CITY OF
OAK RIDGE

August 28, 2012

POST OFFICE BOX 1 • OAK RIDGE, TENNESSEE 37831-0001

Ms. Denisse D. Diaz
Acting Chief
Clean Water Enforcement Branch
Water Protection Division
ATTN: Mr. Dennis J. Sayre
U.S. Environmental Protection Agency, Region 4
61 Forsyth Street, S.W.
Atlanta, Georgia 30303-8960

Dear Mr. Sayre:

Administrative Order No. CWA-04-2010-4772

Enclosed please find one copy of the City of Oak Ridge Wastewater Collection System Remediation Plan. This document is being submitted in compliance with the requirements of Section 16B iv of the subject Order.

The $23 million cost of this Remediation Plan will place extraordinary financial burdens on our community of 12,200 customers translating into approximately $1,900 per account. We have enacted a substantial rate increase in May of this year with another one to follow in January. Combined, these two rate changes totaled a 39 percent increase in user charges.

As you can see from the Plan, we have a total of five projects already designed and are going to immediately take two of these to construction. We are also going to pursue a State Revolving Fund Loan (SRF) to obtain the funds necessary to design and construct all the required projects. We do anticipate further rate increases in the near future because of this loan.

The Citizens of Oak Ridge are committed to improving their sanitary sewer system and will make every reasonable attempt to comply with this Remediation Plan.

I trust you will find the supplied information compliant with the Order. If you have any comments or questions, please contact Mr. Gary Cinder, P.E., Director of Public Works, at 865-425-1875 or email him at gcinder@cortn.org.

In accordance with Item 20 of this Order, the following language is included in this correspondence:

- "I certify under the penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

Sincerely,

Mark S. Watson
City Manager

MSW/ks

Enclosure

pc: Kenneth R. Krushenski, City Attorney
Gary M. Cinder, P.E., Director of Public Works
John West, TDEC
Lamar Dunn, P.E., FACEC, President, LD&A, Inc.

City of Oak Ridge, Tennessee

WASTEWATER COLLECTION SYSTEM REMEDIATION PLAN REPORT

August 2012

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EXECUTIVE SUMMARY

The Remediation Plan (Plan) is the culmination of two years of activities required by the Administrative Order (AO) issued by the United States Environmental Protection Agency (EPA). The Plan is the result of an intensive investigation program of the sewer system. The investigative work and a computerized model of the sewer system were used to define activities required to eliminate sanitary sewer overflows (SSOs). The Plan includes a schedule and estimated cost of projects to be executed over the next three years.

The AO was issued because of the history of SSOs in the system. A Capacity Assessment of the sewer system was required in order to know the magnitude of flows which the system could transport without overflows occurring. That effort required the development of a geographic information system (GIS) to document the size, location, and slope of each sewer in the system, and the location and elevations of each manhole. This data was also used to prepare a computerized model of the system. Rainfall data was collected over the study period and flow measurements taken. Rainfall and the resulting flows were used to calibrate the model. A two (2) year, 24-hour design storm was selected to assess the rated capacity of the sewer system. The model was developed using a skeleton of the system. There were 520 pipes modeled. The model was used to predict flows during both dry weather conditions and wet weather conditions. The model indicated that 27% of the pipes had flows, before rehabilitation, that exceeded their nominal full pipe gravity flow capacity. It also predicted 4% of the manholes would overflow under the design storm conditions.

The AO required a Sewer System Evaluation Survey (SSES). The effort required the entire system to be smoke tested, which was to blow smoke into the sewers and observe locations where it escaped due to defects. All of the manholes were visibly inspected for potential leaks of extraneous water. The entire city owned sewers were inspected by closed circuit television (CCTV) for defects. The data collected was input into the GIS system. There were 6,700 manholes and 1.2 million feet of city owned sewers investigated. The smoke testing also identified some defects in the private laterals (pipes on private property from the home to the city sewers).

The City's pumping stations were inspected and evaluated. The stations were reviewed both for capacity and conditions. It was determined that the capacity of the stations was acceptable; however, some stations were in need of replacement or major upgrade.

With the information available from the Capacity Assessment work and the SSES, methods for corrective action such that the anticipated flow would not cause SSOs were explored. Some of the options included:

a) Replacing the existing smaller pipes with larger pipe using “dig and lay” replacement
b) Constructing Equalization Basins to reduce the instantaneous peak flows which would result from inflow
c) Manhole rehabilitation which may include a new frame and cover, or repairing other leaks
d) Point repairs where isolated defects may occur within the sewer
e) Trenchless sewer rehabilitation
    - Cure-in-place liners
    - Slip lining
f) Trenchless pipe size increase
    - Pipe bursting

After the various options were identified to reduce flow during storm events, projections were developed to estimate the amount of reduction which could be reasonably expected. The removal of inflow/infiltration (I/I) is an inexact science. However, a scientific approach was used for the estimation of removal. The computer model used in the Capacity Assessment (SewerGEMS) was based on I/I hydrographs using the Stormwater Management Model (SWMM). The hydrographs are divided into three volume components (R_1, R_2, and R_3). It was assumed that proper rehabilitation should achieve at least 50% reduction in R_1 and 10% each for R_2 and R_3.

Seven alternatives were evaluated for the elimination of SSOs. The alternatives were screened by a three-step progressive process:

a) Is the alternative hydraulically feasible?
b) Is the alternative economically feasible and practical?
c) What are the differential costs between the economically feasible and practical alternatives?

Table E-1 shows the hydraulic feasibility screenings for the alternatives.

TABLE E-1
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
ALTERNATIVES FOR ELIMINATING SSOS
HYDRAULIC FEASIBILITY

Alternative	Comments
A: Increase Sizes (only)	Hydraulically feasible
B: Add EQ Basins (only)	Hydraulically feasible, but functionally undesirable since a large number of EQ basins distributed through the sewer basin would be required
C: Rehabilitate Selected Pipes/Manholes (only)	Using realistic inflow and infiltration reduction rates, rehabilitation alone will not eliminate SSOs; therefore not hydraulically feasible
D: Increase Sizes Add EQ Basins	Hydraulically feasible
E: Increase Sizes Rehabilitate Pipes/Manholes	Hydraulically feasible
F: Add EQ Basins Rehabilitate Pipes/Manholes Minimal Upsizing of Pipes	Hydraulically feasible
G: Increase sizes Add EQ Basins Rehabilitate Pipes/Manholes	Hydraulically feasible

Tables E-2 through E-7 summarize the results of the analysis of the economics and practicality of the alternatives.

TABLE E-2
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
ALTERNATIVE A
INCREASE SIZES OF SYSTEM COMPONENTS
SCOPE SUMMARY

Category	Description
Upsize Gravity Pipes	Upsize 158 sewer pipes totaling 38,816 feet. Includes portions of: main trunk sewer from termination of East Plant and Emory Valley force mains to Turtle Park pump station in Turtle Park and Central City sewersheds; Y-12 trunk sewer; trunk sewers in East Plant sewershed discharging to East Plant pump station; and other pipes in West End, Turtle Park, Y-12, Central City, East Plant and Emory Valley sewersheds. Modify manholes as required.
Rehabilitate Manholes and Pipes	None.
Modify Force Mains	None.
Increase Capacity of Pump Stations	Increase capacities of East Plant and Emory Valley pump stations to 11,300 gpm and 3,200 gpm, respectively. Increase capacity of Turtle Park pump station to 24,400 gpm.
Increase Capacity of WWTP	Increase WWTP hydraulic capacity to 24,400 gpm.
Add EQ Basins	None.
Result: By inspection, this alternative is cost prohibitive and impractical.	

TABLE E-3
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
ALTERNATIVE D
INCREASE SIZES OF SYSTEM COMPONENTS
ADD FLOW EQUALIZATION BASINS
SCOPE SUMMARY

Category	Description
Upsize Gravity Pipes	Upsize 138 sewer pipes totaling 34,724 feet. Includes portions of: main trunk sewer in Turtle Park and Central City sewersheds, Y-12 trunk sewer; trunk sewers discharging to East Plant pump station; and other pipes in West End, Turtle Park, East Plant and Emory Valley sewersheds. Modify manholes as required.
Rehabilitate Manholes and Pipes	None.
Modify Force Mains	Modify East Plant and Emory Valley pump station force mains to discharge into new EQ basin.
Increase Capacity of Pump Stations	Increase Emory Valley pump station capacity to 3,200 gpm. Increase Turtle Park pump station capacity to 21,700 gpm.
Increase Capacity of WWTP	Increase WWTP capacity to 21,700 gpm.
Add EQ Basins	1 MG (million gallons) at Y-12, 2 MG at East Plant pump station, 0.5 MG in East Plant sewershed, and 2 MG downstream of East Plant and Emory Valley force mains.
Result: By inspection, this alternative is cost prohibitive and impractical.	

TABLE E-4
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
ALTERNATIVE E
INCREASE SIZES OF SYSTEM COMPONENTS
REHABILITATE SELECTED PIPES AND MANHOLES
SCOPE SUMMARY

Category	Description
Upsize Gravity Pipes	Upsize 99 sewer pipes totaling 24,078 feet. Includes portions of: main trunk sewer in the Central City and Turtle Park sewersheds, the Y-12 trunk sewer, the East Plant trunk sewers, and other pipes in the East Plant sewershed. Modify manholes as required.
Rehabilitate Manholes and Pipes	Rehabilitate manholes and pipes in all sewersheds, as required.
Modify Force Mains	None.
Increase Capacity of Pump Stations	Increase East Plant and Emory Valley pump station capacities to 7,600 gpm and 2,300 gpm, respectively. Turtle Park pump station capacity marginal; increase to 21,300 gpm.
Increase Capacity of WWTP	WWTP capacity marginal; increase to 21,300 gpm.
Add EQ Basins	None.
Property	None.
Result: By inspection, this alternative is cost prohibitive and impractical.	

TABLE E-5
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
ALTERNATIVE F
ADD FLOW EQUALIZATION BASINS
REHABILITATE SELECTED PIPES AND MANHOLES
MINIMAL UPSIZING OF PIPES
SCOPE SUMMARY

Category	Description
Upsize/Add Gravity Pipes	Upsize 19 sewer pipes totaling 3,650 feet. Includes portions of East Plant pump station trunk, and other pipes in Turtle Park and East Plant sewersheds. Add 8 sewer pipes totaling 1,946 feet of new pipe in East Plant sewershed. Modify manholes as required.
Rehabilitate Manholes and Pipes	Rehabilitate manholes and pipes in all sewersheds, as required.
Modify Force Mains	Modify East Plant and Emory Valley pump station force mains to discharge into new EQ basin.
Increase Capacity of Pump Stations	None.
Increase Capacity of WWTP	None.
Add EQ Basins	1 MG at Y-12, 2 MG at East Plant pump station, 0.5 MG in East Plant sewershed, and 2 MG downstream of the East Plant and Emory Valley pump stations.
Result: By inspection, this alternative is cost competitive and practical.	

TABLE E-6
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
ALTERNATIVE G
INCREASE SIZES OF SYSTEM COMPONENTS
ADD FLOW EQUALIZATION BASINS
REHABILITATE SELECTED PIPES AND MANHOLES
SCOPE SUMMARY

Category	Description
Upsize/Add Gravity Pipes	Upsize 28 sewer pipes totaling 6,286 feet. Includes the trunk sewers for the East Plant pump station, and other pipes in Turtle Park and East Plant sewersheds. Add 8 sewer pipes totaling 1,946 feet of new pipe in East Plant sewershed. Modify manholes as required.
Rehabilitate Manholes and Pipes	Rehabilitate manholes and pipes in all sewersheds, as required.
Modify Force Mains	Modify East Plant and Emory Valley pump station force mains to discharge into new EQ basin.
Increase Capacity of Pump Stations	None.
Increase Capacity of WWTP	None.
Add EQ Basins	1 MG at Y-12, 2 MG at the East Plant pump station, and 2 MG downstream of the East Plant and Emory Valley pump stations.
Result: By inspection, this alternative is cost competitive and practical.	

It was determined that a combination of actions (explored in alternatives F and G) would be most favorable approach for eliminating SSOs resulting from the design storm. These include:

a) Equalization basins
b) Sewer rehabilitation
c) Manhole rehabilitation
d) Increase selected pipe sizes

Alternatives F and G were then reviewed relative to differential costs. See Table E-7. Alternative G is the least cost.

TABLE E-7
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
COMPARISON OF ALTERNATIVES F AND G
DIFFERENTIALS

Category	Differential	
	Alternative F	Alternative G
Upsize/Add Gravity Pipes	---	$750,000 Upsize 2,636 feet of pipe from 18" to 21" diameter
Rehabilitate Manholes and Pipes	---	---
Modify Force Mains	---	---
Increase Capacity of Pump Stations	---	---
Increase Capacity of WWTP	---	---
Add EQ Basins	$1,100,000 0.5 MG EQ basin in Emory Valley	---

The remediation work effort was prioritized based on ratings that considered the following factors:

- Health and environmental risk
- SSO frequencies and volumes
- Total system defects

Table E-8 shows the unadjusted ratings and the basis for those ratings. Note that the ratings for each metric are relative to the other sewersheds. For each metric, a sewershed was assigned a score of 1 to 4 (with 4 being the most severe rating). These metrics emphasize overflow volumes and frequencies, and pipe defects as identified by the CCTV survey.

TABLE E-8
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
UNADJUSTED RATINGS BASED ON
SSO FREQUENCIES/VOLUMES AND SYSTEM DEFECTS

Metric	Unadjusted Rating by Sewershed					
	Emory Valley	East Plant	Central City	Y-12	Turtle Park	West End
Total CCTV defects	2	4	2	1	3	1
Total CCTV defects/foot of pipe	3	4	3	2	4	1
% of manholes needing major repair	4	3	3	2	2	1
% of pipes in "spine" model over capacity with 2-yr, 24-hr design event	1	3	2	3	4	---
Number of SSOs in "spine" with design event	1	4	2	1	3	1
Volume of SSOs in "spine" with design event	1	2	4	1	3	1
Number of overflows during 2007-2011	1	4	3	2	2	1
SSOs/foot of pipe during 2007-2011	2	3	4	3	2	1
Volume of SSOs/foot of pipe during 2007-2011	3	3	4	2	2	1
Unadjusted Total Rating	**18**	**30**	**27**	**17**	**25**	**8**

Rehabilitation in the Emory Valley sewershed has recently been completed under the "old program." The program consisted of the rehabilitation of sewers and manholes. The lower unadjusted rating (compared to East Plant, Central City and Turtle Park) reflects some of the benefits from that work. However, since the ratings are based partially on overflows and defects identified before and during the rehabilitation program, the rating is still elevated. It is anticipated that its present-day rating is much lower. Post-construction monitoring is currently being conducted to test the effectiveness of the rehabilitation.

Rehabilitation of the sewer system in a specific sewershed does not necessarily address all of the overflow issues in that sewershed. This is particularly the case when a trunk sewer passes through a specific sewershed but is fed by other upstream sewersheds. Rehabilitation of the upstream sewersheds may have a greater effect on eliminating overflows than rehabilitation of the specific sewershed itself. This issue was taken into account by further adjusting the ratings in Table E-8 by applying an adjustment factor ranging from 0 to 1. The adjustment factors were applied based on judgment and in accordance with the scheme shown in Table E-9. The adjusted ratings are shown in Table E-10.

TABLE E-9
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
RATING ADJUSTMENTS

Rating Adjustment	Description
0.00	Overflows in the sewershed are 100% dependent on flows entering the sewershed from upstream sewersheds, or boundary effects from downstream sewersheds. Loads or conditions within the sewershed have little or no effect on SSOs in the sewershed.
0.01 – 0.99	Overflows in the sewershed are partially dependent on the loads and conditions in the sewershed itself, and partially dependent on flows entering the sewershed from upstream sewersheds or boundary effects from downstream sewersheds.
1.00	Overflows in the sewershed are independent of flows entering the sewershed from upstream sewersheds, or boundary effects from downstream sewersheds. Only loads or conditions within the sewershed affect SSOs in the sewershed.

TABLE E-10
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
ADJUSTED RATINGS

Rating	Adjusted Rating by Sewershed					
	Emory Valley	East Plant	Central City	Y-12	Turtle Park	West End
Unadjusted Rating	18	30	27	17	25	8
Adjustment Factor	1.0	1.0	0.4	0.2	0.1	1.0
Adjusted Rating	**18.0**	**30.0**	**10.8**	**3.4**	**2.5**	**8.0**

The Emory Valley Sewershed was addressed in the “old program” and remediation is complete. The remaining sewershed priorities are as follows:

- East Plant
- Central City
- Y-12
- Turtle Park
- West End

Note that West End was assigned last priority due to the minimal amount of work required in that sewershed.

Table E-9 shows the estimated cost for each of the anticipated projects and their proposed schedules. Note that the equalization basin costs do not include allowances for land acquisition. Land requirements will not be known until the preliminary designs of the equalization basins, including exact locations, have been completed.

TABLE E-9
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
PROJECT SCHEDULES AND COSTS

Round	Project	Design and Pre-Construction	Construction NTP through As-Built Close-Out	Cost
1	East Plant I	3/19/12 – 10/23/12	10/29/2012 – 7/14/13	$10,621,200
	East Plant II	3/19/12 – 10/23/12	10/29/2012 – 7/14/13	
	East Plant III	3/19/12 – 2/1/13	2/11/2013 – 11/1/13	
	East Plant IV	3/19/12 – 2/1/13	2/11/2013 – 1/1/14	
	East Plant V	3/19/12 – 2/1/13	2/11/2013 – 11/1/13	
2	East Plant VI	1/10/13 – 8/18/13	8/22/13 – 5/20/14	
	East Plant VII	2/10/13 – 9/18/13	9/22/13 – 6/20/14	
	East Plant VIII	3/10/13 – 10/18/13	10/22/13 – 7/20/14	
	East Plant IX	4/10/13 – 11/18/13	11/22/13 – 8/20/14	
	East Plant X	5/10/13 – 12/18/13	12/22/13 – 9/20/14	
3	Y-12 I	7/14/13 – 2/22/14	2/26/14 – 11/11/14	$744,700
	Y-12 II	7/14/13 – 2/22/14	2/26/14 – 11/11/14	
	Central City I	1/14/14 – 8/22/14	8/26/14 – 5/11/15	$2,165,900
	Central City II	1/14/14 – 8/22/14	8/26/14 – 5/11/15	
4	Turtle Park I	6/11/14 – 1/15/15	1/21/15 – 9/6/15	$2,699,400
	Turtle Park II	6/11/14 – 1/15/15	1/21/15 – 9/6/15	
	West End I	6/11/14 – 1/15/15	1/21/15 – 9/6/15	$744,700
---	Equalization Basins	9/10/12 – 12/12/13	1/2/14 – 8/18/15	$6,114,900
Total Program				$23,090,800

The designs for the Round 1 projects (East Plant I through V) are complete. The immediate next steps in the program are:

- Proceed with State approval of the Round 1 projects, followed by procurement of construction contractor services.

- Proceed with authorization of the designs for the Round 2 projects (East Plant VI through X).
- Proceed with authorization for the design of the flow equalization basins.
- Conduct pre- and post-construction rainfall and flow monitoring to measure the reductions in inflow and infiltration.
- Continue the MOM program activities related to addressing pump station upgrades and private laterals.

SECTION I

INTRODUCTION

The Remediation Plan is the culmination of an intense investigative program of the City of Oak Ridge (City) Wastewater Collection and Transmission System (WCTS). In late September 2010, the United States Environmental Protection Agency (EPA) issued an Administrative Order (AO) for the City to eliminate sanitary sewer overflows (SSOs) and to develop a Management, Operation, and Maintenance (MOM) program. The Remediation Plan is to have specific measures and schedules that, when implemented, will result in the elimination of all constructed overflows and adequate capacity in the WCTS, such that SSOs will be eliminated.

The investigative work which is the basis for the Remediation Plan is data secured in the Capacity Assessment (CA) and the Sewer System Evaluation Survey (SSES). These efforts are described in separate submittals to the EPA. The Sanitary Sewer Capacity Assessment Report is dated April 2012, and the Sewer System Evaluation Study Results Report is dated June 2012. Other associated efforts included developing a system-wide geographical information system (GIS) program identifying all of the assets of the WCTS and the pumping station evaluations. A computerized hydraulic model was developed using the software package SewerGEMS Sanitary. The WCTS was divided into sewersheds for study. Each of the sewersheds was further divided into mini-basins. The mini-basin boundaries correspond to the historical boundaries used by the city in previous infiltration/inflow (I/I) reduction efforts.

