on continuous image. Reading should be placed on screen where it is clearly visible (e.g., if black font, do not place on dark background, if white font, do not place on light background) but not obscure viewing images.
- Inspection should be in direction of flow, except while camera is being used in a reverse setup. Inspection should proceed from upstream to downstream, unless prohibited by an obstruction.
- If upstream (or reverse) setup should be required, establish new inspection run separate from downstream (or normal) setup. Inspection images for both downstream and upstream runs should be submitted at the same time.
- Camera lens should be clean and clear. If material, moisture, or debris obscures image or causes reduced visibility, the lens should be cleaned or replaced prior to proceeding with inspection.
- Camera lens should remain above visible water level and may submerge only while passing through clearly identifiable line sags (or vertical misalignments). If flow is such that camera lens becomes obscured, inspection shall be stopped until flow subsides. If necessary, reschedule inspection. Surcharging (and flooding of camera lens) is not an excusable condition if it has been artificially created upstream, i.e., placement of flow plugs or flushing in pipe.
- Recordings should clearly show corrosion, cracks and fractures, and their severity, in addition to obvious features, i.e., laterals and joints. Pan feature should be used to view defects with appropriate lighting and focus adjustments.
- Reporting of obstructions that restrict flow and cause inspection to be interrupted should be reported to Town’s representative.
- Provide still images of all moderate and severe defect images. If no defects, provide still images of typical conditions every 100 feet in pipe or where flow levels change in accordance with NASSCO PACP.
- Maximum inspection speed: 30 feet per minute, during inspection.
- Line segments should be televised complete from structure-to-structure, as appropriate in one continuous run.
- Video should clearly show structure when starting or ending at a structure, unless a defect or manhole configuration does not allow it.
- Inspection images:
- Digital color; and clear image with non-obstructions blocking view frame

- Measurement:
  - Record should be in English units.
  - Measurement of pipe diameter should be done by physical measurement in upstream (or downstream) access structure.
  - Pipe material and pipe diameter should be verified before beginning inspection.
  - Calipers or measuring rod should be used to determine the diameter of the inlet and outlet pipe.
  - Footage measurements should begin at centerline of upstream manhole.
  - Continuous footage readings should be collected.

2.5.12 Inspection Deliverable Requirements

There are three primary deliverables that should be provided as part of an inspection:

- Inspection report
  - There are many different formats that are appropriate, the most important aspect is for the content of the inspection report to provide the required information outlined in the preceding section in a logical manner and is presented in a manner that is relevant for the Town's decision process. Attachment B provides sample PACP and MACP reports.
- Electronic data using the NASSCO coding system
  - This deliverable should include all data provided in the inspection report in electronic format.
  - It is typical for this data to be provided in a Microsoft Access database.
- Electronic Inspection Video
  - Video images should be at 1:1 scale of vertical to horizontal
  - File naming convention should be logical and be representative of the asset inspected and linked to the Town's asset ID numbering system.

Pipeline example:

- USMH_Direction_DSMH_Date.mpg
- USMH – Upstream manhole asset ID
- DSMH – downstream manhole asset ID
- Direction – direction of inspection, upstream or downstream
- Date – in MMDDYYYY format

Manhole/Inlet example:

- [Manhole/Inlet asset ID] _DATE_#.jpg
- Date – in MMDDYYYY format

2.5.13 Quality Control Review Requirements

For contracted and in-house CCTV inspections, the first step in the quality control (QC) review process is to validate that the equipment, data, and documentation requirements meet NASSCO standards for inspections. The QC review of the inspection data should include at a minimum:

- Review of submitted data to verify format and completion of mandatory fields;
- Verify that all fields are completed on the inspection form;
- Check entries for fields where pick lists are used to verify that valid codes are entered;
- If an inspection cannot be completed, verify that a reason is noted in the comment section; if a severe defect causes the inspection to end, be sure that the defect is coded and that the abandon survey code is included;
- If no reverse inspection completed, reasoning should be documented;
- Check the quality of the CCTV image for color, focus, lighting, and speed;
- Verify that defects are panned, and focus is changed to zoom in on defects, then changed back to infinity when returning to the forward view down the pipe;
- Verify that the manhole numbers and footage counter are displayed throughout the tape;
- Spot-check the defect coding for correct coding, focusing on the more severely deteriorated pipe segments; if the spot-checking reveals errors, then the segment should be checked in greater detail;
- Verify that the correct pipe segments are identified on the storage medium label.

