FEDERAL FACILITY TECHNICAL STANDARDS

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SECTION 1 INTRODUCTION AND PURPOSE

1.1 INTRODUCTION

These Technical Standards provide detailed requirements for completion of the work embodied in the Infiltration and Inflow (I/I) Order, and were developed to ensure a consistent approach for Federal Facilities to comply with such an Order. These Standards include completion dates for various activities, which are described in terms of months or days from the effective date of the Order.

1.2 PURPOSE

The purpose of the Order and these Technical Standards is to reduce or eliminate infiltration and inflow (I/I) in the Hampton Roads Regional Sanitary Sewer System. To this end, the Hampton Roads Sanitation District (HRSD) is authorized to develop and issue I/I Orders (Orders) to individual users and I/I General Orders (Orders) to classes of users. Such Orders shall require an individual user or affected members of a class of users to investigate and identify the presence or absence of I/I that originates on the property of the user; to quantify any such I/I; to develop plans for the reduction or elimination of I/I, subject to HRSD’s approval; and to reduce or eliminate I/I from the user to standards that may be specified in the Order or specified by HRSD thereafter. Such Orders may be phased, at the sole discretion of HRSD, to facilitate the work.

For each Federal Facility having multiple sanitary sewer system connections at a facility, the Order shall apply to all such connections unless specified otherwise.

These Standards cover the analysis of existing data, collection of additional system data, preparation and execution of rehabilitation plans, correction of serious defects requiring prompt attention, and development of a hydrologic model. These Standards have been developed to be information-based so that resources are focused on the areas that require attention to mitigate I/I. Where appropriate, these Standards include quality assurance/quality control procedures related to field data collection.

These Technical Standards, as written, generally provide guidance and a common framework for all activities performed under each Order. Although there are a number of required submittals, many of the individual components of each submittal will vary for each Facility depending on available information, site characteristics, and other factors. Within each section of the Standards, any required items are noted as such. These requirements are also discussed briefly below.

1.3 SUMMARY OF THE FEDERAL FACILITY TECHNICAL STANDARDS

The following is a brief overview of each section of these Technical Standards. HRSD will review and approve submittals, as required in the Standards.

Section 1 – Introduction and Purpose

This section establishes the context for the Technical Standards.

Section 2 – Definition of Terms

This section provides definitions for the major terms used in the Standards.

Section 3 – Data Collection and Flow, Pressure, and Rainfall (FPR) Monitoring

This section provides guidance on I/I characterization, use of previously developed information, system inventory mapping and geographic information system (GIS) data standards, flow monitoring procedures for both model calibration and Sewer System Evaluation Survey (SSES) basin identification, rainfall monitoring, sewer flow evaluation and flow evaluation reporting. Taken together, this section provides the guidance for identification of SSES Basins that require further investigation.

GIS Database: Federal Facilities will be required to submit a GIS database of information to HRSD for review and comment by HRSD within 60 days of the effective date of the Order.

Preliminary FPR Monitoring Plan: The required Preliminary Flow Monitoring Plan shall be received by HRSD within 120 days of the effective date of the Order for their review and approval.

FPR Monitoring and FPR Evaluation Report: A FPR Evaluation Report shall be received by HRSD within 15 months from the date of approval of the Preliminary Flow Monitoring Plan. Flow monitoring for SSES Basin identification performed shall be completed within 12 months of approval of the Preliminary Flow Monitoring Plan. Notification that flow monitoring for SSES Basin identification has been completed, and all associated flow monitoring data shall be received by HRSD within 60 days of Flow Monitoring completion. A copy of the FPR Evaluation Report must be received by HRSD for review and comment before sewer rehabilitation activities are initiated.

Section 4 – Hydrologic Performance Assessment

This section provides the standards for development and application of a hydrologic model that shall be used to evaluate system performance under a variety of hydrologic conditions. Procedures and standards for model development, calibration and verification are included. The model shall be developed within 180 days of completion of the Flow Monitoring and model Development Documentation shall be received by HRSD for review and approval.

Section 5 – SSES Planning

This section establishes the SSES Basin criteria and the requirements for preparing the required SSES Work Plan. This plan shall be received by HRSD within 6 months of the approval date of the Model Development and Documentation for their review and approval. SSES work activities shall be completed within 12 months of HRSD’s approval of the SSES Work Plan and HRSD shall be notified by the Federal Facility that field activities have been completed within 30 days following completion of the work.

Section 6 – Condition Assessment of Sewers and Pump Stations

This section provides guidance and requirements for conducting detailed condition assessment, assessment standards for SSES Basins, and assessment reporting requirements. Sewer main, manhole and sewer lateral inspections shall be conducted and recorded in accordance with National Association of Sewer Service Companies (NASSCO) standards, and all illicit connections shall be removed. Condition Assessment work can be performed simultaneous to flow monitoring. The information developed through these efforts shall be documented and used to develop the Rehab Plan in accordance with the requirements in Section 7. The Rehabilitation Plan Condition Assessment Documentation shall be submitted for review and approval by HRSD prior to commencement of Rehab Plan work.

Section 7 – Rehabilitation Planning and Execution

This section discusses using the results of the SSES work to develop specific plans for rehabilitation, including evaluation of the effectiveness of rehabilitation on I/I reduction, cost estimates and schedules. The Rehabilitation Plan and Condition Assessment Documentation shall be received by HRSD for review and approval within 150 days of completion of the SSES work activities. Peak flow reduction documentation shall be submitted to HRSD within 12 months of completion of rehabilitation activities.

Section 8 – Post Rehabilitation Requirements

This section provides for on-going responsibility for maintenance of the peak flow commitment and annual reporting in conjunction with the permit.

Demonstration Flow, Pressure, and Rainfall Monitoring Plan: The required Demonstration Flow Monitoring Plan shall incorporate any comments from HRSD on the Preliminary Flow Monitoring Plan and FPR Evaluation Report and shall be received by HRSD, for review and comment, prior to completion of sewer rehabilitation activities.

Demonstration Flow Monitoring: Demonstration Flow Monitoring performed after sewer rehabilitation activities have been completed shall be received by HRSD within 12 months of the completion of the rehabilitation activities. The required Demonstration Flow Monitoring Plan shall incorporate any comments from HRSD on the Preliminary Flow Monitoring Plan and FPR Evaluation Report and shall be received by HRSD, for review and comment, prior to completion of sewer rehabilitation activities.

1.4 TECHNICAL STANDARDS REQUIREMENTS, SUBMITTALS & SCHEDULES

The submittals required for HRSD's review and approval by the Technical Standards are shown in Table 1-1 below. Example compliance schedule is shown in Figure 1-1 and a Process Diagram in Figure 1-2.

Table 1-1. Summary of Submittals Required by the Technical Standards

Item	Section Reference	Required Item
1	3.2	GIS data – System Inventory
2	3.3.7	Preliminary Flow, Pressure, and Rainfall Monitoring Plan
3	3.5	Flow, Pressure, and Rainfall Evaluation Report (Pre Rehab)
4	4.5	Hydrologic Model Development Documentation
5	5.2	SSES Work Plan
6	6.7	Condition Assessment Documentation
7	7.6.1	Rehabilitation Plan and Schedule
8	7.6.2	Rehabilitation Plan – Report on Work Completed
9	8.1.1	Demonstration Flow, Pressure, and Rainfall Plan
10	8.1.2	Demonstration Flow, Pressure, and Rainfall Report

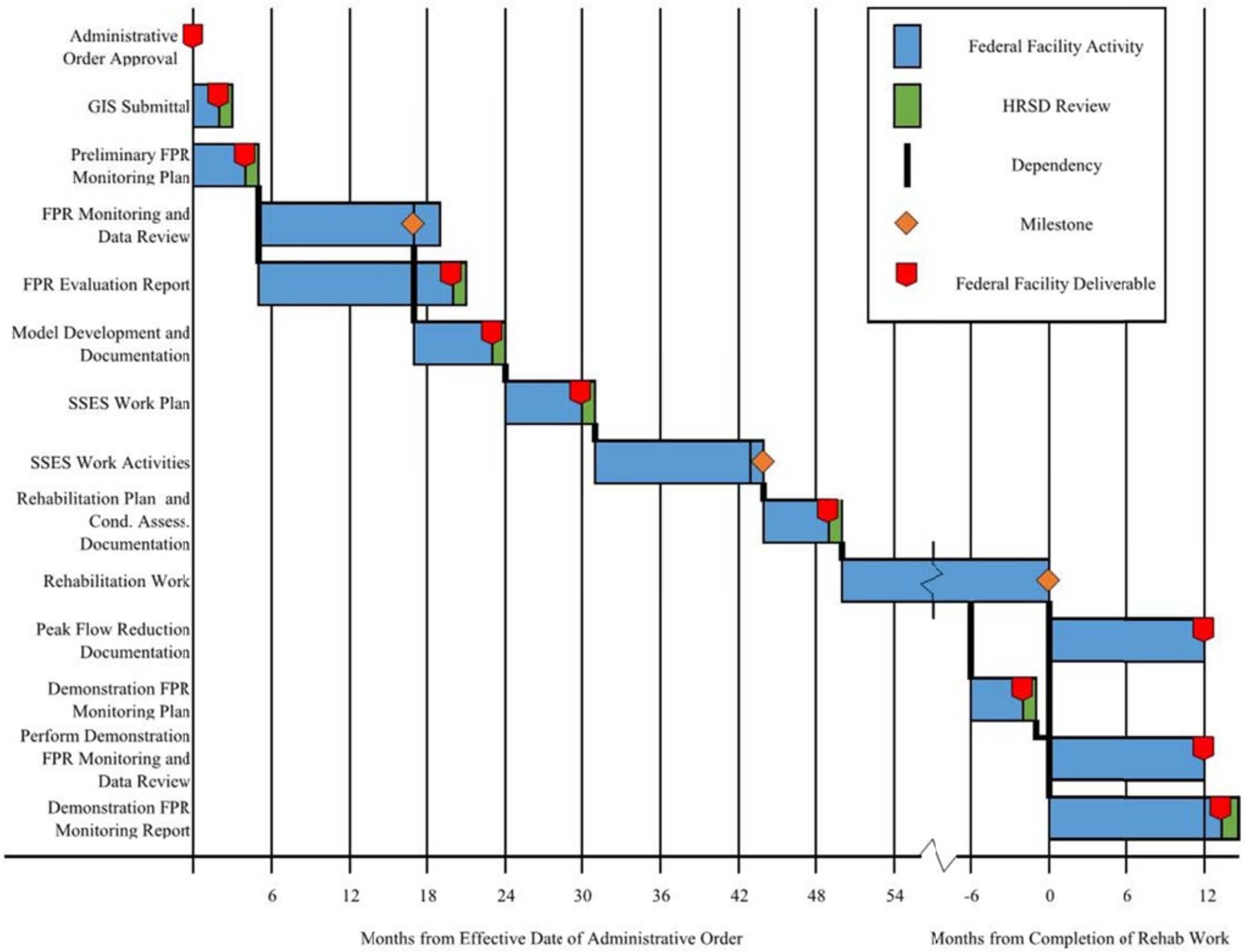

Figure 1-1. Sample Federal Facilities Compliance Schedule

Note: HRSD review periods are shown for illustrative purposes only.

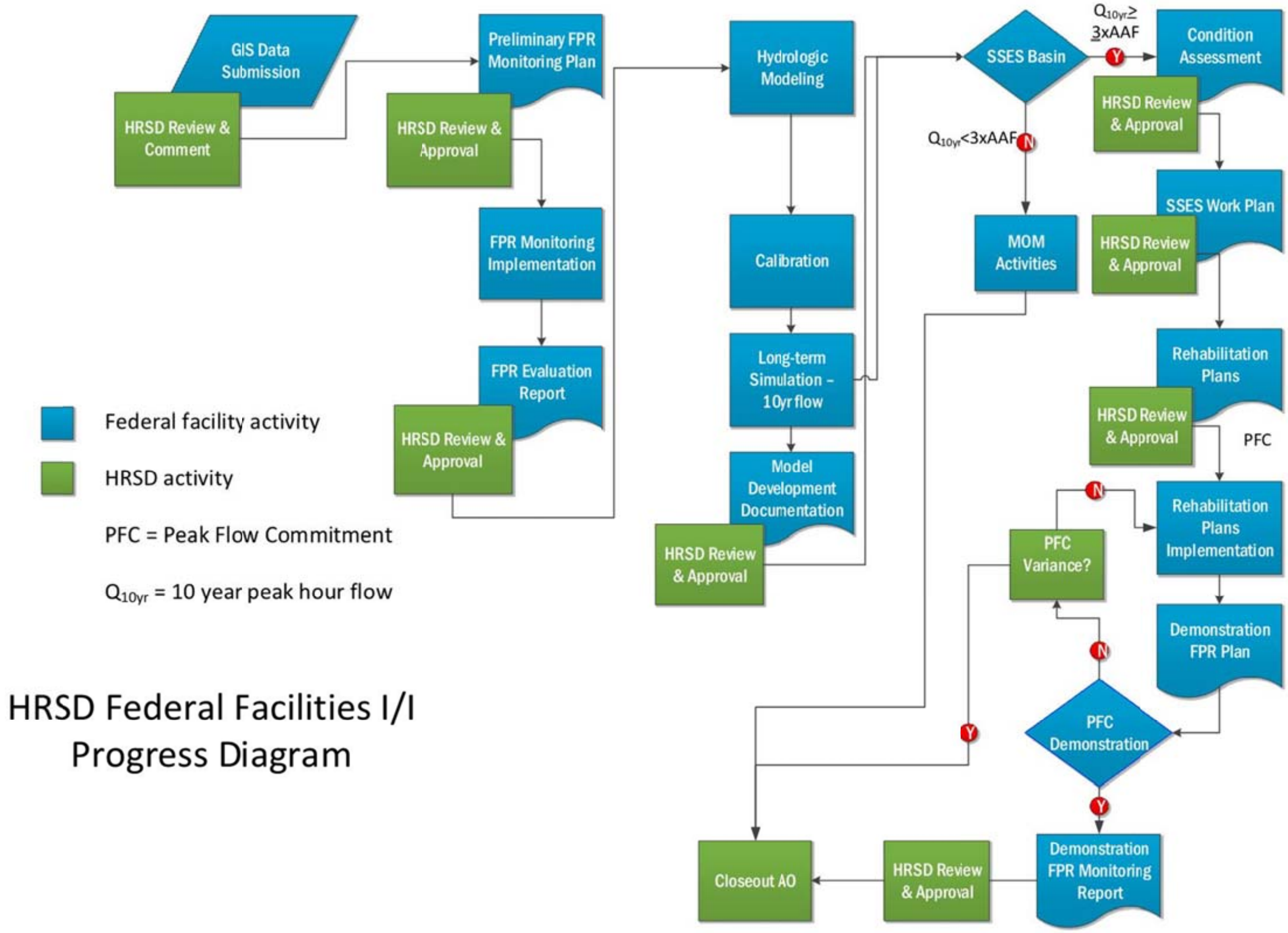

Figure 1-2. Process Diagram

SECTION 2 DEFINITION OF TERMS

The following words and terms that have been used in the Federal Facility Technical Standards shall have the meanings assigned to them below unless the context clearly indicates otherwise. Other commonly used terms in the Technical Standards are defined by reference to terms in the Sewage Collection and Treatment Regulations (SCATR) [9VAC 25-790], unless otherwise specifically defined in these Technical Standards.

