City of Oak Ridge, Tennessee

Capacity Assessment Plan

March 2011

City of Oak Ridge, Tennessee

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SECTION I

INTRODUCTION

A. BACKGROUND

The City of Oak Ridge received an Administrative Order No. CWA-04-2010-4772 from the United States Environmental Protection Agency, Region 4 (EPA), effective September 30, 2010 (EPA, 2010c). The Order requires a number of actions on the part of the City relative to its wastewater treatment plant and associated wastewater collection and transmission system. Item 16.B of the Order requires that the City prepare a System Evaluation and Rehabilitation Plan (SERP) consisting of a Capacity Assessment Plan, a Sewer System Evaluation Survey, and a Collection System Remediation Plan. Item 16.B.i of the Order specifies the requirements for the Capacity Assessment Plan. In general, the requirements relate to analysis methodology (e.g., computer modeling), dry and wet weather loading, rainfall monitoring, flow monitoring, pump (lift) station capacity evaluations, design storm selection, and "worst-case" analysis of sewers affecting critical mini-systems. It is the intention of this Plan to address the requirements of the Order, with particular emphasis on the describing "in detail" … "the overall approach proposed and the specific analysis to be applied" to the assessment (Order, 16.B.i.a). In addition, background on the City's system and on past/ongoing system evaluation and rehabilitation activities is summarized in the Plan.

B. OVERVIEW

The City of Oak Ridge was originally founded in the early 1940's as a result of America's effort to build nuclear weapons. The entire initial infrastructure was constructed by the federal government to support the war effort. After World War II, all municipal functions became a part of the City of Oak Ridge, which at that point in time became incorporated as a city.

The City was served by two wastewater treatment plants built by the federal government. In the early 1980's, a new treatment facility was constructed by the City to replace the two WWII vintage facilities. During the late 1990's, the Wastewater Treatment Plant was expanded.

The Oak Ridge Sewage Collection System is comprised of elements that vary in age from approximately sixty (60) years old to less than one (1) year old. However, the collection system is undergoing major rehabilitation, which began in the mid 1990's.

The Oak Ridge Wastewater Collection System is comprised of the following major elements:

1. A major forty-two (42") inch concrete gravity interceptor extends eastward from the Turtle Park Lift Station to a thirty-six (36") inch concrete interceptor to a point near the intersection of the Oak Ridge Turnpike and South Illinois Avenue.
2. A twenty-seven (27") inch clay gravity interceptor line extends south along South Illinois Avenue serving industrial areas and the D.O.E., Y-12 Plant.
3. A twenty-four (24") inch interceptor extends eastward from the thirty-six (36") inch interceptor near the intersection of the Oak Ridge Turnpike and Illinois Avenue.
4. The eastern areas of the city are served by two (2) major lift stations. One (1) is located at the site of the abandoned east wastewater treatment plant and the other is in Emory Valley. The two (2) east lift stations pump into pressure lines (force mains), which discharge into a gravity sewer in the central city area. This interceptor then extends through the central city to the main interceptor at South Illinois Avenue.
5. The Wastewater Treatment Plant is located in the western portion of the City, and its capacity has been expanded to thirty (30) million gallons per day (MGD).

The Oak Ridge Wastewater Collection System is designed and managed to be a separate sanitary sewage collection system, not a combined sewer system which would also transport stormwater flows. The collection system consists of approximately:

- 1,255,000 linear feet of gravity sewer pipe,
- 6,850 manholes,
- three (3) major lift stations with their respective force mains,
- thirty-two (32) smaller lift stations and force main systems, and
- lateral sewers (privately owned).

SECTION II

PAST SSES ACTIVITIES

The City had a Sewer System Evaluation Survey (SSES) performed in the mid 1970's. In the same time frame, a new wastewater treatment plant was constructed.

In 1991, the Tennessee Department of Environment and Conservation (TDEC), Division of Water Pollution Control, expressed concern to the City of Oak Ridge relative to sewer overflow and by-passing of untreated wastewater to Poplar Creek. The City offered a schedule for correction, which TDEC considered acceptable. An agreement letter (May 16, 1991) for a Corrective Action Program was issued, which proposed a series of rehabilitation projects that would increase the wastewater treatment plant capacity to eliminate by-passing, and would decrease the amount of infiltration and inflow (I/I) into the collection system.

The contracted rehabilitation projects consisted of trenchless technology methods (slip lining, pipe bursting, cured in place pipe, and manhole rehabilitation), and gravity sewer line and manhole replacements. Sewer rehabilitation projects have been designated by letters. As a continuation of work in the Corrective Action Program, the design of Contract "O" is currently in progress. Contract "O" will address issues in the Emory Valley Sewershed, rehabilitate three (3) lift stations, and increase a gravity sewer line in the East Plant Sewershed. The following is a list of completed rehabilitation activities:

- New Sewer Lines ~ 16,085 Feet
- New Manholes ~ 222 EA
- Rehab Manholes ~ 1817 EA (14,773 V.F.)
- New Frame and Covers ~ 720 EA
- Slip Lining ~ 137,027 Feet
- Pipe Bursting ~ 54,422 Feet
- Cured-in-Place Pipe ~ 29,826 Feet
- Fold and Form Lining ~ 1400 Feet
- Point Repairs ~ 33 EA
- Closed Circuit TV ~79,945 Feet

The cost to date for these rehabilitation activities is approximately $10,600,000.00, which represents 22% of the 1.2 million feet of gravity sewer line in the City of Oak Ridge.

The City continues a point repair program that is independent of the contracted rehabilitation projects. The point repair program is used to repair leaks or line collapses that are considered emergencies or a possible threat to public health and safety. The point repairs program has rehabilitated a total of ~ 20,500 linear feet, with ~ 40 point repairs, ~60 rehabilitated manholes (~480 V.F.), and three (3) new manholes.

Eleven (11) of thirty-five (35) lift stations have been rehabilitated through contracted construction projects during the program. The rehabilitation activities have included installing new pumps, completely replacing the lift stations and appurtenances, installing new force mains, and replacing valves on existing force mains. The approximate construction cost for the lift station rehabilitation projects is $2,500,000.00.

During the Corrective Action Program, there was a major wet weather sanitary sewer overflow located in the forty-two (42") inch gravity sewer line upstream of the Turtle Park Lift Station. However, with the improvements that have been made with the sewer rehabilitation projects and treatment plant, this overflow has been eliminated.

City personnel are taking the task of rehabilitating the Emory Valley and East Plant Lift Station. The activities at Emory Valley Lift Station include two (2) new dry pit pumps, all new valves, soft start starters, emergency power by-pass switch, by-pass pump hook-up, two (2) new flow meters, and rebuild of the communitor at a cost of $200,000.00. Rehabilitation cost for the East Plant Station is approximately $65,000.00, which includes two (2) new pumps, soft start starters, new flow meter, and emergency by-pass pump hook-up.

As a continuation of investigative work in the collection system, the City has continued to inspect sewers by closed circuit television (CCTV) using in-house personnel and equipment, physically inspecting manholes, and performing smoke testing.

SECTION III

APPROACH TO MAPPING

A. BACKGROUND

The City converted their wastewater collection system record drawings from a manual format to AutoCAD in the mid 1990's. The original City drawings dated to the 1960's. The AutoCAD record drawings have been amended, as time permitted, to include new construction and rehabilitation activities.

When it became clear that an Administrative Order (Order) was to be issued with a Graphical Information System (GIS) component, the City and their consultant began to formulate the path to that end. A project website was developed, and the City's record drawings were posted as they were.

