

WASTEWATER TRANSPORT SYSTEM
EVALUATION
HUNT ST. AND ROSE ST. PUMP STATION
SERVICE AREAS – STUDY 3

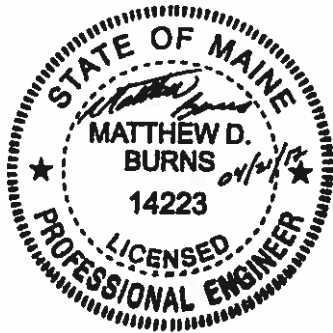
for the
CITY OF BATH, MAINE

APRIL 2017

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**WASTEWATER TRANSPORT SYSTEM EVALUATION
HUNT ST. AND ROSE ST. PUMP STATION
SERVICE AREAS – STUDY 3**

APRIL 2017



Prepared by:

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**CITY OF BATH, ME
WASTEWATER TRANSPORT SYSTEM EVALUATION
HUNT ST. AND ROSE ST. PUMP STATION
SERVICE AREAS – STUDY 3**

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SECTION 1

INTRODUCTION

1.1 GENERAL

Since the 1970s, the City of Bath has been working to identify and eliminate infiltration and inflow (I/I) from the wastewater collection system. In 1993, the City developed its first combined sewer overflow (CSO) master plan and over the last 23 years has spent millions of dollars to eliminate CSOs and develop recommendations for supplemental projects to further reduce CSO events. As part of the 2013 Wastewater System Evaluation and Strategic Plan, Wright-Pierce recommended that the City focus efforts on the Rose St. and Hunt St. service areas in the south end of Bath. The goal of this focus was to eliminate CSOs at Rose St. and possible sanitary sewer overflows (SSOs) at Hunt St. Pump Station prior to upgrading each of these 45-year-old pump stations. A report was developed in 2014 titled “Wastewater Transport System Evaluation – Hunt St. and Rose St. Pump Station Service Areas” which summarized the transport system study conducted by Wright-Pierce in these service areas. As part of the findings of the 2014 report, more detailed field investigations were recommended in the Hunt St. and Rose St. Pump Station service areas to better understand existing conditions. This ‘Study 3’ report summarizes those findings.

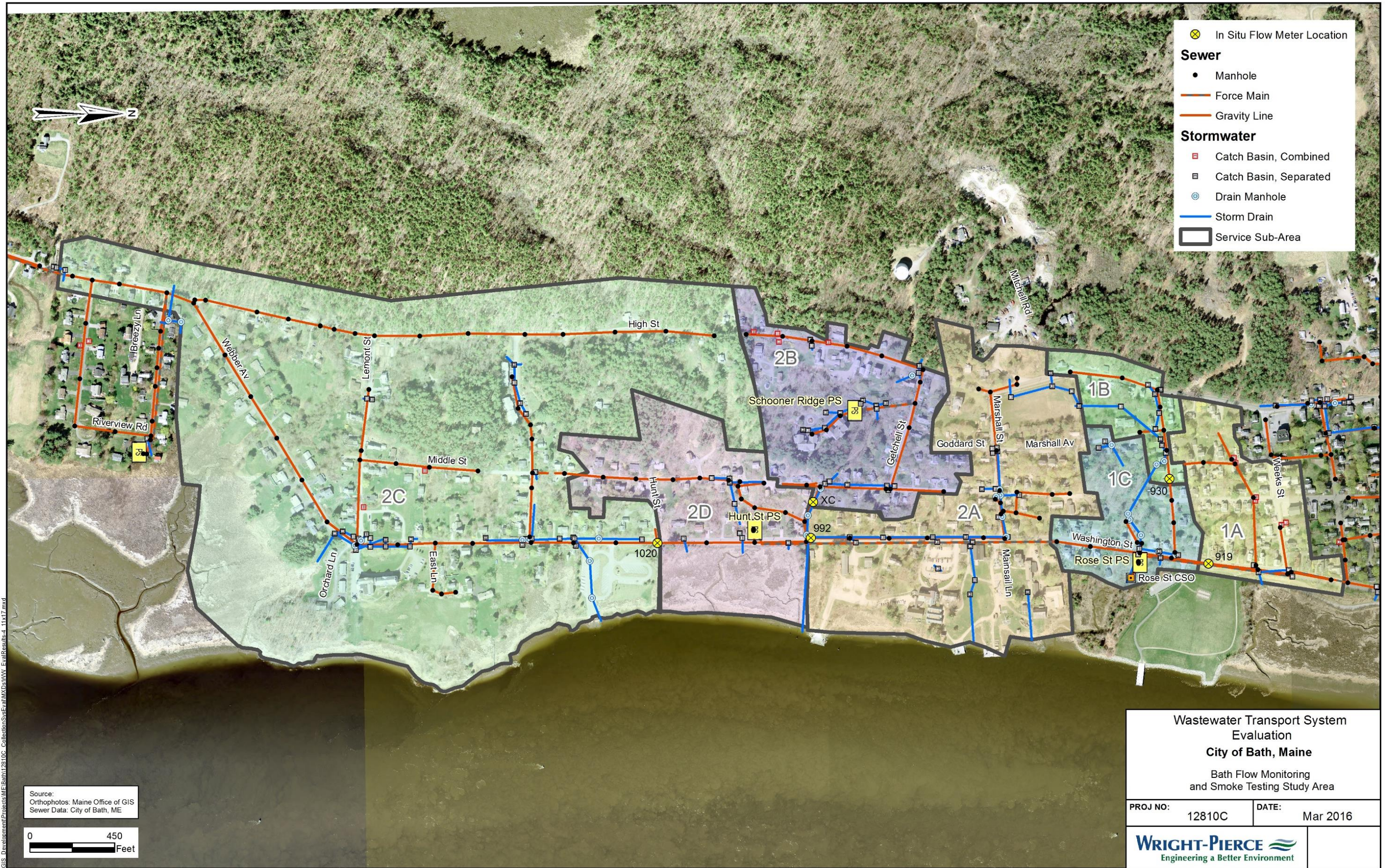
1.2 STUDY AREA

The area investigated as part of this project includes the gravity sewer collection systems associated with the Rose St. Pump Station (Service Area 1) and Hunt St. Pump Station (Service Area 2). Each pump station’s service area has been divided into smaller, sub-areas for more detailed analysis. This phase of the field investigation focuses on service sub-areas 1A, 1B, 1C, 2A, and 2D, identified as the “Study Area”. The initial scope of field investigations included the Study Area only, but grew to include sub-areas 2B and 2C to a limited extent due to field conditions warranting further investigation (i.e. following a sewer main upstream out of the project area due to identified I/I). These service areas are shown in Figure 1-1.

The entire Study Area contains more than 24,000 ft. of sanitary and combined sewers, as well as a separate stormwater collection system. These systems are owned and maintained by the City of Bath.

The Schooner Ridge Condominium complex has a private stormwater collection system, as well as a private sanitary collection system and pump station that contributes flows to the City's collector sewer on Getchell St. These private systems were not investigated as part of this study.

**FIGURE 1-1
STUDY AREA**



⊗ In Situ Flow Meter Location
Sewer
● Manhole
— Force Main
— Gravity Line
Stormwater
■ Catch Basin, Combined
■ Catch Basin, Separated
⊙ Drain Manhole
— Storm Drain
□ Service Sub-Area

Source:
 Orthophotos: Maine Office of GIS
 Sewer Data: City of Bath, ME



**Wastewater Transport System
 Evaluation**
City of Bath, Maine
 Bath Flow Monitoring
 and Smoke Testing Study Area

PROJ NO: 12810C	DATE: Mar 2016

W:\GIS_Development\Projects\12810C_CollectionSystemEvaluation\MXD\DWG_EvalResults-4_11x17.mxd

1.3 PROJECT BACKGROUND AND UNDERSTANDING

To gain a better understanding of the project area, Wright-Pierce reviewed the following plan sets provided by the City:

- Pump Stations – Contract 2, Contract Drawings, Fay Spofford & Thorndike, Inc., July 1969
- Intercepting and Force Main Sewers – Contract 3, Record Plan, Fay Spofford & Thorndike, Inc., August 1969
- Sewers – Contract 4, For Review, Fay Spofford & Thorndike, Inc., August 1969
- Sewer Separation Project – Phase II, Record Drawing, Kimball Chase Co., Inc., July 1988

A portion of the collection system in the study area, including the main interceptor on Washington St., was constructed of asbestos cement pipe in the late 1960s and early 1970s. Hunt St. and Rose St. Pump Stations were also built at this time. The majority of the collection system predates the 1960s, and much of it is likely constructed of clay pipes.

In 1988, portions of the combined system in the Hunt St. Pump Station service area were separated, and the Hunt St. CSO was eliminated.

The Rose St. and Hunt St. Pump Station service areas were both evaluated as part of a 1993 Facilities Planning Report (Whitman & Howard) which was the original CSO Master Plan and the 2006 CSO Master Plan Update (Jacobs Edwards & Kelcey). However, from discussions with the City and review of the 2011 CSO Master Plan update, this area has not been the focus of studies or construction projects in recent years.

Since the 2006 CSO Master Plan Update was compiled by Jacobs Edwards & Kelcey, Ransom Environmental Consultants, Inc. has prepared two CSO Master Plan updates (2008 and 2011). Wright-Pierce has also been assisting the City with many infrastructure projects and studies, including a comprehensive treatment facility evaluation, evaluation of several pump stations, and the I/I removal/CSO investigation study conducted in 2014. The findings and recommendations of the 2014 I/I study led to another CSO Master Plan update, initially drafted in 2015 and that was completed and submitted to Maine DEP on April 7, 2017..

The findings and recommendations of this Phase 3 Study could form the basis for CSO mitigation projects in this area of Bath as identified in the Master Plan.