"AAF" means Annual Average Flow which includes all flows in the sewer system including base sewer flow (BSF), dry weather infiltration (DWI) and Rainfall Derived Inflow and Infiltration (RDII).

"ASCII" means American Standard Code for Information Interchange.

"Base Sewage Flow" means domestic and industrial/process sewage and does not include groundwater or rainfall derived infiltration and inflow.

"CCTV" means closed-circuit television.

"CMMS" means computerized maintenance and management system.

"Days" means consecutive calendar days including weekdays, weekends and holidays.

"Design Flow Rate" means the flow rate specifically used as the basis of design for facilities within the regional sanitary sewer system.

"Diurnal curve" means a graphical or tabular representation of the variation of wastewater flow (excluding rainfall derived inflow/infiltration (I/I) contributions) over a typical, 24-hour cycle.

"DWF" means Dry Weather Peak Hourly Flow.

"DWI" means dry weather infiltration.

"Dry Weather Overflow" means any sanitary sewer overflow for which the underlying cause is not attributable to precipitation related flows.

"Event of Interest" means any wastewater flow event or specific rainfall event which is used to evaluate the performance of the sanitary sewer system.

"Excessive Pump Run Time" means a threshold at which a pumping station meets the relevant SSES Basin planning criterion. Excessive Pump Run Time can be identified by evaluating the daily total run time of all pumps within a pump station under wet weather/peak flow conditions. Excessive Pump Run Time exists when the total run time for all pumps within a pump station exceeds an average of 24 hours per day per pump with one pump out of service. This threshold can be calculated using the following equation:

Excessive Pump Run Time = [(Number of Pumps) – 1] X 24 hours

Excessive pump run time is a threshold that must be compared to actual pump run time under specific flow conditions to identify indications of potential capacity limitations. Excessive pump run time and actual pump run time should be directly compared for pump stations that are comprised of constant speed pumps of equal size, or multi-speed pumps that are running at full speed.

“Federal Facility” means any buildings, installations, structures, land, public works, equipment, aircraft, vessels, and other vehicles and property, owned by, or constructed or manufactured for the purposes of leasing to, the federal government. No transfer of ownership or operation of the Federal Facility or its sewer system shall relieve the Federal Facility of its obligation to ensure the terms of the I/I Order.

“FPR” means Flow, Pressure and Rainfall.

“GIS” means Geographic Information System.

“Gravity Sewer Line” means a pipe that receives, contains and conveys wastewater not normally under pressure, but is intended to flow under the influence of gravity.

“Ground Water” means sub-surface water that is stored in the voids between soil particles.

“HRSD” means Hampton Roads Sanitation District, a political subdivision created by a 1940 Act of the General Assembly of Virginia and charged with the responsibility to provide sewage collection, conveyance, and treatment services for the communities in the Hampton Roads metropolitan area.

“Hydrograph” means the graphical or tabular representation of flow volume over time which could depict a specific hydrologic condition.

“I/I” means infiltration and inflow that is derived from rainwater, groundwater or drainage of unpolluted water and enters the sanitary sewer system.

“Illicit Connection” means an unauthorized connection to the sanitary sewer system, including but not limited to area drains, foundation drains, roof drains and sump pumps. Illicit connections are connections that have been made to the sanitary sewer system without the knowledge and/or approval of HRSD.

“IMS” means information management system, which is a formalized system to manage data.

“Infiltration” means water other than wastewater that enters a sewer system (including sewer service connections) from the ground through such means as defective pipes, pipe joints, connections, or manhole walls. Infiltration does not include, and is distinguished from, inflow.

“Infiltration and Inflow (I/I) Order” means formal notification of a requirement to address a non-compliance issue associated with these Technical Standards. Infiltration and Inflow (I/I) Orders contain compliance schedules designed to address the non-compliance issue(s). Enforcement discretion will be exercised for applicable violations that may occur while the I/I Order is under effect.

“Inflow” means water other than wastewater that enters a sewer system (including sewer service connections) from sources such as, but not limited to, roof leaders, cellar drains, yard drains, area drains, drains from springs and swampy areas, manhole covers, cleanouts, cross connections between storm sewers and sanitary sewers, catch basins, storm waters, surface runoff, street wash waters, or drainage. Inflow does not include, and is distinguished from, infiltration.

“Interceptor Sewer” means a sewer, typically without individual sewer customer connections, that is used to collect and carry flows from main and trunk sewers to a central point for treatment and discharge.

“LACP” means Lateral Assessment Certification Program developed by NASSCO.

“Level of Service” means the peak sewer flow recurrence interval that the Regional Sanitary Sewer System can convey without resulting in a capacity-related SSO.

“LPIII” – Log Pearson III Analysis

“LTS” – Long-term flow simulation

“MACP” means Manhole Assessment Certification Program developed by NASSCO,

“NASSCO” means National Association of Sewer Service Companies.

“NOAA” – National Oceanic and Atmospheric Administration

“ODBC” means Open Database Connectivity.

“PACP” means Pipeline Assessment Certification Program developed by NASSCO.

“Peak Flow” means the maximum hourly-averaged wastewater flow that occurs at a specific location within the sanitary sewer system for the stated flow recurrence.

“Peak Flow Recurrence” means the inverse of the statistical probability of exceeding a certain peak sewer flow in a given year. Typically, these values are expressed in terms of return years, or return frequency. As an example, a 10-year peak flow has a one in 10 (10 percent) probability of being exceeded in any given year.

“Peak Flow Threshold” means the calculated flow of 3 times the Annual Average Flow (AAF).

“Preventable Overflow” or **“Preventable SSO”** means overflows that could have reasonably been prevented through due diligence, proper operations and maintenance, reduction in I/I, or increased capacity of the sanitary sewer system.

“Pumping Station” means facilities comprised of pumps which lift wastewater to a point physically higher than the wastewater elevation in the wet well, including all related electrical, mechanical, and structural systems necessary to the operation of that pumping station.

"Rainfall Recurrence Interval" means the inverse of the statistical probability of achieving a rainfall of a specific intensity, volume, and duration. Typically, these values are expressed in terms of return years. As an example, a 2-year recurrence interval has a 1 in 2 or 50% chance of occurring each year.

"RDII" means rainfall-derived infiltration and inflow. RDII is a parameter that can be measured, estimated or synthetically generated through other means, such as flow monitoring data or hydraulic modeling.

"Regional Sanitary Sewer System" means the collective sanitary sewer systems owned and operated by the Localities and HRSD, as well as the Federal Facility's sanitary sewer system including gravity sewer lines, manholes, pump stations, lift stations, pressure reducing stations, force mains, wastewater treatment plants, and all associated appurtenances.

"Rehabilitation Plan" means documents to be developed individually by each Federal Facility that define specific measures to reduce I/I, address deficiencies identified during the SSES investigations; identify system-wide improvements including control of I/I sources and improvements needed to ensure sustainability of the sanitary sewer infrastructure.

"Replacement" means obtaining and installing equipment, accessories, or appurtenances which are necessary at the end of the useful life of the sanitary sewer system to maintain the capacity and performance for which such works were designed and constructed.

"RTK" means a hydrologic method to predict rainfall derived infiltration and inflow.

"Sanitary Sewer Overflow (SSO)" means the unauthorized intentional or unintentional spill, release, or discharge to waters of the State of untreated wastewater from any portion of a sanitary sewer system before the headworks of a Wastewater Treatment Facility.

"Sanitary Sewer System" means the wastewater collection and transmission system that is comprised of all portions of the individual Federal Facility collection system, including manholes, gravity sewers and force mains, lift stations, pump stations, building sewer laterals and associated appurtenances.

"SCADA" – Supervisory Control and Data Acquisition

"Sewage" means the water-carried wastes created in, or to be carried away from Federal Facilities, together with such industrial wastes as may be present.

"Sewer" means a pipe or conduit, generally closed, for carrying wastewater or sewage.

"Sewer Basin" means all portions of the Federal Facility's sanitary sewer system tributary to a connection to a publically owned interceptor sewer or force main. Generally, the sewers within a sewer basin are hydraulically linked. There may be multiple sewer basins on a single Federal Facility property.

"Sewer Basin Criticality" means an expression of the condition of a sewer basin as it relates to consequence of failure within the associated Federal Facility sanitary sewer system. Sewer basin criticality should consider factors such as environmental risk, public health risk (including potential impacts to drinking water sources from SSOs), economic risk, and operational risk.

"Sewer System Evaluation Survey (SSES)" means a systematic examination of a sanitary sewer system or portion thereof to, at a minimum: i) identify the condition of sewers, manholes, pump stations and associated appurtenances; ii) identify I/I sources, locations, and associated extraneous flow rates; iii) characterize the wastewater flow; and iv) determine technically feasible, cost effective methods of rehabilitation.

"Significant Rainfall Event" means a rainfall event which results in an associated measurable increase of wastewater flow in the sanitary sewer system above dry weather flows. Significant rainfall events are defined solely for the purposes of flow monitoring data analysis.

"SSES Basin" means a defined portion of the Federal Facility's sanitary sewer system that can be separately metered, where historical data and/or flow monitoring data collected indicate high levels of RDII, unresolved SSOs, or other characteristics described in Section 5.1 that warrant investigation. SSES Basins will be subject to investigation to identify infrastructure deficiencies and define the potential for peak flow reduction.

"Supervisory Control and Data Acquisition (SCADA)" means a computer system for gathering and analyzing real time data.

"Surcharge" means the condition where gravity sewer flow depth exceeds the diameter of the sewer line that is conveying the flow.

"Unresolved SSO" means any SSO for which the underlying cause has not been resolved so as to prevent future reoccurrences at that location from that cause.

"USGS" – United States Geologic Survey

"Useful Life" means the length of time, or period during which infrastructure assets operate. Useful life is not synonymous with "design life" which is the period over which infrastructure assets are planned to be used and designed to be operated.

"Water Consumption" means the volume of potable water consumed by residential, commercial, and industrial users as measured by potable water meters.

"WaPUG" – Wastewater Planning Users Group

"WRC" –Water Research Centre

"WEF" – Water Environment Federation

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SECTION 3 PRE-REHAB FLOW, PRESSURE, RAINFALL (FPR) MONITORING AND DATA COLLECTION

3.1 REVIEW OF EXISTING INFORMATION

Development of the Sewer System Evaluation Survey (SSES) program components requires sound system knowledge. Existing sewer system information shall be compiled and evaluated to establish the basis for identifying additional data needs.

Information sources shall include the following, as available and appropriate for the specific system:

- Sewer system maps
- Engineering and design studies, including hydraulic analyses
- SSES studies
- Any existing system condition/inspection data
- Maintenance staff interviews
- Operation and maintenance records
- Treatment plant flow and operation records (where applicable)
- Pumping station flow records and Supervisory Control and Data Acquisition (SCADA) data
- Sanitary Sewer Overflow (SSO) reports
- Customer complaint records
- Existing Asset Condition Data (e.g., closed-circuit television (CCTV) records)

A suitable data acquisition plan shall be developed and implemented to address data gaps and information needs.

3.1.1 Sanitary Sewer Overflow Characterization

The date, cause, location, estimated quantity and frequency of all sanitary sewer overflows (SSOs) that have occurred during the past five (5) years, if available, shall be analyzed to determine where there may be unresolved maintenance, structural, and capacity issues. SSOs should be classified according to the following causes to ensure regional consistency:

- Maintenance
  - Grease
  - Roots
  - Debris (including sediment accumulation)
  - Other
- Infrastructure
  - Pipe Failure/Defects
  - Equipment Failure

- Capacity
  - Weather Related
    - Excessive I/I
    - Unanticipated Wastewater Flows
  - Not Weather Related
    - Pressure Problems
    - Reverse Grade
    - Hydraulic Bottlenecks
    - Inadequately Sized Facilities
- Damage by Others
  - Vandalism
  - Contractor Damage
  - Unauthorized Discharges
- Power Outages
- 3rd Party Actions

SSO evaluation shall be conducted to identify chronic (locations where 2 or more SSOs have occurred during the previous 5 years) problems and develop appropriate I/I mitigation actions. The SSO locations shall be identified on a sanitary sewer system map, preferably in GIS, and coded by cause. This action will facilitate the SSO analysis.

3.1.2 Prior Studies/Planned Construction

Studies that have been completed within five (5) years of the execution date of the I/I Order (Order) may be considered valid provided that the work included in the study substantially meets requirements of the Technical Standards established herein. Prior studies may be submitted to HRSD for review and approval to determine the acceptability in lieu of new studies. Studies older than 5 years should be used to develop the SSES Plan provided that any changes that have occurred in the sanitary sewer system that may impact the results of the study are understood and considered in the use of the data. The areas addressed within prior studies will be identified within the SSES Plan described in Section 5.

Areas of the system that have been rehabilitated within five years prior to the execution date of the Order will be excluded from further SSES work under these guidelines, provided they do not meet the criteria contained in Section 5.1.

Areas covered by prior studies meeting the requirements of this section that will be included in the Rehabilitation Plan under the Order will not be reevaluated, except at the discretion of the Federal Facility for their respective Rehabilitation Plans.

Areas that are, or will be, scheduled for rehabilitation prior to submittal of the Rehabilitation Plan described in Section 7 will be excluded from further SSES work, provided that the rehabilitation project is consistent with the Technical Standards, as appropriate. Rehabilitation projects that have been initiated prior to execution of the Order and have advanced beyond the Preliminary Engineering Report stage will not be impacted by the provisions of the Order. All excluded existing or past projects will require the submittal of a letter requesting the exemption for approval by HRSD.