B. NEED FOR MAPPING

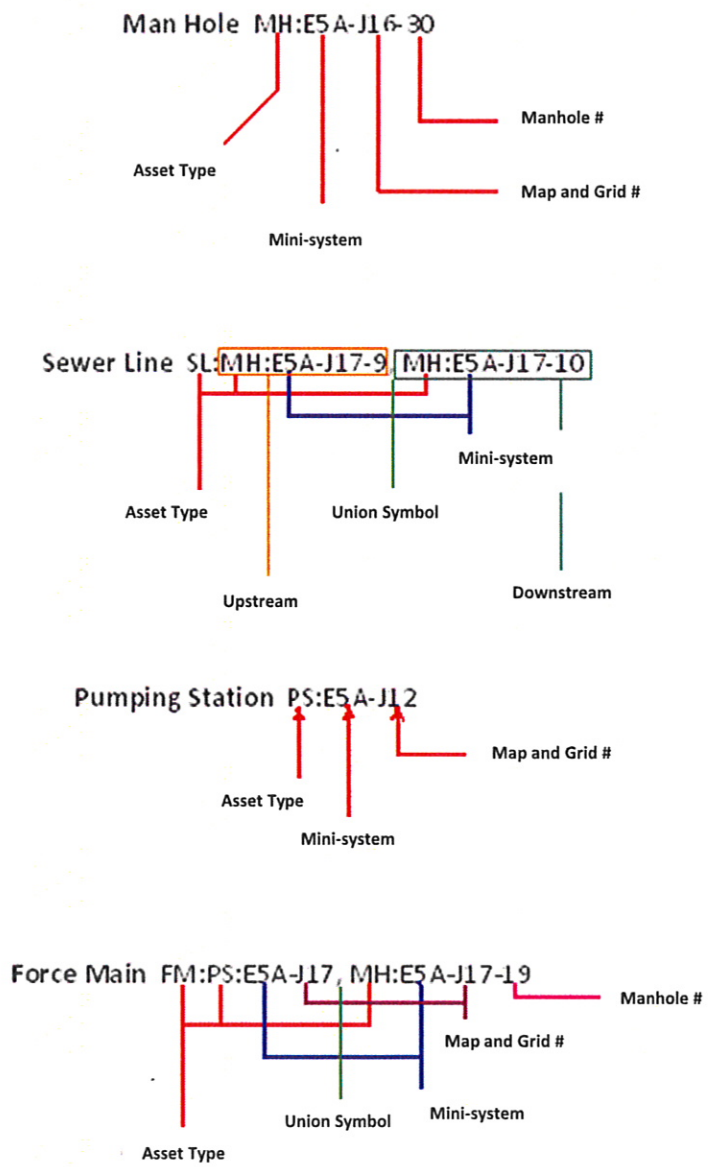
The Capacity Assessment of the collection system requires a hydraulic model. Without good mapping, a meaningful model would be impossible. Other requirements of the Order deal with evaluating the existing condition of the system, which requires certain investigative work. Mapping is required for those activities, as well.

C. PROJECTED ACTIVITIES

As the City approaches the various tasks for the Order, a GIS is essential. The first step was to approach the mapping from an asset management perspective. A naming convention was established to be used throughout all tasks of the Order. Historically, the City of Oak Ridge has used multiple naming conventions for the assets in the system. The existing assets were named several different ways. Some assets were named based on the existing grid system, and some were named based on the mini-system or sewershed where the asset was located. The first task of developing a system map was to rename the entire system into a relevant and contiguous naming convention. In order to keep the current naming systems relevant, the asset name will include references to the mini-system in which it is located, in addition to the grid within which it falls. Each asset has an abbreviated identifier as well. For example, a manhole that falls in mini-system E5A, and on grid map J16 will be consecutively numbered as shown:

MH:E5A-J16-1, MH:E5A-J16-2, MH:E5A-J16-3…etc. Figure III-1 references all of the naming conventions. Sewer lines are referenced by their upstream and downstream manholes.

Figure III-1



The GIS mapping system will integrate into the Information Management System (IMS), which is another component of the Order. The investigative work (smoke testing, manhole inspections, and CCTV inspections) will be used to confirm the accuracy of the mapping as transferred from the incomplete record drawings.

The manhole inspection portion of the investigation involves a field crew of three (3) individuals consisting of a crew leader, recorder, and technician. Each crew has maps of a different mini-system, and each map has manholes with each manhole having an identifier number. The information on each manhole collected includes: pictures with a white board with manhole number and location, depth, material, and condition of manhole; leaks in manhole; pipe size; material; and location of each; flow; top and invert elevation, if available at the time of the inspection; and rehabilitation recommendation. The data collected is entered into a database when each inspection occurs. The data is to be backed up daily on a flash drive by each field crew. The data and pictures are downloaded by a LD&A representative on a weekly basis. The information is downloaded into two separate drives, and all information is given to the GIS representative to be downloaded into the GIS system.

LD&A's representative is confirming the field data by looking at field maps and comparing the maps and pictures to the data that is collected: locations, manhole material, pipe material, sizes, clock positions of pipes, leaks, flows, and rehabilitation recommendations, and that the maps match the pictures and database information. The required modification to the mapping will be updated based on this information.

The smoke testing portion of the investigation includes a crew of four (4) individuals consisting of a crew leader, recorder, and two technicians. Crews have maps and equipment to locate and detect leakage in the system. Each leak is documented with photographs stating location of the individual leaks. All information collected on each leak is entered into the database in the field. Leaks are documented on a field map and a sketch number is given to match the database sketch number. The database and pictures are stored in the same manner as the manhole inspections. This database is checked for accuracy by matching the information to the map/sketches, and pictures. All information has to match up according to the other. As with manhole inspection, mapping is updated as required from this data.

The CCTV part of the investigation has video and database information collected. The data is then put into an Excel spreadsheet, and the information is given to the GIS specialist to be placed into the GIS map. Information received is being checked by comparing existing maps and checking pipe materials along with checking distances between manholes. This is a third review and update of the mapping.

All the data has to match an identifier or label for each asset, whether it is a manhole or sewer line. If data does not match exactly, it will not appear correctly on the GIS map. All errors will be corrected before information is shown. The old mapping system was incomplete. New manholes that are not shown on the maps will be named and incorporated into the mapping system. Every discrepancy will be checked and resolved for a complete and correctly working GIS product.

SECTION IV

MODELING APPROACH

A. OVERVIEW

The Capacity Assessment will *"include an engineering study to comprehensively evaluate the design hydraulic capacity and actual dry weather and wet weather flow conditions for the WCTS"* (Order, 16.B.i.a).

A key component of this study will be a computer model. The model will be used to simulate the operation of the system under observed conditions and under prescribed design conditions. The overall modeling approach will be generally as recommended in *"Computer Tools for Sanitary Sewer System Capacity Analysis and Planning"* (EPA, 2007).

The model will represent the physical characteristics of the system infrastructure, dry weather flow characteristics (wastewater flow and regional groundwater inflow/infiltration), response of the system to wet weather flows (modeled as rainfall dependent inflow/infiltration, or RDII), and local meteorological conditions.

The model will be calibrated and verified based on observed rainfall and flow data.

Once the model is calibrated and verified, it will be used as a tool to determine the design capacity of the existing system. (The model will also be used to evaluate alternatives during the development of the Collection System Remediation Plan.)

In summary, the overall approach for model development is as follows:

- Define physical characteristics of sewer system and service area
- Collect and analyze rainfall and flow data
- Determine dry weather flow characteristics
- Determine wet weather flow characteristics
- Hydraulically load model under observed conditions
- Calibrate and verify model
- Hydraulically load model with design loads
- Use model to assess design capacity of sewer system

The general schedule for the Capacity Assessment Plan is provided in the Appendix.

B. PRIMARY TOOLS AND DATA SOURCES

The computer model of the sewer system will be developed using SewerGEMS Sanitary® (SGS) software. This is a proprietary computer model developed by Bentley Systems, Incorporated. It is basically a GIS-compatible version of SewerCAD®. The program was specifically developed to analyze sanitary sewer systems, and is widely used within the sanitary engineering profession. The program includes a graphical interface, associated databases, and computation engines. The layout of the sewer system network is input using the graphical interface, and the physical attributes of each of the sewer system elements (e.g., pipes, manholes, pumps, etc.) are assigned. The program can analyze both open channel gravity flow, as well as pressure flow (surcharged conditions and force mains). Hydraulic calculations are conducted using standard hydraulic methods. The system may be analyzed in either steady state or extended period simulation modes. For extended period simulations, flows are routed through the system using the convex method. The sewer system model may be hydraulically loaded (dry weather and wet weather) by a variety of methods.

The Sanitary Sewer Overflow Analysis and Planning (SSOAP) software will be used to supplement the SGS model. SSOAP (EPA, 2010a) is a tool developed by EPA for managing and analyzing rainfall and flow data for capacity assessments. The software will be used primarily to determine dry weather and wet weather flow characteristics, and to develop RDII hydrographs for input to SGS.

The physical characteristics of the sewer system will be based on field surveys and inspections of the manholes, gravity sewers, force mains, and lift stations that comprise the system. As indicated elsewhere in the Plan, this information will be incorporated into a comprehensive GIS database for the sewer system.

Flow data will be extracted from records of flow measurements collected at strategic locations within the system using flow monitors. For model calibration, primary monitoring locations were chosen that will best characterize dry weather and wet weather flow patterns. In addition, other flow data collected within the system, including temporary monitors, will be used for supplemental and historical analysis.

Rainfall data will be extracted from records of continuous rainfall measurements collected at several locations within the sewer basin. Three principal rain gauges used for model calibration will be deployed in the basin, strategically located to record data in the northeastern, central and southwestern areas of the basin. Records from other existing gauges installed and operated by various organizations will be used for historical data and to supplement the new principal gauges.

Basic wastewater design loading will be developed from observed dry weather flow data and metered water use data.