1.4 PROJECT GOALS

Wright-Pierce and the City established the following goals for this study:

- Help the City develop a better understanding of the collection system in the Rose St. and Hunt St. Pump Station service areas
- Identify potential point sources of I/I for areas shown to have high I/I in Study 2
- Identify CSO abatement projects and anticipated costs based on preliminary projects identified in the CSO Master Plan Update (CSO Abatement Projects #35 through #39)

The findings and recommendations of this Phase 3 Study could form the basis for CSO mitigation projects in this area of Bath as identified in the Master Plan.

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-

SECTION 2

FIELD INVESTIGATIONS

2.1 PREVIOUS FIELD INVESTIGATION EFFORTS

Wright-Pierce conducted field investigations in the project area as part of Study 2, which included:

- Flow metering
- Instantaneous flow metering
- Smoke testing

The results of these field investigation efforts are summarized in the Study 2 report, and were used to form the basis and scope for further field investigation efforts identified in Study 2 and conducted in Study 3 as outlined below.

2.2 METHODOLOGY

2.2.1 Home Inspections

Wright-Pierce performed home inspections in the project area using a team of two people during the weeks of December 14 and December 21, 2015. Wright-Pierce notified homeowners, with the assistance of the City one week prior to the start of home inspections.

One week after notifications were issued, Wright-Pierce staff made an initial pass through the project area, knocking on doors and inspecting those houses for which residents were home and willing to allow their house to be inspected. For those houses whose residents were not home or available, Wright-Pierce staff left door hangers with a contact number. With the assistance of City staff, residents were able to coordinate convenient home inspection times. For those residents that received door hangers but did not contact Wright-Pierce or the City, a second, and third and final attempt to inspect homes were made. After a third unsuccessful attempt, the door hanger was removed and the home was not inspected.

Two key goals of the home inspections included 1) identifying any illicit connections in the home, including sump pumps, floor drains, perimeter drains, or any other direct inflow point sources that may contribute to inflow, and 2) identifying the location of the sewer lateral, as well as the

direction of the lateral and general location where the lateral ties into the sewer main should I/I separation projects in the area be recommended.

Georeferenced field observations and photos were recorded on mobile devices using Fulcrum, a mobile data collection app. Representations of the home inspection findings are included as figures in Section 2.3. In addition, a shapefile containing collected data was created using ArcGIS and will be provided to the City to supplement their GIS database. Approximate locations of sewer lateral locations for homes with cross-country laterals or illicit connections have been included in the shapefile and results identified in this report.

It should be noted that upon inspection, it became clear that the delineation of the sub-area boundaries needed to be modified to address the homes which are connected to cross country laterals. These homes, which were previously categorized into sub-areas based on parcel location, connect to sewers that are not in their parcel-location-based sub-area. The map representing the home inspection findings has been updated to reflect these new sewershed boundaries, and differs slightly from the sewersheds defined in Study 2.

2.2.2 Manhole Inspections

Wright-Pierce staff conducted manhole inspections of all sanitary sewer manholes in the project area. Manholes that could not be located in the field and manholes that were not accessible were not inspected. As field conditions were identified, the scope of the manhole inspections was increased to include manholes along Getchell St., as well as manholes at the intersection of Washington Ave. and Lemont St. All manhole inspections were conducted from street level. Reports for each manhole inspected were generated and included photographs, sketches, and condition assessment information. To determine the overall manhole condition, a modified version of the National Association of Sewer Service Companies (NASSCO) Manhole Assessment and Certification Program was used. The modified NASSCO approach was selected to meet the needs of the City by allowing all of the identified manholes in the study area to be uniformly inspected within the project budget and schedule. The approach included inspection data of the following parameters:

- Cover Condition
- Rim Condition

- Riser Condition
- Steps Condition
- Invert Condition
- Table Condition
- Any Defects/Leakage Points

For each inspection parameter, detailed information was collected (i.e. cover type, cover diameter, rim material, etc.) and an overall score was assigned to the manhole on a numerical 1 – 5 rating, where the rating corresponds to the following:

- 1 = Excellent
- 2 = Good
- 3 = Fair
- 4 = Poor
- 5 = Immediate Attention Required

Two key goals of the manhole inspections included 1) identifying potential point sources of infiltration within manholes, and 2) determining the overall condition of manholes to allow the City to manage future capital improvement projects to mitigate future I/I.

Georeferenced field observations and photos were recorded on mobile devices using Fulcrum. Representations of the manhole inspection findings are included as figures in Section 2.3. In addition, a shapefile containing collected data was created using ArcGIS and will be provided to the City to supplement their GIS database.

2.2.3 Television Inspection Data Review

Ted Berry Company, Inc. was separately contracted in 2015 by the City to perform closed circuit television (CCTV) inspections of various sewer and stormwater lines in the City of Bath, which included some of the sewer mains in the project area. As part of the Study 2 report, Wright-Pierce recommended that the City continue with CCTV inspections of areas with high I/I. In 2016, after Wright-Pierce had completed field investigations, Wright-Pierce provided the City a list of sewer mains that should be televised by Ted Berry due to the potential for I/I, along with a priority ranking for each main in the project area on the list. Two main factors were used to decide the

priority of sewer lines, which included 1) lines with high flows during wet weather events potentially due to I/I, and 2) lines that may be in poor condition as observed during manhole inspections. The specific lines televised by Ted Berry in 2015 and 2016 are listed below in Section 2.3 along with the findings of each CCTV inspection.

In addition to sewer mains, some sewer laterals were identified as needing TV inspections due to the potential of I/I. These include cross-country laterals, homes with illicit connections, and laterals that serve multiple homes in the Study Area. The locations of the laterals are approximate, and are based on observations during home and manhole inspections. The multi-user cross country lines identified may be contributors of I/I and should be televised and investigated further.

A summary of sewer mains televised by Ted Berry, along with the remaining mains and laterals to be televised and their priority ranking are included in Appendix A.

2.3 FINDINGS

The findings from field investigations are summarized for each sewershed area below. In order to maintain consistency, Wright-Pierce has used the same terminology as that presented in Ted Berry's CCTV reports to describe televised sewer line conditions identified.

2.3.1 Sub-Area 1A (Drains to Rose St. Pump Station)

Previous results of flow metering and smoke testing conducted during Study 2 indicated that this area is subject to large volumes of direct inflow. The presence of inflow was confirmed through smoke testing, which identified six catch basins discharging directly to the sewer system. Smoke testing also identified two locations of the sewer main crossing from Cherry Street to Washington Street (one location on a property off of Cherry Street upstream of SMH-926, one location on a property off of Washington Street between SMH-924 and SMH-917), and one location in a lateral connecting a home to the sewer main with smoke coming from the ground between SMH-925 and SMH-924, suggesting the presence of cracks or holes in the sewer main. These cracks or holes could be causing inflow of groundwater into the sewer line or exfiltration of wastewater into the ground during periods of low groundwater.

As part of Study 3, all 12 sewer manholes in Sub-Area 1A were inspected. Out of the 12 manholes inspected, nine ranged from fair to excellent condition, with three being in poor condition (i.e. cracks in various parts of the manhole, but no defects that require immediate reparative action due to infiltration). No manholes in this sub-area require immediate attention.

33 homes were inspected in Sub-Area 1A, of which eight homes had illicit connections to the sewer system and 24 did not have illicit connections. Eight homes in this area were not inspected due to the lot/house being vacant or for sale, or no response from the homeowner. The homeowner at 33 Weeks Street refused access to Wright-Pierce personnel for an inspection.

During the home inspections, it was discovered that there is a cross-country sewer lateral connecting four homes on Middle Street to the sewer line between SMH-924 and SMH-917. One homeowner identified drainage issues in their backyard in the approximate location of the combined lateral. This connection was unknown at the time of Study 2 smoke testing and was not observed to have smoked. However, since the location of the line was unknown at the time and not visible behind homes, there may have been evidence of smoke that was not noticed by the inspection team.

It should be noted that, though outside of the drainage area of Sub-Area 1A, the house at 45 Weeks Street was inspected and found to have an illicit sump pump connection.

Television inspection data from Ted Berry was available for nine sewer main sections in Sub-Area 1A:

