BALTIMORE COUNTY

DEPARTMENT OF PUBLIC WORKS

Sewershed Repair, Replacement and Rehabilitation (SRRR) Plan
for the Jones Falls Sewershed
Job Order No. 201-077-7031

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Executive Summary

Baltimore County entered into a Consent Decree (CD) on September 20, 2005 with the United States Environmental Protection Agency (EPA), the State of Maryland Department of the Environment (MDE), and the Department of Justice (DOJ). The objective of Paragraph 10 of the CD was to prepare a Sewershed Repair, Replacement, and Rehabilitation (SRRR) Plan that describes the deficiencies identified through Collection System Inspection and the Long Term Capacity/Peak Flow Management Evaluation (LTC/PFME), and recommends repair, replacement, rehabilitation, or other corrective actions necessary to address those deficiencies. This SRRR Plan is for the Jones Falls Sewershed.

The Jones Falls Sewershed is located in the north-central portion of Baltimore County along the City-County line from the northwest corner to York Road. Adjacent sewersheds include the Texas Sewershed to the north, the Longquarter and Herring Run Sewersheds to the east and the Gwynns Falls Sewershed to the west. Baltimore County's portion of the Jones Falls Sewershed drains to the south entering the City of Baltimore's Jones Falls Sewershed at seven (7) separate locations, before ultimately being treated at the Back River Wastewater Treatment Plan. The sewershed measures approximately 13,440 acres in size and is primarily composed of residential properties, with some areas of industrial, commercial, educational and institutional development. The sanitary collection system includes over 1,124,000 linear feet (LF) of circular gravity sewer piping, ranging in size from 6 to 48-inches in diameter; approximately 6,200 manholes and/or other sewer structures; and approximately 19,000 LF of force main and pressure sewer. The sewershed contains four (4) pumping stations. These are the Buchanan Road Pumping Station, the Stanton Woods Pumping Station, the Templegate Pumping Station, and the Stevenson Pumping Station.

Data analysis, evaluation, and decision-making criteria were utilized to identify collection system defects and deficiencies and prioritize the corrective actions. The recommended Corrective Action Plan consists of various structural and hydraulic corrective actions that are needed to address the deficiencies that were identified during the sewershed collection system inspection work. The plan also identifies specific rehabilitation and other corrective actions needed to eliminate model predicted sanitary sewer overflows (SSOs) that were determined by the simulations completed during the Long-Term Capacity/Peak Flow Management Evaluation (LTC/PFME). These condition related corrective action recommendations were defined based on review of field inspection and SSES data that was completed, which included sewer and manhole inspections, smoke and dyed-water testing and night-time flow isolation investigations. The hydraulic corrective actions were determined by model simulations and the inflow and infiltration (I/I) analysis. Some identified structural and condition related corrective actions to correct defects were superseded by the hydraulic corrective action recommendations, and these defects will be corrected when the hydraulic corrective actions are completed.

The County's approach to addressing model-predicted SSOs is to:

1. Complete I/I reduction improvements based on the 10-year/6-hour SCS Type II storm event.
2. Complete select capacity improvements based on the 10-year/6-hour SCS Type II storm event and model-confirmation flow monitoring data.
3. Correct structural deficiencies through collection system rehabilitation or replacement.
4. Complete post-construction flow monitoring and analysis to confirm the effectiveness of the RDII reductions.
5. Confirm model simulations and revise or recalibrate the hydraulic model accordingly, if needed.
6. Determine if additional improvements are needed based on the updated hydraulic model.

Baltimore County has implemented several remedial measures to eliminate SSOs as required by Paragraph 7 of the CD within the Jones Falls Sewershed. The sewershed contains three (3) non-pumping station SSOs. These include SSO 31A (Rider Avenue), SSO 113 (Marnat Road), and SSO 120 (Charles Street Avenue). SSO 31A was eliminated on May 11, 2007 and post elimination flow monitoring of the overflow was conducted in accordance with the CD. There has been no evidence of activity in this SSO since February of 2004. In November of 2009, the County began work on an extensive collection system rehabilitation contract located upstream of SSO 113 aimed at eliminating this SSO. The rehabilitation project was completed in June 2012 and post-rehabilitation flow monitoring of the SSO is currently being conducted. Monitoring of the overflow shows that SSO 113 remains active during wet-weather events. As determined by the LTC/PFME, the overflow is believed to activate as a result of capacity restrictions in the downstream sewers in the City of Baltimore's collection system. The County continues to coordinate with the City of Baltimore regarding capacity improvements that are needed to several of the City's receiving sewers. In June 2010, the County began a rehabilitation contract upstream of SSO 120 aimed at removing I/I from the collection system and eliminating the SSO. The work was completed in July of 2011 and SSO 120 was eliminated on September 20, 2011. The County continues to monitor flow in the sewer to verify that the wet-weather flow is not surcharging the collection system.

The capacity improvements that address items 1 and 2 above, and the structural condition improvements that will address item 3 in the Jones Falls Sewershed are graphically shown on **Map 6-1** and the specific corrective actions defined by meter basin are presented in **Tables 6-5.3** and **6-6.1**. The estimated cost to implement the collection system improvements is $28,300,000, which contains a 40% contingency cost for engineering, construction inspection and estimating.

The recommended schedule for completing the corrective actions within the Jones Falls

Sewershed's collection, pumping and transmission system will be within six (6) years of the EPA and MDE's approval of the Plan per Paragraph 10.B. of the CD.

In accordance with Paragraphs 9, 10, and 11 of the CD, the County will also implement several continuous programs to determine the effectiveness of the corrective actions when completed, and enhance the collection system's operation and maintenance efforts. These programs will include a long-term corrective action flow monitoring and evaluation plan, a sewer cleaning program, and root and grease control programs. The County will also evaluate data collected through post-rehabilitation closed-circuit television (CCTV) inspection of the collection system and review of record drawings, work orders and reported complaints to evaluate the effectiveness of the completed corrective actions, update the collection system model, and determine any subsequent work that is needed as appropriate.

END OF SECTION

Section 1

Introduction

1.0 Introduction (CD Ref. P10.A-C)

1.1 Background

On September 20, 2005, Baltimore County entered into a Consent Decree (CD) with the United States Environmental Protection Agency (EPA), the State of Maryland Department of the Environment (MDE), and the Department of Justice (DOJ). Paragraph 10 of the CD requires the County to prepare a Sewershed Repair, Replacement, and Rehabilitation (SRRR) Plan that describes the deficiencies identified through collection system inspections and the Long Term Capacity/Peak Flow Management Evaluation (LTC/PFME), and provides for the determination of any repair, replacement, rehabilitation, or other corrective actions necessary to correct identified deficiencies. This SRRR Plan is for the Jones Falls Sewershed.

Flow monitoring, Inflow and Infiltration (I/I) analysis, modeling, and inspection of manholes and sanitary sewers were performed in the Jones Falls Sewershed from 2008 through 2012. The County performed all Sewer System Evaluation Survey (SSES) tasks in accordance with Paragraph 8 of the CD. These included closed circuit television (CCTV) inspection of the sanitary sewers, manhole inspections, smoke testing, dyed-water testing and night-time flow isolation testing.

The SRRR Plan addresses each of the criteria defined in Paragraph 10.C of the CD. This criteria is as follows:

i. Evaluate the effectiveness of the projects completed or proposed to be completed pursuant to Paragraph 7.D for the relevant Sewershed. Baltimore County shall use rainfall and flow monitoring data collected in accordance with requirements of Paragraphs 7.D and 9 of the Consent Decree, and shall use the Model developed in accordance with Paragraph 14 of the Consent Decree, to demonstrate the effectiveness of the construction projects.

ii. Identify all deficiencies in the relevant Sewershed discovered during the Collection System Inspection conducted pursuant to Paragraph 8.

iii. Identify all corrective actions taken (including date completed), or to be taken, by Baltimore County (including but not limited to preventive maintenance, repair, replacement, or rehabilitation) to address deficiencies identified during inspection of the relevant Sewershed.

iv. Describe the priority scheme used to set priorities for correcting identified deficiencies within each Sewershed, including any decision not to correct an identified deficiency.

v. Describe the decision-making criteria used to select future corrective action.

vi. Propose a plan and schedule for implementing rehabilitation and other corrective action determined necessary to correct deficiencies in the relevant Sewershed identified during the inspections required by Paragraph 8, taking into consideration the Long-Term Capacity/Peak Flow Management analysis performed for the relevant Sewershed pursuant to Paragraph 9; the prioritization scheme to be applied to correction of these deficiencies; and an estimate of the cost necessary to complete any proposed rehabilitation and other corrective actions.

vii. Propose a plan and schedule for eliminating those physical connections (i.e. cross connections) between the Collection System and the storm water collection system that allow or have the potential to allow sanitary waste to be discharged to the storm water collection system.

viii. Present the results of the Long-Term Capacity/Peak Flow Management Evaluation conducted pursuant to Paragraph 9.C.ii, and determine for each Sewershed the range of storm events as specified in Paragraph 9.C.ii(b) for which the Collection System in its existing condition can convey peak flows without the occurrence of SSOs. As part of its analysis, Baltimore County shall identify all modeled Collection System Components and Pump Stations that cause or contribute to flow restrictions or that have the potential to cause or contribute to overflows.

ix. Consistent with the results of the Long-Term Capacity/Peak Flow Management Evaluation conducted pursuant to Paragraph 9.C.ii, project for each Sewershed the range of storm events as specified in Paragraph 9.C.ii(b) for which the Collection System will be able to convey peak flows without occurrence of SSOs. Such projection shall assume completion of the construction projects required by Paragraph 7 of this Consent Decree and completion of the proposed rehabilitative or other corrective action projects recommended by the SRRR Plan required by Paragraph 10. As part of its analysis, Baltimore County shall identify all modeled Collection System components and Pump Stations that cause or contribute to flow restrictions or that have the potential to cause or contribute to overflows.

x. Present the results of the rainfall and flow monitoring conducted in the Sewershed, including a map that depicts all monitored locations, dates of monitoring, a description of the quality assurance and quality control analyses performed for samples collected and data analyzed and the results of those analyses (i.e., summarize data quality assurance and data “lost” or “qualified”), and present the results of the I/I evaluation performed pursuant to Paragraph 9.C.i., including a description of the smoke testing and dye testing activities performed in the Sewershed, a summary of the results of such testing, a quantification of the rates of I/I for the Sewershed and the portions of the Sewershed’s Collection System impacted by I/I, and any identified sources of I/I to the Collection System located in the Sewershed.

xi. Incorporate into each SRRR Plan a description of additional data collection activities that will be implemented after completion of rehabilitative and other corrective action(s) proposed pursuant to Paragraphs 10.B and 10.C to evaluate their effectiveness consistent with Paragraph 10.E (Performance Assessment).

1.2 Sewershed Meter Basin Summary

As shown in **Map 1-1**, the Jones Falls Sewershed is located in the north-central portion of Baltimore County along the City-County line from the northwest corner to York Road. Adjacent sewersheds include the Texas Sewershed to the north, the Longquarter and Herring Run

Sewersheds to the east and the Gwynns Falls Sewershed to the west. The Jones Falls Sewershed measures approximately 13,440 acres and is primarily composed of residential properties, with some areas of industrial, commercial, educational and institutional development. The sanitary sewer collection system includes over 1,124,000 linear feet (LF) of circular gravity sewer conveyance piping ranging in size from 6- to 48-inches in diameter; approximately 6,200 manholes and other sewer structures; and approximately 19,000 LF of force main and pressure sewer. The Jones Falls Sewershed has four (4) existing pumping stations:

The **Buchanan Road Pumping Station**, located at the terminus of Buchanan Road, is designed to pump flows of 200 gallons per minute (GPM) under existing and ultimate capacity conditions.

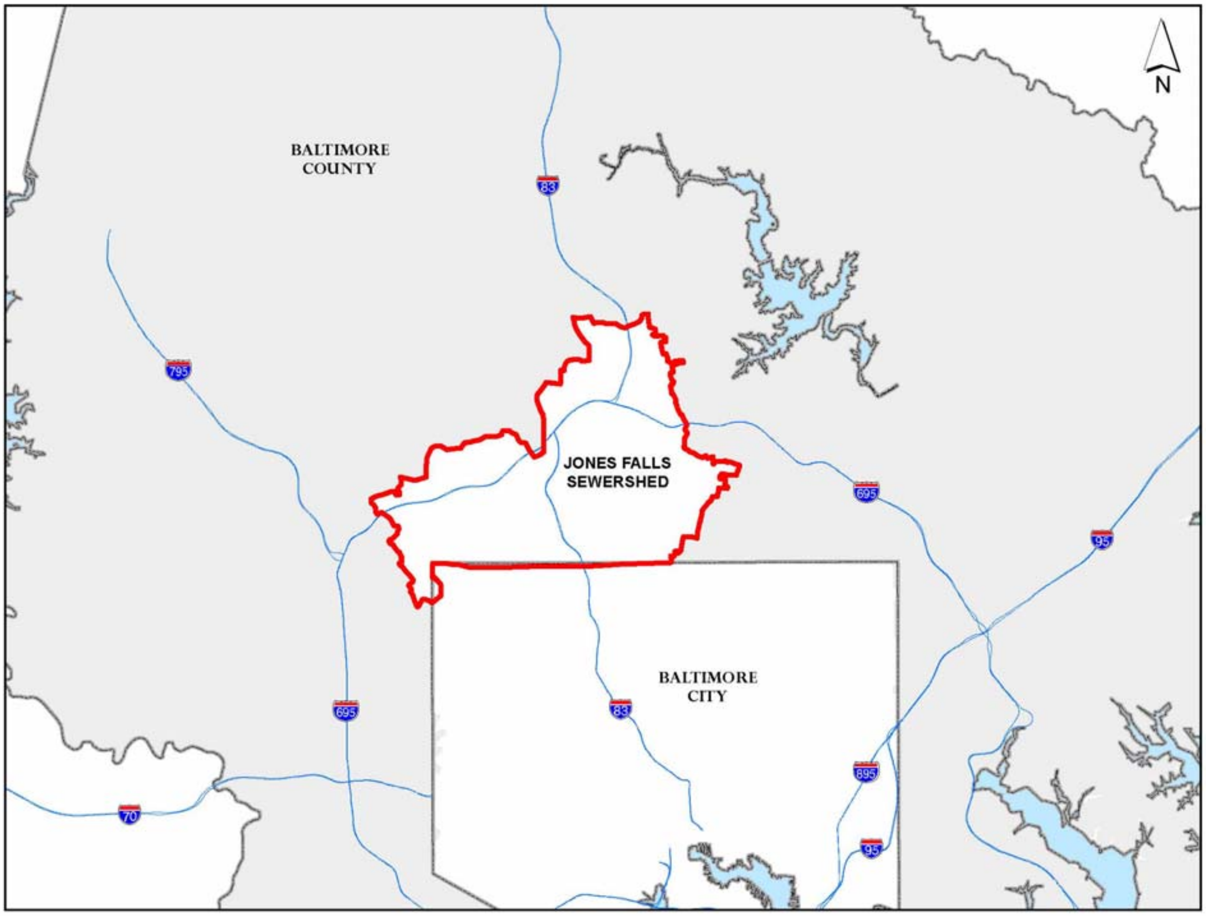
The **Stanton Woods Pumping Station**, located at the terminus of Topping Road, is designed to pump 252 GPM under existing and ultimate capacity conditions.

The **Templegate Pumping Station**, located at the terminus of E Court, which is between Breton Way and Woodvalley Drive has an ultimate capacity of 300 GPM, which is an increase from the existing capacity of 118 GPM.

The **Stevenson Pumping Station**, which was reconstructed in May 2011, is located off the intersection of Keyser Road and Windsong Court. This station is designed to pump 180 GPM, which is a slight increase from the previous capacity of 170 GPM.

The Buchanan Road, Stanton Woods and Templegate Pumping Stations are currently being evaluated in separate engineering evaluation and condition assessment (EE/CA) studies and future improvements will be recommended for those pumping stations.

The sanitary collection system in the Jones Falls Sewershed conveys wastewater to the City of Baltimore's Jones Falls Sewershed at seven (7) separate locations, before ultimately being treated at the Back River Wastewater Treatment Plant.

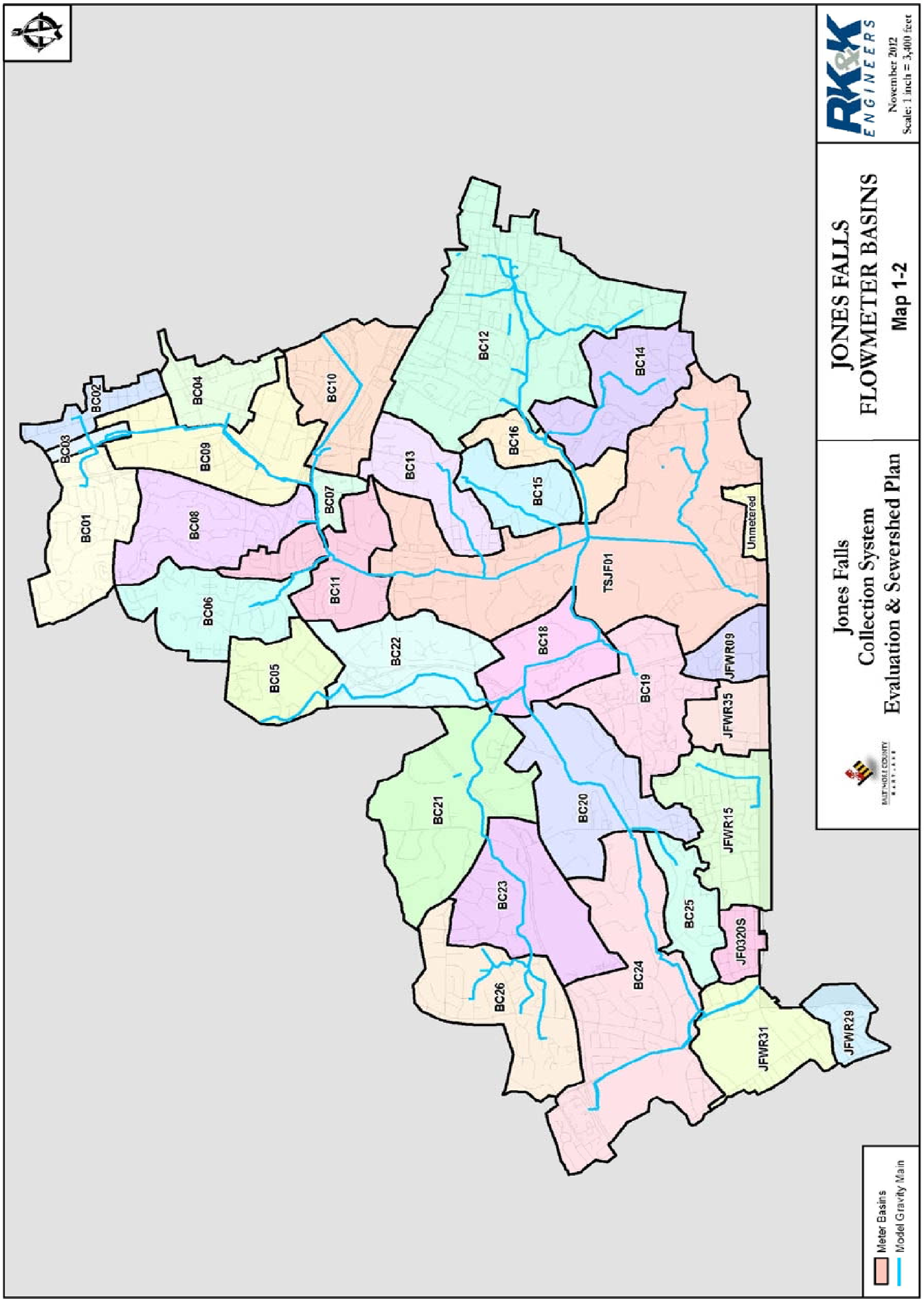


Map 1-1 Jones Falls Sewershed Location Map

During the flow monitoring, the Jones Falls Sewershed was divided into thirty-two (32) flow meter basins as shown in **Map 1-2**, and as described below. The flow meter basin boundaries are generally defined by their associated tributary area, logical division locations within the collection system and at locations where the County's sanitary sewer collection system enters the City of Baltimore's sanitary sewer system.

BC01

Meter Basin BC01 is located in the northern corner of the Jones Falls Sewershed, north of Timonium Road. This meter basin measures approximately 428 acres and is primarily composed of residential with some commercial development. The wastewater collection system in this meter basin consists of approximately 54,543 LF of sewers ranging in size between 8- and 16-inches in diameter and contains 363 manhole structures. Gravity flow from this meter basin is conveyed to Meter Basin BC03. The flow exiting BC01 was measured by a flow meter installed in MH 37990.



Map 1-2 – Jones Falls Sewershed Flow Meter Basins

BC02

Meter Basin BC02 is located in the northeast corner of the Jones Falls Sewershed, north of Timonium Road and east of the Baltimore Light Rail Line. This meter basin measures approximately 138 acres and is primarily composed of commercial development with some residential development. The wastewater collection system in this meter basin consists of approximately 16,434 LF of sewers ranging in size between 8- and 12-inches in diameter and contains 64 manhole structures. Gravity flow from this meter basin is conveyed to Meter Basin BC03. The flow exiting BC02 was measured by a flow meter installed in MH 7253.

BC03

Meter Basin BC03 is located in the northeastern area of the Jones Falls Sewershed. This meter basin measures approximately 43 acres and is primarily composed of industrial and commercial development. This meter basin is south of Timonium Road along the Baltimore Light Rail corridor. The wastewater collection system in this basin consists of approximately 4,440 LF of sewers ranging in size between 8- and 30-inches in diameter and contains 24 manhole structures. Gravity flow from this meter basin is conveyed to Meter Basin BC09. The flow exiting BC03 was measured by a flow meter installed in MH 33463.

BC04

Meter Basin BC04 is located in the northeastern area of the Jones Falls Sewershed, south of W. Ridgely Road between the Baltimore Light Rail and York Road. This meter basin measures approximately 228 acres and is primarily composed of residential and commercial properties. The wastewater collection system in this meter basin consists of approximately 21,558 LF of sewers ranging in size between 8- and 10-inches in diameter and contains 102 manhole structures. Gravity flow from this meter basin is conveyed to Meter Basin BC09. The flow exiting BC04 was measured by a flow meter installed in MH 6977.

BC05

Meter Basin BC05 is located in the northwest area of the Jones Falls Sewershed, in the Brooklandville area. This meter basin measures approximately 294 acres and is primarily composed of residential with some commercial development. The wastewater collection system in this meter basin consists of approximately 22,661 LF of 8-inch diameter sewers and 130 manhole structures. Gravity flow from this meter basin is conveyed to Meter Basin BC22. The flow exiting BC05 was measured by a flow meter installed in MH 43791.

BC06

Meter Basin BC06 is located in the northwest area of the Jones Falls Sewershed, from Timonium Road to south of Interstate I-695, east of Interstate I-83. This meter basin measures approximately 414 acres and is primarily composed of residential development. The wastewater collection system in this meter basin consists of approximately 40,680 LF of sewers ranging in size between 8- and 18-inches in diameter and contains 289 manhole structures.

Gravity flow from this meter basin is conveyed to Meter Basin BC11. The flow exiting BC06 was measured by a flow meter installed in MH 38526.

BC07

Meter Basin BC07 is located in the northeast area of the Jones Falls Sewershed, south of Interstate I-695 near the Interstate I-83/I-695 interchange. This meter basin measures approximately 74 acres and is primarily composed of residential development. The wastewater collection system in this meter basin consists of approximately 8,785 LF of sewers ranging in size between 8- and 24-inches in diameter and contains 53 manhole structures. Gravity flow from this meter basin is conveyed to Meter Basin BC11. The flow exiting BC07 was measured by a flow meter installed in MH 18586.

BC08

Meter Basin BC08 is located in the northern area of the Jones Falls Sewershed, west of Interstate I-83 from Timonium Road to south of Interstate I-695. This meter basin measures approximately 467 acres and is primarily composed of residential development. The wastewater collection system in this meter basin consists of approximately 42,155 LF of sewers ranging in size between 8- and 24-inches in diameter and contains 284 manhole structures. Gravity flow from this meter basin is conveyed to Meter Basin BC07. The flow exiting BC08 was measured by a flow meter installed in MH 19873.

BC09

Meter Basin BC09 is located in the northeast area of the Jones Falls Sewershed, in the Lutherville area. This meter basin measures approximately 539 acres and is primarily composed of residential and commercial properties. The wastewater collection system in this meter basin consists of approximately 56,559 LF of sewers ranging in size between 6- and 30-inches in diameter and contains 272 manhole structures. Gravity flow from this meter basin is conveyed to Meter Basin BC07. The flow exiting BC09 was measured by a flow meter installed in MH NS1079.