C. MODEL EXTENT AND NETWORK

The major axis of the Oak Ridge sanitary sewer system is oriented approximately southwest - northeast, conforming to the ridge-and-valley topography of the Oak Ridge area. The system extends from Melton Hill Lake southwestward approximately eleven (11) miles. Along its minor axis, the system extends approximately five (5) miles (at its widest point) southeast of Black Oak Ridge. See Figure 1 (Appendix). As shown on Figure 2 (Appendix), the sewer system is divided into two divisions, the East Division and the West Division. The East Division and West Division contain 45 and 43 mini-systems, respectively. The northern part of the East Division flows by gravity and force mains to the East Plant Lift Station. The southern part of the East Division flows by gravity and force mains to the Emory Valley Lift Station. The East Plant and Emory Valley stations pump to a force main that discharges to the main gravity interceptor. The West Division flows by gravity and force mains to the main interceptor, which flows to the Turtle Park Lift Station. The Turtle Park station discharges to the Oak Ridge Wastewater Treatment Plant, which discharges by NPDES permit to Poplar Creek. Please refer to Section I of the Plan for more information about the sewer system.

The SGS model will include:

- Main interceptors
- Force mains
- Gravity lines 10-inches in diameter and larger
- Smaller gravity lines (i.e., six (6") and eight (8") inches) when required for model connectivity, or to model a sewershed or sub-sewershed without ten (10") inch or larger lines
- Lift stations

The model will extend to the outflow of the Turtle Park Lift Station force main at the Oak Ridge Wastewater Treatment Plant. For model management convenience, the overall model may be separated into a number of linked submodels.

The network model will consist primarily of gravity pipes, force mains, air relief valves, manholes, and lift stations. The assignment of attributes will be completed during the Capacity Assessment as data is collected.

- Pipes: The primary attributes include length, diameter, upstream and downstream invert elevations, and pipe material. Manning roughness coefficients ("n") for gravity lines, and Hazen-Williams roughness coefficients ("C") for force mains, will be assigned based on the pipe material and condition in accordance with industry standards.

- Manholes: The primary attributes include top (rim) elevation, type of cover (locked or unlocked), ground elevation, invert elevation, manhole diameter, and method of computing headloss through the manhole. In general, the standard method (exit pipe velocity head coefficient) of computing manholes losses will be used, in addition to losses caused by changes in pipe flow direction.

- Lift Stations: Because of their potential for significant influence on the system hydraulics, the Emory Valley, East Plant, and Turtle Park lift stations will be modeled using their rated capacity-head curves, and wetwell storage characteristics. Other lift stations will be assumed capable of conveying inflow up to their rated capacity.

D. RAINFALL AND FLOW DATA MANAGEMENT AND ANALYSIS

SSOAP will be used as follows:

- Rainfall Data Analysis: SSOAP will be used to manage and analyze the rainfall gauge data.

- Flow Data Analysis: SSOAP will be used to manage and analyze the flow data recorded at each monitoring location.

- QA/QC: The databases and utilities in SSOAP will be used to review the rainfall and flow data for QA/QC purposes.

- Calibration/Verification Events: The databases and utilities in SSOAP will be used to review the rainfall and flow data to select the calibration and verification rainfall events.

E. DRY WEATHER FLOW ANALYSIS

Dry weather flow consists of wastewater flow plus regional groundwater inflow/infiltration. The two components may be separated on the basis that the regional groundwater portion is usually relatively constant (varying only seasonally) while the wastewater portion varies hour-to-hour, usually with a daily pattern.

For each flow monitoring location, SSOAP will be used to analyze the flow data for periods with no significant wet weather influences. From this analysis, typical daily flow patterns for the monitored system will be determined for weekdays and weekend days. Also, typical regional groundwater inflow/infiltration rates will be estimated for each monitoring location. In addition, from the monitoring record an estimate of high groundwater flows will be made for use in a "worst case" conditions analysis for critical mini-systems.

F. SELECTION OF MODEL FLOW POINTS AND RDII AREA DETERMINATIONS

SSOAP will be used as an aid in selecting the wet weather calibration and verification events, and in preparing the rainfall input files for the SGS model. An inter-event period of six (6) hours and a minimum event depth of 0.1 inches will be used to define (separate) individual rainfall events for purposes of this analysis.

The events will be selected based on several criteria, including relative uniformity of rainfall over the sewer basin, total depth of rainfall, duration of the event, and corresponding suitable flow data.

Uniformity will be judged by comparing total depths, intensities and durations for the various rain gauges in the basin. Events with large differences between the gauges will not be considered.

The depths of the selected events should be sufficient to produce RDII flow responses at all of the monitoring sites where RDII flows are expected. A minimum depth of one (1") to two (2") inches would be ideal; however, a minimum depth of 0.5-inch will be considered in lieu of a suitable larger event.

The duration of the selected event should not be less than the time for RDII flows to travel from the upper part of the basin to the model outfall node. Therefore, given the approximate hydraulic length of the sewer system, a minimum duration of approximately eight (8) hours is preferred. A duration of approximately twenty-four (24) hours would be ideal to account for delayed RDII response.

The flow data for the period corresponding to the selected rainfall event will be examined to ensure that the data is sufficiently complete and consistent.

G. WET WEATHER FLOW RDII ANALYSIS

Using the rainfall and wet weather flow data for the calibration and verification events, and the results of the dry weather flow analysis, SSOAP will be used to separate the wet weather flow and dry weather flow components of the wet weather flow hydrographs. This decomposition analysis will permit determination of the RDII component of the hydrographs as well as the total volume of RDII.

Prior to the RDII unit hydrograph derivations, the sub-sewershed for each monitoring location must be determined. A sub-sewershed is defined here as the portion of the service area upstream of the monitoring location that contributes wet weather flow to the system. The sub-sewersheds will be delineated using the GIS model of the sewer basin, and will typically consist of several mini-systems. The sewer collection system network, landuse, and topography will be used to estimate the sub-sewershed boundaries. Care will be taken to not significantly over or under estimate the sub-sewershed areas to avoid inconsistencies in the subsequent RDII analysis.

Once the RDII hydrographs and sub-sewershed areas have been determined for a monitoring location, SSOAP will be used to estimate the RDII volume, time-to-peak, and recession characteristics. The triangular unit hydrograph method will be used wherein three separate unit hydrographs are employed to represent the short term, intermediate term, and long term flow response to storm events. The RDII characteristics for each unit hydrograph (R, T and K) will be estimated using the graphical tools within SSOAP. R represents the ratio of RDII volume to rainfall volume. T is the time of peak of the unit hydrograph. K is the unit hydrograph recession time expressed as a multiplier of T. Trial R, T and K values will be used until the observed RDII hydrograph and the computed RDII hydrograph are within reasonable agreement, while conserving the magnitude of total R (i.e., the sum of R for all three unit hydrographs) for the event. Initial selection of abstraction (interception and depression storage) parameters will be based on guidance contained in the SWMM (EPA, 2010b) reference manual.

H. SELECTION OF MODEL FLOW POINTS AND RDII AREA DETERMINATIONS

As previously stated, the flow monitoring sites are proposed at locations that will best characterize flow conditions for the major sub-sewersheds. For modeling purposes, additional flow points will be assigned in Order to properly load and evaluate the system. Flow points will be located at selected manholes. For each flow point, the portion of the sub-sewershed that contributes wet weather flow to the flow point (RDII area) will be delineated in GIS, and the corresponding service area will be used in the RDII hydrograph generation task. The service area for each flow point will also be characterized in Order that unit wastewater loads (see discussion on dry weather loading) may be applied.

I. GENERATION OF RDII HYDROGRAPHS AT FLOW POINTS

SSOAP will be used to generate RDII hydrographs for the selected calibration and verification rainfall events. The software will be used to create RDII area database files for each sub-sewershed, consisting of the area (in acres) and the family of original R-T-K values determined for the sub-sewershed. The R-T-K values for each RDII area will be adjusted if required (a) to account for segments with RDII known to be uncharacteristic of the sub-sewershed, and (b) to keep the model in calibration at the flow monitoring point downstream.

Note that the components of the R-T-K method vary seasonally. In the Oak Ridge area, the most critical rainfall events from the standpoint of depth and duration typically occur during winter and spring. However, the effects of transpiration, surface evaporation, variations in unit runoff and corresponding infiltration, and other seasonal factors prohibit making reliable seasonal adjustments of the parameters. Therefore, winter and spring rainfall events, and summer events of sufficient depth and duration, will be emphasized in this study for determination of the RDII design parameters.

J. DRY WEATHER LOADING AND LOADING CRITERIA

Dry weather flow will be loaded into the SGS model at each flow point using the unit load and daily load pattern option for wastewater flows, and the constant base load option for regional groundwater I/I. The daily wastewater load (i.e., the average flow value by which the pattern will be scaled) will be estimated at each flow point by applying the unit daily load criteria for the area served at that flow point. The unit load criteria will be based on water-use records. The computed average flow will then be scaled in SGS by the daily load patterns determined in the previously discussed dry weather flow analysis. For calibration and verification purposes, the unit load assumptions may require adjustment; however, for design conditions, the prescribed criteria will be used unless justified otherwise. The net result will be time-varying dry weather flow at each flow point, with the average daily flow conforming to water-use in the area served, and the variation of the flow during the day conforming to typical observed diurnal patterns.