Using the GIS information of sewer size, slope and other data, the hydraulic capacity of each reach of the primary sewer within the model was established. The model included most of the pipes larger than 10 inches in diameter. Rainfall data and flow measurements were collected over the study period and used to calibrate the model. The calibrated model was used to estimate the flow rates in the sewers resulting from a 2-year, 24-hour design storm. (The 2-year storm is expected to occur, on the average, once every two years.)

Physical inspections of the sewers were conducted. The manholes were visually inspected for defects. The sewers were smoke tested. A closed circuit television (CCTV) inspection of the sewers was performed. The data collected was published in the above referenced SSES report.

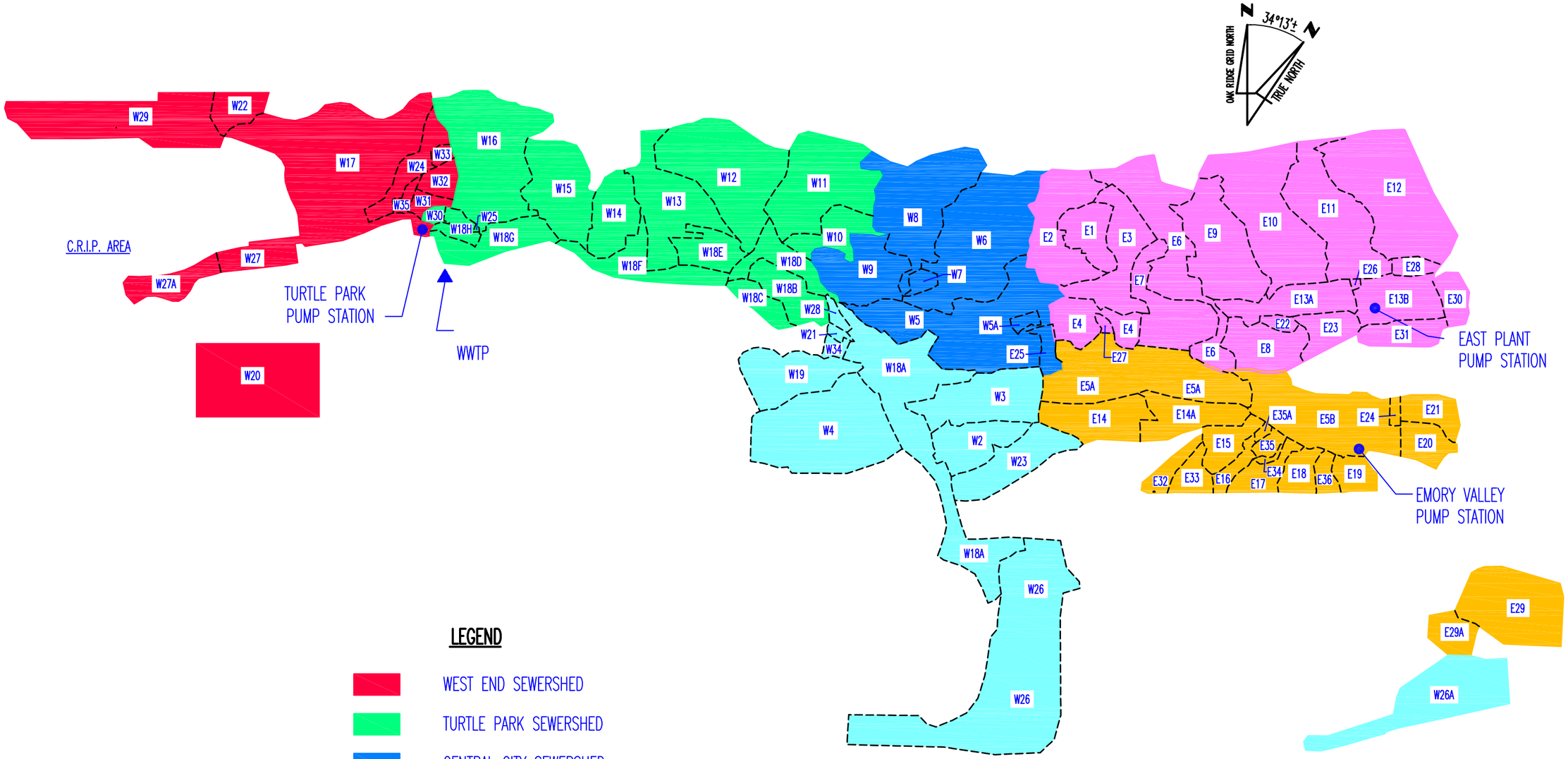
The Remediation Plan will identify the proposed measures to be taken for the WCTS to have adequate capacity to accommodate peak wet weather design storm flows without SSOs. Future work is prioritized based on:

- Relative likely human health and environmental impact risks;
- SSO frequencies of activation; and
- Total SSO volume

The Remediation Plan describes the proposed projects to eliminate the SSOs. An estimate of the cost and schedule for each project is included. The City has retained a program manager to monitor schedule and costs. The program manager will assist the City in assigning the design of the various projects. It is the intent of the City to use multi-designers in order to complete the elimination of SSOs within three years.

Parallel with the remediation program, the City is actively engaged in implementing the MOM programs. The proactive approach of the MOM programs will ensure that the WCTS will be closely monitored for the control of SSOs.

For reference, Figure I-1 and Figure I-2 show the sewer basin, mini-systems arrangement, and other key features that comprise the WCTS.



LEGEND

- WEST END SEWERSHED
- TURTLE PARK SEWERSHED
- CENTRAL CITY SEWERSHED
- EAST PLANT SEWERSHED
- EMORY VALLEY SEWERSHED
- Y-12 SEWERSHED
- ▲ WWTP GAUGE LOCATION
- ● PUMP STATION LOCATION
- W20 MINI-SYSTEM NOTATION

Fig A-1.DWG

LD&A
Lamar Dunn & Associates Inc.

Chattanooga Office: Chattanooga, TN 37411
Corporate Office: Knoxville, TN 37920
Tri-Cities Office: Johnson City, TN. 37615

CITY OF OAK RIDGE
FIGURE I-1
OAK RIDGE SEWER BASIN

DRAWN BY : BAS/MLG
FILE NO. COR232SE06SC11
SCALE : 1"=4000'
DATE: 7-2012

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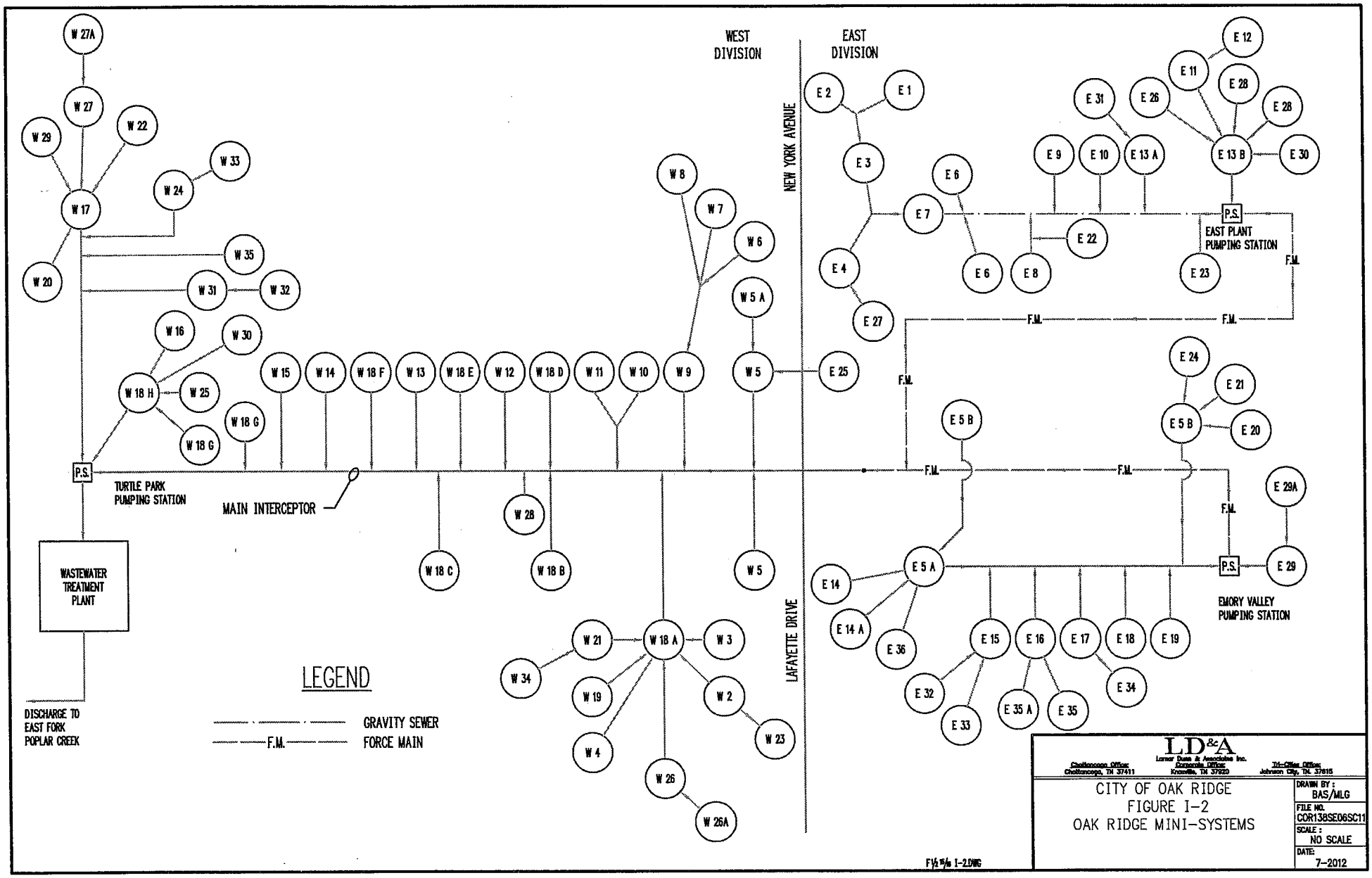


LD&A
Lamar Dunn & Associates Inc.
Corporate Office: Knoxville, TN 37920
Chattanooga Office: Chattanooga, TN 37411
Tri-Cities Office: Johnson City, TN 37615

CITY OF OAK RIDGE
FIGURE I-2
OAK RIDGE MINI-SYSTEMS

DRAWN BY :	BAS/MLG
FILE NO.	COR138SE06SC11
SCALE :	NO SCALE
DATE:	7-2012

SECTION II

SANITARY SEWER OVERFLOW ISSUES

A. GENERAL

As summarized in Section I, the Remediation Plan identifies the proposed measures required to eliminate all sanitary sewer overflows (SSOs) in the City's wastewater collection system under design conditions. In order to develop this plan, issues associated with the occurrence of SSOs have been evaluated based on:

- SSO reports prepared by the City describing all overflow occurring during the five-year period 2007 through 2011
- A Capacity Assessment study and report, completed in April 2012 (COR, 2012a)
- A Pump Station Evaluation and Repair Program study and report, completed in April 2012 (COR, 2012b)
- A Sewer System Evaluation Survey and report, completed in June 2012 (COR, 2012c)

In the discussion that follows, the overall findings of the SSO evaluation are reviewed.

B. CAPACITY ASSESSMENT

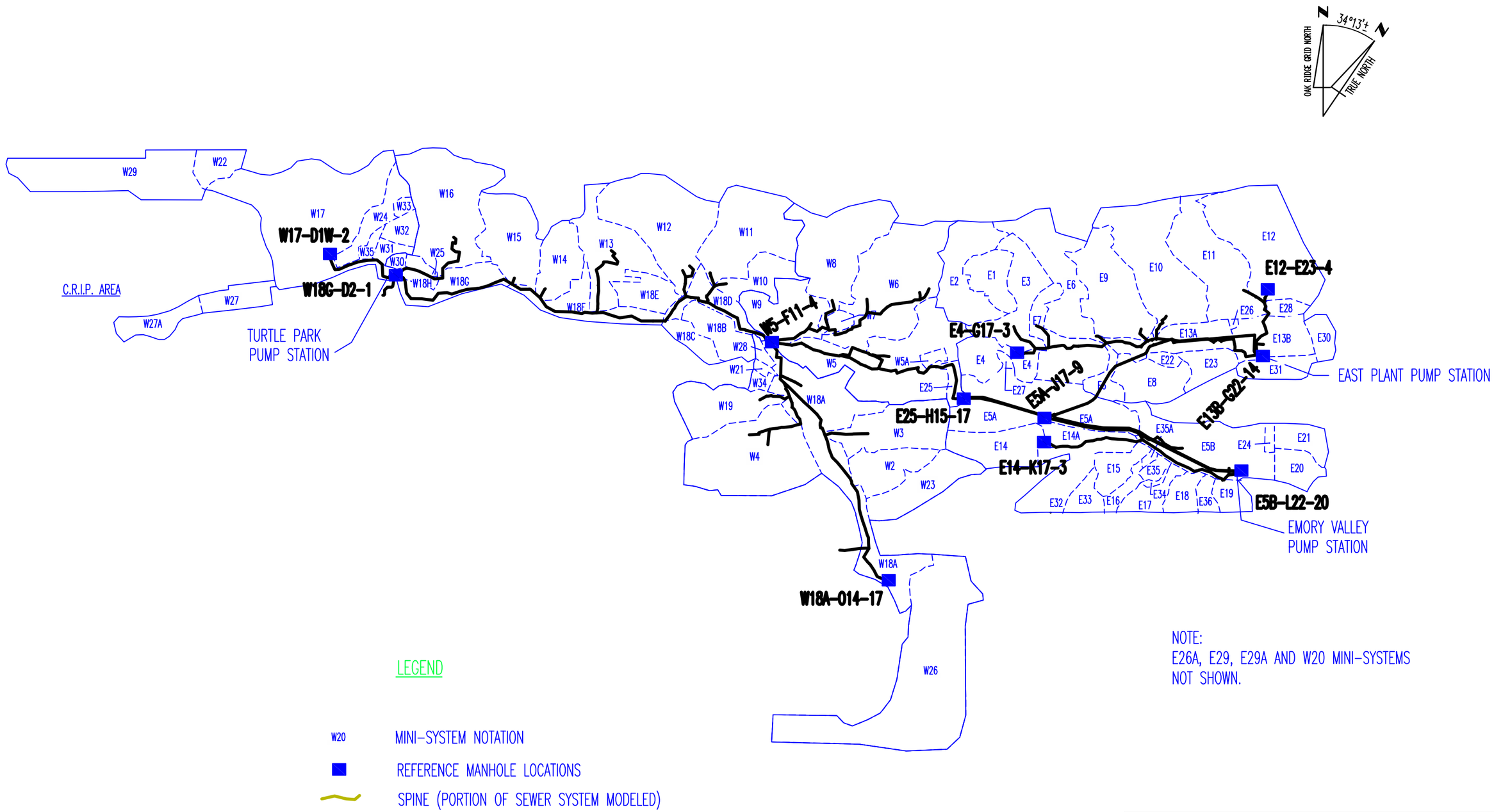
The Capacity Assessment consisted of the following:

- The SSO reports for 2007 through 2011 were reviewed and analyzed.
- The sewage flows at strategic locations within the collection system were monitored using continuous flow meters.
- Continuously-recording rainfall gauges were deployed at three locations within the city, and monitored.
- The collection system was field-surveyed to define the physical characteristics of the pipe, manhole, and pump station network.
- An evaluation of the capacities of the system pump stations was performed (as determined in the pump station study).
- A geographic information system (GIS) representing the collection network, relevant landuse data, and other information was prepared.

- The above-listed resources were used to develop a calibrated SewerGEMS Sanitary computer model (Bentley) of the principal collection system (referred to as the "Spine" in the Capacity Assessment Report), including the effects of rainfall-induced inflow and infiltration. A map of the "Spine" is presented in Figure II-1. The model reflected existing conditions with the exception that all pipes were assumed to have their nominal un-deformed shapes, and were assumed to be clear of obstructions and blockages.
- The computer model was used to identify collection system capacity issues under 2-year, 24-hour design storm conditions.

The results of the assessment were presented in the Capacity Assessment Report. Those results indicate that during the period 2007 through 2011, a total of 405 SSOs occurred at 162 different locations, including at eight existing constructed overflows. Seventy percent of the overflows during this period occurred during or immediately after rainfall events. The remaining 30% were due to blockages, power losses, mechanical failures, etc. Less than 7% of the rainfall-related overflows occurred with rainfall events less than two inches. Only one rainfall-related overflow occurred with a rainfall depth less than 1.7 inches, and that depth (0.6 inches) was preceded the previous day by 1.7 inches of rainfall. The 2-year, 24-hour design storm depth adopted for the Capacity Assessment is 3.32 inches, which exceeds the threshold for rainfall events that cause SSOs. Table II-1 summarizes the five-year period overflow analysis by sewershed. (The table does not include five dry-weather SSOs that were not assigned to a particular sewershed in the overflow reports.)

Figure II-2 shows the locations and frequencies of rainfall-related overflows during the five year period 2007-2012. Please note that some of the indicated overflows pre-date the recently completed remediation activities in the Emory Valley sewershed.



NOTE:
E26A, E29, E29A AND W20 MINI-SYSTEMS NOT SHOWN.

LEGEND

W20 MINI-SYSTEM NOTATION

REFERENCE MANHOLE LOCATIONS

SPINE (PORTION OF SEWER SYSTEM MODELED)

COR138-FIG-A3

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Tri-Cities Office:
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CITY OF OAK RIDGE
FIGURE II-1
OAK RIDGE – SPINE LOCATION

DRAWN BY : BAS/MLG
FILE NO. COR232SE06SC11
SCALE : 1"=4000'
DATE: 7-2012

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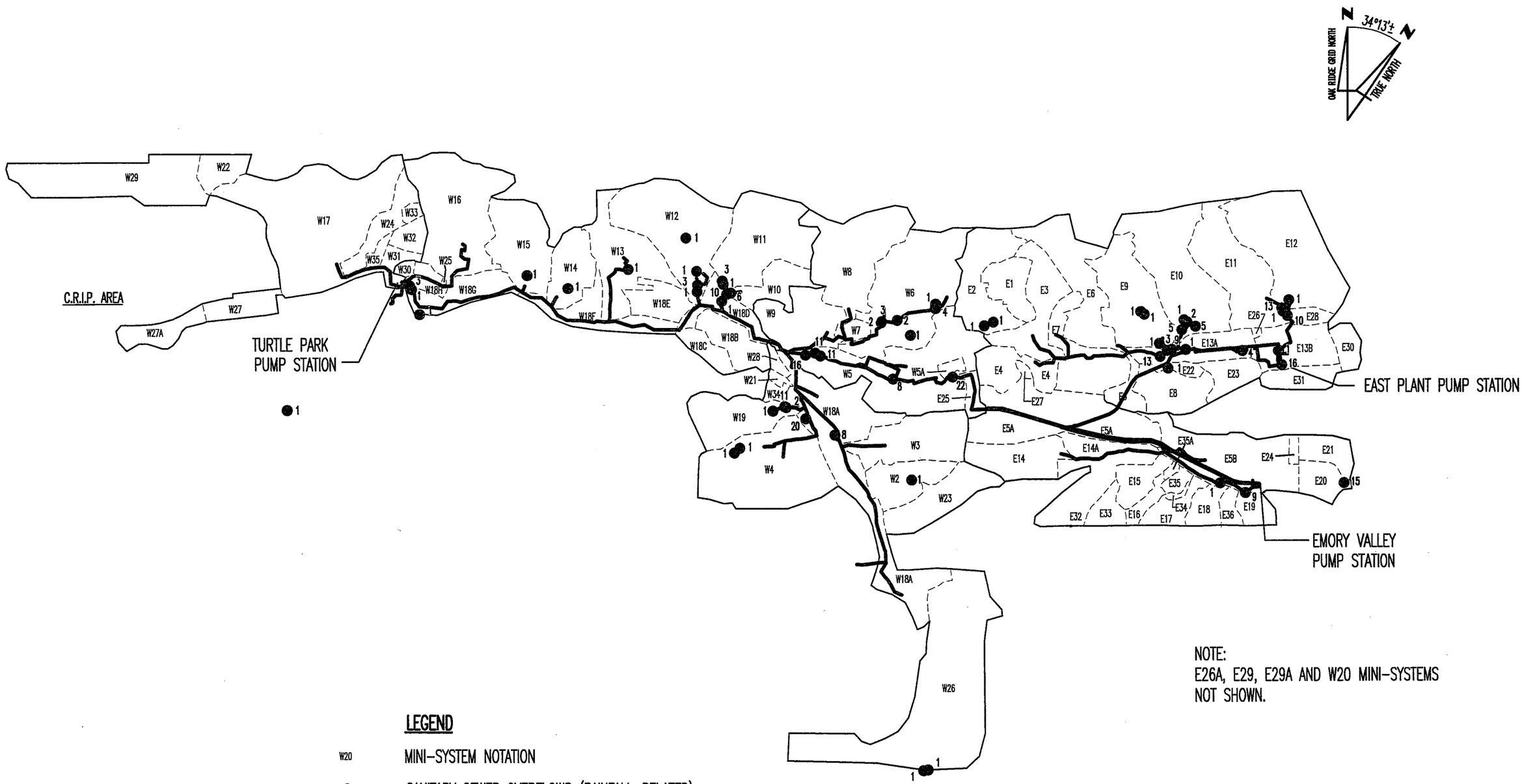

NOTE:
E26A, E29, E29A AND W20 MINI-SYSTEMS NOT SHOWN.

