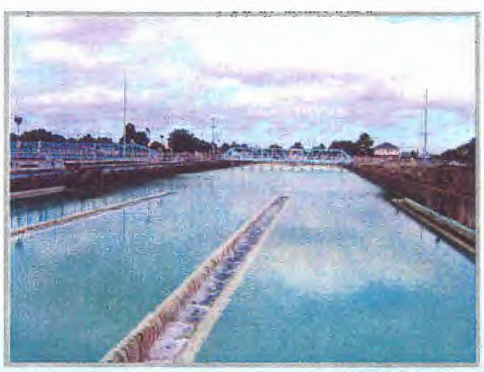
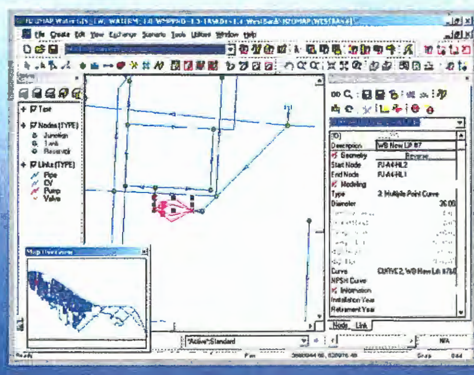
Sewerage & Water Board *of New Orleans*

Water Distribution System Assessment and Capital Improvement Plan

Draft Report



June 2003



MWH

MWH
MONTGOMERY WATSON HARZA

July 11, 2003

Mr. Joseph Becker
Network Engineering
Sewerage & Water Board of New Orleans
8800 South Claiborne Avenue
New Orleans, Louisiana 70148

CCN: 30214
File No.: 14.2.100

Re: Water Distribution System Assessment
Capital Improvement Plan – Draft Report

Dear Mr. Becker:

MWH is pleased to submit the Draft Capital Improvement Plan (CIP) for the Water Distribution System Assessment. This report is submitted in fulfillment of all tasks identified in the scope of work for MWH Amendment No. 8.

The CIP provides an overview of the East and West Bank water distribution systems, the various components of the systemwide GIS, and hydraulic models. The report describes in detail the tasks performed during the model build and calibration processes, system analysis, and results of the evaluation. Recommendations based on the hydraulic and structural evaluation are made for system improvements over 20-year and 40-year periods.

The successful completion of this task has been greatly enhanced by the active participation of the Board staff. We sincerely appreciate their assistance and professionalism.

Sincerely,

Sal Mansour

Sal Mansour
Project Manager

Distribution:

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Delivering Innovative Projects and Solutions Worldwide

Sewerage and Water Board of New Orleans

Water Distribution System Assessment and Capital Improvement Plan

June 2003

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MWH
MONTGOMERY WATSON HARZA

July 2, 2003

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Acknowledgments

The assistance of the Sewerage and Water Board is gratefully appreciated for providing information on the water distribution systems and assisting with all site visits. Without the assistance of Rudy St. Germain and his engineering staff, Jack Huerkamp and his operation and pumping and power staff, Eric Kelly and his staff, the task could not have been completed on schedule.

The information presented within this report reflects the efforts of the Sewerage and Water Board of New Orleans and MWH.

Table of Contents

MWH

Table of Contents

SECTION 5 – MODEL DEVELOPMENT AND CALIBRATION

SECTION 6 – PLANNING AND EVALUATION CRITERIA

SECTION 7 – SYSTEM EVALUATION

SECTION 8 – LEAKAGE MANAGEMENT

SECTION 9 – CAPITAL IMPROVEMENT PLAN

APPENDICES

LIST OF TABLES

LIST OF FIGURES

Executive Summary

ES.1 INTRODUCTION

The Sewerage and Water Board (S&WB) of New Orleans is conducting a comprehensive program to assess the water distribution systems for the East and West Bank of New Orleans. As a part of this effort, MWH with the assistance of subconsultants Earth Tech Inc., Essential Environmental Engineering, Inc., and Integrated Logistical Support, Inc., performed a Water Distribution System Assessment and Hydraulic Model (Water Master Plan) for the distribution systems.