K. WET WEATHER LOADING

For the calibration and verification process, the RDII hydrograph computed for each flow point (as previously discussed) will be applied directly to the flow point using the hydrograph option of SGS. For design conditions, the design storm (instead of the calibration and verification events) will be used in SSOAP to compute an RDII hydrograph for each flow point. The hydrograph will then be loaded into SGS using the hydrograph option.

L. MODEL CALIBRATION AND VERIFICATION

First, one or more dry weather records will be selected to verify that dry weather flows are represented accurately in the SGS model. The SGS model will be executed under dry weather conditions and the resulting daily hydrographs will be compared to the observed data. If necessary, the model will be adjusted to reproduce the observed data satisfactorily.

The SGS model will then be calibrated and verified using the selected rainfall/flow calibration events.

The calibration event rainfall file will be loaded into SGS and the model will be executed. The observed flow and the computed flow hydrographs will be directly compared. If required, certain parameters will be manually adjusted (within a reasonable range) to obtain an acceptable fit between the observed and computed hydrographs. Some potential calibration parameters include:

- unit wastewater loading
- routing coefficients (by varying percent peak flow used in the coefficient calculations)
- R-T-K parameters
- RDII areas
- pipe roughness (n and C values)

Following model calibration, the verification event SSOAP RDII hydrographs file will be input to SGS and the model will be executed. If the verification does not result in a satisfactory fit between the observed and computed hydrographs, the calibration and verification process will be repeated.

M. CAPACITY ASSESSMENT

Once the SGS model has been calibrated and verified, it will be used to assess the capacity of the sewer system based on the adopted design rainfall event. In general, the assessment will be prepared based on guidance provided in Section 6.3 of "Computer Tools for Sanitary Sewer System Capacity Analysis and Planning" (EPA, 2007). The following scenarios will be analyzed:

- Existing sewer system and existing dry weather flows
- Existing sewer system, and existing dry weather and wet weather flows

The capacity of selected pipes, manholes, and lift stations will be reported as follows:

- Pipes:
  - <u>flow capacity</u>, maximum flow capacity used, minimum flow capacity remaining
  - <u>depth capacity</u>, maximum depth capacity used, minimum depth capacity remaining
  - <u>surcharging</u> occurrences, including duration

- Manholes: <u>depth</u> of manhole (top to invert), maximum depth experienced, minimum freeboard remaining, manhole overflow occurrences and duration

- Lift Stations: <u>ratio</u> of model peak flow into lift station wetwell to lift station capacity

Selected pipes, manholes and lift stations will consist of:

- gravity pipe segments on the main gravity interceptor, and other main gravity pipes
- gravity pipe segments where the model indicates less than 25% remaining flow or depth capacity under existing conditions (which would include surcharged gravity pipe segments)
- manholes on the critical gravity pipe segments described above

- receiving manholes at ends of force mains
- manholes with water depths greater than 50% of manhole depth (which would included manhole overflows)
- lift stations will include the three major stations (East Plant, Emory Valley and Turtle Park), plus lift stations within the model network portion of the sewer basin

N. CRITICAL MINI-SYSTEM ANALYSIS

The calibrated model will be used to evaluate "worst-case" conditions for the sewers affecting the critical mini-systems. The same models as defined in the Capacity Assessment will be used, with one modification: The regional groundwater base loading will be adjusted upward to reflect observed maximum levels. Please refer to Section X regarding identification of critical mini-systems.

SECTION V

RAINFALL DATA COLLECTION

A. OVERVIEW

In some areas of the sewer system, rainfall dependent inflow/infiltration (RDII) is a significant portion of the total sewer flow. Therefore, the Capacity Assessment must address the effects of rainfall on the system. In the sections of the Plan discussing the modeling approach and the design rainfall event (Section IV and Section IX), the manner in which the rainfall data will be used analytically was reviewed. In this section of the Plan, the collection of the rainfall data is discussed.

Rainfall data is required for two principal uses:

- Data is required to calibrate and verify the computer model of the sewer system. For model calibration, the data must be collected during the same time frame that the calibration and verification flow data is collected for the area included in the sub-model. For modeling purposes, a relatively short reporting data time interval is required (e.g., 15 minutes).
- Data is required for the correlation of reported occurrences of sewer overflows within the system and the rainfall events that contributed to or led to those overflows. This requires that historical rainfall data be obtained. Hourly data, supplemented by daily data, is satisfactory for this purpose.

B. EXISTING RAINFALL GAUGES AND HISTORICAL RAINFALL RECORDS

Due to the United States Department of Energy (DOE) facilities and federal research activities in and near Oak Ridge, a number of rainfall gauges have been deployed in the area. A search of NOAA web sites and other sources identified the following available rainfall data.

- Ongoing rainfall data, and limited historical rainfall data, collected at multiple gauges at Oak Ridge National Laboratories (ORNL), are available. However, these gauges are located off Bethel Valley Road, several miles south of the extreme southwestern part of the sewer basin, and are separated from the sewer basin by Chestnut Ridge, Pine Ridge, and East Fork Ridge. Ongoing rainfall data collected at the East Tennessee Technology Park (ETTP) is also available. However, ETTP is located several miles southwest of the southwestern boundary of the sewer basin. Therefore, due to spatial concerns and other considerations, the utility of this data for model calibration and overflow/rainfall analysis is limited. There are also several other gauge records available that have limited use for similar reasons.

- There are three (3) gauge records available that will be useful in the Capacity Assessment. A gauge off Laboratory Road at Roane State College has hourly data available from 2002 to the present. This gauge is in the east-central area of the sewer basin. Hourly data from 1999 to the present and 1999 to 2006 are also available from gauges at Y-12 West and Y-12-East, respectively. Y-12 is a DOE facility located in the south-central area of the sewer basin.

C. NEW RAINFALL GAUGES

For systems with significant short-term (inflow) and intermediate term (first infiltration) RDII response, a relatively short time step is required for modeling. A 10- or 15-minute time step is a reasonable increment. While short interval depths may be interpolated from long interval (i.e., 1-hour) data, the inflow and first infiltration components of the RDII response may be excessively masked. Therefore, short interval rainfall data is desired. Since rainfall depths and intensities can vary significantly over a basin of this size, multiple gauges are required to obtain adequate areal coverage of the sewer basin.

As previously discussed, the sewer basin is approximately eleven (11) miles long and five (5) miles wide (at its maximum width). All but four (4) of the 88 mini-systems lie in the valley between Black Oak Ridge and Pine Ridge in the central and northeast part of the basin, and between Black Oak Ridge and East Fork Ridge in the southwestern part of the basin. Therefore, three new primary rain gauges will be deployed. The locations are shown on Figure 1 (Appendix).

- Rain Gauge #1: This gauge will be installed at the City of Oak Ridge Waste Water Treatment Plant. This is a secure area located in the southwestern third of the basin.
- Rain Gauge #2: This gauge will be installed at the City of Oak Ridge Public Works Department complex. This is a secure area located in the central third of the sewer basin.
- Rain Gauge #3: This gauge will be installed at the City of Oak Ridge East Plant Lift Station. This is a secure area located in the northeastern third of the sewer basin.

The principal rain gauges will be Hach units. Specifications for the Hach rain gauges and accessories are as follows:

- Hach Data Logging Rain Gauge, Product Number 2459
- Tipping bucket type with 8-inch diameter collector/funnel with SS screen
- 0.01-inch resolution
- 5% accuracy at 0.5-inches per hour
- epoxy coated aluminum and anodized aluminum material
- base mounting plate with three (3) point spring-loaded leveling adjustment
- solid state memory pack with battery backing
- capacity of 10,080 reporting readings (e.g., 70 days at 10 minutes)
- replaceable 9 VDC alkaline battery (approximately 6 months life)
- data download to PC via RS232 interface
- software for data download and management

D. CALIBRATION AND MAINTENANCE

Field calibration of the gauges will not be required since the gauges are pre-calibrated at the factory. The rain gauges will be prepared, installed, operated and maintained in strict accordance with the user manual. The 19-page manual provides detailed instructions for the gauge. Each gauge will be located in a clear area away from trees and buildings which would block the natural fall of rain. The base plate will be mounted on a firm, flat surface and leveled. Maintenance will consist of routine inspection, cleaning, and replacement of the battery.

E. RAINFALL DATA QA/QC

As previously discussed in Section IV, the downloaded rainfall data will be imported to and managed with the SSOAP software. The quality and completeness of the data will be evaluated as follows:

- The downloaded data will be analyzed in SSOAP to identify individual rainfall events (based on six (6) hour inter-event periods and 0.1-inch minimum event depth).
- The events will be compared to events determined for the other two (2) primary gauges to identify any gross inconsistencies in event dates/times, durations and depths. If gross inconsistencies are indicated, further review of the data will be conducted.

