STORMWATER DRAINAGE STUDY

TOWN OF SUNSET BEACH

BRUNSWICK COUNTY, NC

McGill ASSOCIATES

CONSULTING ENGINEERS
SHALLOTTE, NORTH CAROLINA

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LIST OF ACRONYMS

BMP - Best Management Practice

CAMA - Coastal Area Management Act

CIP - Capital Improvements Plan

Corps - US Army Corps of Engineers

EPA - US Environmental Protection Agency

GIS - Geographic Information System

GPS - Global Positioning System

LID - Low Impact Development

LIDAR - Light Detection and Ranging

NCDEQ - NC Department of Environmental Quality

NPDES - National Pollutant Discharge Elimination System

NPS - Non-Point Source

Plan - Stormwater Management Plan

ROW - Right-of-Way

SWMM - Storm Water Management Model

EXECUTIVE SUMMARY

The Town of Sunset Beach is located in Brunswick County, North Carolina, along the Atlantic coastline and covers about 4,682.3 acres, according to recent studies. About 40% of the Town may be classified as developed, mostly as residential but with some commercial and institutional land uses. The Town includes a mainland portion and an island beach strand that are separated by the Intracoastal Waterway, tidal marshes and creeks. Developed areas on both the island and mainland are served by a stormwater drainage system, much of which was built 20 to 30 years ago. This system requires frequent maintenance and repair, and also contributes to localized flooding problems. The effects of stormwater discharges to local water quality and the surrounding ecosystem have also become an area of concern for the Town.

To address problems associated with the stormwater system and concerns over water quality, the Town retained assistance from McGill Associates, PA (McGill) for the development of a Stormwater Management Plan. This project consists of a survey and assessment of the existing stormwater drainage system to identify and map the location, dimensions, capacity and condition of system components. This project also involves an analysis of water quality issues and remedies related to stormwater discharges. Findings from with stormwater system study were used to develop a Capital Improvements Plan (CIP) to provide recommendations for stormwater drainage infrastructure projects for addressing the identified issues. This Stormwater Management Plan and associated CIP have been developed to facilitate immediate implementation of many major plan elements. The objective in the development of this plan was to provide an action plan and not one filled with suggestions for further study.

A new survey of existing, Town-owned, stormwater drainage infrastructure, including drainage easements, was completed during the summer of 2016 by BM Long & Associates. Stormwater facilities located and evaluated included drop inlets, junction boxes, pipes and pond outfall structures. Survey data included elevations, horizontal location and connectivity. During the survey, the Contractor conducted an evaluation of the condition of all stormwater structures, and noted deficiencies including deteriorated condition, obstructions, damage, evidence or reports of flooding or other problems, and conditions of significance to the structure and function of the storm drainage system. All information was incorporated into the GIS.

Drainage easements were surveyed and conditions were evaluated by Surveyor. Encroachments from private buildings and site improvements were identified in the survey. Assessments included the amount and type of vegetation in the easement boundary and whether the drainage easement was effectively conveying surface flow. The Surveyor provided elevation data and drainage easement boundaries to McGill for mapping purposes. Porter Scientific was utilized for conducting a remote video camera assessment of portions of the storm drainage system that could not be otherwise observed. This assessment identified multiple problem areas, including cracked pipes, leaking or separated pipe joints, blockages, deep sand deposits, and corroded pipe bottoms.

The EPA Stormwater Management Model (SWMM), a computer software program, was used to model stormwater generation and transport through the Town's drainage system. To model a municipal storm drainage system such as that in Sunset Beach, the study area must be initially divided into catchments and sub-catchment areas. Stormwater runoff originates in these areas, and is captured by the routing system (pipes, ditches, etc.), which then transports flow past multiple junctions, where additional runoff enters the routing system , and ultimately to the outfall or endpoint of the modeled area. Information collected during the survey of the existing system was used along with the system-wide assessment of impervious areas to model each area. A simulation of a 30-year, 24-hour storm was used to evaluate the capacity of the system.

Impervious area was measured throughout the project boundary and recorded by category, with the results incorporated into a Geographical Information System (GIS). To evaluate the stormwater runoff the study area was divided into drainage catchments. The assessment of the drainage catchment areas for the Stormwater Management Model (SWMM) shows the average percent impervious coverage for the island to be 49.2% and the mainland to be 18.5%.

The SWMM was also used to evaluate water quality issues related to stormwater discharges from the Town's system. The guiding principle for water quality in Sunset Beach was that if overall discharge quantity could be reduced, then a corresponding reduction in pollutant discharge could also be achieved. SWMM was used to simulate the function of infiltration Best Management Practices (BMPs) and Low Impact Development (LID) strategies that could be incorporated into the Town's stormwater drainage system. Model results indicated that up to 100% of stormwater runoff from a 1.5-inch 3-hour storm could be infiltrated in some areas using perforated pipe infiltration systems and LID strategies.

A Capital Improvements Plan (CIP) has been developed to identify and prioritize needed repairs and upgrades to the stormwater drainage system. This plan also includes measures to improve water quality. Results from the SWMM, combined with the results from the drainage system survey and condition assessment, were used to develop a list of storm drainage system improvement projects. Basic information was collected for each project, such as quantities of pipe and/or junction boxes necessary, pavement repair area, driveway repair area, and other associated quantities. Project components included perforated pipe and infiltration trenches that were incorporated into individual plans to address water quality. This information was used to develop planning-level cost estimates for each identified project. Similar project development information was assimilated for large scale maintenance and restoration of drainage easements.

As drainage system maintenance will be a significant, constant, and long term activity, funding for certain specialized equipment is included in the CIP to enhance the ability of the Town Public Works personnel to perform these activities. Major items include: a street sweeper; a sewer and storm drain pipe inspection camera system; and a hydro-vacuum truck. An important element of this and any drainage system maintenance plan is the necessity to have properly trained, dedicated personnel to manage various aspects of the plan.

A large component of the current project involved mapping the existing storm drainage system and incorporation of the data into a Geographic Information System (GIS). This information is the primary determinant of the recommended CIP projects, and is also intended to guide maintenance activities. The GIS system will only work as intended if used maintained regularly to remain up to date. An item has been included in the CIP project list for GIS system maintenance and consulting, it is also important that the Town dedicate personnel to manage these tasks. CIP Projects were given a ranking based on public safety and consequences of the no-action scenario and a priority list has been developed. Projects are combined into annual lists based on priority, with total cost for each year estimated. The CIP also includes equipment purchases and other measures to facilitate the implementation of the plan, as well as long term system maintenance and management needs.

1.0 INTRODUCTION

1.1 Background

The Town of Sunset Beach is located in Brunswick County, North Carolina, along the Atlantic coastline (see Figure 1. Location Map). The Town of Sunset Beach was incorporated in 1963 and grew slowly for many years. The past 30 years has seen much faster growth with annexation and new development playing a large role. The Town now covers 4,682.3 acres, as reported in the 2016 Draft Coastal Area Management Act (CAMA) Land Use Plan. Approximately 25.5% of the total land area within the corporate limits is considered marsh and generally lies below mean high tide elevation. About 40% of the Town may be classified as developed, mostly as residential but with some commercial and institutional land uses. The remainder of the Town area is split between recreational (includes golf courses) uses and vacant land. The Town has a permanent, year-round population of 3,752, according to 2014 US Census Bureau American Community Survey estimates. During the summer months the population swells to as much as 15,000 with the influx of seasonal residents, tourists, and day visitors. The Town includes a mainland portion and an island beach strand that are separated by the Intracoastal Waterway and tidal marshes and creeks. Developed areas in both the island and mainland are served by a stormwater drainage system, much of which was built 20 to 30 years ago. The aging stormwater infrastructure now requires frequent maintenance and repair, and also contributes to localized flooding problems and related nuisance conditions throughout the Town.

In addition to the needs of addressing various drainage problems, concerns over water quality impacts associated with stormwater discharges and related human and environmental health effects, prompted the Town to seek assistance in developing a Stormwater Management Plan. McGill Associates, P.A. (McGill) was contracted in April of 2016 to provide services necessary to the requested Stormwater Management Plan. This project includes an assessment of the existing stormwater drainage system to identify and map existing conditions. Included in the assessment are the condition, capacity, location, and dimensions of system components, and any known related problems. This project also includes an evaluation of water quality issues related to stormwater discharges with a plan intended to address the identified issues.

1.2 Project Area Description

The focus of this project is the stormwater drainage system owned and operated by the Town of Sunset Beach. This study is confined to areas containing Town maintained stormwater drainage system components and the areas that drain to these components. Excluded from the project area are private developments where the stormwater drainage system is owned and managed by private entities. Also excluded are developments that drain to Town infrastructure but were previously designed and permitted in accordance with State mandated stormwater management ordinance standards. Of the 4,682 acres within the Town limits, about 1,458 acres are open water or marsh land, and were not part of the study area. A total of 1,624 acres are excluded from the study since they were developed under more recent land use regulations, represent lower density development, and incorporate stormwater management practices managed by others. The remaining area of the Town is approximately 1,600 acres, and generally represents the older and more densely developed portion of the Town. This 1600 acres is the study area for this project (see Figure 2. Study Area Map).

1.3 Purpose

The fundamental purpose of this project is to produce a Stormwater Management Plan (Plan) that provides an organized, structured, and data-driven approach to upgrades and modernization of the existing stormwater drainage system within the Town's jurisdiction. This Plan includes information characterizing the existing system, and identifies deficiencies within the system's service area related to both capacity and function. The Plan includes a prioritized Capital Improvements Plan (CIP), with several potential funding strategies designed to address these deficiencies. Further, the Plan includes an assessment of specific water quality issues related to stormwater, making recommendations to decrease stormwater discharge volume and improve water quality in receiving water bodies in and around Sunset Beach (see Figure 3. CIP Project Areas Map).

1.4 Goals

Specific goals of this project are listed below and represent the major tasks performed with the results produced from each.

1. Provide an updated survey and Geographic Information System (GIS) inventory of the Town's stormwater infrastructure; including pipes and other installed elements, as well as drainage easements. This project did not include a detailed survey of ditches and individual driveway pipes, but did map the locations of many of these features and included them in the GIS inventory (see Figure 4. Driveway Pipes Map). This project did not include surveying of stormwater infrastructure on private property.

2. Assess the condition and capacity of the Town's stormwater infrastructure through visual inspection and by modeling the system's capacity to convey a 30-year simulated

design storm. This process, combined with Town staff interviews, produced a list of identified deficiencies within the Town's stormwater drainage system.

3. Investigate water quality issues of concern within the Town. Determine how these issues can be addressed through improvements to existing and future stormwater infrastructure and related activities.

4. Develop a list of proposed solutions to identify system deficiencies that will address both system capacity and water quality issues. Create planning level cost estimates for proposed solutions.

5. Develop a methodology to prioritize proposed solutions and incorporate these into a Capital Improvement Plan with 5-year and 10-year implementation schedules.

6. Identify strategies for funding the Capital Improvements Plan.

2.0 METHODOLOGY

2.1 Data Collection

2.1.1 Existing Studies – Previous Studies

The initial project phase involved meeting with Town officials to discuss and clarify goals and identify specific areas of interest. Existing maps, studies and survey information relating to the current stormwater drainage system were obtained so that a project approach could build on past efforts to the extent practical.

2.1.2 New Survey

BM Long and Associates, was subcontracted to conduct a survey of the Town's stormwater drainage infrastructure. This work included a new survey of existing drainage easements. The field work was completed during the summer of 2016, with assistance provided by Town staff in locating obscured structures, removing manholes and grates, and providing general system information. Town stormwater facilities included drop inlets, junction boxes, pipes and pond outfall structures. Survey data provided elevations, horizontal location and connectivity for all structures. Existing Town drainage easement boundaries were surveyed and encroachments from private buildings, structures and site improvements were identified in the survey. Drainage easement conditions evaluated by the surveyors included the amount and type of vegetation in the easement boundary and a determination of whether the drainage easement was effectively conveying surface flow. McGill translated survey data collected into engineering base mapping for further evaluation.

2.1.3 Visual Assessment

McGill performed a visual assessment of the Town's stormwater facilities in conjunction with the system survey. The visual assessment cataloged existing conditions of pipes and drainage structures, and specific information relating to repair and maintenance needs. Field data collected was georeferenced by survey point or by Global Positioning System (GPS), assimilated into a database, and incorporated into the Geographic Information System (GIS). Existing condition parameters include: inlet type, access diameter, access material, access type, pipe size, pipe material, and pipe flow direction. An inspection form was completed on each facility with the following information collected: overall condition, frame condition, basin wall condition, grate condition, pipe condition, sediment depth and location, areas of erosion, potential contaminants, standing water depth, and recommended maintenance. Photo documentation was completed at each facility.

2.1.4 Video Inspections

Following survey and visual assessment field work, and coordination with the Town's Public Works staff, sections of pipe that could not be visually inspected were prioritized for in-pipe video data collection. Several sections of pipe could not be visually inspected because of obstructions in the pipes that could not be removed by hand, most common was deep sand or sediment deposits. Twenty-one pipe sections were considered high priority for video inspections (see Figure 5.1 and 5.2 Video Footage Maps). Porter Scientific was contracted to provide the video inspections, which were completed in December of 2016 and January of 2017. Hydro-cleaning was performed on numerous pipe segments to gain access and allow camera equipment to capture video. Results from the video inspections are included in the December 13, 2016 and January 10, 2017 Storm Pipe Assessment (Appendix 2). Video data was provided to the Town Utilities Director for file.

2.1.5 Project Area Base Data

Base data gathered for field visual assessment and impervious area assessment included 2012 true color aerial imagery (6" resolution), Brunswick County parcels, Sunset Beach municipal boundary, street centerlines, mapped NC Structures, Light Detection and Ranging (LIDAR) (elevation contours), and United States Department of Agriculture – Natural Resources Conservation Service mapped soils (see Figure 6. Soils Map). This information is used throughout the study and incorporated into GIS.

2.1.6 Impervious Areas

Impervious areas within a natural drainage area or catchment represent the primary source for stormwater runoff. Impervious areas are those parts of the developed landscape that are unable to effectively absorb or infiltrate rainwater and consequently produce stormwater runoff. Gaining a clear understanding of the amount of impervious cover within a given catchment provides the basis of any stormwater management calculations or study. For this project, impervious areas were measured and digitized over the entire 1,600 acre study area. The assessment of impervious cover was completed by overlaying 2012 aerial imagery, parcel data, and existing building footprint data. To facilitate the stormwater modeling phase of the project, drainage area boundaries for each stormwater inlet were overlaid on the impervious cover map to determine impervious cover for each modeled catchment. Excluded areas (portions of the study area with existing stormwater management plans) were not assessed for impervious cover. Roads, driveways, buildings/structures, paved walkways, and other impervious surfaces were measured from aerial imagery by digitizing outlines within GIS. Google Street View was used to verify areas obstructed by tree cover, as well as to help distinguish between sand and gravel driveways. Compacted gravel areas were considered impervious consistent with NCDEQ guidelines (see Figure 7. Impervious Areas Map).

2.1.7 Communication with Town Staff

McGill Associates personnel worked directly with Town Public Works staff while completing the field visual assessment. Town staff assisted in inspections of Town maintained stormwater facilities by locating and providing access to structures. During the course of completing the field assessment, Town staff provided information on known problems related to stormwater facilities and drainage easements, including flooding, nuisance areas, facility failures, access issues, and past maintenance/repairs. Additionally, staff provided information on existing Best Management Practices (BMPs) installed by the Town (see Figure 8. Existing BMP Locations Map and Figures 9 and 10. Floodprone Areas Map).

2.2 Data Assimilation

2.2.1 Geographic Information System and AutoCAD

A Geographic Information System (GIS) is an excellent platform for storing and managing large amounts of location specific data. GIS supports statistical analysis of data layers, modeling, digitizing, data extraction, database management, and map production as well as integration with other database software programs such as Microsoft Excel and Access. GIS was used in the Town of Sunset Beach Stormwater Drainage Study to help determine study area boundaries, and pipe network mapping. It was also helpful in processing data for integration into the Storm Water Management Model (SWMM), impervious area analysis, and managing a large database. All data in the GIS was projected to a common coordinate system (State and Plane, NC - NAD 83, US Feet) for data overlay, analysis and mapping purposes. The GIS database was assembled using Project Area Base Data integrated with Global Positioning System (GPS) data gathered during the field visual assessment. The information collected through the drainage system survey, including structure and pipe elevations and dimensions, and the location of drainage easement boundaries, was incorporated into the GIS. Additional data gathered during field work using GPS and incorporated into the GIS database includes: driveway culverts, roadside ditches and swales, topographic break-lines, problem and flood-prone areas, non-surveyed pipes, BMP locations, as well as ponds and streams where accessible.

Computer-aided drafting (CAD) software was used to review survey data. The stormwater facilities and drainage easement surveys were directly imported into GIS from CAD for data overlay. CAD was used to produce maps and figures for the Final Report and Capital Improvements Plan projects.

2.2.2 Analysis

2.2.2.1 EPA Stormwater Management Model

Stormwater Management Model (SWMM) is described in the user's manual as a "dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas." SWMM operates through two analytical modules: the runoff or hydrologic module and the routing or hydraulic module. To model a municipal storm drainage system such as that in Sunset Beach, the study area must be divided into sub-areas, where runoff originates and is captured by its routing system, which transports the flow past multiple junctions, adding runoff from other areas, to the outfall or endpoint of the modeled area. Terms that will be used throughout this analysis for the land areas modeled are "catchment" and "sub-catchment".

The SWMM model for this project was set up at the catchment level. A catchment is the entire land area that drains to a single outfall, which is the point flow leaves the storm drainage system for good and enters a natural waterbody. Catchments are made up of one or more sub-catchments, which are defined as the land area that drains to a single inlet or pipe. In closed systems, such as on the island, every inlet in a connected series of underground pipes defines a separate sub-catchment. In open systems, as found in many areas of the mainland, open ditches, streams, or ponds connect individual pipes (collectively conduits). In these open systems, the determination of sub-catchment boundaries is more complex and relies on professional judgement or assumptions. In general, for the mainland, sub-catchment boundaries were defined from the point of entry to each successive pipe in a series of conduits from the upper limit of the catchment drainage area to the outfall.

Various properties are assigned to each sub-catchment and each conduit to facilitate the modeling of the system under a broad range of hydrologic and hydraulic scenarios. SWMM also allows for the modeling of Low-Impact Development (LID) and stormwater Best Management Practices (BMPs) to simulate the function of measures adopted to address various water quality issues.

It is important to understand that there is uncertainty with any stormwater modeling exercise and that the amount of uncertainty tends to increase with the complexity of the model, the number of variables involved, and the accuracy of the input data. The SWMM model prepared for this study was developed using the best available data in an effort to maximize the reliability of the modeling results.

2.2.2.2 Model Input and Assumptions

As mentioned earlier, SWMM uses two primary computational modules, one for runoff and the other for routing, with data requirements and assumptions for each discussed separately below.

1. Runoff Module: For a given rainfall event, SWMM generates stormwater runoff from each sub-catchment based on land cover, soils, topographic and other site specific data input into the model. Soils in a large portion of the project area are sandy and tend to have high infiltration rates such that minimal runoff is produced from the rainfall directly onto natural ground or pervious surfaces. Impervious surfaces such as rooftops, driveways, parking areas, sidewalks and roads are the areas where runoff originates.

   Impervious areas are further classified as connected or disconnected to the stormwater routing system. Connected impervious surfaces are those where all rainfall that falls on the surface flows directly into the conveyance system without passing over pervious surfaces. Disconnected impervious areas are those where runoff generated is subsequently routed back to pervious areas where some or all of the volume may infiltrate into the soil before reaching the stormwater conveyance system. To account for the two types of impervious surfaces SWMM requires a value for total impervious cover and a value for the fraction of total impervious cover that is disconnected to be input for each sub-catchment.

   Infiltration of direct rainfall and of runoff routed over pervious areas is an important factor to model correctly, particularly in an area where a large percentage of total rainfall could potentially be infiltrated. SWMM allows for detailed information regarding soil infiltration rates and capacity to be input for the soil type or types present in each Sub-catchment.

   The most fundamental input for a stormwater model is the storm or rainfall event to be modeled. SWMM allows essentially any type of rainfall event to be modeled. For this study, a 30-year, 24-hour storm event was used as a baseline for the evaluation, this storm is referred to as the Baseline Storm throughout this document. This storm event produces 9.8-inches of rain within a 24-hour timeframe. A graphical depiction of this storm event is provided in Table 1.

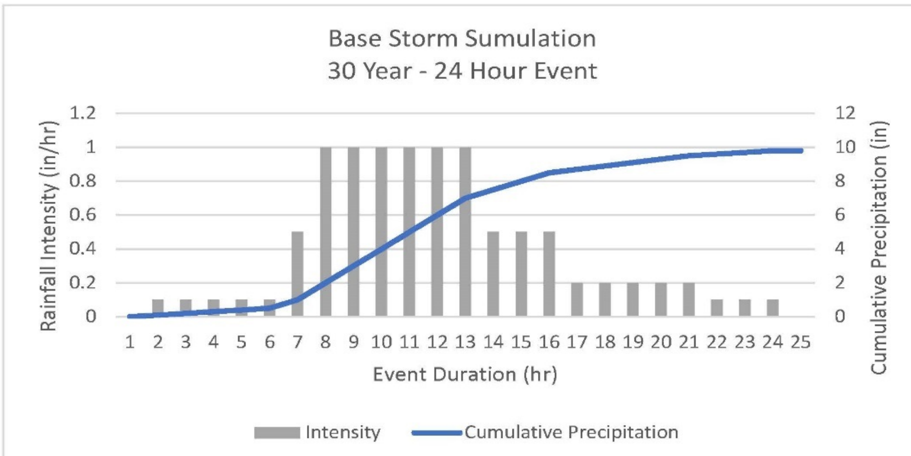

Table 1 – Base Storm Simulation

2. Runoff Module Assumptions: Numerous assumptions are necessary and implicit in any modeling of natural systems. Without assumptions, the effort would become overly burdensome and impractical. The goal of the modeler is to put the greatest effort into the variables that have the most influence on model performance and output with respect to the objectives of a particular study. Several key assumptions used in the development of the sub-catchment runoff module are mentioned below. The assumptions utilized are based on practical experience and accepted engineering practices and should not be construed as arbitrary.