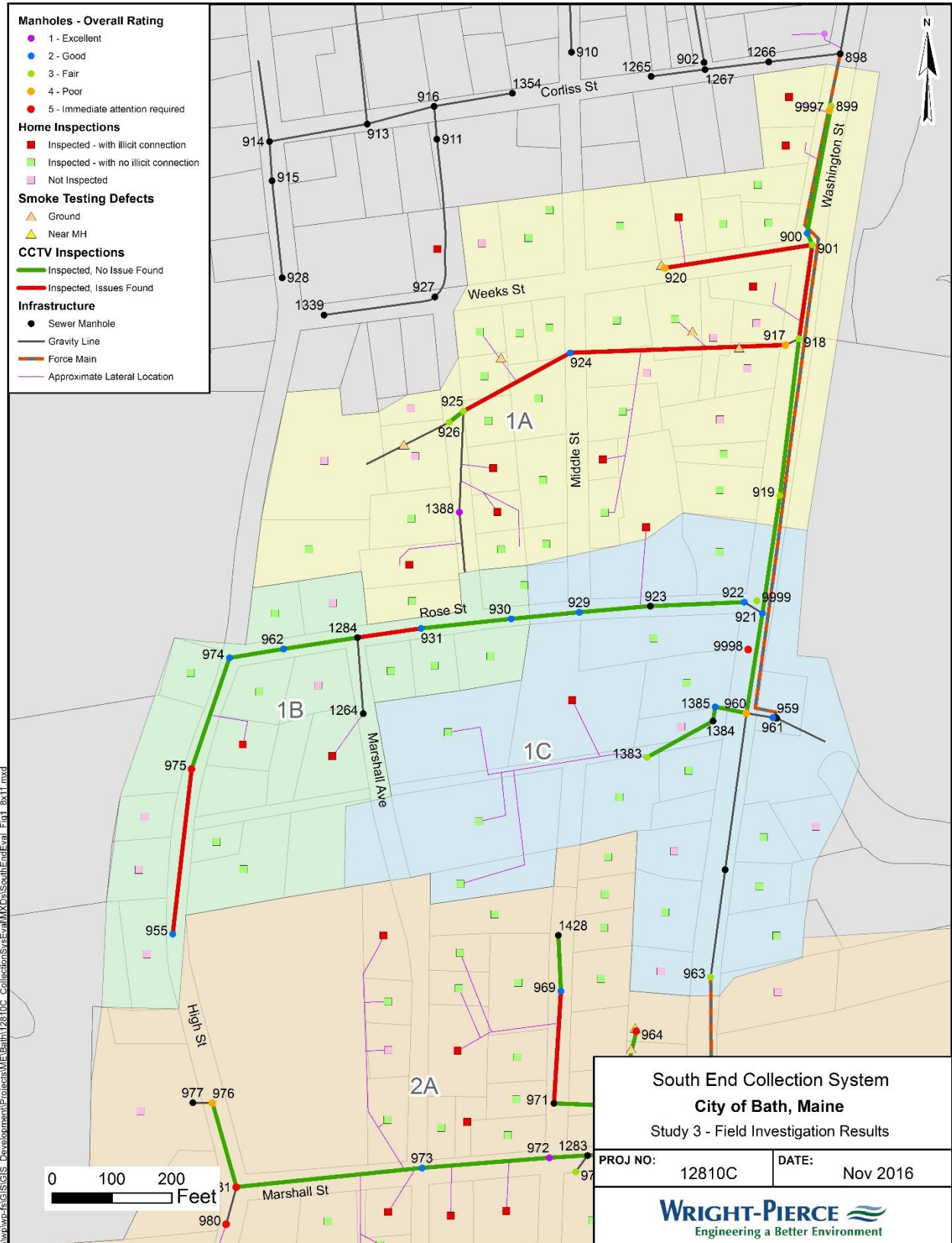
- SMH-899 to SMH-900
- SMH-900 to SMH-901
- SMH-901 to SMH-918
- SMH-918 to SMH-919
- SMH-919 to SMH-921
- SMH-920 to SMH-901
- SMH-924 to SMH-917
- SMH-925 to SMH-924
- SMH-926 to SMH-925

Four of these sections showed significant signs of possible infiltration in the pipe: the sewer section between SMH-901 and SMH-918, between SMH-920 and 901, between SMH-924 and SMH-917, and between SMH-925 and SMH-924. The TV inspection data between SMH-901 and SMH-918 shows that the sewer main is in poor condition and shows signs of infiltration. The video showed many cases of cracks (both longitudinal and latitudinal), broken pipe, and a tap break-in protruding. The section between SMH-925 and SMH-924 showed multiple longitudinal cracks, fractures, and cases of fine root protrusion. Though there were no actual infiltration stains in these sections of piping, breaks and cracks in the pipe could allow infiltration.

The TV inspection data between SMH-920 and SMH-901 showed one infiltration dripper and multiple cases of fine root protrusion through joints and circumferential fractures. The infiltration dripper is a clear indicator of infiltration in the pipe, and other signs present indicate potential infiltration in this section. The video between SMH-924 and SMH-917 showed that the sewer main is in very poor condition and shows signs of infiltration. The video showed numerous issues which could be causing infiltration, such as root penetration, cracks, and joint offsets of the piping.

Please refer to Figure 2-1 for a visual summary of the above findings of the field investigations performed in Sub-Area 1A.

**FIGURE 2-1
SUB-AREAS 1A, 1B, AND 1C FIELD INVESTIGATION RESULTS**



2.3.2 Sub-Area 1B (Drains to Rose St. Pump Station)

Results of the flow metering and smoke testing conducted during Study 2 identified no defects in this sub-area. There is stormwater infrastructure in this area, and it appears to be separate from the sanitary sewer system. Based on the small size of this sub-area and the results of field investigations, Sub-Area 2B likely has a limited impact on the Rose St. Pump Station and CSO.

As part of Study 3, six out of the eight sewer manholes in Sub-Area 1B were inspected. Five of these manholes are in good to excellent condition, and one (SMH-975) needs immediate attention. During the inspection, SMH-975 had groundwater entering the manhole from joints in the barrel dripping down the walls, as well as corrosion of the rim. In addition, a constant steady flow of clean groundwater was coming in above the invert of the outlet pipe. This significant infiltration above the outlet pipe invert suggests that the pipe is broken. It should be noted that a rain event occurred the day before the inspection, which likely contributed to the magnitude of groundwater entering the manhole.

Ten homes were inspected in this sub-area, two of which were found to have an illicit connection. The remaining eight inspected homes had no illicit connection to the sewer. Five homes in this area were not inspected due to the lot/house being vacant or for sale or non-response from the homeowner.

Television inspection data from Ted Berry was available for seven sewer main sections in Sub-Area 1B:

- SMH-955 to SMH-975
- SMH-975 to SMH-974
- SMH-974 to SMH-962
- SMH-962 to SMH-1284
- SMH-1284 to SMH-931
- SMH-931 to SMH-930
- SMH-930 to SMH-929

The TV inspection data between SMH-955 and SMH-975 showed that the sewer main is in poor condition and showed signs of infiltration. The video showed root protrusion into a joint in the pipe, as well a large crack with an infiltration stain. There was also a sizable hole in the pipe, through which soil is visible. The survey, which started at SMH-975, was abandoned approximately 100 feet before reaching SMH-955 due to the inability to navigate the camera further.

The TV inspection data between SMH-1284 and SMH-931 showed four cases of broken pipe where soil is visible. These cases can be seen 34 feet, 48 feet, 103 feet, and 109 feet downstream of SMH-1284. To view the complete reports for the pertinent video inspected sewer lines, see Appendix B.

Please refer to Figure 2-1 for a visual summary of the above findings of the field investigations performed in Sub-Area 1B.

2.3.3 Sub-Area 1C (Drains to Rose St. Pump Station)

Due to lack of an adequate location to install flow meters in the two, short collector sewers that discharge directly to Rose St. Pump Station, Sub-Area 1C was excluded from the Study 2 in situ flow metering. This area has a short cross country collector sewer that discharges to the Washington St. interceptor. No defects were identified in this sub-area during Study 2 smoke testing. However, the cross-country sewer is in a low-lying area where flooding has been observed. If the ground was saturated during smoke testing, smoke may have been unable to penetrate to the ground surface.

As part of Study 3, 10 of the 14 sewer manholes in Sub-Area 1C were inspected. Eight of these manholes are in fair to good condition, one manhole is in poor condition (SMH-960), and one manhole needs immediate attention (SMH-9998 – This manhole was identified in the field and arbitrarily numbered since it was not present in the City’s GIS Database). SMH-960’s invert is corroded and the walls are cracked, which may lead to infiltration, although none was observed at the time of inspection. Bricks are also missing in the table and the risers. A previously connected old storm line has been plugged with bricks, however, there is still some evidence of infiltration from this line. SMH-9998 had not been identified in the City’s GIS database, and it was unclear

based on the inspection of SMH-9998 where the sewer line in the manhole discharges to. It may tie into the line heading towards the pump station and flow may come from SMH-9999 (This manhole was also identified in the field and arbitrarily numbered since it was not present in the City's GIS Database), however this cannot be confirmed without further investigation.

14 homes were inspected in this sub-area, two of which were found to have an illicit connection. The remaining 12 inspected homes had no illicit connection to the sewer. Four homes in this area were not inspected due to the lot/house being vacant or for sale or non-response from the homeowner.

During the house inspections, it was discovered that the short cross-country collector sewer is larger than originally thought. According to lateral discharge locations and anecdotal evidence from homeowners, four homes connect to a shared lateral that runs along an old paper road between Marshall Ave. and Washington St. The lateral discharges into SMH-1383. This connection was unknown at the time of Study 2 smoke testing and was not observed to have smoked. However, since the location of the line was unknown at the time and not visible behind homes, there may have been evidence of smoke that was not noticed by the inspection team.

Television inspection data from Ted Berry was available for seven sewer main sections:

- SMH-929 to SMH-923
- SMH-923 to SMH-922
- SMH-921 to SMH-960
- SMH-960 to SMH-1385
- SMH-1385 to SMH-1384
- SMH-1384 to SMH-1383

The CCTV data did not show any significant signs of I/I in this sub-area, and indicated that the sewer pipes are in good condition. It should be noted that the condition of the shared lateral along the old paper road is unknown and should be investigated further. A cleanout is located upstream of the four tie-in points and may allow for insertion of a camera to collect CCTV data.

Please refer to Figure 2-1 for a visual summary of the above findings of the field investigations performed in Sub-Area 1C.

2.3.4 Sub-Area 2A (Drains to Hunt St. Pump Station)

Flow monitoring performed in Study 2 found peaking factors (ratio of wet weather flows to average flows) to be very high in this sub-area, ranging from 74 to 118 for the three wet weather events analyzed. These peaking factors and the immediate increase in flows during the wet weather events indicate direct inflow to the collection system. The presence of infiltration was also apparent, as it took 2 to 5 days for flows to return to baseline flow rates. Field investigations identified defects along the cross-country sewer line between Middle Street and Washington Street, north of Marshall Street. Continuous clean flow from this line was observed in a manhole on Marshall Street during instantaneous flow metering. A large area of the ground along this cross-country line smoked during testing, and smoke was seen coming from the ground around two manholes. Nearby ground was saturated, so leaks in the cross-country line likely allow a significant amount of infiltration.