- The data from an individual gauge will be analyzed and plotted graphically in SSOAP, and reviewed to identify any anomalous readings (missing data points, spikes, or other inconsistencies). If inconsistencies are indicated, further review of the data will be conducted.
- When inconsistencies are suspected in the data collected at one of the primary gauges, data from the other primary gauges and records available from other sources will be used to evaluate and possibly rectify the data. For example, patterns from the other primary gauges may be used along with hourly or daily data at other gauges to reconstitute part or all of a problematic record. However, record reconstitution will be limited to minor inconsistencies. The default policy will be to exclude the rainfall event or events from QA/QC approval.

SECTION VI

FLOW MONITORING

A. OVERVIEW

As discussed in Section IV, sewer flow data will be collected at selected locations in Order to calibrate the sewer system computer model. There will be three (3) categories of flow monitors:

- Permanent flow meters are located at the waste water treatment plant and at two of the lift stations.
- Semi-permanent flow meters will be located at strategic points in the main sewer system.
- Temporary flow meters will be located at strategic points in the sewersheds. These meters will be rotated among the sewersheds.

It is proposed that a six (6) monitoring period be initially planned, and adjusted if necessary to obtain sufficient flow data. Historical data will also be reviewed.

B. SELECTION OF MONITORING SITES

The permanent monitoring locations are listed below. These are pre-existing and were not specifically selected for the purposes of this study. However, the flow records from these locations will be used to supplement the monitors deployed specifically for this assessment.

- Emory Valley Lift Station effluent
- East Plant Lift Station effluent
- Oak Ridge Wastewater Treatment Plant influent and effluent

The semi-permanent monitoring locations are proposed at points on the main gravity interceptor, and on the influent to three major lift stations. It is intended that these meters remain in place throughout the duration of the monitoring program. These six locations were selected to provide continuous flow data for primary conveyances in the system. Specific locations will be selected that will minimize the extent to which the meters will be affected by adverse conduit hydraulics.

- Emory Valley Lift Station influent gravity line
- East Plant Lift Station influent gravity line

- Main Interceptor gravity line downstream of force main discharge, on Laboratory Road east of the intersection with Lafayette Drive
- Main Interceptor gravity line downstream of inflow from mini-system W18A, located near the intersection of Oak Ridge Turnpike and Illinois Avenue
- Main interceptor gravity line downstream of inflow from mini-system W13, located off Oak Ridge Turnpike, near intersection with Louisiana Avenue
- Main interceptor gravity line influent to Turtle Park Lift Station

The temporary monitoring locations will be finalized during the assessment. Up to five monitoring stations will be rotated in groups for each of the six sewersheds (see Figure 2, Appendix):

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

A temporary monitoring station will be located at the primary outlets of each sewershed. In addition, monitoring stations will be located at key points within the sewershed to define flow records for sub-sewersheds. These records will be critical for calibrating the model.

Preliminary locations for the primary outlet monitoring stations, and selected sub-sewershed monitors for the sewersheds, are discussed below:

- <u>Turtle Park</u>: Turtle Park Lift Station influent from mini-system W18H, and at locations in the sewershed discharging to the main interceptor between the lift station and the intersection of Oak Ridge Turnpike and Illinois Avenue
- <u>West End</u>: Downstream of six (6") inch diameter force main off Oak Ridge Turnpike near intersection with Nebraska Avenue
- <u>Central City</u>: Inflow to the main interceptor from mini-system W9 and inflow to the main interceptor from mini-system W5, and at points located in the commercial/business area between the intersection of Oak Ridge Turnpike and Illinois Avenue and the intersection of Lafayette Drive and Laboratory Road; a sub-sewershed monitor will be placed at the effluent from the junction of mini-systems W6, W7 and W8

- Y-12: As discussed above, a semi-permanent monitor will be assigned to record inflow to the main interceptor from mini-system W18A, located near the intersection of Oak Ridge Turnpike and Illinois Avenue
- East Plant: Likewise, the influent to the East Plant station will have a semi-permanent monitor; sub-sewershed monitors will be located downstream of the effluent from mini-system E13B and downstream of the effluent from mini-systems E3 and E4
- Emory Valley: In this case also, the influent to the Emory Valley station will have a semi-permanent flow monitor; sub-sewershed monitors will be placed at the effluent from mini-systems E5A and E5B

In addition, temporary monitors will be deployed at key locations upstream of problem overflow areas.

C. OAK RIDGE WET AND DRY SEASONS

Historically, precipitation in Oak Ridge has been heaviest in November through July. During this period, mean monthly precipitation varies from 4.32 inches (April) to 5.72 inches (March). The driest months are August through October, with mean monthly depths ranging from 3.02 inches (October) to 3.75 inches (September). Mean annual precipitation is 55.05 inches. (NWS, 2010.) Table VI-1 provides the mean monthly point precipitation for Oak Ridge.

Table VI-1
Mean Monthly and Annual Precipitation, Oak Ridge, TN (NWS, 2010)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
5.13"	4.50"	5.72"	4.32"	5.14"	4.64"	5.16"	3.39"	3.75"	3.02"	4.86"	5.42"	55.05"

D. DRY SEASON MONITORING

In Order to characterize dry weather flows, the monitoring program will include (a) periods of seasonally low flows and/or (b) dry periods distinctly separated in time from wet weather events. Situation (a) will be applicable to all permanent monitoring records since those monitors have been in place for an extended period of time and will be left in place indefinitely. If normal climatic conditions exist during the monitoring program, situation (a) would likely be applicable to the semi-permanent monitoring records as well since the monitoring period will span at least portions of the dry season. However, it is not expected that all of the temporary monitors will be deployed at all temporary monitoring sites during dry seasons due to the rotation of these gauges. Therefore, situation (b) may be typical of some of the temporary flow monitoring records. However, with appropriate antecedent conditions, it is anticipated that such data would be suitable for model calibration purposes.

E. WET SEASON MONITORING

In order to characterize wet weather flows, the monitoring program must include periods of high flow. Similar to the dry weather monitoring conditions discussed above, the permanent monitoring records and possibly the semi-permanent monitoring records would include wet season records. However, it is not expected that all of the temporary monitors will be deployed at all temporary monitoring sites during wet seasons due to the rotation of these gauges. Therefore, some of the temporary wet weather flow monitoring records may include wet weather events during dry seasons. However, with appropriate antecedent conditions, it is anticipated that such data would be suitable for model calibration purposes.

F. EQUIPMENT

Two types of monitors will be used for this study:

- Marsh-McBirney Flo-Tote Model 260 (six units presently available)
- Hach Flo-Tote Model 3 Sensor, Mounting Band and Logger (five units presently available)

The Marsh-McBirney and Hach meter installations are similar. (The Hach meter assembly is basically a more recent version of the Marsh-McBirney meter.) They consist of a debris-shedding transducer sensor, positioned on or near the bottom of the conduit, and held in place by a mounting band. The signal from the sensor is relayed to the primary module by cable. The primary module is usually hung from a ladder rung or other anchor point in the manhole. The primary module has a low voltage operating battery and a backup battery. A storage device in the primary module stores the depth and velocity readings from the sensor. This data is downloaded using a laptop PC via an RS232 communications cable interface. Flo-Ware software installed on the laptop is used to download, analyze and manage the data. Flow is computed as flow area (based on pipe geometry and depth) times average flow velocity. The data may be displayed in tables or graphically, or prepared as file data for export and use in other applications. The units are accompanied by detailed manuals that describe the appropriate setup, calibration, use and maintenance of the equipment.

G. CALIBRATION

Each unit will be field calibrated, and a record of the calibration process will be maintained. The manuals accompanying the Marsh-McBirney and Hach units provide detailed site calibration instructions. The procedure consists of making independent velocity and depth measurements, and computing flow, then comparing those with the values reported by the units. A calibration worksheet is provided with the Marsh-McBirney units and a software "wizard" is provided for use with the Hach units.

H. MAINTENANCE

The units will be maintained in strict accordance with the manufacturers' manuals. Maintenance will be performed following major storm events, when data is downloaded, or monthly, whichever occurs first. Maintenance checks will be documented on forms and photographically. Maintenance will generally consist of:

- checking the physical stability and security of the installation
- clearing the sensor, band, and cables of any debris
- cleaning the sensor
- checking/replacing desiccant and filters
- checking/replacing the operating and backup batteries
- real-time operating status checks

I. FLOW DATA QA/QC

Flow records retrieved from the flow monitors will be imported to SSOAP for QA/QC review of selected flow periods.

- High flow periods and low flow periods will be compared with rainfall data to ensure that the flow regimes are consistent with the rainfall regimes, and are not the result of blockages or other factors.
- Graphical displays of flow versus time (hydrographs) will be reviewed to identify spikes, missing data, or other anomalies that would require additional review.
- Scatter diagrams of depth versus velocity will be reviewed to ensure that the data is consistent (Sands and Stevens, 1995) and to identify surcharge events.
- Dry weather flow diurnal patterns will be reviewed to identify any anomalous patterns.