2.5.14 Post QC Acceptance

The Town can determine at what point the cumulative variance from the minimum requirements set forth in the preceding section will require a re-inspection and should be set forth in any technical specification provided to a contractor providing inspection services. Example of conditions that would warrant requiring a re-inspection include:

- Loss of color or severe red or green color in CCTV footage;
- Recordings with distortion or outside interference;
- View of entire line segment, structure-to-structure (typically manholes) needs to exist in one inspection in order to be acceptable, unless reverse setup or obstruction. If a portion of line is unacceptable, entire segment should be deemed unacceptable and shall be re-inspected;
- Continuous footage meter inaccuracy, or identified defects or features leave doubt as to accuracy of locations or total length;

The Town could choose to accept inspections that do not adhere to minimum requirements if adverse conditions are encountered and re-inspection is not advised. In such a case, enough data should be provided to permit accurate assessment.

2.5.15 Condition Rating Scale and Use

Similar to the inspection process, the summary output from the inspections of an overall asset condition rating should be standardized. The overall linear asset condition score should take into account the number of defects identified, the type of defects and the severity of those defects. This is how the NASSCO system produces a condition rating for PACP and MACP inspections and is an auto-generated scoring from direct entry software that is compliant with NASSCO. The condition scores should be grouped into a condition grade classification that provide basic recommendation(s) for further action. The inspections will provide more detailed information to determine the best available and most appropriate technology for rehabilitation of replacement. **Table 2-3** provides a recommended condition rating scale; this scale is aligned with the NASSCO 1 to 5 rating scale. **Table 2-3** also provides both a general and detailed description of each condition grade, as well as a recommended inspection frequency to continue to monitor assets, especially those that have been identified to be in poor condition. A larger version of **Table 2-3** is provided in **Appendix C.**

Table 2-3 Stormwater Pipe, Inlet & Manhole Asset Condition Rating Scale

Condition grade	General description	Detailed description	Recommended inspection frequency[a]
0	New or excellent condition	Asset with no defects. No action needed.	No more frequent than the inspection cycle period
1	New or excellent condition	Asset with very few minor defects. Inspection frequency would be at the end of the planned system inspection cycle period.	No more frequent than the inspection cycle period
2	Good condition – minor defects only	Asset in good structural and maintenance condition but there are several minor defects or one or two more moderately severe defects. Inspection frequency could be 60 to 80% of the planned system inspection cycle period.	60-80% of inspection cycle period
3	Fair Condition – moderate deterioration	Defects have degraded to a moderate level and are affecting the performance of the asset. Could be a combination of a number of minor and moderate defects. Point repairs or maintenance could be required. Inspection frequency should be within a 3 to 5 year time frame.	3-5 years
4	Poor condition – significant deterioration	Several moderate defects and at least one or more major defects. Point repairs or maintenance may correct deficiency or may need more comprehensive repair or replacement such as lining. May need frequent maintenance. Inspection frequency should be within a 1 to 3 year time frame.	1-3 years
5	Failing or failed asset	Several severe defects are found in most sections of the asset. Replacement, comprehensive rehab, should be scheduled. Emergency repair may be required. Inspection frequency should be on a monthly basis and no greater than one year.	<1 year

2.5.16 Initial Procurement Strategies

If the Town determines a condition assessment is required for a stormwater system asset, the following bullets highlight a series of initial CCTV condition assessment procurement strategies for consideration by the Town:

- Competitively bid conventional CCTV and subaqueous CCTV using the following bid items:
    - CCTV inspection
        - Bid items listed by pipe diameter & manholes/inlets in area to be assessed
    - Storm sewer cleaning
        - Bid items listed by pipe diameter in area to be assessed
        - By level of cleaning required (light through heavy)
    - Temporary pipe plug setting and dewatering for CCTV
        - Bid items listed by pipe diameter in area to be assessed
    - Bypass pumping
        - Bid items listed by pipe diameter in area to be assessed
    - NASSCO compliant reporting and electronic deliverables
    - Traffic control

There are obvious considerations for each bid item that need to be taken into consideration for a final bid package, such as the level of line cleaning required (heavy vs. light cleaning) and if traffic control is required to be compliant with Town standards or Florida DOT standards. These considerations will impact the unit costs for each line item.

The allowance for both CCTV technologies will allow the Town to ascertain the most cost-effective path forward for executing a NASSCO compliant condition assessment.