As part of Study 3, 17 of the 21 sewer manholes in Sub-Area 2A were inspected. 13 of these manholes are in fair to excellent condition, one manhole is in poor condition (SMH-976), and three manholes need immediate attention (SMH-964, SMH-980, and SMH-981). SMH-976's invert and steps are corroded and the walls are cracked. The outlet pipe is also cracked on top and the top of the chimney is corroding away. Wall sections are shifted and cracked, and may be contributing to some infiltration.

SMH-964 showed signs of both inflow and infiltration during the inspection. There is an open channel into the manhole and two holes into the manhole which allow for drainage from the surrounding low-lying area to enter the structure. In addition, the walls and risers of the manhole are broken and the rim is corroded (pitted).

SMH-980 and SMH-981 showed signs of infiltration. In SMH-980, there was steady, clean flow coming into the manhole through a crack in the wall where the grout had eroded away. In addition, the riser and walls of this manhole are cracked. In SMH-981, there was steady infiltration coming into the manhole from two different cracks in the wall. There were also numerous bricks in the inverts (possibly from when the rim was reset), cracking in the riser, and corrosion on the table.

34 homes were inspected in this sub-area, nine of which was found to have an illicit connection. The remaining 25 inspected homes had no illicit connection to the sewer. 13 homes in this area

were not inspected due to the lot/house being vacant or for sale, low priority need for inspection, or non-response from the homeowner.

During the home inspections, two different shared cross-country laterals were discovered. According to lateral discharge locations and anecdotal evidence from homeowners, four homes west of Marshall Ave. connect to a shared lateral that runs parallel to Marshall Ave. before discharging to the Marshall St. sewer main upstream of SMH-973. Homeowners indicated that the lateral has roots which require periodic cleaning. The lateral is located in a low-lying area (shared with Goddard Pond) that has historically had drainage issues, which may lead to infiltration into the system.

A second combined lateral is located on Goddard St. The laterals of three homes on the west side of Goddard St. connect to a common lateral that runs parallel to Goddard St. before discharging to Marshall St. upstream of SMH-973. The lateral is located in a low-lying area which may contribute to infiltration entering the collection system.

These two laterals were unknown at the time of Study 2 smoke testing and was not observed to have smoked. However, since the locations of the lines was unknown at the time and not visible behind homes, there may have been evidence of smoke that was not noticed by the inspection team.

Television inspection data from Ted Berry was available for 16 sewer section in Sub-Area 2A:

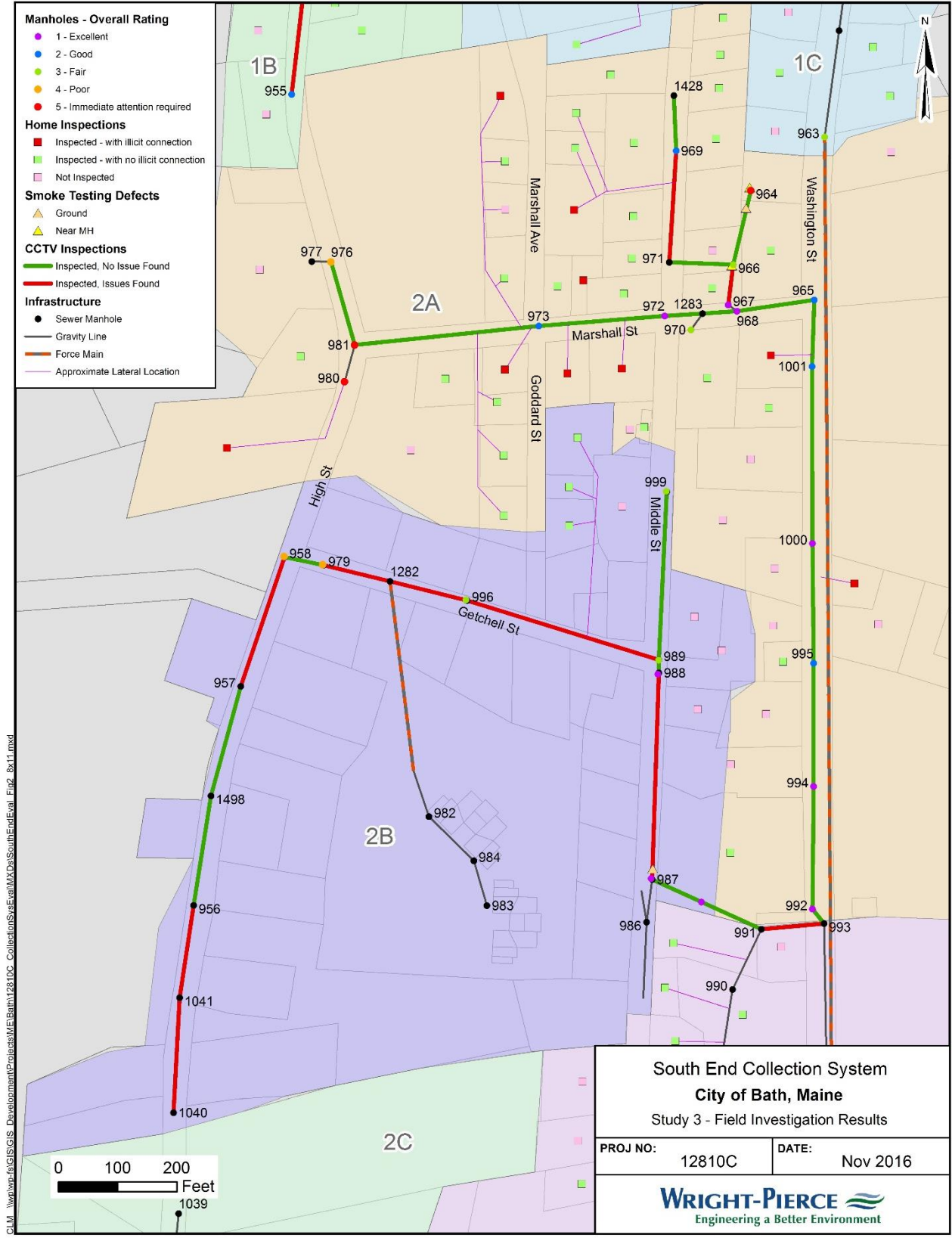
- SMH-964 to SMH-966
- SMH-966 to SMH-967
- SMH-965 to SMH-1001
- SMH-968 to SMH-965
- SMH-969 to SMH-971
- SMH-971 to SMH-966
- SMH-972A to SMH-967
- SMH-973 to SMH-972A
- SMH-976 to SMH-981
- SMH-981 to SMH-973

- SMH-994 to SMH-991
- SMH-995 to SMH-992
- SMH-992 to SMH-993
- SMH-1000 to SMH-995
- SMH-1001 to SMH-1000
- SMH-1428 to SMH-969

Two of these sections showed significant signs of possible infiltration in the pipe: the sewer section between SMH-966 and SMH-967 and between SMH-969 and SMH-971. The TV inspection video between SMH-966 and 967 significant root protrusion throughout the sewer section; the CCTV inspection was abandoned due to the extent of the roots present in the piping. The video for the section between SMH-969 and 971 showed one case of broken pipe with soil visibility as well as multiple (fine and medium) cases of root protrusion at joints. To view the complete reports for this inspection video, see Appendix B.

Please refer to Figure 2-2 for a visual summary of the above findings of the field investigations performed in Sub-Area 2A.

**FIGURE 2-2
SUB-AREAS 2A AND 2B FIELD INVESTIGATION RESULTS**



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2.3.5 Sub-Area 2B (Drains to Hunt St. Pump Station)

Flow monitoring performed in Study 2 found peaking factors ranging from 21 to 50 for the three wet weather events analyzed. These peaking factors and the immediate increase in flows during the wet weather events indicated direct inflow to the collection system. The presence of infiltration was also apparent, as it took up to 10 days for flows to return to baseline flow rates after a wet weather event. The only defect identified in Sub-Area 2B during smoke testing was smoke coming from the ground along the cross-country line between Middle St. and Washington St., near the Middle St. edge of pavement.

Seven of the 15 sewer manholes in Sub-Area 2B were inspected. Five of these manholes are in fair to excellent condition and two manholes are in poor condition (SMH-958 and SMH-979). SMH-958 has cracking in the riser and the invert is full of debris (cement is partially blocking the line). SMH-979 has a broken rim, riser, and wall, as well as a broken invert. While no infiltration was observed, it could occur in both manholes during wet weather conditions.

Three homes were inspected in this sub-area, none of which had an illicit connection to the sewer. Four homes in this area were not inspected due to low priority need for inspection based on Study 2 recommendations.

A shared cross-country lateral north of Getchell St. along Goddard St. was discovered during home inspections. According to lateral discharge locations and anecdotal evidence from homeowners, three homes on the east side of Goddard St. connect to a shared lateral that runs parallel to Goddard St. The lateral is located behind the homes on the east side, and eventually discharges to the Getchell St. sewer main upstream of SMH-989. Homeowners indicated that the lateral has roots and grease which require periodic cleaning. The shared lateral was PVC-lined in approximately 2010 to minimize root intrusion.

Television inspection data from Ted Berry was available for 12 sewer mains in Sub-Area 2B:

- SMH-1040 to SMH-1041
- SMH-1041 to SMH-956
- SMH-956 to SMH-1498
- SMH-1498 to SMH-957

- SMH-957 to SMH-958
- SMH-958 to SMH-979
- SMH-979 to SMH-996
- SMH-996 to SMH-989
- SMH-989 to SMH-988
- SMH-988 to SMH-987
- SMH-987 to SMH-991
- SMH-999 to SMH-989

Six of the sewer sections listed above show signs of infiltration and wear in the sewer main. The sewer between SMH-957 and SMH-958 showed signs of infiltration (six separate infiltration stains and an infiltration drip) as well as points of settled deposits. The survey, which started at SMH-957, was abandoned approximately 125 feet before reaching SMH-958 due to the inability to navigate further. The sewers between SMH-988 and SMH-987 and between SMH-996 and SMH-989 also showed significant signs of infiltration. Though no infiltration drippers could be seen in the videos for these sections, the video between SMH-988 and SMH-987 showed two holes as well as multiple fractures, large joint offsets, and medium root protrusion through the joints. The video between SMH-996 and SMH-989 had one case of broken pipe through which the void was visible.