SECTION VII

LIFT STATION EVALUATION

The City of Oak Ridge presently owns and operates thirty-two (32) lift stations within their wastewater collection system. Two (2) additional lift stations have been constructed by developers but have not been accepted by the City at this time. During the Capacity Assessment, each lift station will be evaluated in an effort to determine the condition of the mechanical, electrical, and site components to determine what improvements are needed to bring the station up to standards, and to prioritize the required improvements. The evaluation data will also be inserted into the City's data base to provide readily accessible information about each station. This lift station data will be used in other parts of the Order. The evaluation will include the following parameters:

1. General Information
   - Station name
   - Location: Physical address and other information such as location relative to lots, houses, etc.
   - Latitude and longitude
2. Mechanical Information
   - Station type: Submersible, suction lift, wetwell/ dry-well
   - Number of pumps, pump manufacturer, and serial numbers
   - Wetwell diameter, total depth, available storage, and invert elevation
3. Force Main
   - Size and material of construction
   - Length
   - Discharge elevation
4. Site Information
   - Fencing (yes/no)
   - Evidence of apparent overflow (yes/no)

5. Electrical Information

    - Power source and service (pole mounted or pad mount transformers, underground or overhead to station)
    - Transformer(s): Type (pad or pole mount), size, identification number(s)
    - Power feed: Voltage and number of phases
    - Main disconnect type (circuit breaker or fused) and size
    - Motor Control: Location (panel, MCC, etc.), controller type (across-the-line, soft start, VFD)
    - Motor Information: Horsepower and speed, brand, and serial number (if different than pumps)
    - Auxiliary Power: Type (diesel, gasoline, LP, none), generator brand, kW

6. Instrumentation

    - Level Control: Bubbler, floats, pressure, probe, etc. and manufacturer
    - Redundant Level Control: Availability (yes/no), number, type, and manufacturer
    - Flow Meter: Availability (yes/no), type (pressure differential, mag meter, ultrasonic, etc.)
    - Elapsed time meters (yes/no)
    - Telemetry: Type (Ethernet, telephone, radio, etc.), and manufacturer
    - Alarm type (horn, light, horn and light, telemetry, etc.)
    - Control Sequence: Lead on/off, lag on/off, high level alarm, low level alarm, etc.
    - Pressure gauge availability (yes/no)

7. Listing of other station equipment such as yard hydrant, air scrubber, communitor, influent screen, yard lighting, etc.

8. Other pertinent information concerning the station not covered in one of the above categories such as valve vault information, by-pass pump connection availability, access road description, issues that need to be addressed, potential safety issues, site specific issues, pump drawdown test results, etc.

9. Digital photographs will be taken of the lift station site, mechanical and electrical equipment, interior of the wetwell, and pumps.

10. Utilizing the serial numbers of the pumps, pump curves will be obtained from City of Oak Ridge records or from factory representatives.

11. A final determination of the overall station mechanical and electrical conditions will be made. The condition will be characterized as excellent, good, fair, poor, or replace.

SECTION VIII

DOWNSTREAM IMPACTS

The model and other system information collected in the assessment will be used to investigate the consequences of several "extreme-case" scenarios. Examples include:

A. CONSTRUCTED BY-PASS ELIMINATION

The model can be used to test a hypothetical situation in which all constructed by-pass (CBP) are eliminated. The results would indicate the theoretical increase in load on the wastewater treatment plant if all CBP were eliminated, but I/I remained the same.

B. I/I ELIMINATION

The model can be used to test a hypothetical situation in which various degrees of I/I are being eliminated. The results would indicate the theoretical decrease in load on the wastewater treatment plant, and the overall performance of the system, if I/I is reduced.

C. LIFT STATION CAPACITIES

The model can be used to test a hypothetical situation in which all lift stations (including major stations) have the capacity to pass wet weather inflow.

D. LIFT STATION SIMULTANEOUS PEAKING

The model can be used to assess interceptor performance if peak discharges from the Emory Valley and East Plant lift stations occur simultaneously.

SECTION IX

DESIGN RAINFALL EVENT

A. OVERVIEW

The SGS computer model of the sewer system will be used to assess the capacity of the various system components under design conditions. The critical design condition will be wet weather loading. Wet weather loading consists of three primary components: wastewater flow, inflow/infiltration from regional groundwater, and rainfall dependent inflow/infiltration (RDII). As previously discussed, wastewater flow and regional groundwater inflow/infiltration (in combination, dry weather flow) will be loaded into the model based on unit loads, load patterns, and base loads. The RDII component will be loaded into the model as hydrographs. The RDII hydrographs will be computed using SSOAP, based on the calibrated R-T-K parameters and RDII areas for the various flow points, and the design rainfall event. The selection of a design rainfall event is discussed in this section of the Plan.

B. SELECTION OF DESIGN RAINFALL EVENT

Unless determined otherwise by the rainfall and overflow analysis (discussed below), the design rainfall event will be the two (2) year, twenty-four (24) hour storm. The two (2) year, twenty-four (24) hour event will be synthesized using the balanced "frequency storm" method (USACE, 2010). This method generates a storm that retains all established depth-duration relationships for any span of time within the event. A similar method was used to develop the well-known original generalized Natural Resources Conservation Service twenty-four (24) hour rainfall patterns (NRCS, 1986). The method proposed here will tailor this approach to Oak Ridge and will be based on more recent rainfall analyses than used in the development of the NRCS distributions. The depths and durations used for the development of the pattern will be extracted from NOAA Atlas 14, Volume 2 (NOAA, 2004). For convenience, the pattern will be developed using the US Army Corps of Engineers computer program, HEC-HMS (USACE, 2010) and extracted for importing into SSOAP.

The two (2) year, twenty-four (24) hour storm theoretically represents a relatively frequent event. However, as synthesized, the depth (in excess of three (3") inches) and the worst-case within-storm intensities represent a reasonable test for the system capacity. Most long events of equal or greater depth are of lower intensity, and shorter events of equal or greater intensity are usually of lower total depth. Therefore, the worst-case rainfall time distribution reflected by the synthesized design storm has a probability of occurring of less than 50% (i.e., the annual probability of a two (2) year average return interval).

C. OAK RIDGE LONG-TERM DEPTH-DURATION-FREQUENCY RAINFALL DATA

The NOAA Atlas 14 Volume 2 web site reports the following point rainfall depth-duration-frequency data (partial duration series) for Oak Ridge, as shown in Table IX-1 and Table IX-2:

Table IX-1
Oak Ridge Depth-Duration Data for 2-Year Event *(NOAA Atlas 14, Volume 2)*

Average Tr	5 min	10 min	15 min	30 min	1 hr	2 hr	3 hr	6 hr	12 hr	24 hr
2 -year	0.40"	0.63"	0.80"	1.10"	1.38"	1.62"	1.75"	2.17"	2.71"	3.32"

Table IX-2
Other Oak Ridge Depth-Duration-Frequency Data *(NOAA Atlas 14, Volume 2)*

Average Tr	15 min	1 hr	6 hr	12 hr	24 hr	2 days	7 days
1-year	0.67"	1.14"	1.82"	2.28"	2.78"	3.40"	4.75"
2-year	0.80"	1.38"	2.17"	2.71"	3.32"	4.06"	5.67"
5-year	0.95"	1.72"	2.64"	3.29"	4.06"	4.95"	6.81"

D. REVIEW OF OVERFLOWS AND RAINFALL DATA

Local rainfall data and sewer overflow records for the last 5 years will be reviewed. A combined chart of overflows versus daily rainfall will be prepared. Hourly data for selected representative events associated with overflows will be analyzed with SSOAP. The objectives of this review will be to:

- Identify any overflow versus rainfall correlations, trends or overflow thresholds that may provide additional insight into the selection of the design storm.
- Determine if an observed recorded rainfall event approximates the synthetic design storm depth, duration and intensity sufficiently that it may be used as the general pattern for the design storm. Observed storms are usually preferable due to the ability to compare actual observed field flow conditions to modeled alternatives.

E. OAK RIDGE RAINFALL DATA FOR LAST FIVE YEARS

As discussed in the rainfall data collection section of the Plan (Section V), there are two existing rainfall gauges in the sewer basin with records spanning the past 5 years; the gauge off Laboratory Road and the gauge in the western part of Y-12. These records provide hourly and daily data and should be representative of the east-central and south-central areas of the sewer basin. Since many of the problematic overflows occur in the eastern part of the basin, these records will be the primary records used in the review of historical data. In Order to address the western part of the sewer basin, hourly and daily data from a gauge at the East Tennessee Technology Park (ETTP) will be used to supplement the other data. The ETTP data is available from 2001 to the present. However the gauge is located several miles southwest of the southwest boundary of the sewer basin and caution will be used when making inferences using the data.