- In procuring CCTV inspection services the Town may want to select an on-call contractor(s) based on their unit bids for a pilot area with all bid items included (heavy cleaning, light cleaning, etc.) to provide for a more robust comparison of contractors.
- The Town could consider procuring cleaning contractors separate from the CCTV contractors, to potentially achieve lower unit prices for line cleaning. The downside to this approach is that the coordination of these contractors will fall to the Town to ensure that the cleaning and CCTV contractors are working in coordination such that lines are cleaned in advance of the CCTV crew's mobilization. If the CCTV crew mobilizes and the lines cannot be inspected, the Town will incur costs from the CCTV contractor that may overtime diminish the unit cost efficiency of procuring a

less expensive cleaning contractor. This procurement strategy may be most viable under a larger programmatic condition assessment approach.

2.6 Local Contractor Experience and Pricing

WRMA has performed a review of the Town's repair and replacement rehabilitation program including review of the process for acquisition of stormwater system condition assessment (CCTV) data.

WRMA has experience working with local contractors and will discuss its experiences with respect to condition assessment and rehabilitation methodologies in coastal environments. Contractors agreed that NASSCO rating systems can effectively be applied to storm sewers. The contractors also believe that laser profiling is not a useful tool in a rehabilitation environment.

With respect to rehabilitation methodologies, contractors indicated that CIPP and slip lining are the only options to repair storm pipes. CIPP is the preferred option, as it can be installed in larger runs. Slip lining is useful in more limited applications, particularly where access is difficult, like under roads or for outfall repairs. The contractors noted that lining with these methods often increase flow rates despite the fact that installation of a liner produces a smaller pipe diameter.

Fold-and-form liners are typically used in sanitary applications and are limited in diameter to 15 inches. Pipe bursting for replacement is not a good option for storm sewers in South Florida. For point repairs, the contractors have found that internal seals are more economical and effective than chemical grouting for large joints. For slip lining projects, the contractors use only heat fused joints; other products used for this application create another joint and are more costly.

The contractors also noted many challenges working within a coastal environment. These challenges include cleaning barnacles and working in the water to assess and repair outfalls, where managing boat traffic can be difficult. The contractors prefer using divers to perform the work but has used coffer damming in the past. Another challenging aspect of working in a South Florida coastal community is extensive dewatering due to the high ground water table and working in tidally influenced areas makes work possible at only certain times of the day.

2.6.1 Condition Assessment and Rehabilitation Cost Considerations

As part of the SWMP the Town of Lake Park will embark on a comprehensive long-term condition assessment program related to its stormsewer infrastructure. The major cost drivers of this program will be the inspection costs to assess the condition of the assets, and the rehabilitation costs to repair the assets. This section considers bid prices from the past four years for similar work for cleaning, CCTV inspection and pipeline rehabilitation, which could be used as a tool to estimate planning-level costs for capital improvements. The following Cost data is grouped by location—Florida, regional (areas outside of Florida but within the southeastern United States) and national (areas outside the southeastern United States). This cost data is not intended to replace project-specific construction cost estimates. Note that open cut replacement is not considered here since the Town has extensive experience with open cut replacements.

Table 2-4 below summarizes CCTV costs with average Florida prices ranging from $3.00/LF up to $6.00/LF. Regionally, average costs ranged from $3.56/LF to $5.50/LF (**Table 2-5**) , while nationally costs were slightly lower, as shown in **Table 2-6**.

Table 2-4 Florida CCTV Inspection Costs

Pipe Diameter (inches)	Unit Cost Per LF (Low)	Unit Cost Per LF (High)	Unit Cost Per LF (Average)	Unit Cost Per LF (Median)
18" to 24"	$1.00	$6.00	$3.00	$2.00
25" to 36"	$2.00	$6.00	$3.33	$2.00
37" to 48"	$2.00	$6.00	$3.67	$3.00
> 48"	$3.00	$8.00	$6.00	$7.00

Table 2-5 Regional CCTV Inspection Costs

Pipe Diameter (inches)	Unit Cost Per LF (Low)	Unit Cost Per LF (High)	Unit Cost Per LF (Average)	Unit Cost Per LF (Median)
18" to 24"	$1.10	$9.07	$3.56	$2.00
25" to 36"	$1.16	$9.47	$3.46	$2.50
37" to 48"	$1.35	$4.00	$2.13	$2.25
> 48"	$1.75	$8.00	$5.50	$8.00

Table 2-6 National CCTV Inspection Costs

Pipe Diameter (inches)	Unit Cost Per LF (Low)	Unit Cost Per LF (High)	Unit Cost Per LF (Average)	Unit Cost Per LF (Median)
18" to 24"	$1.18	$3.70	$2.53	$2.50
25" to 36"	$1.09	$4.35	$2.65	$3.00
37" to 48"	$1.10	$3.25	$2.11	$2.05
> 48"	$1.28	$11.00	$4.38	$3.84

Table 2-7 summarizes typical heavy pipe cleaning costs with average Florida prices ranging from $4.19/LF to $29.94/LF with national prices also slightly less, as shown in **Table 2-8**. These costs do not differentiate between CCTV and inspections that incorporate laser profiling. Adding the laser profile capability to the CCTV inspection typically increases cost by 50%-100% (although laser profiling is not typically used for rehabilitation applications). Note regional pipe cleaning costs were not readily available).