The remaining three sewer mains in the list above showed several cases of root protrusion into the sewer line. The inspection video between SMH-1040 and SMH-1041 showed multiple root issues, and a circumferential crack in the pipe present near SMH-1040. The inspection video between SMH-1041 and SMH-956 showed roots in joints, multiple fractures in the pipe at one section of root protrusion, and one circumferential crack in the pipe (visibly unrelated to root protrusion). The inspection video between SMH-1498 and SMH-957 showed significant root protrusion; because of these roots, the equipment could not navigate further toward SMH-1498, resulting in survey abandonment. To view the complete reports for these inspection videos, see Appendix B.

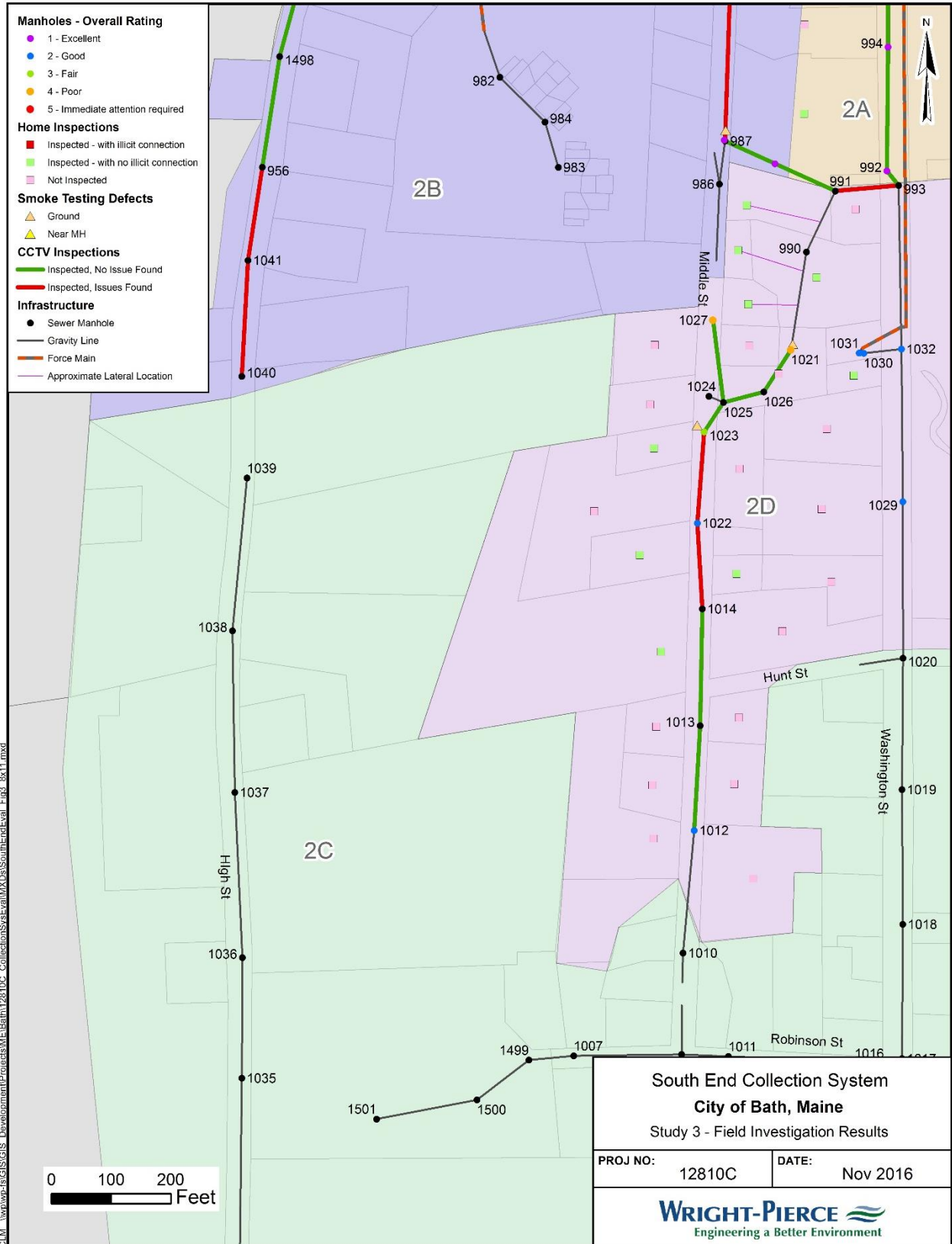
Please refer to Figure 2-2 for a visual summary of the above findings of the field investigations performed in Sub-Area 2B.

2.3.6 Sub-Area 2C (Drains to Hunt St. Pump Station)

As part of Study 2, the flow meter installed in Sub-Area 2C measured flows from the Bridge St. and Riverview Rd. Pump Stations (which are carried to the Hunt St. Pump Station through the Washington St. interceptor) in addition to gravity flows from Sub-Area 2C. Therefore, peaking factors calculated from the flow meter data were representative of the entire Sub-Area 2C and Bridge St. and Riverview Rd. Pump Station service areas. The service areas associated with these two pump stations were not investigated as part of this study, but I/I in these areas could contribute to peak flows at Hunt St. Pump Station. The highest wet weather peaking factor measured for this area was 7, which indicates that there are likely few sources of direct inflow. This was confirmed through smoke testing. The only potential defect identified in Sub-Area 2C during smoke testing was smoke coming from a catch basin at the base of Robinson St. (see Study 2 results). This catch basin was thought to be separated and tied into the nearby stormwater system, so the smoke observed could have migrated through the ground or a plugged cross-connection. No inspections (manhole, home, or TV) were performed as part of Study 3 in this sub-area.

Please refer to Figure 2-3 for a visual summary of the above findings of the field investigations performed in Sub-Area 2C.

**FIGURE 2-3
SUB-AREAS 2C AND 2D FIELD INVESTIGATION RESULTS**



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2.3.7 Sub-Area 2D (Drains to Hunt St. Pump Station)

As part of Study 2, Sub-Area 2D was excluded from in situ flow metering due to the inability to locate two potential metering manholes, and the only other manhole located was clogged with debris. Smoke testing identified potential defects on Middle Street and on the cross-country line that carries flows from Middle Street to the main interceptor on Washington St. Smoke was seen coming from two catch basins on Middle Street. The City's GIS database shows these catch basins as being separated, and there is other stormwater infrastructure in the area, so it's possible that smoke migrated through the ground or through old, plugged cross connections. Smoke was also seen coming from the ground on the west side of Middle Street. This could indicate a broken lateral or drain pipe connected to the sewer. Smoke was also observed coming from the ground on the cross-country line, downstream of SMH-1021.

As part of Study 3, nine of the 17 sewer manholes in Sub-Area 2D were inspected. Seven of these manholes are in fair to good condition and two manholes were in poor condition (SMH-1021 and SMH-1027). SMH-1021 has a cracked riser and walls, as well as missing steps. At the time of inspection, the manhole was surcharged and the condition of the table and invert could not be determined (manhole needs to be cleaned). SMH-1027 has a cracked riser and corroded rim, steps, and table. The walls are seeping and could be a potential source of infiltration. At the time of inspection, there was standing water in the manhole and the inverts had excessive debris blocking flow.

The cross-country line that connects Middle St. and Washington St. has six manholes. Of these six manholes, only one could be inspected. Four manholes could not be located for inspection, and one was located beneath a birdbath that could not be easily moved without potentially damaging private property.

Nine homes were inspected in this sub-area, all of which had no illicit connection to the sewer. 16 homes in this area were not inspected due to the lot/house being vacant or for sale or non-response from the homeowner.

There were television inspection data for eight sewer sections in Sub-Area 2D:

- Between SMH-991 and SMH-993

- Between SMH-1012 and SMH-1014
- Between SMH-1014 and SMH-1022
- Between SMH-1022 and SMH-1023
- Between SMH-1023 and SMH-1025
- Between SMH-1025 and SMH-1026
- Between SMH-1026 and SMH-1021
- Between SMH-1027 and SMH-1025

Three of these sewers showed signs of possible infiltration: the sewers between SMH-991 and SMH-993, between SMH-1014 and SMH-1022, and between SMH-1022 and SMH-1023. Infiltration was seen in two of these sewers: the video between SMH-991 and SMH-993 showed one infiltration stain and the video between SMH-1014 and SMH-1022 showed two cases of significant root protrusion and one infiltration dripper. The video between SMH-1012 and SMH-1014 showed multiple root protrusions. To view the complete reports for these inspection videos, see Appendix B.

Please refer to Figure 2-3 for a visual summary of the above findings of the field investigations performed in Sub-Area 2D.

2.3.8 Summary

Table 2-1 below summarizes the number of homes inspected and number of homes with illicit connections in the project area for discussion with the City Council.

**TABLE 2-1
HOME INSPECTIONS SUMMARY**

Sub-Area	Number of Homes Inspected	Number of Homes with Illicit Connection	Number of Homes not Inspected
1A	33	8	9
1B	10	2	5
1C	14	2	4
2A	34	9	4 ⁽¹⁾
2B	3	0	4
2C	0	0	0
2D	9	0	5 ⁽²⁾

1. An additional 9 'low-priority' homes in Area 2A from Study 2 were not inspected.
2. An additional 9 'low-priority' homes in Area 2D from Study 2 were not inspected.

SECTION 3

RECOMMENDATIONS

3.1 GENERAL

In order to reduce suspected SSOs and recorded CSOs, I/I must be removed from the collection system in the Rose St. and Hunt St. Pump Station service areas. During Study 2, Wright-Pierce recommended additional investigation work be conducted. To date, manhole inspections, house-to-house inspections, and some television inspection of sewers by Ted Berry Co. has been completed.