   Sub-catchment Boundaries: The generally flat condition of the study area combined with sandy soils that rarely show surface drainage patterns made it difficult to definitively determine drainage area boundaries in some locations. In most cases boundaries were drawn based on broad topographic trends, though we acknowledge that micro-topographic features, could result in minor deviations from the catchment and sub-catchment boundaries presented in this report.

Impervious Runoff Routing: As discussed above, a fraction of runoff from impervious areas is routed back to pervious areas. A detailed assessment of the entire study area to accurately quantify this value would have required direct inspection and evaluation of the majority of all impervious surfaces within the study area and this effort was not included in the scope for this study. In order to determine this value for each sub-catchment, a qualitative assessment of the likely flow path for runoff from all areas of the sub-catchment to the storm drainage system inlet was used. Factors considered included the overland distance the runoff would travel, relative development density within the sub-catchment, known presence of overland swales, ditches, or other features that would influence the path of runoff, the proportion of rooftops verses other impervious surfaces within the sub-catchment, and the average slope of the overland flow path. Values ranged from 20% to 90%. The initial assumption of 50% was adjusted up or down depending on the qualitative analysis and professional judgement.

Model Parameters with Lower Significance: In a modeling effort focused on peak flows, it was assumed that the quantity of runoff trapped by depression storage or lost to evaporation would not significantly impact the model output, therefore, default values were used.

3. Routing Module Input: After runoff enters a stormwater inlet or drainage pipe, runoff then travels through a network of conduits that include pipes of various sizes, junction boxes, ditches, streams, and ponds, with final outfall into a natural waterway. The routing module in the Stormwater Management Model (SWMM) calculates the volume, velocity, and flow depth at each node in this system of conduits based on values of size, shape, length, slope, and roughness, among others for each component of the system.

   Physical characteristics of pipes and junction boxes were measured during the field survey and visual assessment of the drainage system performed during the summer of 2016. From the survey data, pipe diameter, length, slope, and roughness were determined. Physical characteristics for non-surveyed conduits, including ditches, streams, and ponds were estimated from Light Detection and Ranging topography (LIDAR), aerial imagery, and photographs, as well as information gathered during the visual assessment.

4. Routing Module Assumptions: Several key assumptions used in the development of the Sub-catchment routing module are mentioned below.

   Pipe Condition: Although many pipes throughout the Town's storm drainage system are damaged, degraded or compromised in some other way, all components were modeled as if they existed in a fully functional condition. The purpose of this assumption is to facilitate an analysis of the system capacity, as designed. The analysis of system condition was made through the visual assessment of each component.

Ditches and Streams: It is assumed that ditches and streams simply pass flow through with no evaporation or infiltration losses and no permanent storage in these systems. There likely are both losses and storage of runoff in these conduits, but for larger storm events, such as the Baseline Storm, these losses become minimally significant making the stated assumption appropriate.

Ponds: As with ditches and streams, ponds were modeled to pass flow through with no losses or permanent storage. However, ponds and some ditches were modeled with temporary storage up to an estimated containment elevation. The containment elevation was the elevation above which water would flood out and flow downstream over land. This elevation was conservatively estimated using LIDAR topography, photographs and information gathered during the visual assessment.

Groundwater: It was assumed that groundwater infiltration into the stormwater drainage system was not a significant factor.

2.2.2.3 Water Quality

An assessment of existing water quality condition and problems was completed through a review of various plans and reports including:

1. Most recent Coastal Area Management Act Land Use Plan (2016 Draft)
2. Lumber River Basin Documents prepared under the statewide watershed planning program administered by NC Department of Environmental Quality (NCDEQ)
3. NC Nonpoint Source Pollution Management Program (2014)

The goal for this component of the project was to integrate strategies and measures that would positively influence water quality into a Capital Improvements Plan (CIP) intended to correct deficiencies throughout the existing stormwater drainage system. The CIP projects are primarily focused on addressing identified problems such as deteriorated or failing pipes or junctions, and known flooding areas. The approach to achieving the water quality goal is to identify opportunities to incorporate water quality enhancement measures into the CIP project list. The guiding principle is that if changes in the system can be made that result in measurable reductions in total runoff volume, from the same storm simulation, then there will be a reduced pollutant load to receiving water bodies.

2.2.2.4 Capital Improvements Plan

The Capital Improvements Plan (CIP) consists of a list of projects that involve substantial replacement, upgrade, and/or modifications to the existing stormwater drainage system. These projects are considered beyond the scope of typical maintenance activities. Selection of the projects is based directly on the findings from various field data collection and stormwater modeling efforts. Basic information was collected for each project, such as quantities of pipe and/or junction boxes needed, pavement repair area, driveway repair area, and other associated quantities. Project components, such as perforated pipe and infiltration trenches, were incorporated into individual plans to address water quality. This information was used to develop planning-level cost estimates for each identified project.

Similar project development information was assimilated for large scale maintenance and restoration of drainage easements. Projects were given a ranking based on public safety and consequences of the no-action scenario, projects are compiled into annual lists based on priority with total cost for each year. The CIP also includes equipment purchases and other measures to facilitate the implementation of the plan and long term system management.

The CIP has been prioritized and separated into annual projects lists for a 10-year implementation period. Projects have also been condensed into a 5-year implementation period for comparison. The CIP has been developed as a stand-alone document and is attached as an addendum to this Plan.

3.0 RESULTS – EXISTING CONDITIONS

3.1 Drainage System Survey and Assessment

Physical characteristics of pipes and junction boxes were measured during the field survey and visual assessment of the drainage system performed during the summer of 2016. From these efforts, pipe diameter, length, slope, and roughness were determined. Physical characteristics for non-surveyed conduits, including ditches, streams, and ponds, were estimated from Light Detection and Ranging topography (LIDAR), aerial imagery, and photographs, as well as information gathered during the visual assessment. The information collected through the drainage system survey included structure and pipe elevations and dimensions, and the location of drainage easement boundaries. All specific information relating to pipes and structures collected during the survey and visual assessment was incorporated into the Geographic Information System (GIS). Additional field data gathered using GPS was also incorporated into the GIS database and includes: driveway culverts, roadside ditches and swales, topographic break-lines, problem and flood-prone areas, non-surveyed pipes, BMP locations, as well as ponds and streams where accessible.

3.2 Results from Video Pipe Inspections

During the field survey and visual inspection of the stormwater drainage system, twenty-one sections of existing pipe were identified to determine the system condition or cause of problems such as flooding, standing water or excessive sediment accumulation. Of the twenty-one sections of pipe initially recommended for video inspection, only ten runs were completed successfully. Deep water and excessive sediment levels were primarily responsible for the low completion rate. Problems identified in the inspected areas included: pipe wall cracking, deep sediment deposition, pipe wall buckling and separation, pipe blockages, deep standing water, and unknown junctions. In response to the limited inspection ability in a few locations during the initial video evaluation, a second effort was completed. The results from follow-up evaluations provided information on obstructions in two pipes. Results of the pipe video inspections are condensed in Appendix 2.

3.3 Impervious Areas

Impervious surfaces were measured throughout the study area and recorded by category as follows:

- Roads: Measured as length and width of all roads within the public right-of-way.
- Right-of-way (ROW): Measured footprint of all non-road impervious surfaces within the public right-of-way, this includes sidewalks, portions of driveways, and portions of parking lots.
- Structures: Measured footprint of primary structure on each parcel within the study area.
- Parcel: Measured footprint of all impervious surfaces, excluding the primary structure, on parcels throughout the study area including driveways, parking lots, out buildings, and walkways.

The results of this assessment show the average impervious cover over the entire 1,600 acre study area to be 20.2%. This number can be broken down to mainland (17.56%) and island (29.24%). With respect to stormwater discharges, the percentage of impervious surfaces increases substantially on the island since there are a limited number of locations served by an existing stormwater drainage system. The island study area is 360 acres but the modeled drainage area for the island stormwater drainage system is only 159.5 acres. The assessment of the catchment drainage areas for the Stormwater Management Model shows the average percentage of impervious surface for the island to be 49.2%, with the mainland at 18.5%. A summary of impervious area by modeled catchment is provided in Table 2.

Table 2 shows a breakdown of impervious area into four categories as defined above. The most significant finding from the impervious analysis is that the area associated with rooftops is the largest component of total impervious cover on both the island and mainland portions of the study area. The amount of stormwater discharge that originates from rooftop drainage is highly dependent on the path this runoff follows from the point of origin to the point of entry to the storm drainage system. There are many factors that affect the ultimate fate of rooftop drainage, including:

- Whether or not the drainage is collected in gutters;
- Whether or not the gutters discharge to pervious or impervious surfaces;
- The soil type and infiltration potential of pervious surfaces receiving rooftop runoff;
- The amount of depression storage or infiltration that occurs along the path from the gutter discharge point to where the runoff enters the stormwater drainage system.

A quantitative analysis of the fate of rooftop drainage for the entire study area is beyond the scope of this study, but a qualitative assessment was conducted in limited areas of both the island and mainland. Findings from this analysis indicate that the fraction of total rooftop area draining directly to the stormwater system is likely to be in the 40% to 60% range for all development. General findings from this analysis are as follows:

- As much as 20% of all rooftop area does not drain into gutters; some structures have no gutters and others are only partially guttered.
- Rooftops that lack gutters drain directly onto pervious surfaces in most cases.
- Rooftops with gutters have the highest rate of discharge directly to impervious surfaces. This occurs as direct discharge to a driveway or via collection system tied to or discharging near a storm drain inlet, roadside swale, or ditch.
- A much higher percentage of commercial or multi-family uses have connected gutter discharges.

3.4 Soils

Soils throughout the study area were found to be almost exclusively fine sand and sand. There are seven major soil types within the studied catchment areas; three on the island and four on the mainland. Each is described below with emphasis on characteristics relative to this Stormwater Management Plan. A Soils Map is provided in figure 6.1.

I. Newhan fine sand (NeE), 2 to 30 percent slopes: This soil type is found on the island on the convex shoulders and slopes of dune features. NeE is classified as excessively drained with a depth to water table of more than 80-inches. This soil type has excellent infiltration potential.

II. Newhan fine sand dredged (NhE), 2 to 30 percent slopes: This soil type consists primarily of historic sandy dredge spoils that have been incorporated into the landscape as dune features on the island. NhE is classified as excessively drained with a depth to water table of more than 80-inches. This soil type has excellent infiltration potential.

III. Corolla fine sand (Co) 0 to 6 percent slopes: This soil type is found on concave troughs on barrier islands. This soil is considered moderately well drained with a depth to water table of 18 to 36-inches. This soil generally infiltrates surface water well but is the least suitable soil for constructed infiltration measures on the island.

IV. Kureb fine sand (KrB), 1 to 8 percent slopes: This soil is found on convex ridges and crests of marine terraces on the mainland. KrB is classified as excessively drained with depth to water table of more than 80-inches. This soil has good infiltration potential.

V. Pactolus fine sand (PaA), 0 to 2 percent slopes: This soil is found on slopes below stream terrace ridges, it may occur in both concave and convex surface features. PaA is classified as moderately well drained with a typical depth to water table of 18 to 36-inches. This soil infiltrates surface water well but has only moderate potential for in-ground infiltration measures.

VI. Wando fine sand (WaB), 0 to 6 percent slopes: This soil is found on the upper slopes and ridges of marine terraces on the mainland. WaB is classified as well drained with typical depth to water table of 48 to 72-inches. This soil is well suited for infiltration measures where depth to water table is greater.

VII. Leon fine sand (Lo) 0 to 2 percent slopes: This soil is found on flat or concave marine terraces on the mainland. Lo is classified as poorly drained with typical depth to water table of 0 to 12-inches. This soil has poor infiltration potential.

3.5 Flood Prone Areas

Sections of the study area considered to be susceptible to flooding include areas that experience periodic or repeated street flooding of yards and damage to property. Flood prone areas occur as a result of existing conditions which may include: inefficient or damaged stormwater conveyance measures, absence of stormwater measures, poorly draining soils, localized topography, obstructions in stormwater system components (sediment, vegetative, debris), or a combination of these factors. Flood prone areas were identified through communication with Town staff, input from local residents, through direct evidence, and as predicted by the Stormwater Management Model. Locations are shown on Figures 9 and 10 (Flood Prone Areas Maps).

3.6 Problem Areas

Problem areas or system deficiencies identified during the survey and visual inspection of the storm drainage system were catalogued by Facility ID, or the alpha-numeric code given to each structural component of the system. Each identified issue was entered into a system database and merged into the Geographic Information System (GIS). Specific issues included:

- Areas of standing water in pipes or junction boxes;
- Areas with excessive sediment accumulation in pipes or boxes;
- Areas with evidence of active soil erosion around structures caused by water entering or leaving the system;
- Areas of ground subsidence around structures or above pipe runs; sink holes or settling;
- Areas within stormwater drainage easements where standing water has been caused by poor drainage or debris blockages;

- Areas within stormwater drainage easements that have become over-grown with vegetation;
- Areas within stormwater drainage easements that are blocked or obstructed by fences, out buildings, or other homeowner related activities such as dumping of debris or yard waste
- Concrete drainage structures (such as inlet or junction boxes) with excessive cracks, crumbling, or other signs of degradation;
- Corroded and unstable stormwater inlet grates;
- Stormwater pipes with corroded bottoms, cracks, crushed inlets, or joint separation;
- Areas identified through video inspection of stormwater pipes.

3.7 Water Quality

3.7.1 Known Problems

Water quality problems are well documented in the coastal regions of North Carolina through the NC Basin-wide Planning Program, Coastal Area Management Act planning requirements, various non-point source (NPS) management programs, and numerous other public and private/Non-Government Organization (NGO) managed programs. The greatest concerns center on the effects of stormwater runoff from developed and agricultural areas to the water quality of tidal creeks, estuaries, and coastal waters of North Carolina and beyond. In the natural waterways within the Town of Sunset Beach, water quality concerns center around bacterial levels in shellfish areas leading to closure or partial closure of shellfish waters. There are also concerns regarding turbidity levels, nutrient levels, dissolved oxygen, and copper. There are multiple sources and causes, both local and regional, for the levels of contaminants noted in the literature. The water quality component of this study focuses on the role stormwater plays locally in the delivery of various sources of water quality contamination.

3.7.2 Causes of Stormwater Related Water Quality Issues

The key water quality problem with stormwater discharges is that rainfall is essentially washing the connected impervious surfaces in Town and efficiently flushing the wash water (inclusive of bacteria, nutrients, sediment and metals) directly into natural water bodies. There are 41 mapped stormwater outfalls in Sunset Beach. All of which discharge directly or indirectly into a natural water body, with minimal opportunity for filtering or settling of pollutants before entering recreational or shell fishing waters. The outfalls on the island are more direct than on the mainland, where many outfalls enter ponds or ditches, allowing for some settling and trapping of pollutants.

3.7.3 Remedy

A well-known obstacle to the development of a comprehensive stormwater management program that includes a strong water quality management component is that, to some extent the two goals, effective drainage and water quality, are often seen as competing and contradictory. However, progress toward meeting these two goals can be made through complimentary approaches. Sunset Beach has in place, in cooperation with Brunswick County, a Stormwater Management Ordinance and associated Stormwater Management Manual and Low Impact Development Guidance Manual. Many of the structural measures and strategies detailed in these documents are precisely what are needed to bring about significant improvements to water quality and also address some of the Town's drainage problems. As a general guiding principle, the policies and programs established to address both these issues should focus on source control to the extent possible, and then on measures to mitigate both flow volumes and pollutant loads as close to the source as practically feasible.

3.7.4 Existing Best Management Practice

Communication with Town staff revealed that efforts have been made to control flooding with the installation of several Best Management Practice (BMP) measures in road right-of-ways. BMP measures include french drain pipes connected to drop inlet basins; dry wells that consist of perforated pipes installed on top of rock beds in a trench or simply trenches filled with stone. These BMP measures promote infiltration and increase stormwater retention. The locations of existing BMP measures are shown on Figure 8. In addition to BMP measures installed in the public right-of-way, there are many single-family homes and other structures on private property that have installed or implemented Low Impact Development (LID) controls or strategies to infiltrate or capture stormwater at the source. There is no accurate inventory of existing LID controls, thus the relative effect on stormwater runoff cannot be estimated.

3.7.5 Review of Existing Regulations

New development and re-development projects in Sunset Beach are regulated through a combination of Town and County ordinances, with additional regulations through various State and Federal agencies. A summary of regulations that address stormwater related quantity and quality issues at the local, State and Federal levels is provided below:

3.7.5.1 Local Regulations

Local regulation is provided both by the Town of Sunset Beach and Brunswick County. Regulations that specifically address stormwater quantity and water quality are administered by Brunswick County Engineering Department. The County ordinance contains requirements for:

1. Stormwater Peak Discharge Control: No net increase in 1-yr., 24-hr. and 10-yr., 24-hr. storms unless variance conditions are satisfied. With a variance, peak discharges can be increased up to 5%.
2. Control Measures to Minimize Pollutant Export: Calculations are required to predict the export of total nitrogen (TN), total phosphorous (TP), total suspended solids (TSS), and fecal coliforms for both the pre- and post-development conditions. Measures, such as LID techniques and structural BMPs are required to the maximum extent practicable, to minimize the export of these pollutants.
3. Riparian Buffers: A minimum 30-foot wide undisturbed vegetated buffer is required along all natural water courses unless variance conditions are satisfied.
4. Discharges of Pollutants from Existing Uses: The ordinance includes several provisions to require owners of existing developed land to identify and minimize the potential for releases of pollutants, monitor and maintain measures installed for this purpose, and report any releases that occur. The ordinance also allows for Town and County personnel to inspect and monitor for illegal discharges, and order corrective measures as necessary to eliminate or minimize such discharges.
5. Maintenance of All Control Measures: Permanent maintenance agreements are required for all control measures installed under the ordinance. Provisions are included to require that easements be recorded around control measures and access corridors, to allow Town personnel to inspect and enforce maintenance requirements.

3.7.5.2 State of North Carolina Regulations

The State of North Carolina regulates water quality and activities that affect water quality through several programs administered by the NC Division of Environmental Quality (NCDEQ), including:

1. Erosion and Sediment Control: NCDEQ provides oversight and assistance to local program personnel in Brunswick County.

2. State Stormwater Program: NCDEQ provides oversight and assistance to local program personnel in Brunswick County.
3. Clean Water Act 401 Program: NCDEQ regulates the discharge of pollutants to all Waters of the State including Waters with special designations such as shell fishing waters (SA) or High Quality Waters (HQW).
4. Coastal Area Management Act (CAMA): NCDEQ administers this program with local governments through the development of approved land use plans and hierarchal permitting structure.

3.7.5.3 US Government Regulation

The US Government regulates stormwater and water quality primarily through the Clean Water Act (CWA). CWA programs are administered at all levels of government, but final responsibility lies with the Federal agencies that oversee the various programs. Programs of significance to Sunset Beach and this effort include:

1. National Pollutant Discharge Elimination System (NPDES): The US Environmental Protection Agency (EPA) administers this program through the states and down to the local level. The Brunswick County Stormwater Management Ordinance was developed to comply with a NPDES permit.

2. CWA Section 404 and Section 10 of the Rivers and Harbors Act (RHA): These programs are administered by the US Army Corps of Engineers (Corps) and regulate the discharge of dredged or fill material to Waters of the US including rivers, streams, wetlands and tidal marshes. Section 10 of the RHA focuses more on issues related to navigability of rivers.

4.0 STORMWATER MANAGEMENT MODELING

4.1 Stormwater Management Model Results

4.1.1 Summary

As described earlier in this study, a catchment is the entire land area that drains to a single outfall, which is the point flow leaves the storm drainage system and enters a natural waterbody. Catchments are made up of one or more sub-catchments, which are defined as the land area that drains to a single inlet or pipe. A total of 41 catchments were modeled in the Stormwater Management Model (SWMM); 20 on the island and 21 on the mainland. Development density is generally higher on the island, leading to higher sub-catchment impervious percentage on the island (avg. 49%) vs the mainland (18.5%). Table 2 provides a breakdown of Catchment impervious cover.

SWMM determines total runoff and peak runoff from each sub-catchment and also generates a runoff coefficient value that represents the fraction of total rainfall that enters the stormwater conveyance system. Results from the simulated 30-year, 24-hour storm that produces 9.8-inches of rain (baseline storm) are included in Appendix 3. SWMM routes runoff from sub-catchments into drop inlets or pipes, then through the system to the outfall. System capacity problems are identified as areas where modeled stormwater flow causes backups (surcharge) in pipes or junctions, flooding at inlets, or other openings in the system. Numerous potential problem areas were identified throughout the study area using these criteria.