3.1.3 Engineering and Operations

Sewer system engineering and operational information that is useful in SSES Planning includes:

- Mapping of the project area showing sanitary sewer systems, streets and roads, contours and spot elevations, and storm sewers and appurtenances
- Design drawings, pump curves, design reports, and operating data (pump run time logs)
- SCADA information to include system pressure, metered flow, pump run times, wet well levels, and alarm and event data
- Information on work order history and maintenance records for sewer facilities
- Historical water consumption data
- Rainfall gauge data
- Groundwater monitoring data where deemed necessary by the Federal Facility

These data shall be used, where available, to identify problem areas within the sanitary sewer system that result from connectivity issues, design limitations, or maintenance issues. These data should also be used to help define the activities needed to further investigate and/or collect additional information about the system.

3.1.4 Other Performance Documentation

Known ongoing operational and/or maintenance problems shall be reviewed prior to the initiation of the field investigations.

3.2 SYSTEM INVENTORY

An inventory of the sewer system's components shall be prepared so that those components can be consistently referenced during the SSES and subsequent analyses. The inventory shall include:

- Gravity mains
- Laterals
- Manholes
- Pump stations
- Force mains
- Vacuum systems
- Appurtenances (i.e., valves, clean outs, siphons)

3.2.1 Mapping Standards

The mapping shall be developed using the Virginia State Plane Coordinate System with NAVD88 vertical control and NAD 1983 HARN State Plane Virginia South FIPS 4502 Feet for horizontal control.

3.2.2 GIS Data Standards

To compile a GIS dataset for the regional sanitary sewer system, the following major datasets are needed:

- Available supplemental GIS base mapping data from each Federal Facility
- Existing sanitary sewer system GIS data from each Federal Facility
- Existing hard copy or other electronic format of sanitary sewer system maps for Federal Facilities where GIS data is not available

Sewer system GIS data shall include gravity pipes, manholes, pump stations, force mains, valves, pressure reducing stations and other pertinent facilities. The GIS data shall be transferable to HRSD. The GIS data formatting shall be agreed upon between the Federal Facility and HRSD prior to data collection activities associated with the Order. HRSD shall provide each Federal Facility with a data-mapping scheme for the transfer of GIS data. The Federal Facility shall provide the necessary data to HRSD in the agreed upon format. All GIS data shall have metadata associated with each data set.

Submittal of GIS data to HRSD for review and approval shall be in accordance with Section 1.

3.2.3 Existing Physical Attribution

Physical attribution is needed to describe the various facilities within the system. At a minimum, the following attributes shall be included for each feature used in modeling:

Pipe:

- Feature ID
- Upstream and downstream manholes or junctions
- Pipe size (inside diameter)
- Length
- Gravity line invert elevations (upstream and downstream)
- Pipe material
- Approximate pipe installation date
- Pipe condition
- Pipe type, i.e., force main or gravity sewer

Manholes:

- Manhole ID
- Diameter/size
- Spatial coordinates
- Invert elevation
- Rim elevation
- Ground elevation
- Sealed or unsealed lid
- Sump elevation
- Approximate manhole installation date
- Construction material (i.e. brick, pre-cast, etc.)

Pumping Stations:

- Pump station ID
- Wet well physical attributes (i.e., dimensions including critical wet well elevations)
- Pumping capacity (i.e., pump performance curves, draw down test results)Number of pumps
- Pump impeller size
- Pump manufacturer
- Type of drive (i.e., variable speed, dual speed, or constant speed)
- Control logic (i.e., wet well elevations at which each pump turns on, reaches full speed, and turns off)
- Piping details (including influent pipe elevation and all pipe sizes within the station)
- Flow equalization/storage attributes and control strategy
- Special equipment (e.g., pressure regulating valves)
- Flood plain location
- Approximate pump/pump station installation date
- Low rim elevation (the elevation of the lowest rim in the PS gravity collection system)

Where data are not available, assumptions must be made to complete the data set based on engineering judgment.

3.3 FLOW, PRESSURE & RAINFALL (FPR) MONITORING PROGRAM

The FPR monitoring program shall be conducted to characterize the flow regime in the sanitary sewer system under existing conditions and after sewer rehabilitation work is performed. The objectives of the FPR monitoring program are as follows:

- Collect representative dry and wet weather flow data for the sewer basin(s)
- Measure flow rate amounts of wastewater conveyed to the HRSD sanitary sewer system
- Identify conditions that cause sewer surcharging
- Observe and quantify dry weather infiltration

- Quantify rainfall derived inflow and infiltration (RDII) volumes
- Correlate RDII with rainfall volumes and intensities
- Determine and assist in prioritizing SSES Basins
- Obtain data necessary for hydrologic model calibration and demonstrate that peak flow reductions have been achieved
- Observe and quantify potential dry-weather inflow (e.g., manholes located in low-lying areas which may be inundated in dry-weather by tidal effects or stream flow)

The scope of the FPR monitoring program shall be developed to ensure data collection is adequate to meet the program objectives. Before defining the scope, the Federal Facility shall determine:

- The adequacy of existing data from prior studies (e.g., study areas in which no significant changes have occurred since the flow monitoring took place)
- Extent that pump station data can be used to quantify flows
- Equipment types and availability
- Where flow monitoring is needed
- Types of flow to be monitored
- Cost to collect and evaluate the data
- The seasonal variations of flow within the sanitary sewer system, if significant

3.3.1 Meter Site Selection and Basin Delineation

Selection of meter location sites is critical to defining sewer basins. Flow meter and pressure (for force main/pump stations) sites shall be selected so that the entire flow and pressures for the area of interest can be characterized. This may require multiple meters for areas with parallel sewers or complex connectivity. Metering sites should also be considered at boundary points for calibration and validation of hydrologic model(s). Meter sites shall be compatible with the minimum requirement of the flow monitoring equipment manufacturer relative to physical site constraints. A minimum of one basin needs to be delineated that corresponds to the terminal pump station connecting to HRSD.

Sewer basin delineation can be accomplished through use of sewer mapping. It is important that the meter locations are strategically selected to provide an appropriate delineation of sanitary sewer system basins.

If at any time a previously selected site is removed or replaced after approval of the Preliminary Flow, Pressure, Rainfall Plan, HRSD's P3 division shall be notified and it shall be noted within the FPR Evaluation Report.

3.3.2 Acceptable Flow Measures and Record Keeping

Equipment should consist of one or more of the following: open channel flow monitors, SCADA data (pump run times, discharge pressure and volumetric data) capable of computing flow, or monitoring flow in force mains. Flow monitoring equipment shall include a data logger, communication device and sensing unit. Volumetric flow monitoring must use staged storage if the metered sanitary sewer system surcharges on a regular basis. Where pressure pipe flow monitoring is to be performed for pump discharge flow measurements, magnetic flow meters or ultrasonic meters should be used. Where flow is measured in force mains, pressure shall also be measured. All gravity sewer metering equipment shall be capable of recording in both low flow and surcharged conditions for wet weather monitoring. The Federal Facility must utilize engineering judgment in the selection of flow monitoring methods and the application of the resulting data. The flow monitoring equipment, methods and application of the resulting data shall be reviewed and approved by HRSD as part of the required Preliminary Flow, Pressure, and Rainfall Monitoring Plan (Section 3.3.7).

Strengths and limitations for each flow monitoring method shall be evaluated considering characteristics of the flow to be measured and the location to be monitored. Note that the pump station volumetric method of determining flow rate is not reliable for conditions where wet well levels surcharge into the incoming sewer lines, or where variable frequency drive units are in place, unless other metering is used to account for flows being discharged from or entering the pump station. Pump curves and system curves shall be verified when using this methodology to estimate flow rates. Caution should be exercised in application of this methodology. It is most appropriate for pump or lift stations with constant speed pumps that discharge to gravity sewers.

3.3.3 Duration of Flow Monitoring

For the purposes of model calibration and identifying areas for SSES activities, flow monitoring shall be conducted. The flow data shall capture a representative sample of dry weather flows as well as several storm events of varying magnitudes. Flow monitoring shall be conducted for a duration that satisfies the following minimum criteria:

Flow Monitoring for Model Calibration and Verification and SSES Basin Identification

- Flow monitoring shall provide data that characterizes seasonal variations and captures the peak seasonal sanitary sewer system flows.
- Flow monitoring shall record three (3) individual wet-weather flow events of greater than one (1) inch of accumulation, including at least one (1) event with at least a one-year recurrence interval. These events shall capture system response under a variety of antecedent rainfall and groundwater conditions.
- Flow monitoring shall provide data that characterizes any unique flow to the facility (i.e. – ship discharge, etc.)
- Flow monitoring shall continue for sufficient time between rain events for the flow to return to dry weather conditions.
- Flow monitoring period shall capture typical diurnal variations in dry-weather flow, including weekends and weekdays.

If these events do not occur during the 12-month period, HRSD will work with the Federal Facility to determine whether the monitoring needs to be extended or sufficient rainfall for calibration for the hydraulic model(s) has been collected. If the monitoring period is extended, subsequent milestones that are directly impacted by the extension will also be adjusted.

Flow monitoring for SSES Basin identification or for peak flow reduction demonstration shall be completed and submitted to HRSD as specified in Section 1 of the Standards.

Selection of locations for flow monitoring shall include pump stations that are representative of a group of pump stations that exhibit similar responses to the variables which impact peak flow. Examples of the variables that shall be considered include, but are not limited to: the average age of the gravity sewers in the sewer basin; pipe material and joint type; soil-type and porosity; maximum, minimum and yearly groundwater elevations; proximity to surface water bodies; tidal influence; ratio of pervious to non-pervious surface area; service areas size; land use; historic I/I data; seasonal population patterns; and sanitary sewer system construction materials.

Flow monitoring data shall be reviewed for conformance with the criteria for model calibration and verification, as well as SSES Basin identification, as stated above. Flow monitoring shall continue until adequate data are obtained.

Verification of a hydrologic model involves comparing flow-monitoring data outside of the data set used for calibration to the predicted results of the model for the same conditions. The verification process should identify inaccuracies in the model not identified during calibration phase. Data requirements for verification shall include wet-weather events not used for calibration.

3.3.4 Data Accuracy Specifications

Flow and pressure monitoring accuracies will be based on typical accuracies for the type of equipment used. Flow and pressure meters shall provide an average, maximum and minimum values at 5-minute intervals or less.

Prior to installation of any meter and/or gauge, the device shall be calibrated according to manufacturer's recommendations. The calibration of open channel flow meters will be checked periodically after installation using supplemental velocity and/or level measurement devices, where the use of such devices is practical. Calibration records shall be included in the flow evaluation report to demonstrate that the equipment was properly calibrated. Any recalibration required during the monitoring period shall be noted and also included in the report. The meters shall be maintained in a manner that shall provide for a minimum data reliability during periods of calibration for the hydraulic model(s):

- Seventy-five percent (75%) data reliability for each individual meter during a monthly monitoring period.
- Ninety percent (90%) for all meter data should be maintained during qualifying rain events.

Data reliability means the percentage of flow data that has been collected and is not obviously incorrect (i.e., flat lines or drifted from known calibration levels).

Rainfall, flow and pressure monitoring shall be carried out in accordance with current standard practices, and shall generally be in conformance with widely used industry guidance such as Water Research Centre's (WRC) "A Guide to Short Term Flow Surveys of Sewer Systems", Water Environment Federation's (WEF) MOP FD-6 "Existing Sewer Evaluation and Rehabilitation", and NASSCO's "Manual of Practices".

The use of pressure side flow meters is appropriate only if they are accompanied with additional upstream monitoring or calculations that account for potential surcharging that may occur but may not be observable via the pressure side flow meter. The use of pressure side flow meters and the upstream surcharge monitoring/calculations shall be included in the Preliminary Flow, pressure, and Rainfall Monitoring Plan and shall be reviewed and approved by HRSD as specified in Section 1 of the Standards.

3.3.5 Rainfall Monitoring

Rainfall monitoring shall be done to obtain the data needed to compare wet weather sewer flow to rainfall volume, duration and intensity. The relationship between peak sewer flow and rainfall shall be used during the evaluation of the sewer system's performance and the prediction of RDII. Rainfall gauges shall be of the continuous recording type, and store data in 15-minute increments. Rain gauges shall be distributed throughout the area covered by the sanitary sewer system on a minimum of every 10 square miles. Federal Facilities with a total area covered by the sanitary sewer system of less than 10 square miles shall install at least one rain gauge. That density should provide reasonable coverage and representation of variations in rainfall intensity, duration and accumulation throughout the sewer system. Rainfall gauges shall be capable of recording rainfall at 0.1-inch intervals or less.

Rain data can be supplemented from gauges maintained by the United States Geologic Survey (USGS), the National Oceanic and Atmospheric Administration (NOAA) or HRSD rainfall records. Radar rainfall records derived from radar information that is calibrated with rain gauges maintained by the USGS, NOAA, or the Federal Facilities are also acceptable.

Rain gauges shall be in the general vicinity of the flow and pressure monitoring site and the nearest gauge shall be used for calibration of the model(s). To provide regional consistency, for long-term hydrologic simulations of sanitary sewer systems long-term historical rainfall data shall be used from the Norfolk International Airport (Airport Code ORF).

If HRSD rainfall records are used, valid data needs to be officially requested through HRSD's Data Analysis Section. Data requests may take 2-3 weeks to process.

3.3.6 Groundwater Monitoring

Groundwater level data shall be used, where available, to establish the potential for groundwater infiltration into the sewer system. Groundwater data can be used in conjunction with flow data to analyze infiltration based on the relationship between the groundwater table level and the elevation of the sewers.

3.3.7 Preliminary Flow, Pressure, and Rainfall (FPR) Monitoring Plan

A Preliminary Flow Monitoring Plan shall be developed and must be received by HRSD for review and approval as specified in Section 1 of the Standards. The Preliminary Flow Monitoring Plan shall include the following minimum information:

TITLE PAGE

- Project/Report Title
- Report Date
- Federal Facility Contact Information

EXECUTIVE SUMMARY

FLOW, PRESSURE, RAINFALL MONITORING METHODOLOGY

EVALUATION OF EXISTING DATA FOR COMPLIANCE WITH THE TECHNICAL STANDARDS

- SCADA Derived Flow Data
- Sanitary Sewer Evaluation Studies
- Flow Surveys

ASSESSMENT OF FLOW DATA REQUIREMENTS FOR SSES BASIN IDENTIFICATION

FLOW MONITORING SITE SELECTION

- Site Selection Criteria
- Mapping of Flow Monitoring Sites

PRESSURE MONITORING SITE SELECTION

- Site Selection Criteria
- Mapping of Pressure Monitoring Sites

RAINFALL GAUGE SITE SELECTION

- Site Selection Criteria
- Mapping of Rainfall Gauge Monitoring Sites

GROUNDWATER LEVEL SENSOR LOCATIONS

- Site Selection Criteria
- Mapping of Rainfall Gauge Monitoring Sites

MONITORING EQUIPMENT

- Equipment types to be used
- Use of SCADA System (if applicable)
- Data acquisition plan

IMPLEMENTATION SCHEDULE

DATA COLLECTION ACTIVITIES

- Data Acquisition Plan
- Data Collection Period

DATA MANAGEMENT

- Data Transfer
- Data Review
- Data Storage
- Data Verification
- Data Reporting

QA/QC PROCEDURES

3.4 FLOW, PRESSURE, RAINFALL MONITORING IMPLEMENTATION

Sewer flow monitoring information shall be used to characterize the performance of the sanitary sewer system during dry and wet weather flow conditions and to characterize the flow conditions that cause surcharging and/or overflows within the system.