Wright-Pierce developed recommendations for CSO abatement projects based on results of the field investigations and evaluations. While not all sewers were television-inspected, and not all homes and manholes were inspected, sufficient information exists to make specific project recommendations. These recommendations supplement and refine projects identified in Study 2 based on updated information gathered during field investigations.

Planning-level costs have been prepared for the recommended projects. These planning-level costs were developed using standard cost estimating procedures consistent with industry standards utilizing concept layouts and unit cost information. Total project capital costs include an allowance of 45% of the estimated construction costs to account for construction contingency, design and construction engineering, permitting, as well as financing, administrative, and legal expenses. The project cost information presented herein is in current dollars and is based on ENR Index 10278 (March 2017).

These estimates have been developed primarily for evaluating alternative solutions and are generally reliable for determining the relative costs of various options. Many factors arise during final design (e.g. site conditions, owner-selected features and amenities, code issues, etc.) that cannot be definitively identified and estimated at this time. These factors are typically covered by the 45% allowance described above. However, this allowance may not be adequate for all circumstances.

3.2 COLLECTION SYSTEM PROJECTS

Per discussions with DEP and the City, the collection system projects have been broken up into Phase 1 and Phase 2 projects to allow for compliance with the CSO Master Plan schedule. Phase 1 would be completed in 2017 and consists of investigations, sewer relining, and manhole relining/regrouting. All other recommendations would be completed in 2018 as part of a Phase 2.

3.2.1 Sub-Area 1A (Drains to Rose St. Pump Station)

Figure 3-1 summarizes the recommended project for Sub-Area 1A. The following work is included as part of Phase 1:

Sanitary

- Reline entire cross country sewer (approximately 750 ft.) and conduct lateral repairs as necessary (approximately 15 laterals) between SMH-925 and SMH-917.
- Re-grout and waterproof SMH-917.

Other

- Survey work in select areas of Sub-Area 1A to confirm structure locations and inverts
- Additional house inspections for eight homes that were not inspected during Study 3 that may be impacted by the sanitary and storm system project recommendations above.
- Complete CCTV inspection of the remaining sewer mains and laterals identified in Appendix A (approximately 700 ft.)
- Investigate separation of two homes with illicit connections on Washington Ave north of Weeks St. These homes may be separated by routing sump pump discharge to yard, where it will sheet flow to existing stormwater system on Washington Ave.

Estimated Phase 1 project cost = \$120,000

The following work is included as part of Phase 2:

Sanitary

- Replace existing sewer with new sewer between SMH-920 and SMH-901.
- Install new sewer manhole at SMH-920.

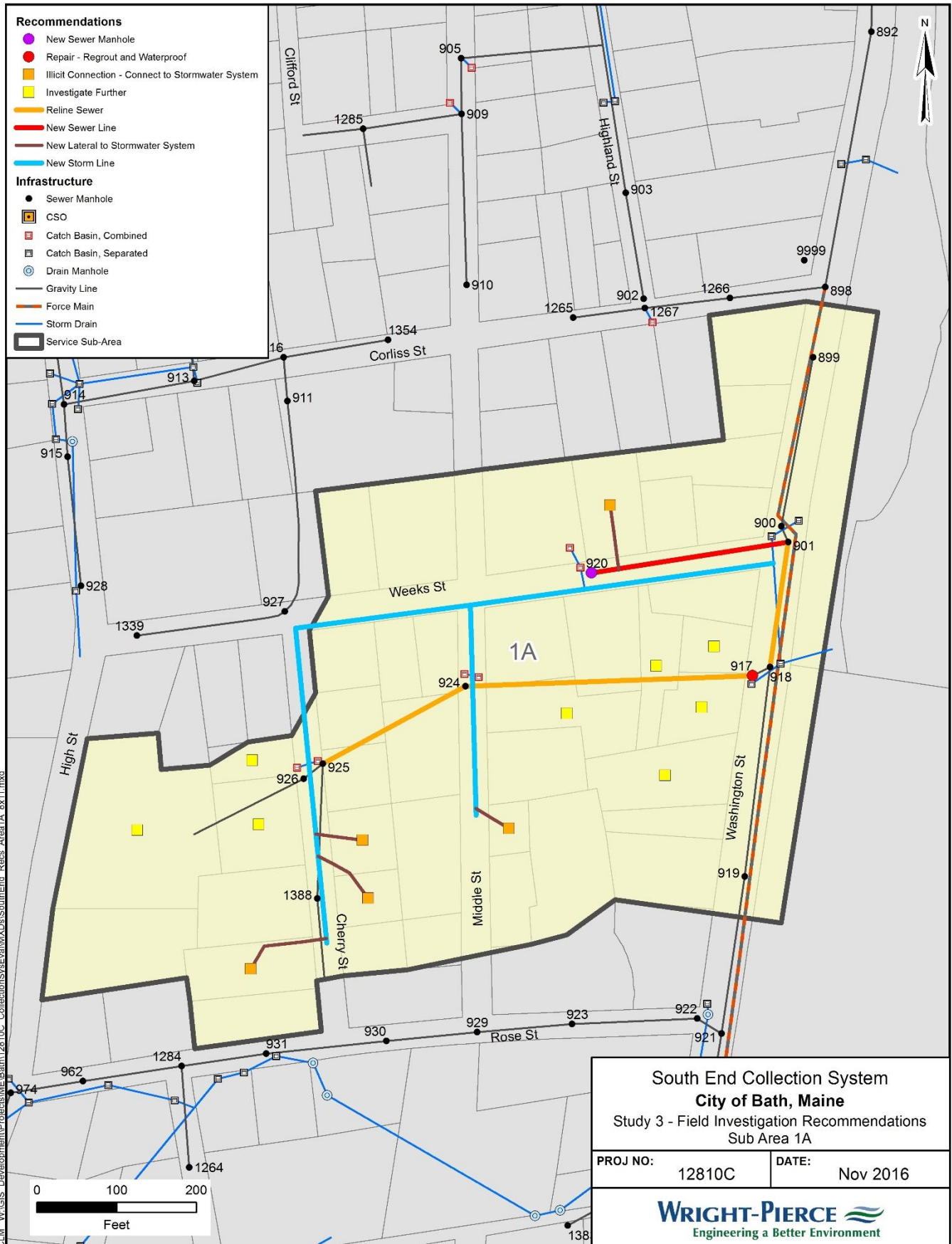
Storm

- Install approximately 1,300 ft. of new storm drain piping on Cherry St., Middle St., and Weeks St. Tie new storm drain piping into existing storm drain system on Washington Ave.
- Disconnect six combined catch basins from the sanitary sewer system, install new catch basins, and connect to new storm piping.
- Disconnect five houses with illicit connections. Install new storm drain laterals and connect to new storm piping. Provide storm drain wyes for all other houses that may have illicit connections to allow for future tie-in to new stormwater system.

Estimated Phase 2 project cost = \$701,000

It should be noted that Wright-Pierce analyzed installing new sewers in lieu of relining the existing sewers from SMH-925 to SMH-917 as outlined above. However, this alternative was deemed cost prohibitive and was not investigated further.

**FIGURE 3-1
RECOMMENDED PROJECT: SUB-AREA 1A**



3.2.2 Sub-Area 1B (Drains to Rose St. Pump Station)

Figure 3-2 summarizes the recommended project for Sub-Area 1B, which includes the following work as part of Phase 1:

Sanitary

- Reline approximately 400 ft. of sewer on High St. (between SMH-955 to SMH-975) and Rose St. (between SMH-1284 and SMH-931)
- Re-grout and waterproof SMH-975

Other

- Complete CCTV inspection of the remaining sewer mains and laterals identified in Appendix A (approximately 280 ft.)

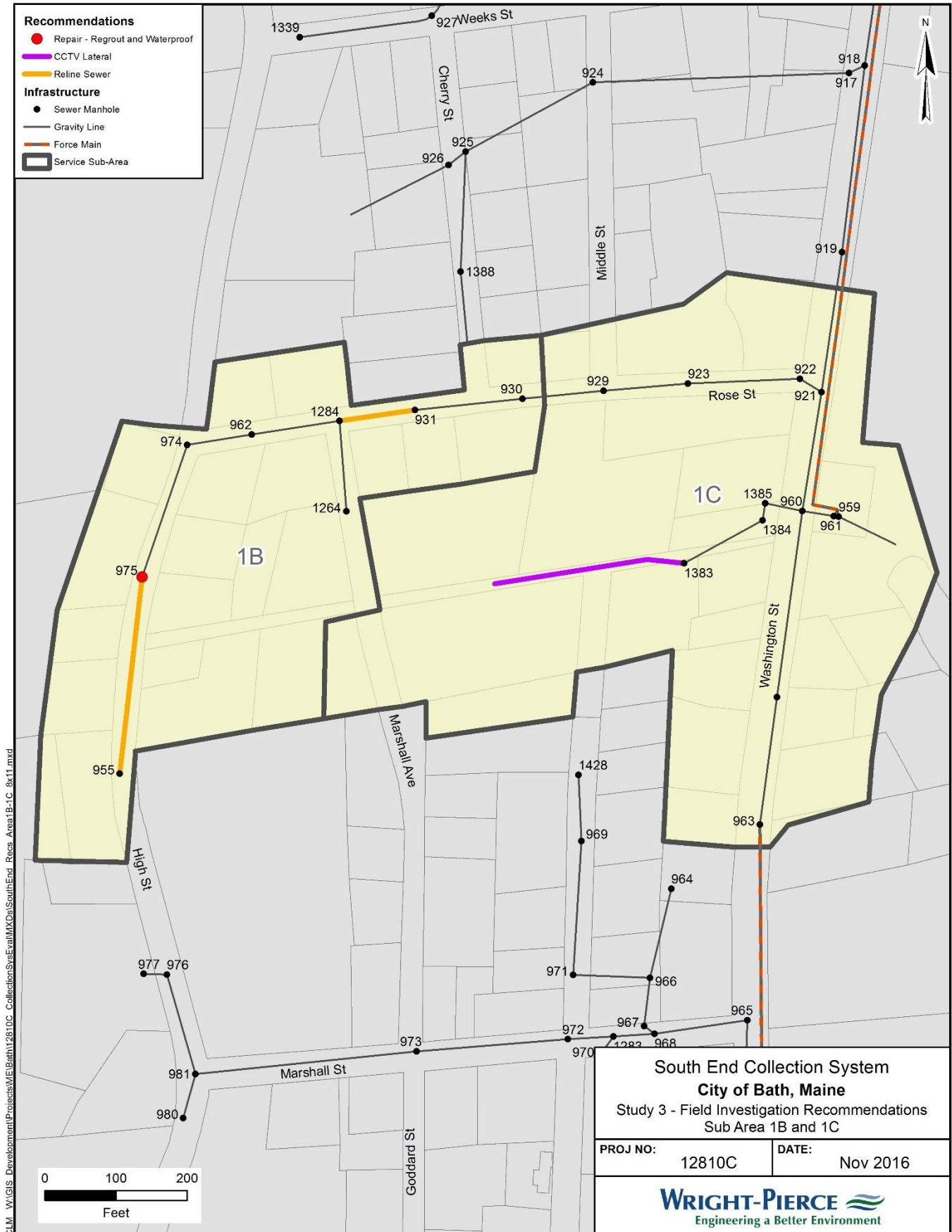
Estimated Phase 1 project cost = \$62,000