The capacity analysis for the existing drainage system was based on the baseline storm simulation. Despite the magnitude of the baseline storm event, modeled runoff coefficients remained fairly low compared to the percent impervious coverage of the contributing drainage area. This is primarily attributed to the prevalence of sandy soils throughout the study area. Even the most restrictive soils modeled have a moderate infiltration rate when compared to piedmont soils.

In several areas, the model results matched the reports of known flooding problem areas, which increased confidence in various model coefficients. Model results also indicated several pipe segments that currently flow at capacity or under pressure during the base storm event. These results are incorporated into both the project selection and prioritization criteria for the CIP.

In addition to impervious cover, other factors highly correlated to stormwater runoff volume are the relative “connectedness” of the impervious areas to the stormwater conveyance system and soil type. Connected impervious areas are those that flow from the source to the stormwater conveyance system directly, or over other impervious surfaces. Disconnected impervious areas are those that flow from the source (e.g. a rooftop gutter drain) back to a pervious area such as a lawn or landscaped area. The soil type, slope, and length of flow path are important factors in determining what fraction of the runoff from disconnected impervious areas infiltrates into the soil and how much ends up in the stormwater drainage system. See Table 2.

IMPERVIOUS AREA SUMMARY BY CATCHMENT							
ISLAND							
Catchment Number	Area (ac)	Imperv Area (ac)	Imperv %	Imperv Roads (ac)	Imperv Drives (ac)	Imperv Structures (ac)	Imperv Parcel (ac)
1	16.4	8.9	54.5%	1.8	0.6	4.5	2.0
2	8.5	3.5	41.4%	0.9	0.4	1.5	0.8
3	5.6	3.0	53.7%	0.6	0.3	1.4	0.6
4	17.1	9.3	54.5%	1.8	0.9	4.6	2.0
5	35.2	15.5	44.1%	3.2	1.8	5.1	5.3
6	26.0	13.0	49.7%	2.5	1.4	5.5	3.6
7	15.3	8.9	58.2%	1.7	1.2	3.7	2.4
8	0.7	0.4	53.6%	0.1	0.1	0.1	0.1
9	1.8	1.1	60.1%	0.4	0.1	0.3	0.2
10	0.7	0.4	63.3%	0.1	0.1	0.1	0.2
11	1.9	0.9	44.6%	0.4	0.1	0.3	0.1
12	0.6	0.3	46.4%	0.1	0.0	0.1	0.1
13	2.4	1.4	59.9%	0.4	0.2	0.5	0.3
14	7.0	4.1	58.4%	0.8	0.7	1.5	1.1
15	3.4	1.9	57.3%	0.3	0.3	0.7	0.6
16	2.8	1.8	65.6%	0.4	0.3	0.6	0.6
17	1.1	0.3	29.8%	0.1	0.0	0.1	0.0
18	3.3	1.9	59.0%	0.3	0.3	0.8	0.6
19	1.7	0.9	54.8%	0.1	0.1	0.5	0.3
20	8.0	4.9	61.7%	0.8	0.9	1.5	1.8
TOTALS	**159.5**	**82.7**	**51.82%**	**16.7**	**10.0**	**33.4**	**22.6**
Percent of Total Imperverious Area				**20.22%**	**12.04%**	**40.38%**	**27.36%**

Table 2 – Impervious Areas Per Catchment - Island

IMPERVIOUS AREA SUMMARY BY CATCHMENT							
MAINLAND							
Catchment Number	Area (ac)	Imperv Area (ac)	Imperv %	Imperv Roads (ac)	Imperv Drives (ac)	Imperv Structures (ac)	Imperv Parcel (ac)
21	1.8	1.5	86.3%	0.1	0.0	0.0	1.4
22	3.6	0.2	6.7%	0.0	0.0	0.1	0.1
23	4.3	1.0	23.1%	0.3	0.0	0.5	0.2
24	13.5	3.0	22.0%	0.7	0.1	1.4	0.8
25	18.2	4.0	21.8%	0.7	0.3	1.5	1.4
26	25.9	5.8	22.3%	0.9	1.0	1.9	1.9
27	10.8	2.7	24.6%	0.9	0.5	1.2	0.1
28	1.1	0.6	55.4%	0.3	0.0	0.1	0.2
29	31.1	5.4	17.4%	1.7	0.3	2.2	1.2
30	10.5	1.9	17.8%	0.6	0.1	0.4	0.7
31	18.1	4.3	23.6%	1.0	0.1	2.2	0.9
32	27.3	7.8	28.6%	2.1	0.3	3.9	1.5
33	1.2	0.0	1.1%	0.0	0.0	0.0	0.0
34	4.2	0.9	21.8%	0.3	0.0	0.3	0.2
35	82.1	14.6	17.8%	4.0	1.1	6.9	2.6
36	8.5	1.9	22.2%	0.5	0.1	0.8	0.5
37	89.6	17.7	19.7%	5.0	1.4	9.0	2.3
38	3.5	1.0	27.1%	0.5	0.0	0.2	0.1
39	31.9	5.2	16.4%	1.8	0.4	2.8	0.3
40	2.7	0.4	15.4%	0.2	0.0	0.2	0.0
41	2.3	0.5	22.8%	0.3	0.0	0.2	0.0
TOTALS	**392.2**	**80.3**	**20.48%**	**22.2**	**5.8**	**35.8**	**16.5**
Percent of Total Imperverious Area				**27.61%**	**7.23%**	**44.62%**	**20.54%**

Table 2 – Impervious Areas Per Catchment - Mainland

SWMM allows the runoff from disconnected impervious areas to be modeled as a percentage of the total runoff flowing back to or across pervious areas before reaching an inlet to the conveyance system. Based on observed conditions in the study areas, the percentage of disconnected impervious surfaces ranged from 20% to 90%. Because of the high infiltration rates of many of the soils in the study area, reductions in both total runoff and peak runoff from the current level of disconnected impervious surface, range from near zero (areas of poor soils) to over 60%. Typical results range from 30% to 40%. Most of the existing disconnection appears to be passive, or simply the result of existing conditions, as opposed to active disconnection, which would occur through the implementation of LID practices.

4.1.2 Water Quality Analysis

As discussed previously in this document, the primary approach to reducing water quality impacts from stormwater discharges is to reduce the total volume of stormwater that is released. Achieving a reduction in stormwater discharge volume is generally thought to be more successful when measures are implemented at or as close to the source as practicable. Several strategies were modeled for a few typical situations within the Sunset Beach study area and results indicate significant potential reductions in total and peak discharges. These strategies include:

1. Disconnecting impervious areas, particularly rooftop gutter drains in residential areas.
2. Installing perforated storm drainage pipe in place of conventional drainage pipe in areas with high infiltration potential.
3. Installing bio-retention or dry-well systems around drop inlet structures in areas with high infiltration potential.
4. Installing infiltration trenches along roadside ditches in areas with high infiltration potential.

As noted above, many areas of impervious cover are currently disconnected from the stormwater drainage system, resulting in substantially lower values for total runoff and peak runoff than would be expected in areas with similar development density. This condition highlights the opportunity to achieve even higher reductions in total and peak runoff by increasing the percentage of all impervious surfaces that are disconnected, and through the expanded use of LID strategies throughout the Town.

Use of such measures was modeled to estimate the ability to infiltrate stormwater runoff after it enters the storm drainage system. Several scenarios were modeled using 3-hour storm events ranging from 0.1-inches per hour to 0.6-inches per hour. Results were compared for sub-catchments with and without infiltration measures utilized. Results indicated that reductions in volume can be 100% for rain events of 1.0-inch with the installation of 60 linear feet of perforated pipe in drainage areas of 1.0 to 3.5 acres with average impervious cover of 50%. These are much smaller rain events than the base storm used to evaluate pipe system capacity, but smaller storms are much more common. Over the course of a year, total reductions in stormwater discharge volume could be very significant.

In addition to source control, consideration was given to water quality strategies that can be implemented at some of the stormwater outfalls to provide additional settling and filtering of the stormwater before it is released into streams or estuary waters. The primary approach would be to construct forebays at the outfalls that would function as constructed wetlands and detention basins. These measures would require periodic maintenance, and in some cases may be difficult to design and permit. Because of regulatory constraints associated with jurisdictional waters and tidal waters in particular, this approach would have limited to zero applicability on the island, where all discharge points are directed to the tidal marsh or tidal creeks. On the mainland, the applicability of this approach would again be limited because of permitting requirements, but there are some opportunities where end of pipe measures could be installed without excessive regulatory constraints. These measures are not included in the current CIP project list since a final determination of feasibility is best made as part of the project design phase.

5.0 RECOMMENDATIONS

The following recommendations are intended to address problems with the existing stormwater drainage system and improve water quality in area waterbodies by proposing strategies that will advance both of these goals. There will be times when effective dual-goal strategies are not practical or appropriate, but with the initial focus on that approach, final application of such strategies will be maximized.

5.1 Infrastructure Improvements Recommendations

Based on the findings from field data collection and stormwater modeling efforts, a list of recommended projects has been incorporated into the Capital Improvements Plan (CIP) and has been prioritized for 5-year and 10-year implementation periods. The CIP has been developed as a stand-alone document and is attached as an addendum to this plan. In an effort to avoid redundancy, only a brief overview is provided here.

5.1.1 Pipe Network

1. *CIP Projects*: Identified projects involve the replacement and sometimes relocation of portions of existing stormwater drainage infrastructure. In many cases the repair of a single section of pipe was not possible without affecting connecting pipes. Projects were developed to reflect the minimum work necessary to address the range of identified problems and restore proper drainage functionality to the surrounding area. Projects were prioritized based first and foremost on public safety, and then on criteria selected to reflect the failure potential and relative cost of system failure in the project area.

2. *Maintenance Related*: Many problems identified throughout the stormwater drainage system can be adequately addressed, at least in the short term, through maintenance operations. Examples of this type of problem include: minor structural repairs to inlet and junction boxes and grates; grouting around pipe connections to prevent leaks; cleaning and removal of sediment and debris; and minor improvements at pipe inlet and outlet locations. Specific information about these problems has been incorporated into the GIS and database provided to the Town.

   As drainage system maintenance will be a significant, constant, and long term activity, funding for certain specialized equipment is included in the CIP to enhance the Town's ability to schedule and perform the recommended maintenance activities. Major items included are: a street sweeper; a sewer and storm drain pipe inspection camera system;

and a hydro-vacuum truck. This equipment enhances the ability of the Town Public Works staff to diagnose and correct problems in closed pipe infrastructure throughout the jurisdiction. The street sweeper and hydro-vacuum truck will serve dual roles in maintaining the functionality of portions of the storm drainage infrastructure and enhancing the function of installed water quality measures. With the expanded maintenance capability it will be important for the Town to have properly trained and dedicated personnel to implement and oversee many elements of this program.

3. *GIS System*: A large component of the current project involved mapping the existing storm drainage system and incorporation of the data into GIS. This information is the primary determinant of the recommended CIP projects, and is also intended to serve to guide maintenance activities. Such a system will only work as intended if used regularly and maintained to remain up to date. An item has been included in the CIP project list for GIS system maintenance and consulting.

5.1.2 Easement Network

In addition to projects focused on stormwater pipes and associated structures, a group of projects is included in the CIP to address specific drainage problems and large scale maintenance work within the network of Town drainage easements. Although there are drainage easements through much of the Town, all of the drainage easement projects identified are located on the mainland, south and east of Sunset Boulevard North, in an area with an array of swales, ditches, small streams, and ponds that carry stormwater from source areas to the Intracoastal Waterway. The easement projects are ranked with highest priority given to those that will improve current drainage problems, and then to projects focused on large scale maintenance or rehabilitation of drainage features. For each of the easement projects there are identified maintenance and construction needs to improve drainage function. The specific needs of each easement are different and depend on multiple factors. An estimate of the needs for these projects is included in the CIP project document, with proposed activities including: clearing, regrading, stabilization, and drainage pipe installation.

5.2 Water Quality Recommendations

The recommendations provided in this section focus on actions that are likely to have a positive influence on water quality by reducing stormwater runoff volume through strategies focused on both source control and treatment of collected stormwater. Recommendations are also provided to enhance the effectiveness of the stormwater management program through data collection and monitoring of existing and future measures, seeking ways to expand the use of

Low Impact Development (LID) strategies and structural Best Management Practices (BMP's), and to increase community awareness of the importance of water quality and how everyone can play a role in its improvement.

5.2.1 Infiltration

As discussed previously, the most effective strategy to improve water quality in the waters in and around Sunset Beach is to reduce to total volume of stormwater that is discharged directly to these waters. In many areas of the Town the sandy soils and depth to water table are ideal for the use of infiltration measures. Soils mapped throughout the community have infiltration rates between 0 inches per hour and 40 inches per hour. The soils that are considered good for infiltration measures have infiltration rates of at least 6 inches per hour and a depth to water table of 48 inches or greater. The soils considered fair for infiltration measures are limited by either infiltration rate or depth to water table, the areas mapped with these soil types will likely have mix of suitable and unsuitable sites. The areas mapped as poor for infiltration measures tend to have both low infiltration rates and shallow depth to water table. Figure 6.2 shows the approximate location of soils considered good, fair, and poor for infiltration measures. Recommended efforts to increase infiltration should focus first on source control and then as close to the source as possible, where flow volume is generally lower. Areas in the upper portions of drainage basins will tend to have soils with greater infiltration potential, and the volume of runoff to be infiltrated will be less. This increases the chance for achieving a zero-runoff condition in these areas.

Structural infiltration measures are proposed as part of the Capital Improvement Plan and included in many of the suggested projects. They include:

1. *Perforated Pipe Infiltration Trenches*: Involves replacing standard High-Density Polyethylene (HDPE) pipe with perforated HDPE of the same diameter in areas where soils have high infiltration potential and estimated pipe depth allows sufficient distance above the seasonal high water table. Pipes would be installed in a fabric lined trench, with a 6-inch to 12-inch washed gravel bed. Limitations include areas of unsuitable soils or areas where pipe depths are excessive.

2. *Dry Well or Bio-retention Measure*: Can be installed at inlet structures in soils with high infiltration potential. Inlet elevations are set to allow for a depressed zone around the grate for stormwater to collect and filter into a gravel bed surrounding the inlet structure. Dry wells can also be installed as an isolated measure, not connected to the storm drainage system. Dry wells provide less infiltration surface area than perforated pipes, but are well

suited in areas where pipe depths are excessive or pipe replacement is otherwise not needed. Dry wells have the advantage of removing a portion of the sediment load in stormwater runoff before it enters the pipe system.

3. *Infiltration Swale*: To be installed in areas of high infiltration potential where concentrated flow approaches an inlet structure. Measure consists of an excavated linear trench back-filled with material of high infiltration potential. The surface of the trench can be grassed. This measure has the same advantages as dry wells and is well suited for intercepting stormwater runoff before it reaches the underground drainage system.

A large portion of the total impervious cover within the study area for this project is rooftops. SWMM data reveals that if a high percentage of all roof drainage is infiltrated through the use of french drain systems, connected to gutter drains or similar practices, there could be up to a 30% reduction of total runoff volume in some areas. To achieve this kind of result would require a dedicated effort, combined with funding measures to retrofit exiting homes. Based on the qualitative assessment of rooftop drainage, some have implemented this practice, but there is no data available to accurately determine the number of independent infiltration systems that have actually been installed. Steps to support grant application efforts could include:

- Conduct a survey to acquire data that would be useful to quantify the issue, with results input into the Geographic Information System (GIS);
- Public outreach to inform property owners of the issue and describe steps they can take to improve water quality in their community;
- Apply for funding to subsidize homeowner installation of simple approaches;
- Reinforce guidelines and require implementation for all new development and redevelopment.

Infiltration does not only occur at the source of runoff, but can be enhanced at multiple locations along the overland flow path of stormwater runoff until it enters the storm drainage system. In some cases, this flow path is hundreds of feet long. Strategies to promote increased infiltration are site specific, both from the standpoint of opportunity and need. In areas where soils have lower infiltration rates, and the water table is shallow, there is little opportunity. In areas where there is no concentrated overland flow during moderate to heavy rain events, there is minimal improvement opportunity. Options to consider for enhancing infiltration of stormwater runoff along the flow path from source to inlet include:

- *Identify Areas of Need*: Town Public Works staff or others could systematically drive through each mapped stormwater sub-catchment during runoff producing rain events and map the areas where overland flow is observed. These locations could be uploaded into the GIS. This task could also be accomplished by volunteer committee members or consultants. Locations could be identified on paper maps and transferred to GIS afterward.

- *Match Need with Opportunity*: Overlay areas of need with mapped areas of suitable soils for infiltration. This process can be managed through the GIS.
- *Install Infiltration Enhancement Measures*: Measures to consider include: infiltration trenches or swales, dry well structures, bio-retention basins, and flow diversion into natural vegetated areas.

5.2.2 Other Structural Measures

In some situations parking lots or other areas with large impervious footprints not otherwise treated through Stormwater Ordinance requirements can be treated using structural Best Management Practices (BMPs). Examples include large scale infiltration basins, segmental pavers or other permeable pavement approaches.

5.2.3 Ponds

There are several existing ponds on the mainland that are functioning components of the stormwater drainage system. Many of the ponds are controlled by weir outlet structures. There is an opportunity to examine each pond to determine the potential to retrofit for improvement in their functionality as water quality Best Management Practices without compromising the integrity of the overall drainage system. A couple of options to consider could be: construct forebays at pipe inlets to trap sediment within easily maintained areas; and modify the outlet structures to allow for additional storage and retention time for storm generated runoff. Constraints to this approach include regulatory requirements associated with Jurisdictional Waters of the United States, minimal available head at the downstream dam, and the potential for upstream flooding.

5.2.4 Non-structural

The existing LID Guidance is comprehensive and well developed with regard to the range and description of strategies, measures and structures described. Much of the material is described as guidance and use is not mandatory. It is not known how many LID installations have occurred since the guidance document was published. The development of a system for tracking the location and details of installed LID measures would allow the Town to gain an understanding of which measures work best in various settings. Other options to consider include:

- Explore options for how to increase the adoption of LID approaches with both new and existing land uses.
- Develop incentives for all types of land uses to adopt LID practices.
- Increase awareness for both residents, land owners, and visitors of the need and value of good water quality and the role everyone can play to advance the goal.
- Drainage Easements are a critical component of the Town's stormwater drainage system. Increase awareness of the role the easements play, consider clearly marking the easement boundaries, and develop a system to report problems with easements.

The Stormwater Management Ordinance requires that engineering practices and/or LID practices be used to the maximum extent practicable to meet design standards and control the export of pollutants and related impacts to water quality. It is not known how many measures have been installed as a result of these and other regulatory requirements. If such information was known and input into the GIS, along with information about the designs and function of the measures, this would improve the Town's overall understanding of stormwater quantity and quality within jurisdictional limits. Options to consider that would advance the goal of tracking the use of stormwater BMPs and related drainage issues throughout the entire jurisdiction include:

- Begin to track key information about stormwater from all new development and re-development in the Town's GIS. This may require increased coordination with Brunswick County. Key information might include: site impervious cover; calculated stormwater discharge from the site for a particular design storm; BMP information including type, location, and design details; and the path of stormwater flow after leaving the site.
- Develop a system to identify and map stormwater drainage information specific to existing developments in areas previously excluded from this study and systematically incorporate this information into the GIS.
- Study the effectiveness of stormwater management measures installed under the requirements of the current ordinance, and determine if these measures have served to meet the Town's goals.
- Continue to input impervious coverage data collected from this study. Expand the mapping area to include the entire Town and develop a protocol for keeping this information up to date.

6.0 NEXT STEPS

Implementation of this Plan and associated Capital Improvements Plan (CIP) will require specific action on the part of the Town Boards and Administration. The following action items provide a general guide to some suggested initial steps to successfully launch this process.

- Formal adoption of the Plan and CIP by the Town
- Establishment of an Implementation Team that will be responsible for development of timelines for major goals and objectives outlined in the Plans
    - This could be comprised solely of Town staff or could be combination of members representing the Town, private entities, civic organizations, etc.
- Identify budgetary needs to meet objectives
    - This would include annual general budget items considerations but could also incorporate considerations of a public stormwater utility to fund a wider reaching stormwater program.
- Annual review of CIP budgets
    - This would include review of projected cost estimates contained within the CIP to compare the unit costs to current market trends. It would also include comparing the proposed CIP projects to other proposed capital projects to leverage potential overlaps and minimize re-work that could result from performing the projects out of sequence (i.e. paving a road and then damaging in a subsequent year to install drainage improvements).
- Move forward with the annual projects in accordance with the general annual schedule provided in the CIP.
    - This would include the development of engineered plans, bidding, and construction of the projects as outlined in the CIP.
- Review of Completed CIP projects and pending projects
    - This would include either formal or informal evaluation of the effectiveness of installed projects along with consideration of new technologies that may be developed which could potentially improve efficiency or cost-effectiveness of proposed CIP projects.