F. SANITARY SEWER OVERFLOWS (SSOS) FOR LAST FIVE YEARS

Detailed records of overflows are available, including all overflows for the last five years. Overflows are documented on standard forms with information such as address or location of overflow, type of occurrence (e.g., at a manhole or at a house back-up), the dates and times when the overflow started and ended, an estimate of the overflow volume, the cause of the overflow, remedial measures, and overflow destination (e.g., to a creek or to a storm drain). This data is routinely summarized in tabulation-style reports that provide the address or location, and the dates and times when the overflow started and ended. These summary reports will be used to chart overflows versus rainfall.

SECTION X

CRITICAL MINI-SYSTEMS

"Critical Mini-systems" are defined as those mini-systems that:

- have experienced sanitary sewer overflows within the past five (5) years
- have, or have had within the past five (5) years, a constructed overflow built
- are upstream of areas experiencing sanitary sewer overflows or having constructed overflows

Overflow reports for the period September 2005 through December 2010 have been reviewed. Table X-1 summarizes manholes, and the associated mini-systems, that have constructed overflows. Table X-2 summarizes all other manholes and locations that have experienced overflows during the review period.

Table X-1
Constructed Overflows

Manhole*	Mini-System Where Located	Address	Contributing Mini-Systems (Whole or Part)
D9-43	W11	143 Iroquois Road	W11
D14-37	W6	120 Porter Road	W6
D1007	E11	119 Athens Road	E11
F701	E9, E13A	100 Dresden Road	E1, E2, E3, E4, E6, E7, E9, E27
F702	E13A	Belgrade Road	E1, E2, E3, E4, E6, E7, E9, E27
F703	E13A	Coalyard Road	E1, E2, E3, E4, E6, E7, E9, E27
F903	E13A	535 Oak Ridge Turnpike	E1, E2, E3, E4, E6, E7, E9, E10, E27
G15-13	W5A, E25	117 North Purdue Avenue	W5A, E25
J11-14	W18A	216 South Illinois Avenue	W4, W18A
L24-1	E20	697 Melton Lake Drive	E20, E21
MB-03	W6	Providence Road	W6
N55-7	W13	165 Louisiana Avenue	W13

* *"Old" manhole numbering system, which was used in overflow report entries*

Manholes experiencing sanitary sewer overflows within the past five (5) years are tabulated below in Table X-2.

Table X-2
Manholes Experiencing Overflows

Mini System	Manhole*	Address
E12	E23-C1005A	130 Athens Road
E12	C23-26	319 East Drive
E12	G22-14	Old East Plant
E12	MH	119 Athens Road
E12	C1005	138 Athens Road
E13B	Pump Station	East Plant Pump Station
E13B	B22-14	East Plant Pump Station
E13B	Pump Station	East Plant Pump Station
E13B	Pump Station	East Plant Pump Station
E13B	G19-F702	535 Oak Ridge Turnpike
E13B	E22-13	151 Cairo Lane
E13B	G22-13	151 Cairo Lane
E13B	G22-14	151 Cairo Lane
E13B	F22	Cairo Lane
E13B	Pump Station	East Plant Pump Station
E13B	Pump Station	East Sewer Pump Station
E13B	G22-18	E Sewer Plant
E14A	J18-1	100 Elmhurst Drive
E19	G22-14	151 Cairo Lane
E19	M22-5	105 Belle Creek Drive
E29A	P26-2	18 Radisson Cove
E30	G24-8	100 Melton Lake Peninsula
E35A	K20-8	107 Columbia Drive
E35A	F17-D414	23 E Tennessee Avenue
E5B	BO 10" FM	Emory Valley/Columbia
E5B	K22-9	136 Balboa Circle
E8	H20-6-C-1	19 Converse Lane
E8	MH 6-C-1	19 Converse Lane
E8	G20-3	Coe Road Lift Station
W12	D9-25	137 Jarrett Lane

Table VIII-2 Manholes Experiencing Overflows (continued)		
Mini System	**Manhole***	**Address**
W12	C8-8	365 Jefferson Avenue
W12	C8-L54-12	365 Jefferson Avenue
W12	D4-15	242 Jefferson Avenue
W12	L54-9	341 Livingston Avenue
W12	MH	247 Jefferson Avenue
W12	C8-42	113 Jarrett Lane
W12	MH	253 Jefferson Avenue
W12	D9-6	215 Jefferson Avenue
W14	E6-N56-5	123 Seneca Road South
W14	C-06	124 Seneca Road North
W14	D06-N56-5	121 Seneca Road South
W14	C6	110 Station Lane
W15	D5-8	103 Briar Road
W16	C3-25	103 Mohawk Road
W16	B-3-9	144 Montana Avenue
W16	MH	E Melbourne/Robertsville
W16	MH	111 Woodridge
W16	A3-3	106 Woodridge Lane
W16	M-59-20	110 Bradley Avenue
W17	AN3W	1129 Outer Drive
W17	C1-W-10	123 Normandy Road
W17	B2-W-3	1037 West Outer Drive
W17	B01	147 Nebraska Avenue
W17	B1W-6	113 Newridge Road
W18B	F10-AO-16	Villanova Road
W18B	E9-A9-5	298 Roberstsville Road
W18B	W-18B	1650 Oak Ridge Turnpike
W18D	E10-AP-5	Iroquois Road
W18D	E10-2-82	Iroquois Road
W18G	E2-5	200 Hermitage Blvd
W18G	D2-3	Monterey Road
W18G	D5-40	127 Sanford Lane
W19	H11-3	189 Tusculum Drive

Table VIII-2 Manholes Experiencing Overflows (continued)		
Mini System	**Manhole***	**Address**
W19	H113A	191 Tusculum Drive
W2	H2W-5	211 Gum Hollow Road
W2	H2W-5	211 Gum Hollow Road
W2	MH	102,104,108 Paris Lane
W20	H-4W	111 Graceland Road
W20	MH	215 Gum Hollow
W26	S14-A	Scarboro Road
W29	AW5-3	106 Willian Lane
W29	A4W-9	112 Whippoorwill Drive
W3	K13	107 Morris Lane
W3	K13-41B	235 Manhattan Avenue
W3	S49-4A	235 Manhattan Avenue
W3	R48-33B	168 Manhattan Avenue/Woodland School
W3	B3-12	Manhattan Avenue(Hollow)
W5	G15-D-40	117 N Perdue Avenue
W5	G15-D-40	117 N Perdue Avenue
W5	G15-D-40	117 N Perdue Avenue
W5	G11-8	1403 Oak Ridge Turnpike
W5	G11-8	1403 Oak Ridge Turnpike
W5	G15-13	117 Perdue Avenue
W5	E14-D109	116 Newkirk Lane East
W5	G11-8	1403 Oak Ridge Turnpike
W5	B11-8	A K Bissell Park
W5	G13-12	1284 Main Street
W5	G11-8	1403 Oak Ridge Turnpike
W5	G15-13	117 N Perdue Avenue
W5	E15-OJV-1	101 Newcomb Road West
W5	G11-8	A K Bissell Park
W5	G15-13	131 Marquette
W5	DA-31	102 E Pasadena Road
W8	C13-18	360 Outer Drive West
W8	MH-T1	142 Hillside
W8	T-73	256 Highland Avenue

Table VIII-2
Manholes Experiencing Overflows
(continued)

Mini System	Manhole*	Address
W8	31-3	22/220 Hillside Road
W8	MH D11-7	105 N Hickory Lane
WWTP	E2	200 Monterey Road
WWTP	MH D-1W-15	2760 Oak Ridge Turnpike

** "Old" manhole numbering system, which was used in overflow report entries*

Overflows defining the Critical Mini-Systems are primarily due to excessive inflow and infiltration from heavy rainfall events.