BC10

Meter Basin BC10 is located in the eastern area of the Jones Falls Sewershed, along Interstate I-695 from Charles Street to York Road. This meter basin measures approximately 430 acres and is primarily composed of residential with some commercial development. The wastewater collection system in this meter basin consists of approximately 48,902 LF of sewers ranging in size between 8- and 24-inches in diameter and contains 256 manhole structures. Gravity flow from this meter basin is conveyed to Meter Basin BC07. The flow exiting BC10 was measured by a flow meter installed in MH 42231.

BC11

Meter Basin BC11 is located in the northwestern area of the Jones Falls Sewershed, in the Riderwood area. This meter basin measures approximately 404 acres and is primarily composed of residential with some institutional development. The wastewater collection system in this meter basin consists of approximately 41,649 LF of sewers ranging in size between 8- and 27-inches in diameter and contains 235 manhole structures. Gravity flow from this meter basin is conveyed to Meter Basin TSJF01. The flow exiting BC11 was measured by a flow meter installed in MH 6944.

BC12

Meter Basin BC12 is located in the eastern area of the Jones Falls Sewershed, in the vicinity of Towson University. This meter basin measures approximately 1,296 acres and is primarily composed of residential, institutional and commercial development. The wastewater collection system in this meter basin consists of approximately 140,464 LF of sewers ranging in size between 6- and 21-inches in diameter and contains 689 manhole structures. Gravity flow from this meter basin is conveyed to Meter Basin BC16. The flow exiting BC12 was measured by a flow meter installed in MH 22222.

BC13

Meter Basin BC13 is located in the eastern area of the Jones Falls Sewershed, from Bellona Avenue to Charles Street, south of Joppa Road. This meter basin measures approximately 315 acres and is primarily composed of residential and commercial properties. The wastewater collection system in this meter basin consists of approximately 30,486 LF of sewers ranging in size between 8- and 12-inches in diameter and contains 192 manhole structures. Gravity flow from this meter basin is conveyed to Meter Basin TSJF01. The flow exiting BC13 was measured by a flow meter installed in MH 18456.

BC14

Meter Basin BC14 is located in the southeast area of the Jones Falls Sewershed, and includes the Sheppard-Pratt Health System and St. Joseph's Medical Center. This meter basin measures approximately 445 acres and is primarily composed of residential and institutional properties. The wastewater collection system in this meter basin consists of approximately 27,154 LF of sewers ranging in size between 6- and 12-inches in diameter and contains 153 manhole structures. Gravity flow from this meter basin is conveyed to Meter Basin BC16. The flow exiting BC14 was measured by a flow meter installed in MH 34177.

BC15

Meter Basin BC15 is located in the southeastern area of the Jones Falls Sewershed, from Bellona Avenue to Charles Street. This meter basin measures approximately 254 acres and is primarily composed of residential development. The wastewater collection system in this meter basin consists of approximately 13,638 LF of sewers ranging in size between 8- and 12-inches in diameter and contains 92 manhole structures. Gravity flow from this meter basin is conveyed to Meter Basin TSJF01. The flow exiting BC15 was measured by a flow meter installed in MH 22456.

BC16

Meter Basin BC16 is located in the southeastern area of the Jones Falls Sewershed, between Bellona Avenue and Charles Street, south of Rolandvue Road. This meter basin measures approximately 210 acres and is primarily composed of residential development. The wastewater collection system in this meter basin consists of approximately 20,705 LF of sewers ranging in size between 8- and 36-inches in diameter and contains 107 manhole structures. Gravity flow from this meter basin is conveyed to Meter Basin TSJF01. The flow exiting BC16 was measured by a flow meter installed in MH 61947.

BC18

Meter Basin BC18 is located in the southwestern area of the Jones Falls Sewershed, west of Lake Roland and includes Robert E. Lee Park. This meter basin measures approximately 343 acres and is primarily composed of residential development. The wastewater collection system in this meter basin consists of approximately 11,815 LF of sewers ranging in size between 8- and 30-inches in diameter and contains 29 manhole structures. Gravity flow from this meter basin is conveyed to Meter Basin TSJF01. The flow exiting BC18 was measured by a flow meter installed in MH 20755.

BC19

Meter Basin BC19 is located in the southwestern area of the Jones Falls Sewershed, along Interstate I-83 north of the City-County line. This meter basin measures approximately 445 acres and is primarily composed of residential with some commercial development. The wastewater collection system in this meter basin consists of approximately 41,580 LF of sewers ranging in size between 6- and 12-inches in diameter and contains 274 manhole structures. Gravity flow from this meter basin is conveyed to Meter Basin BC18. The flow exiting BC19 was measured by a flow meter installed in MH 33711.

BC20

Meter Basin BC20 is located in the southwestern area of the Jones Falls Sewershed, west of Interstate I-83 and north of Old Pimlico Road. This meter basin measures approximately 590 acres and is primarily composed of residential with some institutional development. The wastewater collection system in this meter basin consists of approximately 44,098 LF of sewers ranging in size between 8- and 18-inches in diameter and contains 250 manhole structures. Gravity flow from this meter basin is conveyed to Meter Basin BC18. The flow exiting BC20 was measured by a flow meter installed in MH 20770.

BC21

Meter Basin BC21 is located in the western area of the Jones Falls Sewershed, between Interstate I-83 and Greenspring Avenue, south of Interstate I-695. This meter basin measures approximately 721 acres and is primarily composed of residential with some institutional development. The wastewater collection system in this meter basin consists of approximately 16,989 LF of sewers ranging in size between 8- and 18-inches in diameter and contains 98 manhole structures. Gravity flow from this meter basin is conveyed to Meter Basin BC18. The flow exiting BC21 was measured by a flow meter installed in MH 36912.

BC22

Meter Basin BC22 is located in the western area of the Jones Falls Sewershed, between Interstate I-83 and Falls Road, near Interstate I-695. This meter basin measures approximately 464 acres and is primarily composed of residential and institutional development. The wastewater collection system in this meter basin consists of approximately 23,854 LF of sewers ranging in size between 8- and 24-inches in diameter and contains 122 manhole structures. Gravity flow from this meter basin is conveyed to Meter Basin BC18. The flow exiting BC22 was measured by a flow meter installed in MH 34385.

BC23

Meter Basin BC23 is located in the western area of the Jones Falls Sewershed, west of Greenspring Avenue and north of Interstate I-695. This meter basin measures approximately 542 acres and is primarily composed of residential development. The wastewater collection system in this meter basin consists of approximately 28,858 LF of sewers ranging in size between 8- and 15-inches in diameter and contains 159 manhole structures. Gravity flow from this meter basin is conveyed to Meter Basin BC21. The flow exiting BC23 was measured by a flow meter installed in MH 36930.

BC24

Meter Basin BC24 is located in the western area of the Jones Falls Sewershed, between Park Heights Avenue and Greenspring Avenue, north of Smith Avenue. This meter basin measures approximately 1,071 acres and is primarily composed of residential, commercial and institutional development. The wastewater collection system in this meter basin consists of approximately 87,268 LF of sewers ranging in size between 6- and 16-inches in diameter and contains 522 manhole structures. Gravity flow from this meter basin is conveyed to Meter Basin BC20. The flow exiting BC24 was measured by a flow meter installed in MH 33527.

BC25

Meter Basin BC25 is located in the southwestern area of the Jones Falls Sewershed, between Park Heights Avenue and Greenspring Avenue, north of Smith Avenue. This meter basin measures approximately 227 acres and is primarily composed of residential development. The wastewater collection system in this meter basin consists of approximately 17,895 LF of sewers ranging in size between 8- and 12-inches in diameter and contains 126 manhole structures. Gravity flow from this meter basin is conveyed to Meter Basin BC20. The flow exiting BC25 was measured by a flow meter installed in MH 32254.

BC26

Meter Basin BC26 is located in the western area of the Jones Falls Sewershed, north of Interstate I-695 and east of Park Heights Avenue. This meter basin measures approximately 575 acres and is primarily composed of residential development. The wastewater collection system in this meter basin consists of approximately 52,871 LF of sewers ranging in size between 8- and 15-inches in diameter and contains 321 manhole structures. Gravity flow from this meter basin is conveyed to Meter Basin BC23. The flow exiting BC26 was measured by a flow meter installed in MH 36951.

The Stanton Woods, Stevenson and Templegate Wastewater Pumping Stations are located in Meter Basin BC26. Wastewater from the Stanton Woods Pumping Station is conveyed through a 6-inch diameter force main to gravity MH 45855 located in Meter Basin BC26. Wastewater from the Stevenson Pumping Station is conveyed through a 6-inch diameter force main to gravity MH 41040 located in Meter Basin BC26, and the wastewater from the Templegate Pumping Station is conveyed through a 6-inch diameter force main to gravity MH 46749 located in Meter Basin BC26.

TSJF01

Meter Basin TSJF01 is located in the southern area of the Jones Falls Sewershed, north of the City-County line from Interstate I-83 to York Road. This meter basin measures approximately 1,817 acres and is primarily composed of residential with some institutional development. The wastewater collection system in this meter basin consists of approximately 80,001 LF of sewers ranging in size between 6- and 42-inches in diameter and contains 442 manhole structures. Gravity flow from this meter basin is conveyed to Baltimore City's gravity system. The flow exiting TSJF01 was measured by a flow meter installed in manhole S19II2017MH (County MH TCM27).

The Buchanan Road Wastewater Pumping Station is located in Meter Basin TSJF01. Wastewater from this pumping station is conveyed through a 6-inch diameter force main to gravity MH 48253 located in Meter Basin TSJF01.

JF0320S

Meter Basin JF0320S is located in the southern area of the Jones Falls Sewershed, north of the City-County line from Seven Mile Lane to Labyrinth Road. This meter basin measures approximately 83 acres and is primarily composed of residential development. The wastewater collection system in this meter basin consists of approximately 9,283 LF of sewers ranging in size between 8- and 10-inches in diameter and contains 68 manhole structures. Gravity flow from this meter basin is conveyed to Baltimore City's gravity sewer system. The flow exiting JF0320S was measured by a flow meter installed in Baltimore City manhole S04II2004MH.

JFWR09

Meter Basin JFWR09 is located in the southern area of the Jones Falls Sewershed, north of the City-County line west of Interstate I-83. This meter basin measures approximately 204 acres and is primarily composed of residential and commercial properties. The wastewater collection system in this meter basin consists of approximately 11,616 LF of 8-inch diameter sewers and contains 23 manhole structures. Gravity flow from this meter basin is conveyed to Baltimore City's gravity sewer system. The flow exiting JFWR09 was measured by a flow meter installed in Baltimore City manhole S17GG2004MH.

JFWR15

Meter Basin JFWR15 is located in the southern area of the Jones Falls Sewershed, north of the City-County line from Labyrinth Road to Greenspring Avenue. This meter basin measures approximately 234 acres and is primarily composed of residential with some commercial and institutional development. The wastewater collection system in this meter basin consists of approximately 33,853 LF of sewers ranging in size between 8- and 15-inches in diameter and contains 297 manhole structures. Gravity flow from this meter basin is conveyed to Baltimore City's gravity sewer system. The flow exiting JFWR15 was measured by a flow meter installed in Baltimore City manhole S05II2003MH.

JFWR29

Meter Basin JFWR29 is located in the southwestern area of the Jones Falls Sewershed, west of the City-County line and west of Reisterstown Road. This meter basin measures approximately 268 acres and is primarily composed of residential, institutional and commercial development. The wastewater collection system in this meter basin consists of approximately 24,983 LF of sewers ranging in size between 8- and 10-inches in diameter and contains 60 manhole structures. Gravity flow from this meter basin is conveyed to Baltimore City's gravity sewer system. The flow exiting JFWR29 was measured by a flow meter installed in Baltimore City manhole S04EE2004MH.

JFWR31

Meter Basin JFWR31 is located in the southwestern area of the Jones Falls Sewershed, near the northwest corner of the City-County line, and east of Old Pimlico Road. This meter basin measures approximately 398 acres and is primarily composed of residential with some institutional development. The wastewater collection system in this meter basin consists of approximately 53,415 LF of sewers ranging in size between 6- and 15-inches in diameter and contains 101 manhole structures. Gravity flow from this meter basin is conveyed to Baltimore City's gravity sewer system. The flow exiting JFWR31 was measured by a flow meter installed in Baltimore City manhole S06II2012MH.

JFWR35

Meter Basin JFWR35 is located in the southern area of the Jones Falls Sewershed, north of the City-County line, east of Old Pimlico Road. This meter basin measures approximately 216 acres and is primarily composed of residential development. The wastewater collection system in this meter basin consists of approximately 25,684 LF of sewers ranging in size between 6- and 10-inches in diameter and contains 134 manhole structures. Gravity flow from this meter basin is conveyed to Baltimore City's gravity sewer system. The flow exiting JFWR35 was measured by a flow meter installed in Baltimore City manhole S13GG2016MH.

END OF SECTION

Section 2

Effectiveness of Paragraph 7 Projects

2.0 Effectiveness of Remedial Corrective Actions Required by Paragraph 7 Projects (CD Ref. P10.C.i)

Paragraph 10.C of Baltimore County's Consent Decree (CD) requires that the effectiveness of the projects completed in accordance with Paragraph 7 be evaluated. The purpose of the corrective actions completed in accordance with Paragraph 7 was to eliminate Pumping Station and Non-Pumping Station Sanitary Sewer Overflows (SSOs) in the sewershed. An "SSO Structure", as defined in Section IV AA of the County's CD, is any structure constructed in Baltimore County for the purpose of allowing discharge from the separate sanitary sewer collection system at a point prior to the systems connection with the City of Baltimore's collection system or the head works of either the Patapsco or Back River Wastewater Treatment Plants. Three (3) Non-Pumping Station SSOs existed in the Jones Falls Sewershed. These SSOs include: SSO 31A (Rider Avenue), SSO 113 (Marnat Road) and SSO 120 (Charles Street Avenue). Information pertaining to these SSOs is detailed below:

2.1 SSO Locations

SSO 31A (Rider Avenue) was located at 8206 Rider Avenue in the Riderwood area of Baltimore County. This SSO contained an 18-inch diameter overflow pipe that was located in MH 6954 in SSA 45-59-16-01 (Meter Basin BC11) and discharged to Roland Run.

SSO 113 (Marnat Road) is located at the intersection of Marnat Road and Hattan Road in the Pikesville area of Baltimore County. This SSO contains a 12-inch diameter overflow pipe constructed in MH 793 in SSA 45-10-22-01 (Meter Basin JF0320S). The SSO discharges to a storm drain, which ultimately drains to the Western Run branch of the Jones Falls.

SSO 120 (Charles Street Avenue) was located at 442 Charles Street Avenue in the Towson area of Baltimore County. This SSO contained an 8-inch diameter overflow pipe constructed in MH 2402A in SSA 45-58-06-02 (Meter Basin BC12). This manhole is located 600-feet downstream of MH 2402 and the overflow discharged into Towson Run.

Figure 2-1 below shows the manholes containing SSOs 31A, 113 and 120.

Figure 2-1

SSO 31A (MH 6956) SSO 113 (MH 793) SSO 120 (MH 2402A)

2.2 Elimination Plan and Implementation

Baltimore County has implemented remedial measures to eliminate these SSOs. The following is an overview of the remedial measures including the elimination plans that have been implemented for SSO 31A, SSO 113 and SSO 120.

SSO 31A

Flow monitoring of SSO 31A began on February 12, 2004. No overflows were recorded since the overflow monitoring device was installed. The County's elimination plan for the Rider Avenue non-pumping station SSO 31A, consisted of sealing the 18-inch diameter overflow pipe. SSO 31A was sealed on May 11, 2007. Post elimination flow monitoring of the overflow was conducted in accordance with Section V.7.C.v of the CD and there has been no evidence of SSO activity since February of 2004. No additional field work was performed at this location.

SSO 113

Flow monitoring associated with SSO 113 began on February 12, 2004. Since the flow monitoring program began, thirteen (13) recorded overflow events have occurred. The County's elimination plan for the Marnat Road non-pumping station SSO 113, consists of implementing a rehabilitation program in the SSO 113 meter basin for the sanitary sewers and manhole structures that were identified as exhibiting defects that could contribute to wet-weather sources of peak flow. In support of the SSO elimination efforts, the County inspected 14,713 linear feet (LF) of 8-inch and 300 LF of 10-inch diameter sanitary sewer in the vicinity of SSO 113. In November 2008, RK&K completed a comprehensive review of this information and prepared rehabilitation documents to address the system deficiencies identified in an attempt to eliminate wet-weather sources contributing to peak flows to SSO 113. As part of Contract 09124 SXO, forty-four (44) sanitary manholes were rehabilitated; approximately 7,149 LF of sanitary collector sewer was lined and seventy-two (72) sewer house connection seals were installed to address sewer connection defects. Rehabilitation of the SSA was completed in June 2012. Post rehabilitation flow monitoring of SSO 113 is being conducted in accordance with Section V.7.C.v of the CD and shows that SSO 113 still remains active during wet-weather events. The current SSO elimination date is September 20, 2016. The County continues to coordinate with the City of Baltimore regarding the capacity improvements of the sewers located downstream of the SSO in the City, and is evaluating options for design and construction of a County relief sewer.

SSO 120

Flow monitoring for SSO 120 also began on February 12, 2004. During the flow monitoring program, six (6) overflows occurred. The County's elimination plan for the Charles Street Avenue non-pumping station SSO 120 consisted of placing a 6-inch diameter siphon, located immediately downstream of the SSO, on a "special" cleaning and maintenance list. This requires that the siphon be cleaned a minimum of once every six (6) months. This siphon was identified during inspections as having maintenance issues and creating surcharge conditions in the sewer and activating SSO 120. In addition, in December 2009, Baltimore County replaced a collapsed segment of collector sewer that was located downstream of SSO 120 (MH 901893 to MH 16595). This was also believed to be creating a restriction in the conveyance system. Completion of this work assisted in reducing flow levels; however, it did not eliminate activation of the SSO. In June 2010, Baltimore County bid Contract 10034 SX0 – Charles Street Avenue, SSO No. 120 – Sanitary Sewer Rehabilitation to address wet-weather sources of peak flow contribution that resulted in the continued activation of SSO 120. As part of Contract 10034 SXO, forty-eight (48) manholes were rehabilitated, seven (7) point repairs were completed, approximately 13,826 LF of sanitary collector sewer was rehabilitated using CIPP lining and 323 sewer house connections were air tested and chemically sealed to address house connection defects. The work was substantially complete in July of 2011. SSO 120 was sealed on September 20, 2011 and the County continues to monitor flow in the sewer in accordance with Section V.7.C.v of the CD to evaluate the collection system response to wet-weather flow and to evaluate the impacts of elimination of SSO 120 on the collection system.

2.3 Post–Construction Flow Monitoring

Per Section V.7.C.v of the CD, the County is required to monitor and evaluate impacts of the elimination of an SSO structure for 18 months following elimination. The County eliminated SSO 31A in May of 2007 following no recorded overflow activity since metering activities began at the overflow manhole in February 12, 2004. The County continues to monitor SSO 113, which remains active with several wet-weather discharges occurring in 2012. The County also continues to monitor SSO 120 to evaluate the impacts of elimination of SSO 120 on the collection system.

2.4 Evaluation of Construction Projects

At the time of this report, sanitary sewer and manhole rehabilitation in SSA 45-10-22-01 (SSO 113 – Marnat Road) and SSA 45-58-06-02 (SSO 120 - Charles Street Avenue) have been completed and the rehabilitation work and the SSO pipes removed and incorporated into the Long-Term Capacity/Peak Flow Management Evaluation (LTC/PFME) modeling simulations. The modeling simulations incorporated the reduction of RDII volume, RDII peak flow and base infiltration (BI). Also, the friction coefficient of the rehabilitated sewers has been revised to match that of a smoother pipe surface (reduced Manning's "n" value) that is a result of the CIPP lining installed in these sewers.

This methodology was only applied to the modeling simulations to verify the effectiveness of the rehabilitation work under future flow conditions. In the baseline flow conditions (the conditions during flow monitoring), the non-pumping station SSOs were modeled as open without rehabilitation in the SSA where the SSOs are located. The following is a summary of the evaluation of the SSOs in the Jones Falls Sewershed:

SSO 31A

Baltimore County eliminated SSO 31A in May of 2007 following no evidence of SSO activity in more than three (3) years. Further evaluation of the SSO was not required.

SSO 113

SSO 113 continues to activate following a comprehensive rehabilitation effort completed in early 2012 to remove wet-weather sources of Inflow and Infiltration (I/I) from the collection system. Based on post-rehabilitation flow metering results, I/I was reduced in the collection system in this SSA as a result of the rehabilitation; however, downstream restrictions in the City sewers continue to impact the collection system associated with SSO 113. RK&K provided analysis of the overflows at SSO 113. The analysis included comparison of the monitored flow data for the September 7, 2011 storm (peak intensity of 2.88 in/hr) to the model predicted post-rehabilitation results for the SSO 113 area. Using the model, it was determined that if the SSO 113 overflow pipe was eliminated, the collection system would be able to store and convey the additional flow generated by the September 7, 2011 storm; however, the Hydraulic Grade Line (HGL) would be elevated above the SSO and could potentially cause sewer backups in the basements of nearby homes located along the sewer's alignment. An alternative to prevent elevation of the HGL would be to add capacity to the collection system by constructing relief sewers or increasing the size of the existing sewers that are located in the City's collection system downstream of SSO 113. The following manhole to manhole sewer segments would require additional capacity:

- MH 793 – MH TCM85 (Baltimore City Sewer)
- MH TCM85 – MH SO4II2004MH (Baltimore City Sewer)
- MH S04II2004MH – MH S04II2008MH (Baltimore City Sewer)

These existing sewers have a diameter of 8-inches and replacement of the sewers with approximately 596 LF of new 12-inch diameter sewer is expected to add sufficient capacity to reduce the HGL compared to the existing system, allowing the SSO to be eliminated.

The County is also contemplating a diversion of flow away from the SSO. The County believes that because of the basement elevations of the properties located nearest to the SSO, a diversion of the upstream flow away from the SSO manhole may create a more effective solution with less system maintenance requirements. A time of performance extension was granted by the regulators for elimination of SSO 113. The revised elimination date for removal of the SSO is September 20, 2016.

SSO 120

Baltimore County closed SSO 120 on September 20, 2011, following implementation of a specialized sewer cleaning program and rehabilitation activities completed within the SSA. The County continues to monitor this SSO in accordance with Section V.7.C.v of the CD to verify that the flow is not surcharging during wet-weather events. The hydraulic model simulations of the 10-year/6-hour synthetic design storm indicate that the HGL does not exceed the top of the sewer and the manholes do not surcharge.

Model simulations predict that the expected discharge, resulting from the implementation of the corrective actions completed for SSO 113 and SSO 120, will be reduced and the corrective actions have been effective in reducing overflows by reducing wet-weather sources of I/I from the collection system.

END OF SECTION

Section 3

Infiltration and Inflow Analysis

3.0 Infiltration and Inflow Analysis (P.9.C.i)

Paragraph 9 of the CD requires that the County perform rainfall and flow monitoring with the purpose of: (i) quantifying inflow and infiltration, (ii) evaluating the impact of inflow and infiltration on the collection system, and (iii) completing a Long-Term Capacity/Peak Flow Management Evaluation, including development of a hydraulic model.

Meter basins that were noted as exhibiting excessive I/I, were included in County Sanitary Sewer Evaluation Survey (SSES) investigations.

3.1 Overall Description

To characterize flows within the sewage collection system and correlate rainfall to inflow and infiltration (I/I), the County completed a flow monitoring program within the Jones Falls Sewershed. The monitoring program consisted of the installation of twenty-six (26) flow meters within the sewershed that were installed from February 1, 2008 through November 30, 2008. These flow meters are referred to as the County Meters. In addition to the flow meters installed by the County, data from six (6) flow meters installed as part of the City of Baltimore's Jones Falls flow monitoring program were also utilized. These flow meters were located along or near the City-County line and are referred to as the Boundary Meters. The metering period for these six (6) flow meters was from May 9, 2006 through May 18, 2007. RK&K utilized rainfall data from six (6) rain gauges located in the vicinity of the Jones Falls Sewershed. **Table 3-1.1** provides a list of all Jones Falls Sewer Service Areas (SSA's), their assigned meter basins, and the associated flow monitoring sites.