3.4.1 Data Collection

Sewer flow, force main pressure, and rainfall information shall be collected (downloaded) at periodic intervals for the duration of the monitoring period. In cases where area-velocity meters are used to monitor flow in gravity sewers, a site visit after a major storm event is advisable to confirm meter conditions and to download the meter data. Data logging of the sensor readings shall be as described in Section 3.3.4.

Electronic transmission or collection of data for flow, and or pressure monitoring and rainfall gauging sites is desirable, where feasible and appropriate.

3.4.2 Instrument Maintenance

Instrument operation should be checked periodically. Problems with the instrument should be corrected as soon as possible to sustain data collection and data reliability at the highest level. Calibration records shall be submitted as part of the FPR Evaluation Report.

3.4.3 Data Storage Format and Warehousing

The metered data shall be stored in an open data format that can easily be accessed in an ODBC (Open data base connectivity) compliant format.

Data for each meter shall be uniquely identified and shall be distinguishable from the data from other meters. Further, the data shall be labeled and stored in a manner that will allow ease of site location identification and determination of the dates of collection.

HRSD’s Telog server shall not be relied upon for data storage.

3.5 FLOW, PRESSURE, RAINFALL EVALUATION REPORT (POST-FLOW MONITORING/PRE-REHAB)

Prior to rehabilitation, a FPR Evaluation Report shall be developed and must be received by HRSD as specified in Section 1 of the Standards. The FPR Evaluation Report shall be used to present flow data per Section 3.4 and shall be based on the Preliminary FPR Monitoring Plan submitted to HRSD, with any changes or modifications clearly indicated.

3.5.1 Data Summaries

Flow data summaries to be included in the FPR Evaluation Report shall present the flow data and observed flow conditions supported by graphical and tabular presentations of flow, wet well level, velocity, and pressure where applicable. Each summary shall include the following information:

3.5.1.1 Graphical Representation of Data

A graphical time-series plot (hydrograph) of flow rate vs. time data, as well as associated recorded rainfall data, shall be presented for each specific flow monitoring method below for selected rainfall events as well as the monitoring period.

Additional data summaries for various flow-monitoring methods are suggested below:

- Open Channel Flow Meters: Graphs (scatter graph) of flow depth versus velocity
- Force Main Flow Meters: Graphs of flow rate, associated system pressure versus time and associated rainfall
- Volumetric Flow Calculation: Graphs of wet well levels, calculated flow rate and associated rainfall
- Alternate methodologies for flow measurement and hydrograph development: Verified pump and system curves
- Data Reliability summary of all meters on a monthly basis

3.5.1.2 Tabular Data

A tabulation of hourly average, maximum, minimum, and peak hour flow rate recorded during the flow-monitoring period shall be submitted in electronic form with calculated site statistics in

.xls format or similar. Total flows over the 12 months of data collection shall be used to generate the Average Flow (AAF). The following data shall be submitted in electronic form with calculated statistics in .xls format for each specific flow metering method:

- Site Statistics:
  - Average flow (gpm)
  - Peak Hourly Flow for time period (gpm)
  - Average Pressure (psi and HGL in feet, NAVD88) – if applicable
  - Peak Hourly Pressure (psi and HGL in feet, NAVD88) – if applicable
- Each storm events summary used for calibration events to include:
  - Event Date
  - Rain gauge used in analysis
  - Rainfall amount
  - Recurrence interval
- Open Channel Flow Meters:
  - Time
  - Scattergraph (Flow depth vs Velocity)
  - Flow rate
- Force Main Flow Meters:
  - Time
  - Associated rainfall
  - Flow rate
  - Pressure
  - Pump run status
- Volumetric Flow Calculation:
  - Time
  - Associated rainfall
  - Wet well levels
  - Pump run status
  - Pump run times
  - Flow rate calculation
  - Pressures, where available
  - Staged storage, if surcharging exists
- Alternate methodologies for flow measurement and hydrograph development:
  - Time
  - Wet well levels
  - Pump run status
  - Pump run times
  - Discharge pressure data
  - Flow rate calculation
  - Other data as necessary to verify the appropriateness of the approach and quality of the results
- Calibration records
- Data reliability summary of all meters on a monthly basis

- Data excluded
- Maintenance activities
- Installation report: A summary of the installation details associated with each meter location, including a sketch of the manhole, wet well and/or force main configuration details and identifying related installation information.
- A rainfall analysis that estimates the rainfall recurrence interval for significant rainfall events.

3.5.2 Installation Report

A summary of the installation details associated with each meter location, including a sketch or photographs of the manhole, wet well and/or force main configuration details and identifying related installation information.

3.6 SEWER FLOW EVALUATION

The primary objectives of the flow evaluation are to characterize sewer flow under a range of hydrologic conditions, quantify peak flow for the purposes of identifying SSES Basins, and to develop the hydrographs needed to calibrate a hydrologic model. The sewer flow evaluation shall include quantification of base sewage flow, dry weather infiltration (DWI) and rainfall-derived inflow/infiltration (RDII) using the following procedure:

- Separate periods of dry and wet-weather flow with respect to rainfall data
- Establish a typical 24-hour, dry-weather sewer hydrograph
- Estimate DWI by determining flow rate during off peak hours
- Extract RDII by subtracting the dry-weather flow hydrograph from the wet weather hydrograph for the event or events of interest (Water Environment Research Foundation, Using Flow Prediction Technologies to Control Sanitary Sewer Overflows, 1999)

3.6.1 Data Analysis

Sewer flow consists of base flow and RDII, as shown on Figure 3-1. The first step in determining the peak flow reduction potential is to quantify the components. The following sections describe processes for determining each component of the total wastewater flow.

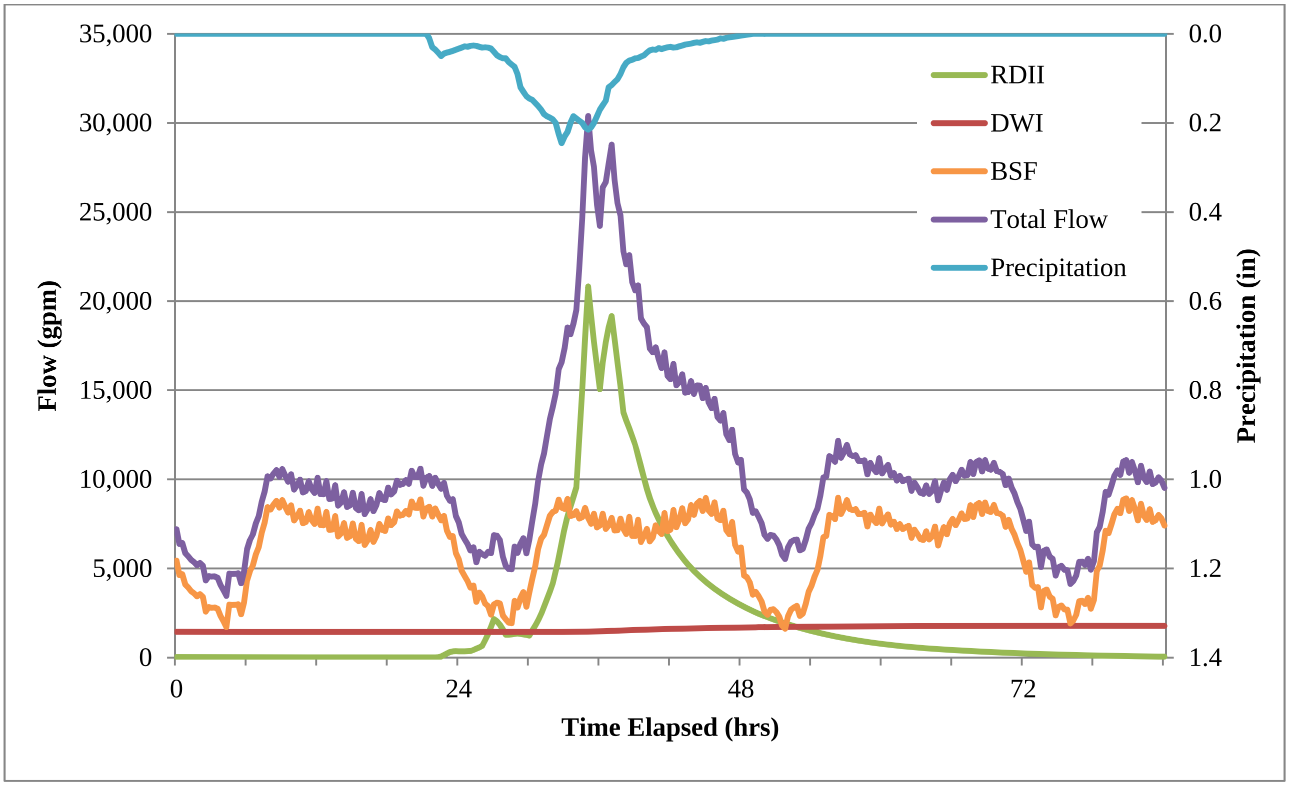

Figure 3-1. Example Components of Sewer Flow

3.6.1.1 Base Sewage Flow

Base sewage flow (BSF) is defined as the domestic and industrial/process sewage flow in the sanitary sewer system. It does not include DWI or RDII. The quantity of BSF shall be determined by each Federal Facility and shall be based on information and conditions specific to the Facility. In general, however, a dry weather period with low groundwater should be used for determining BSF values. In tidally influenced areas, periods of low tide should also be used for determining BSF values. Water consumption should be used to verify flow meter data. If water consumption is proposed to be more representative of BSF values than the flow meter, supporting documentation and/or engineering analysis must be submitted to HRSD for review and approval. In either case, the BSF value and method of determination shall be submitted to HRSD for review and approval as part of the FPR Evaluation Report.

3.6.1.2 Dry Weather Peak Hourly Flow (DWF)

The Dry Weather Peak Hourly Flow (DWF) is composed of BSF and DWI. The flow at each flow-monitoring site shall be used as the basis for determining the DWF for the metered areas and for estimating the dry weather infiltration entering the sewers. In determining the DWF, days with rainfall (and the following three days) shall be excluded from the analysis, and a minimum of 1 year of flow data shall be used. Dry day flows identified for each monitoring site shall be averaged to determine the shape of the hourly diurnal curve for each metered area. A comparison of peak hourly flows is suggested to identify anomalies in flow patterns. The diurnal curve for each metered area represents the DWF behavior and shall be used as input to the hydrologic analyses.

3.6.1.3 Dry Weather Infiltration (DWI)

Dry weather infiltration (DWI) for each metered area shall be estimated by subtracting the BSF from the DWF. DWI is heavily influenced by groundwater, thus the time of year used for determining DWF and DWI are critical and engineering judgment shall be applied in the estimation of DWI. As median dry weather groundwater conditions are desired for this analysis, thus flow monitoring for determining DWF and DWI shall be performed between July and August.

3.6.1.4 Rainfall Derived Infiltration/Inflow (RDII) Evaluation

RDII is the component of total wastewater flow resulting from rainwater entering the sewer system.

RDII is generally a substantial portion of the total sewer flow that occurs during wet-weather. In many cases, particularly in older sewers, RDII should be the largest component of wet-weather flow. RDII varies with rainfall volume, rainfall intensity, antecedent moisture conditions, the condition of the collection system, and other factors, including storm driven tidal effects. The constituents of RDII are infiltration and inflow.

Flows occurring during and after rainfall events that are higher than the dry weather diurnal curve represent potential RDII. The extraneous flow quantity is estimated by subtracting the measured hourly flow diurnal pattern from the wet weather hydrograph. After taking into account temporal and usage variations, the accumulated extraneous wet weather flow volume can then be estimated. The extraneous wet weather flow quantity (in gallons) for each monitoring site can be divided by the total rainfall accumulation (in gallons) over the metered area to calculate an RDII factor, expressed as a percentage of the total accumulated rainfall that entered the sanitary sewer system.

In addition to estimating the volumetric contribution of rainfall to the sanitary sewer system flow, peak one (1) hour flow shall be observed in conjunction with each rainfall event. The peak one (1) hour flow is critical for identifying basins that will require SSES activities as described in Section 5.1.

The rainfall-derived infiltration can be graphically observed in the receding portion of the wet weather hydrograph. After the rainfall event has passed and the peak flow response has passed, the slower decline of flow back to normal dry weather conditions may be an indicator of the wet weather infiltration. Volumetric quantification of this flow in the system can help determine the volume of I/I entering the system.

Illicit connections may contribute significantly to RDII values in an SSES Basin and shall be removed prior to development of peak flows as described in Section 4 and Rehabilitation Plans as described in Section 7, unless the Federal Facility determines them to be an insignificant source of RDII. Additional flow monitoring may be required after the removal of the illicit connections to accurately determine RDII in an SSES Basin. When estimating the influence of illicit connections to the RDII, care should be taken to consider drainage area, runoff coefficients and the capacity of the structure to accept the peak runoff generated by the drainage area.

SECTION 4 HYDROLOGIC PERFORMANCE ASSESSMENT

4.1 MODEL DEVELOPMENT

The hydrologic model is being developed so that wet weather flows can be simulated. The model will be used in conjunction with long term simulation to estimate the 10 year peak flow. Model development is the construction and calibration of a hydrologic model using collected data. This process includes:

- Physical data entry
- Sub-basin delineation
- Base flow estimation
- RDII generation

The hydrologic model shall be developed in accordance with the timelines and sequencing shown in Section 1 of the Standards.

4.1.1 Physical Data Entry

The data describing the collection system geometry will form the attributes and boundaries of the model. These data should be entered directly from GIS or from other database formats. Regardless of the data source, care shall be taken to ensure that the network connectivity and attributes are correctly represented in the model.