LEGEND

W20	MINI-SYSTEM NOTATION
●	SANITARY SEWER OVERFLOWS (RAINFALL-RELATED)
9	NUMBER OF OVERFLOW EVENTS
—	SPINE (PORTION OF SEWER SYSTEM MODELED)

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Tri-Cities Office: Johnson City, TN. 37615

CITY OF OAK RIDGE
FIGURE II-2
SANITARY SEWER OVERFLOWS
(RAINFALL-RELATED)
2007 THRU 2011

DRAWN BY : JCA/MLG
FILE NO. COR232SE06SC11
SCALE : 1"=4000'
DATE: 08/2012

TABLE II-1
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
SUMMARY OF FIVE-YEAR PERIOD (2007–2011) OVERFLOW ANALYSIS

Item	Emory Valley	East Plant	Central City	Y-12	Turtle Park	West End
Feet of Pipe	148,777	334,310	185,998	198,837	268,194	113,463
Number of Manholes	716	1,990	1,007	1,024	1,385	558
Total SSOs	30	134	93	55	78	10
Wet-Weather SSOs	25	90	81	47	38	1
Wet-Weather SSO Volume; 1,000 gallons	2,661	7,565	6,881	2,737	2,391	27
Wet-Weather SSOs per 100 Manholes	3.5	4.5	8.0	4.6	2.7	0.2
Wet-Weather SSOs per 10,000 feet of Pipe	1.7	2.7	4.4	2.4	1.4	0.1
Wet-Weather SSOs gallons/Manhole	3,717	3,801	6,832	2,673	1,727	48
Wet-Weather SSOs gallons/foot of Pipe	17.9	22.6	37.0	13.8	8.9	0.2
Wet-Weather SSOs 1000 gallons/SSO	106	84	85	58	63	27

The computer model was used to predict flows within the primary sewer system. Under dry-weather conditions, and in the absence of critical blockages, power losses, mechanical failures, etc., the system has sufficient capacity without causing any overflows. However, under design wet-weather conditions, the analysis indicated that 27% of the 520 pipes modeled in the existing primary system prior to rehabilitation had peak flows in excess of their nominal full pipe gravity flow capacity. In addition, of the 518 manholes modeled in the primary system a total of 19 (4%) would overflow under design storm conditions. Summaries of the capacity and overflow analyses, listed by sewershed, are presented in tables II-2 and II-3.

TABLE II-2
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
SUMMARY OF PIPES WITH FLOWS
IN EXCESS OF FULL PIPE GRAVITY FLOW CAPACITY
SPINE MODEL
(2-YEAR, 24-HOUR DESIGN EVENT)

Sewershed	Turtle Park	East Plant	Emory Valley	Central City	Y-12	West End
Total No. of Pipes	126	97	68	118	98	13
No. of Pipes Over Capacity (OC)	49	32	7	21	27	6
8” Pipes: OC/Total No.	11/26	2/5	2/3	0/18	3/7	4/5
10” Pipes: OC/Total No.	2/17	11/22	1/44	0/28	0/6	0/0
12” Pipes: OC/Total No.	3/17	0/21	0/1	1/9	4/26	2/8
15” Pipes: OC/Total No.	0/0	0/1	3/18	0/10	0/11	0/0
16” Pipes: OC/Total No.	0/5	0/0	1/2	0/0	0/0	0/0
18” Pipes: OC/Total No.	0/0	11/38	0/0	0/0	2/12	0/0
20” Pipes: OC/Total No.	0/0	0/0	0/0	4/6	0/1	0/0
21” Pipes: OC/Total No.	0/0	7/9	0/0	16/38	3/12	0/0
24” Pipes: OC/Total No.	0/0	1/1	0/0	5/8	6/20	0/0
27” Pipes: OC/Total No.	0/0	0/0	0/0	0/0	2/3	0/0
36” Pipes: OC/Total No.	30/42	0/0	0/0	1/1	0/0	0/0
42” Pipes: OC/Total No.	3/19	0/0	0/0	0/0	0/0	0/0

TABLE II-3
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
SUMMARY OF OVERFLOWS BY SEWERSHED – SPINE MODEL
(2-YEAR, 24-HOUR DESIGN EVENT)

Sewershed	Number of Overflows	Overflow Volume (Gallons)
Turtle Park	6	683,261
Central City	3	1,209,648
Y-12	1	36,194
Emory Valley	0	0
East Plant	9	306,917
West End	0	0
Total	19	2,236,020

The model was used to analyze hydraulic grade line (HGL) profiles under design storm peak flow conditions for the seven main pipe network segments. (See Appendix E of the Capacity Assessment report.) The profile analysis indicated the following:

- Two segments of gravity sewer in the East Plant sewershed, totaling approximately 15,000 feet in the model, had approximately 10,000 feet of pipe with significant surcharging.
- Two segments of gravity sewer in the Emory Valley sewershed, totaling approximately 17,000 feet in the model, had approximately 2,500 feet of pipe with minor surcharging.
- A 12,000 feet segment of the Y-12 sewershed gravity sewer had approximately 4,000 feet of surcharged pipe, and the remaining 8,000 feet was near capacity. The surcharging occurred in the downstream portion, where the Y-12 main sewer discharges into the main trunk sewer.
- A 3,700 feet segment of sewer in the West End sewershed had significant surcharging in approximately 1,200 feet of small diameter pipe in the upper portion of the segment.
- The main trunk sewer, between the end of the Emory Valley and East Plant pump station force mains and the Turtle Park pump station, is approximately 29,000 feet in length. Approximately 22,000 feet of the trunk was surcharged under design storm conditions. The downstream 7,000 feet reach was not surcharged but was near capacity. Note that the Emory Valley and East Plant pump stations discharge into the upstream portion of the trunk, and the Y-12 main sewer enters the trunk in the upper half of the segment.

Flow records and model simulations confirmed that the East Plant and Emory Valley pump stations often operate simultaneously. This causes the common segment of the force mains for these pump stations to be loaded in excess of the individual pump station design head, resulting in reduced overall performance. On the other hand, the existing simultaneous peak flow condition under design storm conditions overloads the downstream sewer beyond capacity. Therefore, improvement to the common force main segment alone would exacerbate this situation under present inflow and infiltration conditions.

Flow records and model simulations also confirmed that wet weather flow from the Y-12 main sewer peaks within the same hour as the main interceptor.

The Turtle Park pump station collects all sewage flow from the sewer basin and pumps it through force mains to the Oak Ridge Wastewater Treatment Plant (WWTP). The capacity of the station is 30 MGD. The peak 2-year, 24-hour design event flow rate at the Turtle Park pump station was computed directly by the model. The predicted peak flow rate of 25 MGD is less than the rated capacity of the station.

In addition to the Turtle Park station, the sewer basin contains 33 other pump stations. The pump station capacities were evaluated by comparing the available pumping capacities to estimated peak unrestricted incoming design flow rates or incoming pipe capacities, whichever controlled inflow rates. The design peak inflow rates at six of the smaller pump stations exceed the rated pumping capacities. However, these six marginally undersized pump stations do not contribute to SSOs.

In summary, the existing wastewater collection system Capacity Assessment indicated that:

- The existing system is adequate for dry weather flows in the absence of pipe deformation/damage, critical blockages, power losses, mechanical failures, etc.
- The Turtle Park pump station and the Oak Ridge wastewater treatment plant have adequate capacity for design wet weather flows under existing conditions. Except for six relatively small pump stations, the remaining pump stations have adequate capacity to pump design flows. However, these six pump stations do not contribute to SSOs.
- The existing sewer pipe network is generally not adequate under wet weather conditions. The sewer system experiences excessive inflow and infiltration as indicated by the pronounced response of the system to rainfall, both in increased volume and peak flow rates. The excessive inflow and infiltration, exacerbated by timing effects (see below), causes surcharging and overflows.

- The main gravity interceptor between the Emory Valley and East Plant force main terminals, and the Illinois Avenue area, is overloaded during wet weather conditions, resulting in surcharging and overflows. This condition is caused by excessive inflow and infiltration, and timing effects.
- Incoming flow from the Y-12 sewershed exerts significant hydraulic loads on the main interceptor. The frequently simultaneous peak discharges from the East Plant and Emory Valley pump stations, and near simultaneous peaking from Y-12, are significant factors causing the system overloads.
- Although wet weather overflows occur at a number of locations in the sewer basin under design conditions, the most significant overflows are associated with the East Plant sewershed and the main interceptor at and upstream of the Illinois Avenue area. The latter includes the segment receiving incoming flow from Y-12.
- Surcharging in the interceptor and other main sewers cause hydraulic grade line "flattening" in the incoming secondary collectors, thus substantially reducing the effective capacity of those sewers.

C. SEWER SYSTEM EVALUATION SURVEY

Effective planning to eliminate SSOs requires characterization of the existing condition of the system. Therefore, the City conducted a Sewer System Evaluation Survey (SSES) of the sewer basin.

The study consisted of:

- Field surveys to determine the locations and elevations of the manholes, pipes, and other features that make up the collection system
- Detailed inspections of all manholes
- Smoke testing of the system
- Closed circuit television video (CCTV) surveys of the system
- Incorporation of the above data into the GIS database of the system, thus documenting and mapping the physical condition of the system components

The condition of each of approximately 6,700 manholes in the system was documented. Degradation such as deterioration, cracking or spalling of the manhole walls; inadequate or damaged frames and covers; excessive settlement; poorly sealed pipe openings, etc. were noted.

Smoke testing of the system revealed the locations of defects in the sewer pipes and private laterals due to breaks or fractures in the lines, open joints, improper service connections, damaged cleanouts, missing cleanout caps, etc. The testing included more that 1.2 million feet of publically owned sewer, plus service laterals.

The City's CCTV surveys of the collection system were systematically reviewed, and all observed defects were documented for remediation planning and design purposes. Defects included degraded pipes, broken or fractured pipes, open or offset joints, misalignment, excessive sags, root penetrations, improper connections, zones with high rates of infiltration, etc. Thus, the CCTV program provided the type of information needed to develop specific remediation measures to be applied at specific locations within the system.

The results of the SSES, including supporting data and summaries of the findings, were presented in the SSES report. Table II-4 is a general summary of the findings.

Note that the table differentiates between major and minor manhole defects and extent of subsequent repairs. However, the table does not categorize the severity of sewer pipe defects observed in the smoke testing and CCTV inspections. The tabulated values are intended to provide an overview of the occurrence of defects and general indication of the integrity of the pipes in each sewershed.

TABLE II-4
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
DEFECTS IDENTIFIED BY SSES

Item		Emory Valley	East Plant	Central City	Y-12	Turtle Park	West End
Feet of Pipe		148,777	334,310	185,998	198,837	268,194	113,463
Number of Manholes		716	1,990	1,007	1,024	1,385	558
Smoke Defects	Manholes	251	538	145	177	297	114
	Main Lines	42	95	20	7	22	2
	Laterals	188	251	132	88	192	43
	Catch Basins	12	13	12	4	3	0
	Storm Sewers	0	6	0	0	3	0
	Roof Drains	3	5	4	0	0	0
	Other	5	21	7	5	9	0
	Total	501	929	320	281	526	159
CCTV Defects on Main Lines		1,361	5,170	1,859	643	3,988	159
Manhole Smoke Defects per 100 Manholes		35	27	14	17	21	20
Main Line Smoke Defects per 10,000 feet of Pipe		2.8	2.8	1.1	0.4	0.8	0.2
Main Line CCTV Defects per 10,000 feet of Pipe		91	155	100	32	149	14
% of Manholes Requiring Major Repair		5.4%	3.3%	2.7%	2.1%	2.0%	0.9%
% of Manholes Requiring Minor Repair		23.7%	35.5%	38.2%	32.9%	27.9%	35.5%

Table II-5 summarizes the 25 mini-systems with 10 or more CCTV defects per 1,000 feet of pipe.

TABLE II-5
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
MINI-SYSTEM CCTV DEFECTS
10 OR MORE DEFECTS PER 1,000 FEET OF PIPE

Sewershed	Mini-systems with 10 or More CCTV Defects per 1,000 feet
Emory Valley	E24 (46), E5B (20), E5A (13), E36 (9)
East Plant	E28 (29), E2 (26), E9 (24), E10 (22), E1 (18), E6 (16), E12 (15), E13A (14),E8 (12), E11 (11)
Central City	W9 (14), W6 (12)
Y-12	None
Turtle Park	W10 (40), W18B (28), W12 (25), W16 (25), W18C (21), W15 (17), W18E (16), W25 (11), W11 (10)
West End	None

D. PUMP STATION CAPACITIES

Parallel to the Capacity Assessment and Sewer System Evaluation Survey, the City conducted a comprehensive Pump Station Evaluation (PSE) of each of the 34 pump stations in the sewer basin. The PSE consisted of inspecting each station, and collecting information regarding its condition and operation. The data collected were used to rank the stations based on a numerical rating scheme intended to prioritize the stations relative to any necessary upgrades and repairs. The capacity of each station was compared to expected peak flows, as previously discussed. The results of the PSE were summarized in the Pump Station Evaluation and Repair Program report. Although several of the stations operate beyond their intended design conditions to pass the incoming peak flows (e.g., number of pumps running), all of the pump stations except six of the smaller stations have sufficient capacity to pass nominal peak flows. However, under existing conditions, those six marginally undersized pump stations do not contribute to the occurrence of SSOs. General upgrading of the pump stations is discussed in Section V.

SECTION III

REMEDIATION METHODS

A. GENERAL

As previously discussed, the Capacity Assessment quantified the occurrence of sanitary sewer overflows in the City's wastewater collection system, and identified the primary causes and characteristics of the system and SSOs. The study confirmed that the capacity of the existing pipe system is exceeded under significant wet weather conditions due to the size of some of the sewer pipes, excessive inflow and infiltration, and the timing of peak flows entering the system. Is addition, the Sewer System Evaluation Survey determined that defects in the sewer collection system allow excessive infiltration and in some cases, significantly reduce hydraulic capacity. These issues are typically addressed by applying one or more of the remediation methods listed below.

- Reduce the timing effects by constructing flow equalization (EQ) basins.
- Increase capacities by increasing the size of selected system components (e.g., sewer pipes) by replacement and in-situ methods.
- Reduce inflow and infiltration by rehabilitating/repairing selected sewers and manholes.

B. METHODS

The methods considered in this study for eliminating SSOs include flow equalization basins to reduce peak flows and to address timing issues, increasing the size of selected sewers to gain capacity, and rehabilitation of selected sewers and manholes to reduce inflow and infiltration. A brief discussion of each method follows.

Flow Equalization

Flow equalization basins are typically used to "minimize random or cyclic peaking" (TDEC, 1989) of loads treated by a wastewater treatment plant. However, as utilized here, the basins are primarily intended to provide temporary storage of wastewater so as to manage the rate and timing of discharges within the collection system itself. When coordinated with other remedial measures, the use of equalization basins can minimize the extent to which sewer pipes will need to be upsized as well as eliminate the need to increase the capacities of the primary pump stations and the WWTP.

Increasing Pipe Size

In some cases increasing the size (i.e., diameter) of a segment of sewer pipe can be economically advantageous. The additional capacity gained alone can lower the hydraulic grade line, and reduce or eliminate the frequency of sewer surcharging.

There are two basic approaches to increasing the size of an existing sewer pipe: the in-situ "pipe bursting method" and the "dig-and-lay" (or "excavate-and-replace") method.

"Pipe bursting" is a trenchless method, which allows pipe replacement without having to remove existing pipes. The method involves inserting a cone-shaped bursting tool into the existing pipe, pulling it through the host pipe using a static pull cable or actuated tool, and breaking the pipe as the tool moves forward. In the static cable version, a pull cable is strung through the pipe and connected at the other end to a winch or backhoe, which pulls the cable (and bursting tool) through the pipe. In the actuated tool version, a pneumatically driven hammer mechanism pounds the tool through the pipe while a cable winch pulls the tool lightly to keep it stable. Afterward a length of replacement pipe is assembled by butt-welds above ground to the appropriate length, attached to the bursting tool, and then pulled into the newly fractured host pipe, thereby replacing it. Laterals are reconnected in a separate operation so the new pipe can "relax," or contract to a stable length after being stretched. Generally, pipe bursting works best with clay, cast-iron or unreinforced concrete sewers and in clay and silt soils. Pipe bursting typically has been a common choice in areas that have issues with:

- Traffic disruption and control
- Disruption to properties (access to and easement use)
- Paving damage
- Shoring requirements
- Excavation dewatering
- Noise
- Restoration (paving, driveways, sidewalks, fences, landscaping)

The **"dig-and-lay"** method consists of the conventional "excavate-and-replace" approach whereby the existing pipe is removed by excavation, the trench is prepared, a replacement pipe is installed, service connections are restored, and the pipe is backfilled. When the pipe is upsized, modifications or replacement of the affected manholes are usually required. With this method a number of defects can also be addressed (see following discussion on sewer rehabilitation) that may not be possible using the pipe bursting method.

These include correction of misaligned pipe, severe pipe degradation, and excessive sags or humps. The main disadvantages are surface disruption/damage, utilities, easements, noise, dewatering, traffic control, and cost.

Sewer and Manhole Rehabilitation

Excessive inflow and infiltration is the most significant contributor to SSOs; 70% of the SSOs during the five-year period 2007 through 2011 were rainfall-related. Since degradation of wastewater collection system components has a direct effect on excessive inflow and infiltration, the most favorable alternatives for eliminating SSOs rely on the reduction of rainfall-induced inflow and infiltration through sewer and manhole rehabilitation.

Sewer pipes may be rehabilitated by a number of methods. For the types of issues encountered in the Oak Ridge system, the following were considered:

- Pipe Bursting
- Dig-and-Lay
- Point Repairs
- Cured-in-Place
- Slip Lining
- Pipe Lining

The **"pipe bursting"** and **"dig-and-lay"** methods were previously reviewed in the discussion of pipe upsizing.

The **"point repair"** method is often used when a sewer pipe problem is limited to one or two areas and isolated repairs are more economical than a total pipe repair. The repair method used depends on the nature of the defect. There are four basic types of point repair methods: excavate-and-replace, mechanical, cure-in-place, and chemical grouting.

- Excavate-and-replace: This option requires excavating at the location for the point repair, removing the failed segment of pipe, replacing the segment, and reconnecting using a flexible coupling or a hard connection coupling. The repaired area is then stabilized with stone or concrete and backfilled.
- Mechanical: This option involves a sheet-metal sleeve that is placed over the repair area and expanded into place. The sleeve has locking tabs to prevent collapse once installed, and the portion of the sleeve in contact with the pipe is often coated with a hydrophilic chemical to seal leaks.

- Cure-in-place method: This method involves an ambient temperature-cured resin, much like the cure-in-place liners. A clamp is placed over the repair and expanded into place with an air-filled bladder, which is left in place for a specified amount of time to allow the resin to cure.
- Chemical grout: Chemical grout is usually made up of hydrophilic polymers that are injected into cracks and leaking joints. Specially designed remote-control devices, called packers, force the grout into the crack or joint.