Table 3-1.1
Jones Falls SRRR: Corrective Action Recommendation Plan
JONES FALLS METER BASINS, FLOW METER SITES AND SSA's

Meter Basin	Meter Site	SSA
BC01	37990	45-59-35-01, 45-59-35-02, 45-59-35-03, 45-59-35-04, 45-59-35-05, 45-59-35-06, 45-59-35-07, 45-59-35-08, 45-59-35-09
BC02	7253	45-59-34-00*
BC03	33463	45-59-33-00*, 45-59-34-00*
BC04	6977	45-59-30-01, 45-59-30-02, 45-59-30-03
BC05	43791	45-73-03-01, 45-73-03-02, 45-73-04-00
BC06	38526	45-59-15-01, 45-59-15-02, 45-59-15-03, 45-59-15-04, 45-59-15-05
BC07	18586	45-59-16-01, 45-59-16-02, 45-59-17-01*, 45-59-18-00, 45-59-19-00, 45-59-20-01*
BC08	19873	45-59-17-01*, 45-59-17-02, 45-59-17-03, 45-59-17-04, 45-59-17-05, 45-59-17-06, 45-59-17-07, 45-59-17-08
BC09	NS1079	45-59-21-00, 45-59-22-00, 45-59-23-00, 45-59-24-00, 45-59-25-00, 45-59-26-00, 45-59-27-00, 45-59-28-00,

Table 3-1.1 Jones Falls SRRR: Corrective Action Recommendation Plan **JONES FALLS METER BASINS, FLOW METER SITES AND SSA's**		
Meter Basin	Meter Site	SSA
		45-59-29-00, 45-59-31-00, 45-59-32-00, 45-59-33-00*
BC10	42231	45-59-20-01*, 45-59-20-02, 45-59-20-03, 45-59-20-04, 45-59-20-05, 45-59-20-06
BC11	6944	45-59-10-00, 45-59-11-00, 45-59-12-00, 45-59-13-00, 45-59-14-00
BC12	22222	45-58-06-01, 45-58-06-02, 45-58-06-03, 45-58-06-04, 45-58-06-05, 45-58-06-06, 45-58-06-07, 45-58-06-08, 45-58-07-00, 45-58-08-00, 45-58-09-01, 45-58-09-02, 45-58-09-03, 45-58-10-00, 45-58-11-00, 45-58-20-01, 45-58-20-02, 45-58-20-03, 45-58-20-04, 45-58-20-05, 45-58-20-06, 45-58-21-01, 45-58-21-02, 45-58-21-03, 45-58-21-04, 45-58-21-05, 45-58-21-06, 45-58-21-07, 45-58-22-00, 45-58-23-01, 45-58-23-02, 45-58-23-03, 45-58-23-04, 45-58-24-00, 45-58-25-00, 45-58-26-01, 45-58-26-02, 45-58-27-00, 45-58-28-00
BC13	18456	45-59-05-02, 45-59-05-03, 45-59-05-04
BC14	34177	45-55-07-00, 45-58-02-00
BC15	22456	45-59-01-00
BC16	61947	45-58-01-00, 45-58-03-00, 45-58-04-00, 45-58-05-00
BC18	20755	45-61-00-00, 45-62-01-00, 45-63-00-00, 45-64-00-00, 45-65-00-00, 45-67-00-00
BC19	33711	45-62-02-00, 45-62-03-01, 45-62-03-02, 45-62-03-03, 45-62-03-04, 45-62-03-05, 45-62-03-06, 45-62-03-07, 45-62-03-08
BC20	20770	45-66-01-00, 45-66-02-00, 45-66-03-00, 45-66-04-00, 45-66-05-00, 45-66-06-00, 45-66-07-00, 45-66-08-00, 45-66-09-01*
BC21	36912	45-68-01-00, 45-68-02-00, 45-68-03-00, 45-68-04-01, 45-68-04-02, 45-68-05-00, 45-68-06-01, 45-68-06-03, 45-68-06-04
BC22	34385	45-69-00-00, 45-70-00-00, 45-71-00-00, 45-72-00-00, 45-73-01-00, 45-73-02-00
BC23	36930	45-68-07-00, 45-68-08-00, 45-68-09-00, 45-68-10-00, 45-68-11-00, 45-68-12-01, 45-68-13-00, 45-68-14-00
BC24	33527	45-66-10-00, 45-66-11-00, 45-66-12-00, 45-66-13-00, 45-66-14-00, 45-66-16-00, 45-66-17-00, 45-66-18-01, 45-66-18-02, 45-66-18-03, 45-66-18-04
BC25	32254	45-66-09-01*, 45-66-09-02, 45-66-09-03, 45-66-15-00
BC26	36951	45-68-06-02, 45-68-15-01, 45-68-15-02, 45-68-15-03, 45-68-16-01, 45-68-16-02, 45-68-17-01, 45-68-18-00

Table 3-1.1 Jones Falls SRRR: Corrective Action Recommendation Plan **JONES FALLS METER BASINS, FLOW METER SITES AND SSA's**		
Meter Basin	Meter Site	SSA
TSJF01	S19II2017	45-51-00-00, 45-52-00-00, 45-53-00-00, 45-54-00-00, 45-55-01-00, 45-55-02-00, 45-55-03-00, 45-55-04-00, 45-55-04-01, 45-55-04-02, 45-55-06-00, 45-56-00-00, 45-57-00-00, 45-59-02-00, 45-59-03-00, 45-59-04-00, 45-59-05-01, 45-59-06-00, 45-59-07-00, 45-59-08-00, 45-59-09-00, 45-60-00-00
JF0320S	S04II2004	45-10-22-01
JFWR09	S17GG2004	45-10-01-01
JFWR15	S05II2003	45-10-02-06
JFWR29	S04EE2004	45-10-21-00
JFWR31	S06II2012	45-10-22-02, 45-10-22-03
JFWR35	S13GG2016	45-10-02-01

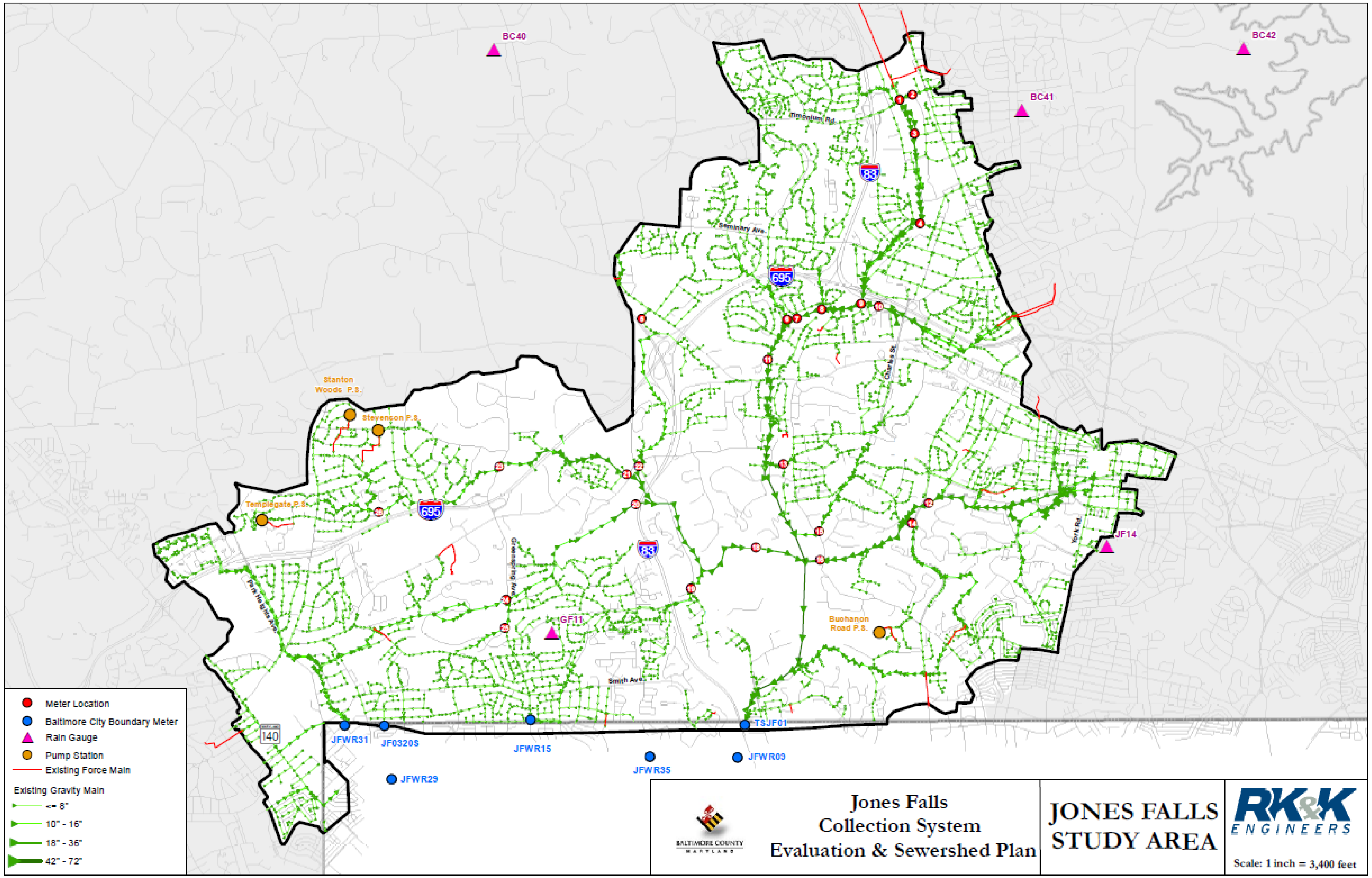
*A few SSAs discharge to multiple Flow Meters. SSAs were split during modeling efforts according to the Flow Meter location to better represent field conditions.

3.2 Rain Gauge Monitoring Program (CD Ref. P9.B.i, P10.C.x)

Rainfall within the County was measured using a network of forty-five (45) separate rain gauge stations with a minimum coverage of one (1) rain gauge station per ten (10) square miles as well as data compiled by Doppler radar for the project area, as required by the CD, utilizing a minimum resolution of one (1) pixel per four (4) square kilometers. Calamar software was used to create calibrated radar rainfall images for storm events that exceeded 0.5-inches. Rain gauges BC40RG, BC41RG, BC42RG, BC49RG, GF11RG and JF14RG were used for the I/I analysis of the data gathered within the flow meter basins in the Jones Falls collection system. **Map 3-1** depicts the locations of the rain gauges.

The rain gauges were installed as part of the County's overall rainfall monitoring program. Each rain gauge records 0.01-inch increments of precipitation at 5-minute intervals. For the purposes of analysis, a qualifying rainfall event was defined as a minimum of 0.50-inches of rain occurring without a break of more than 300 minutes.

There were a total of twenty (20) storm events exceeding 0.5-inches that occurred during the flow monitoring period for the County Meters. The dates of these storm events and the average rainfall measured at the rain gauge stations are listed in **Table 3-2.1**. The storm of September 27, 2008 was the most significant storm event that occurred during the flow monitoring period, measuring over 6-inches of rain at one (1) of the rain gauge stations and averaging 4.62 inches. There were also three (3) other storm events within the monitoring period that measured an average of at least 2-inches of rainfall.



Map 3-1: Jones Falls Sewershed Rain Gauge Locations

Table 3-2.1 Jones Falls SRRR: Corrective Action Recommendation Plan **LIST OF STORMS AND RAINFALL AMOUNTS FOR THE COUNTY METERS**			
Date	Average Depth (in)	Peak Intensity (in/hr)	Duration (hr)
February 1, 2008	2.00	1.99	12
February 12, 2008	0.99	0.57	11
March 4, 2008	0.62	0.07	13
March 7, 2008	0.83	0.07	28
March 19, 2008	0.66	0.09	13
April 3, 2008	0.65	0.23	22
April 20, 2008	1.87	0.45	24
April 28, 2008	1.29	0.18	17
May 8, 2008	1.52	0.12	34
May 11, 2008	2.24	2.24	30
May 16, 2008	0.75	0.07	12
June 3, 2008	0.95	0.34	27
July 30, 2008	0.59	0.49	64
August 13, 2008	1.00	0.78	12
August 29, 2008	0.94	0.26	37
September 5, 2008	2.21	1.59	19
September 12, 2008	1.30	0.24	11
September 27, 2008	4.62	3.94	34
October 25, 2008	1.21	0.28	18
November 13, 2008	1.25	0.07	14

There were twenty-seven (27) storm events exceeding 0.5-inches that occurred during the metering period of the Boundary Meters. The dates of these storm events and the average rainfall measured at the rain gauge stations are listed in **Table 3-2.2**. The storm of June 25, 2006 resulted in the highest rainfall, with a rainfall amount of 5.24-inches. There were also four (4) additional storm events that generated rainfall amounts between 2- and 3-inches.

Table 3-2.2 Jones Falls SRRR: Corrective Action Recommendation Plan **LIST OF STORM AND RAINFALL AMOUNTS FOR BOUNDARY METERS**			
Date	Average Depth (in)	Peak Intensity (in/hr)	Duration (hr)
May 11, 2006	1.68	2.52	12
May 14, 2006	0.79	1.04	18
June 19, 2006	0.55	1.99	14
June 24, 2006	0.85	1.52	18
June 25, 2006	5.24	3.91	120
July 5, 2006	2.31	2.07	14
July 22, 2006	1.28	2.33	5
September 1, 2006	1.94	0.41	48
September 5, 2006	1.63	1.29	16
September 14, 2006	1.64	0.77	44
September 28, 2006	1.02	1.12	6
October 5, 2006	1.73	0.40	48
October 17, 2006	1.14	0.36	16
October 19, 2006	0.56	0.39	14
October 27, 2006	1.63	0.48	18
November 7, 2006	1.47	0.49	18
November 16, 2006	2.24	2.63	6
November 22, 2006	0.55	0.27	18
December 22, 2006	0.94	0.31	18
December 25, 2006	0.57	0.21	12
December 31, 2006	0.84	0.55	18
January 7, 2007	0.83	0.24	18
March 1, 2007	0.92	0.32	18
March 15, 2007	2.00	0.24	60
March 23, 2007	0.53	0.16	22
April 11, 2007	0.62	0.45	16
April 14, 2007	2.66	0.63	40

3.3 Flow Monitoring Program (CD Ref. P9.B.ii, P10.C.X)

The flow monitoring program consisted of installing twenty-six (26) flow meters within the County's collection system. The flow meters measured both depth and velocity, from which, flow was calculated at consistent 15-minute intervals.

Data Quality Control/Quality Assurance is discussed in the Inflow and Infiltration Evaluation Report, found in **Appendix B** of this report.

Figure 3-1 depicts a schematic of the Jones Falls Sewershed flow monitoring plan and **Table 3-3.1** provides a list of the flow monitors, including the location and installation period. See **Appendix A** for site reports of the flow meter locations.

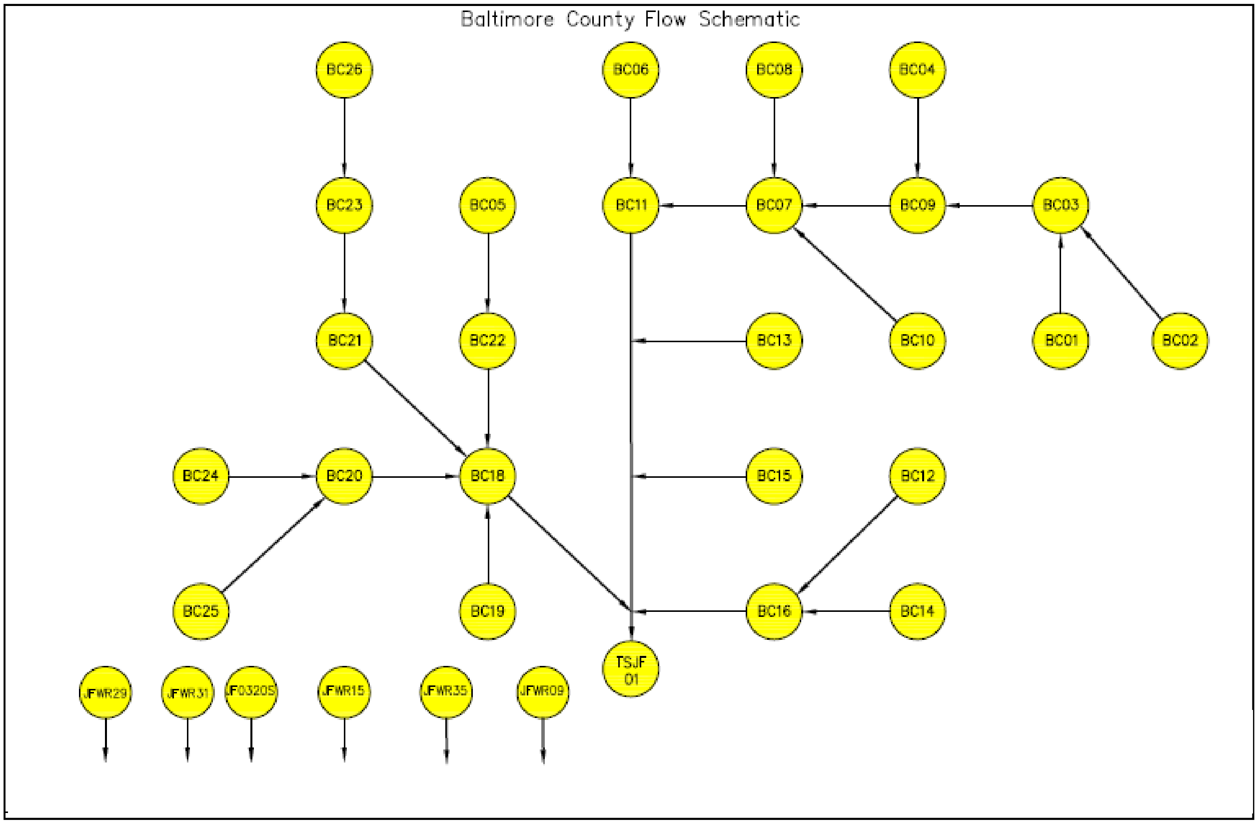


Figure 3-1 Jones Falls Sewershed Monitoring Plan Schematic

Table 3-3.1 Jones Falls SRRR: Corrective Action Recommendation Plan **JONES FALLS SEWERSHED METER LOCATIONS AND INSTALLATION HISTORY**		
Meter Site	MH Location	Installation Period
BC01	37990	02/01/2008 – 11/30/2008
BC02	7253	02/01/2008 – 11/30/2008
BC03	33463	02/01/2008 – 11/30/2008
BC04	6977	02/01/2008 – 11/30/2008
BC05	43791	02/01/2008 – 11/30/2008
BC06	38526	02/01/2008 – 11/30/2008
BC07	18586	02/01/2008 – 11/30/2008
BC08	19873	02/01/2008 – 11/30/2008
BC09	NS1079	02/01/2008 – 11/30/2008
BC10	42231	02/01/2008 – 11/30/2008
BC11	6944	02/01/2008 – 11/30/2008
BC12	22222	02/01/2008 – 11/30/2008
BC13	18456	02/01/2008 – 11/30/2008
BC14	34177	02/01/2008 – 11/30/2008
BC15	22456	02/01/2008 – 11/30/2008
BC16	61947	02/01/2008 – 11/30/2008
BC18	20755	02/01/2008 – 11/30/2008
BC19	33711	02/01/2008 – 11/30/2008
BC20	20770	02/01/2008 – 11/30/2008
BC21	36912	02/01/2008 – 11/30/2008
BC22	34385	02/01/2008 – 11/30/2008
BC23	36930	02/01/2008 – 11/30/2008
BC24	33527	02/01/2008 – 11/30/2008
BC25	32254	02/01/2008 – 11/30/2008
BC26	36951	02/01/2008 – 11/30/2008
TSJF01	City MH S19II2017	02/01/2008 – 11/30/2008
JF03_20S	City MH S04II2004	05/09/2006 – 05/18/2007
JFWR09	City MH S17GG2004	05/09/2006 – 05/18/2007
JFWR15	City MH S05II2003	05/09/2006 – 05/18/2007
JFWR29	City MH S04EE2004	05/09/2006 – 05/18/2007
JFWR31	City MH S06II2012	05/09/2006 – 05/18/2007
JFWR35	City MH S13GG2016	05/09/2006 – 05/18/2007

3.4 Weather Analysis (CD Ref. P9.C.ii)

Dry-weather flow (DWF) is defined as flow in a sanitary sewer during periods of dry-weather in which the sanitary sewer is under minimum influence of I/I. DWF consists of base sanitary flow

(BSF) and base infiltration (BI). BSF is comprised of residential, commercial, and institutional wastewater discharges as well as wastewater discharges from industrial properties. BI is flow that enters the sanitary sewer system through pipe joints, sewer pipe defects and defective manhole walls, benches, and pipe seals. Sources of data used in determining the dry-weather flows included water consumption records; the rainfall/flow monitoring data; population estimates; estimates of the collection system tributary to each flow monitor; and estimates of the sewershed area tributary to each flow monitor.

Using Sliicer, an analysis tool developed by ADS® Environmental Services, Inc., RK&K established parameters to generate flow components for analysis of I/I in the Jones Falls Sewershed's collection system. The flow analyses obtained using the Sliicer.com™ software provided estimates of the components of the DWF, which consists of the BSF and the BI rate. Typically, minimum sewer flows occur during the summer and during the night, between the hours of 2 a.m. and 4 a.m. During these hours, it is assumed that most of the sewer flow is due to BI. The Stevens/Schutzbach equation was used to estimate BI. The Stevens-Schutzbach Method is an iterative regression technique used to fit the Manning Equation to flow monitoring data. The Stevens/Schutzbach equation used to estimate BI is as follows:

*BI = (0.4*Min. Daily Flow)/(1-0.6(Min. Daily Flow/Average Daily Flow)^(Min. Daily Flow^0.7)).*

The BSF was then estimated as the DWF rate less the BI estimate. Dry days were defined according to the following criteria:

Number of Prior Days	Cumulative Antecedent Rain (Inches)
1	0.1
3	0.4
5	1.0

For meter basins that exhibited negative or zero net BI, the BI was calculated as 90 percent of the minimum flow. Negative BI could be due to a difference in dry-weather days selected between cumulative flow meters and a possible blockage in the collection system. The following flow meters had the BI computed as 90 percent of the minimum flow: BC07; BC11; BC18; BC21; BC22; and TSJF01. **Table 3-4.1** summarizes the BI and average DWF calculated during the dry-weather analysis for each meter basin.

Table 3-4.1
Jones Falls SRRR: Corrective Action Recommendation Plan
INFILTRATION AND INFLOW ANALYSIS AVERAGE DRY-WEATHER FLOW

Basin	Summer				Winter			
	Weekday		Weekend		Weekday		Weekend	
	BI (mgd)	ADF (mgd)	BI (mgd)	ADF (mgd)	BI (mgd)	ADF (mgd)	BI (mgd)	ADF (mgd)
County Meters								
BC01	0.049	0.240	0.048	0.244	0.065	0.316	0.067	0.323
BC02	0.033	0.094	0.031	0.094	0.040	0.107	0.035	0.108
BC03	0.296	0.535	0.217	0.463	0.314	0.367	0.293	0.383
BC04	0.057	0.127	0.062	0.121	0.099	0.176	0.108	0.178
BC05	0.079	0.163	0.084	0.141	0.100	0.184	0.100	0.160
BC06	0.090	0.211	0.093	0.224	0.103	0.228	0.108	0.248
BC07*	0.001	0.227	0.004	0.321	0.006	0.049	0.004	0.028
BC08	0.101	0.288	0.100	0.323	0.154	0.367	0.159	0.414
BC09	0.396	0.892	0.312	0.725	1.079	1.328	1.087	1.336
BC10	0.156	0.452	0.173	0.428	0.176	0.502	0.179	0.449
BC11*	0.143	0.604	0.016	0.354	0.060	0.146	0.048	0.110
BC12	0.471	1.546	0.514	1.354	0.528	1.681	0.576	1.467
BC13	0.051	0.143	0.051	0.138	0.076	0.190	0.074	0.181
BC14	0.225	0.464	0.226	0.431	0.259	0.456	0.261	0.428
BC15	0.012	0.028	0.012	0.029	0.012	0.031	0.012	0.032
BC16	0.018	0.345	0.060	0.295	0.156	0.523	0.147	0.425
BC18*	0.051	0.147	0.061	0.169	0.047	0.126	0.056	0.146
BC19	0.115	0.436	0.125	0.451	0.126	0.448	0.139	0.456
BC20	0.006	0.221	0.006	0.226	0.016	0.253	0.009	0.241
BC21*	0.013	0.028	0.005	0.010	0.024	0.056	0.020	0.047
BC22*	0.011	0.027	0.014	0.029	0.018	0.041	0.019	0.037
BC23	0.066	0.128	0.059	0.128	0.081	0.174	0.085	0.185
BC24	0.201	0.400	0.206	0.379	0.245	0.493	0.264	0.492
BC25	0.091	0.169	0.091	0.164	0.130	0.197	0.125	0.197
BC26	0.125	0.270	0.129	0.269	0.122	0.253	0.122	0.249
TSJF01*	0.001	0.022	0.002	0.005	0.017	0.042	0.061	0.148
Boundary Meters								
JF03_20S	0.042	0.086	0.051	0.105	0.058	0.100	0.055	0.100
JFWR09	0.141	0.287	0.151	0.270	0.104	0.240	0.103	0.220
JFWR15	0.074	0.281	0.101	0.305	0.129	0.328	0.125	0.346
JFWR29	0.188	0.601	0.198	0.570	0.016	0.462	0.172	0.444
JFWR31	0.183	0.259	0.185	0.270	0.446	0.515	0.471	0.521
JFWR35	0.038	0.087	0.042	0.092	0.051	0.111	0.052	0.116

* For Meter Basins that exhibited negative or zero net BI, the BI was calculated as 90 percent of the minimum flow.