The focus of the Water Master Plan includes the development of a geographic information system (GIS), the construction of a hydraulic model of the water distribution systems, and the assessment of system hydraulic performance. In addition, the project focused on the 20-year structural needs (beginning in 2005) and the development of a leakage management program. The final result of the Water Master Plan is a prioritized Capital Improvement Plan (CIP) for the East and West Bank distribution systems.

The CIP is the culmination of over a year of effort in understanding the distribution systems, developing and utilizing the hydraulic model, and analyzing the system needs. The CIP identifies the capacity and structural requirements of the distribution systems to supply quality water services to the customers of New Orleans. The CIP also addresses areas within the distribution systems that require structural improvements and additional hydraulic capacity as a result of the evaluation.

The structural assessment confirms that the condition of the distribution systems is as suspected by the S&WB: the majority of the mains are near the end of their design life, with little residual life (remaining years of service). Nearly one third of the system is close to 100 years old, and less than one third of the system is under 40 years old. With the advanced age of the water distribution systems comes decreased structural condition.

The actual pipes have, for the most part, survived beyond their design life despite the constant and sometimes extreme movement of the New Orleans soils (primarily settlement, with uplifts during heavy rainfalls). However, the aging pipe joints (which can become brittle with age), valves, and fire hydrants have experienced deterioration and failures at increasing rates, resulting in increased leakage. Aging valves and fire hydrants also fail because of wear from moving components, resulting in leakage.

Leakage, even small amounts, can undermine pipe bedding and lead to breaks in any of the system components. With these breaks, structural integrity decreases and more leaks occur. The cycle can continue to worsen in a downward spiral if not addressed in a systematic manner. The structural rehabilitation recommendations presented in the CIP provide the systematic program needed to address the structural needs of the distribution systems.

The hydraulic capacity analysis suggests that the systems, in general, appear to have sufficient capacity to supply the existing water demand, therefore requiring no immediate or future upgrades to meet the planning horizon for the year 2025. With the implementation of the structural rehabilitation recommendations included in the CIP, breaks and leaks should be reduced. System capacity should be evaluated periodically during the structural rehabilitation implementation period.

A 20-year needs assessment, based on the structural and capacity requirements, is outlined in the CIP. This needs assessment is projected to be implemented starting in the year 2005 and continuing through 2025.

An alternative CIP is also presented providing a reduced annual capital cost for the 20-year implementation of the structural rehabilitation recommendations. The alternative CIP projects the 20-year needs assessment over a 40-year implementation period, from the year 2005 through 2045.

ES.2 EXISTING WATER DISTRIBUTION SYSTEMS

Existing information for the East and West Bank distribution systems was collected and reviewed to develop an understanding of the systems. Through the process of reviewing the existing maps, databases, and field books available from the S&WB, ArcView GIS files were created. The GIS files provide a spatial database for all water facilities, which allows for improved management of data and an easily accessible data source.

Each of the water distribution systems consist of a purification plant, multiple ground-level storage tanks, pumping stations at the purification plant, water transmission and distribution mains, and an elevated storage tank. A summary of the East and West Bank systems is as follows:

- Two (2) water purification plants have a total hydraulic capacity of 272 million gallons per day (MGD).
- Average daily production is approximately 141 MGD.
- Average metered consumption is approximately 72 MGD.
- Five (5) distribution pump stations have capacities ranging from 4 to 50 MGD each.
- Twelve (12) ground-level storage tanks have a total capacity of 48 MG.
- Two (2) elevated storage tanks have a total capacity of 4 MG.
- Eight (8) major distribution lines range from 20 to 50 inches in diameter.
- Over 70 percent of water mains are less than or equal to eight (8) inches in diameter.
- Sixty (60) percent of water main material is cast iron.
- Thirty (30) percent of water main material is asbestos cement.
- Fifty (50) percent of water mains were installed prior to 1930.

ES.3 HYDRAULIC AND STRUCTURAL SYSTEM ANALYSIS

The hydraulic capacity of the water systems was evaluated using ArcView GIS, the hydraulic model utilizing H_2O Map software, and performance criteria developed by the S&WB. The performance criteria included pressure, velocity, fire flow, storage volume, and existing conditions.

The structural condition of the water systems was evaluated through a macro analysis using the KANEW computer model and a micro analysis using a rehabilitation and replacement prioritization process. The structural condition was evaluated with respect to the performance criteria such as water main age, material, history of breaks, customer impact, and location. In addition to these analyses, core samples of pipes were retrieved to analyze the structural condition of water mains within a range of age.