The **"cured-in-place"** method introduces a polyester felt liner into the sewer pipe through the existing manholes. The liner is impregnated with a resin that will expand and set with application of heat. The liner is introduced under water pressure, and the resin is cured with the induction of steam or heated air. The final product is a full pipe liner with no seams that molds to the shape of the existing pipe to ensure a good seal. This method is unlike the dig-and-lay method, which requires repairing the disturbed roadway. At manholes, cementitious materials are used to ensure a water tight seal between the newly lined pipe and the manhole. This rehabilitation method allows a project to proceed with low to no impact on the surrounding area and has a high success rate in rehabilitating gravity sewer lines. Where suitable, this alternative is cost effective and desirable due to its low impact and relatively short construction time.

The **"slip lining"** method involves inserting a new pipe into an old pipe through an insertion pit. This process may or may not require flow by-passing. The process leaves an annular space between the host pipe and liner, which can be sealed at the ends or filled with grout along the length. Slip lining is not as flexible as other pipe lining options and cannot negotiate curves or offsets. However, this lining is a good option for many replacement problems. Pipe liners can eliminate the need for excavation and as a result, the installation costs can be 50% to 80% of the cost for excavation and replacement. Slip lining may be advantageous when no increase in hydraulic capacity is needed, and when the following issues are present:

- Traffic disruption and control
- Disruption to properties (access to and easement use)
- Paving damage
- Shoring requirements
- Excavation dewatering
- Noise
- Restoration (paving, driveways, sidewalks, fences, landscaping)

"Pipe lining" is a method in which the existing pipe does not have to be removed. This procedure involves inserting a liner into the existing pipe, which renews the interior surface and can increase the structural capacity of the old pipeline. With pipe lining the pipe will be repaired with no damage to the streets. Some of the advantages for pipe lining are:

- Trenchless
- Strong
- Cures fast
- Reliable
- Environmentally friendly
- Long-lasting
- Easy to install
- Cost competitive
- Non-disruptive
- Speed of installation
- Restores pipe integrity

There are two basic types of pipe lining options: cure-in-place thermoset liners and thermoplastic (fold-and-form) liners.

- Thermoset (cure-in-place) liners are cloth-like fiber shells filled with thermosetting resin, usually polyester. Liner installation is a three-step process, beginning with "wetting out," in which resin is applied to the inside of the fiber shell liner tube and forced to go deep within the cloth fibers. Then the liner is placed into the pipe via a manhole (after flow has been by-passed elsewhere). Next, the material is filled with water to insert the tube through the pipe run and curing begins. Curing the pipe involves heating the water used in the second step and circulating it in the pipe for a certain period of time (depending on the size of the repair). When this step is complete, the liner is mechanically bonded to the interior of the existing pipe. The cured liner is very rigid and corrosion-resistant.
- Thermoplastic (fold-and-form) liners are thermoplastic polyvinyl chloride (PVC) or HDPE liners that have been deformed to fit easily within an existing pipe. The liner is heated with hot water or steam to soften it and then is inserted into the sewer through a manhole. Once the liner is in place, heat and pressure are applied to mold the material to the pipe's round shape. Once in place, the liner then is cooled to retain its shape, fitting snugly inside the pipe without adhering to the surface, so they can be replaced easily, if necessary.

Manhole repairs are performed by entering the manhole and making the repairs or by excavating the manhole to make the repairs. Issues that typically require excavating the manhole include:

- Manhole needs to be replaced
- Manhole-to-pipe boot needs to be repaired or replaced
- Manhole invert needs to be raised or lowered
- Repairs to the frame and cover are needed

Many manhole defects can be addressed without excavating the manhole. Issues that can usually be repaired without excavating the manhole include:

- Grouting
- Invert repairs
- Step repairs
- Leak repairs

A variety of methods and materials are available for making repairs in-situ to manholes. The most commonly used methods are:

- Preformed manhole units are one-piece monolithic manhole units made to be installed within an existing concrete, brick, or precast manhole.
- Poured-in-place concrete liners are poured-in-place thick-wall, seamless concrete manhole liners that extend from the bench to the frame. After segmented, stackable steel forms are positioned into the manhole, and concrete is carefully poured into the forms. When the concrete has sufficiently cured, the forms are disassembled and removed.
- Cured-in-place liners are one-size fits-all liners made to fit all manhole types including barrel sections, eccentric and concentric cones constructed of brick and mortar, pre-cast, or block. The liner is usually constructed with polyester circular-knit fabric which is vacuum impregnated with either a silicate or polyurethane resin, depending on the application, and is cured under pressure at ambient temperatures in about one hour.
- Cementitious coatings/grouts are modified rapid setting cementitious mortar used for horizontal, vertical and overhead patching of concrete and masonry. The mortar is sprayed or hand trowel-applied to a minimum 1/2-inch thickness.
- Polymer-based coatings/grouts are epoxy coating liners that protect concrete and steel surfaces in the wastewater industry, which can be applied by brush, roller, trowel or spray.

- Mechanical seals/inserts are PVC, stainless steel or HDPE inserts installed between the entry castings and the precast concrete cones and flat top sections for a corrosion resistant and watertight connection.

SECTION IV

PROJECTED INFLOW AND INFILTRATION REDUCTION

A. GENERAL

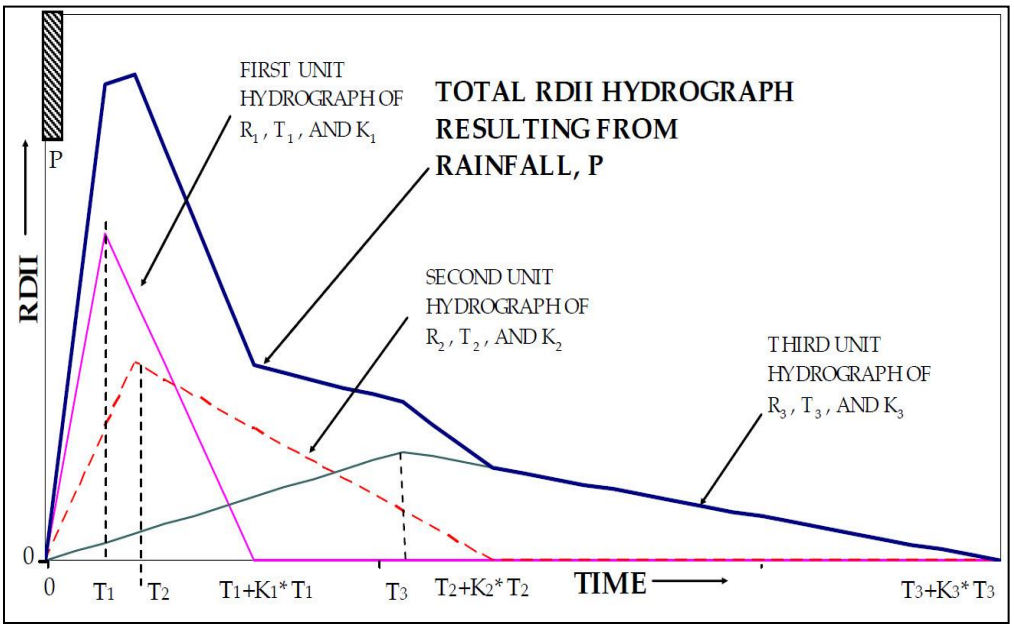
As determined in the Capacity Assessment, rainfall derived inflow and infiltration generates hydraulic loads that are, at times, in excess of the capacity of the wastewater collection system. The magnitude of the effects of inflow and infiltration is illustrated by the pronounced response of measured sewer flows to rainfall events, and the occurrence of overflows associated with wet weather. Excessive inflow and infiltration is a function of the condition of the sewer system, primarily the manholes, pipes, and service laterals. The condition of the manholes and sewer pipes documented in the SSES revealed the need for a rehabilitation program to address issues associated with SSOs. The result of the manhole and sewer rehabilitation program will be a reduction in the rates and volumes of rainfall-related inflow and infiltration introduced into the collection system. In order to estimate the effect of inflow and infiltration reduction on the elimination of overflows, an estimate of the projected removal rates was required.

B. APPROACH

The wet weather SewerGEMS Sanitary computer model used in the Capacity Assessment was based on inflow and infiltration hydrographs generated using the Stormwater Management Model (SWMM; EPA, 2010b). SWMM generates inflow and infiltration hydrographs (flow versus time) based on rainfall and “unit” hydrographs that define the immediate, intermediate and long-term responses to rainfall based on volume and timing parameters. The RDII (rainfall-derived inflow and infiltration) unit hydrograph method is well documented in the literature (EPA, 2008). The basic premise is that the response of a sewer to rainfall-derived inflow and infiltration may be represented by three linear triangular unit hydrographs. See Figure IV-1 (EPA, 2007). The three unit hydrographs are intended to independently represent rapid, intermediate, and delayed flow responses to rainfall occurring over the effective service area upstream of the reference flow location.

(For more information about this subject, refer to Section VIII of the Capacity Assessment Report.)

FIGURE IV-1
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
REDUCTION IN DESIGN PEAK INFLOW AND INFILTRATION RATES
RDII (I/I) UNIT HYDROGRAPH CONCEPT



For purposes of the Remediation Plan analysis, it was assumed that the timing parameters (T and K in Figure IV-1) will not change significantly between pre- and post-rehabilitation. However, the volume parameters were assumed to change as a result of the rehabilitation of the manholes and sewer pipes.

Typically, the most immediate sewer flow response to rainfall is the inflow component of inflow and infiltration. The volume typically associated with inflow is reflected by the "R_1" volume parameter for the leading (immediate) unit hydrograph. R_1 is defined as the ratio of rainfall volume that enters the sewer to total rainfall falling on the contributing land surface area. Likewise, R_2 and R_3 represent these ratios for intermediate and longer-term infiltration. As discussed in the Capacity Assessment Report, these parameters for existing conditions were assigned to the various segments of the sewer system based on calibration using observed rainfall and flow data.

For the purposes of this analysis, the following conservative assumptions were made in order to estimate the reduction in inflow and infiltration due to the rehabilitation program:

- R_1 was reduced by 50%.
- R_2 and R_3 were reduced by 10% each.

The rehabilitation program is expected to remove more than this amount of sewer inflow and infiltration volume. However, the reductions in volume, in particular R_2 and R_3, were assumed conservatively low since the rehabilitation program itself does not include private laterals. However, as part of the MOM program, the collection system will be monitored post-construction to identify problem areas with critically high inflow and infiltration from laterals. Those areas will be addressed as part of the MOM program.

The adjustments to R_1, R_2 and R_3 were made to the SWMM inflow and infiltration model using the design rainfall events, and the resulting hydrographs were transferred to the SewerGEMS Sanitary model for further analysis of the system.

C. RESULTS

Figures IV-2 through IV-8 illustrate the reductions in peak inflow and infiltration rates for the 60 hydraulic loading points in the spine model (as identified by manhole number).

FIGURE IV-2
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
REDUCTION IN DESIGN PEAK INFLOW AND INFILTRATION RATES
EAST PLANT SEWERSHED LOAD POINTS

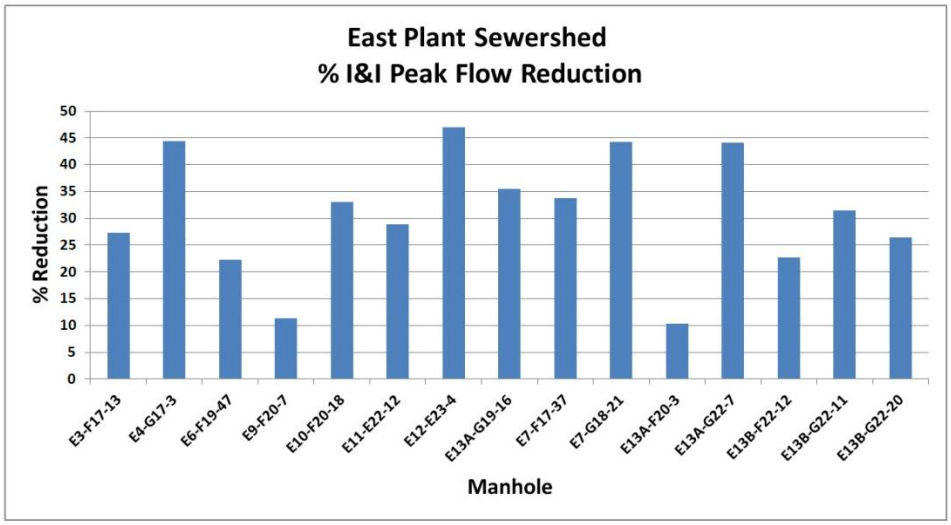


FIGURE IV-3
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
REDUCTION IN DESIGN PEAK INFLOW AND INFILTRATION RATES
EMORY VALLEY SEWERSHED LOAD POINTS

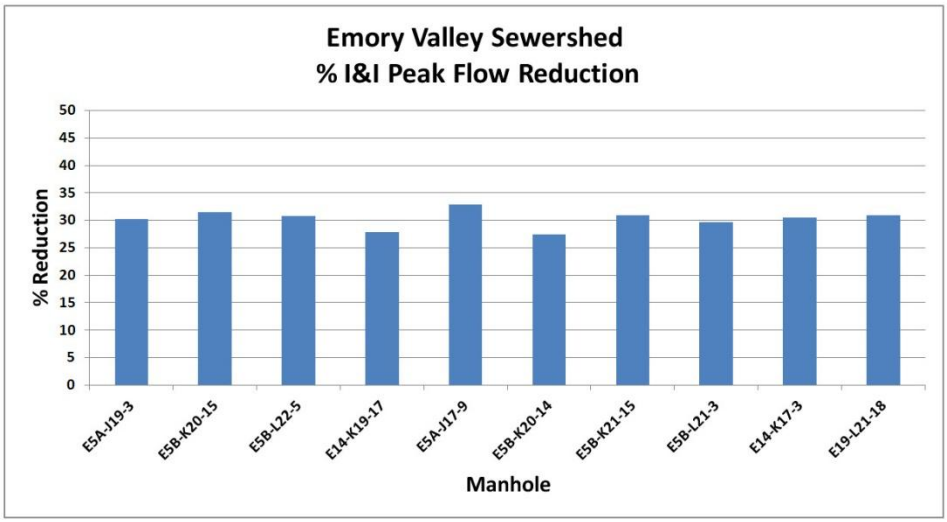


FIGURE IV-4
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
REDUCTION IN DESIGN PEAK INFLOW AND INFILTRATION RATES
CENTRAL CITY SEWERSHED LOAD POINTS

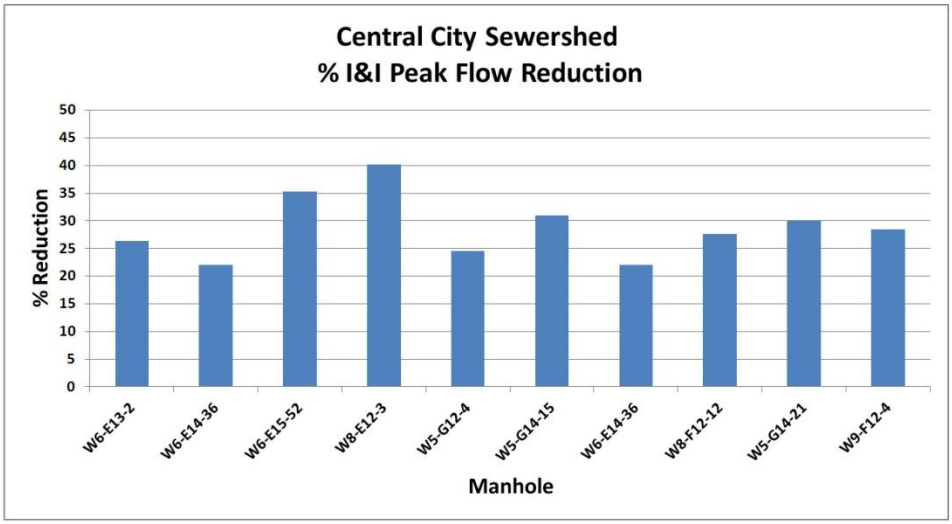


FIGURE IV-5
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
REDUCTION IN DESIGN PEAK INFLOW AND INFILTRATION RATES
Y-12 SEWERSHED LOAD POINTS

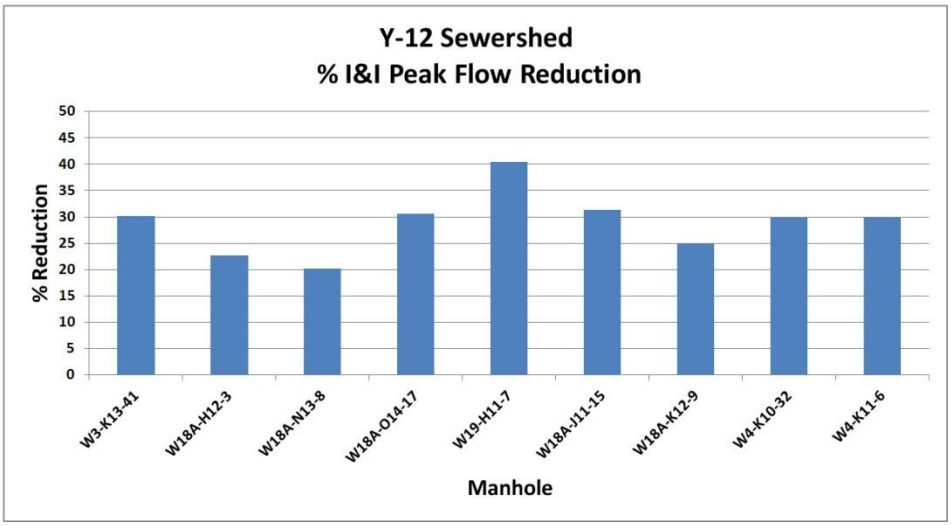


FIGURE IV-6
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
REDUCTION IN DESIGN PEAK INFLOW AND INFILTRATION RATES
TURTLE PARK SEWERSHED LOAD POINTS

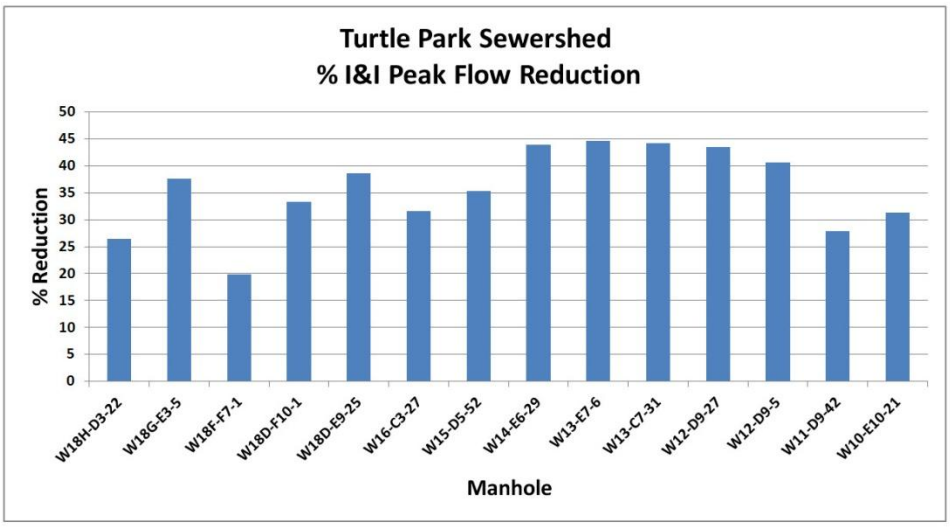


FIGURE IV-7
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
REDUCTION IN DESIGN PEAK INFLOW AND INFILTRATION RATES
WEST END SEWERSHED LOAD POINTS

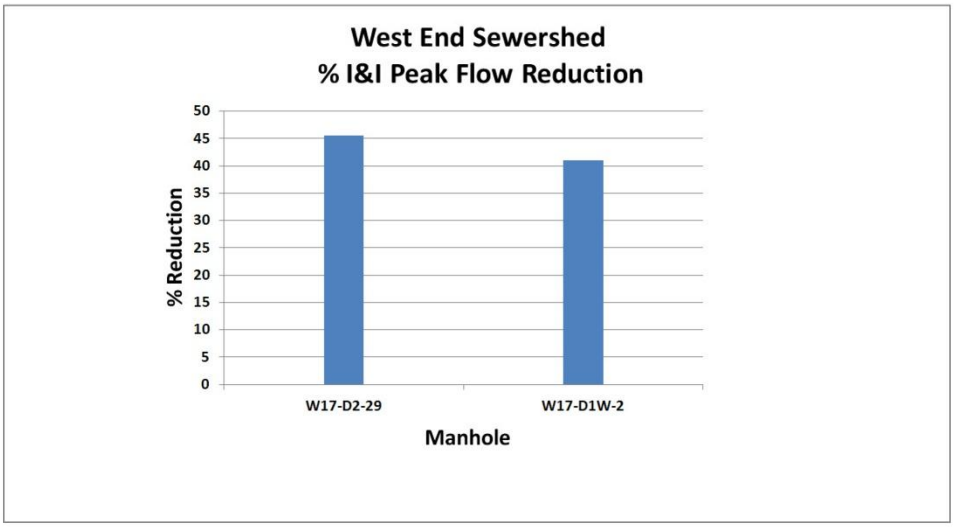
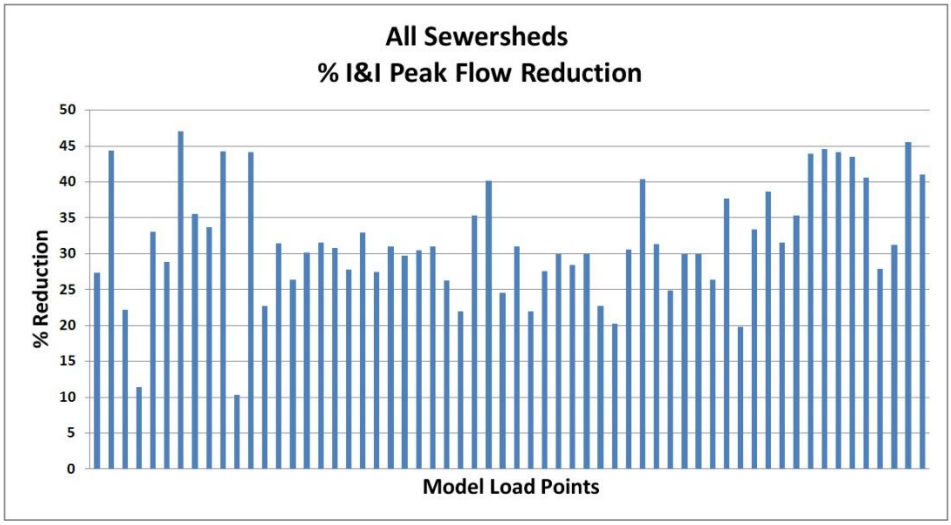


FIGURE IV-8
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
REDUCTION IN DESIGN PEAK INFLOW AND INFILTRATION RATE
LOAD POINTS FOR ALL SEWERSHEDS



As indicated, the peak inflow and infiltration rates are reduced at the loading points by 10% to 47% for the design storm, with an average reduction of 32%.