3.4.1 Infiltration Analysis

The BI was normalized based on gallons per day per inch-diameter mile (gpd/in/d/m) to compare the meter basins and to identify those with severe infiltration. The inch-diameter miles of a meter basin are determined by multiplying the length of sewer pipes in miles. The criteria to determine if a meter basin exhibited excessive BI comes from the EPA handbook Facilities Planning, 1982. This criteria is defined below:

CRITERIA FOR NORMALIZED BI	
Size of Basin(LF)	Non-Excessive Rate (gpd/in/d/m)
> 100,000	< 3,000
10,000-100,000	< 6,000
< 10,000	< 10,000

For summer weekdays, there are two (2) meter basins which exceed the criteria for normalized BI: Meter Basins BC03 and BC14. For winter weekdays, Meter Basins BC03, BC09 and BC14 exceed the BI criteria. None of the Boundary Meters exceed the criteria for either summer or winter. The dry-weather results indicate that the meter basin draining to Meter BC03 has higher than expected rates of wastewater production and BI during the summer season. This is likely due to the valve controlling the flow from the Texas Pumping Station was probably not completely closed during most of the flow monitoring. This valve is normally in the closed position and flow from the Texas Pumping Station travels to the Longquarter Pumping Station outside of the Jones Falls Sewershed.

Occasionally the County will open the by-pass valve, which allows the flow from the Texas Pumping Station to enter into the Jones Falls Sewershed upstream of Flow Meter BC03. From the metering data, it appears that flow was passing through this valve during the monitoring period prior to September of 2008. Beginning in early September 2008, the flow rates measured at BC03 drop considerably and BI is not considered high for the winter months. Meter Basin BC14 shows excessive BI for both summer and winter.

Map 5 contained in the Inflow and Infiltration Evaluation Report depicts the severity of the BI for the summer season, normalized by gpd/in/m. **Map 6** contained in the Inflow and Infiltration Evaluation Report depicts the BI for the winter season. The infiltration rate was divided into three (3) different ranges. As shown, the BI doesn't change drastically between the two seasons and the BI in the west side of the sewershed is relatively low. Refer to the Inflow and Infiltration Evaluation Report for the Jones Falls Sewershed, which is contained in **Appendix B** of this report, for a more detailed description of the infiltration analysis and the referenced maps.

3.5 Wet-Weather Analysis (CD Ref. P9.C.ii)

Wet-weather analysis was used to quantify the rainfall-dependent infiltration and inflow (RDII) in the Jones Falls Sewershed. Each qualified storm from **Tables 3-2.1** and **3-2.2** were analyzed for each flow meter using the Sliicer.com software. For each storm, a pre-composition period (typically 24-hours prior to the storm event) was established to adjust the dry-day hydrograph to match the actual hydrograph immediately prior to the start of the storm. This either raises or lowers the dry-day hydrograph so that the calculated RDII is a result of only the storm event. To estimate RDII, the Sliicer program overlays the typical dry-day hydrograph on the storm's hydrograph. The difference between the two hydrographs represents the RDII.

3.5.1 Inflow Analysis

The RDII was normalized by linear feet (LF) of pipe and inches of rainfall. For RDII, a criterion of 10 gallons per linear foot of pipe, per inch of rainfall (gal/lf/in of rainfall) was selected for identifying meter basins exhibiting excessive rates of RDII. The County Meter basins with a normalized RDII rate greater than 10 gal/lf/in of rainfall are Meter Basins BC03, BC07, BC09, BC16, BC18 and TSJF01. The Boundary Meter basins with a normalized RDII rate greater than 10 gal/lf/in of rainfall are Meter Basins JF0320S, JFWR09 and JFWR29. The RDII severity for the Jones Falls Sewershed is depicted in **Map 7**, which is contained in the Inflow and Infiltration Evaluation Report in **Appendix B** of this report.

Although Meter Basins BC03 and BC07 show a normalized RDII rate of greater than 10 gal/lf/in of rainfall, it is believed that the results for these relatively small meter basins are highly influenced by the flow that was by-passed from the Texas Pumping Station, and therefore the consideration as basins exhibiting excessive I/I is questionable. To be conservative, both of these meter basins are shown as having excessive RDII in **Map 7**. Furthermore, although BC09 shows a normalized RDII rate less than 10 gal/lf/in, the normalized RDII (8.44 gal/lf/in) is close to the criteria threshold, and because BC09 is located on a main interceptor sewer comprising a significant area (approximately 539 acres), BC09 is a meter basin considered as exhibiting excessive I/I. However, in **Map 7**, BC09 will be included in the "5–10 gal/lf/in of rain" category and not in the ">10 gal/lf/in of rain" category due to the normalized RDII being 8.44 gal/lf/in.

The RDII was also analyzed using capture coefficient. The criteria for this metric are derived from the Interim Inflow and Infiltration Report, West and Cadden, 1994. This report indicates that meter basins with a capture coefficient of 10 percent or greater are considered to exhibit excessive RDII, meter basins between 5 and 10 percent possibly exhibit excessive RDII, and meter basins with less than 5 percent are considered as not exhibiting excessive RDII. Using this metric, the only meter basins with a capture coefficient greater than 10 percent are BC03 and BC07. Based on the preceding discussion, Meter Basins BC03, BC07, BC09, BC16, BC18, TSJF01, JF0320S, JFWR09 and JFWR29 are considered to exhibit excessive RDII. Results of the wet-weather analysis are summarized in **Table 3-5.1**. Refer to **Appendix B,** Inflow and Infiltration Evaluation Report for the Jones Falls Sewershed, for a more detailed discussion of the inflow analysis.

Table 3-5.1 Jones Falls SRRR: Corrective Action Recommendation Plan JONES FALLS SEWERSHED WET-WEATHER ANALYSIS						
Meter Basin	RDII (gal/lf/in)	Capture Coefficient (R)		Meter Basin	RDII Ranking	Capture Coefficient Ranking
County Meters						
BC01	2.06	0.94%		BC07	1	1
BC02	7.92	3.47%		BC03	2	2
BC03	38.29	22.05%		BC18	3	7
BC04	9.74	3.38%		BC16	4	3
BC05	2.21	0.64%		TSJF01	5	8
BC06	1.97	0.70%		BC04	6	5
BC07	51.22	32.67%		BC09	7	6
BC08	5.22	1.62%		BC02	8	4
BC09	9.01	3.18%		BC08	9	9
BC10	3.27	1.35%		BC22	10	14
BC11	3.60	1.59%		BC25	11	12
BC12	1.78	0.71%		BC11	12	10
BC13	1.97	0.73%		BC10	13	11
BC14	1.10	0.36%		BC21	14	25
BC15	0.73	0.13%		BC05	15	19
BC16	12.56	4.50%		BC19	16	16
BC18	16.08	2.31%		BC01	17	13
BC19	2.16	0.72%		BC06	18	18
BC20	1.13	0.30%		BC13	19	15
BC21	2.94	0.26%		BC12	20	17
BC22	4.62	0.88%		BC23	21	23
BC23	1.74	0.34%		BC24	22	20
BC24	1.38	0.42%		BC20	23	24
BC25	4.47	1.25%		BC26	24	23
BC26	1.14	0.38%		BC14	25	22
TSJF01	11.62	1.79%		BC15	26	26
Boundary Meters						
JF0320S	18.31	7.54%		JF0320S	1	2
JFWR09	10.33	2.17%		JFWR29	2	1
JFWR15	9.16	4.87%		JFWR09	3	5
JFWR29	14.95	8.71%		JFWR15	4	3
JFWR31	6.55	3.24%		JFWR31	5	4
JFWR35	3.89	1.70%		JFWR35	6	6

The scattergraphs developed for each meter basin show that the flow, in most meter basins, is contained within 50 percent of the pipe's diameter. Nine (9) of the twenty-five (25) County Meters experienced surcharging at some period during the flow monitoring. Of the nine (9) flow monitoring sites, five (5) experienced surcharging on more than one occasion. The nine (9) metering sites that experienced surcharging are: BC02; BC04; BC05; BC06; BC07; BC08; BC09; BC11 and BC12. Surcharging occurred when flow was by-passed from the Texas Pumping Station and during storm events. The storm events that caused surcharging were the February 1, 2008, July 23, 2008, and the September 27, 2008 storms. Flow by-passing from the Texas Pumping Station that caused surcharging occurred on the following dates: April 9, 2008; May 7, 2008; July 31, 2008; and August 26, 2008. Although none of the flow monitoring sites recorded overflows, non-pumping station SSO 120, located along Charles Street Avenue, overflowed during the September 27, 2008 storm.

3.6 Infiltration/Inflow Evaluation (CD Ref. P9.C.ii)

For dry-weather flow, the criteria for identifying meter basins with excessive BI rates were based upon gallons per day per inch-diameter mile (gpd/in/d/m) using the table from the EPA Handbook - Facilities Planning, 1982, which is shown in Section 3.4.1. Using the established criteria, the meter basins that exhibit excessive BI rates are BC03, BC09 and BC14.

For wet-weather flow, a criterion of 10 gallons/linear foot per inch of rain (gal/lf/in) was selected for identifying meter basins exhibiting excessive normalized rates of RDII. A capture coefficient criterion of 10 percent was also used. Using this criteria, meter basins that exhibit excessive RDII are BC03, BC07, BC09, BC16, BC18, TSJF01, JF0320S, JFWR09 and JFWR29.

Meter basins that exhibited excessive I/I were investigated further by sanitary sewer evaluation surveys (SSES).

For the complete Inflow and Infiltration Evaluation Report, see **Appendix B** of this report.

END OF SECTION

Section 4

Collection System Inspection

Collection System Inspection

4.0 Collection System Inspection (CD Ref. P8 & P10.C.ii)

4.1 Overview

Baltimore County's portion of the Jones Falls Sewershed measures approximately 13,440 acres in size and contains over 1,124,000 linear feet (LF) of gravity sewer pipe ranging in size from 6-inches to 48-inches in diameter. The sewershed also contains approximately 6,200 manhole structures; 19,000 LF of force main and pressure sewer, and four (4) pumping stations. The sewershed's collection system conveys wastewater from Baltimore County to the City of Baltimore's Jones Falls Sewershed at seven (7) separate locations before being treated at the City of Baltimore's Back River Wastewater Treatment Plant.

In accordance with Paragraph 8 of the Consent Decree (CD) and the approved inspection plan, the sanitary collection system piping, 8-inches in diameter and larger and associated manhole structures were identified for inspection in the Jones Falls Sewershed. From March 2006 through September 2012, sanitary sewers and manholes in 177 Sewershed Service Areas (SSA's) in thirty-one (31) flow meter basins were inspected. All inspections were completed in accordance with Baltimore County's standard closed-circuit television (CCTV) and manhole inspection protocols.

Review of the data collected as part of this inspection effort was completed in accordance with the criteria set forth in Paragraph 8 of the CD. Reviews included all Paragraph 8.C.ii, 8.C.ia, and 8.C.iv sanitary sewers and manholes that had condition rankings of either 4 or 5, and all Paragraph 8C.ii, 8.C.ia, 8.C.iv and 15.B.ib sanitary sewers and manholes that were located within SSA's that were identified by analysis as exhibiting excessive inflow and infiltration (I/I). The inspection data collected by Baltimore County's Bureau of Utilities was accessed for review utilizing Baltimore County's Consent Decree Web Portal. This data included CCTV inspections of sanitary collection system piping 8-inches in diameter and larger, manhole inspection data, including inspection photographs and other Sanitary Sewer Evaluation Survey (SSES) type data including night-time flow isolation testing, and smoke and dyed-water testing information. Review of this data, in concert with the modeling and Inflow and Infiltration (I/I) evaluation information, will allow development of a comprehensive rehabilitation and corrective action plan to address collection system defects and deficiencies that contribute to model predicted collection system Sanitary Sewer Overflows (SSO) in the Jones Falls Sewershed.

The collection system and SSES investigation work that was reviewed in accordance with Paragraph 8 of the CD included:

- 715 manhole inspections
- 251,000 LF of CCTV sewer inspections
- Four (4) pumping stations inspections
- 3,176 LF of force main inspections
- 132,008 LF of smoke testing
- 121 night-time flow isolation tests in 18 SSA's
- 66 scheduled dyed-water tests to be completed in 21 SSA's

4.2 Manhole Inspections

Manhole inspection characterizes the condition and connectivity of a sanitary collection system. Manholes were inspected as required by Paragraph 8 of the CD. The manhole inspection data reviewed typically served multiple purposes, which included characterizing the general condition of the structure, identifying collection system connectivity, assisted in defining the general condition of the sewer segments that were connected to the structure, provided defect observation data required for condition assessment, identified potential sources of I/I to the collection system, and allowed development of subsequent repair recommendations.

Manhole inspections were completed by Baltimore County's Bureau of Utilities and recorded on standard manhole inspection forms in accordance with the County's standard manhole inspection protocols. To avoid manned-entry of the manholes for inspection and possible safety risks, the inspections were completed using specialized pole mounted manhole inspection cameras.

715 manhole inspections were reviewed in accordance with the CD requirements; however, three (3) of manholes included in this review were not assigned a rating by the original inspection crews. The inspection data reviewed was contained on the County's Consent Decree Web Portal and included inspection forms and condition photographs taken during the inspections. Each manhole was defined by a specific County manhole ID, SSA location and the CD paragraph reference. The inspection forms also indicated the date when the inspection was completed and the manhole's structural condition rating.

Map 4-1 – Sewer and Manhole Inspections Completed - shows the collection system manholes that were inspected and reviewed in accordance with the priority identification scheme described in Section 6 of this report.

Table 4-2.1 – Manhole Defect Summary Table provides an overview of the common defects that were observed in the manholes that were reviewed.

Table 4-2.1 Jones Falls SRRR: Collection System Investigation **MANHOLE DEFECT SUMMARY TABLE**		
Defect Type	Quantity of Defects	Percent
Cover	64	9%
Frame	82	12%
Frame Seal	82	12%
Corbel	184	26%
Wall	179	25%
Bench	31	4%
Trough	17	2%
Pipe Seals	46	6%

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Jones Falls Collection System Evaluation & Sewershed Plan

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Map 4-1 Sewer and Manhole Inspections Completed

Table 4-2.2 – Summary of Manhole Defects by Manhole provided in **Appendix E** of this report identifies all manholes contained in the Jones Falls Sewershed by meter basin and SSA, and identifies the specific defects that were contained in each manhole reviewed and if corrective action is required.

4.3 Closed Circuit Television (CCTV) Inspections (CD Ref. P10.C.ii)

CCTV inspection is a process of internally inspecting sewers in the collection system to assess the condition of the piping and identify conditions that require action. Baltimore County's Bureau of Utilities conducted CCTV inspections of all sewers that were required to be inspected under Paragraph 8.ci or Paragraph 8.cii of the CD. In addition, sewers in meter basins that were located within SSA's that were identified by analysis as exhibiting excessive I/I and/or model predicted SSOs were also inspected and included in the review.

The CCTV inspection data reviewed served multiple purposes, which included characterizing the general condition and maintenance requirements of the sewers, identifying system connectivity, identifying potential sources of I/I to the collection system, and allowing development of subsequent repair and/or maintenance recommendations.

The collection system inspections were completed in accordance with the National Association of Sewer Service Companies (NASSCO) utilizing the Pipeline Assessment Certification Program (PACP) coding requirements. Where field conditions precluded the use of standard CCTV inspection equipment, specialized equipment or heavy cleaning was utilized to complete the work. Approximately 46,977 LF of sewers inspected required heavy cleaning to remove roots, grease and/or other heavy debris that initially precluded the inspection of these sewers.

CCTV inspections were completed in thirty-one (31) of the thirty-two (32) flow meter basins within the Jones Falls Sewershed. A total of 251,000 linear feet (LF) of CCTV inspection was reviewed by NASSCO PACP certified technicians using inspection data contained on the County's Web Portal. The CCTV inspection data archived on the portal was cataloged by SSA and manhole to manhole sewer segment number for ease of access. The portal also provided the status of the pipe segments (i.e. active or inactive), the utility owner (i.e. public or private), type of sewer (i.e. collector, force main, etc.), pipe size, length, date of sewer installation, CD Paragraph reference number and any pertinent repair or maintenance history.

Map 4-1 – Sewer and Manhole Inspections Completed - shows the collection system sanitary sewers that were inspected and reviewed in accordance with the priority identification scheme described in Section 6 of this report.

Table 4-3.1 – **Summary of CCTV Inspections** contained in **Appendix C** of this report provides an overview of the CCTV inspection reviews performed in each SSA of the Jones Falls Sewershed. The Table identifies the SSA and flow meter basin where the sewer is located, the sewer segments CD Paragraph reference number, identification of sewers that are located in areas identified by evaluation as high I/I SSA's, the total length of the sewer as contained in the County's GIS, and the length of sewer that was actually inspected and reviewed.

Table 4-3.2 – Sewer Defect Summary Table categorizes the defects recorded during the CCTV inspections and identified during subsequent review of the data. **Table 4-3.3 – Summary of Sewer Defect PACP Codes** contained in **Appendix D** of this report details each specific defect type, whether the defect is classified as a constructional, structural or operation and maintenance related, PACP inspection codes recorded, a brief description of the defect, the number of defects that occurred and the number of affected sewer segments.

Table 4-3.4 – Summary of Sewer Defects by Sewer Segment contained in **Appendix E** of this report identifies all sewer segments contained in the Jones Falls Sewershed by meter basin and SSA, and details each specific defect that was contained in the sewer segment reviewed and if corrective action is required.

Table 4-3.2
Jones Falls SRRR: Collection System Investigation
SEWER DEFECT SUMMARY TABLE

Defect Type	Quantity of Defects	Percent
Break-in Tap/Connections	699	5.2%
Broken Pipe	398	3.0%
Collapsed Pipe	3	0.0%
Cracks in Pipe	1,109	8.3%
Defective Joints	2,645	19.8%
Deformed Pipe	17	0.1%
Deposits	103	0.8%
Pipe Fractures	1,424	10.7%
Grease	2,064	15.5%
Hole in Pipe	167	1.3%
Infiltration	503	3.8%
Missing Wall	24	0.2%
Roots	612	4.6%
Surface Deterioration	3,559	26.7%

Defects were considered to be structural deficiencies that existed in the collection system manholes and sewers, which either, had the potential to contribute I/I to the collection system, cause an SSO, or could jeopardize the continuity or conveyance of flow through the collection system.

4.4 Smoke Testing (CD Ref. P10.C.ii)

Smoke tests were completed as part of the SSES work in forty-eight (48) of the SSA's in the Jones Falls Sewershed and the results from these tests recorded in accordance with the County's standard smoke testing protocols. 132,008 LF of the smoke testing was completed within the sewershed and the results contained on the County's web portal for review. The results of these reviews are outlined in **Table 4-4.1 – Smoke Testing Critical Defect Summary**. The locations selected for smoke testing were based on the I/I evaluation, which is described in Section 3 of the SRRR Plan.

Smoke testing observations that were identified at manhole covers and clean-out locations were generally considered insignificant contributors of I/I to the collection system. These sources are not indicative of significant sources of inflow to the collection system that smoke testing seeks to identify. For example, if smoke is emitted from a house connection lateral's clean-out that has a missing or damaged cover, it is typically not indicative of a significant inflow source to the collection system, unless the clean-out is located in a low lying area and subject to significant ponding or run-off during a wet-weather event. Smoke that originates through pick holes in a manhole cover were also not considered significant contributors of I/I to the collections system.

Smoke testing observations that were identified at illicit down spout and drain connections; storm drain inlets or from mainline sewer defects were considered significant and likely sources of I/I to the collection system. Defects identified through smoke testing were either forwarded to the County's plumbing inspection division for correction or recommended for additional confirmatory testing utilizing dyed-water.

Table 4-4.1 - **Smoke Testing Critical Defect Summary Table** summarizes the defects that were identified during the review of the smoke testing data.

Table 4-4.1
Jones Falls SRRR: Collection System Investigation
SMOKE TESTING CRITICAL DEFECT SUMMARY TABLE

Source Type	Quantity of Defects	Percent
Down Spout	3	8%
Basement Drain	11	29%
Water Valve Vault	1	2%
Storm Drain Inlet	14	37%
Storm Drain Manhole	4	12%
Foundation Drain	2	5%
Mainline Sewer	2	5%
Verizon Box Smoking	1	2%

4.5 Dyed-Water Testing

Potential defects that were identified during the smoke testing or other field inspections were put on a list for confirmatory dyed-water testing. The County is currently completing dyed-water testing at sixty-six (66) separate locations throughout the Jones Falls Sewershed. These tests will be used to better isolate and identify collection system defects and sources of I/I. All dyed-water tests are being completed in accordance with the County's standard testing protocols and the results recorded and forwarded to the County's Bureau of Utilities for corrective action.

Table 4-5.1 – Dyed-Water Testing Summary Table summarizes the defects that were identified during the review of the smoke testing data and scheduled for dyed-water testing. **Appendix F** of this report contains the complete listing of locations scheduled for dyed-water testing.

Table 4-5.1
Jones Falls SRRR: Collection System Investigation
DYED-WATER TESTING SUMMARY TABLE

Source Type	Quantity	Percent
Cleanout Cap Broken	1	1%
Cleanout Cap Missing	6	10%
House Downspout	2	3%
Foundation Drain	2	3%
House Mainline Cleanout	1	1%
House Cleanout	4	6%
MH – Surrounding Area	21	32%
MH - Cover	21	32%
Mainline Sewer	5	7%
Storm Drain Inlet	3	4%
Unknown	1	1%

4.6 Night-Time Flow Isolation Testing

Night-time Flow isolation testing was performed by Baltimore County in eighteen (18) SSA's within the Jones Falls Sewershed. Night-time flow isolation was used to identify and measure possible Base Infiltration (BI) that exists in the sewer segments tested and identify areas where additional SSES inspection work should be completed. The objective of the testing is to isolate specific sewer segments and measure flow that occurs during early morning hours, typically between midnight and 5:00 a.m. Flow in the isolated sewer segment should be minimal at that time and observed flow is typically found to be infiltration in the sewer. **Table 4-6.1 – Night-Time Flow Isolation Testing Summary Table** summarizes the meter basins that exhibited elevated levels of BI and were recommended for additional SSES investigations. **Appendix G** of this report contains a complete listing of the locations where night-time flow isolation tests were performed and the results of the testing.

Table 4-6.1 Jones Falls SRRR: Collection System Investigation NIGHT-TIME FLOW ISOLATION TESTING SUMMARY TABLE			
Meter Basin	Pipe Segments Tested	No. of Segments w/ gpd/im > 10,000	No. of Segments w/ gpd/im > 10,000
BC02	22	0	0.0%
BC03	3	0	0.0%
BC04	24	4	16.7%
BC05	18	2	11.1%
BC09	54	9	16.7%
Total:	121	15	12.4%

4.7 Force Main Condition Assessment

The Jones Falls Sewershed contains four (4) force mains. These include the 6-inch diameter ductile iron pipe (DIP) force main from the Buchanan Road Pumping Station, which was constructed in 1980 and is 1,076 linear feet (LF) in length; the 6-inch diameter Cast Iron (CI) force main from the Stanton Woods Pumping Station, which was constructed in 1974 and is 2,100 LF in length; the 6-inch diameter CI force main from the Templegate Pumping Station, which was constructed in 1975 and is 1,270 LF in length; and the 6-inch diameter CI force main from the Stevenson Pumping Station, which was constructed in 1970 and is 1,788 LF in length.