4.1.2 Sub-basin Delineation and Flow Assignment

Sub-basin delineation is the determination of tributary areas to various key points within the collection system. Flow assignment is the correlation of the flow from a tributary area to a specific node within the system. Sub-basins shall be delineated using a combination of sewer maps and topographic maps. Flow from tributary areas shall be assigned in a manner that represents the sewer systems characteristics.

4.1.3 Components of Flow

Considerations of the components of flow for the sake of the performance assessment are as follows. For further description of the components of flow, see Section 3.5.1.

4.1.3.1 Separation of Base Flow and RDII

Total observed sewer flow shall be separated into base flow and RDII using the following procedure:

- Separate periods of dry and wet-weather flow with respect to rainfall data
- Establish a typical 24-hour, dry-weather sewer hydrograph

- RDII is extracted by subtracting the dry-weather flow hydrograph from the total flow hydrograph measured during a specific wet weather event or events of interest

4.1.4 Base Flow Estimates and Projections

Base flows are estimated by summing the base sewage flow, as determined by the Federal Facility in Section 3, and dry weather infiltration.

Variability exists in all unit flow rates. Industrial unit flow rates, in particular, tend to have the greatest variation due to the volume of process water used in production, production schedule, and production methods. In the absence of industry specific information, flow monitoring should be considered.

It may be necessary during model calibration and testing to adjust the unit flow rates to match the observed base flow.

4.1.4.1 Variations in Base Flow

Base flow may vary daily, weekly, or seasonally. Daily variations in base flow shall be accounted for using diurnal curves. Diurnal curves shall be normalized based on daily average dry-weather flow to produce a unit diurnal curve. The resulting diurnal curve will consist of a series of 24 hourly values, one for each hour of a typical day. Unit diurnal curves shall be used to develop dry-weather flow hydrographs based on observed or predicted flow. Figure 4-1 illustrates a typical diurnal curve.

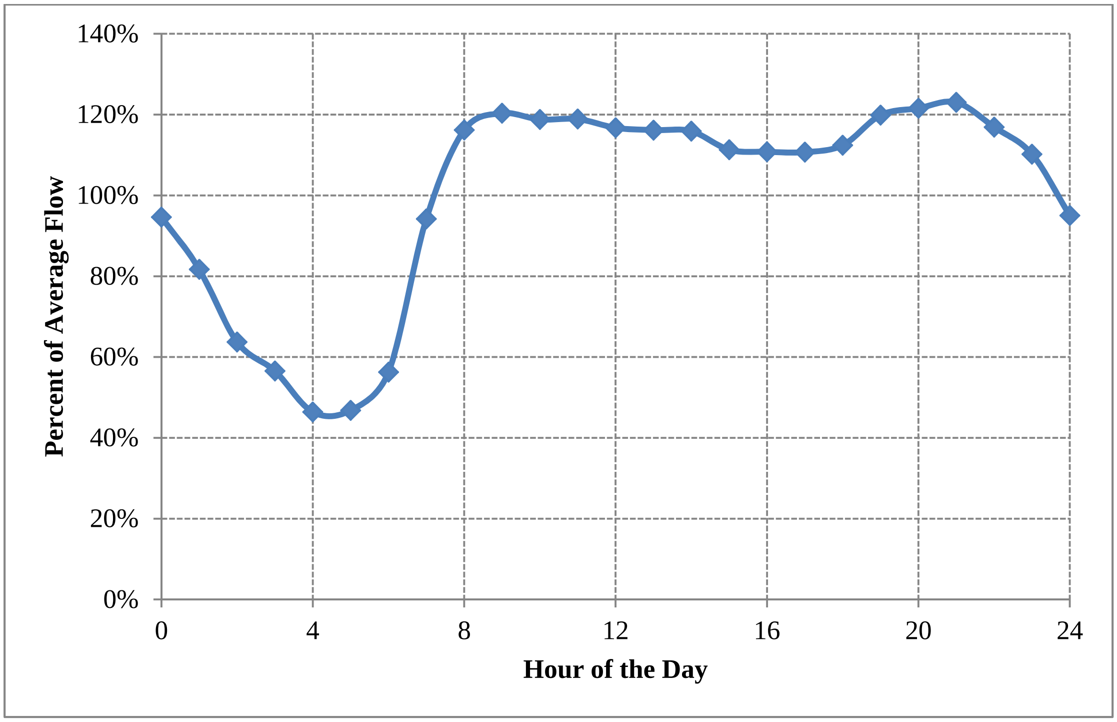

Figure 4-1. Example Diurnal Curve

Unit diurnal curves shall be created by:

- Developing a typical dry-weather hydrograph from a representative period as described below
- Dividing the dry-weather flow hydrograph by the daily average dry-weather flow, for the representative period

This unit hydrograph can be multiplied by daily average flows for various population conditions. This provides a method to generate future hydrographs based on population projections. A representative period of several days of dry-weather flow data should be used for the development of the unit hydrograph, including weekdays and weekends.

4.1.5 Rainfall Derived Infiltration and Inflow Generation

RDII generation techniques shall be limited to those that estimate a wet weather RDII hydrograph, as described in this section. The modeler should use engineering judgment to select the RDII generation technique.

Note that some of these methods may not be available in all commercially available hydrologic modeling software. In order to apply a method not included in a given software package, sewer hydrographs will need to be developed outside of the software. Note that no method is more accurate or precise than the data which are used to develop the RDII estimate.

The modeler shall use engineering judgment when projecting RDII for future conditions. This assessment shall be made based on pipe age, condition, current versus future extent of sanitary sewer system, and experience.

RDII flow generated from models calibrated using a relatively short history of rainfall and flow records (i.e. less than the requirements in Section 3) should be used cautiously and more data should be collected to confirm the model results.

4.1.5.1 Synthetic Unit Hydrograph

This method follows a similar theory as used for developing unit hydrographs for stream hydrology. The shape of the unit hydrograph is a function of the basin’s characteristics. Up to three unit hydrographs are commonly used to simulate the fast, medium and slow recession response of a sewer basin to rainfall as shown on Figure 4-2 and is commonly referred to as the RTK method. Up to three unit hydrographs may be required to accurately predict RDII due to the fact that infiltration and inflow exhibit different responses to rainfall. Inflow typically exhibits a rapid reaction to rainfall while infiltration exhibits a more gradual response.

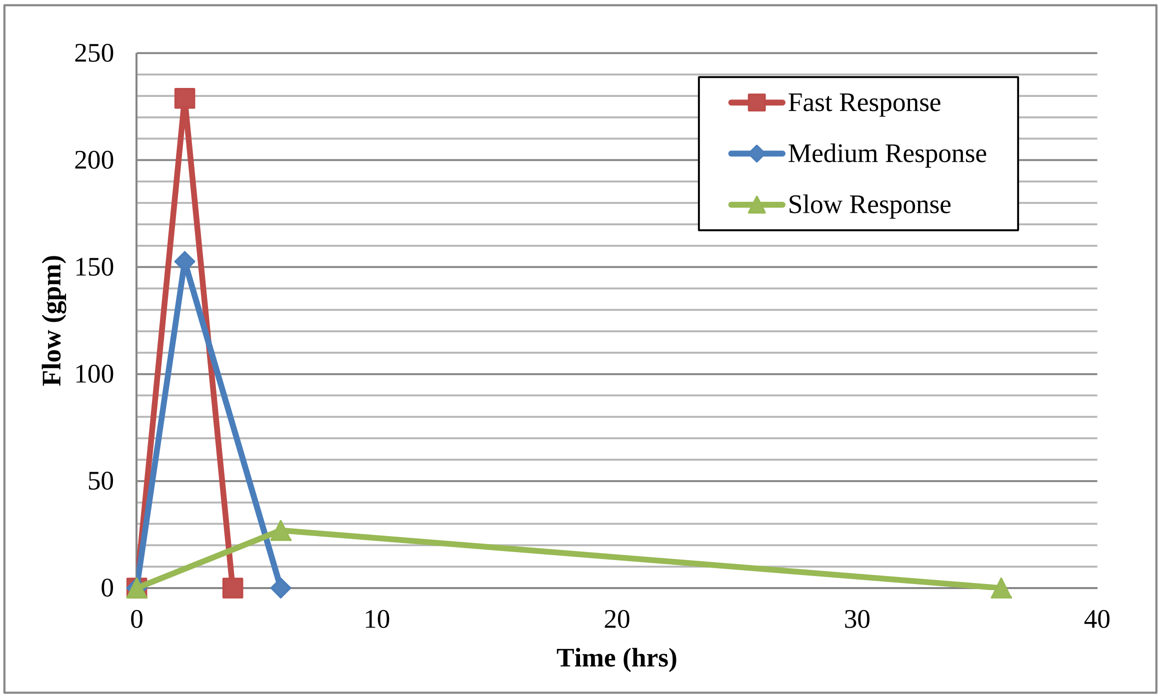

Figure 4-2. Synthetic Unit Hydrographs

4.1.5.2 Hydrologic Methods

This technique simulates the hydrologic cycle including direct runoff, indirect inflow from sources such as foundation drains, groundwater entry through system defects, and the impact of antecedent moisture conditions. Such methods, available in most commercial software, perform a mass balance on the rainfall, sewer flows and soil moisture to simulate RDII over all seasons and antecedent moisture conditions.

This RDII generation method can be made to match a measured flow hydrograph with a wide range of coefficient values; this could result in an inaccurate representation of RDII generation if these variables are adjusted improperly. Experience is needed to choose those parameter sets that will be most appropriate under a variety of rainfall conditions.

4.2 MODEL DEVELOPMENT PROCESS

4.2.1 Model Requirements

Models shall use hydrologic analysis solutions that will accurately model dry and wet weather responses.

4.2.2 Model Development Process

The Federal Facility shall develop and maintain a hydrologic model of the sanitary sewer system within the facility and upstream of the Regional Hydraulic Model. Measured dry and wet weather flow data will be used to calibrate and verify the Facility hydrologic model.

4.3 CALIBRATION AND VERIFICATION

4.3.1 Calibration

Calibration refers to the process of checking the predicted (modeled) flow against actual observed flow, given the rainfall conditions observed for the same period. This process includes double-checking initial input variables for reasonableness and adjustment of input variables. This process shall be followed by verification using a different set of data than was used for calibration. Auto calibration functions native to the modeling software that do not require engineering judgment shall not be used.

Reliable flow monitoring data is critical to be able to calibrate the model to dry and wet weather conditions. Additionally, accuracy of network connectivity and boundary conditions (i.e. outlet conditions, pump control) are also critical in calibrating the model. Identification and correction of errors in network connectivity prior to variable adjustment will save labor during calibration.

Base flow and RDII shall be treated as separate components during calibration. Base flow shall be calibrated adequately before making adjustments to RDII. If base flows were over predicted to match the total sewer flow, then the RDII would consequently be under predicted. This could produce gross inaccuracies in predicted flow, particularly in evaluation of future conditions when base flows are extrapolated to account for population growth.

Adjustment of model variables can be guided by both graphical and statistical methods. During the initial iterations, it is convenient to use a graphical comparison of modeled and observed flow, as shown on Figure 4-3.

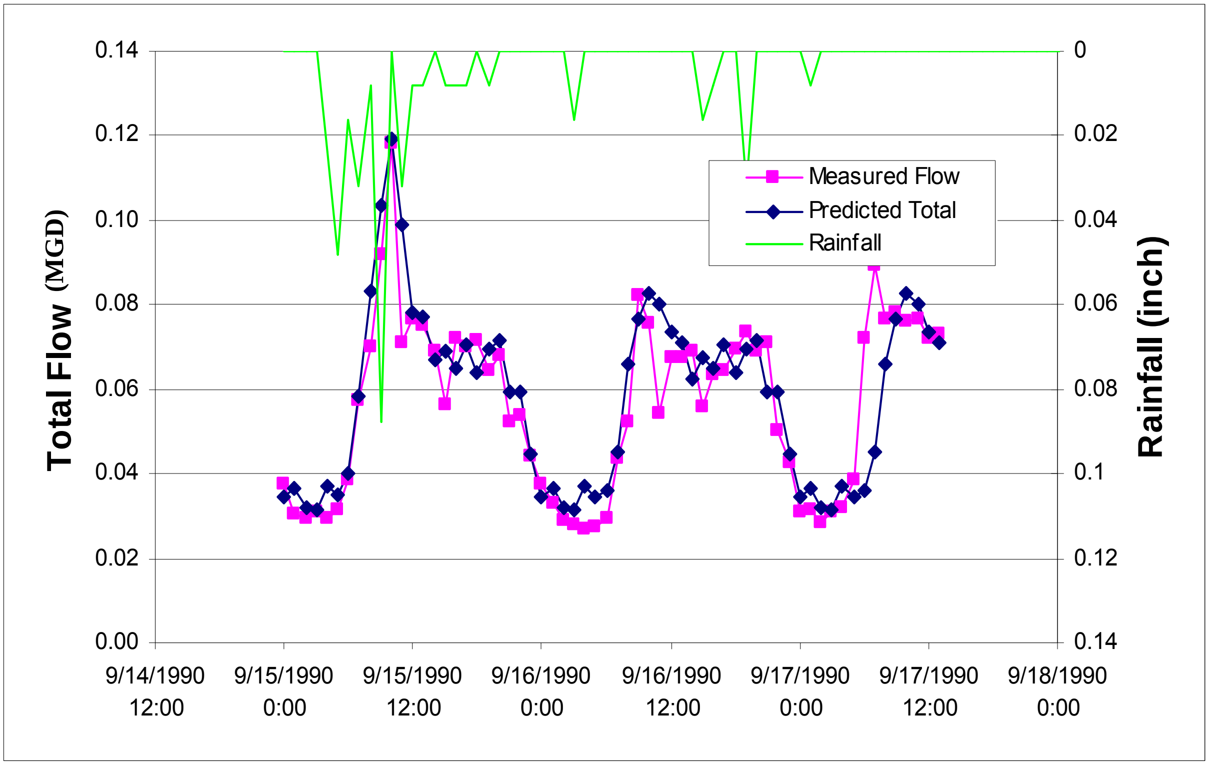

Figure 4-3. Modeled Versus Observed Hourly Flow

Graphing modeled and actual flows provides a quick analysis of model accuracy. This can be used early in calibration to identify large discrepancies and make broad adjustments to the model. Criteria for consideration during graphical analyses are hydrograph shape, peak flow rate, and peak and trough timing. This shall be applied to both dry and wet weather conditions.

Statistical methods provide quantitative comparisons to modeled and observed flows. Calibrated models shall meet the following statistical standards for dry and wet-weather flows. These standards will also be applied for model verification.