Only two of the points had reductions less than 20%, and 13 of the points had reductions of 40% or greater. It is difficult to compare the reductions predicted here with reductions experienced on other projects since there is sparse data available in the literature for similar projects, and reporting methods are not consistent (Lukas et al, 2003). However, based on the information that is available, the predicted reductions are considered to be reasonable and conservative.

Using the reduced inflow and infiltration flow hydrographs, the SewerGEMS Sanitary model was run for a theoretical scenario where all other elements of the model remain as in existing conditions. The theoretical model with rehabilitation alone reflects a pronounced decrease in overflow volumes, as would be expected. For the 2-year, 24-hour design rainfall event (3.32 inches), the reduction in overflow volume is 65%. However, the number of manholes in the model experiencing SSOs decreased by only one (18 overflows versus 19) compared to existing conditions. This indicates that rehabilitation alone will not eliminate SSOs. Additional measures such as pipe size increases and flow equalization basins are required, as verified in the alternatives analysis. (See Section VI.)

D. NOTES ON MODELING OF Y-12 PLANT FLOWS

The Capacity Assessment study consisted of flow monitoring at a number of locations within the City's sewer system. Based on those data, along with rainfall data and other information, a relatively detailed calibration of the computer model for the City's sewersheds was possible. However, the detailed monitoring did not include the area of the U.S. Department of Energy (DOE) Y-12 plant which discharges into the City's sewer system in the Y-12 sewershed. Therefore, in order to account for the Y-12 plant flows, the Capacity Assessment model included a single Y-12 plant inflow load point at the location where the Y-12 plant sewer discharges into the City's system. In the following discussion, the manner in which the Y-12 plant inflows were estimated is presented, along with other relevant observations.

As previously discussed, the method employed for estimating wet-weather flows was the RDII unit hydrograph. With this method, the total flow equals the sum of dry-weather base flow (including groundwater infiltration and sewage flow), and RDII. In order to apply the method to the Y-12 plant load point, flow and rainfall records were obtained from DOE by the City. Rainfall records for the Y-12 plant site were made available in tabular and graphical form for eight events between February 2011 and January 2012. The depth of the rainfall events ranged from 0.6 inches to 4.9 inches. In addition, flow records were provided for these events for a DOE meter located on the Y-12 plant sewer just upstream of where it discharges to the City's system.

The October 19, 2011 rainfall event was used to develop RDII unit hydrographs for the Y-12 plant discharge. This event was selected because:

- The flow at both the beginning and the end of the RDII component of the hydrograph was approximately 350-400 gallons per minute (GPM) which is consistent with the dry weather flow typically observed at that location.
- Antecedent rainfall conditions were suitable (i.e., no preceding excessive rainfall)
- The rainfall depth of 2.15 inches was sufficient to clearly define a flow hydrograph, and the duration of the main portion of the rainfall (approximately 8 to 9 hours) was sufficient to engage the contributing area.
- The hydrograph had a natural and relatively smooth shape with no indications of meter issues or unusual RDII response.
- The October 19, 2011 was also used in the calibration of the model for the City's sewersheds.

Figures IV-9 and IV-10 show the rainfall and flow records provided by DOE.

FIGURE IV-9
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
Y-12 PLANT FLOW RECORD FOR OCTOBER 19, 2012 EVENT

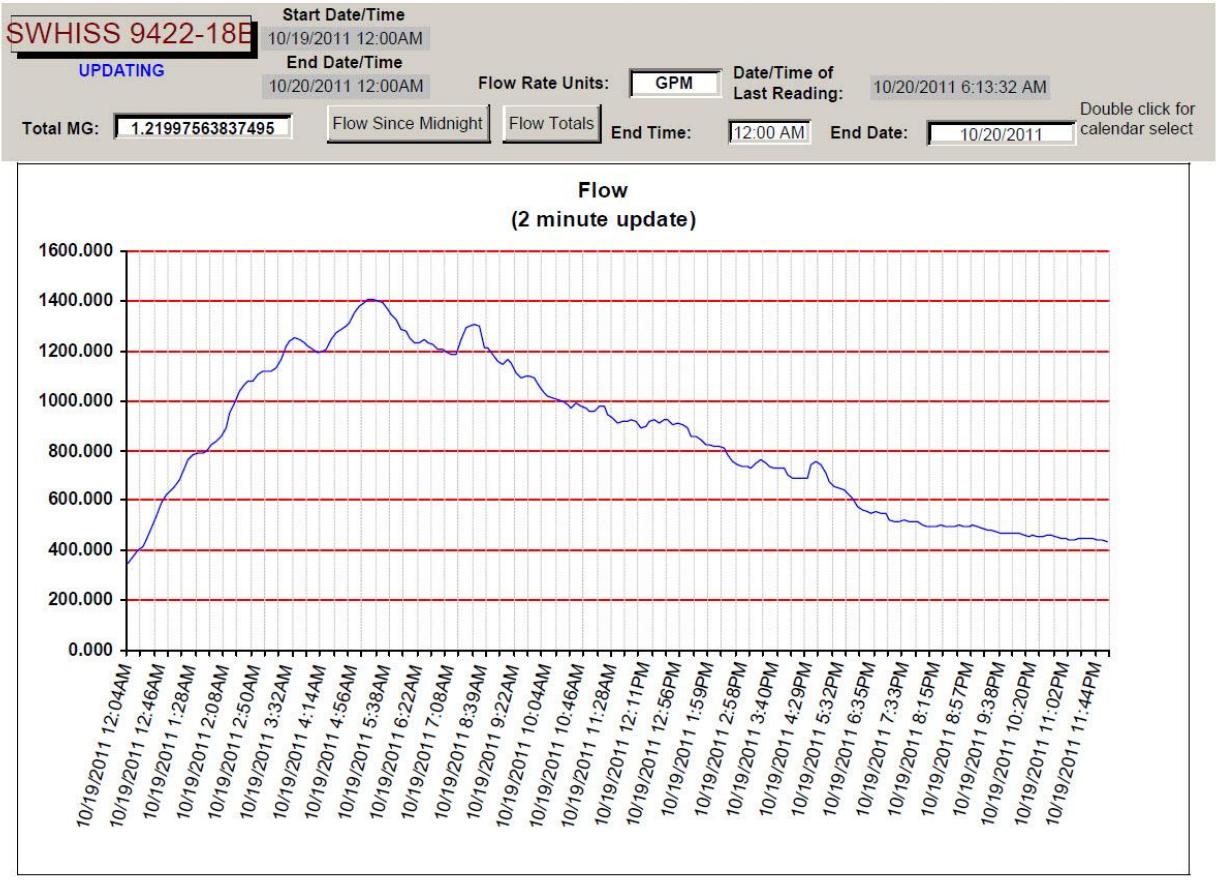
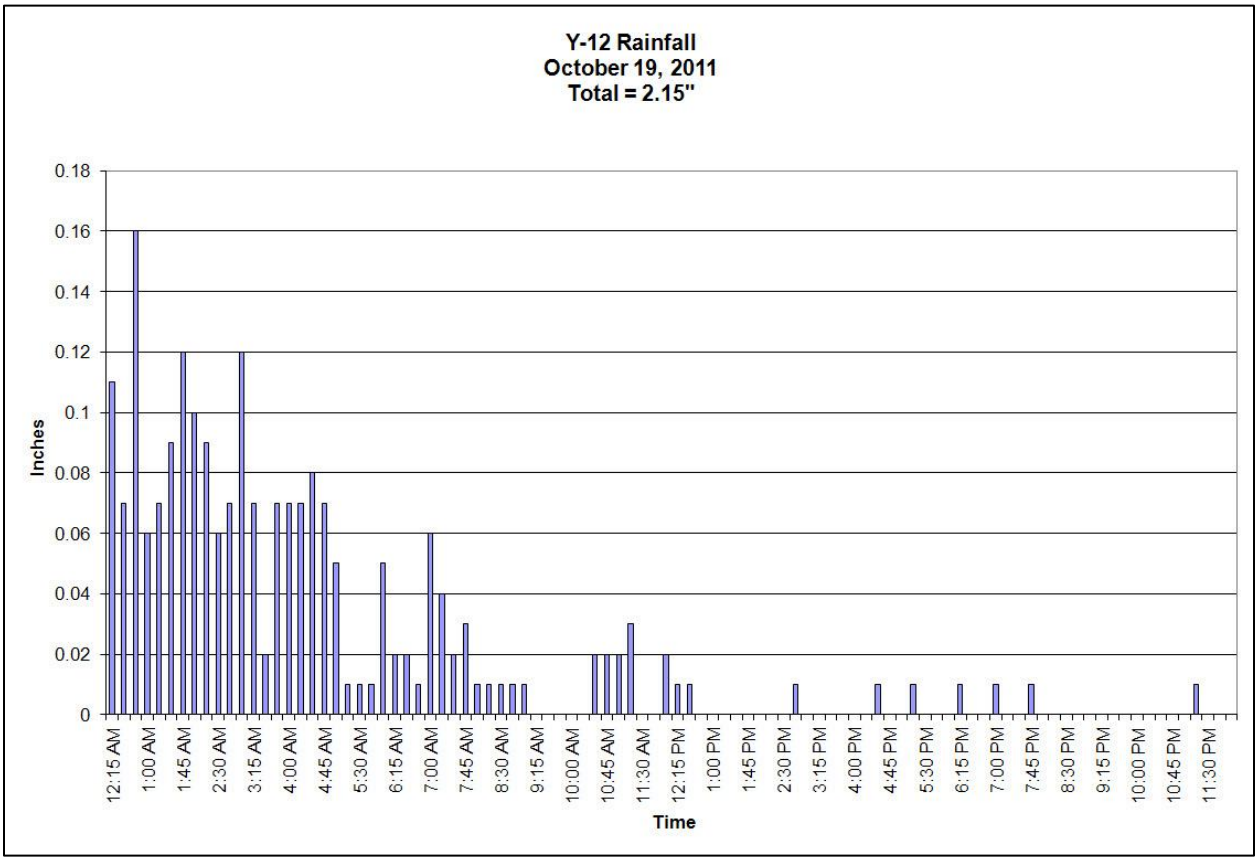
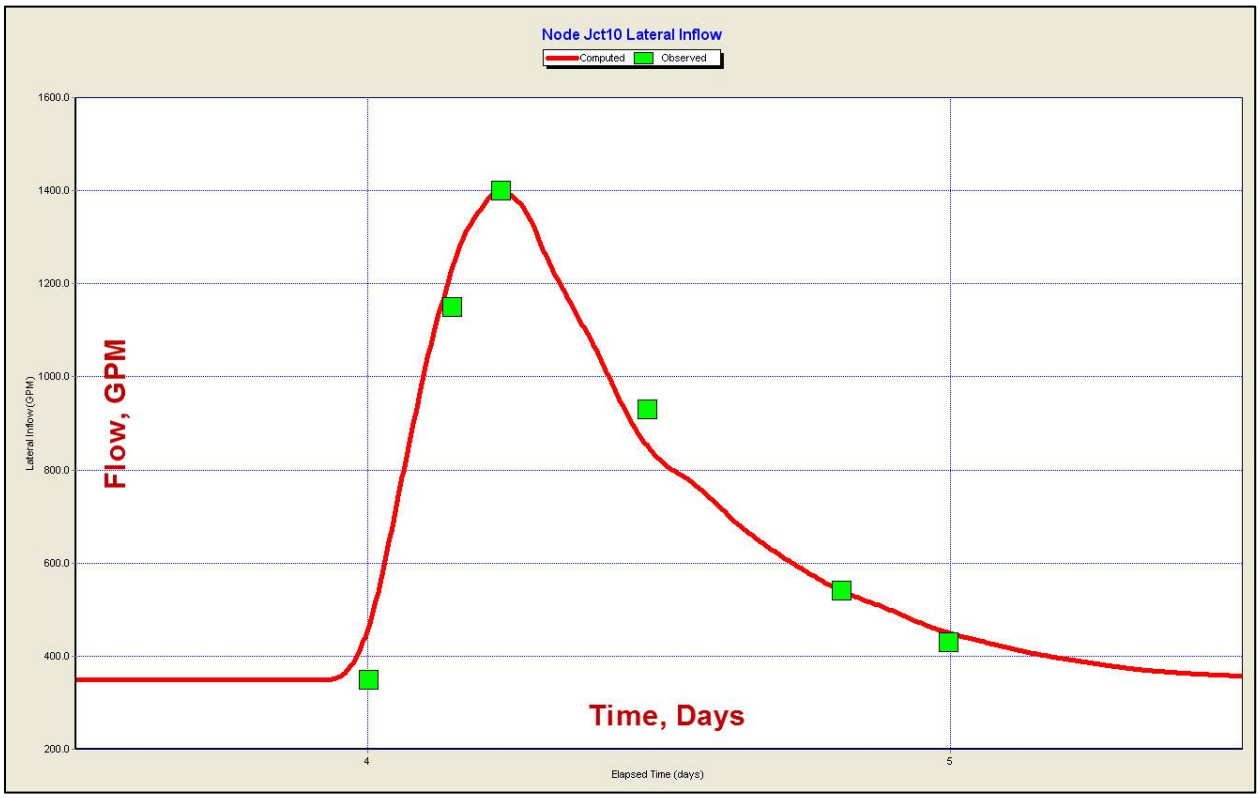


FIGURE IV-10
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
Y-12 PLANT RAINFALL RECORD FOR OCTOBER 19, 2011 EVENT



For calibration purposes, the October 19, 2011, flow record was simplified by selecting six points that reasonably reflect the shape of the hydrograph. The resulting calibration file and the rainfall data were then used in SWMM to develop the RDII parameters for the inflow and infiltration unit hydrographs. The calibrated hydrograph (solid red line) and target calibration hydrograph points (green squares) are shown in Figure IV-11.

FIGURE IV-11
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
Y-12 PLANT FLOW CALIBRATION



The calibrated RDII unit hydrograph parameters developed in this manner were subsequently used, without reduction, to generate design event hydrographs for input to the SewerGEMS model.

Figure IV-12 shows a plot of peak flow versus total rainfall depth (independent of duration) for the eight observed data sets provided by DOE, as well as the peak flows computed by the models for the 2-year and 5-year, 24-hour events. As indicated, the modeled flows and the observed flows follow a common trend except for two observed events. Those anomalous events appear to be associated with intense short duration storms (5 to 10-year events), wet antecedent conditions, and possibly other factors. The two events produced high peak flows but relatively limited volume.

Instead of attempting to re-calibrate the model to those events, the characteristics of the two anomalous events were considered when sizing the recommended flow equalization basins. (See Section VI.)

FIGURE IV-12
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
Y-12 PLANT FLOWS VERSUS RAINFALL
OBSERVED AND MODELED

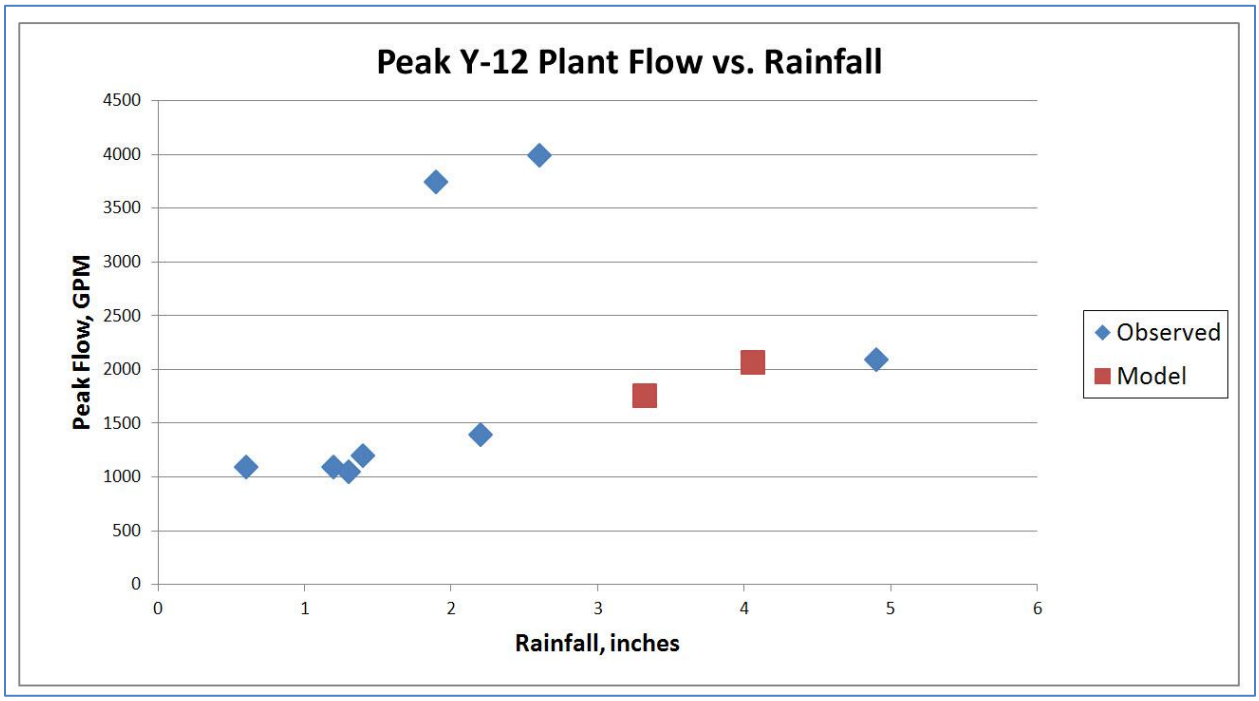


Table IV-13 provides a comparison of the modeled peak flow entering manhole W18A-N13-5 from the Y-12 plant and the City's system, but without any flow equalizations basins. Under existing and rehabilitated conditions (without equalization basins), the Y-12 plant flow represents 55% to 63% of the peak flows, respectively.