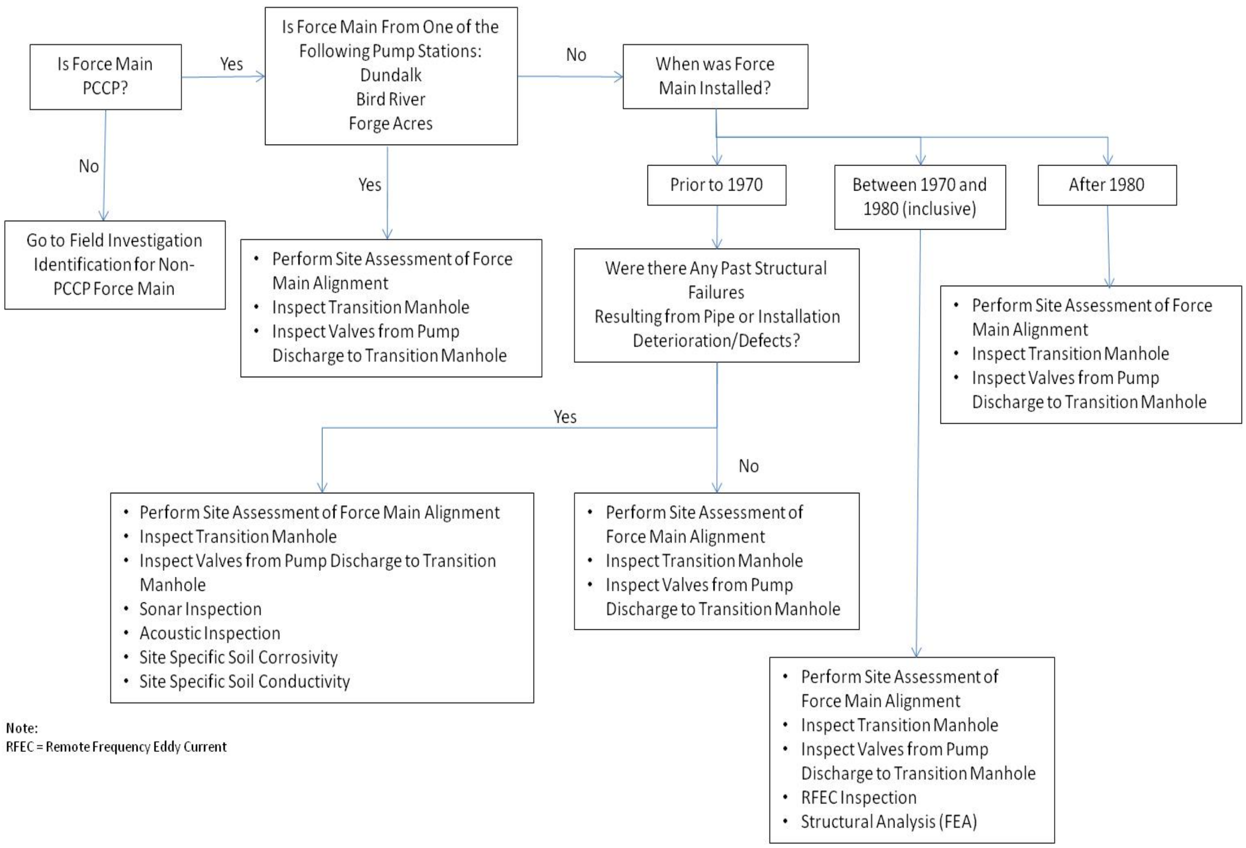
In accordance with Paragraph 8D.ii.of the CD, the County developed a standard process to determine the appropriate inspection/evaluation methodology to be used to adequately assess the condition of each force main in their collection system. The process was developed for two main pipe material categories: pre-stressed concrete cylinder pipe (PCCP) and non pre-stressed concrete cylinder pipe. A separate process was developed specifically for PCCP force mains due to the possibility of sudden and catastrophic structural failure that is typically associated with this type of pipe material. The review process is based upon the following risk assessment criteria:

1. Pipe Material
2. Age
3. Break History
4. Consequence of Failure
5. Current Available Technology

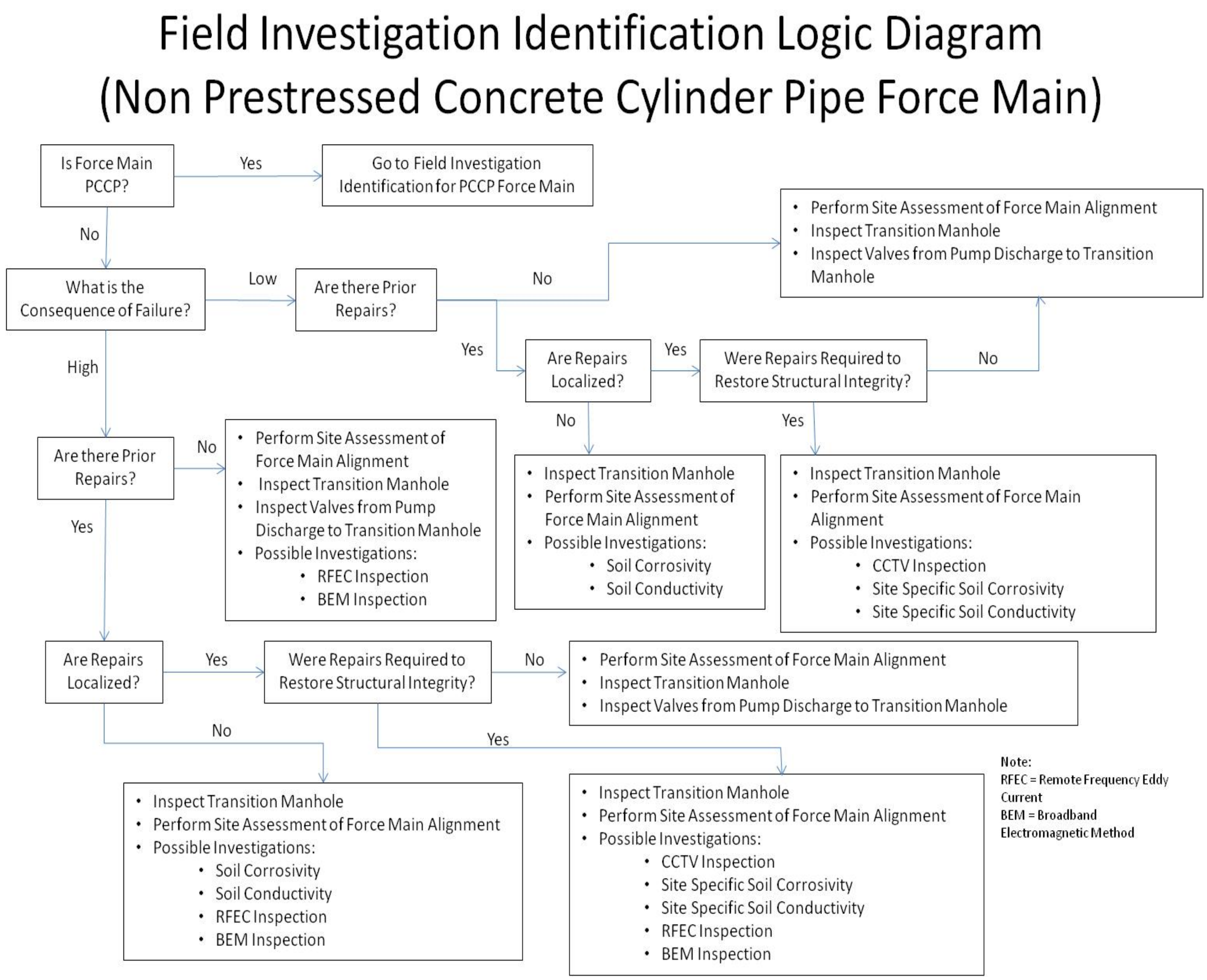
Equipment availability, supplemental information, existing site conditions and/or pumping station operating conditions may require an inspection method that differs somewhat from those identified by the County's standard process.

The two inspection identification/evaluation methodologies are summarized in the logic diagrams provided on the following pages. Since the force mains in the Jones Falls Sewershed are 6-inches in diameter and smaller and constructed of either CI or DIP, the process used for review was based on the non pre-stressed concrete cylinder pipe criteria.

Field Investigation Identification Logic Diagram (Prestressed Concrete Cylinder Pipe Force Main)



Note:
RFEC = Remote Frequency Eddy Current



Consequence of Failure

The consequence of force main failure is determined based on the following criteria:

1. Accessibility (i.e. surface features such as a stream or highway that would delay the repair of a broken force main)
2. Pipe Diameter (SSO volume from a broken force main is a function of pipe diameter)
3. Response time (i.e. the maximum time required to fill the pumping station wet well and surcharge the collection system without causing a sanitary sewer overflow or basement backup)

Each criterion is assigned a weighted value and a Relative Importance Factor as summarized in **Table 4-7.1 – Force Main Consequence of Failure Index Rating** to calculate the Consequence of Failure Index Rating.

Table 4-7.1
Force Main Consequence of Failure Index Rating

Criteria	Weighting	Normalized Weighting	Relative Importance Factor
Accessibility			2
Accessible	0	0.00	
Inaccessible	1	1.00	
Diameter			3
≤ 6”	1	0.2	
7” to 11”	2	0.4	
12” to 16”	3	0.6	
17” to 24”	4	0.8	
≥ 25”	5	1.00	
Response Time			1
Response Time > Inspection Time	0	0.00	
Retention Time < Inspection Time	1	1.00	

Force Main Inspections

Condition assessment investigations were performed for the Buchanan Road, Stanton Woods, Templegate and Stevenson Force Mains and associated transition manholes. These inspections consisted of the following activities:

1. Site assessment of the force main’s alignment
2. Inspection of existing appurtenances
3. Inspection of the force main’s transition manhole

Additionally the following information was reviewed:

1. Force main break history
2. Pumping station operating conditions (current and future)
3. Record drawings

The results of the force main investigations in the Jones Falls Sewershed can be found in the individual Force Main Condition Assessment Reports included in **Appendix H** of this report. A summary of these reports are provided below:

Buchanan Road Force Main: A survey of the 6-inch diameter DIP force main associated with this pumping station was conducted on April 11, 2011. Review of the information and investigation findings shows that this force main is in good structural and operational condition and there were no improvements recommended for continued use of the force main.

The force main’s transition manhole inspection was performed on April 29, 2011. Based on the review of the inspection findings, the force main’s transition manhole is in good structural condition.

Stanton Woods Force Main: A survey of the 6-inch diameter CI force main associated with this pumping station was conducted on April 11, 2011. Review of information and investigation findings shows that this force main is in good structural and operational condition and there were no improvements recommended for continued use of this force main.

The force main's transition manhole inspection was performed on April 29, 2011. Based on the review of the inspection findings, the force main's transition manhole is in good structural condition.

Templegate Force Main: A survey of the 6-inch diameter CI force main associated with this pumping station was conducted on April 11, 2011. Review of information and the investigation findings shows that this force main is in good structural and operational condition and there were no improvements recommended for continued use of this force main.

The force main's transition manhole inspection was performed on April 29, 2011. Based on a review of available information and investigation findings, the force main's transition manhole is in good structural and operational condition.

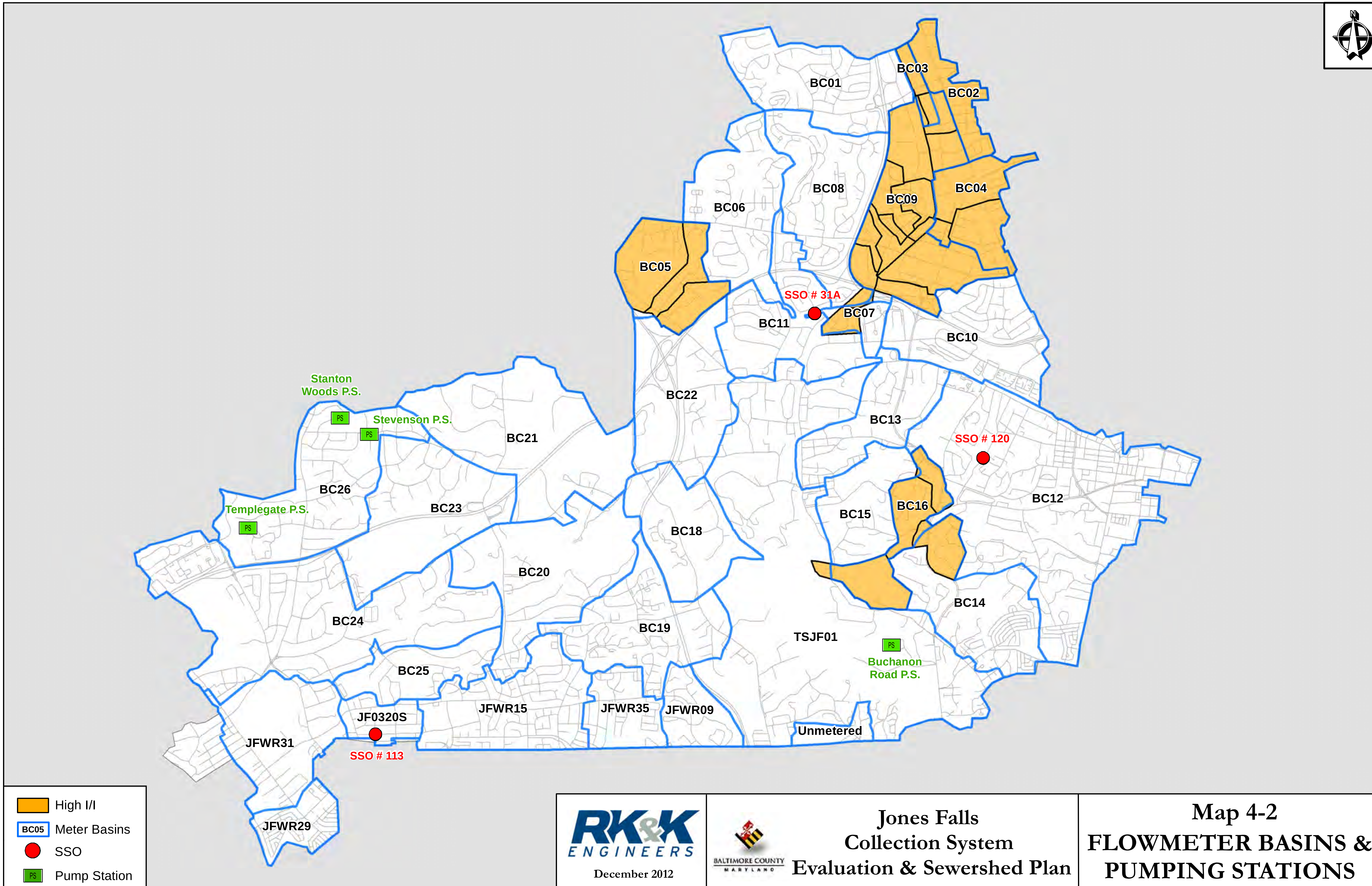
Stevenson Force Main: A survey of the 6-inch diameter DIP force main associated with this pumping station was conducted on April 11, 2011. Review of information and the investigation findings shows that this force main is in good structural and operational condition and there were no improvements recommended for the continued use of the force main.

The force main's transition manhole inspection was performed on April 29, 2011. Based on a review of available information and investigation findings, the force main's transition manhole is in good structural and operational condition.

4.8 Pumping Station Review and Assessment

The Jones Falls Sewershed collection pumping and transmission system contains four (4) pumping stations. These include the Buchanan Road Pumping Station, which is located at the terminus of Buchanan Road and designed to pump flows of 200 gallons per minute (GPM) under existing and ultimate capacity conditions; the Stanton Woods Pumping Station, which is located at the terminus of Topping Road and designed to pump 252 GPM under existing and ultimate capacity conditions; the Templegate Pumping Station, which is located at the terminus of E Court, between Breton Way and Woodvalley Drive and designed to pump 300 GPM under ultimate capacity conditions; and the Stevenson Pumping Station, which is located at the intersection of Keyser Road and Windsong Court and designed to pump 180 GPM under existing and ultimate capacity conditions.

Map 4-2 – Flow Meter Basins & Pumping Stations shows the location of the pumping stations within the Jones Falls Sewershed.



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Jones Falls
Collection System
Evaluation & Sewershed Plan

Map 4-2
FLOWMETER BASINS &
PUMPING STATIONS

Baltimore County is currently undertaking, or has previously completed all of the measures set forth in Paragraph 13 of the CD. Baltimore County is in the process of ensuring that adequate backup power systems are installed and maintained for each of the pumping stations in accordance with Paragraph 13.C, installing a Supervisory Control and Data Acquisition (SCADA) system for remote monitoring of each of the pumping stations in accordance with Paragraph 13.D, and conducting inspections of the pumping stations in accordance with Paragraph 13.E of the CD.

Baltimore County has also completed an Engineering Evaluation and Condition Assessment (EE/CA) of all four (4) of the pumping stations in the Jones Falls Sewershed as required by Paragraph 13.F of the CD. The reports have been submitted under separate cover for review and approval in accordance with Paragraph 13.F.iii of the CD. The Stevenson Pumping Station was designated as a Tier 2 station in Appendix D of the CD. The County completely replaced this pumping station with a new station, which included backup power and a SCADA system. Construction was completed in 2011. The Buchanan Road, Stanton Woods and the Templegate Pumping Stations were designated as Tier 3 pumping stations. Improvements to these pumping stations to correct all Priority 1 and 2 ranked deficiencies, as defined in Paragraph 13.F.iv of the CD, and outlined in the EE/CA reports are intended to be completed in accordance with specific schedules as approved

Baltimore County has also completed a pumping station equipment inventory, transferred its pump maintenance record keeping system into an electronic information management system, and implemented a pumping station preventative maintenance program in accordance with Paragraphs 13.G-I of the CD. In addition, the County has ensured that an updated operation and maintenance manual is being maintained, at the Stevenson Pumping Station in accordance with Paragraph 13.J. of the CD.

END OF SECTION

Section 5

Collection, Pumping & Transmission System Modeling

5.0 Collection, Pumping and Transmission System Modeling (CD Ref. P.10.C.viii/ix)

5.1 Background

Paragraph 14A of the Consent Decree (CD) requires Baltimore County to develop and maintain a computerized collection, pumping and transmission system model for each sewershed to evaluate the impact of recommended corrective actions including I/I rehabilitation projects, proposed system modifications, upgrades and expansions to the transmission system's capacity and assess the capacity of and performance of the collection system during dry- and wet-weather. Furthermore, Paragraph 10 of the CD requires that the SRRR Plan present the results of the Long-Term Capacity/Peak Flow Management Evaluation (LTC/PFME) using the collection, pumping and transmission system model.

Paragraphs 10.C.viii and ix of the CD require the following be included in the SRRR Plan:

- Determine for each Sewershed the range of storm events as specified in Paragraph 9.C.ii(b) for which the collection system in its existing condition can convey peak flows without the occurrence of SSOs.
- Project for each Sewershed, the range of storm events as specified in Paragraph 9.C.ii(b) for which the collection system will be able to convey peak flows without the occurrence of SSOs. Such projection shall assume completion of the construction projects required by Paragraph 7 of the CD, and completion of the proposed rehabilitative or other corrective action projects recommended by the SRRR Plan required by Paragraph 10 of the CD.
- Identify all modeled collection system components and pumping stations that cause or contribute to flow restrictions or that have the potential to cause or contribute to overflows.

This section summarizes the development of the collection, pumping and transmission system model for the Jones Falls Sewershed, the calibration of this model, the hydraulic capacity analysis and the LTC/PFME.

5.2 Hydraulic Model Development

The collection, pumping and transmission system model of the Jones Falls Sewershed includes:

- All gravity sewers 10-inches in diameter and larger.
- All 8-inch diameter sewers included as necessary for system connectivity or to improve the accuracy of the model.
- All gravity sewers that have caused or contributed, or that are likely to cause or contribute, to capacity related SSOs.
- All manholes, junctions and sewer structures located along the modeled sewers.
- All gravity sewers that convey wastewater from one pumping station service area to another sewer service area.

- Two (2) weir structures.
- Two (2) non-pumping station SSOs.
- Four (4) existing pumping stations.
- The force mains that convey wastewater from the four (4) existing pumping stations.
- The gravity sewers that convey wastewater through the Texas by-pass valve into the Jones Falls Sewershed.

The developed model is capable of predicting the following:

- Rate of wastewater and temporal variation of rate of flow in the force mains and the major gravity sewers.
- Hydraulic pressure (psig) or hydraulic grade line (HGL) of wastewater at any point in force mains and the major gravity sewers.
- Flow capacity of each of the pumping stations in the collection system.
- Flow capacity of each pumping station with its back-up pump out-of-service.
- Peak flows to and/or from each pumping station during storm events of a magnitude of up to 20 years.
- Likelihood and location of SSOs within those portions of each sewershed modeled under high flow conditions, including pumping station service areas where the pumping station's back-up pump is out-of-service, and considering available wet-well capacity, existing functional off-line storage capacity, and normal in-line storage capacity.
- If adequate capacity exists for future growth.
- Performance of planned system improvements.

The hydraulic model also includes the diurnal flow pattern and base infiltration (BI) for each flow meter basin. There are 1,410 separate nodes and links and approximately 328,000 LF of sewer pipe contained in the calibrated model. The two (2) weir structures that were incorporated into the model are located along the Towson Run Interceptor at Manhole 33296 and at Manhole 37986 in the main trunk sewer within Meter Basin BC03. Pipe sediment and debris has also been accounted for in the model based on review of sonar and laser profiling data provided by Baltimore County. The County's wastewater geodatabase was used as the initial source of information for populating the pipes and node networks of the hydraulic model. Data was also used from field survey efforts, along with record and as-built documents to make editing changes to the hydraulic model. The invert and rim elevations of manholes, and location coordinates from the field survey data was used to supplement the GIS data. Data obtained from the record documents included: incoming and outgoing pipe sizes, shapes and types; invert elevations; manhole locations; and pumping station data, which included the number of pumps and their respective capacities. This data was utilized if field survey data was not available for a particular manhole. Where necessary, elevations from record drawings were adjusted to NAVD 88 datum. Additionally, field investigations were also conducted to confirm pump curve data and performance.

The model is also:

- Configured based on representative, accurate and verified system attribute data (i.e., pipe sizes and invert elevations, manhole rim elevations, etc.).
- Calibrated using spatially and temporally representative rainfall data and flow data, either existing or obtained under this CD pursuant to Paragraph 9.
- Verified using spatially and temporally representative rainfall data and flow data independent of the data used to calibrate the model.

Refer to **Appendix I** in this report for the Model Development and Calibration Report for the Jones Falls Sewershed, for a complete description of the development and calibration of the model.

5.3 Model Calibration (CD Ref P14.B.ii)

The model calibration consisted of two steps; dry-weather calibration and wet-weather calibration.

5.3.1 Dry-Weather Calibration

The dry-weather calibration process consisted of adjusting sub-catchment parameters until the model predictions closely match the results of the flow monitoring. Dry-weather flow consists of base sanitary flow (BSF) and base infiltration (BI).

The criteria established for the dry-weather calibration are:

- The modeled peak flow rate should be within -10 to +20 percent of the observed peak flow rate.
- The modeled volume of flow should be within -10 to +20 percent of the observed flow volume.
- Simulated diurnal pattern and hydrograph shape should reasonably match the observed.
- The timing of the peaks should be within one hour.

5.3.2 Wet-Weather Calibration

Following completion of the dry-weather calibration, wet-weather calibration was performed. The wet-weather flow component in sanitary sewers is referred to as rainfall-dependent infiltration and inflow (RDII). Simulation of wet-weather flow uses the SWMM RUNOFF routine in the InfoWorks CS program as a synthetic storm hydrograph generator. Several sub-catchment parameters, including the runoff coefficient, basin slope, runoff routing value and basin width, were adjusted to yield observed-simulated comparisons within calibration parameters noted below.

The following seven (7) storms were selected for calibrating the model for the County Meters (the County and Boundary Meters are defined in Section 1 of the SRRR Plan):

- February 1, 2008
- March 4, 2008
- March 7, 2008
- March 19, 2008
- April 3, 2008
- April 28, 2008
- May 8, 2008

For the model including the Boundary Meters, the following six (6) storms were used for calibrating the model:

- June 24, 2006
- July 5, 2006
- October 5, 2006
- October 17, 2006
- October 19, 2006
- October 27, 2006

These storms, selected for calibration for both the County and Boundary Meters provide a range of durations, intensities and volumes.

The following guidelines were used for the wet-weather calibration:

- The modeled peak flow rate should be within -10 percent and +25 percent of the observed peak flow rate.
- The modeled volume of flow should be within -10 percent and +20 percent of the observed.
- The shape and timing of the hydrographs should be similar.
- The modeled depth of flow at surcharged and non-surcharged pipe segments is similar to the observed depths of flow.

Storms that occurred during the winter season show a greater response to rainfall, resulting in greater RDII than storms that occur during the summer, and would provide more conservative model predictions. The model, calibrated using winter storms, is accurate for winter storms; however, it will likely over-predict for summer storms. Since a design storm could occur at any time during the year, the winter storms were deemed sufficient and used to calibrate the model. Summer storms typically are of shorter duration and higher intensity than winter storm events. In addition, the ground is typically dryer and the water table is lower in the summer than the winter season. This leads to less runoff per rain volume compared to winter storms. Winter storms are typically longer in duration, but lower in intensity than summer storm events. When the ground is saturated and the water table higher, more runoff occurs per the same amount of rain for winter storms compared to the summer storms.