For dry-weather flow (i.e., base flows), the following standards shall be used for calibration, in addition to matching general hydrograph shape. These standards shall be met for at least 2 dry-weather days.

- Predicted time of peaks and troughs shall be within 1 hour of the observed flow
- Predicted peak flow rate shall be within +/- 10 percent of the observed flow data
- Predicted volume of flow over 24-hours shall be within +/- 10 percent of observed flow

For wet-weather flow (base flow and RDII), the following standards shall be met for calibration, in addition to matching general hydrograph shape. These standards are based on generally accepted practices, and conform to the guidance published in Wastewater Planning Users Group (WaPUG) Code of Practice for the Hydraulic Modeling of Sewer Systems (2002). These standards are desirable for model calibration for the wet-weather events described in Section 3.3.3.

- Predicted time of peaks and troughs shall be within 1 hour of the observed flow
- Predicted peak flow rates shall be within -15 percent and +25 percent of the observed flow
- Predicted volume of the wet-weather event shall be within +20 percent and -10 percent of the observed flow
- Predicted pump discharge pressure within +/- 10% of observed pressures
- Predicted surcharge depth in manholes or other structures shall be within +1.5 feet and -0.3 feet of the observed depth
- Predicted non-surcharged water surface elevations shall be within +/- 0.3 feet of the observed depth

If a model cannot meet the calibration criteria, the model should be considered sufficiently calibrated using engineering judgment if:

- The reason for non-compliance has been identified but cannot be modeled, and has been determined to be unimportant to the model's purpose and use. This shall be supported by credible evidence.
- The reason for the discrepancy cannot be identified, but an assessment of the effect of likely causes on the accuracy of the model has shown that this will not be detrimental to the use of the model.

4.3.2 Verification

Verification is the process of checking a model against data that were not used for calibration. The calibrated model is run with different rainfall data than those used in the calibration, and the results compared against corresponding flow data. Verification standards shall follow the same criteria used to evaluate the model during calibration. An overall quality review of the input data, network connectivity, assumptions, and simplifications shall be conducted during model verification.

In the event that a model does not meet the verification criteria, the cause of the situation shall be carefully reviewed. This situation may warrant inclusion of additional flow monitoring data in the analysis, field studies to determine system anomalies (e.g., heavy sediment accumulations) not included in the model, or revisiting the data input.

If a model cannot meet the verification criteria, the model may be considered sufficiently verified using engineering judgment if:

- The reason for non-compliance has been identified but cannot be modeled, and has been determined to be unimportant to the model's purpose and use. This shall be supported by credible evidence.
- The reason for the discrepancy cannot be identified, but an assessment of the effect of likely causes on the accuracy of the model has shown that this will not be detrimental to the use of the model.

4.4 LONG TERM FLOW SIMULATIONS

Long-term flow simulation (LTS) shall be used to assess recurrence frequencies for peak flows or volumes. Specific recurrence frequencies are established using probabilistic analysis discussed in this section. Long-term flow simulation takes into account a wide range of historical rainfall patterns, and provides sufficient data with which to define the recurrence interval of peak flows. Because the antecedent soil moisture conditions for a given rain event can have a dramatic effect on the RDII response of a sewer system, this Standard does not promote the analysis of sewer flow frequency based on specified rainfall frequencies.

Flow monitoring data will not be available for a sufficient period of record or for the location of interest to perform a probability analysis of measured flow. Therefore, calibrated hydrologic models will be used to develop a simulated flow record for the duration of a historic rainfall record. Generally, rainfall data is available for a much longer period of record than typically found in sewer flow monitoring.

Once a calibrated model has been developed, a long history of rainfall shall be applied to the model to generate a long-term history of sewer flows. The resulting modeled sewer flows provide an estimation of the actual sewer flows for a given period of rainfall. The predicted sewer flow from the long-term simulation shall be subjected to probabilistic analysis to determine the recurrence interval for various events.

Typically, for event frequency analyses, the length of the rainfall record required shall be at least twice the frequency of the peak flow recurrence being evaluated. For example, to confidently predict the 5-year peak flow recurrence event would require 10 years of rainfall data. However, to provide regional consistency, long-term historical rainfall data shall be used from the Norfolk International Airport (Airport Code ORF) for long-term hydrologic simulations of sanitary sewer systems and at least 50 years of hourly data shall be used in the LTS.

Log-Pearson Type III distribution probabilistic analysis shall be used to determine event recurrence intervals and can be applied to both peak hourly flow and volume. This method is detailed in most hydrology textbooks. An example of a peak hourly flow probability graph is shown on Figure 4-4. The estimated 10 year peak hour flow shall be compared with the peak flow threshold to determine post-rehabilitation flow target (peak flow commitment). See section 7.3.

By applying the probabilistic analysis to recorded flows and rainfall events recorded during the flow monitoring phases, simulations can be performed to identify the anticipated results of applying historical conditions to updated flow conditions. The results of these simulations can determine whether or not the flows have been satisfactorily reduced to within the standards set in Section 7.3 or whether additional rehabilitation is needed to bring the system into compliance.

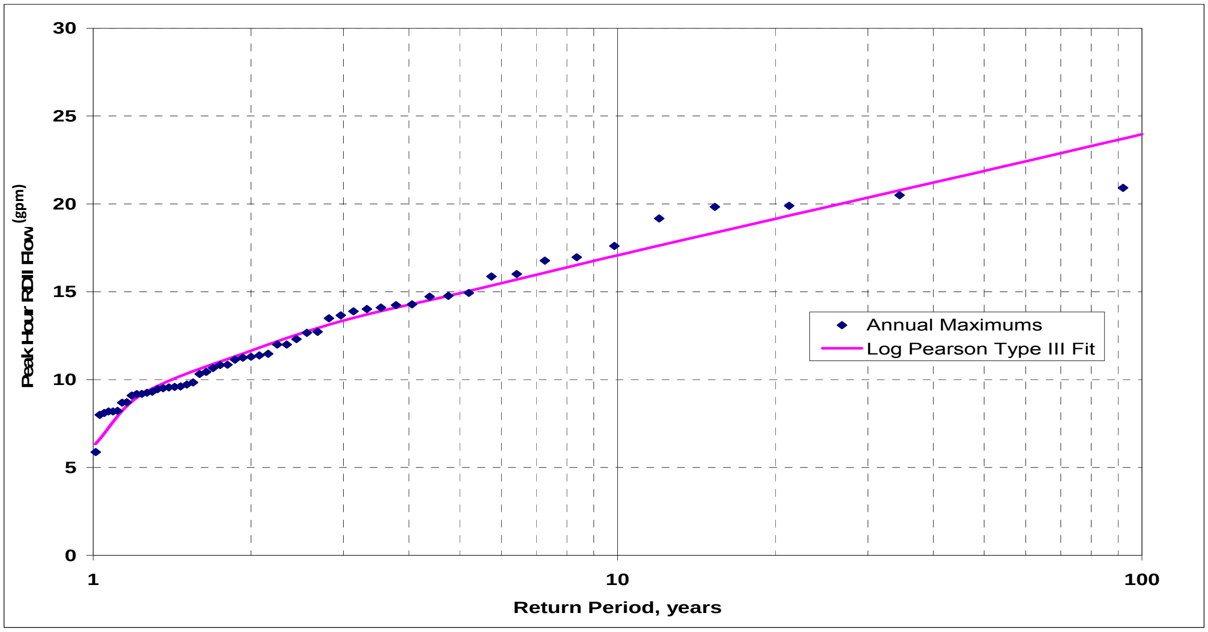

Figure 4-4. Example of Probability Plot

4.5 HYDROLOGIC MODEL DEVELOPMENT DOCUMENTATION

Modeling work shall be documented to support the model and the conclusions drawn from its use as well as to provide a record for assessment of the model's suitability for other projects. Model development documentation shall be received by HRSD for review and approval as specified in Section 1 of the Standards.

Modeling documentation shall be developed which includes the following information:

- Model development, including data sources
- Model calibration and verification methods and results
- Estimated 10 year peak hour flow recurrence
- The Annual Average Flow
- The peak hourly dry weather flow
- The dry weather infiltration flow

4.5.1 Model Development Documentation

This section of the model documentation shall document work from project inception through calibration, including:

- Project definition and purpose
- Data description, sources, reliability and location of data storage
- Assumptions and simplifications
- Flow estimation methodology
- Calibration records including initial variable assumptions and justifications for variable adjustments outside of accepted ranges

The record of data shall be as specific as possible, referencing firm or agency of origin, date, format, modifications, and any commentary regarding data quality or assumptions about the data.

4.5.2 Model Verification Documentation

The purpose of the model verification section of the model documentation is to document the accuracy of the model against data other than that used for calibration. This section shall include:

- Metrics indicating the models compliance with verification standards
- Description and justification of changes to the model during verification
- Graphs comparing predicted to actual flow both for the verification period and the original calibration period
- Comments of the model's suitability for the intended use, particularly if the model does not meet one or more verification standards
- Analysis used to evaluate the suitability of a model not conforming to the verification standards
- Limitations of the model

SECTION 5 SSES PLANNING

A sewer system evaluation survey (SSES) Plan shall be developed considering the results of sewer flow monitoring and other relevant information, including the sanitary sewer overflow (SSO) characterization analyses. The plan shall identify SSES Basins; the activities to be performed in those basins; and a schedule for conducting the SSES work. SSES Basins shall be selected based on the criteria presented in Section 5.1 in conjunction with utility personnel knowledge of the system.

5.1 SSES BASIN CRITERIA

Sewer basins that are known or suspected of meeting the following criteria shall be included in the SSES Plan:

- Basins with unresolved wet-weather SSOs, except where SSOs have only resulted during rainfall conditions in excess of a 10 year, 24 hour rainfall recurrence interval
- Basins with unresolved SSOs caused by infrastructure defects (pipe sags, offset joints, broken pipe, etc.)
- Basins exceeding a peak hourly flow of 3 times the Annual Average Flow (AAF), where this peak flow is a 10-year peak flow recurrence as determined by the procedures described in Section 4
- Basins served by pump stations that exhibit excessive pump run time

5.2 SSES PLAN DEVELOPMENT

An SSES Plan shall be developed to meet the following objectives:

- Identify and prioritize basins for investigation
- Establish baseline estimates of I/I
- Select the detailed approach to provide sufficient information for condition assessment activities including hydraulic, corrosion and structural investigation
- Coordinate improvements to records and mapping that may be needed
- Establish a schedule of activities

Prioritization of basins for investigation shall be based on the following:

- An initial estimate of potential volume of I/I reduction in each basin (i.e., gallons per day)
- The number and severity of SSOs that occur within the basins
- Historical information about the system such as number of repairs and operation and maintenance history (including pump stations and force mains)

The typical approach to detailed investigations is to perform preliminary evaluations as a basis for ascertaining the need for further detailed field investigations. For example, when the case can be clearly identified for replacement of certain reaches of sewer mains based on initial field reconnaissance, supplemental field investigations may not be cost effective or necessary.

Conversely, there may be cases where the cost of further detailed investigations can potentially result in project cost savings through better defining the required scope of upgrade work.

Information from the field investigations is used to evaluate sanitary sewer system conditions. Field investigations to be used in the SSES are detailed in Section 5, and generally include:

- Gravity Sewers
    - Manhole Inspections
    - CCTV Inspections
    - Smoke Testing
    - Dye Testing
    - Night Flow Isolation
- Pump Station Inspection
- Force Main Assessment

A minimum investigative program in all SSES Basins shall include pump station evaluation, manhole inspections, and determination of critical inspection areas. At a minimum, SSES Basins that exhibit wet weather flows in excess of the peak flow threshold shall be evaluated using smoke testing, and all gravity sewer locations that have identified unresolved dry weather overflows shall be investigated with CCTV.

5.2.1 Identification of Areas for Inspection

SSES Basins shall be selected based on the criteria established in Section 5.1 and best available information about the system. These areas need to be uniquely identifiable to track SSES activities and for ease of reference.

Each basin shall be inventoried to identify the specific facilities that will be investigated and scope of the investigation. Verification of system connectivity will also be necessary to trace sources of I/I. This shall include mapping of:

- Pipelines
- Manholes
- Pump Stations
- Pumps
- Force Mains
- Valves
- Air Release Valves
- Flow Control Structures
- Stream or Aerial Crossing
- Siphons

5.2.2 SSES Plan Submittal

All work related to the SSES Plan shall be completed prior to the submittal of the Rehabilitation Plan described in Section 7. A detailed schedule for conducting the SSES work shall be established in the SSES Plan, which shall be reviewed and approved by HRSD. This plan must be received by HRSD as specified in Section 1 of the Standards.

A specific schedule outlining the activities to be conducted shall be established for inclusion in the SSES Plan. The schedule shall include the following milestone: Completion of SSES Field Activities and notification that field activities have been completed, as specified in Section 1 of the Standards.

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SECTION 6 CONDITION ASSESSMENT OF SEWERS AND PUMP STATIONS

6.1 OBJECTIVE

Condition assessment of specific sanitary sewer system assets shall be conducted in order to develop a prioritized rehabilitation program that addresses deficiencies that contribute to I/I. If system assets are to be completely replaced under Section 7, Rehabilitation Plan, condition assessment may not be necessary or may be deferred. This section provides guidance on development of condition assessment programs to be incorporated into SSES Plans per Section 5 based on the background data review, flow monitoring, and specific problems that are identified.

6.2 ASSESSMENT STANDARDS FOR GRAVITY SEWER SYSTEM

6.2.1 National Association of Sewer Service Companies (NASSCO)

In an effort to standardize sewer pipe defect coding and ratings in the United States, NASSCO has developed industry-accepted standards. NASSCO has also developed rating standards for manhole and lateral defects as well. The following programs have been developed by NASSCO:

- A standard coding system
- A training and certification program
- Standardized data format
- A certification for data collection software vendors
- Mapping symbology standards
- A standard condition rating system

All defect coding and condition assessment shall be based on NASSCO standards to provide consistency.

6.2.1.1 Pipeline Assessment Certification Program (PACP)

The PACP establishes standards for the assessment of sewer mains using information obtained through CCTV inspections. This standard will be used to assess, evaluate and categorize gravity mains within the sanitary sewer systems.

6.2.1.2 Manhole Assessment Certification Program (MACP)

The MACP uses the established defect coding system found in the PACP and incorporates many of the American Society of Civil Engineers (ASCE) manhole standards as well. The MACP standard will be used to assess, evaluate and categorize manholes within the sanitary sewer systems.