FIGURE IV-13
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
MODELED FLOWS INTO MANHOLE W18A-N13-5

	2-Yr, 24-hr Design Event		5-Yr, 24-Hr Freeboard Event	
	Before Rehab	After Rehab	Before Rehab	After Rehab
From City Sewer	1,440 GPM	1,050 GPM	1,750 GPM	1,260 GPM
From Y-12 Plant Sewer	1,760 GPM	1,760 GPM	2,070 GPM	2,070 GPM
Total of Peak Flows into the Manhole	3,200 GPM	2,810 GPM	3,820 GPM	3,330 GPM

SECTION V

PUMP STATIONS AND WASTEWATER TREATMENT PLANT

A. PUMP STATIONS

In the Pump Station Evaluation study (PSE), the pump stations in the collection system were discussed relative to size and condition. None of the stations were identified as needing to be upsized; however, there were maintenance and mechanical/electrical matters to be addressed. A scoring system was applied to the stations to prioritize upgrading. Table V-1 lists all the stations and their final score. (The lower the score, the higher the priority.) Table V-2 provides the scoring details.

The Gregory's, Castlewood, and Westview stations are currently being upgraded. Other stations are to be addressed under the routine management, operations and maintenance (MOM) program.

TABLE V-1
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
PUMP STATION RELIABILITY STUDY RATINGS

Pump Station	Score	Pump Station	Score
Palisades #4	28	Rivers Run	51
Palisades #2	29	Warehouse Road	51
Gregory's	31	Rolling Links	51
Scarboro	32	Whippoorwill	53
Castlewood	34	Wolf Creek	53
Westview	34	Radisson Cove	54
Palisades #3	34	Centennial Bluff	54
Palisades #1	35	East Plant	55
Emory Heights	37	Park Meade	57
Peach Orchard	46	Pump House Rd	58
Marina	47	Graceland	58
WATO	48	Gum Hollow	59
Rockbridge Green	49	Home Depot	59
Oak Hills	49	Williams	59
West Outer	50	Summit Ridge	60
Southwood	50	Riversway	64
Fairbanks	50	Emory Valley	64

TABLE V-2
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
PUMP STATION RELIABILITY STUDY RATINGS

STATION	FORCE MAIN				DESIGN CAPACITY		SITE ACCESS	WATER / LIGHTING	SECURITY		PERSONNEL	PUMPS				SCREENING	PRESS GAUGE / FLOW METER	SPARE PARTS	POWER		CONTROLS			SCADA	TOTAL SCORE
	AGE	MATERIAL	REPL. PARTS	FAILURE HISTORY	WET	DRY			ACCESS CONTROL	SIGNAGE		AGE	MOTOR SPEED	FAILURE HISTORY	TYPE				SOURCE(S)	BACK-UP	NEMA RATING	CONDITION	REDUNDANCY		
	4	2	1	3	5	5	2	1	1	1	8	4	1	6	2	1	2	3	4	2	1	8	2	5	---
PALISADES #4	2	2	1	3	2	2	1	1	0	0	8	1	1	2	0	0	0	0	2	0	0	0	0	0	28
PALISADES #2	2	2	1	3	2	2	2	1	0	0	8	1	1	2	0	0	0	0	2	0	0	0	0	0	29
GREGORY'S	2	2	1	3	5	5	0	0	0	0	8	1	1	1	0	0	0	0	1	0	0	1	0	0	31
SCARBORO	0	1	1	1	4	4	2	0	1	0	8	1	1	1	0	0	1	2	3	0	0	1	0	0	32
CASTLEWOOD	2	2	1	3	5	5	1	0	0	0	8	1	1	3	0	0	0	0	1	0	0	1	0	0	34
WESTVIEW	2	2	1	3	5	5	1	0	0	0	8	1	1	0	2	0	0	1	2	0	0	0	0	0	34
PALISADES #3	2	2	1	3	5	5	1	1	0	0	8	1	1	2	0	0	0	0	2	0	0	0	0	0	34
PALISADES #1	2	2	1	3	5	5	2	1	0	0	8	1	1	2	0	0	0	0	2	0	0	0	0	0	35
EMORY HEIGHTS	0	0	1	2	0	5	2	0	0	0	8	2	1	3	2	0	0	3	2	0	1	3	2	0	37
PEACH ORCHARD	0	0	0	1	5	5	1	0	0	0	8	3	1	6	2	0	0	3	3	0	1	5	2	0	46
MARINA	2	1	1	0	5	5	2	0	0	0	8	4	1	6	2	0	1	3	2	0	1	3	0	0	47
WATO	1	1	1	3	5	5	2	0	0	0	8	3	1	6	2	0	0	3	1	0	1	3	2	0	48
ROCKBRIDGE GREEN	4	2	1	3	5	5	0	1	0	0	8	4	1	4	2	0	1	3	2	0	1	2	0	0	49
OAK HILLS	4	2	1	3	0	5	2	1	1	0	8	2	1	4	1	0	1	2	4	0	1	4	2	0	49
WEST OUTER	2	2	1	3	5	5	0	1	0	0	8	3	0	2	0	0	1	3	2	2	1	8	2	0	50
SOUTHWOOD	3	2	1	3	5	5	2	1	0	0	8	2	1	4	2	0	0	3	3	0	1	2	2	0	50
FAIRBANKS	1	0	1	3	5	5	2	1	0	0	8	3	1	6	2	0	0	3	4	0	1	2	2	0	50
RIVERS RUN	3	1	1	3	3	5	0	1	0	0	8	3	1	6	2	0	0	3	3	0	1	5	2	0	51
WAREHOUSE ROAD	1	1	1	3	5	5	1	1	1	0	8	2	1	6	2	0	0	3	3	0	1	4	2	0	51
ROLLING LINKS	3	2	1	3	5	5	2	1	0	0	8	3	1	6	2	0	1	3	2	0	1	2	0	0	51
WHIPPOORWILL	3	2	1	3	3	3	2	0	0	0	8	3	1	6	2	0	0	3	3	0	1	7	2	0	53
WOLF CREEK	4	2	1	3	5	5	2	1	0	0	8	4	1	0	2	0	1	3	2	0	1	6	2	0	53
RADISSON COVE	2	1	1	3	5	5	2	0	1	0	8	4	1	6	2	0	0	3	2	0	1	5	2	0	54
CENTENNIAL BLF	4	2	1	3	5	5	2	1	0	0	8	4	1	0	2	0	1	3	2	0	1	7	2	0	54
EAST PLANT	2	1	1	3	5	5	2	1	1	1	8	1	1	3	2	1	1	1	2	2	1	6	0	4	55
PARK MEADE	3	1	1	3	5	5	2	1	1	0	8	3	1	6	0	0	1	3	3	2	1	6	1	0	57
PUMP HOUSE RD	1	1	1	2	5	5	2	1	1	0	8	4	1	6	2	0	1	3	3	0	1	8	2	0	58
GRACELAND	2	1	1	3	5	5	2	1	0	0	8	4	1	6	2	0	1	3	2	0	1	8	2	0	58
GUM HOLLOW	2	0	1	3	2	5	2	0	0	0	8	4	1	6	2	0	1	3	2	2	1	8	2	0	59
HOME DEPOT	4	2	1	3	5	5	2	1	0	0	8	4	1	6	2	0	1	3	4	0	1	4	2	0	59
WILLIAMS	2	1	1	3	5	5	2	1	0	0	8	3	1	6	2	0	1	3	2	2	1	3	2	0	59
SUMMIT RIDGE	4	2	1	3	5	5	2	1	0	0	8	4	1	6	2	0	1	3	2	0	1	7	2	0	60
RIVERSWAY	4	2	1	3	5	5	2	1	0	0	8	4	1	6	2	0	1	3	3	2	1	8	2	0	64
EMORY VALLEY	3	1	1	3	2	5	2	1	1	1	8	4	1	6	2	1	1	3	3	2	1	8	0	4	64

B. WASTEWATER TREATMENT PLANT

Under the "old program", the WWTP and influent pumping station were upgraded to handle a hydraulic load of 30 MGD. The plant discharges to the East Fork of Poplar Creek which has a limited assimilative capacity. The monthly average limits for Biochemical Oxygen Demand (BOD) are 8 mg/l and 15 mg/l, respectively, for summer and winter. The Total Suspended Solids (TSS) limit is 30 mg/l (monthly average).

Due to the limited assimilative capacity of the receiving stream, it would not be practical to add additional flow. Therefore, if more flow would be proposed for the treatment plant, the point of discharge would by necessity be relocated. If the discharge point is relocated, it would be at the Clinch River, west of the treatment plant. The outfall line would be 48 inches or greater in diameter. The “straight-line” distance from the WWTP to the Clinch River is approximately 6.5 miles; a sewer route would be longer. The cost would be more than $18,000,000 (the estimated cost of the sewer pipe and installation only). There would be substantial additional issues associated with land acquisition. In addition, there would be substantial additional costs associated with modifications at the Turtle Park pump station and WWTP, increasing the sizes of selected segments of the existing sewer system, environmental costs, an outfall facility, and other items. Therefore, it would be prohibitive to relocate the point of discharge.

An alternative to relocation of the point of discharge for the WWTP would be to construct another treatment plant. That other facility would be located at the site of the current East Plant pump station. The discharge would be in the Clinch River near mile 52.0. For the first four or five decades of sewage collection and treatment in Oak Ridge, there was a two-plant scenario. It was deemed non-feasible to continue the cost of operations for two relatively small plants in lieu of a medium-sized plant. It is suspected that if a new discharge was permitted on the east end of the sewer basin, it would require tertiary level treatment. If the capital cost of the plant and an alternate collection program were comparable, the added cost of manning and operating a second treatment plant would be unattractive.

SECTION VI

ALTERNATIVES FOR ELIMINATING SSOS

A. GENERAL

As previously discussed, the primary remediation methods considered in this study for eliminating SSOs are:

- Constructing of flow equalization basins.
- Increasing the size of selected system components (e.g., sewer pipes), including limited adding of new pipes.
- Rehabilitating/repairing selected sewers and manholes.

Table VI-1 illustrates the matrix of possible combinations of the three basic approaches.

TABLE VI-1
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
MATRIX OF APPROACHES TO ELIMINATE SSOS

Alternative	Increase Sizes of Selected System Components	Add Flow Equalization (EQ) Basins	Rehabilitate/Repair Selected Sewers and Manholes
A	X		
B		X	
C			X
D	X	X	
E	X		X
F		X	X
G	X	X	X

B. SCREENING OF ALTERNATIVES

The alternatives were screened by a three-step progressive process.

- Is the alternative hydraulically feasible?
- Is the alternative economically feasible and practical?
- What are the differential costs between the economically feasible and practical alternatives?

Each of the tabulated alternatives was first tested for "hydraulic" feasibility using the SWMM and SewerGEMS Sanitary models. "Hydraulic" feasibility indicates that the alternative will eliminate SSOs. The analysis was conducted using both the 5-year, 24-hour rainfall event (4.06 inches) and the 2-year, 24-hour design rainfall event (3.32 inches), distributed as described in the Capacity Assessment Report. The larger event was used as a "freeboard" event to provide a margin (or "factor of safety") against overflows under the 2-year design storm condition. This approach was deemed desirable for two reasons. First, a model is an estimation of real-world conditions and processes. As such, the results are subject to an unknown degree of uncertainty. Second, climatic issues such as long-term changes in rainfall patterns and depths also add an element of uncertainty. The incorporation of a margin through the use of the larger storm provides an indirect way of systematically addressing at least some of those uncertainties. Table VI-2 summarizes the results of the analysis.

TABLE VI-2
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
ALTERNATIVES FOR ELIMINATING SSOS
HYDRAULIC FEASIBILITY

Alternative	Comments
A: Increase Sizes (only)	Hydraulically feasible
B: Add EQ Basins (only)	Hydraulically feasible, but functionally undesirable since a large number of EQ basins distributed through the sewer basin would be required
C: Rehabilitate Selected Pipes/Manholes (only)	Using realistic inflow and infiltration reduction rates, rehabilitation alone will not eliminate SSOs; therefore not hydraulically feasible
D: Increase Sizes Add EQ Basins	Hydraulically feasible
E: Increase Sizes Rehabilitate Pipes/Manholes	Hydraulically feasible
F: Add EQ Basins Rehabilitate Pipes/Manholes Minimal Upsizing of Pipes	Hydraulically feasible
G: Increase sizes Add EQ Basins Rehabilitate Pipes/Manholes	Hydraulically feasible

As indicated, all alternatives except Alternative C were determined to be hydraulically feasible. However, although Alternative B is hydraulically feasible, it was not given further consideration due to the undesirably large number of flow equalization basins that would be required. Therefore, alternatives A, D, E, F and G were selected for further analysis.

Next, screening-level scopes were considered for each of the alternatives based on the physical requirements determined using the hydraulic model. The scopes were reviewed for economic and operational practicality. Tables VI-3 through VI-7 summarize the results of the scope analysis.

TABLE VI-3
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
ALTERNATIVE A
INCREASE SIZES OF SYSTEM COMPONENTS
SCOPE SUMMARY

Category	Description
Upsize Gravity Pipes	Upsize 158 sewer pipes totaling 38,816 feet. Includes portions of: main trunk sewer from termination of East Plant and Emory Valley force mains to Turtle Park pump station in Turtle Park and Central City sewersheds; Y-12 trunk sewer; trunk sewers in East Plant sewershed discharging to East Plant pump station; and other pipes in West End, Turtle Park, Y-12, Central City, East Plant and Emory Valley sewersheds. Modify manholes as required.
Rehabilitate Manholes and Pipes	None.
Modify Force Mains	None.
Increase Capacity of Pump Stations	Increase capacities of East Plant and Emory Valley pump stations to 11,300 gpm and 3,200 gpm, respectively. Increase capacity of Turtle Park pump station to 24,400 gpm.
Increase Capacity of WWTP	Increase WWTP hydraulic capacity to 24,400 gpm.
Add EQ Basins	None.
Result: By inspection, this alternative is cost prohibitive and impractical.	

TABLE VI-4
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
ALTERNATIVE D
INCREASE SIZES OF SYSTEM COMPONENTS
ADD FLOW EQUALIZATION BASINS
SCOPE SUMMARY

Category	Description
Upsize Gravity Pipes	Upsize 138 sewer pipes totaling 34,724 feet. Includes portions of: main trunk sewer in Turtle Park and Central City sewersheds, Y-12 trunk sewer; trunk sewers discharging to East Plant pump station; and other pipes in West End, Turtle Park, East Plant and Emory Valley sewersheds. Modify manholes as required.
Rehabilitate Manholes and Pipes	None.
Modify Force Mains	Modify East Plant and Emory Valley pump station force mains to discharge into new EQ basin.
Increase Capacity of Pump Stations	Increase Emory Valley pump station capacity to 3,200 gpm. Increase Turtle Park pump station capacity to 21,700 gpm.
Increase Capacity of WWTP	Increase WWTP capacity to 21,700 gpm.
Add EQ Basins	1 MG (million gallons) at Y-12, 2 MG at East Plant pump station, 0.5 MG in East Plant sewershed, and 2 MG downstream of East Plant and Emory Valley force mains.
Result: By inspection, this alternative is cost prohibitive and impractical.	

TABLE VI-5
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
ALTERNATIVE E
INCREASE SIZES OF SYSTEM COMPONENTS
REHABILITATE SELECTED PIPES AND MANHOLES
SCOPE SUMMARY

Category	Description
Upsize Gravity Pipes	Upsize 99 sewer pipes totaling 24,078 feet. Includes portions of: main trunk sewer in the Central City and Turtle Park sewersheds, the Y-12 trunk sewer, the East Plant trunk sewers, and other pipes in the East Plant sewershed. Modify manholes as required.
Rehabilitate Manholes and Pipes	Rehabilitate manholes and pipes in all sewersheds, as required.
Modify Force Mains	None.
Increase Capacity of Pump Stations	Increase East Plant and Emory Valley pump station capacities to 7,600 gpm and 2,300 gpm, respectively. Turtle Park pump station capacity marginal; increase to 21,300 gpm.
Increase Capacity of WWTP	WWTP capacity marginal; increase to 21,300 gpm.
Add EQ Basins	None.
Property	None.
Result: By inspection, this alternative is cost prohibitive and impractical.	

TABLE VI-6
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
ALTERNATIVE F
ADD FLOW EQUALIZATION BASINS
REHABILITATE SELECTED PIPES AND MANHOLES
MINIMAL UPSIZING OF PIPES
SCOPE SUMMARY

Category	Description
Upsize/Add Gravity Pipes	Upsize 19 sewer pipes totaling 3,650 feet. Includes portions of East Plant pump station trunk, and other pipes in Turtle Park and East Plant sewersheds. Add 8 sewer pipes totaling 1,946 feet of new pipe in East Plant sewershed. Modify manholes as required.
Rehabilitate Manholes and Pipes	Rehabilitate manholes and pipes in all sewersheds, as required.
Modify Force Mains	Modify East Plant and Emory Valley pump station force mains to discharge into new EQ basin.
Increase Capacity of Pump Stations	None.
Increase Capacity of WWTP	None.
Add EQ Basins	1 MG at Y-12, 2 MG at East Plant pump station, 0.5 MG in East Plant sewershed, and 2 MG downstream of the East Plant and Emory Valley pump stations.
Result: By inspection, this alternative is cost competitive and practical.	

TABLE VI-7
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
ALTERNATIVE G
INCREASE SIZES OF SYSTEM COMPONENTS
ADD FLOW EQUALIZATION BASINS
REHABILITATE SELECTED PIPES AND MANHOLES
SCOPE SUMMARY

Category	Description
Upsize/Add Gravity Pipes	Upsize 28 sewer pipes totaling 6,286 feet. Includes the trunk sewers for the East Plant pump station, and other pipes in Turtle Park and East Plant sewersheds. Add 8 sewer pipes totaling 1,946 feet of new pipe in East Plant sewershed. Modify manholes as required.
Rehabilitate Manholes and Pipes	Rehabilitate manholes and pipes in all sewersheds, as required.
Modify Force Mains	Modify East Plant and Emory Valley pump station force mains to discharge into new EQ basin.
Increase Capacity of Pump Stations	None.
Increase Capacity of WWTP	None.
Add EQ Basins	1 MG at Y-12, 2 MG at the East Plant pump station, and 2 MG downstream of the East Plant and Emory Valley pump stations.
Result: By inspection, this alternative is cost competitive and practical.	

The results of the scope analysis indicate that Alternatives F and G offer the most practical and economically feasible overall approaches. These two alternatives were further evaluated by preparing a screening-level differential cost comparison between the two alternatives. (Costs common to both alternatives are not included.) This analysis is shown in Table VI-8.

TABLE VI-8
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
COMPARISON OF ALTERNATIVES F AND G
DIFFERENTIAL COSTS

Category	Differential	Alternative F	Alternative G
Upsize/Add Gravity Pipes	Upsize 2,636 feet of pipe from 18" to 21" diameter	---	$750,000
Rehabilitate Manholes and Pipes	Same	---	---
Modify Force Mains	Same	---	---
Increase Capacity of Pump Stations	None	---	---
Increase Capacity of WWTP	None	---	---
Add EQ Basins	0.5 MG EQ basin in Emory Valley	$1,100,000	---

C. SELECTION OF ALTERNATIVE

Alternative G is the least cost, and was selected as the recommended alternative.

SECTION VII

RECOMMENDED REMEDIAL MEASURES

A. GENERAL

Based on the previously described analyses, Alternative G is the recommended remedial approach for eliminating SSOs within the City's sanitary sewer collection system. This alternative is cost competitive, and provides a high degree of control over the hydraulic loading in the system. The recommended remedial measures will consist of rehabilitating selected sewers and manholes, constructing three flow equalization basins, and increasing the size of selected sewer pipes. Please note that these measures are in addition to the recently completed rehabilitation in the Emory Valley sewershed.

B. REHABILITATION

The frequency of occurrence and volumes of SSOs within the system are strongly correlated to inflow and infiltration of rainfall. It is therefore recommended that rehabilitation be performed on selected sewers and manholes in accordance with the infrastructure conditions determined in the SSES, using the most appropriate remediation methods. Rehabilitation will reduce the volumes and peak flows of rainfall-induced inflow and infiltration into the system by repairing defects.