FIGURE 1

LOCATION MAP

FIGURE 1.
LOCATION MAP

MARCH 2017

STORMWATER DRAINAGE STUDY

TOWN OF SUNSET BEACH

BRUNSWICK COUNTY, NORTH CAROLINA

McGill ASSOCIATES
ENGINEERING·PLANNING·FINANCE
1915 EVANS ROAD CARY, NC 27513 PH. (919) 378-9111 FIRM LICENSE # C-0459

<u>FIGURE 2</u>

STUDY AREA MAP

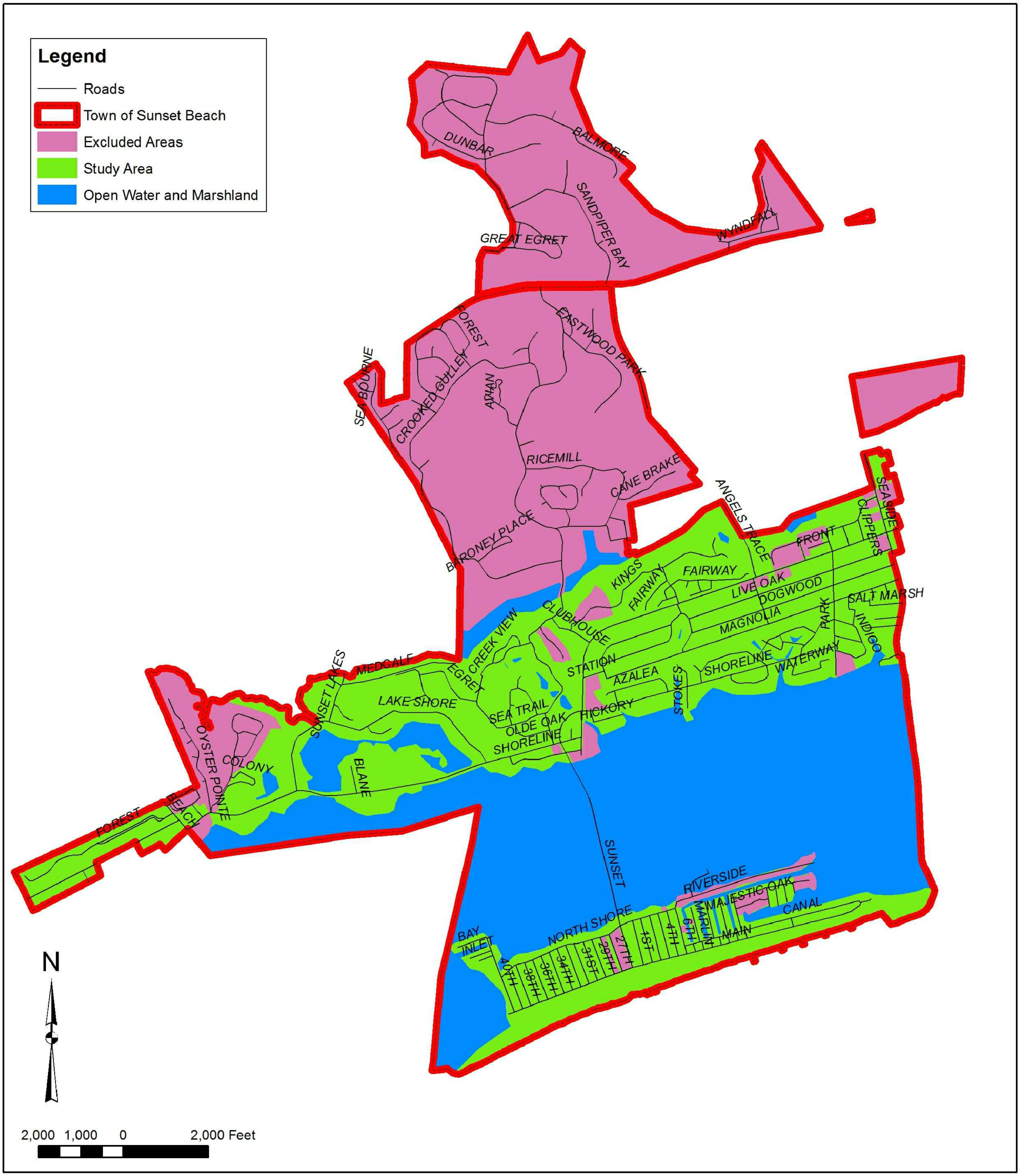

FIGURE 2.
STUDY AREA MAP

FEBRUARY 2017

STORMWATER DRAINAGE STUDY

TOWN OF SUNSET BEACH

BRUNSWICK COUNTY, NORTH CAROLINA

McGill ASSOCIATES
ENGINEERING·PLANNING·FINANCE
1915 EVANS ROAD CARY, NC 27513 PH. (919) 378-9111 FIRM LICENSE # C-0459

<u>FIGURE 3</u>

CIP PROJECT AREAS MAP

McGILL ASSOCIATES
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STORMWATER DRAINAGE STUDY
TOWN OF SUNSET BEACH
BRUNSWICK COUNTY, NORTH CAROLINA

FIGURE 3.
CIP PROJECT
OVERVIEW MAP
FEBRUARY 2017

FIGURE 4

DRIVEWAY PIPES

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STORMWATER DRAINAGE STUDY
TOWN OF SUNSET BEACH
BRUNSWICK COUNTY, NORTH CAROLINA

FIGURE 4.
DRIVEWAY PIPES
MAP

FEBRUARY 2017

FIGURE 5.1

VIDEO FOOTAGE MAP – ISLAND

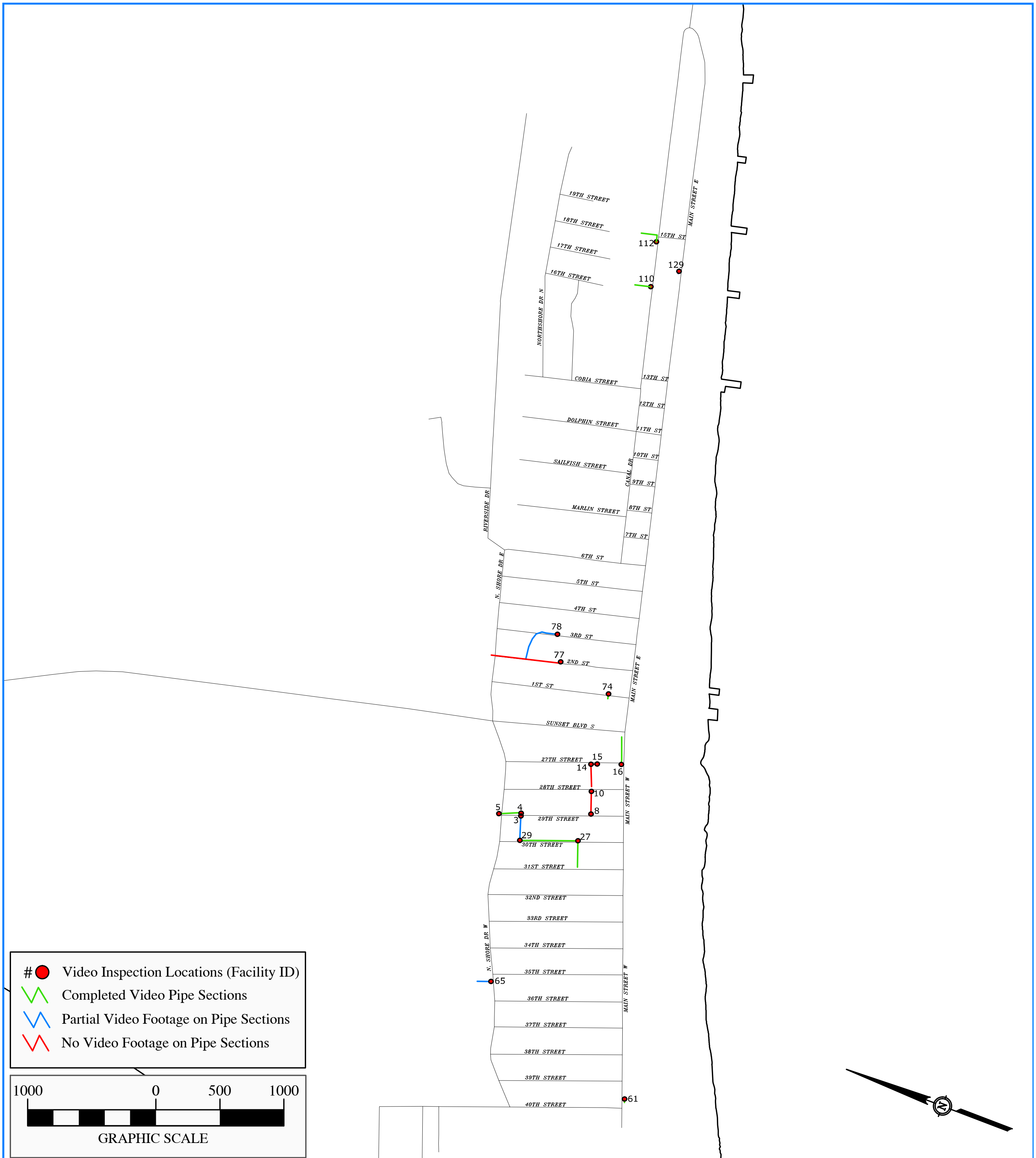

FIGURE 5.1
VIDEO FOOTAGE SECTIONS
STORM PIPE ASSESSMENT
ISLAND

JANUARY 2017

STORMWATER DRAINAGE STUDY

TOWN OF SUNSET BEACH

BRUNSWICK COUNTY, NORTH CAROLINA

McGill
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1915 EVANS ROAD CARY, NC 27513 PH. (919) 378-9111 FIRM LICENSE # C-0459

<u>FIGURE 5.2</u>

VIDEO FOOTAGE MAP – MAINLAND

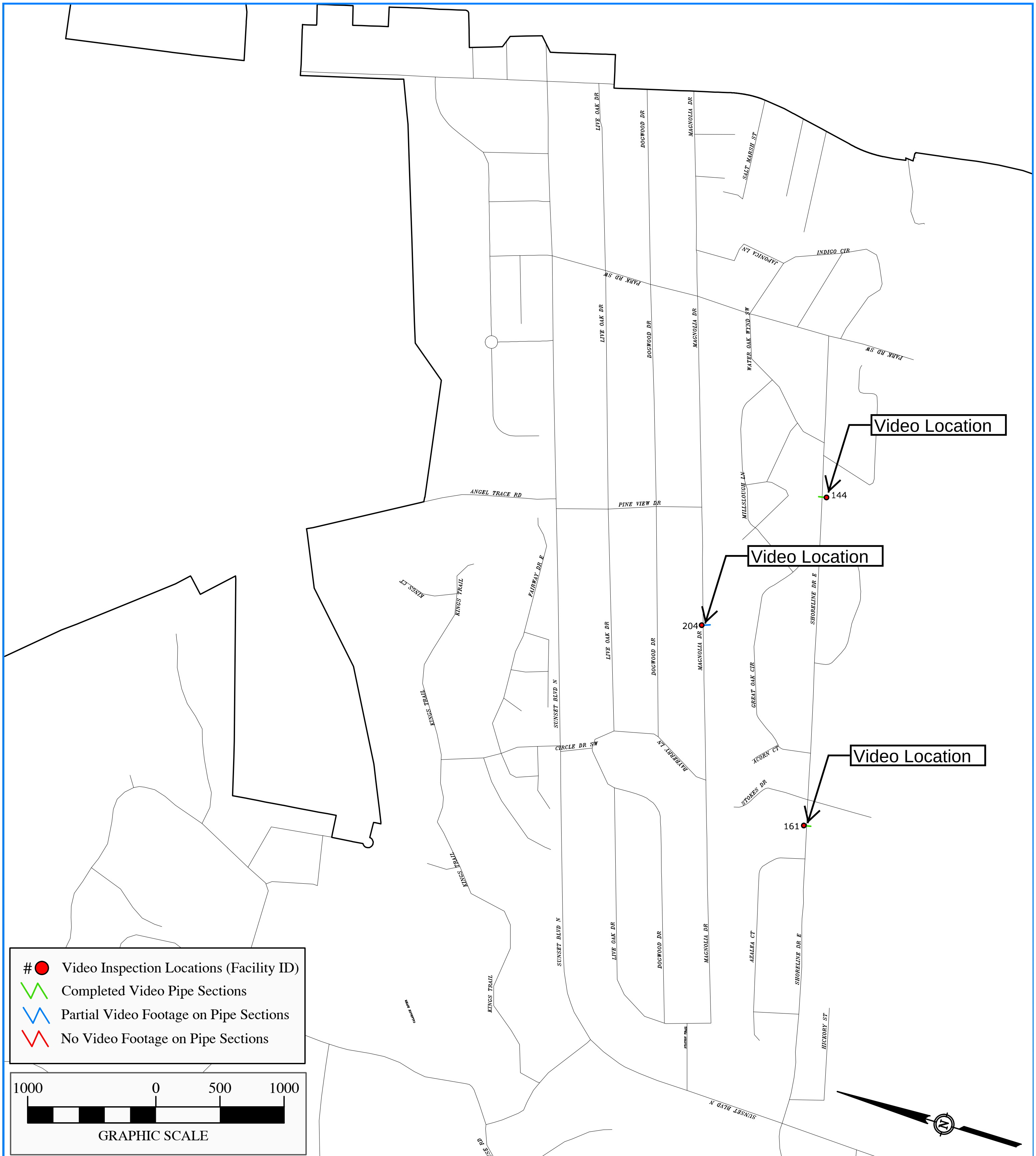


FIGURE 5.2
VIDEO FOOTAGE SECTIONS
STORM PIPE ASSESSMENT
MAINLAND

JANUARY 2017

STORMWATER DRAINAGE STUDY

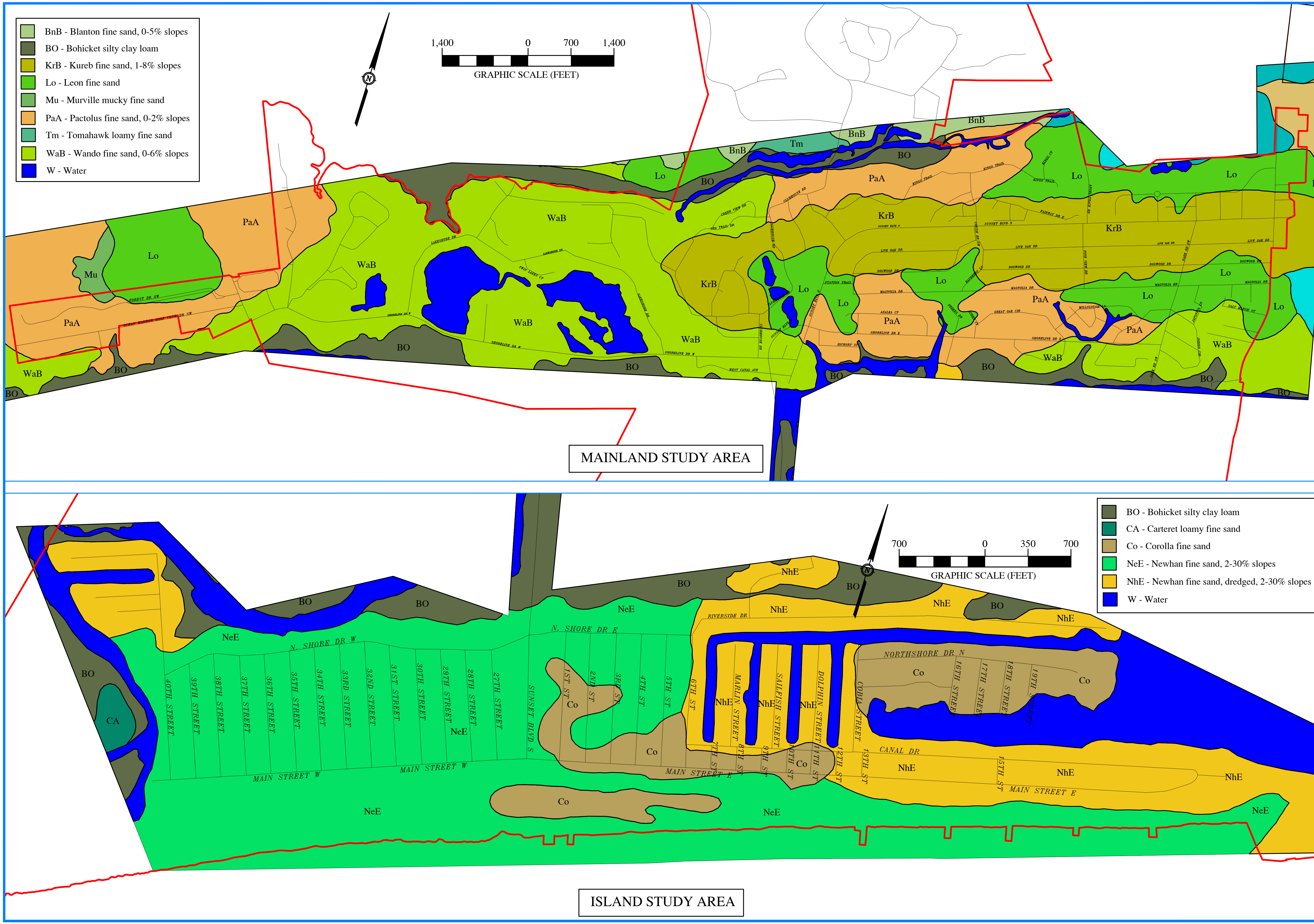
TOWN OF SUNSET BEACH

BRUNSWICK COUNTY, NORTH CAROLINA

McGill ASSOCIATES
ENGINEERING·PLANNING·FINANCE
1915 EVANS ROAD CARY, NC 27513 PH. (919) 378-9111 FIRM LICENSE # C-0459

FIGURE 6.1

SOILS MAP



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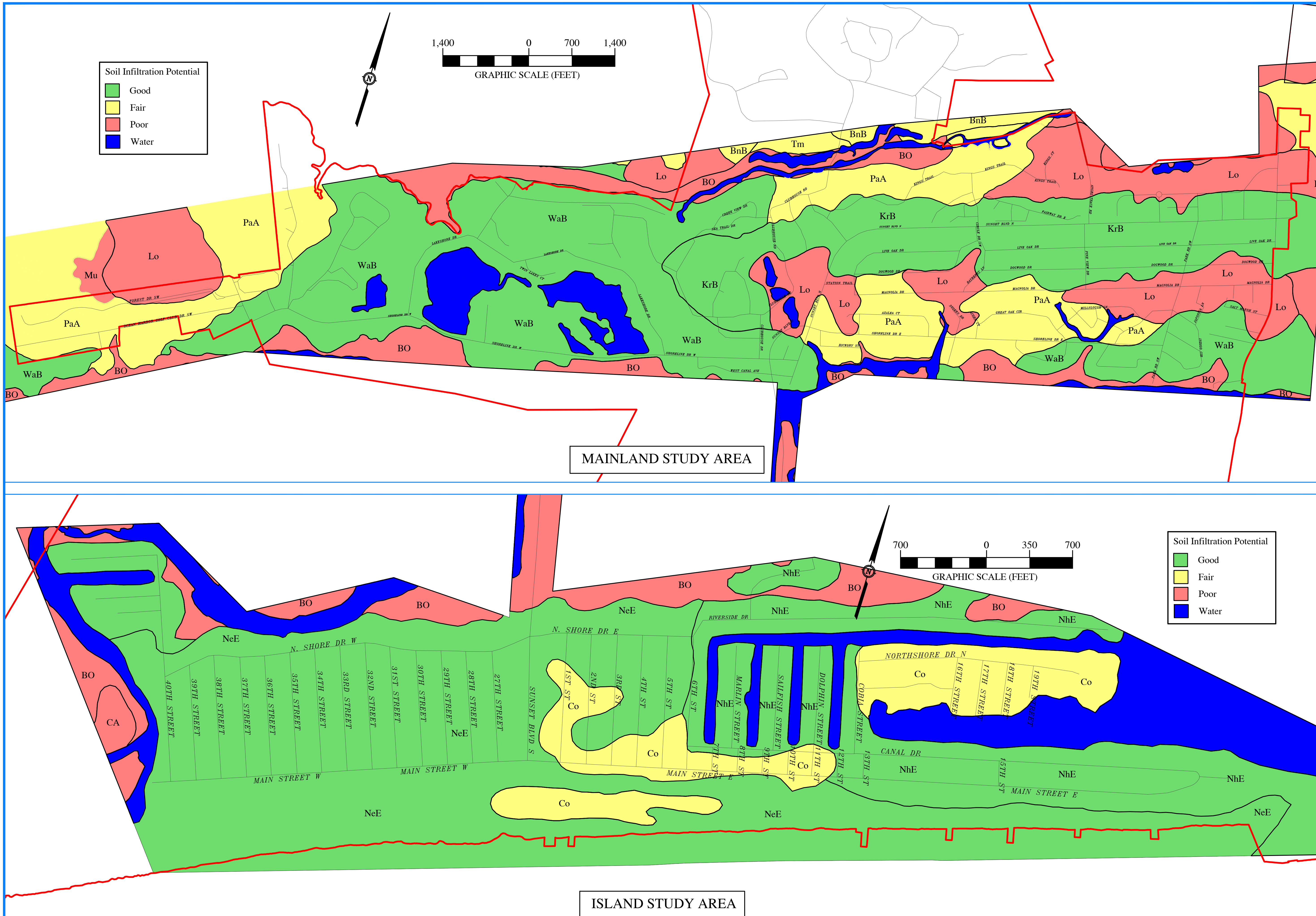
STORMWATER DRAINAGE STUDY
TOWN OF SUNSET BEACH
BRUNSWICK COUNTY, NORTH CAROLINA

FIGURE 6.1
SOILS MAP
FEBRUARY 2017

FIGURE 6.2

INFILTRATION POTENTIAL MAP



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STORMWATER DRAINAGE STUDY
TOWN OF SUNSET BEACH
BRUNSWICK COUNTY, NORTH CAROLINA