6.3 DATA NEEDS AND DATA MANAGEMENT

The initial flow monitoring and system data review will give an indication of the field investigations that are necessary to further assess the condition of assets within SSES Basins. Condition assessment requires that certain data be collected to describe the facilities in the SSES Basins and their condition. Various investigation methods can be used to assess the infrastructure components and collect asset information. An example of the types of investigative activities that should be used to assess a range of issues is presented in Table 6-1. The matrix provides general guidance as to appropriate field investigations that should be used to assess the various infrastructure elements.

Data collected during the field investigations will indicate the existing condition of assets within SSES Basins. That information should be compiled in an Information Management System (IMS), such as a computerized maintenance management system (CMMS), if available. The collected information can be managed within the IMS and GIS systems to facilitate rehabilitation planning and execution. At a minimum, the data shall be stored in an open data format that can easily be accessed in an ODBC (Open data base connectivity) compliant format.

Table 6-1. Example Field Investigation Data Needs Matrix

	Records Review	CCTV Mainline	CCTV Lateral	Manhole Inspection	Smoke Testing	Dye Testing	Night Flow Isolation	Pressure Monitoring	Flow Monitoring	Groundwater Monitoring	Rainfall Gauging	Hydrologic Modeling	Pumping Test	Wet Well Inspection	Pump Run Time Assessment
SERVICE LATERALS															
Capacity															
Evidence of I/I			●		●	●		●		●					
SSOs			●		●	●		●							
Surcharging			●					●							
Structural Condition															
Material Stability			●												
Age	●														
Maintenance															
Roots	●		●												
Grease	●		●												
MAINLINE SEWERS															
Capacity															
Evidence of I/I	●	●			●	●	●		●	●	●	●			
SSOs	●	●			●	●	●		●	●	●	●			
Surcharging	●	●				●			●	●	●	●			
Min Slopes or Grade Reversal	●	●													
Structural Condition															
Line Failure	●	●			●	●									
Sags		●													
Joint Misalignment		●			●	●									
Defect Rehabilitation	●	●			●	●									
Age	●	●			●										
Maintenance															
Roots		●													
Grease		●													
MANHOLES															
Capacity															
Evidence of I/I						●	●		●	●	●	●			
SSOs						●	●		●	●	●	●			
Surcharging						●			●	●	●	●			
Structural Condition															
Material Stability						●									
Age						●									
Maintenance															
Roots	●			●											
Grease	●			●											
FORCE MAINS															
Capacity															
Excessive System Pressure	●							●		●	●	●	●		●
Surcharging	●								●	●	●	●			
SSOs	●								●	●	●	●			
Structural Condition															
Air Vents	●														
Pipe Failures	●														
PUMP STATIONS															
Capacity															
Excessive Pump Runtimes	●								●	●	●	●	●		●
Surcharging	●								●	●	●	●		●	
SSOs	●								●	●	●	●		●	
Structural Condition															
Material Stability	●													●	
Age	●													●	
Operations															
Air Entrainment	●													●	

6.4 FIELD INVESTIGATION APPROACH

The objective of the field investigation is to provide an appropriate level of system information to support sound rehabilitation and/or replacement decisions, and identify I/I sources that require abatement.

Field investigations shall be conducted in a comprehensive or phased approach to identify deficiencies in SSES Basins. A phased approach should be used to progressively evaluate and screen SSES Basins. For example, if an SSES Basin has been designated due to excessive pump run times, it may be beneficial to evaluate the pump station operating conditions prior to initiating a detailed investigation of the tributary gravity sewer system. The phased investigation approach should be planned as follows:

- Initial Field Reconnaissance and Records Review
    - Manhole Checks
    - Pump Station, Wet Well, and Force main Evaluation
    - Critical Location Inspection Determination
- Limited Field Inspection
    - Manhole Inspections
    - Smoke/Dye Testing
    - Limited CCTV/Digital Imaging Inspection Associated with Dye Testing
    - Night Flow Isolation
- Comprehensive Field Evaluation
    - Comprehensive CCTV/Digital Imaging Inspection
    - Comprehensive Manhole Inspections
- Prompt Attention to Identified Severe System Deficiencies

Various types of investigations can be used to identify where rehabilitation or repair work should be performed and to determine the type and extent of rehabilitation. In SSES Basins that have known I/I problems or defects that have resulted in sanitary sewer overflows (SSOs), a comprehensive condition assessment of the gravity sewer system should be initiated without the need for a phased approach. The field investigation techniques described herein should be undertaken as a comprehensive field evaluation or should be focused on a specific field activity where known problems exist. The field reconnaissance program should be based on the background data review, flow monitoring data, pump run time analysis, existing condition assessment and SSES reports, evaluation of SSO history, sewer service call history and review of engineering and operations information.

6.5 PROCEDURES FOR ASSESSMENT ACTIVITIES

The following procedures for sanitary sewer system assessment activities define available and consistent techniques to be used in field investigation. Performing these activities in a consistent manner will aid in the evaluation of data, and can provide a regionally common basis for condition assessment.

The following sections provide guidelines for conducting field investigation of sanitary sewer systems. Activities that should be implemented include:

- Gravity Sewers
    - Manhole Inspections
    - CCTV Inspections
    - Smoke Testing
    - Dye Testing
    - Night Flow Isolation
- Pump Station Inspection
- Force Main Assessment

6.5.1 Gravity Sewers

Gravity sewers shall be inspected for structural conditions, capacity problems and maintenance issues which may negatively impact performance. Gravity sewer inspections shall include manhole inspections, CCTV inspections, smoke testing, dye testing, and night flow isolation, as appropriate.

6.5.1.1 Manhole Inspections

One of the most useful methods to determine sanitary sewer system condition is to perform and document inspections of manholes. Manholes have the potential to allow significant quantities of I/I into the sanitary sewer system (such as when manhole lids are lower than the surrounding surface and drain storm water when streets are flooded during wet weather). Manhole inspections can also provide indication of surcharged conditions in mainline sewers. Manhole inspections should be conducted to obtain information on manhole conditions and to observe sewer flow conditions, including indications of unacceptable surcharging. Manhole inspections shall be conducted in SSES Basins that potentially have I/I problems. Manhole inspections shall be conducted in accordance with NASSCO standards.

Each manhole shall be assigned a unique identifier. The manhole identifier will be used to identify each manhole where an inspection is performed. Information and condition ratings should be collected on the manhole cover, frame, adjustment rings, cone, steps, wall, bench and channel as well as connecting influent and effluent pipelines.

In conjunction with manhole inspection activities, manholes and cleanouts in areas subject to flooding, ponding, or submerged tidal conditions should be observed and noted. It should be noted if the cleanout is broken or if the manhole cover allows ponded water to enter the manhole.

A topside (or non-entry) manhole inspection should be conducted to determine overall structural condition of the manhole. The surrounding area should be observed and noted if the manhole is located in an area that is conducive to flooding over the top of the manhole. Manholes found to be surcharged should be re-inspected during a lower flow period. If a topside manhole observation provides evidence of the manhole being a significant I/I source, an internal manhole observation (i.e., pole camera or manhole entry) shall be made to specifically determine what defects exist in the manhole and its connecting pipes. This information shall be used to determine what corrective measures will be needed to correct the observed deficiencies.

6.5.1.2 CCTV Inspections

CCTV inspection should be used to assess the condition of sewer lines by identifying structural problems, points of infiltration and inflow, capacity issues, and system blockages. The data collected should be compatible with and easily integrated by the Federal Facility's IMS. The CCTV inspection shall be conducted and recorded in accordance with NASSCO PACP© standards.

6.5.1.3 Smoke Testing

Smoke testing should be conducted as part of the evaluations in areas that are suspected to have inflow problems. Limited CCTV inspections should be used in conjunction with smoke testing to verify the location of cross connections and inflow sources that are identified.

Smoke testing shall be conducted during dry weather and at low tide and shall be carried out in conformance with widely used industry guidance such as EPA Handbook 625/6-91-030 "Sewer System Infrastructure Analysis and Rehabilitation" Section 4.3.6, and WEF Manual of Practice FD-6 "Existing Sewer Evaluation and Rehabilitation".

The entire section being tested should be visually inspected by walking along the route of sewer line watching for smoke leaks. The location of smoke leaks should be marked, noted, numbered and photographed. The photograph number corresponding to each leak should be recorded. Cleanouts and failures that are observed to produce smoke should also be noted if they are in an area subject to flooding.

6.5.1.4 Dye Testing

Dyed water testing should be used to verify connectivity, direction of flow, sources of I/I, as well as illicit connections to the system. Dye testing should be used to complement smoke testing to verify these sources.

Prior to dye testing, the line to be tested should be cleaned. The downstream manhole should be monitored to observe if dyed water passes through the system and the estimated quantity noted. If sufficient dye water passes through the downstream manhole, a CCTV inspection should be performed to identify the location and magnitude of the source of flow.

6.5.1.5 Night Flow Isolation

Night flow isolations should be used to trace sources of infiltration. Night flow isolations should be used to locate and quantify the amount of infiltration entering a sewer system. Night flow isolations are typically performed to narrow down and identify reaches that have excessive infiltration that can be pinpointed for further investigations.

Night flow isolations typically are performed during low flow periods, between the hours of midnight and 6 AM. The flow measurement should be conducted with a weir structure that is suitable for the size pipe being isolated. The upstream reaches should be plugged, whenever flow conditions warrant, providing a quantification of infiltration in each reach of line. When flow conditions do not allow for plugging, differential measurements should be used upstream and downstream for the section of pipe being investigated. Any known sewage flows that contribute flow normally under nighttime conditions in the line under investigation should be noted for the section of line under investigation.

6.5.2 Pump Stations

Pumping stations shall be inspected for structural conditions, capacity problems and maintenance issues which may negatively impact performance. Typical maintenance issues include, but are not limited to:

- Grease: Grease buildup interferes with station operation by inhibiting the operation of level sensors. Impeller wear: Entry of sandy soil and grit into the wet wells by way of structural defects in the gravity sewers reduce effective wet well capacity and cause excessive impeller wear.
- Mechanical and electrical failures: Inadequate preventive maintenance increases the risk of mechanical and/or electrical failures.
- Excessive pump run times: Excessive run times can be an indicator of capacity issues or equipment wear.
- Influent surcharge: Improper “pump on” set point or inlets constructed close to pump centerline can lead to influent pipeline surcharge.
- Wet well surcharge, SSOs: System head on manifolded networks exceeds the pumping capability of the pumping station or influent flow that exceeds pumping capacity can lead to overflows and excessive pump runtimes.

Pumping station inspections and evaluations shall be conducted in a consistent manner. Visual inspections should be made of various features of the pumping station, and the results documented. Some of the key information that should be obtained during the inspection is outlined below.

Building Condition: Visually inspect the interior, exterior and roof of the building for physical or structural problems and record defects that may allow I/I to enter the sewer system.

Pumps and Motors: From the manufacturer’s data plates and any up-to-date maintenance information, record the pump head in feet, the capacity in gallons per minute and the impeller diameter in inches for each pump. Record the horsepower and listed RPM for the motors. Observe the pumps and motors for vibrations, sounds, temperature and odor. The operating logs should be reviewed. The operations staff should be consulted to determine under what conditions and how long all pumps operate at the same time.

Wet Well: Inspect the wet well in a dewatered state to ensure a complete and proper visual inspection. Accumulation of debris, sediment and grease buildup should be removed when the wet well is drained for the inspection. The walls should be observed for coating condition, spalling or softness of concrete, erosion of concrete and the condition of bottom fillets.

Corrosion of Ancillary Equipment: While the wet well is in a dewatered state and after cleaning, inspect the ventilation system ducts and fans, access hatch, interior railing, access ladder and platforms, pump control system, pump rails, and interior piping for corrosion.

Dry Well: Inspect the dry well for structural conditions of concern.

Piping: Visually inspect the piping, valves (check, isolation, surge relief and air relief) and other fittings for corrosion, leakage, coating system condition, and proper operation.

Emergency Generator/Pump: Observe the generator/pump while running under load to verify its operation, noting excessive noise, dark exhaust, and ease of generator/pump starting. Test to ensure that the device will automatically start upon loss of power.

Air Entrainment: Air entrainment into the pumping system and force main can create hydrogen sulfide buildup and corrode system piping and appurtenances. This corrosion can lead to system failures and allow I/I to enter the sewer system. Air entrainment can also create a loss of capacity. Several activities can be performed to reduce the potential for air entrainment into the system. These include:

- Minimum wet well levels should be set to a point where pumps do not entrain air
- Pump packing and stuffing box should be adjusted so air is not entering the pump
- Piping including inlet, bleed-off, sump pump piping and relief flows should be plumbed to avoid cascading into the wet well causing excess agitation
- Screening systems that catch debris should be inspected and cleaned regularly to ensure that excess build up does not create cascading of wastewater into the wet well
- Air bubbler lines should be located away from pump inlets
- Wet well mixer level settings should be verified to confirm that they are below the low water level and that they do not create vortexes
- Air release valves should be inspected and maintained to ensure proper operation

Pump stations and force main systems should be routinely inspected to make sure these potential sources of air are minimized to avoid excessive air entrainment. Corrections required to avoid these conditions should be noted and prioritized.

Pump Drawdown Tests. Pump drawdown tests provide a simple, accurate, and direct method to measure total pumping rate. Pump drawdown tests are conducted by measuring the volumetric change in the wet well due to pump action. The test often requires temporary flow measurement on the influent sewer to account for the effects of incoming flow. This step may not be necessary if the wet well can be isolated.

6.5.3 Vacuum System

Several vacuum systems exist within the regional sanitary sewer system. Generally vacuum systems do not pose a major source of I/I unless illicit connections are made at the service tap.

Because the system is constantly under negative pressure, failures are usually realized when a loss of vacuum occurs. Vacuum systems will be excluded unless there are unresolved overflows.

6.6 PROMPT REPAIRS

6.6.1 Conditions to Warrant Prompt Repairs

Certain asset conditions will warrant prompt corrective action when found during the course of the SSES work. Defects that pose an imminent risk of failure and warrant prompt repair under a prompt repair approach should include, but are not limited to, partially collapsed pipe, pipe with holes (missing sections), pipe with extensive exposed rebar (concrete), joints that are displaced more than 10% of the pipe diameter, and pipe with displaced bricks, where such defects are determined to:

- Pose an immediate threat to the environment
- Pose an imminent threat to the health and safety of the public
- Create operational problems that may result in SSOs
- Contribute substantial infiltration to the system

These assets may be operable at the time of discovery but could have potential for severe consequences and a high likelihood of failure.