Table 2-7 Florida Pipe Cleaning Costs

Pipe Diameter (inches)	Unit Cost Per LF (Low)	Unit Cost Per LF (High)	Unit Cost Per LF (Average)	Unit Cost Per LF (Median)
18" to 24"	$1.75	$7.50	$4.19	$4.00
25" to 36"	$3.43	$11.00	$7.22	$8.00
37" to 48"	$6.00	$17.00	$10.46	$9.75
> 48"	$10.00	$75.00	$29.94	$25.75

Table 2-8 National Pipe Cleaning Costs

Pipe Diameter (inches)	Unit Cost Per LF (Low)	Unit Cost Per LF (High)	Unit Cost Per LF (Average)	Unit Cost Per LF (Median)
18" to 24"	$2.25	$4.76	$3.59	$4.00
25" to 36"	$5.00	$7.00	$5.73	$5.20
37" to 48"	$9.66	$9.66	$9.66	$9.66
> 48"	-	-	-	-

CIPP pipe lining costs are summarized in **Tables 2-9 through 2-11**. **Table 2-9** summarizes average Florida CIPP lining costs ranging from $89.14/LF up to $685.83/LF. Regional average CIPP costs range from $101.93/LF to $317.50/LF, while national average CIPP costs range from $77.36/LF to $558.75/LF.

Table 2-9 Florida CIPP Lining Costs

Pipe Diameter (inches)	Unit Cost Per LF (Low)	Unit Cost Per LF (High)	Unit Cost Per LF (Average)	Unit Cost Per LF (Median)
18" to 24"	$60.00	$140.00	$89.14	$87.50
25" to 36"	$110.00	$221.00	$143.69	$144.00
37" to 48"	$185.00	$338.00	$235.19	$232.50
> 48"	$400.00	$950.00	$685.83	$690.00

Table 2-10 Regional CIPP Lining Costs

Pipe Diameter (inches)	Unit Cost Per LF (Low)	Unit Cost Per LF (High)	Unit Cost Per LF (Average)	Unit Cost Per LF (Median)
18" to 24"	$86.00	$135.00	$101.93	$99.13
25" to 36"	$152.00	$210.00	$179.00	$175.00
37" to 48"	$275.00	$360.00	$317.50	$317.50
> 48"	-	-	-	-

Table 2-11 National CIPP Lining Costs

Pipe Diameter (inches)	Unit Cost Per LF (Low)	Unit Cost Per LF (High)	Unit Cost Per LF (Average)	Unit Cost Per LF (Median)
18" to 24"	$44.50	$150.00	$77.36	$75.00
25" to 36"	$110.00	$220.00	$156.27	$150.00
37" to 48"	$200.00	$400.00	$285.01	$270.02
> 48"	$420.00	$650.00	$558.75	$575.00

Table 2-12 summarizes typical slip lining costs with Florida average prices ranging from $69.58/LF to $430.42/LF, depending on pipe diameters. National average costs slip lining range from $72.33/LF to $295.55/LF, as presented in **Table 2-13**.

Table 2-12 Florida Slip Lining Costs

Pipe Diameter (inches)	Unit Cost Per LF (Low)	Unit Cost Per LF (High)	Unit Cost Per LF (Average)	Unit Cost Per LF (Median)
18" to 24"	$45.00	$103.00	$69.58	$65.00
25" to 36"	$85.00	$300.00	$158.20	$148.00
37" to 48"	$145.00	$450.00	$288.22	$268.18
> 48"	$225.00	$765.00	$430.42	$395.00

Table 2-13 National CIPP Lining Costs

Pipe Diameter (inches)	Unit Cost Per LF (Low)	Unit Cost Per LF (High)	Unit Cost Per LF (Average)	Unit Cost Per LF (Median)
18" to 24"	$45.00	$100.00	$72.33	$75.00
25" to 36"	$100.00	$134.00	$121.50	$122.50
37" to 48"	$130.00	$328.00	$173.50	$155.00
> 48"	$170.00	$492.00	$295.55	$225.00

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WRMA