The calibrated model of the Jones Falls Sewershed is capable of reproducing the dry-weather and wet-weather flow at each meter. A detailed description of the model development and calibration is provided in the Model Development and Calibration Report for the Jones Falls sewershed, which is included in **Appendix I** of this report.

Table 5-3.1 provides a summary of the dry- and wet-weather calibration at each meter. This table provides a comparison between observed and simulated values for dry- and wet-weather conditions. It also provides a description of the classification of the vulnerability and lists reasons for instances where the model results do not fall within the desired range for calibration.

TABLE 5-3.1 MODEL CALIBRATION SUMMARY TABLE

Meter Basin ID	Meter Manhole No.	Identified as Exhibiting High I/I (yes/no)[1]	Contributing Meter Basin(s)		Dry-Weather Calibration Percent Difference between Observed vs. Calibrated		Summer Wet-Weather Calibration Percent of Storms Outside Acceptable Range[2]		Winter Wet-Weather Calibration Percent of Storms Outside Acceptable Range[2]		Vulnerability and Reason for Over/Under Prediction in Basin[3]	
			Meter Basin ID	Identified as Exhibiting High I/I (yes/no)[1]	Total Volume	Peak Flow	RDII Volume	Peak Flow	Peak Flow	RDII Volume		
BC01	37990	No	None	N/A	-1%	-16%	22% (2 under-predict by as much as -27%, 0 over-predict)	44% (3 under-predict, 1 over-predicts, from -37% low to +38% high)	43% (3 under-predict from -12% to -20%)	0%	Low - No SSOs for storms up to and including a 20-year storm	For the 3 storms where the model under-predicts the peak, the observed data has a higher response to the event than the other storms
BC02	7253	No	None	N/A	-1%	-22%	33% (3 under-predict as much -65%, 0 over predict)	89% (5 over-predict, 3 under-predict from -73% low to +69% high)	14% (1 over-predicts 29%)	43% (3 over-predict from 21% to 52%)	Significant - Model predicts SSOs beginning with the 2-yr storm	For the 2 storms where the model over-predicts the volume and the one storm where the model over-predicts the peak, the observed data does not have much of a response to the event as the other storms
BC03	33463	Yes	BC01, BC02	No	14%	-18%	57% (2 under-predict, 2 over-predict, from -28% low to +52% high)	43% (1 under-predicts, 2 over-predict, from -30% low to +41% high)	29% (2 over-predict from 33% to 56%)	57% (4 under-predict from -13% to -33%)	Significant - Model predicts SSOs beginning with the 2-yr storm	Monitored data may be questionable due to over and under-predictions in the model. This irregularity is potentially impacted by the Texas Bypass.
BC04	6977	No	None	N/A	-3%	-15%	45% (2 under-predict, 2 over-predict, from -29% to +71%)	78% (5 under-predict, 2 over-predict from -49% low to +80% high)	43% (2 under-predict from -14% to -11% & 1 over-predict 29%)	29% (1 under-predicts -15% & 1 over-predicts 27%)	Low - No SSOs for storms up to and including a 20-year storm	For the 2 storms where the model under-predicts the peak & the 1 storm where the model under-predicts the volume, the observed data has a higher response to the event than the other storms. For the 1 event where the volume over-predicts and the 1 event where the peak over-predicts the monitored data does not have much of response to the event
BC05	43791	No	None	N/A	-4%	-19%	25% (2 under-predicted by as much -17% low, 0 over-predict)	50% (four under-predict by as much as - 53%)	43% (3 under-predict from -13% to -35%)	0%	Low - No SSOs for storms up to and including a 20-year storm	For the 3 storm events were the model peak under-predicts, the observed data has a higher response to the event
BC06	38526	No	None	N/A	0%	-12%	38% (2 under-predict, 1 over-predicts, from -15% low to +23% high)	62% (2 under-predict, 3 over-predict, from -23% low to + 54% high)	29% (2 under-predict from -13% to -15%)	0%	Low - No SSOs for storms up to and including a 20-year storm	For the 2 storm events were the model peak under-predicts, the observed data has a slightly higher response to the event
BC07	18586	No	BC01 thru BC04, BC08 thru BC10	BC03 & BC09 Only	8%	-7%	75% (5 over predict, 1 under-predicts from -37% low to +111% high)	62% (5 over predict, 0 under predict, with 4 >= +77%)	33% (1 over-predicts 27%)	0%	Significant - Model predicts SSOs beginning with the 2-yr storm	There appears to be some irregularity in this meter basin. For most of the storm used for calibration, the model over-predicts. Irregularity can be attributed to the Texas bypass.
BC08	19873	No	None	N/A	1%	-6%	44% (2 under-predict, 2 over-predict from -39% low to +48% high)	44% (3 under-predict, 1 over-predicts, from -29% to +74%)	57% (1 under-predict -20% & 3 over-predict from 42% to 54%)	71% (4 over-predict from 32% to 36% and 1 under-predicts -22%)	Low - No SSOs for storms up to and including a 20-year storm	For the storms where the model under-predicts the peak and/or volume, the observed data has a slightly higher response to the events. For the 2 storms where the model over-predicts the peak and/or volume, the observed data doesn't have much of a response to the event to the rainfall event.
BC09	NS1079	Yes	BC01 thru BC04	BC03 Only	-14%	-14%	44% (1 under-predicts, 3 over-predict, from -45% low to +106% high)	89% (over predicts >100% for 4 of 9 storms)	43% (3 over-predict from 25% to 46%)	43% (3 under-predict from -12% to -24%)	Low - No SSOs for storms up to and including a 20-year storm	There appears to be some irregularity in this meter basin. For most of the storm used for calibration, the model will under-predict the volume but over-predict the peak and vice versa. Irregularity can be attributed to the Texas bypass.
BC10	42231	No	None	N/A	-3%	-6%	11% (1 under-predicts 12%, 0 over-predict)	22% (2 under-predict as much as 34%, 0 over-predict)	14% (1 under-predicts -17%)	14% (1 under-predicts -25%)	Low - No SSOs for storms up to and including a 20-year storm	For the 1 storm where the model under-predicts the peak and the volume, the observed data shows a higher response to the event
BC11	6944	No	BC01 thru BC04, BC06 thru BC11	BC03 & BC09 Only	-12%	-6%	75% (1 under-predicts, 5 over-predict from -11% low to +108% high)	75% (over-predicts > 76% on 4 of 9 storms)	33% (2 over-predict from 41% to 46%)	17% (1 over-predicts 23%)	Significant - Model predicts SSOs beginning with the 2-yr storm	For the 2 storms where the model over-predicts the peak, the observed data does not have much of a response to the event as the other storms.
BC12	22222	No	None	N/A	-4%	-13%	11% (1 under-predicts by 16%, 0 over-predict)	22% (1 under-predicts by -21%, 1 over-predicts by +39%)	50% (3 under-predict from -16% to -20%)	17% (1 under-predicts 14%)	Moderate - Model predicts SSOs beginning with the 20-yr storm	For the 3 storms where the model under-predicts the peak and 1 storm where the model under-predicts the peak and volume, the observed data has a higher response to the event than the other storms

TABLE 5-3.1 MODEL CALIBRATION SUMMARY TABLE

Meter Basin ID	Meter Manhole No.	Identified as Exhibiting High I/I (yes/no)[1]	Contributing Meter Basin(s)		Dry Weather Calibration Percent Difference between Observed vs. Calibrated		Summer Wet Weather Calibration Percent of Storms Outside Acceptable Range[2]		Winter Wet Weather Calibration Percent of Storms Outside Acceptable Range[2]		Vulnerability and Reason for Over/Under Prediction in Basin	
			Meter Basin ID	Identified as Exhibiting High I/I (yes/no)[1]	Total Volume	Peak Flow	RDII Volume	Peak Flow	Peak Flow	RDII Volume		
BC13	18456	No	None	N/A	-26%	-40%	33% (2 under-predict, 1 over-predicts, from -35% low to +33% high)	44% (1 under-predicts by -18%, 3 over-predict with 2 >75% high)	57% (4 under-predict from -20% to -29%)	43% (3 under-predict from -15% to -24%)	Low - No SSOs for storms up to and including a 20-year storm	For the 4 storms where the model under-predicts the peak and volume and the 1 storm where the model under-predicts the peak, the observed data has a higher response to the event than the other storms
BC14	34177	Yes	None	N/A	-2%	-7%	33% (0 under-predict, 3 over-predict from +28% to +33%)	67% (3 under-predict, 3 over-predict, from -17% low to +45% high)	29% (2 under-predict from -11% to -12%)	0%	Low - No SSOs for storms up to and including a 20-year storm	For the 2 storms where the model under-predicts the peak, the observed data has a higher response to the event than the other storms
BC15	22456	No	None	N/A	-1%	-20%	43% (1 under-predicts, 2 over-predict, from -15% low to +29% high)	57% (4 under-predict, from -22% to -62%, 0 over-predict)	67% (4 under-predict from -13% to -29%)	16% (1 over-predicts 22%)	Low - No SSOs for storms up to and including a 20-year storm	Irregular data causes meter basin to under-predict peak and to be close to over-predict volume
BC16	61947	Yes	BC12, BC14	BC14 Only	-3%	-16%	11% (0 under-predict, 1 over-predicts by +27%)	44% (1 under-predicts, 3 over-predict from -22% low to +54% high)	0%	0%	Moderate - Model predicts SSOs beginning with the 10-yr storm	All events within calibration parameters
BC18	20755	Yes	BC05, BC19 thru BC26	No	-1%	-3%	22% (2 under-predict as much as -14%, 0 over-predict)	22% (2 under-predict by as much as -20%, 0 over-predict)	0%	0%	Moderate - Model predicts SSOs beginning with the 10-yr storm	All events within calibration parameters
BC19	33711	No	None	N/A	1%	-8%	0% (all within range)	11% (1 under-predicts by -11%, 0 over-predict)	0%	0%	Moderate - Model predicts SSOs beginning with the 10-yr storm	All events within calibration parameters
BC20	20770	No	BC24, BC25	No	1%	-8%	44% (1 under predicts by -15%, 3 over-predict from +21% to +26%)	22% (2 under-predict by as much as -24% low, 0 over-predict)	29% (2 under-predict -19%)	0%	Moderate - Model predicts SSOs beginning with the 10-yr storm	For the 2 storms where the model under-predicts the peak, the observed data shows a higher response to the event
BC21	36912	No	BC23, BC26	No	-4%	-8%	56% (2 under-predict, 3 over-predict, from -24% low to +35% high)	44% (3 under-predict, 1 over-predicts, from -40% low to +30% high)	29% (2 under-predict from -11% to -31%)	14% (1 over-predicts 38%)	Low - No SSOs for storms up to and including a 20-year storm	For the 2 storms where the model under-predicts the peak and 1 storm under-predicts the volume, the observed data shows a higher response to the event
BC22	34385	No	BC05	No	-4%	-21%	56% (2 under-predict, 3 over-predict, from -53% low to +42% high)	44% (2 under predict, 2 over-predict, from -43% low to +44% high)	29% (2 under predict -20%)	14% (1 over-predicts 24%)	Significant - Model predicts SSOs beginning with the 2-yr storm	For the 2 storms where the model under-predicts the peak, the observed has a higher response to the event. For the 1 storm where the volume over-predicts, the observed data doesn't have much of a response to the event
BC23	36930	No	BC26	No	0%	-4%	22% (2 under-predicted by as much as 19%, 0 over-predict)	22% (2 under predicted by as much as 43%, 0 over-predict)	43% (2 under-predict from -19% to -27% & 1 over-predict 27%)	0%	Low - No SSOs for storms up to and including a 20-year storm	Observed data responds irregularly to the storm events causing the meter basin to over-predict and under-predict the peaks. Volume within calibration parameters.
BC24	33527	No	None	N/A	1%	-13%	33% (1 under-predicts by -16%, 2 over-predict by as much as +40%)	33% (2 under-predict, 1 over-predicts from -28% low to +31% high)	29% (2 under-predict from -13% to -26%)	0%	Low - No SSOs for storms up to and including a 20-year storm	For the 2 storms where the model under-predicts the peak, the observed data shows a higher response to the event
BC25	32254	No	None	N/A	0%	-7%	44% (1 under-predicts, 3 over-predict, from -16% low to +30% high)	33% (2 under-predict, 1 over-predicts, from -35% low to +50% high)	17% (1 under-predicts -25 %)	0%	Moderate - Model predicts SSOs beginning with the 20-yr storm	For the 1 storms where the model under-predicts the peak, the observed data shows a higher response to the event
BC26	36951	No	None	N/A	-1%	4%	11% (one under-predicts by -29%, 0 over-predict)	56% (5 under-predict by as much as -40%, 0 over-predict)	29% (2 under-predict from -18% to -27%)	14% (1 under-predicts -12%)	Low - No SSOs for storms up to and including a 20-year storm	For the 2 storms where the model under-predicts the peak and 1 storm where the model under-predicts the peak and volume, the observed data shows a higher response to the event
TSJF01	TCM27	Yes	BC01 thru BC26	BC03, BC09, BC14, BC16 & BC18	-3%	-6%	40% (0 under-predict, two over-predict by as much as 62%)	60% (0 under-predict, 3 over-predict by as much as 96%)	14% (1 over-predicts 28%)	29% (2 over-predict from 23% to 25%)	Moderate - Model predicts SSOs beginning with the 10-yr storm	For the 1 storm where the model over-predicts the peak and the 2 storms where the model over-predicts the volume, the observed data does not have much of a response to the event as the other storms

[1] Based on Jones Falls Inflow/Infiltration Report

[2] Acceptable Range is defined as: +25/-15% (peak flow) and +20/-10% (total volume)

[3] Winter Wet-Weather Calibration discussion focus (more conservative approach)

TABLE 5-3.1 MODEL CALIBRATION SUMMARY TABLE

Meter Basin ID	Meter Manhole No.	Identified as Exhibiting High I/I (yes/no)[1]	Contributing Meter Basin(s)		Dry-Weather Calibration Percent Difference between Observed vs. Calibrated		Wet-Weather Calibration Percent of Storms Outside Acceptable Range[2]		Vulnerability and Reason for Over/Under Prediction in Basin	
			Meter Basin ID	Identified as Exhibiting High I/I (yes/no)[1]	Total Volume	Peak Flow	Peak Flow	RDII Volume		
JF0320S	S04II2004	Yes	None	N/A	-23%	0%	67% (2 under-predict -35% to -20% and 2 over predict 36% to 45%)	33% (1 under-predicts -17% and 1 over-predicts 30%)	Significant - Model predicts SSOs beginning with the 2-yr storm	Monitored data flow appears to be impacted differently by each storm event, causing the model to over and under predict.
JFWR09	S17GG2004	Yes	None	N/A	-6%	1%	67% (2 under-predict from -40% to -14% and 2 over-predicts 20% to 191%)	50% (1 under-predicts -20% and 2 over-predict 60% to 25%)	Low - No SSOs for storms up to and including a 20-year storm	Monitored data flow appears to be impacted differently by each storm event, causing the model to over and under predict.
JFWR15	S05II2003	No	None	N/A	-13%	6%	17% (1 over-predict 525%)	33% (1 under-predicts -21%, 1 over-predicts 99%)	Low - No SSOs for storms up to and including a 20-year storm	Model over-predicts drastically only during the 7/5/2006 storm. The only other volume under-prediction is slightly outside criteria which could have been caused by rounding.
JFWR29	S04EE2004	Yes	None	N/A	-13%	9%	16% (1 over-predict from 203%)	50% (3over-predict 31% to 51%)	Significant - Model predicts SSOs beginning with the 2-yr storm	The only over-prediction in the peak is during the 7/5/2006 storm. The volume over-prediction (besides the one caused by the 7/5/2006 storm) is close to the volume tolerance and could have been impacted by less flow being recorded during the storms in question by the flow monitor
JFWR31	S06II2012	No	None	N/A	-17%	-7%	50% (3 over-predict 52% to 287%)	83% (2 under-predict -15% and 3 over-predict 34% to 42%)	Significant - Model predicts SSOs beginning with the 2-yr storm	Monitored data flow appears to be impacted differently by each storm event, causing the model to over and under predict.
JFWR35	S13GG2016	No	None	N/A	-28%	9%	50% (2 under-predict -47% to -28% and 1 over-predicts 679%)	22% (1 under-predicts -27% and 1 over-predicts 113%)	Low - No SSOs for storms up to and including a 20-year storm	Model over-predicts drastically only during the 7/5/2006 storm. The model under-predicts peak and volume during the 10/19/2006 storm but it is slightly outside of the criteria. The flow monitored could have recorded additional flow during that particular storm only. The over model under-prediction could have also been impacted by flow monitoring recording additional flow.

**In the 7/5/2006 storm all the boundary meters monitored data (listed above) did not respond to the storm causing significant over-predictions in the model

5.4 Baseline Capacity Analysis (CD Ref P10.C.viii)

An evaluation and assessment of the existing and future capacity of the collection, pumping and transmission system is required using the calibrated model. The calibrated model was used to analyze the response of the collection system under dry-weather flow and during five (5) design storm events under baseline and future (Year 2025) flow conditions and to evaluate the ability of the collection, pumping and transmission system to convey peak flows under both dry- and wet-weather conditions. These design storms include the following:

DESIGN STORM DATA					
Design Storm	2-Year/ 6-Hour Storm	2-Year/ 24-Hour Storm	10-Year/ 6-Hour Storm	10-Year/ 24-Hour Storm	20-Year/ 24-Hour Storm
Total Rainfall (in.)	2.37	3.38	3.50	5.19	5.80
*Peak Intensity (in/hr)	1.84	4.63	2.71	7.11	7.95
**Average Intensity (in/hr)	0.39	0.14	0.58	0.22	0.24

*Peak Intensity based on 0.1 hour increment
**Average Intensity based on entire duration of the storm

The rainfall distribution used is the SCS Type II distribution developed by the U.S. Natural Resources Conservation Service (NRCS).

As stated in the CD, Paragraph 9, the baseline condition is defined as the conditions in effect at the time flow metering is completed.

Boundary conditions were applied in the model at the model's connection points with the City of Baltimore. These boundary conditions are time series data for each design storm event that were provided by the City of Baltimore based on the City's modeling of the Jones Falls collection system. The boundary conditions represent the flow level expected at the connection points between the City of Baltimore and Baltimore County. The boundary conditions were provided on June 9, 2011 and were applied for both baseline and future conditions. The boundary conditions received from the City of Baltimore are provided in **Appendix J** of this report.

The baseline and future conditions differ in several parameters:

- Population and employment will increase from the baseline conditions (Year 2008) to the future conditions (Year 2025). Based on population and employment projections provided by Baltimore County, the population will increase approximately 4.7 percent from the baseline to future conditions and employment will increase by approximately 2.9 percent.

- Non-Pumping Station SSOs 113 (Marnat Avenue) and 120 (Charles Street Avenue) were open during the flow metering period and were included in the baseline model. A third SSO, SSO 31A (Rider Avenue), was eliminated by Baltimore County prior to the start of the flow metering and was therefore not included in the baseline model. SSO 120 (Charles Street Avenue) was sealed on September 20, 2011 and SSO 113 (Marnat Avenue) will be eliminated in the future. None of the Non-Pumping Station SSOs are included in the future conditions model.
- The future conditions model includes the rehabilitation of sewers and manholes in SSA's 45-10-22-01 and 45-58-06-02, which are located upstream of SSOs 113 and 120, respectively. Following the Baltimore County SRRR guidelines, the modeling of rehabilitated pipes included a 35 percent reduction of RDII and a 23 percent reduction of the BI. Additionally, the friction coefficient was revised to match that of a smoother pipe surface (reduced Manning's "n" value) that is the result of installation of the cured-in-place pipe lining (CIPP).
- Pumping station capacities under baseline conditions reflect the conditions that existed during the flow metering period. The future (Year 2025) conditions model incorporates the ultimate pumping station capacities.

Capacity Analysis Results

There are no model-predicted overflows or surcharges that occur during dry-weather conditions in the baseline model. Furthermore, the model predicts that none of the non-pumping station SSOs would activate during dry-weather.

Under baseline conditions, the model predicts SSOs for design storms beginning with the 2-year/24-hour storm. The model predicts that Non-Pumping Station SSOs 113 and 120 become active during wet-weather under baseline conditions. SSO 113 becomes active during the 2-year/6-hour storm and SSO 120 becomes active during the 10-year/24-hour storm. A summary of the model results under baseline conditions is presented in **Table 5-4.1**:

Table 5-4.1
Jones Falls SRRR: Corrective Action Recommendation Plan
SUMMARY OF BASELINE MODEL ANALYSIS

Storm Event	Total Number of SSOs	Total Volume of Overflows (MG)
2-Year/6-Hour Storm	8	0.1111
2-Year/24-Hour Storm	14	0.5258
10-Year/6-Hour Storm	14	0.8483
10-Year/24-Hour Storm	29	3.5005
20-Year/24-Hour Storm	38	5.1425

The model-predicted overflows listed in the Hydraulic Capacity Assessment Report, provided in **Appendix K** of this report and in **Table 5-4.1**, were reduced by the incorporation of additional 8-inch diameter collection system piping and revisions to the flow loading locations into the model. The addition of these 8-inch diameter pipes eliminate falsely predicted SSOs in the model that were caused by isolated flow loading points rather than actual collection system deficiencies.

Table 5-4.2 lists the manhole number and volume of overflow for each design storm event under baseline conditions. A complete description of the capacity analysis is presented in the Jones Falls Hydraulic Capacity Assessment Report, included in **Appendix K** of this report.

Table 5-4.2
Jones Falls SRRR: Corrective Action Recommendation Plan
BASELINE CONDITIONS - MODEL PREDICTED SSO VOLUMES (MG)

	Manhole No.	SSA	2-Year/ 6-Hour Storm	2-Year/ 24-Hour Storm	10-Year/ 6-Hour Storm	10-Year/ 24-Hour Storm	20-Year/ 24-Hour Storm
1	6883	45-54-00-00	0	0	0	1.1382	1.8882
2	6954	45-59-16-01	0.0024[1]	0.0354	0.0688	0.1827	0.2433
3	7252	45-59-34-00	0.0018[1]	0.0451[1]	0.0514[1]	0.1506[1]	0.1902[1]
4	7254	45-59-34-00	0.0006[1]	0.0038[1]	0.0062[1]	0.0082[1]	0.0101[1]
5	7289	45-59-34-00	0.0008[1]	0.0017[1]	0.0026[1]	0.0028[1]	0.0032[1]
6	7298	45-58-01-00	0	0	0	0.0221[1]	0.0465[1]
7	7315	45-58-05-00	0	0	0	0	0.0152[1]
8	7332	45-58-06-01	0	0	0	0	0.0024[1]
9	17752	45-55-01-00	0	0	0	0	0.0006
10	17755	45-55-02-00	0	0	0	0.0506[1]	0.0824
11	17757	45-55-02-00	0	0	0	0.0017	0.0123
12	20756	45-60-00-00	0	0	0	0.0827	0.1365
13	20758	45-60-00-00	0	0	0	0.2274	0.2828
14	20768	45-65-00-00	0	0	0	0.0894	0.1592
15	20775	45-66-04-00	0	0	0	0	0.001
16	22010	45-59-18-00	0.0544[1]	0.1203	0.1887	0.2237	0.2568
17	22012	45-59-19-00	0.0196[1]	0.1419	0.2206	0.2745	0.3117
18	22013	45-59-19-00	0	0.0759	0.1258	0.3429	0.4334
19	30726	45-66-03-00	0	0	0	0.0087	0.021
20	32258	45-66-09-02	0	0	0	0	0.0082
21	32260	45-66-09-02	0	0	0	0	0.0027
22	33527	45-66-08-00	0	0	0	0.0317	0.0766
23	33530	45-66-09-02	0	0	0	0	0.0002[1]
24	33531	45-66-09-02	0	0	0	0	0.0001[1]
25	33707	45-62-01-00	0	0	0	0.1496	0.2051
26	33708	45-62-01-00	0	0	0	0.0239	0.0466
27	44213	45-70-00-00	0	0	0	0.0117	0.0168
28	44215	45-70-00-00	0	0	0	0	0.0002
29	44219	45-71-00-00	0	0.0142	0.034	0.0802	0.1045

Table 5-4.2
Jones Falls SRRR: Corrective Action Recommendation Plan
BASELINE CONDITIONS - MODEL PREDICTED SSO VOLUMES (MG)

	Manhole No.	SSA	2-Year/ 6-Hour Storm	2-Year/ 24-Hour Storm	10-Year/ 6-Hour Storm	10-Year/ 24-Hour Storm	20-Year/ 24-Hour Storm
30	53270	45-69-00-00	0	0	0	0.0085	0.0123
31	55251	45-58-01-00	0	0	0	0.0595[1]	0.1453[1]
32	7052M	45-59-30-01	0	0	0	0.002[1]	0.0038[1]
33	1583	45-10-22-02	0	0.0052	0.009	0.0146	0.0148
34	1585	45-68-15-01	0	0.003	0.0062	0.0352	0.0519
35	3410	45-10-21-00	0	0.0009[1]	0.0036[1]	0.0112[1]	0.0111[1]
36	15756	45-10-22-01	0.0234[1]	0.0655[1]	0.1081[1]	0.1803[1]	0.223[1]
37	15754	45-10-22-01	0.0081[1]	0.0126[1]	0.0209[1]	0.0207[1]	0.0227[1]
38	901644	45-10-21-00	0	0.0003[1]	0.0024[1]	0.0652[1]	0.0998[1]
		TOTALS:	0.1111	0.5258	0.8483	3.5005	5.1425

[1] Model-predicted SSOs eliminated by inclusion of additional network and revisions to flow loading locations

5.5 Future Condition Capacity Analysis (CD Ref P10.C.ix)

Future conditions are defined as the expected hydraulic conditions that would exist in Year 2025, using population and employment projections. Section 5.4 describes the differences between the baseline and the future conditions. For future conditions, it has been assumed that the BI due to pipe deterioration will be minimal, so the same value for BI is used for baseline and future conditions, except in those areas where pipe and manhole rehabilitation is planned or has been completed.