Rehabilitation will be performed in a phased approach, broken down into distinct projects. The sequence of these projects will be in accordance with the prioritization set forth in Section VIII. Descriptions, schedules, and costs for the rehabilitation projects are presented in Section IX.

C. FLOW EQUALIZATION BASINS

Three flow equalization basins are recommended. The basins will reduce the peak flows within the system, thereby recovering system hydraulic capacity. In addition, the basins regulate the timing of discharges in the system, thereby mitigating the adverse effects of simultaneous or near-simultaneous peaking. Flow equalization basins will be constructed at the following locations:

- <u>On the main sewer downstream of the US Department of Energy's Y-12 facility</u>: At times, under existing conditions, peak discharges from the Y-12 facility tend to overwhelm the downstream sewer. The proposed basin will be used to regulate the rate of discharge from the Y-12 facility as well as the upper part of the City's system.

- At the East Plant pump station: Under existing conditions, peak flows influent to the pump station require that both pumps discharge simultaneously. This is operationally undesirable, and overloads the downstream system as well. A flow equalization basin will allow regulation of the pump station influent rate, permitting single pump operation under design conditions and resulting in reduced downstream hydraulic loading rates.
- The East Plant pump station and Emory Valley pump station force mains: The existing configuration of the force mains for these two pump stations results in high discharge heads under peak flow conditions. In addition, the combined peak flow from the two stations, even with the planned East Plant equalization basin, is excessive and causes surcharging of the system downstream. The equalization basin will provide a more efficient force main configuration, and will also permit regulation of flows passed to the main trunk sewer downstream.

Descriptions, schedules, and costs for the flow equalization basin projects are presented in Section IX.

D. INCREASING PIPE SIZES

Rehabilitating selected manholes and sewer pipes and constructing flow equalization basins recovers a significant degree of pipe hydraulic capacity in the collection system. However, sections of the system would still have excessive surcharging and SSOs. The recommended remedial measures include increasing the size of portions of the East Plant pump station trunks, and selected collector sewers in the Turtle Park, Central City and East Plant sewersheds. Increasing the pipe sizes will be by replacement and pipe-bursting, as appropriate.

As with the rehabilitation program, upsizing of the selected pipes will be performed in a phased approach in accordance with the prioritization set forth in Section VIII. Upsizing will be included in the rehabilitation projects.

E. PROJECTED HYDRAULIC GRADE LINE

The SewerGEMS Sanitary model for the recommended alternative indicates no overflows for the 2-year, 24-hour design event or the 5-year, 24-hour freeboard event. Plots of the hydraulic grade line for the design event are provided in Figures VII-1 through VII-7. Figure II-1 shows reference manhole locations for the ends of each of these profiles.

Figure VII-1
HGL Profile #1
2-Yr, 24-Hr Design Event
Central City and Turtle Park Main Trunk: E25-H15-17 to W18G-D2-1

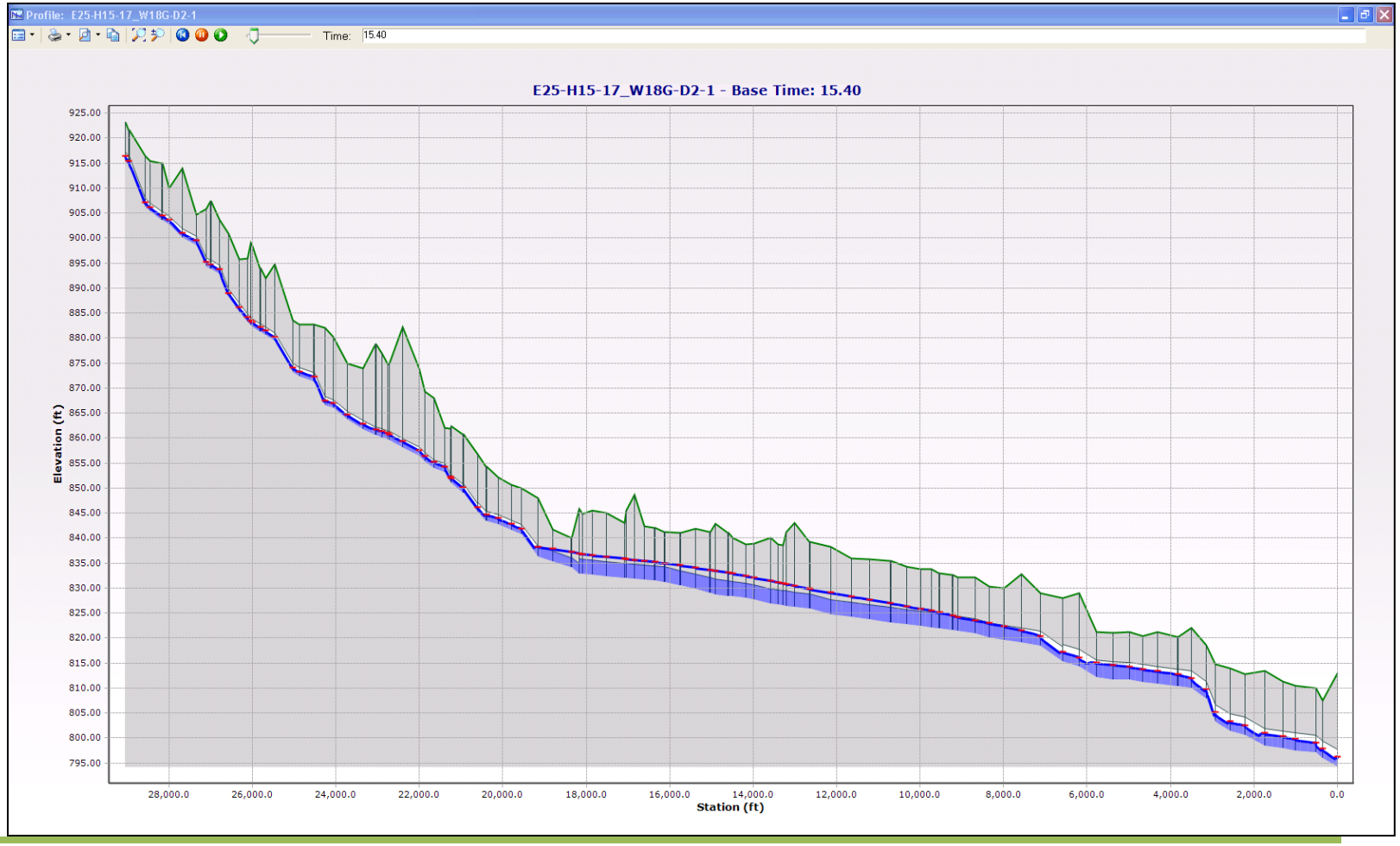


Figure VII-2
HGL Profile #2
2-Yr, 24-Hr Design Event
Y-12 Trunk: W18A-O14-17 to W5-F11-4

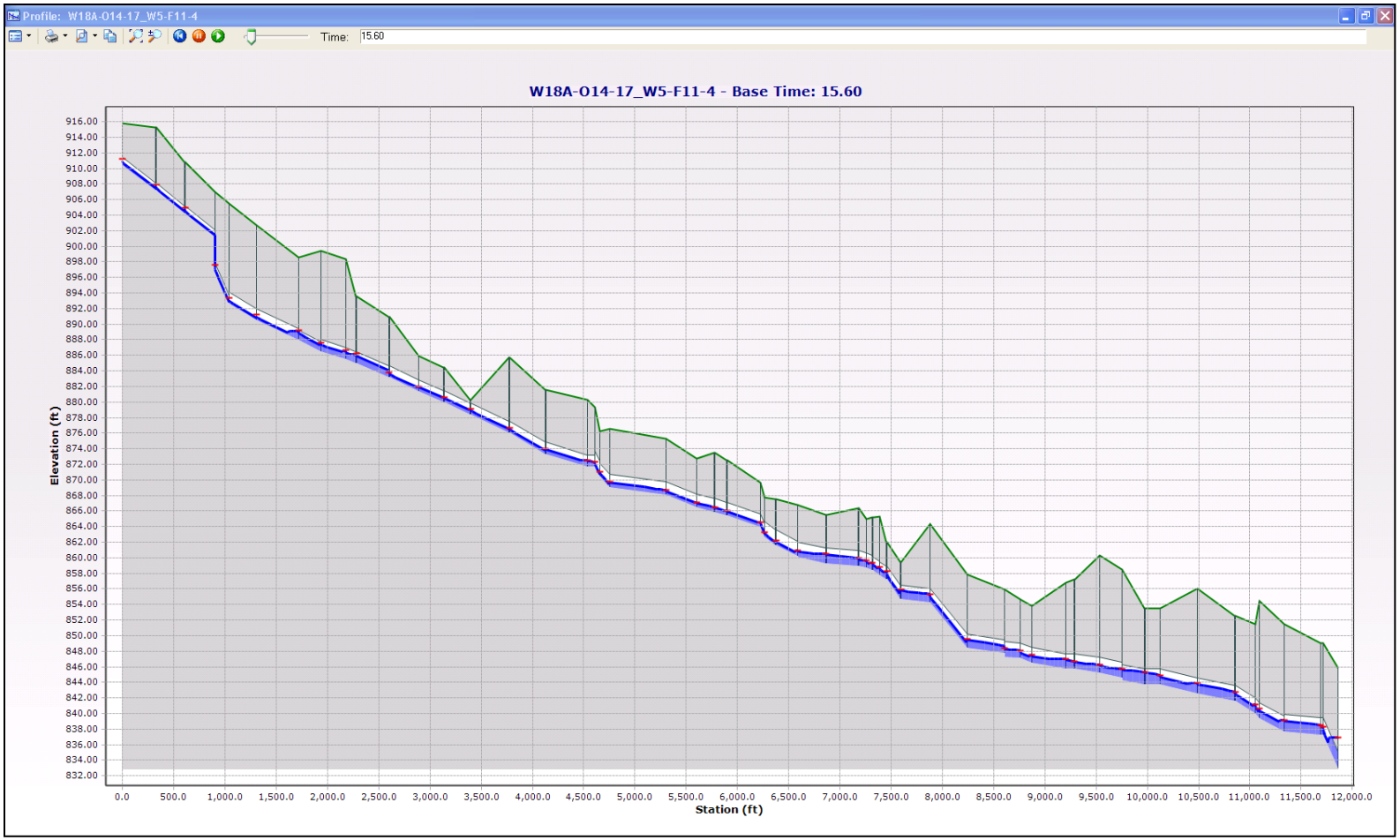


Figure VII-3
HGL Profile #3
2-Yr, 24-Hr Design Event
East Plant Trunk: E4-G17-3 to E13B-G22-14

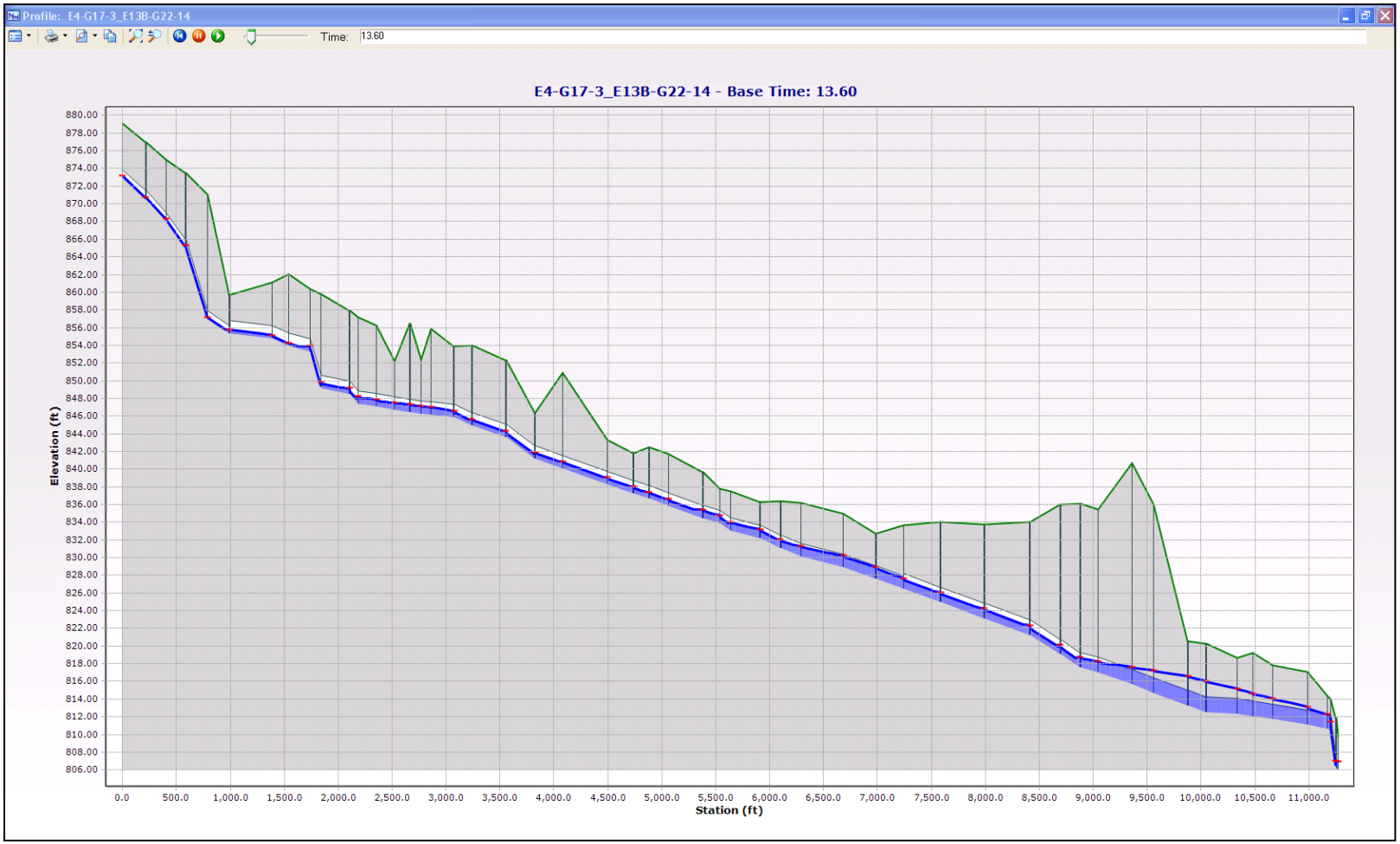


Figure VII-4
HGL Profile #4
2-Yr, 24-Hr Design Event
East Plant Trunk: E12-E23-4 to E13B-G22-14

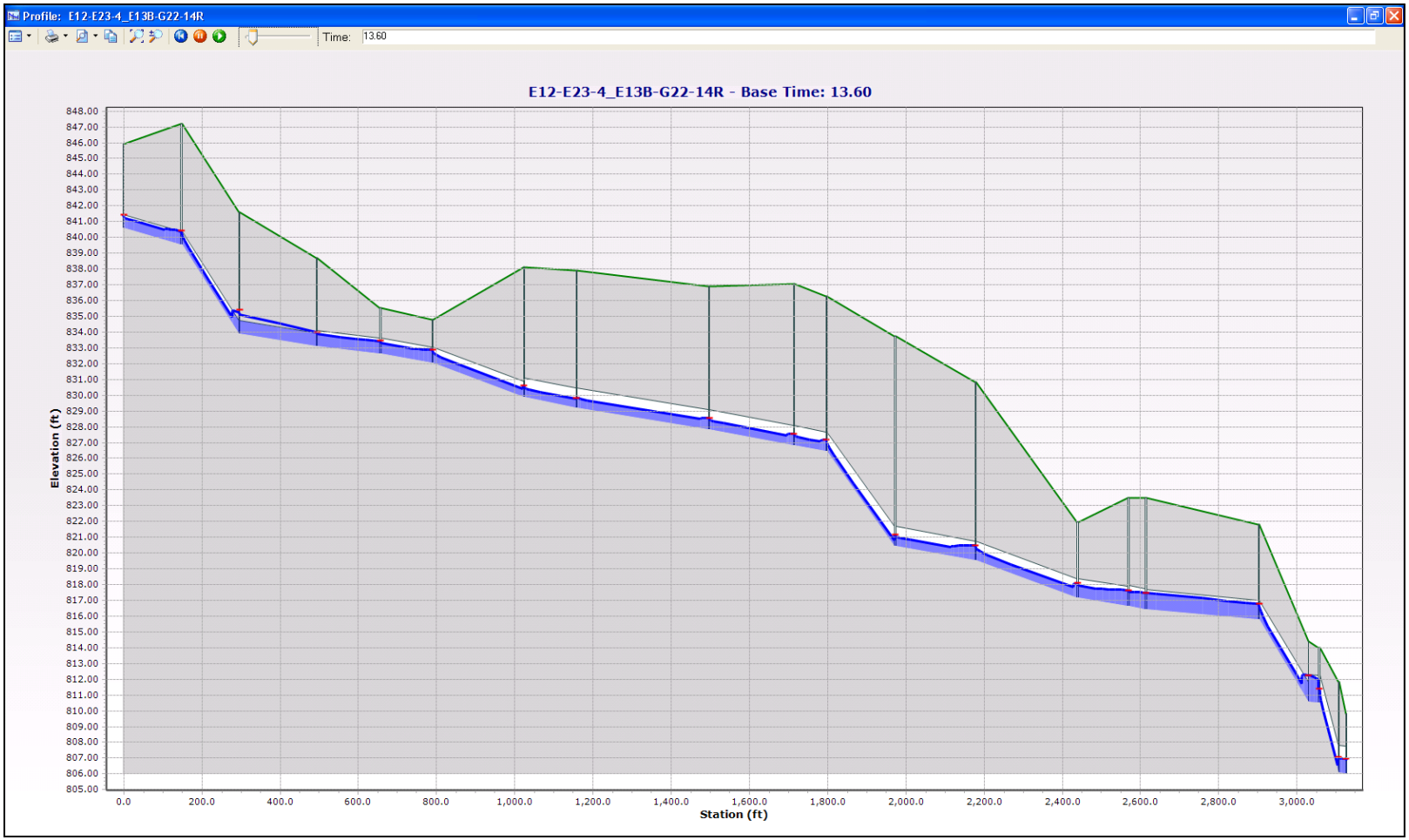


Figure VII-5
HGL Profile #5
2-Yr, 24-Hr Design Event
Emory Valley Trunk: E14-K17-2 to E5B-L22-20

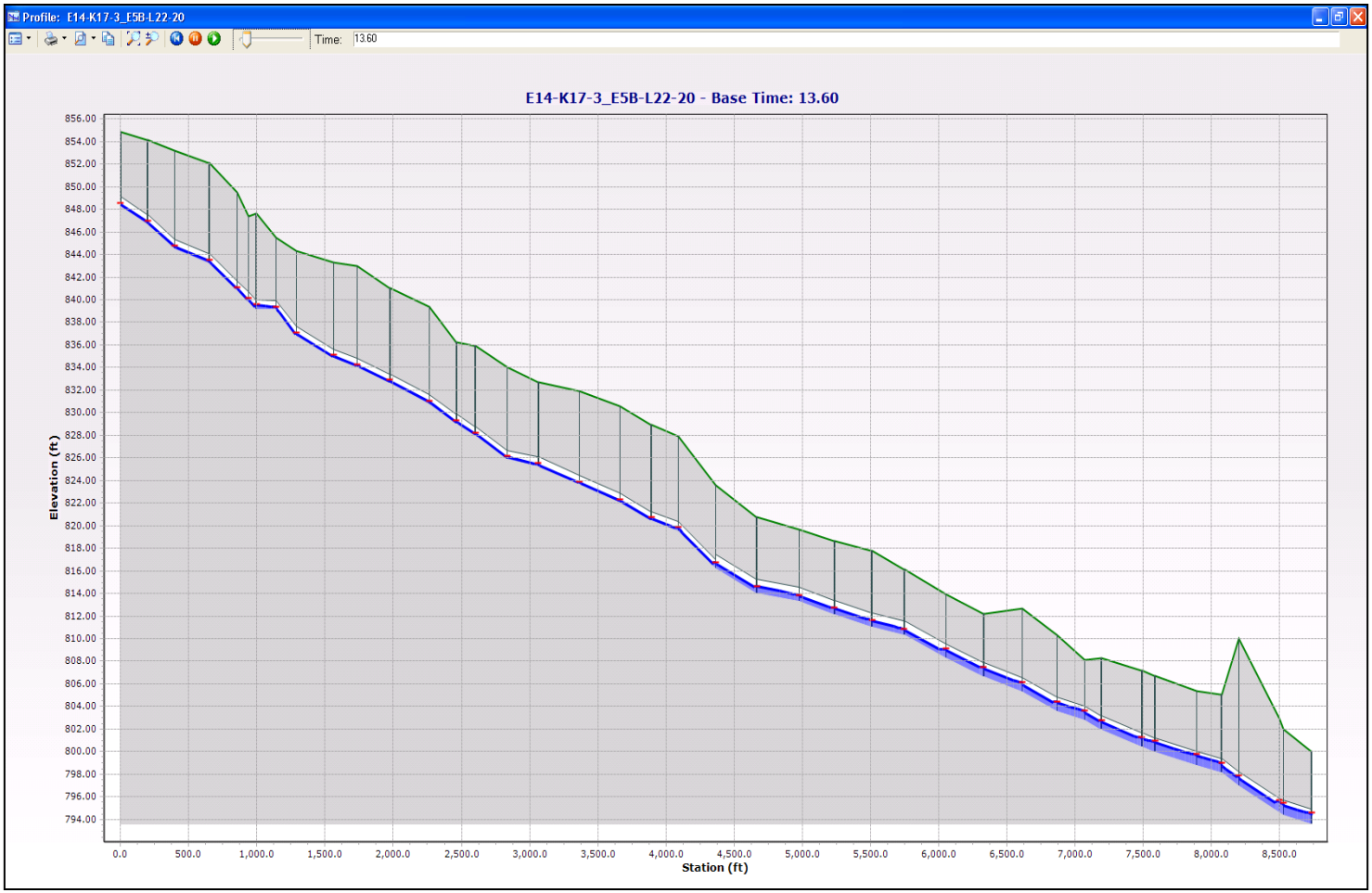


Figure VII-6
HGL Profile #6
2-Yr, 24-Hr Design Event
Emory Valley Trunk: E5A-J17-9 to E5B-L22-20