FIGURE 6.2.
SOIL INFILTRATION POTENTIAL

MAY 2017

FIGURE 7

IMPERVIOUS AREAS MAP

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STORMWATER DRAINAGE STUDY

TOWN OF SUNSET BEACH

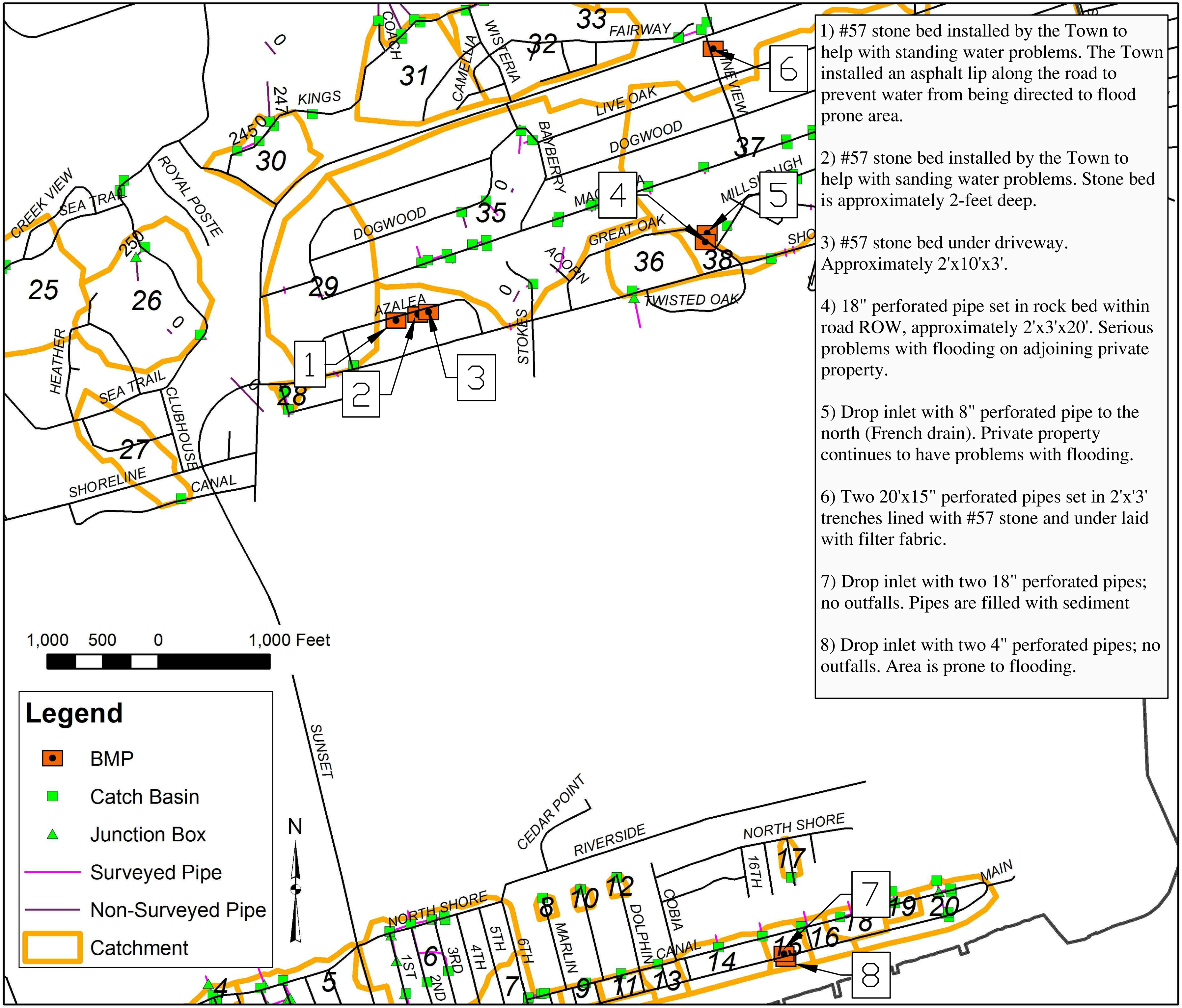
BRUNSWICK COUNTY, NORTH CAROLINA

FIGURE 7.
IMPERVIOUS AREAS
MAP

FEBRUARY 2017

FIGURE 8

BMP LOCATIONS



1) #57 stone bed installed by the Town to help with standing water problems. The Town installed an asphalt lip along the road to prevent water from being directed to flood prone area.

2) #57 stone bed installed by the Town to help with sanding water problems. Stone bed is approximately 2-feet deep.

3) #57 stone bed under driveway. Approximately 2'x10'x3'.

4) 18" perforated pipe set in rock bed within road ROW, approximately 2'x3'x20'. Serious problems with flooding on adjoining private property.

5) Drop inlet with 8" perforated pipe to the north (French drain). Private property continues to have problems with flooding.

6) Two 20'x15" perforated pipes set in 2'x3' trenches lined with #57 stone and under laid with filter fabric.

7) Drop inlet with two 18" perforated pipes; no outfalls. Pipes are filled with sediment

8) Drop inlet with two 4" perforated pipes; no outfalls. Area is prone to flooding.

FIGURE 8.
BMP LOCATION MAP

MARCH 2017

STORMWATER DRAINAGE STUDY
TOWN OF SUNSET BEACH
BRUNSWICK COUNTY, NORTH CAROLINA

McGill ASSOCIATES
ENGINEERING·PLANNING·FINANCE
1915 EVANS ROAD CARY, NC 27513 PH. (919) 378-9111 FIRM LICENSE # C-0459

FIGURE 9

FLOOD PRONE AREAS – ISLAND

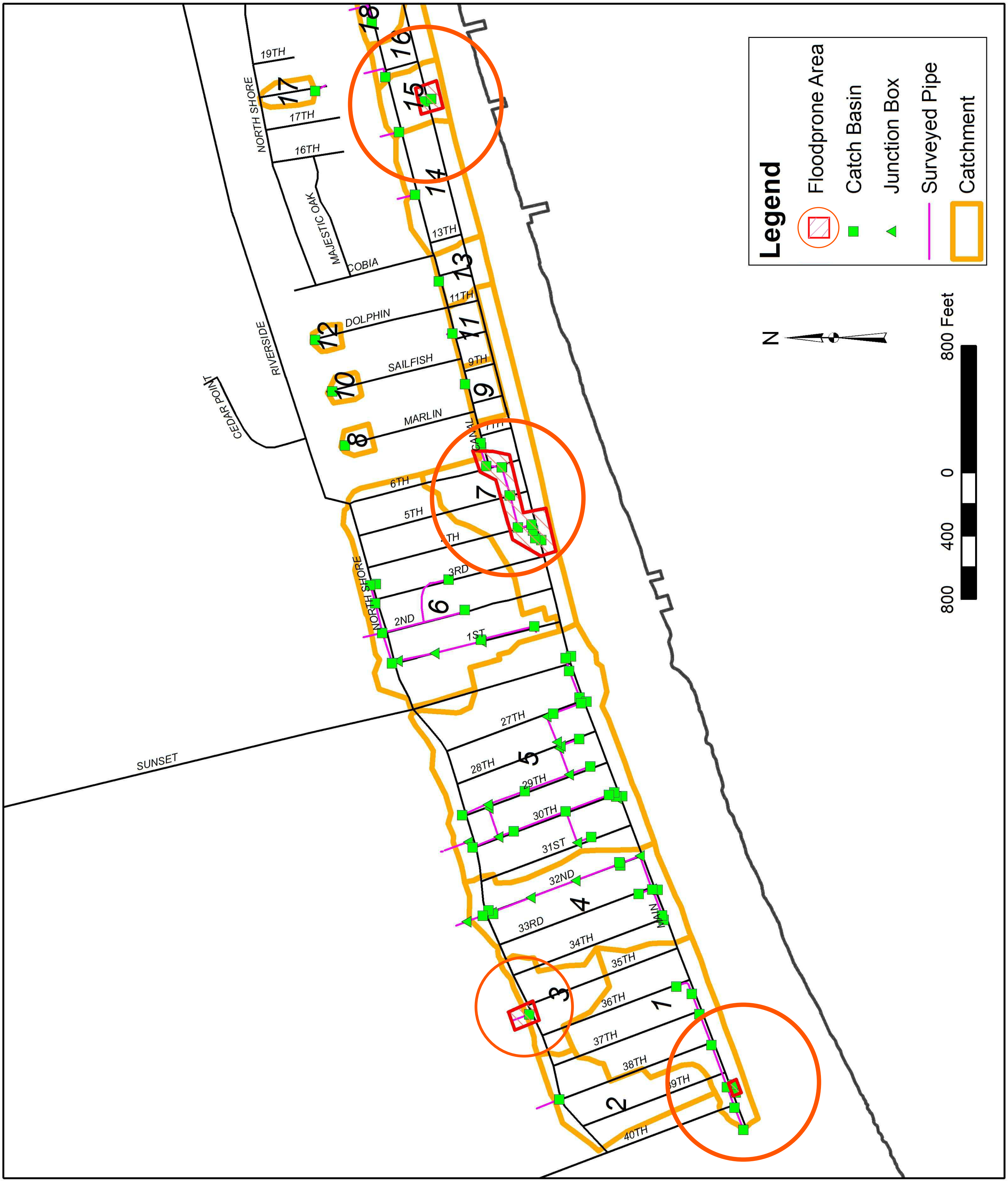


FIGURE 9.
FLOOD PRONE AREAS
ISLAND

MARCH 2017

STORMWATER DRAINAGE STUDY

TOWN OF SUNSET BEACH

BRUNSWICK COUNTY, NORTH CAROLINA

McGill
ASSOCIATES
ENGINEERING·PLANNING·FINANCE
1915 EVANS ROAD CARY, NC 27513 PH. (919) 378-9111 FIRM LICENSE # C-0459

FIGURE 10

FLOOD PRONE AREAS - MAINLAND

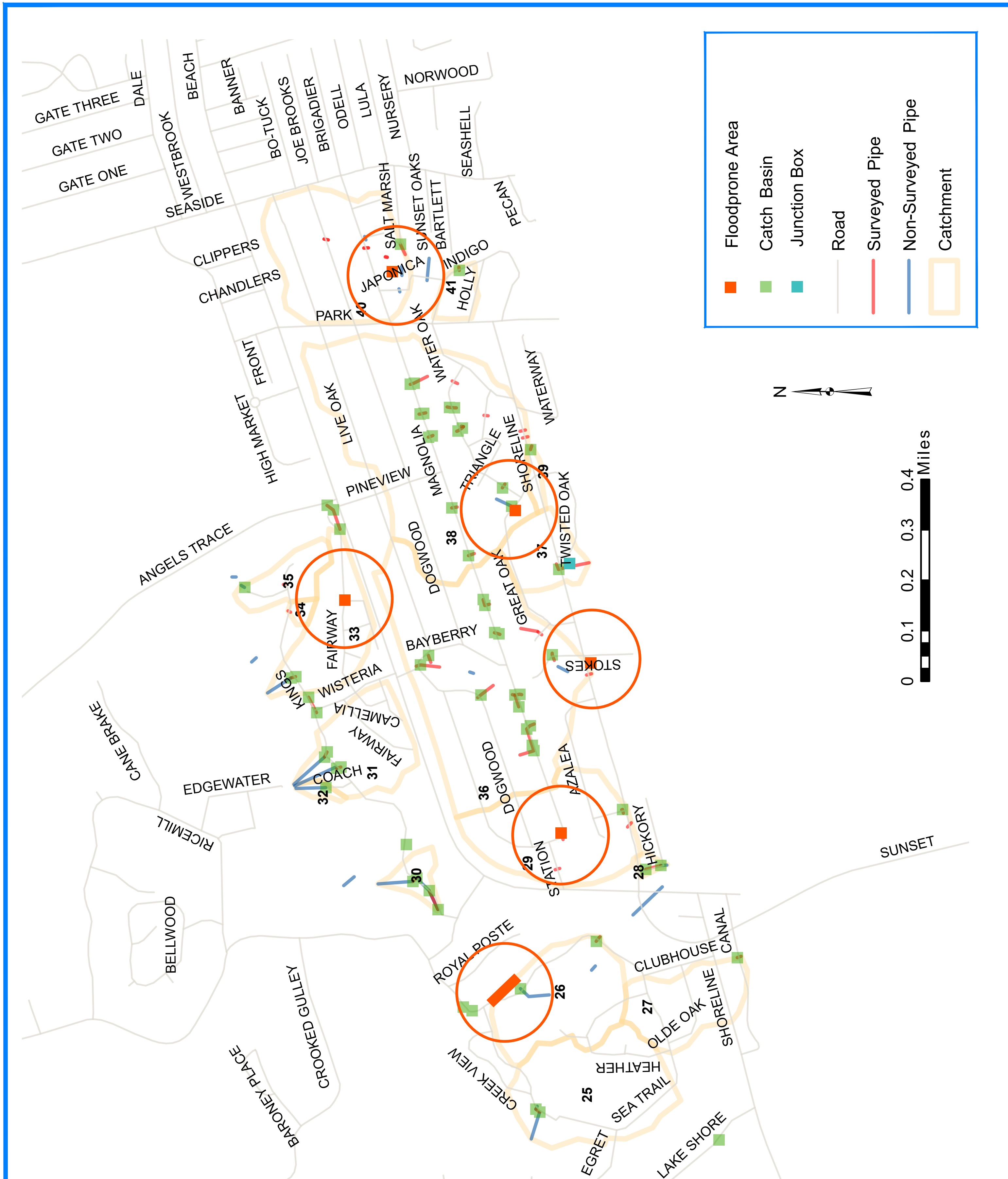


FIGURE 10.
FLOOD PRONE AREAS
MAINLAND

MAY 2017

STORMWATER DRAINAGE STUDY

TOWN OF SUNSET BEACH

BRUNSWICK COUNTY, NORTH CAROLINA

McGill ASSOCIATES
ENGINEERING·PLANNING·FINANCE
1915 EVANS ROAD CARY, NC 27513 PH. (919) 378-9111 FIRM LICENSE # C-0459

APPENDIX 1

CIP – DRAINAGE EASEMENTS

McGill ASSOCIATES
ENGINEERING·PLANNING·FINANCE
1915 EVANS ROAD CARY, NC 27513 PH. (919) 378-9111 FIRM LICENSE # C-0459

STORMWATER DRAINAGE STUDY
TOWN OF SUNSET BEACH
BRUNSWICK COUNTY, NORTH CAROLINA

CIP DRAINAGE EASEMENT PROJECTS - MAINLAND

FEBRUARY 2017

McGill ASSOCIATES
ENGINEERING·PLANNING·FINANCE
1915 EVANS ROAD CARY, NC 27513 PH. (919) 378-9111 FIRM LICENSE # C-0459

STORMWATER DRAINAGE STUDY

TOWN OF SUNSET BEACH

BRUNSWICK COUNTY, NORTH CAROLINA

CIP DRAINAGE EASEMENT PROJECTS - ISLAND

FEBRUARY 2017

APPEDNDIX 2

STORMWATER PIPE ASSESSMENT

VIDEO INSPECTIONS TABLE

And

Storm Pipe Assessment - Town of Sunset Beach
Engineer's Project No.

Report Date

December 13, 2016

Performed By

Porter Scientific, Inc.

Cleaning & CCTV- Report, Analysis, and Recommendations

Engineer's Project No. Unknown
I&I Study – Sunset Beach, North Carolina

Submitted by: **Porter Scientific, Inc.**
Report by: **Jeff Jacobs**

Hydro-Cleaning and CCTV was performed for multiple days resulting in the generation of Twenty (20) video files with the following summary of results and recommendations;

Summary:
Cleaning of the lines were performed on some segments multiple times (heavy cleaning) in order to get the camera equipment to a point to collect some video, but even at that point some were only short runs.

1. **The majority of issues were either obstacles and/or deposits, occurrences at multiple locations.**
2. **Of the lines only ten (10) were successfully completely videoed.**
3. **Three (2) segments the water level prevented a complete evaluation.**
4. **Four (4) segments there were left off, requested by owner representative to ignore.**
5. **No cleaning was performed on three (3) segments.**
6. **Noted some unknown junction boxes on two (2) segments.**

Recommendations:

1. **In order to complete all of the evaluations, heavy cleaning, rotary heads be required to clear some of the obstacles and settled deposits from the lines.**
2. **The heavy cleaning should/would also help clear up some of the issues with the high water levels, possible blockage.**

Attachments:
Work Summary Report, DVDs, and Daily Tabular Reports.

Storm Water Pipe Assessment

SUNSET BEACH North Carolina

PORTER SCIENTIFIC EST. 1997

McGill ASSOCIATES

Work Plan

Facility ID	Pipe Length	Street Location	Inlet Type	Comment1	Clean Footage	CCTV Footage	Notes/Details
3 & 29	190	29th to 30th	Other (See Comment)	Pipe 1 appeared to be damaged; recommend camera to review pipe condition.	150	17	Could not complete CCTV
4 & 5	180	29th	Manhole (Closed Lid)	Camera recommended on pipe 2 to examine condition.	170	170	CCTV Complete
8 & 10	180	28th to 29th	Manhole (Closed Lid)	Sediment in pipes 1 and 2. Recommend camera on pipe 3 due to altered path.	180	0	Could not clean to access, asked abandon effort for this line, no CCTV
14	175	27th to 28th	Manhole (Closed Lid)	Pipe 1 is 14a outlet pipe 2 is 14b inlet.	178	0	Could not clean to access, asked abandon effort for this line, no CCTV
161	55	Shoreline Dr.	Pond Outlet Structure - pipe outfall	Reoccurring surface subsidence above pipe on south side of Shoreline Drive. Examining pipe from outlet, appears to be disjunct in places, with changes in angle, possibly separating at seams.	0	38	No Cleaning, CCTV Complete
144	60	Shoreline Dr.	Pond Outlet Structure - pipe outfall	Subsidence above pipe at surface. Pipe appears disjunct from lower end possibly separating at seams with noticeable changes in pipe angles on different sections. Flood prone area. History of problems with outfall pipe.	0	51	No Cleaning, CCTV Complete
15	50	27th	Drop Inlet in Yard	Pipe 15a rank 2 inspection grade15b is rank 3	0	0	Asked not to clean or CCTV
16	35	27th	Drop Inlet in Yard	Pipe 1 is 16a south inlet. Pipe 2 is 16b north outlet. Pipe 3 is 16c east inlet.	180	180	Jetter did hanging up, 2-CCTV runs, complete
61	55	W. Main & 40th	Drop Inlet in Pavement	Need camera run in pipe 2 don't know where pipe goes. Flood prone area.	228	227	CCTV Complete
74	40	1st	Drop Inlet in Yard	West pipe has an unknown connection. Camera recommend to be run on pipe 2.	70	68	CCTV Complete. 2-CCTV runs
65	110	N. Shore @ 35-36th	Drop Inlet in Yard	Bad flooding at inlet property owners came out and described flooding their drives and yards.	10	9	Under Water, Could not complete

Work Plan

Facility ID	Pipe Length	Street Location	Inlet Type	Comment1	Clean Footage	CCTV Footage	Notes/Details
77	10	2nd	Drop Inlet in Yard	Connects to junction box under road that is not visible from surface. Rank 2 camera.	200	0	Could not clean to access, asked abandon effort for this line, no CCTV
78	390	2nd to 3rd	Drop Inlet in Yard	Pipe curves to the west connects with 2nd street.	370	6	Too much debris
110	120	Canal Dr	Drop Inlet in Pavement	Pipe curves approximately 30' from basin. Camera rank 2.	124	122	CCTV Complete
112	180	Canal Dr	Drop Inlet in Pavement	Erosion at the curb. Pipe appears to be getting crushed or compressed. Camera rank 2.	165	163	CCTV Complete
204	65	Magnolia Dr	Drop Inlet in Yard	Outfall	165	43	Under Water, Could not complete
27	850	30-31st	Drop Inlet in Yard	Pipe 3 CB 1000	446	650	Three (3) CCTV segments
129	40	1177	Drop Inlet in Yard	Flood prone area. Berm along road isolates inlet.	15	13	Pipe Blocked, could complete CCTV
TOTAL	2785				2651	1757	

Project Information

PROJECT NAME:	CREATED:	CATALOG NAME:
Sunset Beach	2016.12.06	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

Customer:	McGill Associates
Responsible:	Michael Norton
Department:	
Post-Office Box:	
Street:	
Location:	
Telephone:	910-367-6869
Telefax:	
Mobile Phone:	
E-Mail:	

Project Leader:	Cody Locklear
Responsible:	Camera Operator
Department:	Field Crew
Post-Office Box:	
Street:	719 Old Main Road
Location:	Pembroke, NC 28372
Telephone:	910-374-2034
Telefax:	
Mobile Phone:	
E-Mail:	

Contractor:	Porter Scientific, Inc.
Responsible:	Jeff Jacobs
Department:	Environmental
Post-Office Box:	P.O. Box 1359
Street:	719 Old Main Road
Location:	Pembroke, NC 28372
Telephone:	910-521-0549
Telefax:	910-521-3599
Mobile Phone:	
E-Mail:	

Table Of Contents

PROJECT NAME:	CREATED:	CATALOG NAME:
Sunset Beach	2016.12.06	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

Section List

PROJECT NAME:	CREATED:	CATALOG NAME:
Sunset Beach	2016.12.06	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

No.	Section	City	Street	Length	Length Total	Date
1	ID 61 - Unknown			197.59 ft	197.59 ft	2016.12.06
2	ID 4 - ID 5			134.51 ft	332.10 ft	2016.12.06
				332.10 ft	332.10 ft	

Damage Class Legend

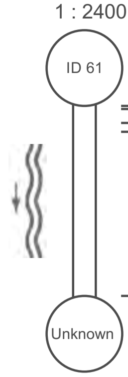
PROJECT NAME:	CREATED:	CATALOG NAME:
Sunset Beach	2016.12.06	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

1	Excellent Condition Minor Defects - Failure unlikely in the foreseeable future.
2	Good Condition Defects that have not begun to deteriorate - Pipe unlikely to fail for at least 20 years.
3	Fair Condition Moderate defects that will continue to deteriorate - Pipe may fail in 10-20 years.
4	Poor Condition Severe defects that will become grade 5 defects within the foreseeable future - Pipe will probably fail in 5-10 years.
5	Immediate Attention Defects require immediate attention - Pipe has failed or will likely fail within the next 5 years or sooner.