Boundary conditions were applied in the model at the model's connection points with the City of Baltimore. These boundary conditions are time series data for each design storm event that were provided by the City of Baltimore based on the City's modeling of the Jones Falls collection system. The boundary conditions represent the flow level expected at the connection points between the City of Baltimore and Baltimore County. The boundary conditions were provided on June 9, 2011 and were applied for both baseline and future conditions. The boundary conditions received from the City are provided in **Appendix J** of this report.

Capacity Analysis Results

Similar to the baseline conditions model, there are no model-predicted overflows or surcharges during dry-weather conditions for the future conditions model. A summary of the model results under future conditions is presented in **Table 5-5.1**:

Table 5-5.1 Jones Falls SRRR: Corrective Action Recommendation Plan **SUMMARY OF FUTURE MODEL ANALYSIS**		
Storm Event	Total Number of SSOs	Total Volume of Overflows (MG)
2-Year/6-Hour Storm	9	0.1356
2-Year/24-Hour Storm	15	0.5609
10-Year/6-Hour Storm	15	0.8773
10-Year/24-Hour Storm	30	3.3431
20-Year/24-Hour Storm	37	4.9449

The model-predicted overflows listed in the Hydraulic Capacity Assessment Report, provided in **Appendix K** of this report and in **Table 5-5.1**, were reduced by the incorporation of additional 8-inch diameter collection system pipes and revisions to the flow loading locations into the model. The addition of these 8-inch diameter pipes eliminate falsely predicted SSOs that were caused by isolated flow loading points in the model rather than actual collection system deficiencies.

Table 5-5.2 lists the manhole number and the volume of overflow for each design storm event under future conditions. A complete description of the capacity analysis is presented in the Jones Falls Hydraulic Capacity Assessment Report, included in **Appendix K** of this report.

Table 5-5.2 Jones Falls SRRR: Corrective Action Recommendation Plan **FUTURE CONDITIONS - MODEL PREDICTED SSO VOLUMES (MG)**							
	Manhole No.	SSA	2-Year/ 6-Hour Storm	2-Year/ 24-Hour Storm	10-Year/ 6-Hour Storm	10-Year/ 24-Hour Storm	20-Year/ 24-Hour Storm
1	6883	45-54-00-00	0	0	0	1.031	1.7816
2	6954	45-59-16-01	0.003[1]	0.0374	0.0597	0.1832	0.2441
3	7252	45-59-34-00	0.0019[1]	0.046[1]	0.053[1]	0.1515[1]	0.1915[1]
4	7254	45-59-34-00	0.0005[1]	0.0033[1]	0.0049[1]	0.0077[1]	0.009[1]
5	7289	45-59-34-00	0.0008[1]	0.0017[1]	0.0025[1]	0.0028[1]	0.0031[1]
6	7298	45-58-01-00	0	0	0	0.0034[1]	0.0249[1]
7	17752	45-55-01-00	0	0	0	0	0.0006
8	17755	45-55-02-00	0	0	0	0.0507	0.0826
9	17757	45-55-02-00	0	0	0	0.0016	0.0121
10	20756	45-60-00-00	0	0	0	0.0558	0.109
11	20758	45-60-00-00	0	0	0	0.2067	0.262
12	20768	45-65-00-00	0	0	0	0.0966	0.1681
13	20775	45-66-04-00	0	0	0	0	0.001
14	22010	45-59-18-00	0.0568[1]	0.1235	0.1909	0.228	0.261
15	22012	45-59-19-00	0.0223[1]	0.1455	0.2238	0.2785	0.3156

Table 5-5.2 Jones Falls SRRR: Corrective Action Recommendation Plan FUTURE CONDITIONS - MODEL PREDICTED SSO VOLUMES (MG)							
	Manhole No.	SSA	2-Year/ 6-Hour Storm	2-Year/ 24-Hour Storm	10-Year/ 6-Hour Storm	10-Year/ 24-Hour Storm	20-Year/ 24-Hour Storm
16	22013	45-59-19-00	0	0.0802	0.1286	0.3492	0.4397
17	30726	45-66-03-00	0	0	0	0.01	0.0225
18	32258	45-66-09-02	0	0	0	0	0.009
19	32260	45-66-09-02	0	0	0	0	0.0034
20	33527	45-66-08-00	0	0	0	0.0382	0.0837
21	33530	45-66-09-02	0	0	0	0	0.0003[1]
22	33531	45-66-09-02	0	0	0	0	0.0003[1]
23	33707	45-62-01-00		0	0	0.1572	0.2129
24	33708	45-62-01-00	0	0	0	0.0275	0.0515
25	44213	45-70-00-00	0	0	0	0.0121	0.0173
26	44215	45-70-00-00	0	0	0	0	0.0002
27	44219	45-71-00-00	0	0.0156	0.0344	0.0815	0.106
28	53270	45-69-00-00	0	0	0	0.0087	0.0124
29	55251	45-58-01-00	0	0	0	0.0014[1]	0.0585[1]
30	7052M	45-59-30-01	0	0	0	0.002[1]	0.0038[1]
31	1583	45-10-22-02	0	0.0053	0.0089	0.0129	0.0148
32	1585	45-68-15-01	0	0.003	0.0063	0.0369	0.052
33	3410	45-10-21-00	0	0.0012[1]	0.0038[1]	0.0094[1]	0.0113[1]
34	15753	45-10-22-01	0.0093[1]	0.0103[1]	0.0156[1]	0.0158[1]	0.0176[1]
35	15754	45-10-22-01	0.0168[1]	0.0203[1]	0.0324[1]	0.0313[1]	0.0341[1]
36	15756	45-10-22-01	0.0242[1]	0.067[1]	0.1097[1]	0.1827[1]	0.2256[1]
37	901644	45-10-21-00	0	0.0006[1]	0.0028[1]	0.0688[1]	0.1018[1]
		TOTALS	0.1356	0.5609	0.8773	3.3431	4.9449

[1] Model-predicted SSOs eliminated by inclusion of additional network and revisions to flow loading locations

5.6 Long Term Capacity/Peak Flow Management Evaluation (CD Ref P10.C.ii)

In accordance with Paragraph 9 of the CD, calibrated model simulations and analyses were conducted to identify, evaluate and recommend the corrective actions necessary to eliminate model-predicted SSOs for each of the five (5) design storms. The future conditions (Year 2025) model was used for this alternative analysis.

The expanded model network and revisions to the flow loading locations discussed in Sections 5.4 and 5.5 impacted the model results for the five (5) synthetic design storm simulations. For the 2-year/6-hour design storm, the expanded model network and revisions to the flow loading locations eliminated all the model-predicted SSOs and therefore no corrective actions are necessary for this design storm. The LTC/PFME Report provided in **Appendix L** of this report summarizes the recommended corrective actions for each design storm.
A description of the complete alternative analysis results and cost estimates is included in the

Jones Falls Sewershed's LTC/PFME Report, which is provided in **Appendix L** of this report.

5.6.1 SSO Control Improvement

Paragraph 9.C.ii.d of the CD indicates that improvements to the collection system to ensure adequate capacity must be identified and the improvements considered should include:

- Increasing pumping station capacity
- Rehabilitation of sewers and manholes to reduce I/I
- Installation of larger replacement pipes or relief sewers

The future conditions model incorporates the closure of Non-Pumping Station SSOs 31A, 113 and 120, and the completion of Paragraph 7 projects for rehabilitation of SSA's 45-10-22-01 and 45-58-06-02, which drain to SSOs 113 and 120, respectively. Rehabilitation of SSA 45-10-22-01 (SSO 113) was completed under Contract 09124 SXO in early 2012 and rehabilitation of SSA 45-58-06-02 (SSO 120) was completed under Contract 10034 SXO in July 2011. Two (2) of the three (3) non-pumping station SSOs have already been eliminated. These include Non-Pumping Station SSO 31A, which was closed on May 11, 2007 and Non-Pumping Station SSO 120, which was sealed on September 20, 2011. The County continues to coordinate with the City of Baltimore regarding the capacity improvements of the sewers located downstream of SSO 113 in the City, and is evaluating options for design and construction of a County relief sewer to eliminate activation of this SSO.

5.6.2 Assumptions

The following assumptions were made during the analysis of the LTC/PFME:

- Following the Baltimore County SRRR Guidelines, it was assumed that rehabilitation would reduce BI by 23 percent, the total RDII volume by 35 percent and the peak RDII flow by 37 percent when possible. Due to the complexity of the collection system, in some cases a reduction of 36 percent of the capture coefficient was implemented.
- BI due to pipe deterioration will be minimal, so the same value for BI is used for baseline and future conditions, except in those areas where pipe and manhole rehabilitation is planned or has already been completed.
- The ultimate pumping station capacities were used.

5.6.3 Cost Estimation

To estimate the corrective action costs for elimination of model-predicted SSOs, Table 4-5 from the Baltimore County SRRR Plan Guidelines was used. This table includes unit costs for corrective actions including: in-situ (in-place) sewer repairs; lateral connection repairs; sewer lining; pipe replacement; pipe bursting; sewer point repairs; sliplining; installation of manhole frame seals; manhole inflow inserts; manhole lining and manhole replacement. Cost estimates were prepared for each design storm event.

A complete description of the corrective action analyses is presented in the Jones Falls Sewershed LTC/PFME Report, which is included in **Appendix L** of this report.

END OF SECTION

Section 6

Corrective Action Recommendation Plan

6.0 Corrective Action Recommendation Plan (CD Ref. P.10.C.iii-vii)

6.1 Overview

The Corrective Action Recommendation Plan discussed in this section consists of various structural and hydraulic corrective action recommendations needed to address the deficiencies identified during the collection system investigations and modeling activities for the Jones Falls Sewershed. The Plan also identifies specific rehabilitation and other corrective actions needed to eliminate model predicted sanitary sewer overflows (SSOs) that were determined by the Long-Term Capacity/Peak Flow Management Evaluation (LTC/PFME). Previous chapters of this SRRR Plan present detailed discussions of the various investigations that were completed, and provide a summary of the deficiencies that were identified. The condition related corrective action recommendations were defined based on review of field inspection and SSES data such as sewer and manhole inspections, smoke and dyed-water testing and night-flow isolation investigations as discussed in Section 4 of this report. As discussed in Sections 3 and 5 of this report, the hydraulic corrective actions were determined by modeling and the inflow and infiltration (I/I) analysis. Data analysis and evaluation was utilized to identify the necessary corrective actions required to address the deficiencies identified within the collection system. Some identified condition corrective actions were superseded by hydraulic corrective action recommendations. As an example, a recommended sewer insitu spot repair (repair to correct a specific defective area in a segment of pipe) would not be necessary if the sewer segment was recommended for cured-in-place (CIPP) lining to address hydraulic capacity deficiencies.

This section provides a brief discussion of the corrective actions that have or is in the process of being completed within the Jones Falls Sewershed to address collection system deficiencies, followed by the recommended corrective actions. Estimates of probable construction costs required to implement the recommended corrective actions have also been provided.

6.2 Completed Corrective Actions (CD Ref. P.10.Ciii)

Baltimore County has completed several remedial corrective actions within the Jones Falls Sewershed as required by Paragraph 7 of the Consent Decree (CD). These include I/I reduction and pumping station and force main assessment and upgrade projects. The County has also eliminated several Non-Pumping Station SSO structures.

The total cost of the projects implemented to date by Baltimore County in the Jones Falls Sewershed is approximately $6.35 Million. The following is an overview of the corrective actions that have been completed in the Jones Falls Sewershed to date.

6.2.1 Pumping Station Improvements

As detailed in Section 4, the Jones Falls Sewershed contains four (4) pumping stations. These include the Buchanan Road Pumping Station; the Stanton Woods Pumping Station; the Templegate Pumping Station and the Stevenson Pumping Station. The County is currently undertaking, or has previously completed, measures set forth in Paragraph 13 of the CD for these pumping stations. The County has completed an Engineering Evaluation and Condition Assessment (EE/CA) for all four (4) of the pumping stations as required by Paragraph 13.F of the CD. Reports have been submitted for review and approval in accordance with Paragraph 13.F.iii of the CD. All deficiencies defined in Paragraph 13.F.iv of the CD, and outlined in the EE/CA reports for the Buchanan Road, Stanton Woods and the Templegate Pumping Stations are being completed in accordance with Paragraph 13.F.iv.(a) of the CD. The work and costs associated with these pumping stations is summarized below:

- Buchanan Road Pumping Station - The conceptual cost estimate for the upgrades to the Buchanan Road Pumping Station is $1,580,525.
- Stanton Woods Pumping Station - The conceptual cost estimate for the upgrades to the Stanton Woods Pumping Station is $1,135,000.
- Templegate Pumping Station - The conceptual cost estimate for the upgrades to the Templegate Pumping Station is $1,687,033.
- Stevenson Pumping Station - Construction of the new Stevenson Pumping Station was completed in May of 2011. The cost for the upgrades to this station was $921,000.

6.2.2 Sewer/Manhole Rehabilitation for Non-Pumping Station SSO Structure Elimination

As detailed in Section 2, the Jones Falls Sewershed contains three (3) Non-Pumping Station SSOs. These include SSO 31A (Rider Avenue), located in Meter Basin BC11; SSO 113 (Marnat Road), located in Meter Basin JF0320S; and SSO 120 (Charles Street Avenue), which is located in Meter Basin BC12. The County has completed sewer and manhole rehabilitation projects in several of the SSA's that are tributary to these SSOs to eliminate overflows. This work is summarized below:

- Rider Avenue Non-Pumping Station **SSO 31A** – The SSO was eliminated on May 11, 2007 by the County at nominal cost, and post elimination flow monitoring of the SSO was conducted in accordance with Section V.7.C.v of the CD.

- Marnat Road Non-Pumping Station **SSO 113** – Under Contract 09124 SXO, forty-four (44) manholes were rehabilitated, 7,149 linear feet (LF) of sewer was lined and seventy-two (72) sewer house connections were sealed. The work was completed in June 2012 at a cost of $442,928 and post-rehabilitation flow monitoring of the SSO is currently being conducted in accordance with Section V.7.C.v of the CD.

- Charles Street Avenue Non-Pumping Station **SSO 120** – Under Contract 10034 SX0, forty-eight (48) manholes were rehabilitated, seven (7) point repairs were completed, 13,826 LF of sewer was lined and 323 sewer house connections were sealed. The work was completed in July of 2011 at a cost of $585,022 and the SSO was eliminated on September 20, 2011. The County continues to monitor the SSO in accordance with Section V.7.C.v of the CD.

6.3 Priority Scheme Identification

For the purpose of prioritizing defects identified through the collection system investigations, the County prioritized the inspection data review to address sewer and manhole defects that may contribute to SSOs in the collection system. This prioritization process included review of the CCTV and manhole inspection data in accordance with the criteria set forth in Paragraph 8 of the CD. Reviews included all Paragraph 8.C.ii, 8.C.ia, and 8.C.iv sanitary sewers and manholes that had Bureau of Utilities (BU) or National Association of Sewer Service Companies (NASSCO) Pipeline Assessment and Certification Program (PACP) ratings of 4 or 5. The PACP ratings were used when a BU rating was not available. Manholes were rated by the inspection crews and review of the data prioritized using the structural and I/I ratings to develop pertinent corrective actions to address the deficiencies identified.

Reviews were also completed for all sewers and manholes that were located in meter basins that exhibited excessive I/I identified through the I/I analysis, regardless of CD Paragraph designation or rating. These priority basins included: BC02, BC03, BC04, BC05, BC07, BC09, BC14 and BC16.

The County has also identified specific sewer defects that, based on the County's experience, may compromise the structural integrity of the sewer. **Table 6-3.1 – Critical Defect Summary** provides a listing of these specific defects. Sewers with critical defects were also reviewed.

Table 6-3.1
Jones Falls SRRR: Corrective Action Recommendation Plan
CRITICAL DEFECT SUMMARY

Structural Defect Description			
Defect Group	Defect Descriptor/Modifier	Value Reference	PACP Code
Lining Failure	Detached	---	LFD
Surface Damage	---	---	S
	Aggregate Missing	---	SAM
	Reinforcement Visible	---	SRV
	Reinforcement Projecting	---	SRP
	Reinforcement Corroded	---	SRC
	Missing Wall	---	SMW
	Corrosion	---	SCP
Hole	---	---	H
	Soil Visible	---	HSV
	Void Visible	---	HVV
Deformed	---	---	D
	Vertical	---	DV
	Horizontal	---	DH
Collapse	---	---	P
	Pipe	---	XP

Table 6-3.1 Jones Falls SRRR: Corrective Action Recommendation Plan **CRITICAL DEFECT SUMMARY**			
Structural Defect Description			
Defect Group	Defect Descriptor/Modifier	Value Reference	PACP Code
	Brick	---	XB
Weld Failure	Longitudinal	---	WFL
	Circumferential	---	WFC
	Multiple	---	WFM
	Spiral	---	WFS
Fracture	Multiple	---	FM
Broken	---	---	B
	Soil Visible	---	BSV
	Void Visible	---	BVV
Brickwork	Missing	---	MB
	Dropped Invert	Large	DI
	Missing Mortar	Large	MM

6.4 Structural Deficiency Corrective Action Plan

Structural defects identified in the sewers and manholes in the County's Priority Scheme Identification Plan as described in Section 6.3 of this report may contribute to a SSO, and therefore will be addressed by the County.

Table 6-4.1 – Manhole Condition Rating Summary summarizes the condition ratings of the manholes that were reviewed in support of the Jones Falls Sewershed SRRR Plan.

Table 6-4.1 Jones Falls SRRR: Corrective Action Recommendation Plan **MANHOLE CONDITION RATING SUMMARY**			
Overall Rating	Rating Description	Manhole Count	Percent
1	Excellent Condition	464	65.2%
2	Good Condition	165	23.2%
3	Fair Condition	50	7.0%
4	Poor Condition	29	4.1%
5	Immediate Attention Required	4	0.6%
	Totals:	712	100%

Table 6-4.2 – Manhole Condition Rating Summary By Meter Basin further defines and summarizes the condition ratings of the manholes that were reviewed by flow meter basin.

Table 6-4.2
Jones Falls SRRR: Corrective Action Recommendation Plan
MANHOLE CONDITION RATING SUMMARY BY METER BASIN

Flow Meter Basin	Manholes Reviewed	No. of Manholes by Overall Condition Rating				
		1	2	3	4	5
BC02	64	52	5	7	0	0
BC03	17	15	1	1	0	0
BC04	97	71	16	10	0	0
BC05	125	51	65	6	3	0
BC07	24	22	1	1	0	0
BC08	2	0	0	0	2	0
BC09	256	170	61	22	3	0
BC11	6	1	1	0	3	1
BC12	10	3	0	0	6	1
BC14	4	0	3	1	0	0
BC15	1	0	1	0	0	0
BC16	94	79	11	2	2	0
BC18	1	0	0	0	0	1
BC20	1	0	0	0	1	0
BC25	1	0	0	0	1	0
JFWR15	4	0	0	0	4	0
TSJF01	5	0	0	0	4	1
Totals:	712	464	165	50	29	4

Table 6-4.3 – Manhole Condition Rating Summary By SSA contained in **Appendix M** of this report summarizes the condition ratings of the manholes that were reviewed by SSA.

Table 6-4.4 – Sewer Condition Rating Summary summarizes the condition ratings of the sanitary sewers that were reviewed as part of the Jones Falls Sewershed SRRR Plan.

Table 6-4.4
Jones Falls SRRR: Corrective Action Recommendation Plan
SEWER CONDITION RATING SUMMARY

Overall Rating	Rating Description	Sewer Count	Percent
1	Excellent Condition	488	42.3%
2	Good Condition	275	23.9%
3	Fair Condition	220	19.1%
4	Poor Condition	92	8.0%
5	Immediate Attention Required	78	6.8%
	Totals:	1,153	100%

Table 6-4.5 – Sewer Condition Rating Summary By Meter Basin further defines and summarizes the condition ratings of the sanitary sewers that were reviewed by flow meter basin.

Table 6-4.5 Jones Falls SRRR: Corrective Action Recommendation Plan **SEWER CONDITION RATING SUMMARY BY METER BASIN**						
Flow Meter Basin	Sewer Segments Reviewed	No. of Sewers by Overall Rating				
		1	2	3	4	5
BC01	15	2	5	5	2	1
BC02	64	40	17	4	1	2
BC03	20	18	0	1	0	1
BC04	94	46	21	17	5	5
BC05	118	102	9	3	3	1
BC06	4	1	0	0	1	2
BC07	27	16	1	6	3	1
BC08	11	4	6	0	1	0
BC09	267	150	59	36	13	9
BC10	30	3	9	10	5	3
BC11	16	1	6	8	0	1
BC12	167	19	40	54	30	24
BC13	24	4	11	7	1	1
BC14	19	5	6	4	3	1
BC15	1	1	0	0	0	0
BC16	69	43	9	4	7	6
BC20	13	1	8	3	1	0
BC24	38	6	17	10	4	1
BC25	7	2	2	3	0	0
BC26	12	4	4	2	1	1
JFWR15	55	9	24	16	1	5
JFWR29	29	2	11	14	0	2
JFWR31	17	3	4	6	3	1
JFWR35	8	1	1	5	1	0
TSJF01	28	5	5	2	6	10
Totals:	1,153	488	275	220	92	78

Table 6-4.6 – Sewer Condition Rating Summary By SSA contained in **Appendix N** of this report defines and summarizes the ratings of the sanitary sewers that were reviewed by SSA.

6.5 Recommended Collection System Improvements

After the manhole, sewer and capacity deficiencies were determined, rehabilitation methods were reviewed and pertinent rehabilitation and repair technologies and corrective actions were selected to address the specific manhole and sanitary sewers that contained defects.

6.5.1 Recommended Manhole Improvements

The following manhole repair or rehabilitation methods were selected to address structural and/or operational and maintenance (O&M) deficiencies identified in the manhole structures:

- Clean Manhole was recommended for manholes that contained excess debris and/or root intrusion that would not be addressed under the manhole lining work or when additional repair work was not specified for the manhole.
- Frame Seals were recommended when infiltration was identified in either the frame and cover adjustment area or at the interface between the structure and the frame and cover. The frame seal could be either internally or externally installed.
- Inflow Inserts were recommended when inflow was observed around the manhole cover or when the cover was subject to ponding.
- Manhole Lining was recommended for manholes with significant cracks, fractures, infiltration defects, or surface damage (chemical and mechanical)
- Replacement of the Manhole was recommended for manholes that were so severely deteriorated that rehabilitation was not an option.
- Replacement of the Frame and Cover was recommended for manholes that contained defective manhole frame and covers. This could also be referenced to install water-tight frames and covers when sealing of the manhole was required to prevent an SSO.
- Resetting of the Frame and Cover was recommended when the existing frame and cover was in serviceable condition, but dislodged and not affixed to the structure.

Table 6-5.1 contained in **Appendix O** of this report lists all recommended manhole improvements.

6.5.2 Recommended Sanitary Sewer Improvements

The following sewer repairs and/or sewer rehabilitation methods were selected to address structural and/or O&M type deficiencies that were identified in the sanitary sewers:

- Sewer Lining (CIPP) was recommended for pipes containing cracks, fractures or infiltration defects. CIPP lining was also recommended for pipes that contained encrustations or root defects because encrustation indicates infiltration and roots are a source of infiltration. This is a trenchless method that reinstates the structural integrity of the sewer and reduces infiltration in a pipe segment. As part of the lining process, lateral reinstatements shall be air tested and grouted to provide a watertight connection to the liner system.