No Phase 2 work is envisioned for Sub-Area 1B at this time.

3.2.3 Sub-Area 1C (Drains to Rose St. Pump Station)

No I/I removal projects are recommended at this time, as part of Phase 1 or Phase 2. However, the City should clean and television-inspect the sewers in this area every 5 to 10 years and make any necessary improvements. Additionally, the City should CCTV the combined shared lateral that four homes share along the old paper road upstream of SMH-1383. Figure 3-2 summarizes remaining investigative work to be completed in Sub-Area 1C.

**FIGURE 3-2
RECOMMENDED PROJECTS: SUB-AREA 1B AND SUB AREA 1C**



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3.2.4 Sub-Area 2A (Drains to Hunt St. Pump Station)

Figure 3-3 summarizes the recommended project for Sub-Area 2A. The following work is included as part of Phase 1:

Sanitary

- Reline approximately 190 ft. of sewer on Middle St. between SMH-969 and SMH-971
- Re-grout and waterproof SMH-980 and SMH-981.

Other

- Complete CCTV inspection of the remaining sewer mains and laterals identified in Appendix A (approximately 850 ft.).
- Survey work in select areas of Sub-Area 2A to confirm structure locations and inverts
- Additional manhole location and inspections for two manholes on Middle St. that were not inspected during Study 3 that may be impacted by relining the sewer main (SMH-1428, SMH-971).
- Additional house inspections for three homes that were not inspected or whose potentially illicit connection could not be verified during Study 3 that may be impacted by the sanitary and storm system project recommendations above.

Estimated Phase 1 project cost = \$36,000

The following work is included as part of Phase 2:

Sanitary

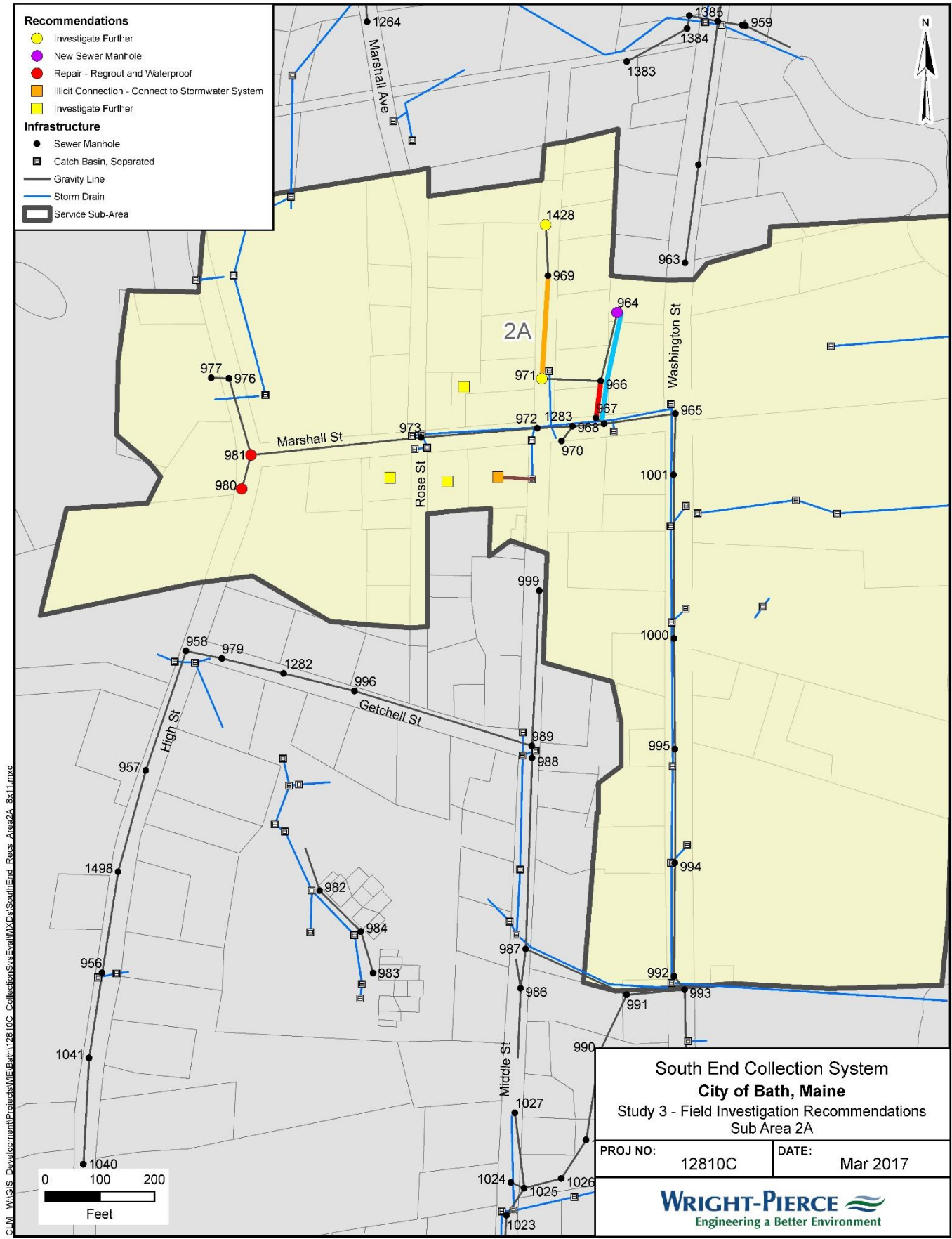
- Install new manhole to replace SMH-964 and replace approximately 75 ft. of cross-country sewer between SMH-966 and SMH-967. Connect new sewer to existing sewer on Marshall St.

Storm

- Reroute sump pump of 250 Middle St. to nearby stormwater catch basin. Perimeter drains around the foundation of the property collect significant groundwater that is discharged to the sewer system.
- Install approximately 200 ft. of new storm drain piping between Middle St. and Washington St. Tie new storm drain piping into existing storm drain system on Marshall St.

Estimated Phase 2 project cost = \$120,000

**FIGURE 3-3
RECOMMENDED PROJECT: SUB-AREA 2A**



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3.2.5 Sub-Area 2B (Drains to Hunt St. Pump Station)

Figure 3-4 summarizes the recommended project for Sub-Area 2B, which includes the following work as part of Phase 1:

Sanitary

- Reline approximately 1500 ft. of sewer on Getchell St. and Middle St. including:
 - SMH-1040 to SMH-956
 - SMH-957 to SMH-958
 - SMH-979 to SMH-989
 - SMH-988 to SMH-987
- Re-grout and waterproof SMH-979.