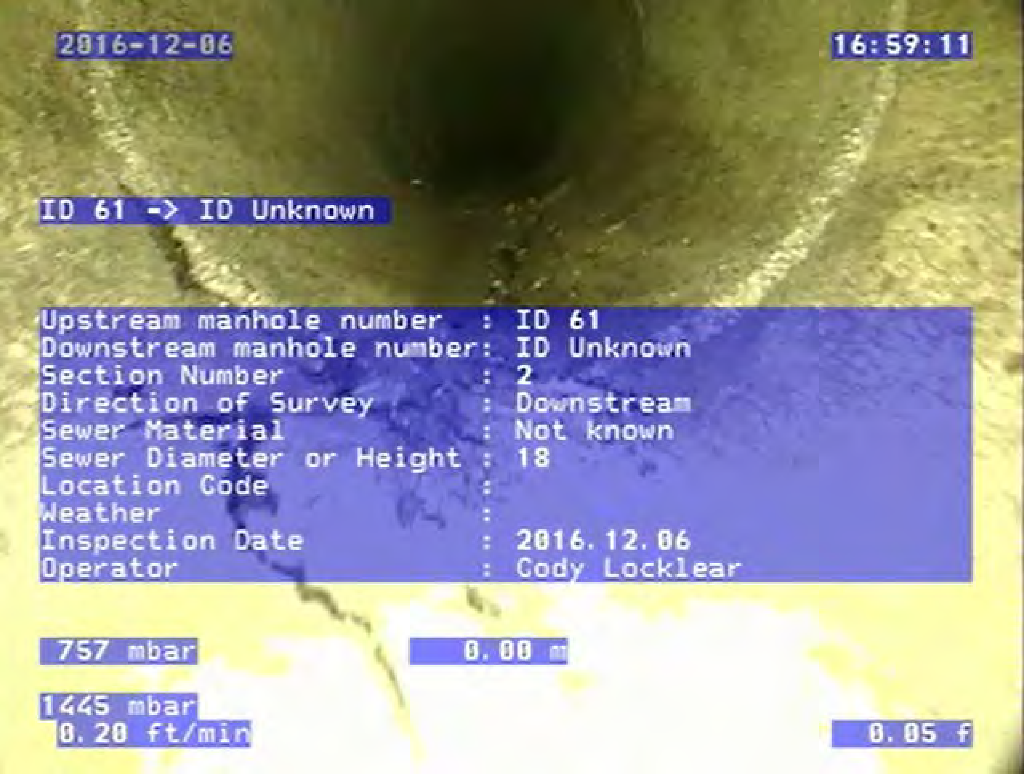
Section Protocol

SECTION NAME:	SECTION NUMBER:	CATALOG NAME:
ID 61 - Unknown	1	NASSCO PACP-4 United States
CUSTOMER:	**PROJECT LEADER:**	**CONTRACTOR:**
McGill Associates	Cody Locklear	Porter Scientific, Inc.

UPSTREAM MANHOLE NUMBER: ID 61	DOWNSTREAM MANHOLE NUMBER: Unknown	
MUNICIPAL:	START NODE STREET NAME:	
LOCATION CODE:	DIRECTION OF SURVEY: Downstream	CALCULATED LENGTH: 197.59 ft
INSPECTION DATE: 2016.12.06	PURPOSE OF SURVEY:	
WEATHER:	SEWER MATERIAL: Not known	
LINING METHOD:	SEWER DIAMETER OR HEIGHT: 18	
PRE-CLEANED:	SEWER SHAPE: Circular	
COMMON REMARKS:		



1 : 2400	POSITION	DC	CODE	OBSERVATION	VIDEO POS	PHOTO
	30.01 ft		CM	Crack Multiple, from 12 o'clock, to 12 o'clock	00:01:28	
	33.23 ft		CM	Crack Multiple, from 1 o'clock, to 1 o'clock	00:01:43	
	47.66 ft		CM	Crack Multiple, from 1 o'clock, to 1 o'clock	00:02:16	
	56.88 ft		AJB	Junction Box, Unkown box	00:02:48	
	227.60 ft		AJB	Junction Box, AEP...ID Unknown	00:00:00	


2016-12-06
16:59:11
ID 61 -> ID Unknown
Upstream manhole number : ID 61
Downstream manhole number: ID Unknown
Section Number : 2
Direction of Survey : Downstream
Sewer Material : Not known
Sewer Diameter or Height : 18
Location Code :
Weather :
Inspection Date : 2016.12.06
Operator : Cody Locklear
757 mbar
0.00 m
1445 mbar
0.20 ft/min
0.05 f


2016-12-06
17:00:29
ID 61 -> ID Unknown
761 mbar
0.00 m
1453 mbar
29.32 ft/min
30.00 f


2016-12-06
17:01:21
ID 61 -> ID Unknown
Crack Multiple, from 12 o'clock, to 12 o'clock
763 mbar
0.00 m
1455 mbar
0.00 ft/min
33.23 f


2016-12-06
17 02 18
ID 61 -> ID Unknown
Crack Multiple, from 1 o'clock, to 1 o'clock
764 mbar
0.00 m
1460 mbar
0.00 ft/min
47.67 f

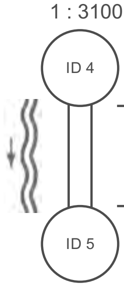

2016-12-06
17 03 46
ID 61 -> ID Unknown
Junction Box, Unkown box
764 mbar
0.00 m
1465 mbar
0.00 ft/min
56.87 f

2016-12-06
17:08:09
ID 61 -> ID Unknown
774 mbar
0.00 m
1478 mbar
62.78 ft/min
225.15 f

Section Protocol

SECTION NAME:	SECTION NUMBER:	CATALOG NAME:
ID 4 - ID 5	2	NASSCO PACP-4 United States
CUSTOMER:	**PROJECT LEADER:**	**CONTRACTOR:**
McGill Associates	Cody Locklear	Porter Scientific, Inc.

UPSTREAM MANHOLE NUMBER: ID 4	DOWNSTREAM MANHOLE NUMBER: ID 5	
MUNICIPAL:	START NODE STREET NAME:	
LOCATION CODE:	DIRECTION OF SURVEY: Downstream	CALCULATED LENGTH: 134.51 ft
INSPECTION DATE: 2016.12.06	PURPOSE OF SURVEY:	
WEATHER:	SEWER MATERIAL: Not known	
LINING METHOD:	SEWER DIAMETER OR HEIGHT: 18	
PRE-CLEANED:	SEWER SHAPE: Circular	
COMMON REMARKS:		



1 : 3100	POSITION	DC	CODE	OBSERVATION	VIDEO POS	PHOTO
	0.00 ft		AMH	Manhole, AMH MH ID 4	00:00:00	
	134.51 ft		DSF	Deposits Settled Fine, 5 % of cross sectional area, at 6 o'clock, Abandoned Survey....	00:00:00	


2016-12-06
18 04 16
ID 4 -> ID 5
Upstream manhole number : ID 4
Downstream manhole number: ID 5
Section Number : 4
Direction of Survey : Downstream
Sewer Material : Not known
Sewer Diameter or Height : 18
Location Code :
Weather :
Inspection Date : 2016.12.06
Operator : Cody Locklear
739 mbar
0.00 m
1443 mbar
0.00 ft/min
0.00 f


2016-12-06
18:05:01
ID 4 -> ID 5
741 mbar
0.00 m
1445 mbar
32.87 ft/min
26.82 f


2016-12-06
18 08 36
ID 4 -> ID 5
755 mbar
0.00 m
1460 mbar
0.00 ft/min
135.01 f


2016-12-06
17 27 20
ID 65 -> ID Unknown
Upstream manhole number : ID 65
Downstream manhole number: ID Unknown
Section Number : 3
Direction of Survey : Downstream
Sewer Material : Not known
Sewer Diameter or Height : 18
Location Code :
Weather :
Inspection Date : 2016.12.06
Operator : Cody Locklear
748 mbar
0.00 m
1453 mbar
0.00 ft/min
0.00 f

2016-12-06
17 27 28
ID 65 -> ID Unknown
749 mbar
0.00 m
1455 mbar
25.98 ft/min
1.65 f


2016-12-06
17 42 28
ID 65 -> ID Unknown
752 mbar
0.00 m
1445 mbar
44.28 ft/min
9.00 f

Project Information

PROJECT NAME:	CREATED:	CATALOG NAME:
Sunset Beach 2.0	2016.12.07	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

Customer:	McGill Associates
Responsible:	
Department:	
Post-Office Box:	
Street:	
Location:	
Telephone:	
Telefax:	
Mobile Phone:	
E-Mail:	

Project Leader:	Cody Locklear
Responsible:	Camera Operator
Department:	Field Crew
Post-Office Box:	
Street:	719 Old Main Road
Location:	Pembroke, NC 28372
Telephone:	910-374-2034
Telefax:	
Mobile Phone:	
E-Mail:	

Contractor:	Porter Scientific, Inc.
Responsible:	Jeff Jacobs
Department:	Environmental
Post-Office Box:	P.O. Box 1359
Street:	719 Old Main Road
Location:	Pembroke, NC 28372
Telephone:	910-521-0549
Telefax:	910-521-3599
Mobile Phone:	
E-Mail:	

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PROJECT NAME:	CREATED:	CATALOG NAME:
Sunset Beach 2.0	2016.12.07	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

Section List

PROJECT NAME:	CREATED:	CATALOG NAME:
Sunset Beach 2.0	2016.12.07	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

No.	Section	City	Street	Length	Length Total	Date
1	ID 4 - ID 5			169.61 ft	169.61 ft	2016.12.07
2	ID 3 - ID 29			10.99 ft	180.60 ft	2016.12.07
3	ID 29 - ID 3			6.99 ft	187.58 ft	2016.12.07
4	ID 27 - Catch base (2)			344.96 ft	532.54 ft	2016.12.07
5	ID 27 - Catch base			288.74 ft	821.28 ft	2016.12.07
6	ID 27 - Catch base (3)			26.34 ft	847.62 ft	2016.12.07
				847.62 ft	847.62 ft	

Damage Class Legend

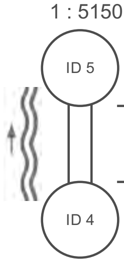
PROJECT NAME:	CREATED:	CATALOG NAME:
Sunset Beach 2.0	2016.12.07	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

1	Excellent Condition Minor Defects - Failure unlikely in the foreseeable future.
2	Good Condition Defects that have not begun to deteriorate - Pipe unlikely to fail for at least 20 years.
3	Fair Condition Moderate defects that will continue to deteriorate - Pipe may fail in 10-20 years.
4	Poor Condition Severe defects that will become grade 5 defects within the foreseeable future - Pipe will probably fail in 5-10 years.
5	Immediate Attention Defects require immediate attention - Pipe has failed or will likely fail within the next 5 years or sooner.

Section Protocol

SECTION NAME:	SECTION NUMBER:	CATALOG NAME:
ID 4 - ID 5	1	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

UPSTREAM MANHOLE NUMBER: ID 4	DOWNSTREAM MANHOLE NUMBER: ID 5
MUNICIPAL:	START NODE STREET NAME:
LOCATION CODE:	DIRECTION OF SURVEY: Upstream; CALCULATED LENGTH: 169.61 ft
INSPECTION DATE: 2016.12.07	PURPOSE OF SURVEY:
WEATHER:	SEWER MATERIAL: Not known
LINING METHOD:	SEWER DIAMETER OR HEIGHT: 18
PRE-CLEANED:	SEWER SHAPE: Circular
COMMON REMARKS:	

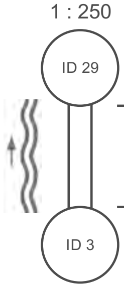


1 : 5150	POSITION	DC	CODE	OBSERVATION	VIDEO POS	PHOTO
	0.00 ft		AMH	Manhole, AMH ID 5	00:00:00	
	169.61 ft		AEP	End of Pipe, AEP ID 4	00:15:25	

Section Protocol

SECTION NAME:	SECTION NUMBER:	CATALOG NAME:
ID 3 - ID 29	2	NASSCO PACP-4 United States
CUSTOMER:	**PROJECT LEADER:**	**CONTRACTOR:**
McGill Associates	Cody Locklear	Porter Scientific, Inc.

UPSTREAM MANHOLE NUMBER: ID 3	DOWNSTREAM MANHOLE NUMBER: ID 29	
MUNICIPAL:	START NODE STREET NAME:	
LOCATION CODE:	DIRECTION OF SURVEY: Upstream	CALCULATED LENGTH: 10.99 ft
INSPECTION DATE: 2016.12.07	PURPOSE OF SURVEY:	
WEATHER:	SEWER MATERIAL: Not known	
LINING METHOD:	SEWER DIAMETER OR HEIGHT: 18	
PRE-CLEANED:	SEWER SHAPE: Circular	
COMMON REMARKS:		



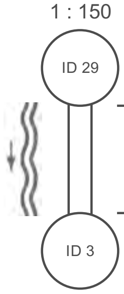
1 : 250	POSITION	DC	CODE	OBSERVATION	VIDEO POS	PHOTO
	0.00 ft		AMH	Manhole, AMH ID 3	00:00:00	
	10.99 ft		OBC	Obstacles Thru Connection, 5 % of cross sectional area, at 6 o'clock, Abandoned Survey....too much water flow	00:00:00	

2016-12-07
10 53 45
ID 3 <- ID 29
Upstream manhole number : ID 3
Downstream manhole number: ID 29
Section Number : 2
Direction of Survey : Upstream
Sewer Material : Not known
Sewer Diameter or Height : 18
Location Code :
Weather :
Inspection Date : 2016.12.07
Operator : Cody Locklear
749 mbar
0.00 m
1433 mbar
31.88 ft/min
1.36 f

Section Protocol

SECTION NAME:	SECTION NUMBER:	CATALOG NAME:
ID 29 - ID 3	3	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

UPSTREAM MANHOLE NUMBER:	DOWNSTREAM MANHOLE NUMBER:	
ID 29	ID 3	
MUNICIPAL:	START NODE STREET NAME:	
LOCATION CODE:	DIRECTION OF SURVEY:	CALCULATED LENGTH:
	Downstream	6.99 ft
INSPECTION DATE:	PURPOSE OF SURVEY:	
2016.12.07		
WEATHER:	SEWER MATERIAL:	
	Not known	
LINING METHOD:	SEWER DIAMETER OR HEIGHT:	
	26	
PRE-CLEANED:	SEWER SHAPE:	
	Circular	
COMMON REMARKS:		



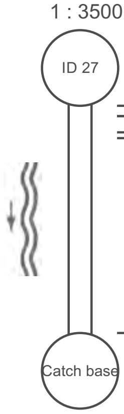
1 : 150	POSITION	DC	CODE	OBSERVATION	VIDEO POS	PHOTO
	0.00 ft		AMH	Manhole, AMH ID 29	00:00:00	
	6.99 ft		OBC	Obstacles Thru Connection, 5 % of cross sectional area, at 6 o'clock, Abandoned Survey....cant get over pipe	00:00:00	


2016-12-07
11:32:20
ID 29 -> ID 3
Upstream manhole number : ID 29
Downstream manhole number: ID 3
Section Number : 3
Direction of Survey : Downstream
Sewer Material : Not known
Sewer Diameter or Height : 26
Location Code :
Weather :
Inspection Date : 2016.12.07
Operator : Cody Locklear
755 mbar
0.00
1455 mbar
35.23 ft/min
1.46

Section Protocol

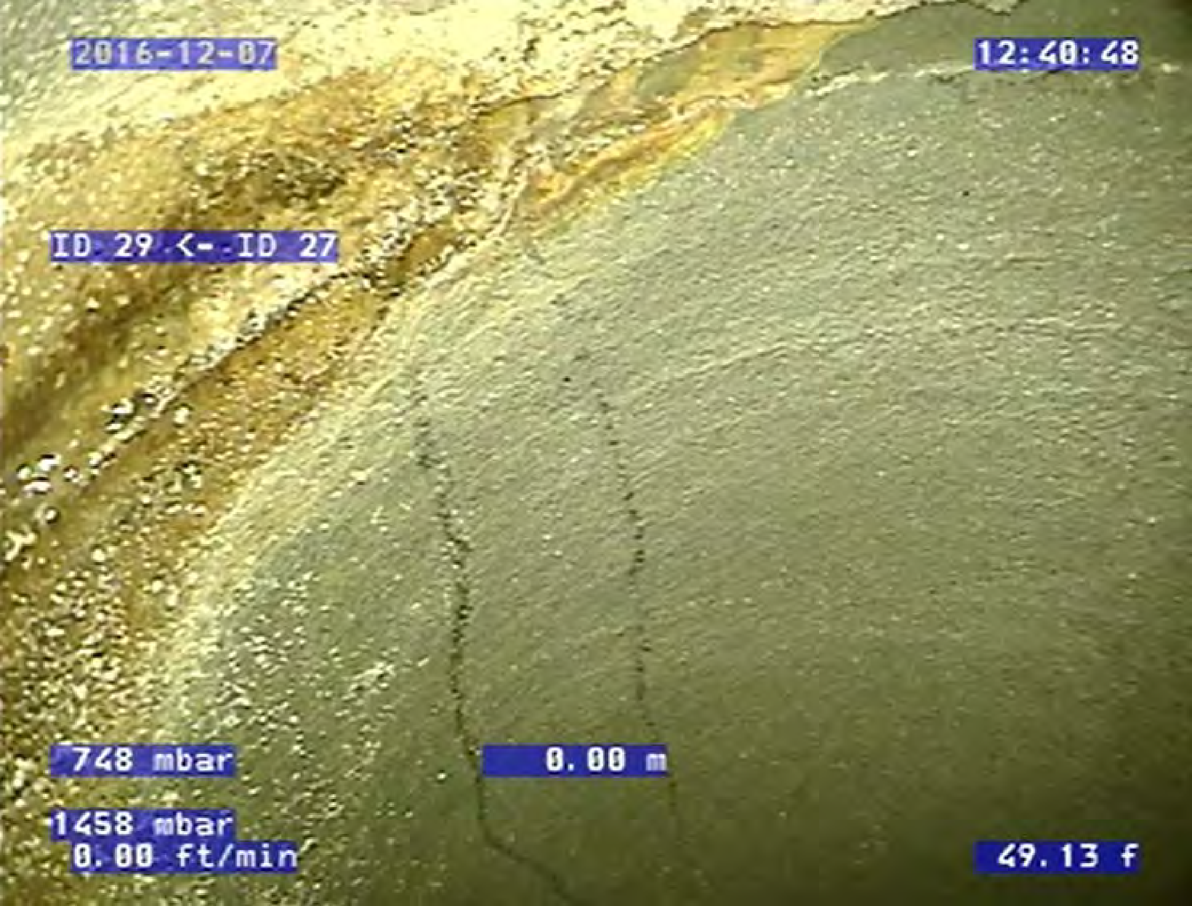
SECTION NAME:	SECTION NUMBER:	CATALOG NAME:
ID 27 - Catch base (2)	4	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

UPSTREAM MANHOLE NUMBER: ID 27	DOWNSTREAM MANHOLE NUMBER: Catch base	
MUNICIPAL:	START NODE STREET NAME:	
LOCATION CODE:	DIRECTION OF SURVEY: Downstream	CALCULATED LENGTH: 344.96 ft
INSPECTION DATE: 2016.12.07	PURPOSE OF SURVEY:	
WEATHER:	SEWER MATERIAL: Not known	
LINING METHOD:	SEWER DIAMETER OR HEIGHT: 26	
PRE-CLEANED:	SEWER SHAPE: Circular	
COMMON REMARKS:		



1 : 3500	POSITION	DC	CODE	OBSERVATION	VIDEO POS	PHOTO
	0.00 ft		AMH	Manhole, AMH ID 27	00:00:00	
	15.65 ft		CL	Crack Longitudinal, at 12 o'clock	00:00:58	
	15.65 ft		JSM	Joint Separated Medium, 0 ° displacement	00:01:14	
	40.28 ft		CL	Crack Longitudinal, at 12 o'clock	00:02:02	
	49.13 ft		CM	Crack Multiple, from 10 o'clock, to 9 o'clock	00:00:00	
	344.96 ft		ACB	Catch Basin, AEP..ID 29	00:00:00	

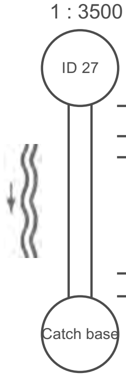

2016-12-07
12:36:22
ID 29 <- ID 27
746 mbar
0.00 m
1445 mbar
0.00 ft/min
15.64 f


2016-12-07
12:40:48
ID 29 <- ID 27
748 mbar
0.00 m
1458 mbar
0.00 ft/min
49.13 f

Section Protocol

SECTION NAME:	SECTION NUMBER:	CATALOG NAME:
ID 27 - Catch base	5	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