- Insitu (in-place) Repairs were recommended when short sections of pipe contained holes, fractures of other isolated defects that could be addressed without the need for excavation. Spot repairs are a modified form of CIPP pipe lining, which can be used for localized pipe repairs (3 to 20 feet in length) instead of open cut excavation.

- Point Repairs ("Excavate and Replace") were recommended for pipe segments that contained holes, offset joints, breaks, multiple fractures or pipe ovality that was greater than 10% and could not be rehabilitated using a CIPP liner. This work typically involves open-cut excavation to replace the damaged pipe with a new pipe segment. In open-cut situations, PVC pipe of the same or larger diameter as the existing pipe will be installed and reconnected to existing service laterals.

  It should be noted, that a combination of defects may require the use of several repair methods to correct the deficiencies identified in a pipe segment. This could include completing a "Dig-Up and Replace Point Repair, an Insitu (in-place) Spot Repair and CIPP Lining of the entire sewer segment. For example, if a pipe segment was identified to have a break and significant (40%) loss of cross-sectional area in addition to other structural defects, an open-cut point repair may be required to repair the break prior to CIPP lining the sewer segment to address the remaining defects in the sewer segment.

- Lateral Connection Repairs were recommended for each defective or leaking service connection to reduce infiltration. The sewer house connection repair consisted of the CIPP lining of the first 2 to 3 feet of the lateral pipe and the full circumference of the mainline sewer at the connection with a one-piece sewer house connection seal. Depending on the condition of the lateral connection at the time of design, CIPP lining, chemical or structural grouting or open-cut lateral connection replacement are also options that should be considered. All defective connections should be assessed during the design phase to determine the most appropriate method of repair/rehabilitation.

Table 6-5.2 in **Appendix O** contains all of the recommended mainline sewer repairs by sewer segment.

A summary of the recommended sewer and manhole corrective action improvements by flow meter basin are shown in **Table 6-5.3 – Recommended Sewer and Manhole Condition Improvements By Meter Basin**.

Table 6-5.3
Jones Falls SRRR: Corrective Action Recommendation Plan
RECOMMENDED SEWER AND MANHOLE CONDITION IMPROVEMENTS BY METER BASIN

Flow Meter Basin	Sewers				Manholes						
	In-Situ Repair all sizes (LF)	Sewer Lining all sizes (LF)	Point Repair all sizes (Ea.)	Lateral Conn. Repair (Ea.)	Clean Manhole (Ea.)	Replace MH Frame and Cover (Ea.)	Reset MH Frame and Cover (Ea.)	Install Frame Seal (Ea.)	Install Inflow Insert (Ea.)	Replace Manhole (Ea.)	MH Lining (Ea.)
BC01	0	1,806	0	9	0	0	0	0	0	0	0
BC02	0	0	0	69	26	0	0	27	5	0	0
BC03	0	0	0	2	0	0	3	12	0	0	0
BC04	0	0	1	87	16	0	2	61	3	0	0

Table 6-5.3 Jones Falls SRRR: Corrective Action Recommendation Plan **RECOMMENDED SEWER AND MANHOLE CONDITION IMPROVEMENTS BY METER BASIN**											
	Sewers				**Manholes**						
Flow Meter Basin	In-Situ Repair all sizes (LF)	Sewer Lining all sizes (LF)	Point Repair all sizes (Ea.)	Lateral Conn. Repair (Ea.)	Clean Manhole (Ea.)	Replace MH Frame and Cover (Ea.)	Reset MH Frame and Cover (Ea.)	Install Frame Seal (Ea.)	Install Inflow Insert (Ea.)	Replace Manhole (Ea.)	MH Lining (Ea.)
BC05	5	1232	0	5	10	14	4	82	68	0	42
BC06	5	0	0	1	0	0	0	0	0	0	0
BC07	4	1,383	1	1	2	0	3	4	1	0	16
BC08	0	1,798	0	20	1	0	0	1	0	0	2
BC09	0	0	3	90	51	2	15	123	6	1	0
BC10	0	4,455	0	31	0	0	0	0	0	0	0
BC11	0	2,821	0	15	1	0	2	2	0	0	6
BC12	78	33,129	3	317	4	0	2	4	0	0	9
BC13	0	3,453	0	15	0	0	0	0	0	0	0
BC14	5	3,071	0	36	0	0	1	0	0	0	2
BC15	0	0	0	0	0	0	0	0	0	0	0
BC16	8	3,272	0	0	10	0	13	10	4	0	37
BC18	0	0	0	0	0	0	1	0	0	0	1
BC19	0	0	0	0	0	0	0	0	0	0	0
BC20	6	2,355	0	18	1	0	1	0	0	0	1
BC21	0	0	0	0	0	0	0	0	0	0	0
BC22	0	0	0	0	0	0	0	0	0	0	0
BC23	0	0	0	0	0	0	0	0	0	0	0
BC24	8	7,601	0	41	0	0	0	0	0	0	0
BC25	0	465	0	3	1	0	1	1	0	0	2
BC26	13	1,265	0	3	0	0	0	0	0	0	0
JF0320S	0	0	0	0	0	0	0	0	0	0	0
JFWR09	0	0	0	0	0	0	0	0	0	0	0
JFWR15	21	9,985	0	44	0	0	2	1	0	0	2
JFWR29	7	5,925	0	50	0	0	0	0	0	0	0
JFWR31	0	3,600	0	36	0	0	0	0	0	0	0
JFWR35	2	2,242	0	5	0	0	0	0	0	0	0
TSJF01	15	3,226	2	14	0	1	0	4	0	0	5
Total:	177	93,084	10	912	123	17	50	332	87	1	125

A summary of the recommended sewer and manhole improvements by SSA are shown in **Table 6-5.4 – Recommended Sewer and Manhole Condition Improvements By SSA** in **Appendix O** of this report.

6.5.3 Recommended Pumping Station Improvements

As previously indicated, the Jones Falls Sewershed contains four (4) pumping stations. These include the Buchanan Road Pumping Station; the Stanton Woods Pumping Station; the Templegate Pumping Station and the Stevenson Pumping Station.

As described in Sections 4 and 6.2.1, the County is currently undertaking, or has previously completed all of the measures set forth in Paragraph 13 of the CD for the pumping stations in the Jones Falls Sewershed.

The County is in the process of ensuring that adequate backup power systems are installed and maintained for each of the pumping stations in accordance with Paragraph 13.C, installing a Supervisory Control And Data Acquisition (SCADA) system for remote monitoring of each of the pumping stations in accordance with Paragraph 13.D, and conducting inspections of the pumping stations in accordance with Paragraph 13.E of the CD.

The County has completed EE/CA inspections of all four (4) of the pumping stations as required by Paragraph 13.F of the CD. The reports have been submitted for review and approval in accordance with Paragraph 13.F.iii of the CD. The County has also completely replaced the Stevenson Pumping Station with a new station, which includes backup power generation and a SCADA system. Construction of the Stevenson Pumping Station was completed in 2011. The Buchanan Road, Stanton Woods and the Templegate Pumping Stations were designated as Tier 3 pumping stations. Improvements to these pumping stations to correct all Priority 1 and 2 ranked deficiencies, as defined in Paragraph 13.F.iv of the CD, and outlined in the EE/CA reports will be completed in accordance with the approved schedules.

The County has also completed a pumping station equipment inventory, transferred its pump maintenance record keeping system into an electronic information management system, and implemented a pumping station preventative maintenance program in accordance with Paragraphs 13.G-I of the CD. In addition, the County has ensured that an updated operation and maintenance manual is being maintained, at the new Stevenson Pumping Station in accordance with Paragraph 13.J. of the CD.

All pumping stations are currently being addressed in accordance with the CD requirements and are of adequate capacity to handle peak flows resulting from a 20-year/24-hour design storm based on the results of the LTC/PFME.

6.5.4 Recommended Force Main Improvements

The Jones Falls Sewershed contains four (4) pumping station force mains. These include a 6-inch diameter ductile iron pipe (DIP) force main from the Buchanan Road Pumping Station; a 6-inch diameter Cast Iron (CI) force main from the Stanton Woods Pumping Station; a 6-inch diameter CI force main from the Templegate Pumping Station; and a 6-inch diameter CI force main from the new Stevenson Pumping Station.

In accordance with Paragraph 8D.ii. of the CD, Baltimore County developed a standard process to inspect and evaluate the condition of the force mains in their collection system. The results of the force main investigations can be found in the individual Force Main Condition Assessment Reports located in **Appendix H** of this report. No corrective actions are recommended for the force mains in the Jones Falls Sewershed.

6.6 Recommended Sewer Capacity Improvements

Baltimore County's method to evaluate the collection system's capacity deficiencies and identify and evaluate proposed corrective actions focuses on eliminating model-predicted SSOs by reducing sources of wet-weather induced I/I and improving collection system maintenance. This process includes completion of the following:

1. Identify SSA's exhibiting excessive I/I.
2. Identify model-predicted SSOs.
3. Complete SSES investigations in SSA's exhibiting excessive I/I that contribute to model-predicted SSOs to locate wet-weather sources of I/I.
4. Complete model-verification flow monitoring at model-predicted SSO locations.

   The goal of the flow monitoring is to:
   - Confirm model simulation results.
   - Quantify wet-weather flow contributing to model-predicted SSOs.
5. Complete comprehensive collection system improvements that focus on:
   - Dry-weather flow I/I reduction (i.e. excessive base inflow).
   - Wet-weather flow I/I reduction.
   - Dry-weather flow capacity relief (i.e. undersized pipes).
   - Wet-weather flow capacity relief (i.e. undersized pipes).
   - Dry-weather flow preventive maintenance (i.e. cleaning, root control, etc.).
   - Wet-weather flow preventive maintenance (i.e. cleaning, root control, etc.).
6. Complete post-construction flow monitoring to determine the effectiveness of the system improvements/corrective actions.
7. Based on the post-construction flow monitoring data, update and recalibrate the collection system model as necessary.

Based on extensive and continuing pre- and post-construction I/I reduction flow monitoring and analysis, the County estimates that I/I can be significantly reduced as a result of a comprehensive sewer/manhole rehabilitation program of the public collection system. Conservatively, the model simulations completed to fulfill the LTC/PFME requirements included in Section 5 of this report assume a 35-percent reduction in peak inflow and a 23-percent reduction in groundwater infiltration.

Comprehensive I/I reduction rehabilitation in an area consists of rehabilitating all sewer pipes, including grouting of service connection reinstatements to the mainline sewer, and complete rehabilitation of all manholes.

A detailed description of the basis of I/I reduction and model-predicted capacity corrective actions is provided in the Long Term Capacity/Peak Flow Management Evaluation Report, provided in **Appendix L** of this report. A summary of the recommended capacity improvements by meter basin is shown in **Table 6-6.1 – Recommended Sewer and Manhole Capacity Improvements By Meter Basin**. The capacity improvements that will be implemented by the County in Meter Basins BC02, BC03, BC04, BC09, BC22, JFWR31 and TSJF01 are shown on **Map 6-1**.

Table 6-6.1
Jones Falls SRRR: Corrective Action Rehabilitation Plan
RECOMMENDED SEWER AND MANHOLE CAPACITY IMPROVEMENTS BY METER BASIN

Meter Basin	Pipe Rehabilitation	Manhole Rehabilitation	
	Sewer Lining All Sizes, Including Service Reinstatement Sealing (LF)	Manhole Lining (EA)	Seal Manholes (EA)
BC02	16,434	64	
BC03	5,311	28	
BC04	21,475	101	
BC09	62,891	291	
BC22			3
TSJF01			1
JFWR31			7

6.7 Alternative Storm Distribution

In accordance with Paragraph 9.C.ii(b) of the CD, model simulation results for the 2, 10 and 20-year/24-hour SCS Type II stom1 events are presented in the Capacity Assessment and Long Term Capacity/Peak Flow Management Evaluation report. However, as stipulated in Paragraph 9.C.ii(b) of the CD, the County may utilize an alternative rainfall distribution. The County has reviewed various rainfall distribution methodologies and believes the recommendations outlined in the Maryland Hydrology Panel's *Application of Hydrologic Methods in Maryland* report are more representative of actual storm events experienced in Baltimore County and will result in more accurate predictions of the synthetic design events compared to the SCS Type II storm events.

The Maryland Hydrology Panel, convened by the Maryland State Highway Administration and the Maryland Department of Environment, prepared the report to present "a set of hydrologic modeling procedures that are designed to ensure optimal balance between preserving the environmental quality of Maryland streams and (infrastructure) hydraulic performance and safety. "In Section 3.6 of the report, the Panel details their experiments, which indicate that "the 2-, 5-, and 10-year flood peaks generated by the TR-20 model using the 24-hour design storm duration are often significantly higher than those predicted by the USGS-based equations. " Based on their analysis, the Panel recommends that the "10-, 5-, and 2-year storm events should be derived using either the 6-hour or 12-hour design storm duration."

Based on a review of the Panel's analysis, the County recognizes that deficiencies exist in the synthetic design storm procedure and concurs that the 2- and 10-year/6-hour design storms are more representative of actual County rainfall patterns. Additionally, an analysis of the County's sewersheds indicated that the largest sewersheds (i.e. Gwynns Falls, Patapsco and Jones Falls) all have times of concentration less than six (6) hours. The majority of the County's sewersheds are smaller and will have times of concentration that are significantly less than six (6) hours.

Figure 3.22 of the Panel's report indicates spatial distribution adjustments required based on sewershed area. Since most of the County sewersheds are less than 10 square miles in area and in accordance with the SCS National Engineering Handbook, Section 4, the County has not applied the distribution adjustment.

6.8 Baltimore City/County Boundary Conditions

This Recommendation Plan to eliminate the model-predicted SSOs is based on boundary conditions agreed upon by the City of Baltimore and Baltimore County. A copy of the City's hydraulic condition at each boundary location for the 10-year/6-hour storm event is provided in **Appendix J** (Boundary Conditions Time Series) of this report. The County may re-analyze and/or revise this Corrective Action Recommendation Plan if there is any deviation from these boundary conditions or delay in implementing the boundary conditions.

6.9 Wastewater/Storm Water Cross Connection Elimination (CD Ref. P.10.C.vii)

In accordance with Paragraph 9.C of the CD, the County must develop a plan for elimination of physical cross connections between the sanitary sewer collection system and the storm water collection system that allows, or has the potential to allow, sanitary waste to be discharged to the storm water collection system.

SSO 113 (Marnat Road) is the remaining non-pumping station SSO in the Jones Falls Seweshed's collection system. This SSO consists of a 12-inch diameter overflow pipe constructed in MH 793 in SSA 45-10-22-01 (Meter Basin JF0320S). When active, the SSO discharges to a storm drain that enters the Western Run branch of the Jones Falls.

As indicated in Section 2, the County began work on Contract 09124 SXO in November of 2009, which consisted of completing an extensive rehabilitation program upstream of SSO 113 aimed at reducing I/I in the collection system that contributes to the activation of this SSO. As part of this contract, forty-four (44) sanitary manholes were rehabilitated, 7,149 linear feet (LF) of sewer was lined and seventy-two (72) sewer house connection seals were installed. The project was completed in June 2012 and post-rehabilitation flow monitoring of the SSO is currently being conducted in accordance with Section V.7.C.v of the CD. Monitoring shows that SSO 113 remains active during wet-weather events and the County continues to coordinate with the City of Baltimore regarding capacity improvements that are needed to several of the receiving sewers located downstream of the SSO in the City. The County has filed a time of performance extension request with the EPA and committed to completing additional investigations and developing system improvements to correct collection system deficiencies required to eliminate this SSO. The additional investigations that the County has completed include CCTV, SSES investigations, cleaning and capacity analysis and modeling. The County continues to work to determine how the collection system surrounding this SSO functions during wet- and dry-weather to determine the cause of the continued activation of this SSO during wet-weather.

6.10 Performance Assessment Program (CD Ref. P.10.E)

In accordance with Paragraph 10.E of the CD, the County must conduct a performance assessment of the work performed in the Jones Falls Sewershed to determine the effectiveness of the corrective action work that has been performed.

The following additional data collection activities may be implemented after completion of the rehabilitation and corrective action work per CD Reference Paragraph 10.c.xi:

- Rainfall Monitoring
- Flow Monitoring
- Post-Rehabilitation CCTV
- Review of Record Drawings
- Review of Reported Complaint Data
- Review of Work Orders

Post-rehabilitation flow monitoring is recommended to be performed in areas in which rehabilitation projects have already been completed by the County and in those meter basins that have been recommended for rehabilitation upon completion of the rehabilitation work.

Flow monitoring should preferably be performed at the same locations where flow monitoring was previously performed for this study. Collection of data at the same locations will allow for pre- and post-rehabilitation flow comparisons and recalibration of the hydraulic model to post-rehabilitation conditions if necessary. An I/I analysis should be performed subsequently to quantify the reduction of I/I in the rehabilitated areas. Per Baltimore County's SRRR Guidelines, it is recommended that post-rehabilitation flow monitoring capture at least six (6) measurable rain events of varying intensity and duration for the I/I analysis.

The County will evaluate the data collected at each location to determine the effectiveness of the completed corrective actions and to determine the subsequent work as appropriate.

6.11 Sewer Cleaning Program (CD Ref. P.10.C.iii)

The County's approved Collection System O&M Plan, dated January 12, 2006, requires the County to clean all gravity sewers that are 8-inches in diameter or larger on a seven (7) year cycle, subject to future cleaning frequency re-evaluations.

In addition to the O&M Plan, the County's Bureau of Utilities maintains a recurring specials cleaning list, which identifies specific sewer segments that require routine cleaning. A copy of this specials list, including a map which shows specific SSA's that are cleaned on a regular basis is contained in **Appendix P** of this report. The recurring specials list is reviewed and revised on a regular basis based on historical customer complaints, recorded historical O&M defects/observations and sewer location.

This cleaning program typically addresses conditions, which cause or contribute to water quality concerns or public health degradation, occur in high public use or public access areas or can be avoided through preventive maintenance.

6.12 Fats, Oils and Grease Control Program (CD Ref. P.10.C.iii)

The County's Fats, Oils and Grease (FOG) control program is detailed in the approved revised FOG Program Modification Plan, dated August 21, 2009. In accordance with the Plan, the County inspects FOG generating facilities using the risk scoring system and FOG generator identification evaluation developed by the County for the program. The inspection findings and FOG generating facility enforcement history is recorded in the County's FOG database for use in the County's annual FOG control program effectiveness evaluation. Program/analysis revisions that are identified by the effectiveness evaluation are addressed accordingly.

In addition to the FOG program, the County's Bureau of Utilities maintains a recurring specials cleaning list, which identifies specific sewer segments that experience grease deposition and require routine cleaning. A copy of this specials list, including a map showing the SSA's that require frequent cleaning, is contained in **Appendix P** of this report. The recurring specials list is reviewed and revised on a regular basis based on historical customer complaints, recorded historical O&M defects/observations and FOG control program inspection findings.

On September 16, 2010, the County posted on its Department of Environmental Protection & Sustainability website, a FOG manual to be used by local Food Service Facilities as a guide for complying with the County's revised Food Service Facilities Regulations. The County continues inspecting FOG generating facilities using the revised risk scoring system and the FOG generator identification evaluation. To address residential FOG generators, the County will develop informational material that describes the effects of FOG on the wastewater collection system. The material will also be distributed to residential property owners.

The regular cleaning associated with the FOG program will aid in addressing conditions which cause or contribute significantly to water quality or public health degradation, occur in high public use or public access areas or can be avoided through preventive maintenance.

6.13 Root Control Program (CD Ref. P.10.C.iii)

The County's Bureau of Utilities maintains a root control program as detailed in the approved Collection System Operation and Maintenance Plan, dated January 12, 2006. The root control program consists primarily of mechanical root cutting and the application of chemical root inhibitors to treat root growth in the sewers on an as-needed basis. Additionally, the Bureau of Utilities maintains a specials list, which identifies specific sewer segments that require routine root control. The specials list is reviewed and revised by the County on a regular basis, based on historical customer complaints, recorded historical O&M defects/observations and sewer location. A copy of the specials cleaning list is contained in **Appendix P** of this report.

Regular root cutting and/or chemical root treatment and maintenance will be applied to these sewers to prevent continued root intrusion as outlined in the approved County O&M Plan. The root control program will assist in addressing conditions that cause or contribute significantly to water quality or public health degradation, occur in high public use or public access areas or can be avoided through preventive maintenance.

6.14 Corrective Action Recommendation Plan

The County believes the most logical approach to addressing model-predicted SSOs in the Jones Falls Sewershed is to:

1. Complete comprehensive I/I reduction rehabilitation of public manholes and sewers within SSA's exhibiting excessive I/I or other areas that contribute to model predicted SSOs determined by model simulations using the 10-Year/6-Hour SCS Type II storm event.
2. Complete select capacity improvements based on a model simulation of the 10-Year/6-Hour SCS Type II storm event.
3. Correct identified structural deficiencies through rehabilitation or replacement.
4. Complete post-construction flow monitoring and analysis to confirm the I/I reduction effectiveness.
5. Confirm model simulations or revise the collection system model, if necessary.
6. Determine if additional improvements are needed based on the updated collection system model.

Areas selected for comprehensive I/I reduction in the Jones Falls Sewershed include Meter Basins BC02, BC03, BC04 and BC09. These meter basins and all structural recommendations are shown on **Map 6-1**.

The capacity improvements that address Items 1 and 2 above will be implemented by the County are described as follows:

- I/I reduction through rehabilitation - Perform comprehensive I/I rehabilitation of the public collection system in Meter Basins BC02, BC03, BC04 and BC09.

- In-Line Storage – Seal manholes and increase the hydraulic grade line (HGL) in the sewer segments upstream of the sealed manholes.

6.15 Corrective Action Implementation Schedule (CD Ref. P.10.Cvi)

The recommended improvements to the Jones Falls Sewershed's collection system which are contained in this SRRR Plan are estimated to be completed within six (6) years of the EPA and MDE's approval of this Plan per Paragraph 10.B. of the CD.

6.16 Corrective Action Recommendation Plan Cost Estimate (CD Ref. P.10.C.vi)

To estimate the corrective action costs, unit costs for the recommended corrective actions were utilized from Table 4-5 from the Baltimore County SRRR Plan Guidelines to develop the estimates provided in this report.

The estimated cost to implement the corrective actions identified in this report is $28,300,000. **Table 6-16.1 – Cost Estimate For All Corrective Action Improvements** summarizes these corrective action costs for the Jones Falls Sewershed. Detailed cost estimates by Meter Basin are provided in **Table 6-16.2** in **Appendix Q** of this report.

Table 6-16.1
Jones Falls SRRR: Corrective Action Recommendation Plan
COST ESTIMATE FOR ALL CORRECTIVE ACTION IMPROVEMENTS

Item	Total Cost
Capacity Recommendations (Basins 02, 03, 04, 09)	
Pipe Rehabilitation	$ 8,110,964.00
Manhole Rehabilitation	$ 2,144,092.00
Subtotal:	$ 10,255,056.00
Structural Recommendations	
Pipe	$ 5,842,586.00
Lateral	$ 2,808,960.00
Manholes	$ 1,249,145.00
Subtotal:	$ 9,900,691.00
Engineering, Construction Inspection, Administration, Contingency (40%):	$ 8,062,298.80
Total Estimated Cost:	$ 28,218,045.80
Cost:	$ 28,300,000.00

Map 6-1 shows the collection system improvements that have been completed in the Jones Falls Sewershed as well as the corrective actions that have been recommended in this report.

END OF SECTION

Pumping Station

Manhole Corrective Actions

- Clean
- Clean & Frame and Cover Work *
- Clean, Line & Frame and Cover Work *
- Clean & Line
- Frame and Cover Work *
- Line & Frame and Cover Work *
- Line
- Replace
- Sewer Manholes

Sewer Corrective Actions

- Lateral Connection Repair
- Lining & Lateral Connection Repair
- Point Repair & Lateral Connection Repair
- In-Situ Spot Repair & Lateral Connection Repair
- Lining
- Lining & Point Repair
- Point Repair
- In-Situ Spot Repair
- Sewer Mains
- Meter Basins
- Jones Falls Sewer Service Areas
- Proposed Rehabilitation of Meter Basin
- Previously Rehabilitated SSA's

* Frame and Cover Work includes any of the following corrective actions or a combination of the following corrective actions: Frame Seal, Inflow Insert, Replace Frame and Cover, Reset Frame and Cover and Seal Manhole.

RK&K ENGINEERS

December 2012

0 750 1,500 2,250 3,000
Feet

Jones Falls Collection System Evaluation & Sewershed Plan

BALTIMORE COUNTY MARYLAND

Map 6-1
Sewer, Manhole and Hydraulic Corrective Action Recommendations Map

Appendices

Appendices

Appendix Sections A through Q

Appendices A through Q are contained on a separate disk that has been included with this report.