6.6.2 Removal of Illicit Connections

Illicit connections that contribute substantial inflow to the sanitary sewer system warrant prompt corrective action when discovered. Illicit connections that are identified in the sanitary sewer system shall be eliminated through a prompt repair rehabilitation approach, where practical. Such connections may include storm drains and area drains that are directly connected to the sanitary sewer system. Any SSES Basin with one or more illicit connections must have flow monitoring re-performed after the illicit connections are removed, unless the Federal Facility can demonstrate that inflow contributions from these illicit connections is insignificant as described in Section 3.

6.7 CONDITION ASSESSMENT DOCUMENTATION

Upon completion of the field investigations, documentation shall be prepared that references the field procedures used and presents the investigation results, alternative analyses, findings, conclusions, and recommendations. These documents will be used to prepare the rehabilitation plan as described in Section 7 and shall be submitted to HRSD for review and approval as specified in Section 1 of the Standards. The documentation shall include the following minimum content:

TITLE PAGE

- Project Title
- Federal Facility Contact Information
- Vicinity Map

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- Field Investigation Results
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FINDINGS, CONCLUSIONS & RECOMMENDATION

APPENDICES

- Field Data (Compiled Raw & Analyzed)
- System overview and detailed maps, for all project types

Note: This format is a general guideline to be used in sewer basin investigations.

SECTION 7 REHABILITATION PLANNING AND EXECUTION

7.1 PURPOSE

A Rehabilitation Plan shall be developed for HRSD's review and approval to address deficiencies identified in the sewer system evaluation survey (SSES) Basins; system-wide improvements including control of I/I sources; and improvements needed to ensure sustainability of the regional sanitary sewer system and protect water quality, human health, and the environment. Rehabilitation shall be considered the repair or replacement of existing sewer assets to restore or improve the performance of the regional sanitary sewer system.

Factors to be considered in the development of the Rehabilitation Plan include:

- Location, cause and frequency of sanitary sewer overflows (SSOs)
- Structural condition of assets
- Infiltration and inflow (I/I) reduction potential
- Criticality of the pump station, sewer basin, or sewer
- Durability and useful life of various remedies
- Economic feasibility of rehabilitation versus replacement

The structural conditions of the assets shall be identified in the Condition Assessment documentation described in Section 6.7. The durability, useful life, and I/I mitigation effects of rehabilitation measures shall be considered when comparing asset repair versus asset replacement alternatives.

The criticality of individual assets shall be considered during the prioritization of projects in the Rehabilitation Plan. The prioritization shall consider the risk and consequence of failures that may be prevented or mitigated by each project. Projects that mitigate I/I, SSOs, and conditions leading to environmental, public health, or safety risks will be given the highest priority.

7.2 GOALS

The goals of the Rehabilitation Plan are to:

- Reduce I/I and thereby peak flows
- Ensure sustainability of the infrastructure assets by addressing identified deficiencies
- Identify means and methods to remedy the problems
- Establish prioritization of rehabilitation efforts

7.3 I/I REDUCTION APPROACH

Engineering judgment should be used to estimate the percent I/I that can be removed within an SSES Basin based on observed defects, general pipe/manhole condition, material of construction, and estimated I/I contributions within the sanitary sewer system. Consideration shall be given to the "fluid" nature of the I/I sources, particularly if rehabilitation is limited to specific components in the total system. A common error in estimating the effectiveness of rehabilitation is to assume net sewer service area effects will be equal to the sum of the I/I values initially allocated to specific rehabilitation components. Rehabilitation in one area can result in raising the groundwater level, increasing leakage in previously adequate sewers because of increased hydraulic head. Historically, peak flows represent a surcharge condition, in which rehabilitation efforts will not register any overall reduction until peak flows have been reduced below the capacity of the limiting conveyance segment of the surcharged section. Understanding the effectiveness of the sewer rehabilitation I/I control program is essential to making the right decisions regarding rehabilitation versus increasing conveyance capacity. Additional guidance information may be found in the WEF Manual of Practice FD-06 – "Existing Sewer Evaluation and Rehabilitation", and WERF Publication 99-WWF-8 - "Reducing Peak Rainfall Derived Infiltration/Inflow Rates – Case Studies and Protocols."

Various rehabilitation and replacement methods have differing levels of effectiveness, maintenance impacts and life spans. These variations should be considered when evaluating the costs and benefits of alternatives.

In SSES Basins where the projected 10-year peak hour flow recurrence is less than 6 times the Annual Average Flow (AAF), rehabilitation or replacement work shall reduce peak flows to not more than the peak flow threshold (3 times the AAF). Where the projected 10-year peak hour flow recurrence is greater than 6 times the AAF, minimum I/I reduction in the basin shall be 60 percent. Where the projected 10-year peak hour flow recurrence is less than 3 times the AAF, no I/I reduction is required. In SSES Basins where illicit connections have been removed, this calculation shall be based on flow monitoring data collected after all illicit connections were removed. Demonstration of peak flow reductions shall be required as described in Section 3 of the Technical Standards.

Example:
Basin 1:
AAF = 1 MGD
Peak Flow Threshold = 3 x 1 MGD = 3 MGD
10-year projected peak hour flow = 5 MGD
6 x AAF = 6 x 1 MGD = 6 MGD
Peak Flow Commitment = 3 MGD

Basin 2:
AAF = 1 MGD
Peak Flow Threshold =3 x 1 MGD = 3 MGD
10-year projected peak hour flow = 7 MGD
6 x AAF = 6 x 1 MGD = 6 MGD
Peak Flow Commitment = 7 MGD - (7 MGD -1 MGD) x 60% = 3.4 MGD

In either case, the Federal Facility shall make an affirmative commitment in terms of post rehabilitation peak flow in all SSES Basins. All costs developed in the Rehabilitation Plan shall be stated in the dollar value in the year the plan is submitted.

When the Federal Facility demonstrates that it has achieved the required peak flow reduction through flow monitoring, hydrologic modeling and long term simulation, no further rehabilitation efforts are required under the order. Use of representative or associated flow data shall not be used to demonstrate achievement of the required peak flow reduction. Flow monitoring shall meet the Technical Standards data accuracy specifications (Section 3.3.4) and shall be conducted in each SSES basin until three individual rainfall events, each of which has a 24 hour rainfall accumulation of at least 1 inch and one of which has at least 1.5 inches of rainfall accumulation over 24 hours, are monitored.

Demonstration of achievement of the peak flow reductions shall be submitted to HRSD in a Demonstration Flow Monitoring Report. Peak flow reductions shall be maintained in perpetuity and shall represent the maximum allowable 10-year peak flow rate from the Federal Facility.

Should the Federal Facility find it has not achieved its peak flow reduction, additional rehabilitation efforts shall be performed until the required peak flow reduction is achieved. If the Facility believes that additional rehabilitation work will not achieve the required peak flow reduction or that this work is cost prohibitive, the Facility may propose to use a storage facility in lieu of additional I/I reduction. The sizing of the storage facility, location and operational set points (e.g. peak discharge rate allowed before activation of the storage) shall be determined through the application of the hydrologic modeling and long term simulation, and coordination with HRSD. Storage facilities shall not be proposed until the Federal Facility has completed all work proposed in their original Rehabilitation Plan. A preliminary design report including the above-mentioned details shall be provided to HRSD for their review and approval. This report shall include post rehabilitation flow monitoring data per Section 3.5.1.2 recalibrated post rehabilitation hydrologic model and post rehabilitation 10-year peak flow.

7.4 PRIORITIZATION OF PROBLEMS AND IDENTIFIED DEFECTS

The prioritization of significant defects is needed to develop a plan to systematically reduce I/I. The prioritization shall focus on the most severe defects and areas with the majority of SSO occurrences. In addition, there are several other factors that need to be considered when working through the prioritization. Items to consider when prioritizing rehabilitation activities include:

- Number and severity of system defects
- Number of SSOs that could be avoided if the system were rehabilitated
- Operation and maintenance history and costs
- Quantity of I/I entering the system and potential for I/I reduction
- Probability and consequence of failure of the sanitary sewer system
- Available capacity
- Estimated cost of the proposed rehabilitation
- Technical complexity of the rehabilitation activities and potential secondary impacts

A ranking system shall be developed that accounts for factors that influence the prioritization of system improvements. Individual utilities should weight the criteria differently and/or should add additional criteria based on their need and desired priorities. In any case, the prioritization shall consider the above criteria as a minimum.

7.5 REHABILITATION ALTERNATIVES EVALUATION

Alternative approaches to rehabilitation shall be considered in the development of the Rehabilitation Plan. This should include rehabilitation, capacity upgrades, flow diversions, and/or replacement. Key factors in deciding a rehabilitation method for various facilities will include the: structural condition, mechanical condition, capacity requirements, type of material, accessibility, conflicting utilities and other facilities, extent of repair needed, remaining useful life and cost of rehabilitation or replacement.

7.5.1 Rehabilitation vs. Replacement

It will be necessary to determine if failing portions of the system can be rehabilitated or if they will require replacement. Factors affecting this decision include:

- Available capacity
- Structural condition
- Remaining useful life
- Estimated rehabilitation effectiveness
- Future needs
- Change in system functionality or operation
- Pipe slope
- Restoration requirements
- Cost

7.5.2 Methods of Rehabilitation

Several technologies are available for consideration in developing the Rehabilitation Plan, and new technologies are routinely emerging. The Rehabilitation Plan shall consider the application of commonly used rehabilitation and replacement methods, advantages and limitations of the technique. The full range of available rehabilitation methods should be considered at the time the Federal Facility develops the Rehabilitation Plan as described in Section 7.6.

7.6 REHABILITATION PLAN

7.6.1 Rehabilitation Plan and Schedule

Rehabilitation Plans shall be developed to define specific measures that will be taken to reduce infiltration and inflow, the cost associated with the proposed rehabilitation, and the planned schedule for rehabilitation activities. The schedule shall contain sufficient interim milestones so that progress may be assessed as the work progresses. The Rehabilitation Plan shall be received by HRSD for review and approval as specified in Section 1 of the Standards.

7.6.2 Report on Work Completed

Progress on rehabilitation projects that are implemented between the execution date of the I/I Order and the submittal of the Rehabilitation Plan shall be submitted to HRSD as an Appendix to the Rehabilitation Plan. Progress Reports on projects completed after approval of the Rehabilitation Plan shall be submitted to HRSD annually or as required in the I/I Order, whichever is more frequent. Peak flow reduction documentation shall be submitted to HRSD for review within 12 months of the completion of the rehabilitation activities.

7.7 REHABILITATION PLAN EXECUTION

The Federal Facility shall execute the approved Rehabilitation Plan in accordance with the approved schedule. If deviations from the Plan become necessary due to discovery of previously unknown physical conditions in the collection system, the Federal Facility shall seek HRSD's approval for the deviations and provide sufficient documentation of the changed conditions.

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SECTION 8 POST REHABILITATION REQUIREMENTS

8.1 PURPOSE

Following completion of rehabilitation, post rehabilitation flow monitoring and demonstration of achievement of the peak flow commitment, the Federal Facility shall be responsible for any and all actions necessary to maintain the actual 10 year peak hour flow below the peak flow commitment. Such actions may be included, but are not limited to flow monitoring, hydrologic modeling, rehabilitation and/or construction and operations of on-site wet weather peak flow storage.

The Federal Facility shall prepare and submit an Annual Report to HRSD that provides information demonstrating ongoing compliance with the peak flow commitment. Such report will be a requirement of the HRSD permit and the substance, form and timing of the report shall be as prescribed in the permit.

8.1.1 Demonstration Flow, Pressure, and Rainfall (FPR) Monitoring Plan

A Demonstration Flow, Pressure, and Monitoring Plan shall be developed and must be received by HRSD for review and approval as specified in Section 1 of the Standards. The Preliminary Flow Monitoring Plan shall include the following minimum information:

TITLE PAGE

- Project/Report Title
- Report Date
- Federal Facility Contact Information

EXECUTIVE SUMMARY

FLOW, PRESSURE, RAINFALL MONITORING METHODOLOGY

- Evaluation of Existing Data
    - SCADA Derived Flow Data
    - Sanitary Sewer Evaluation Studies
    - Flow Surveys

FLOW MONITORING SITE SELECTION

- Site Selection Criteria
- Mapping of Flow Monitoring Sites

PRESSURE MONITORING SITE SELECTION

- Site Selection Criteria
- Mapping of Pressure Monitoring Sites

RAINFALL GAUGE SITE SELECTION

- Site Selection Criteria
- Mapping of Rainfall Gauge Monitoring Sites

GROUNDWATER LEVEL SENSOR LOCATIONS

- Site Selection Criteria
- Mapping of Rainfall Gauge Monitoring Sites

MONITORING EQUIPMENT

- Equipment types to be used
- Use of SCADA System (if applicable)
- Data acquisition plan

IMPLEMENTATION SCHEDULE

DATA COLLECTION ACTIVITIES

- Data Acquisition Plan
- Data Collection Period

DATA MANAGEMENT

- Data Transfer
- Data Review
- Data Storage
- Data Verification
- Data Reporting

QA/QC PROCEDURES

8.1.2 Demonstration Flow Monitoring Report (Post Rehab)

Following rehabilitation, a summary report shall be prepared documenting the:

- Flow monitoring activities performed;
- Flow monitoring data collected;
- Flow analyses conducted;
- Impact of removing illicit connections on peak flows;
- Findings; and
- Conclusions.

These flow evaluation reports shall be used to demonstrate that the post rehabilitation flows meet the targets contained in Section 7. The evaluation report shall include the following information:

TITLE PAGE

- Project Title
- Report Date
- Federal Facility Contact Information

EXECUTIVE SUMMARY

INTRODUCTION

FLOW, PRESSURE and RAINFALL MONITORING METHODOLOGY & APPROACH

- Use of Existing Data
- Monitoring Site Selection
- Monitoring Equipment Used
- Data Collection Activities
- Data Reliability summary of all meters on a monthly basis
- QA/QC Procedures

MONITORED FLOW CHARACTERIZATION AND ASSESSMENT

- Data Analysis Overview
- Base Sewage Flow Development
- Dry Weather Flow Analysis
- Dry Weather Infiltration Analysis: RDII and Rainfall Analysis with hydrographs and graphical displays of flow, pressure data with rainfall
- Post-rehabilitation 10 year peak flows and LPIII analysis

FINDINGS and CONCLUSIONS

- Discussions of Findings
- Demonstration of achievement of post rehabilitation target flows

APPENDICES

- Field Data
- System monitoring location maps
- Wet weather hydrographs
- Graphical displays of flow and pressure data with rainfall

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