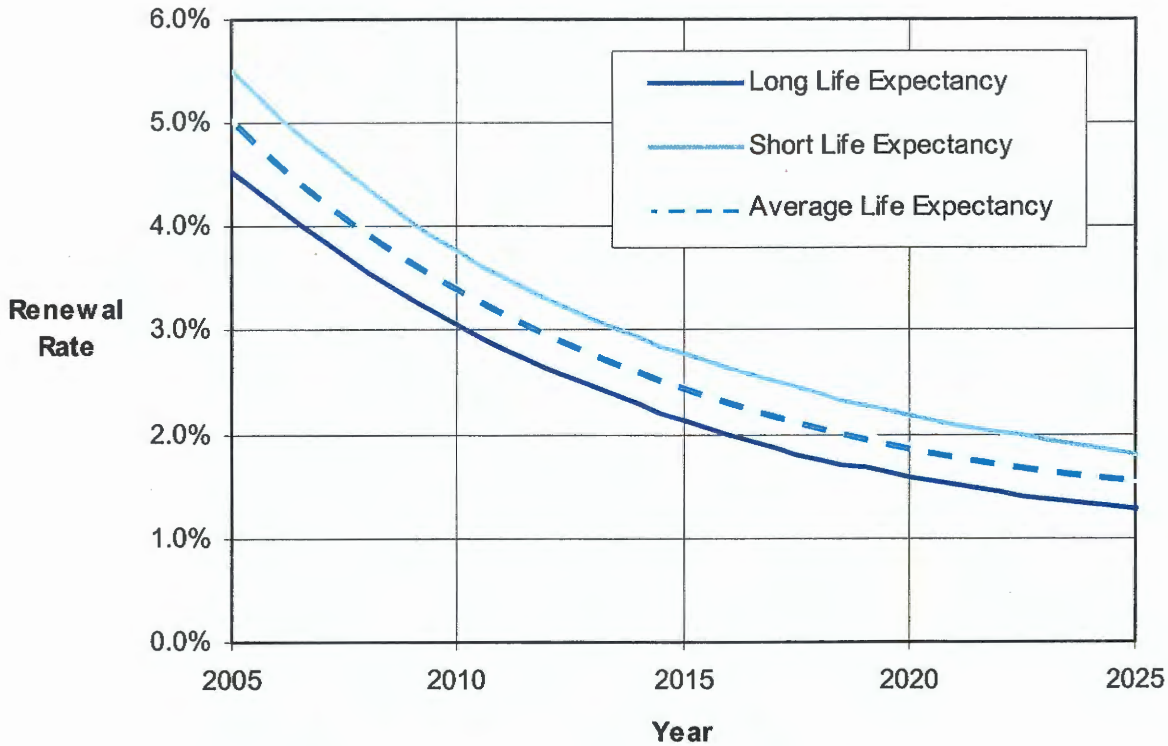
Regarding the hydraulic analysis, the East and West Bank distribution systems were determined to have an adequate supply of raw water and hydraulic capacity to deliver sufficient water to meet existing customer demand. The result of the analysis suggests that the systems, in general, appear to have sufficient capacity to supply the existing water demand, therefore requiring no immediate or future upgrades to meet the planning horizon for the year 2025. With a goal established in the future for reduction in breaks and leaks, the system capacity should continuously be evaluated with the hydraulic model during the implementation of the plans to meet this goal.

With respect to the structural analysis, the evaluation of the systems confirmed that the water main networks are beyond or nearing the end of their design life and in need of structural rehabilitation. In addition, there is a significant portion of water distributed into the system that is currently unaccounted for and thus not generating revenue for the S&WB.

A substantial quantity of unaccounted for water (UFW) is presumed to be due to leakage throughout the distribution systems, as it could not be accounted for otherwise. This unaccounted leakage is likely due to joints, valves, and fire hydrants which have deteriorated or broken over the years primarily due to the unique soil conditions in New Orleans, which are exacerbated by the extremes in rainfall conditions (periods of greater than normal rainfall followed by periods of drought). Because this apparent leakage is such a significant and costly system deficiency, which will further decrease structural integrity and increase leakage, it is recommended in the CIP that a leakage management program be implemented as a priority. This leakage management program will help pinpoint the areas with the highest leakage levels and establish priorities for repair.