SECTION XI

REFERENCES

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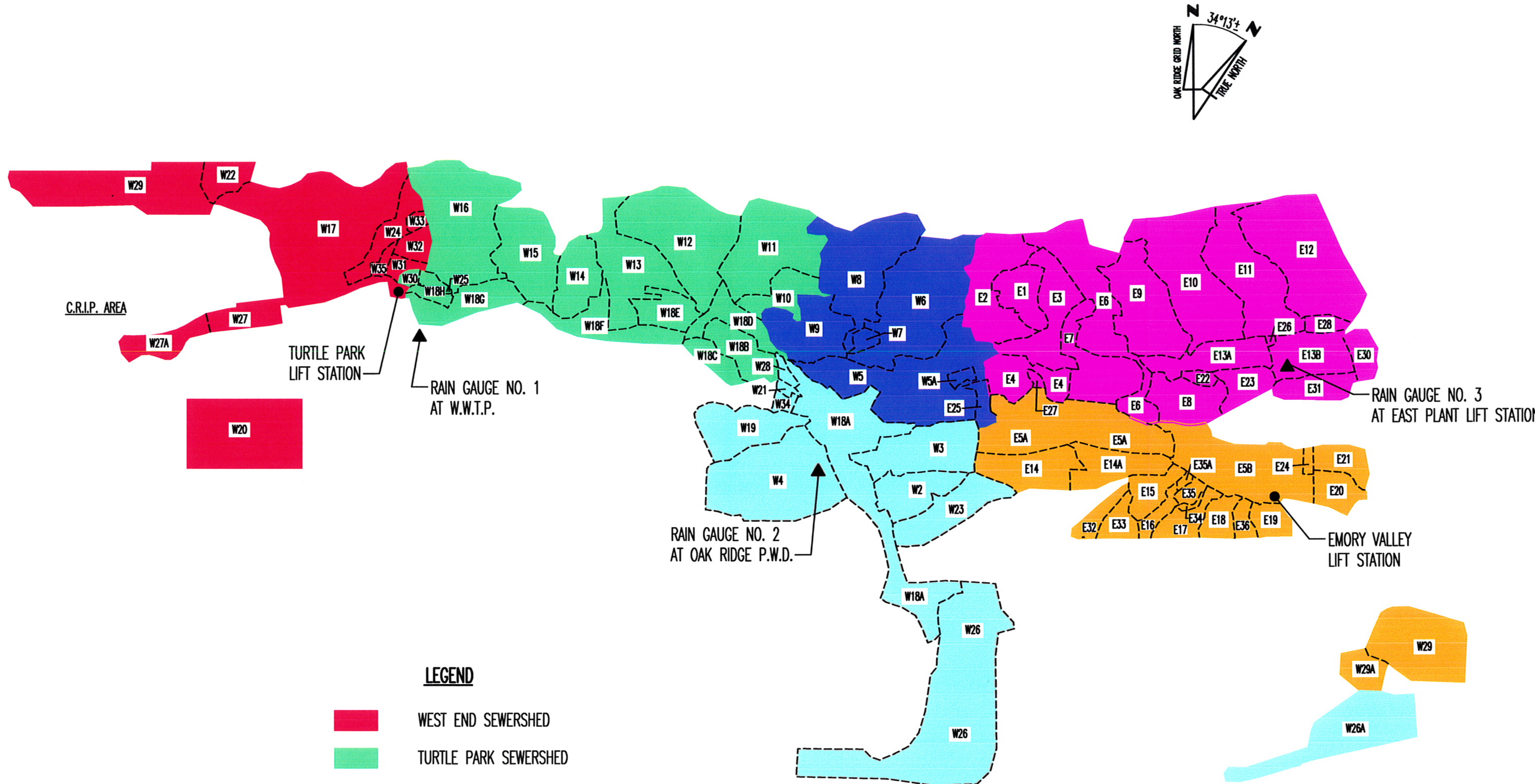
APPENDIX

City of Oak Ridge
Capacity Assessment Plan - Schedule

	Month																							
Task	1		2		3		4		5		6		7		8		9		10		11		12	
1. Base																								
Determine model extents	1																							
Select flow monitoring (sub-sewershed) locations	1																							
Delineate sub-sewershed areas		1																						
Select model flow points		1																						
Obtain water use data for each monitor and flow point			1	1																				
Delineate model flow point areas			1																					
Evaluate lift station capacities	1	1	1	1																				
Determine performance data for main lift stations	1	1	1	1																				
Build base model file		1	1	1	1	1																		
2. Rain Gauges																								
Deploy rain gauges	1																							
Collect and QA/QC rain data		1	1	1	1	1	1	1	1	1	1													
Event-analysis of rain data				1	1	1	1	1	1	1	1	1												
3. Flow Monitors																								
Deploy/move flow monitors	1			1			1			1														
Collect and QA/QC flow data		1	1	1	1	1	1	1	1	1	1	1												
4. Calibration & Verification Events Selection																								
Select Dry C/V events													1											
Select Wet C/V events													1											
5. Design Rain Event																								
Rain/flow correlation analysis													1											
Design rain event analysis													1											
6. Dry flow data analysis at each monitor point																								
Wastewater flow & GW separation														1										
GW load & criteria development														1										
Pattern development														1										
Dry load & criteria development														1										
7. Wet flow data analysis at each monitor point																								
RDII and dry flow separation															1									
GW load & criteria development (compare with above)															1									
RDII decomposition															1									
RDII criteria development																1								
8. Dry calibration and verification																								
Load model and run															1									
Compare, adjust																1								
9. Wet calibration and verification																								
RDII hydrograph calcs (observed rain events)																	1							
Load model and run (observed rain events)																	1	1						
Compare, Adjust																		1						
10. Capacity assessment																								
RDII hydrograph calcs (design rain event)																			1					
Load model and run																			1					
Extract results																			1					
11. Critical mini-systems analysis																								
Repeat with highest observed GW																				1				
12. Downstream impacts																								
Repeat with specified scenarios																				1				
13. Preliminary report																								
Prepare preliminary report																					1	1		
14. Final Report																								
Prepare final report																								1



LEGEND

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

COR04001.DWG

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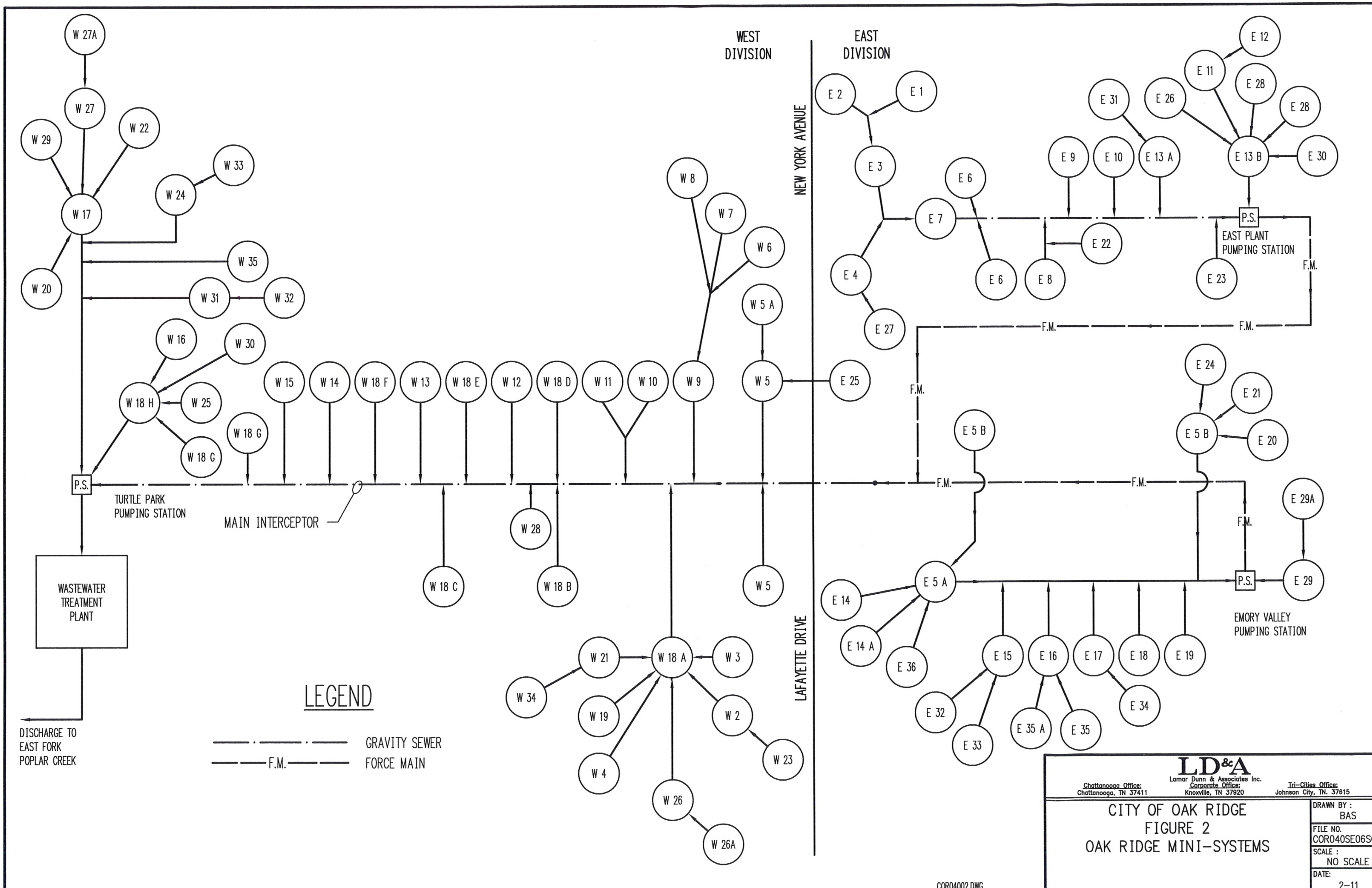
CITY OF OAK RIDGE
FIGURE 1
OAK RIDGE SEWER BASIN

DRAWN BY :	BAS
FILE NO.	COR040SE06SC11
SCALE :	1"=4000'
DATE:	2-11



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CITY OF OAK RIDGE
FIGURE 2
OAK RIDGE MINI-SYSTEMS

DRAWN BY :	BAS
FILE NO.	COR040SE06SC11
SCALE :	NO SCALE
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