Other

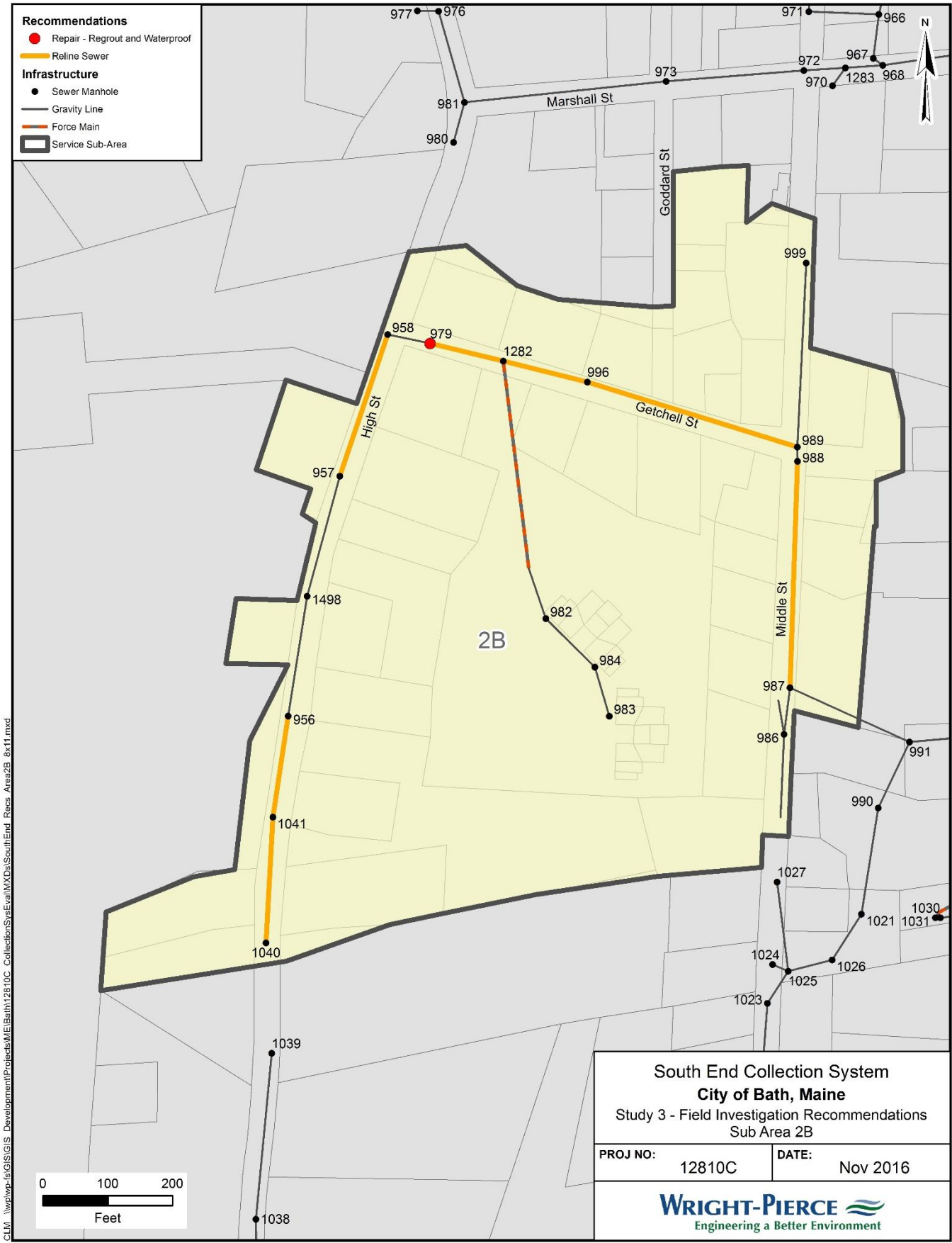
- Complete CCTV inspection of the remaining sewer mains and laterals identified in Appendix A (approximately 200 ft.)

Estimated Phase 1 project cost = \$240,000

The City should also investigate potential sources of I/I in the Schooner Ridge condominium complex's system.

No Phase 2 work is envisioned in Sub-Area 2B at this time.

**FIGURE 3-4
RECOMMENDED PROJECT: SUB-AREA 2B**



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3.2.6 Sub-Area 2C (Drains to Hunt St. Pump Station)

No major I/I removal projects are recommended at this time, as part of Phase 1 or Phase 2. However, the City should clean and television-inspect the sewers in this area every 5 to 10 years and make any necessary improvements. The City should also conduct dye testing to confirm a potential cross-connection between SMH-1016 and DMH 1267. If the cross-connection is found to be active, it should be resealed.

3.2.7 Sub-Area 2D (Drains to Hunt St. Pump Station)

Figure 3-5 summarizes the recommended project for Sub-Area 2D. The following work is included as part of Phase 1:

Sanitary

- Reline approximately 300 ft. of sewer on Middle St. from SMH-1014 to SMH-1023.

Other

- Survey work in select areas of Sub-Area 2D to confirm structure locations and inverts.
- Complete CCTV inspection of the remaining sewer mains and laterals identified in Appendix A (approximately 1,400 ft.)

Estimated Phase 1 project cost = \$53,000

The following work is included as part of Phase 2:

Sanitary

- Replace existing cross-country sewer with new sewer between SMH-1021 and SMH-991.
- Replace existing cross-country sewer manholes with new sewer manholes (SMH-1021, SMH-990, and SMH-991).
- Repair lateral and/or drain in front yard of 158 Middle St., which indicated potential I/I during smoke testing.

Estimated Phase 2 project cost = \$155,000

3.2.8 Summary

Table 3-1 summarizes the Phase 1 and Phase 2 project costs for each sub-area. Post-construction flow metering should be conducted after any I/I removal project to determine the effectiveness of the project and to collect data for future pump station and pipe sizing. Estimated cost of post-construction metering of the entire area is \$25,000 to \$30,000.

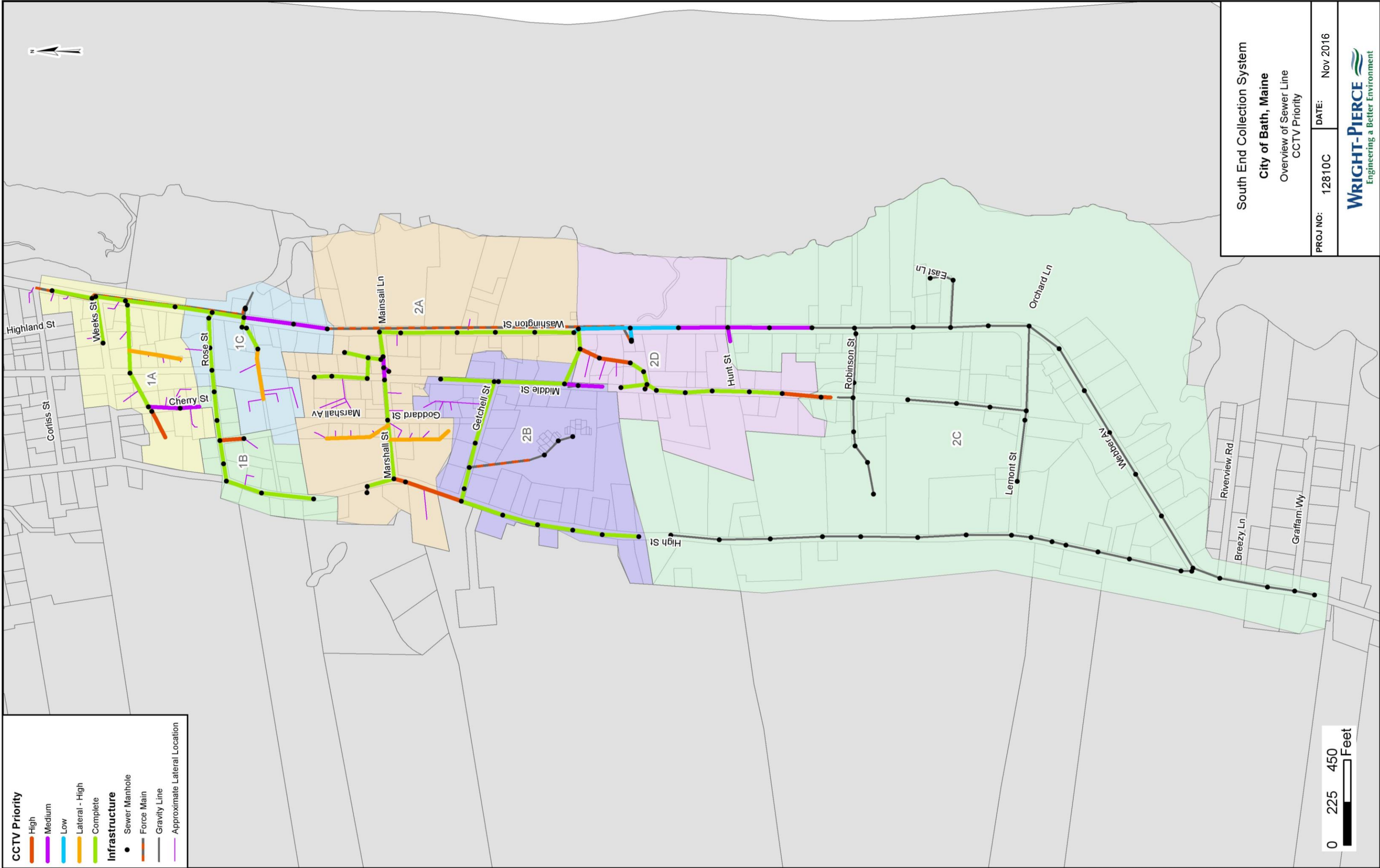
**TABLE 3-1
SUMMARY OF PROJECT COSTS**

Service Sub Area	Estimated Phase 1 Project Cost	Estimated Phase 2 Project Cost	Estimated Total Project Cost
1A	\$120,000	\$701,000	\$821,000
1B	\$62,000	-	\$62,000
1C	-	-	-
2A	\$36,000	\$120,000	\$156,000
2B	\$240,000	-	\$240,000
2C	-	-	-
2D	\$53,000	\$155,000	\$208,000
Total	\$511,000	\$976,000	\$1,487,000

The City should budget to have the entire collection system periodically cleaned to ensure full system capacity. This is not included in the cost estimates presented in this report, as this is typically a recurring maintenance cost to the City and is not specific to the Study Area only.

Appendix A

Overview of Sewer Line CCTV Priority



CCTV Priority

- High
- Medium
- Low
- Lateral - High
- Complete

Infrastructure

- Sewer Manhole
- Force Main
- Gravity Line
- Approximate Lateral Location

South End Collection System
 City of Bath, Maine
 Overview of Sewer Line
 CCTV Priority

PROJ NO: 12810C DATE: Nov 2016

WRIGHT-PIERCE
 Engineering a Better Environment

Appendix B

Ted Berry Television Inspection Reports



Ted Berry Company
521 Federal Rd
Livermore Maine 04253
207-897-3348

Project Summary

US MH	DS MH	Pipe ID	Date	Street	Material	Size	Total	Insp
368	366		3/9/2015	North St	Polyethylene	20	26	26

Pipe Size: 20

Total Ln.: 26

Inspected Ln.: 26

Project Total Ln.: 3361.1

Project Inspected Ln.: 3937.3