In conjunction with the structural analysis performed as part of the Water Master Plan, a range of water main life expectancies (long to short) was used to provide annual rates of renewal for the distribution systems. The average of the two renewal rates was used to develop recommendations for network replacement in the CIP. **Figure ES-1** on the following page shows the renewal rates over the 20-year period based on a long (optimistic), short (pessimistic), and an average life expectancy. According to the average life expectancy renewal rate, approximately five (5) percent of the distribution systems is recommended for replacement within the first year of construction (2005).

Figure ES-1
Annual Water Main Renewal Rates

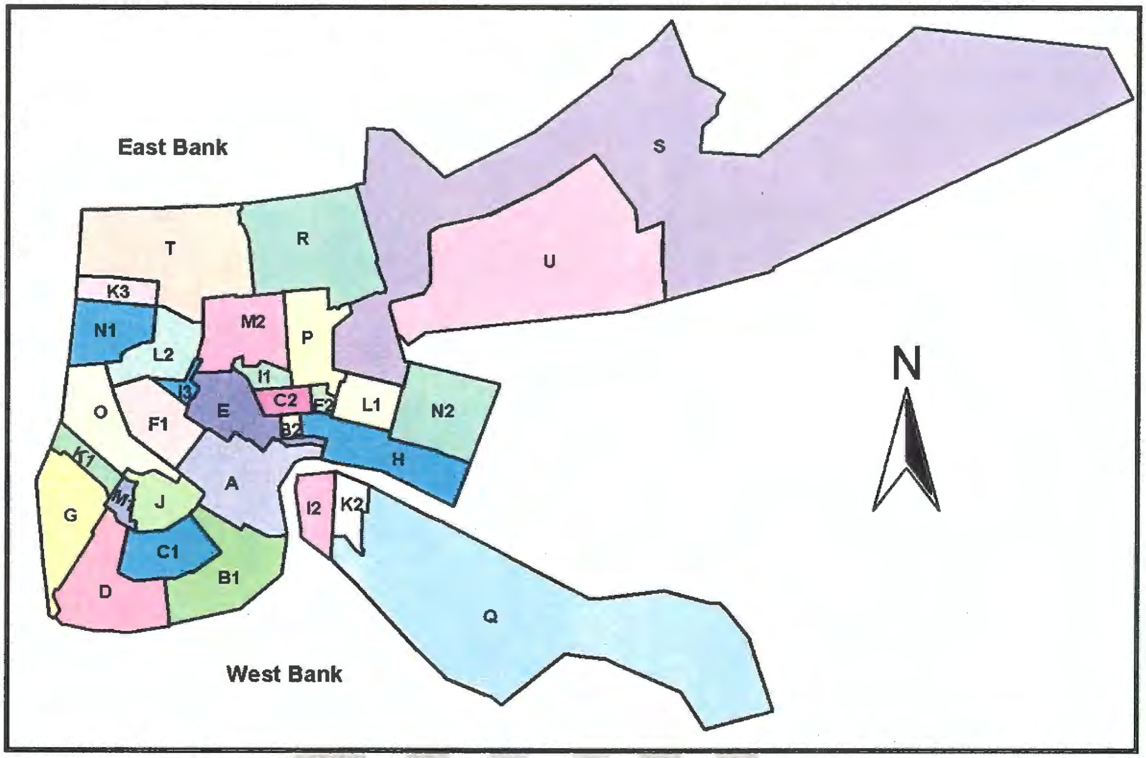


By applying the annual water main renewal rates from 2005 to 2025 to the specific mains in the distribution systems, a plan for replacement and rehabilitation over the 20-year period was developed. The recommended network replacement and rehabilitation program is organized within 21 project areas throughout the city. **Figure ES-2** on the following page shows the project area boundaries. A total of 929 miles, or approximately 60 percent of the system, is recommended for replacement based on the prioritization analysis.