UPSTREAM MANHOLE NUMBER: ID 27	DOWNSTREAM MANHOLE NUMBER: Catch base	
MUNICIPAL:	START NODE STREET NAME:	
LOCATION CODE:	DIRECTION OF SURVEY: Downstream	CALCULATED LENGTH: 288.74 ft
INSPECTION DATE: 2016.12.07	PURPOSE OF SURVEY:	
WEATHER:	SEWER MATERIAL: Not known	
LINING METHOD:	SEWER DIAMETER OR HEIGHT: 26	
PRE-CLEANED:	SEWER SHAPE: Circular	
COMMON REMARKS:		



1 : 3500	POSITION	DC	CODE	OBSERVATION	VIDEO POS	PHOTO
	0.00 ft		AMH	Manhole, AMH ID 27	00:00:00	
	45.82 ft		CL	Crack Longitudinal, at 12 o'clock	00:00:00	
	77.77 ft		CL	Crack Longitudinal, at 12 o'clock	00:03:21	
	254.00 ft		CS	Crack Spiral, from 12 o'clock, to 6 o'clock	00:00:00	
	288.74 ft		AEP	End of Pipe, Aep..catch base	00:00:00	

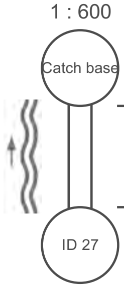

2016-12-07
14:58:12
ID 27 -> Catch base
753 mbar
0.00 m
1448 mbar
0.00 ft/min
45.83 f


2016-12-07
15 00 15
ID 27 -> Catch base
755 mbar
0.00 m
1455 mbar
0.00 ft/min
77.76 f

Section Protocol

SECTION NAME:	SECTION NUMBER:	CATALOG NAME:
ID 27 - Catch base (3)	6	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

UPSTREAM MANHOLE NUMBER: ID 27	DOWNSTREAM MANHOLE NUMBER: Catch base	
MUNICIPAL:	START NODE STREET NAME:	
LOCATION CODE:	DIRECTION OF SURVEY: Upstream	CALCULATED LENGTH: 26.34 ft
INSPECTION DATE: 2016.12.07	PURPOSE OF SURVEY:	
WEATHER:	SEWER MATERIAL: Not known	
LINING METHOD:	SEWER DIAMETER OR HEIGHT: 26	
PRE-CLEANED:	SEWER SHAPE: Circular	
COMMON REMARKS:		



1 : 600	POSITION	DC	CODE	OBSERVATION	VIDEO POS	PHOTO
	0.00 ft		AMH	Manhole, AMH ID 27	00:00:00	
	26.34 ft		DSF	Deposits Settled Fine, 5 % of cross sectional area, at 6 o'clock, Abandoned Survey....too much sand in line.	00:00:00	


2016-12-07
17:22:11
ID 27 <- Catch base
770 mbar
0.00 m
1470 mbar
0.79 ft/min
24.81 f

Project Information

PROJECT NAME:	CREATED:	CATALOG NAME:
Sunset Beach 3.0	2016.12.08	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

Customer:	McGill Associates
Responsible:	Michael Norton
Department:	
Post-Office Box:	
Street:	
Location:	
Telephone:	910-367-6869
Telefax:	
Mobile Phone:	
E-Mail:	

Project Leader:	Cody Locklear
Responsible:	Camera Operator
Department:	Field Crew
Post-Office Box:	
Street:	719 Old Main Road
Location:	Pembroke, NC 28372
Telephone:	910-374-2034
Telefax:	
Mobile Phone:	
E-Mail:	

Contractor:	Porter Scientific, Inc.
Responsible:	Jeff Jacobs
Department:	Environmental
Post-Office Box:	P.O. Box 1359
Street:	719 Old Main Road
Location:	Pembroke, NC 28372
Telephone:	910-521-0549
Telefax:	910-521-3599
Mobile Phone:	
E-Mail:	

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PROJECT NAME:	CREATED:	CATALOG NAME:
Sunset Beach 3.0	2016.12.08	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

Section List

PROJECT NAME:	CREATED:	CATALOG NAME:
Sunset Beach 3.0	2016.12.08	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

No.	Section	City	Street	Length	Length Total	Date
5	ID 74 - Catch base			68.81 ft	68.81 ft	2016.12.08
2	ID 110 - Catch base			122.74 ft	191.55 ft	2016.12.08
3	ID 112 - Catch base			163.70 ft	355.26 ft	2016.12.08
4	ID 129 - End of pipe			15.55 ft	370.80 ft	2016.12.08
5	End of pipe - ID 129			17.02 ft	387.83 ft	2016.12.08
6	Catch base - ID 74			0.00 ft	387.83 ft	2016.12.08
7	ID 78 - Unknown			6.86 ft	394.68 ft	2016.12.08
				394.68 ft	394.68 ft	

Damage Class Legend

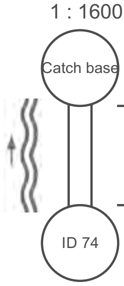
PROJECT NAME:	CREATED:	CATALOG NAME:
Sunset Beach 3.0	2016.12.08	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

1	Excellent Condition Minor Defects - Failure unlikely in the foreseeable future.
2	Good Condition Defects that have not begun to deteriorate - Pipe unlikely to fail for at least 20 years.
3	Fair Condition Moderate defects that will continue to deteriorate - Pipe may fail in 10-20 years.
4	Poor Condition Severe defects that will become grade 5 defects within the foreseeable future - Pipe will probably fail in 5-10 years.
5	Immediate Attention Defects require immediate attention - Pipe has failed or will likely fail within the next 5 years or sooner.

Section Protocol

SECTION NAME:	SECTION NUMBER:	CATALOG NAME:
ID 74 - Catch base	5	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

UPSTREAM MANHOLE NUMBER: ID 74	DOWNSTREAM MANHOLE NUMBER: Catch base	
MUNICIPAL:	START NODE STREET NAME:	
LOCATION CODE:	DIRECTION OF SURVEY: Upstream	CALCULATED LENGTH: 68.81 ft
INSPECTION DATE: 2016.12.08	PURPOSE OF SURVEY:	
WEATHER:	SEWER MATERIAL: Not known	
LINING METHOD:	SEWER DIAMETER OR HEIGHT: 24	
PRE-CLEANED:	SEWER SHAPE: Circular	
COMMON REMARKS:		



1 : 1600	POSITION	DC	CODE	OBSERVATION	VIDEO POS	PHOTO
	0.00 ft		AMH	Manhole, AMH ID 74	00:00:00	
	68.81 ft		DNF	Deposits Ingress Fine, 5 % of cross sectional area, at 6 o'clock, Abandoned Survey....too much sand in line.	00:04:47	

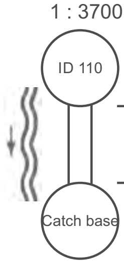

2016-12-08
11:21:18
ID 74 <- Catch base
738 mbar
0.00 m
1460 mbar
75.57 ft/min
23.39 f


2016-12-08
11:25:12
ID 74 <- Catch base
742 mbar
0.00 m
1440 mbar
48.61 ft/min
64.87 f

Section Protocol

SECTION NAME:	SECTION NUMBER:	CATALOG NAME:
ID 110 - Catch base	2	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

UPSTREAM MANHOLE NUMBER: ID 110	DOWNSTREAM MANHOLE NUMBER: Catch base	
MUNICIPAL:	START NODE STREET NAME:	
LOCATION CODE:	DIRECTION OF SURVEY: Downstream	CALCULATED LENGTH: 122.74 ft
INSPECTION DATE: 2016.12.08	PURPOSE OF SURVEY:	
WEATHER:	SEWER MATERIAL: Not known	
LINING METHOD:	SEWER DIAMETER OR HEIGHT: 24	
PRE-CLEANED:	SEWER SHAPE: Circular	
COMMON REMARKS:		



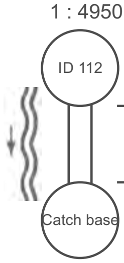
1 : 3700	POSITION	DC	CODE	OBSERVATION	VIDEO POS	PHOTO
	0.00 ft		AMH	Manhole, AMH ID 110	00:00:00	
	122.74 ft		AEP	End of Pipe, AEP..End of pipe	00:09:57	


2016-12-08
10 12 08
ID 110 -> Catch base
717 mbar
0.00 m
1395 mbar
56.09 ft/min
4.26 f

Section Protocol

SECTION NAME:	SECTION NUMBER:	CATALOG NAME:
ID 112 - Catch base	3	NASSCO PACP-4 United States
CUSTOMER:	**PROJECT LEADER:**	**CONTRACTOR:**
McGill Associates	Cody Locklear	Porter Scientific, Inc.

UPSTREAM MANHOLE NUMBER: ID 112	DOWNSTREAM MANHOLE NUMBER: Catch base
MUNICIPAL:	START NODE STREET NAME:
LOCATION CODE:	DIRECTION OF SURVEY: Downstream — CALCULATED LENGTH: 163.70 ft
INSPECTION DATE: 2016.12.08	PURPOSE OF SURVEY:
WEATHER:	SEWER MATERIAL: Not known
LINING METHOD:	SEWER DIAMETER OR HEIGHT: 24
PRE-CLEANED:	SEWER SHAPE: Circular
COMMON REMARKS:	



1 : 4950	POSITION	DC	CODE	OBSERVATION	VIDEO POS	PHOTO
	0.00 ft		AMH	Manhole, AMH ID 112	00:00:00	
	163.70 ft		AEP	End of Pipe, APE...End of pipe	00:03:33	

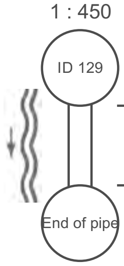

2016-12-08
10 39 42
ID 112 -> Catch base
Upstream manhole number : ID 112
Downstream manhole number: Catch base
Section Number : 3
Direction of Survey : Downstream
Sewer Material : Not known
Sewer Diameter or Height : 24
Location Code :
Weather :
Inspection Date : 2016.12.08
Operator : Cody Locklear
724 mbar
0.00 m
1400 mbar
0.00 ft/min
0.00 f


2016-12-08
10:43:39
ID 112 -> Catch base
735 mbar
0.00 m
1418 mbar
26.17 ft/min
161.38 f

Section Protocol

SECTION NAME:	SECTION NUMBER:	CATALOG NAME:
ID 129 - End of pipe	4	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

UPSTREAM MANHOLE NUMBER: ID 129	DOWNSTREAM MANHOLE NUMBER: End of pipe	
MUNICIPAL:	START NODE STREET NAME:	
LOCATION CODE:	DIRECTION OF SURVEY: Downstream	CALCULATED LENGTH: 15.55 ft
INSPECTION DATE: 2016.12.08	PURPOSE OF SURVEY:	
WEATHER:	SEWER MATERIAL: Not known	
LINING METHOD:	SEWER DIAMETER OR HEIGHT: 24	
PRE-CLEANED:	SEWER SHAPE: Circular	
COMMON REMARKS:		



1 : 450	POSITION	DC	CODE	OBSERVATION	VIDEO POS	PHOTO
	0.00 ft		AMH	Manhole, AMH ID 129	00:00:00	
	15.55 ft		AEP	End of Pipe, AEP...End of pipe	00:01:53	

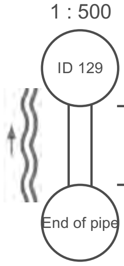

2016-12-08
11:00:44
ID 129 -> Catch base
Upstream manhole number : ID 129
Downstream manhole number: Catch base
Section Number : 4
Direction of Survey : Downstream
Sewer Material : Not known
Sewer Diameter or Height : 24
Location Code :
Weather :
Inspection Date : 2016.12.08
Operator : Cody Locklear
737 mbar
0.00 m
1423 mbar
4.92 ft/min
0.10 f


2016-12-08
11 00 55
ID 129 -> Catch base
738 mbar
0.00 m
1423 mbar
68.88 ft/min
12.00 f

Section Protocol

SECTION NAME:	SECTION NUMBER:	CATALOG NAME:
End of pipe - ID 129	5	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

UPSTREAM MANHOLE NUMBER: End of pipe	DOWNSTREAM MANHOLE NUMBER: ID 129	
MUNICIPAL:	START NODE STREET NAME:	
LOCATION CODE:	DIRECTION OF SURVEY: Upstream	CALCULATED LENGTH: 17.02 ft
INSPECTION DATE: 2016.12.08	PURPOSE OF SURVEY:	
WEATHER:	SEWER MATERIAL: Not known	
LINING METHOD:	SEWER DIAMETER OR HEIGHT: 24	
PRE-CLEANED:	SEWER SHAPE: Circular	
COMMON REMARKS:		



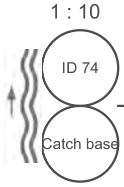
1 : 500	POSITION	DC	CODE	OBSERVATION	VIDEO POS	PHOTO
	0.00 ft		AMH	Manhole, AMH ID 129	00:00:00	
	17.02 ft		AEP	End of Pipe, AEP..End of pipe	00:00:00	


2016-12-08
11 06 50
End of pipe <- ID 129
739 mbar
0.00 m
1438 mbar
71.44 ft/mir
14.27 f

Section Protocol

SECTION NAME:	SECTION NUMBER:	CATALOG NAME:
Catch base - ID 74	6	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

UPSTREAM MANHOLE NUMBER: Catch base	DOWNSTREAM MANHOLE NUMBER: ID 74	
MUNICIPAL:	START NODE STREET NAME:	
LOCATION CODE:	DIRECTION OF SURVEY: Upstream	CALCULATED LENGTH: 0.00 ft
INSPECTION DATE: 2016.12.08	PURPOSE OF SURVEY:	
WEATHER:	SEWER MATERIAL: Not known	
LINING METHOD:	SEWER DIAMETER OR HEIGHT: 24	
PRE-CLEANED:	SEWER SHAPE: Circular	
COMMON REMARKS:		



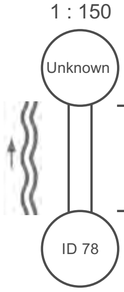
1 : 10	POSITION	DC	CODE	OBSERVATION	VIDEO POS	PHOTO
	0.00 ft		AMH	Manhole, AMH ID 74	00:00:00	


2016-12-08
11 29 44
Catch base <- ID 74
740 mbar
0.00 m
1430 mbar
0.20 ft/min
3.20 f

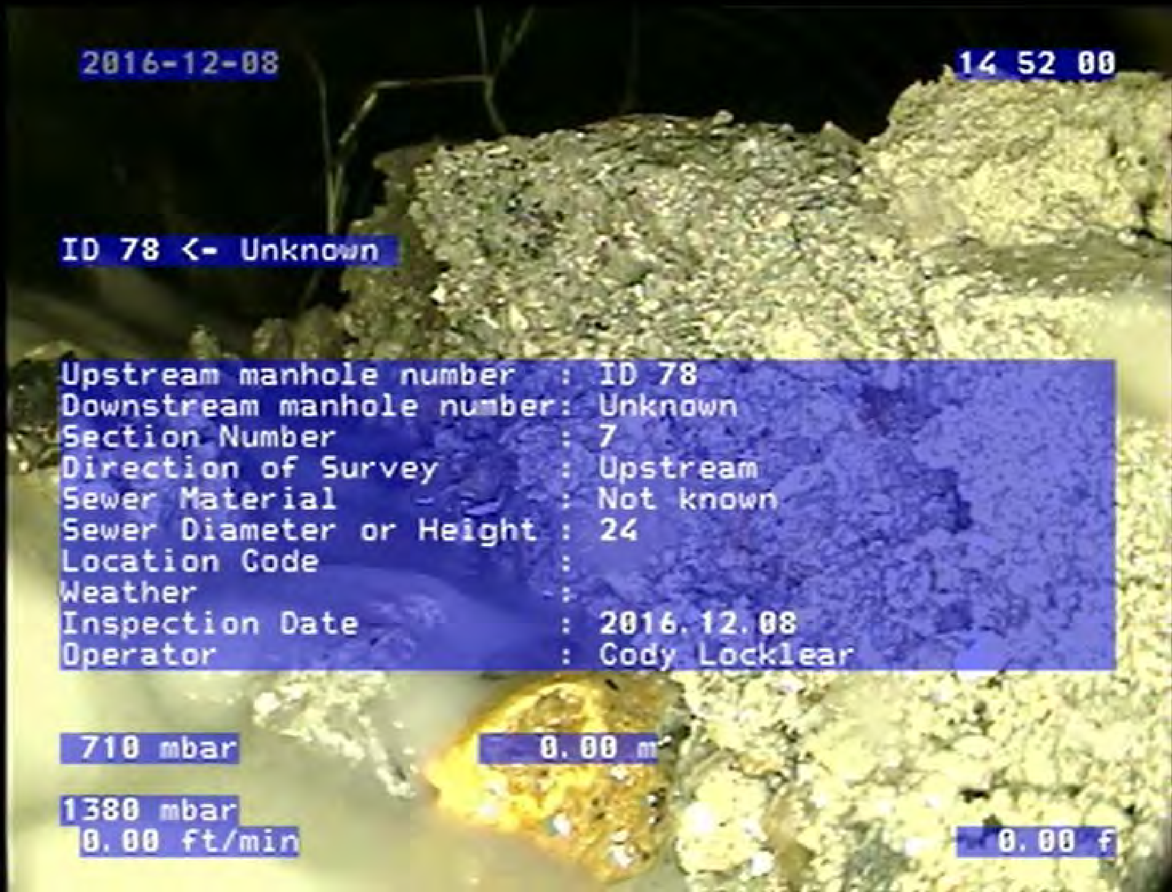
Section Protocol

SECTION NAME:	SECTION NUMBER:	CATALOG NAME:
ID 78 - Unknown	7	NASSCO PACP-4 United States
CUSTOMER:	**PROJECT LEADER:**	**CONTRACTOR:**
McGill Associates	Cody Locklear	Porter Scientific, Inc.

Field	Value	Field	Value
UPSTREAM MANHOLE NUMBER:	ID 78	DOWNSTREAM MANHOLE NUMBER:	Unknown
MUNICIPAL:		START NODE STREET NAME:	
LOCATION CODE:		DIRECTION OF SURVEY:	Upstream
		CALCULATED LENGTH:	6.86 ft
INSPECTION DATE:	2016.12.08	PURPOSE OF SURVEY:	
WEATHER:		SEWER MATERIAL:	Not known
LINING METHOD:		SEWER DIAMETER OR HEIGHT:	24
PRE-CLEANED:		SEWER SHAPE:	Circular
COMMON REMARKS:			



1 : 150	POSITION	DC	CODE	OBSERVATION	VIDEO POS	PHOTO
	0.00 ft		AMH	Manhole, AMH ID 78	00:00:00	
	6.86 ft		DSF	Deposits Settled Fine, 5 % of cross sectional area, at 6 o'clock, Abandoned Survey....too much sand in line.	00:00:00	


2016-12-08
14 52 00
ID 78 <- Unknown
Upstream manhole number : ID 78
Downstream manhole number: Unknown
Section Number : 7
Direction of Survey : Upstream
Sewer Material : Not known
Sewer Diameter or Height : 24
Location Code :
Weather :
Inspection Date : 2016.12.08
Operator : Cody Locklear
710 mbar
0.00 m
1380 mbar
0.00 ft/min
0.00 f


2016-12-08
17 35 24
ID 78 <- Unknown
724 mbar
0.00 m
1398 mbar
24.80 ft/min
6.90 f

Project Information

PROJECT NAME:	CREATED:	CATALOG NAME:
Sunset Beach 4.0	2016.12.09	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

Customer:	McGill Associates
Responsible:	
Department:	
Post-Office Box:	
Street:	
Location:	
Telephone:	
Telefax:	
Mobile Phone:	
E-Mail:	

Project Leader:	Cody Locklear
Responsible:	Camera Operator
Department:	Field Crew
Post-Office Box:	
Street:	719 Old Main Road
Location:	Pembroke, NC 28372
Telephone:	910-374-2034
Telefax:	
Mobile Phone:	
E-Mail:	

Contractor:	Porter Scientific, Inc.
Responsible:	Jeff Jacobs
Department:	Environmental
Post-Office Box:	P.O. Box 1359
Street:	719 Old Main Road
Location:	Pembroke, NC 28372
Telephone:	910-521-0549
Telefax:	910-521-3599
Mobile Phone:	
E-Mail:	

Table Of Contents

PROJECT NAME:	CREATED:	CATALOG NAME:
Sunset Beach 4.0	2016.12.09	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

Section List

PROJECT NAME:	CREATED:	CATALOG NAME:
Sunset Beach 4.0	2016.12.09	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

No.	Section	City	Street	Length	Length Total	Date
1	ID 161 - Catch base			38.57 ft	38.57 ft	2016.12.09
2	ID 144 - End of pipe			51.10 ft	89.68 ft	2016.12.09
3	ID 204 - End of pipe			43.03 ft	132.71 ft	2016.12.09
4	Catch base - ID 16			179.58 ft	312.29 ft	2016.12.09
5	ID 16 - Catch base			1.51 ft	313.80 ft	2016.12.09
				313.80 ft	313.80 ft	

Damage Class Legend

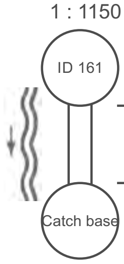
PROJECT NAME:	CREATED:	CATALOG NAME:
Sunset Beach 4.0	2016.12.09	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

1	Excellent Condition Minor Defects - Failure unlikely in the foreseeable future.
2	Good Condition Defects that have not begun to deteriorate - Pipe unlikely to fail for at least 20 years.
3	Fair Condition Moderate defects that will continue to deteriorate - Pipe may fail in 10-20 years.
4	Poor Condition Severe defects that will become grade 5 defects within the foreseeable future - Pipe will probably fail in 5-10 years.
5	Immediate Attention Defects require immediate attention - Pipe has failed or will likely fail within the next 5 years or sooner.