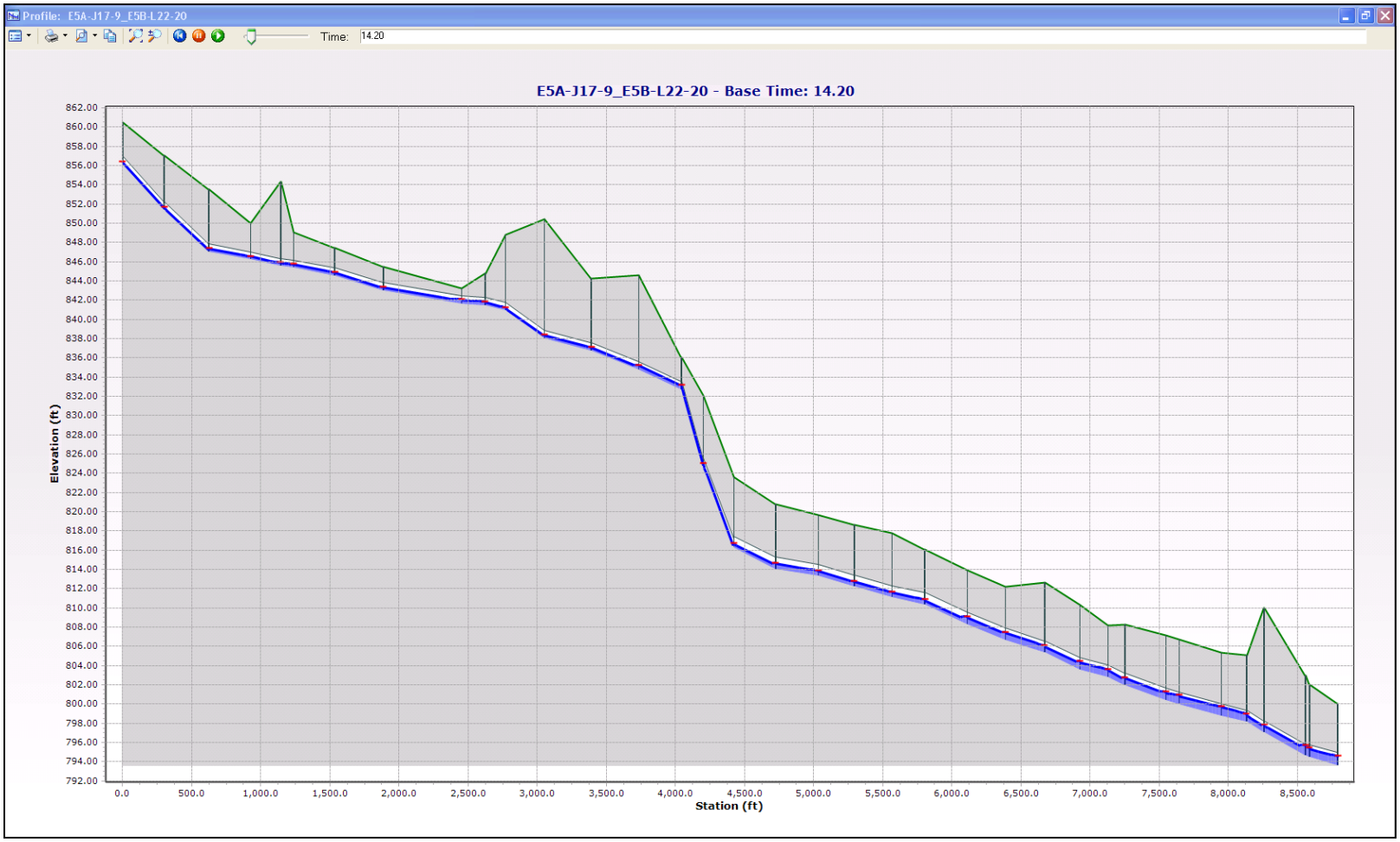
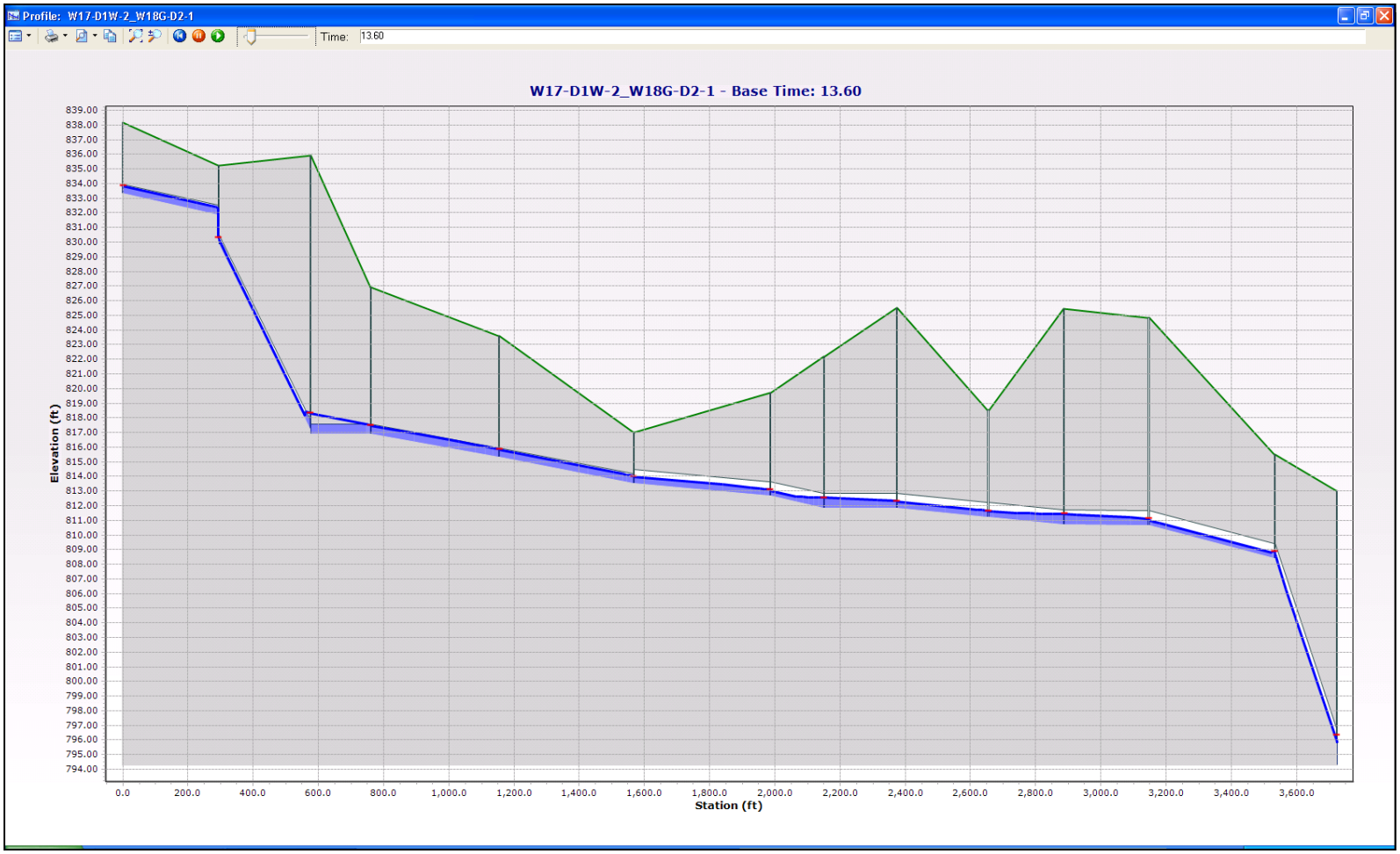


Figure VII-7
HGL Profile #7
2-Yr, 24-Hr Design Event
West End Trunk: W17-D1W-2 to W18G-D2-1



SECTION VIII

PRIORITIZATION OF REMEDIAL MEASURES

A. OVERVIEW

The remedial measures recommended for elimination of SSOs, as summarized in Section VII, represent a system-wide program of improvements. From a practical and financial perspective, the program must be implemented in phases. Therefore, a prioritization analysis was performed. The key factors used to set improvement priorities were:

- Health and environmental risks
- SSO frequencies and volumes

B. HEALTH AND ENVIRONMENTAL RISK

A primary consideration for prioritization based on human health and environmental risk should be the potential pathways for SSOs to enter the groundwater and surface water systems. The entire service area for the Oak Ridge collection system is essentially fully developed. In addition, the area is relatively steep and is underlain with karst geology. As a result, significant overflows in any portion of the sewer basin can possibly enter the groundwater or stormwater systems. Therefore, risk based on location within the service area alone is not explicitly defined.

C. SSO FREQUENCY AND VOLUMES

The Capacity Assessment provides adequate information for characterizing the historical and predicted frequency and volume of SSOs under existing collection system conditions. The SSES results provide data regarding the spatial distribution of defects within the system components that cause wet weather SSOs. This information was provided in the tables presented in Sections II and III. These sources of information were used to create an unadjusted ranking whereby each sewershed was assigned a score of 1 to 4 (with 4 being the most severe rating) for the metrics in the following list. These metrics emphasize overflow volumes and frequencies, and pipe defects as identified by the CCTV survey.

- Total CCTV defects
- Ten or more CCTV defects per 1,000 feet of pipe
- Total CCTV defects per foot of pipe

- % manholes needing major repair
- % pipes in "spine" model over capacity with 2-yr, 24-hr design event
- Number of wet-weather SSOs with 2-yr, 24-hr design event
- Volume of wet-weather SSOs with 2-yr, 24-hr design event
- Number of wet-weather SSOs during 2007 through 2011
- Number of wet-weather SSOs per foot of pipe during 2007 through 2011
- Volume of wet-weather SSOs per foot of pipe during 2007 through 2011

Table VIII-1 summarizes the application of this rating method for each sewershed.

TABLE VIII-1
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
UNADJUSTED RATINGS BASED ON
SSO FREQUENCIES/VOLUMES AND SYSTEM DEFECTS

Metric	Unadjusted Rating by Sewershed					
	Emory Valley	East Plant	Central City	Y-12	Turtle Park	West End
Total CCTV defects	2	4	2	1	3	1
Total CCTV defects/foot of pipe	3	4	3	2	4	1
% of manholes needing major repair	4	3	3	2	2	1
% of pipes in "spine" model over capacity with 2-yr, 24-hr design event	1	3	2	3	4	---
Number of SSOs in "spine" with design event	1	4	2	1	3	1
Volume of SSOs in "spine" with design event	1	2	4	1	3	1
Number of overflows during 2007-2011	1	4	3	2	2	1
SSOs/foot of pipe during 2007-2011	2	3	4	3	2	1
Volume of SSOs/foot of pipe during 2007-2011	3	3	4	2	2	1
Unadjusted Total Rating	**18**	**30**	**27**	**17**	**25**	**8**

The above unadjusted rating table indicates that the East Plant, Central City, and Turtle Park sewersheds will have the worst overall combination of SSOs and system defects. Y-12 has an intermediate unadjusted rating, and West End has the lowest unadjusted rating.

Rehabilitation in the Emory Valley sewershed has recently been completed under the “old program.” The program consisted of the rehabilitation of sewers and manholes. The lower unadjusted rating (compared to East Plant, Central City and Turtle Park) reflects some of the benefits from that work. However, since the ratings are based partially on overflows and defects identified before and during the rehabilitation program, the rating is still elevated. It is anticipated that its present-day rating is much lower. Post-construction monitoring is currently being conducted to test the effectiveness of the rehabilitation.

Rehabilitation of the sewer system in a specific sewershed does not necessarily address all of the overflow issues in that sewershed. This is particularly the case when a trunk sewer passes through a specific sewershed, but is fed by other upstream sewersheds. Rehabilitation of the upstream sewersheds may have a greater effect on eliminating overflows than rehabilitation of the specific sewershed itself. This issue was taken into account by further adjusting the ratings in Table VIII-1 by applying an adjustment factor ranging from 0 to 1. The adjustment factor was applied based on judgment and in accordance with the following scheme:

Factor = 1

Overflows in the sewershed are 100% dependent on the loads and conditions in the sewershed itself. Loads or conditions upstream or downstream of the sewershed have little or no effect on SSOs in the sewershed.

Factor = 0.01 to 0.99

Overflows in the sewershed are partially dependent on the loads and conditions in the sewershed itself, and partially dependent on flows entering the sewershed from upstream sewersheds or boundary effects from downstream sewersheds.

Factor = 0

Overflows in the sewershed are 100% dependent on flows entering the sewershed from upstream sewersheds, or boundary effects from downstream sewersheds. Loads or conditions within the sewershed have little or no effect on SSOs in the sewershed.

The adjusted ratings are summarized in Table VIII-2.

TABLE VIII-2
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
ADJUSTED RATINGS

Rating	Adjusted Rating by Sewershed					
	Emory Valley	East Plant	Central City	Y-12	Turtle Park	West End
Unadjusted Rating	18	30	27	17	25	8
Adjustment Factor	1.0	1.0	0.4	0.2	0.1	1.0
Adjusted Rating	**18.0**	**30.0**	**10.8**	**3.4**	**2.5**	**8.0**

D. PRIORITY

As indicated by the adjusted ratings in Table VIII-2, the East Plant and Emory Valley sewersheds have the highest rating and thus highest priority based on volume and frequencies of SSOs. The recently completed rehabilitation in Emory Valley places that sewershed as the first priority by default. It should be noted that Emory Valley having a lower rating than East Plant is largely due to the proactive work already done in that sewershed (which was ongoing during the referenced five-year SSO analysis period). The third priority is Central City. Although West End is indicated as fourth priority, the work to be done in that sewershed is minor. Turtle Park and Y-12 have similar priority. In summary the ratings indicate that the highest priority sewersheds are in the eastern part of the sewer basin.

The above priorities were reviewed against the health and environmental risk factors previously discussed. The reduction of hydraulic loads in the main trunk that runs through Central City by rehabilitating the East Plant and Central City systems is consistent with the health and environmental risk factors.

Based on this analysis, the recommended priorities for rehabilitating the sewer system are as listed in Table VIII-3. (West End was moved to Priority 6 since it involves minimal work.)

TABLE VIII-3
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
REHABILITATION PRIORITIES BY SEWERSHED

Priority	Sewershed
1	Emory Valley
2	East Plant
3	Central City
4	Y-12
5	Turtle Park
6	West End

SECTION IX

REMEDIATION PROJECTS

A. PROJECT DESCRIPTIONS

Remediation in the Emory Valley sewershed was accomplished under the "old program" as previously discussed. Remediation in the remaining sewersheds will be accomplished in the current program by completing 18 individual projects. Table IX-1 summarizes (not schedules) the projects by sewershed and facilities. Emory Valley is included in the table in order to reflect all recent, ongoing, and upcoming remediation work.

TABLE IX-1
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
PROJECT DESCRIPTIONS

Sewershed or Facilities	Description
Emory Valley Projects I – II ("old program")	These projects are completed. They consisted of rehabilitation of manholes and sewer pipes.
East Plant, Projects I - V	These ongoing projects consist of rehabilitation of manholes and sewer pipes, and installation of new pipes to address capacity and/or alignment issues.
East Plant, Projects VI – X	These projects will consist of rehabilitation of manholes and sewer pipes, and upsizing selected pipes.
Y-12, Projects I – II	These projects will consist of rehabilitation of manholes and sewer pipes.
Central City, Projects I – II	These projects will consist of rehabilitation of manholes and sewer pipes.
Turtle Park, Projects I – II	These projects will consist of rehabilitation of manholes and sewer pipes, and upsizing selected pipes.
West End, Project I	These projects will consist of rehabilitation of manholes and sewer pipes.
Flow Equalization Basins	This project will consist of constructing three flow equalization basins: a 1 MG facility on the Y-12 sewershed trunk, a 2 MG facility at the East Plant pump station, and a 2 MG facility at the discharge of the East Plant and Emory Valley force mains.

B. PROJECT SCHEDULES AND COSTS

A summary of the schedules and estimated costs for the remediation projects is provided in Table IX-2.

TABLE IX-2
CITY OF OAK RIDGE
WASTEWATER COLLECTION SYSTEM – REMEDIATION PLAN REPORT
PROJECT SCHEDULES AND COSTS

Round	Project	Design and Pre-Construction	Construction NTP through As-Built Close-Out	Cost
1	East Plant I	3/19/12 – 10/23/12	10/29/2012 – 7/14/13	$10,621,200
	East Plant II	3/19/12 – 10/23/12	10/29/2012 – 7/14/13	
	East Plant III	3/19/12 – 2/1/13	2/11/2013 – 11/1/13	
	East Plant IV	3/19/12 – 2/1/13	2/11/2013 – 1/1/14	
	East Plant V	3/19/12 – 2/1/13	2/11/2013 – 11/1/13	
2	East Plant VI	1/10/13 – 8/18/13	8/22/13 – 5/20/14	
	East Plant VII	2/10/13 – 9/18/13	9/22/13 – 6/20/14	
	East Plant VIII	3/10/13 – 10/18/13	10/22/13 – 7/20/14	
	East Plant IX	4/10/13 – 11/18/13	11/22/13 – 8/20/14	
	East Plant X	5/10/13 – 12/18/13	12/22/13 – 9/20/14	
3	Y-12 I	7/14/13 – 2/22/14	2/26/14 – 11/11/14	$744,700
	Y-12 II	7/14/13 – 2/22/14	2/26/14 – 11/11/14	
	Central City I	1/14/14 – 8/22/14	8/26/14 – 5/11/15	$2,165,900
	Central City II	1/14/14 – 8/22/14	8/26/14 – 5/11/15	
4	Turtle Park I	6/11/14 – 1/15/15	1/21/15 – 9/6/15	$2,699,400
	Turtle Park II	6/11/14 – 1/15/15	1/21/15 – 9/6/15	
	West End I	6/11/14 – 1/15/15	1/21/15 – 9/6/15	$744,700
---	Equalization Basins	9/10/12 – 12/12/13	1/2/14 – 8/18/15	$6,114,900
Total Program				$23,090,800

SECTION X

IMMEDIATE NEXT STEPS

The designs for the Round 1 projects (East Plant I through V) are complete. The next immediate steps in the program are:

- Proceed with State approval of the Round 1 projects, followed by procurement of construction contractor services.
- Proceed with authorization of the designs for the Round 2 projects (East Plant VI through X).
- Proceed with authorization for the design of the flow equalization basins.
- Continue pre- and post-construction rainfall and flow monitoring to measure the reductions in inflow and infiltration.
- Continue the MOM program activities related to addressing pump station upgrades and private laterals.

SECTION XI

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