Section Protocol

SECTION NAME:	SECTION NUMBER:	CATALOG NAME:
ID 161 - Catch base	1	NASSCO PACP-4 United States
CUSTOMER:	**PROJECT LEADER:**	**CONTRACTOR:**
McGill Associates	Cody Locklear	Porter Scientific, Inc.

UPSTREAM MANHOLE NUMBER: ID 161	DOWNSTREAM MANHOLE NUMBER: Catch base	
MUNICIPAL:	START NODE STREET NAME:	
LOCATION CODE:	DIRECTION OF SURVEY: Downstream	CALCULATED LENGTH: 38.57 ft
INSPECTION DATE: 2016.12.09	PURPOSE OF SURVEY:	
WEATHER:	SEWER MATERIAL: Not known	
LINING METHOD:	SEWER DIAMETER OR HEIGHT: 18	
PRE-CLEANED:	SEWER SHAPE: Circular	
COMMON REMARKS:		



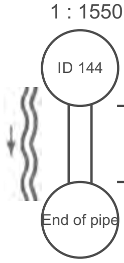
1 : 1150	POSITION	DC	CODE	OBSERVATION	VIDEO POS	PHOTO
	0.00 ft		AMH	Manhole, AMH ID 161	00:00:00	
	38.57 ft		AEP	End of Pipe, AEP..End of pipe	00:03:18	


2016-12-09
09 35 11
ID 161 -> Catch base
683 mbar
0.00 m
1320 mbar
26.76 ft/min
37.15 f

Section Protocol

SECTION NAME:	SECTION NUMBER:	CATALOG NAME:
ID 144 - End of pipe	2	NASSCO PACP-4 United States
CUSTOMER:	**PROJECT LEADER:**	**CONTRACTOR:**
McGill Associates	Cody Locklear	Porter Scientific, Inc.

UPSTREAM MANHOLE NUMBER: ID 144	DOWNSTREAM MANHOLE NUMBER: End of pipe	
MUNICIPAL:	START NODE STREET NAME:	
LOCATION CODE:	DIRECTION OF SURVEY: Downstream	CALCULATED LENGTH: 51.10 ft
INSPECTION DATE: 2016.12.09	PURPOSE OF SURVEY:	
WEATHER:	SEWER MATERIAL: Not known	
LINING METHOD:	SEWER DIAMETER OR HEIGHT: 18	
PRE-CLEANED:	SEWER SHAPE: Circular	
COMMON REMARKS:		

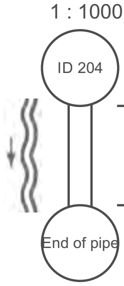


1 : 1550	POSITION	DC	CODE	OBSERVATION	VIDEO POS	PHOTO
	0.00 ft		AMH	Manhole, AMH ID 144	00:00:00	
	51.10 ft		AEP	End of Pipe, AEP..End of pipe	00:02:32	

Section Protocol

SECTION NAME:	SECTION NUMBER:	CATALOG NAME:
ID 204 - End of pipe	3	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

UPSTREAM MANHOLE NUMBER: ID 204	DOWNSTREAM MANHOLE NUMBER: End of pipe	
MUNICIPAL:	START NODE STREET NAME:	
LOCATION CODE:	DIRECTION OF SURVEY: Downstream	CALCULATED LENGTH: 43.03 ft
INSPECTION DATE: 2016.12.09	PURPOSE OF SURVEY:	
WEATHER:	SEWER MATERIAL: Not known	
LINING METHOD:	SEWER DIAMETER OR HEIGHT: 18	
PRE-CLEANED:	SEWER SHAPE: Circular	
COMMON REMARKS:		



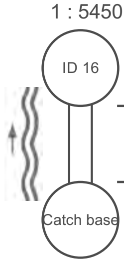
1 : 1000	POSITION	DC	CODE	OBSERVATION	VIDEO POS	PHOTO
	0.00 ft		AMH	Manhole, AMH ID 204	00:00:00	
	43.03 ft		OBC	Obstacles Thru Connection, 5 % of cross sectional area, at 6 o'clock, Abandoned Survey....too much water flow	00:00:00	


2016-12-09
11 40 07
ID 204 -> End of pipe
721 mbar
0.00 m
1385 mbar
51.56 ft/min
38.76 f

Section Protocol

SECTION NAME:	SECTION NUMBER:	CATALOG NAME:
Catch base - ID 16	4	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

UPSTREAM MANHOLE NUMBER: Catch base	DOWNSTREAM MANHOLE NUMBER: ID 16	
MUNICIPAL:	START NODE STREET NAME:	
LOCATION CODE:	DIRECTION OF SURVEY: Upstream	CALCULATED LENGTH: 179.58 ft
INSPECTION DATE: 2016.12.09	PURPOSE OF SURVEY:	
WEATHER:	SEWER MATERIAL: Not known	
LINING METHOD:	SEWER DIAMETER OR HEIGHT: 18	
PRE-CLEANED:	SEWER SHAPE: Circular	
COMMON REMARKS:		



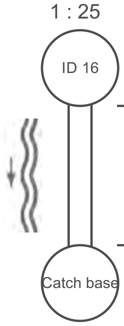
1 : 5450	POSITION	DC	CODE	OBSERVATION	VIDEO POS	PHOTO
	0.00 ft		AMH	Manhole, AMH Catch base	00:00:00	
	179.58 ft		AEP	End of Pipe, AEP..ID 16	00:03:03	


2016-12-09
15 06 48
Catch base <- ID 16
701 mbar
0.00 m
1338 mbar
49.59 ft/min
177.64 f

Section Protocol

SECTION NAME:	SECTION NUMBER:	CATALOG NAME:
ID 16 - Catch base	5	NASSCO PACP-4 United States
CUSTOMER:	PROJECT LEADER:	CONTRACTOR:
McGill Associates	Cody Locklear	Porter Scientific, Inc.

UPSTREAM MANHOLE NUMBER: ID 16	DOWNSTREAM MANHOLE NUMBER: Catch base	
MUNICIPAL:	START NODE STREET NAME:	
LOCATION CODE:	DIRECTION OF SURVEY: Downstream	CALCULATED LENGTH: 1.51 ft
INSPECTION DATE: 2016.12.09	PURPOSE OF SURVEY:	
WEATHER:	SEWER MATERIAL: Not known	
LINING METHOD:	SEWER DIAMETER OR HEIGHT: 18	
PRE-CLEANED:	SEWER SHAPE: Circular	
COMMON REMARKS:		



POSITION	DC	CODE	OBSERVATION	VIDEO POS	PHOTO
0.00 ft		AMH	Manhole, AMH ID 16	00:00:00	
1.51 ft		DSF	Deposits Settled Fine, 5 % of cross sectional area, at 6 o'clock, Abandoned Survey....too much sand in line.	00:00:43	


2016-12-09
15:16:59
ID 16 <- Catch base
Upstream manhole number : ID 16
Downstream manhole number: Catch base
Section Number : 5
Direction of Survey : Upstream
Sewer Material : Not known
Sewer Diameter or Height : 18
Location Code :
Weather :
Inspection Date : 2016.12.09
Operator : Cody Locklear
710 mbar
0.00 m
1355 mbar
0.00 ft/min
0.23 f

APPENDIX 3

SWMM – BASELINE STORM RESULTS SUMMARY

Stormwater Management Model Results
Sunset Beach Stormwater Study
Island Subcatchment Summary
Base Storm Sumulation - 30 year/24 hour storm
Jan-17

Sub- Catchment Name	Area acres	%Imperv	Total Precip inches	Total Infil inches	Total Runoff inches	Total Runoff 10^6-gal	Peak Runoff CFS	Runoff Coeff
S1-1	0.3	68	9.8	6.46	3.32	0.03	0.1	0.339
S1-2	0.3	56	9.8	7.05	2.73	0.02	0.08	0.279
S1-3	0.4	67	9.8	6.51	3.27	0.04	0.14	0.334
S1-4	0.9	46	9.8	7.54	2.25	0.05	0.21	0.229
S1-6	2.3	49	9.8	7.39	2.39	0.15	0.57	0.244
S1-7	3.5	53	9.8	7.19	2.59	0.25	0.94	0.264
S1-9	4.1	51	9.8	7.29	2.49	0.28	1.05	0.254
S1-5	4.2	55	9.8	7.09	2.68	0.31	1.16	0.274
S1-8	0.4	57	9.8	7	2.79	0.03	0.11	0.284
S2-1	8.5	40	9.8	7.83	1.95	0.45	1.71	0.199
S_3-1	5.6	51	9.8	7.79	1.99	0.3	1.15	0.203
S_4-1	1.5	56	9.8	6.77	3.01	0.12	0.47	0.307
S_4-2	1.7	59	9.8	6.32	3.46	0.16	0.61	0.353
S_4-3	1.7	63	9.8	6.09	3.69	0.17	0.65	0.377
S_4-4	0.4	47	9.8	7.49	2.29	0.02	0.09	0.234
S_4-5	3.5	55	9.8	7.1	2.69	0.26	0.97	0.274
S_4-6	2.5	45	9.8	8.03	1.76	0.12	0.45	0.179
S_4-7	2.1	50	9.8	7.83	1.95	0.11	0.42	0.199
S_4-8	2.2	55	9.8	6.56	3.22	0.19	0.73	0.329
S_4-9	0.7	52	9.8	7.75	2.03	0.04	0.15	0.207
S_4-10	0.7	38	9.8	8.67	1.11	0.02	0.08	0.114
S_5-1	0.9	49	9.8	7.39	2.39	0.06	0.22	0.244
S_5-2	1.5	52	9.8	7.75	2.03	0.08	0.31	0.207
S_5-3	2.8	53	9.8	7.71	2.07	0.16	0.6	0.211
S_5-4	1.5	31	9.8	8.88	0.91	0.04	0.14	0.093
S_5-5	2.2	41	9.8	8.18	1.6	0.1	0.36	0.163
S_5-6	1.1	44	9.8	7.64	2.15	0.06	0.24	0.219
S_5-7	2.6	34	9.8	8.46	1.33	0.09	0.36	0.135
S_5-8	2.6	42	9.8	8.14	1.64	0.12	0.44	0.167
S_5-9	1.5	57	9.8	6.72	3.06	0.12	0.47	0.312
S_5-10	0.4	54	9.8	7.67	2.11	0.02	0.09	0.215
S_5-11	2.2	48	9.8	7.44	2.34	0.14	0.53	0.239
S_5-12	4.1	27	9.8	8.74	1.05	0.12	0.45	0.108
S_5-13	4.8	20	9.8	9.01	0.78	0.1	0.39	0.08

Sub- Catchment Name	Area acres	%Imperv	Total Precip inches	Total Infil inches	Total Runoff inches	Total Runoff 10^6-gal	Peak Runoff CFS	Runoff Coeff
S_5-14	0.6	58	9.8	6.95	2.83	0.05	0.18	0.289
S_5-15	0.4	28	9.8	8.97	0.82	0.01	0.03	0.084
S_5-16	0.6	19	9.8	8.86	0.93	0.02	0.06	0.095
S_5-17	1.5	53	9.8	6.16	3.62	0.15	0.56	0.37
S_5-18	2.7	51	9.8	6.05	3.73	0.27	1.04	0.381
S_5-19	0.9	46	9.8	6.41	3.37	0.08	0.31	0.344
S_6-1	3.4	55	9.8	6.56	3.22	0.3	1.13	0.329
S_6-2	2.3	42	9.8	8.14	1.64	0.1	0.39	0.167
S_6-3	1.6	34	9.8	7.8	1.99	0.09	0.33	0.203
S_6-4	3.3	47	9.8	7.95	1.84	0.16	0.63	0.187
S_6-5	2.5	42	9.8	8.14	1.64	0.11	0.42	0.167
S_6-6	6.7	51	9.8	6.3	3.49	0.63	2.41	0.356
S_6-7	2.9	38	9.8	7.19	2.6	0.2	0.78	0.265
S_6-8	1.8	52	9.8	6.73	3.05	0.15	0.57	0.311
S_6-9	1.5	43	9.8	8.1	1.68	0.07	0.26	0.171
S_7-1	5.5	63	9.8	6.7	3.07	0.46	1.75	0.314
S_7-2	2.3	51	9.8	7.04	2.74	0.17	0.65	0.28
S_7-3	0.6	52	9.8	6.99	2.8	0.05	0.17	0.285
S_7-4	0.7	59	9.8	6.9	2.88	0.05	0.21	0.294
S_7-5	1.2	60	9.8	6.85	2.93	0.1	0.36	0.299
S_7-6	2.2	47	9.8	7.26	2.53	0.15	0.57	0.258
S_7-7	1.3	57	9.8	6.72	3.06	0.11	0.41	0.313
S_7-8	0.8	50	9.8	7.1	2.68	0.06	0.22	0.274
S_7-9	0.3	42	9.8	7.53	2.26	0.02	0.07	0.23
S_7-10	0.5	55	9.8	6.83	2.95	0.04	0.15	0.301
S_8-1	0.7	53	9.8	6.93	2.85	0.05	0.21	0.29
S_9-1	1.8	55	9.8	6.83	2.95	0.14	0.55	0.301
S_10-1	0.7	59	9.8	6.9	2.88	0.05	0.21	0.294
S_11-1	1.9	44	9.8	7.42	2.36	0.12	0.46	0.241
S_12-1	0.6	39	9.8	7.5	2.28	0.04	0.14	0.233
S_13-1	2.4	58	9.8	6.67	3.12	0.2	0.77	0.318
S_14-1	7	57	9.8	6.72	3.06	0.58	2.21	0.312
S_15-1	3.3	57	9.8	6.72	3.06	0.27	1.04	0.312

Sub-Catchment Name	Area acres	%Imperv	Total Precip inches	Total Infil inches	Total Runoff inches	Total Runoff 10^6-gal	Peak Runoff CFS	Runoff Coeff
S_16-1	2.8	64	9.8	6.65	3.12	0.24	0.9	0.319
S_17-1	1.1	30	9.8	8.03	1.76	0.05	0.2	0.179
S_18-1	1.4	53	9.8	6.94	2.85	0.11	0.41	0.291
S_18-2	1.9	58	9.8	4.12	5.67	0.29	1.11	0.578
S_19-1	1.7	54	9.8	6.88	2.9	0.13	0.51	0.296
S_19-2	0.1	12	9.8	9.09	0.7	0	0.01	0.072
S_20-1	3.5	69	9.8	6.74	3.03	0.29	1.1	0.309
S_20-2	1.5	50	9.8	7.1	2.69	0.11	0.42	0.274
S_20-3	1.6	45	9.8	7.37	2.42	0.11	0.4	0.247
S_20-4	1.3	64	9.8	6.65	3.13	0.11	0.42	0.319
S_20-5	0.1	42	9.8	7.53	2.26	0.01	0.02	0.23

Stormwater Management Model Results
Sunset Beach Stormwater Study
Mainland Subcatchment Summary
Base Storm Sumulation - 30 year/24 hour storm
Jan-17

Sub-Catchment Name	Area acres	%Imperv	Total Precip inches	Total Infil inches	Total Runoff inches	Total Runoff 10^6-gal	Peak Runoff CFS	Runoff Coeff
S_21-1	2.1	73	9.8	5.5	4.28	0.24	0.93	0.436
S_22-1	3.6	7	9.8	9.52	0.27	0.03	0.1	0.028
S_23-1	4.3	23	9.8	8.22	1.57	0.18	0.7	0.16
S_24-1	13.5	22	9.8	8.5	1.29	0.47	1.8	0.131
S_25-1	3	38	9.8	7.56	2.23	0.18	0.69	0.227
S_25-2	9.3	20	9.8	8.62	1.17	0.3	1.13	0.12
S_26-1	19.8	18	9.8	9.09	0.7	0.38	1.44	0.072
S_26-2	0.9	28	9.8	8.42	1.37	0.03	0.13	0.139
S_27-1	4.2	16	9.8	8.86	0.94	0.11	0.41	0.096

Sub- Catchment Name	Area acres	%Imperv	Total Precip inches	Total Infil inches	Total Runoff inches	Total Runoff 10^6-gal	Peak Runoff CFS	Runoff Coeff
S_28-1	1.1	55	9.8	6.56	3.22	0.1	0.37	0.329
S_29-1	6.7	19	9.8	8.68	1.11	0.2	0.77	0.114
S_29-2	6.9	13	9.8	8.28	1.51	0.28	1.99	0.154
S_29-3	5.1	16	9.8	9.01	0.78	0.11	0.41	0.08
S_29-4	2.8	24	9.8	8.5	1.29	0.1	0.37	0.132
S_29-5	3.9	26	9.8	8.52	1.27	0.13	0.51	0.13
S_29-6	4.1	13	9.8	8.06	1.74	0.19	1.45	0.177
**								
S_35-1	17.9	17	9.8	8.8	1	0.48	1.84	0.102
S_35-10	1.7	13	9.8	9.03	0.76	0.04	0.13	0.078
S_35-11	2	22	9.8	7.03	2.76	0.15	0.98	0.282
S_35-12	4.2	16	9.8	9.01	0.78	0.09	0.34	0.08
S_35-13	1.5	31	9.8	8.12	1.66	0.07	0.26	0.17
S_35-14	0.7	51	9.8	7.79	1.99	0.04	0.14	0.203
S_35-15	0.4	30	9.8	8.32	1.46	0.02	0.06	0.149
S_35-16	0.8	28	9.8	8.42	1.37	0.03	0.11	0.139
S_35-17	0.8	29	9.8	8.09	1.7	0.04	0.14	0.173
S_35-18	6.2	17	9.8	8.8	1	0.17	0.64	0.102
S_35-19	1.7	14	9.8	8.97	0.82	0.04	0.14	0.084
S_35-2	5.7	17	9.8	8.8	1	0.15	0.59	0.102
S_35-20	2.8	20	9.8	9.01	0.78	0.06	0.23	0.08
S_35-21	2.2	21	9.8	7.31	2.48	0.15	0.95	0.253
S_35-22	2.6	13	9.8	9.48	0.32	0.02	0.09	0.032
S_35-23	7.7	17	9.8	8.8	1	0.21	0.79	0.102
S_35-3	2.3	7	9.8	9.39	0.41	0.03	0.1	0.042
S_35-4	5.9	18	9.8	8.74	1.05	0.17	0.64	0.108
S_35-5	5.4	18	9.8	8.74	1.05	0.15	0.59	0.108
S_35-6	4.5	12	9.8	9.21	0.59	0.07	0.27	0.06
S_35-7	1.4	30	9.8	8.03	1.76	0.07	0.25	0.179
S_35-8	3.5	19	9.8	8.68	1.11	0.11	0.4	0.114
S_35-9	0.4	41	9.8	8.18	1.6	0.02	0.07	0.163
S_36-1	8.5	22	9.8	8.61	1.18	0.27	1.04	0.121
S_37-1	12	2	9.8	9.72	0.08	0.03	0.1	0.008
S_37-10	1.9	7	9.8	9.52	0.27	0.01	0.05	0.028
S_37-11	0.3	40	9.8	7.89	1.89	0.02	0.09	0.193
S_37-12	10.6	21	9.8	8.66	1.13	0.32	1.23	0.115
S_37-13	16	18	9.8	8.11	1.68	0.73	3.92	0.171
S_37-14	0.4	44	9.8	7.45	2.33	0.03	0.14	0.237
S_37-15	2.7	12	9.8	9.33	0.47	0.03	0.13	0.048
S_37-16	0.2	32	9.8	8.22	1.56	0.01	0.03	0.159

Sub-Catchment Name	Area acres	%Imperv	Total Precip inches	Total Infil inches	Total Runoff inches	Total Runoff 10^6-gal	Peak Runoff CFS	Runoff Coeff
S_37-17	2.1	20	9.8	8.62	1.17	0.07	0.25	0.12
S_37-18	5	18	9.8	9.09	0.7	0.1	0.36	0.072
S_37-19	9.2	22	9.8	8.5	1.29	0.32	1.22	0.131
S_37-2	1.1	27	9.8	8.21	1.58	0.05	0.18	0.161
S_37-20	2.6	10	9.8	9.41	0.39	0.03	0.1	0.04
S_37-3	3.2	20	9.8	9.01	0.78	0.07	0.26	0.08
S_37-4	9.3	19	9.8	8.68	1.11	0.28	1.07	0.114
S_37-5	4.6	20	9.8	8.62	1.17	0.15	0.56	0.12
S_37-6	3.4	17	9.8	8.96	0.83	0.08	0.29	0.085
S_37-7	0.2	36	9.8	8.38	1.4	0.01	0.03	0.143
S_37-8	4.5	18	9.8	9.09	0.7	0.09	0.33	0.072
S_37-9	0.3	28	9.8	8.15	1.64	0.01	0.05	0.167
S_38-1	3.5	26	9.8	8.39	1.4	0.13	0.5	0.142
S_39-4	15.5	18	9.8	8.91	0.88	0.37	1.41	0.09
S_39-2	7	13	9.8	8.07	1.73	0.33	2.38	0.176
S_39-3	5.5	17	9.8	7.68	2.12	0.32	2.22	0.216
S_39-1	4.1	23	9.8	7.48	2.31	0.26	1.62	0.236
S_40-1	2.7	15	9.8	8.92	0.88	0.06	0.25	0.09
S_41-1	2.3	22	9.8	8.5	1.29	0.08	0.31	0.131

d model results inconclusive for Catchments 30-34