ES.4 CAPITAL IMPROVEMENT PLAN

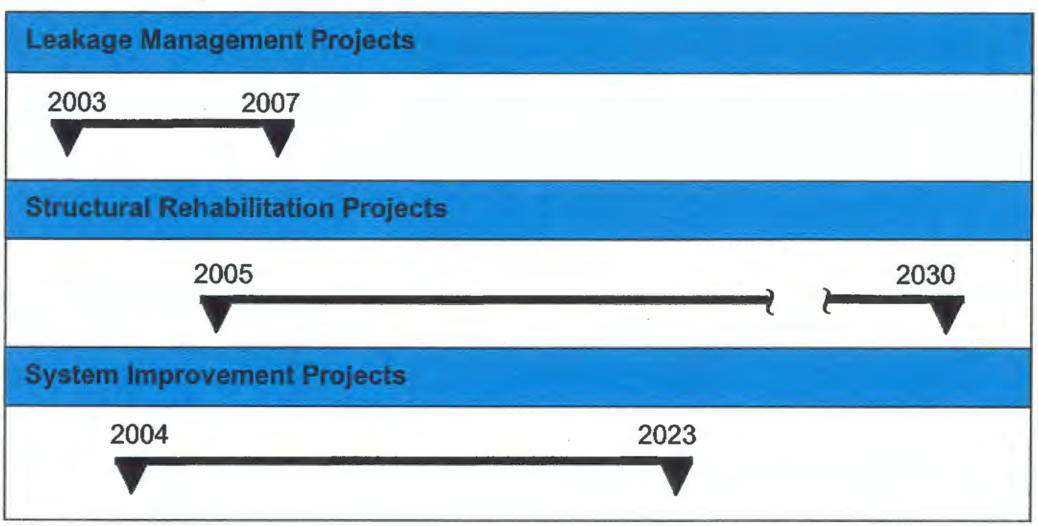
Based on the results of the analysis performed as part of this Water Master Plan, a total of 31 projects were identified to implement systemwide improvements. Several of the recommendations are for the S&WB to continue existing system improvements such as the valve and hydrant inspection and maintenance programs.

Figure ES-2
Structural Rehabilitation Project Areas



The projects are grouped into one of three categories: leakage management (4), structural rehabilitation (21), or system improvements (6), as shown in the summary schedule for the CIP in **Figure ES-3** below.

Figure ES-3
CIP Summary Schedule



Note:
1 – Not to scale.

Leakage management and system improvement projects recommended in the CIP are scheduled to begin in 2003 and 2004. Currently, the S&WB performs repairs on distribution system main breaks on a continuous basis. It is anticipated that this effort will continue in conjunction with the other efforts recommended in the CIP.

Implementation of the structural rehabilitation program presented in the CIP is recommended to begin in 2005 in order to accommodate the additional time required for the design and bid phases, and end in 2030. One structural project area is scheduled for initiation every other year and the last project initiated in 2025. The duration for the implementation of each project area is estimated to be five (5) years, including design, bid and award, and construction phases. The recommended improvements reflect the 20-year structural needs of the system; however, implementation for the CIP is scheduled over a 27-year period.

Planning level capital cost estimates were developed for the 31 proposed projects including the continuation of existing programs currently performed by the S&WB. These existing projects conducted by the S&WB include the valve, hydrant, and customer meter inspection and maintenance programs.

The preliminary cost estimates for the structural rehabilitation projects are based on water main replacement utilizing conservative, "open cut" construction methods. As the projects progress through the design phase, the cost estimates will change after the rehabilitation methods to be utilized for specific mains are refined. For example, trenchless technology methods for water main rehabilitation are currently evolving and the viability and cost effectiveness for these methodologies should, therefore, be evaluated and applied as appropriate during the implementation phase.

For purposes of preparing the preliminary cost estimates for the structural rehabilitation projects, the capital cost components for structural projects include:

- construction (including materials and installation),
- construction allowances and contingency (30%),
- engineering and design services during construction (10%),
- construction management (10%), and
- legal and administrative costs (2%).

The construction allowances and contingency allocates potential cost accrued for temporary restoration, chlorination and testing, temporary services, traffic management, bypass pumping, conflict resolution, damage claims, and planning level uncertainties. The capital cost for all projects includes equipment and installation costs, when applicable. An annual rate of three (3) percent inflation was calculated for each project category to the mid-point of the project duration. A summary of the proposed projects and the estimated capital cost is shown in **Table ES-1** on the following page.

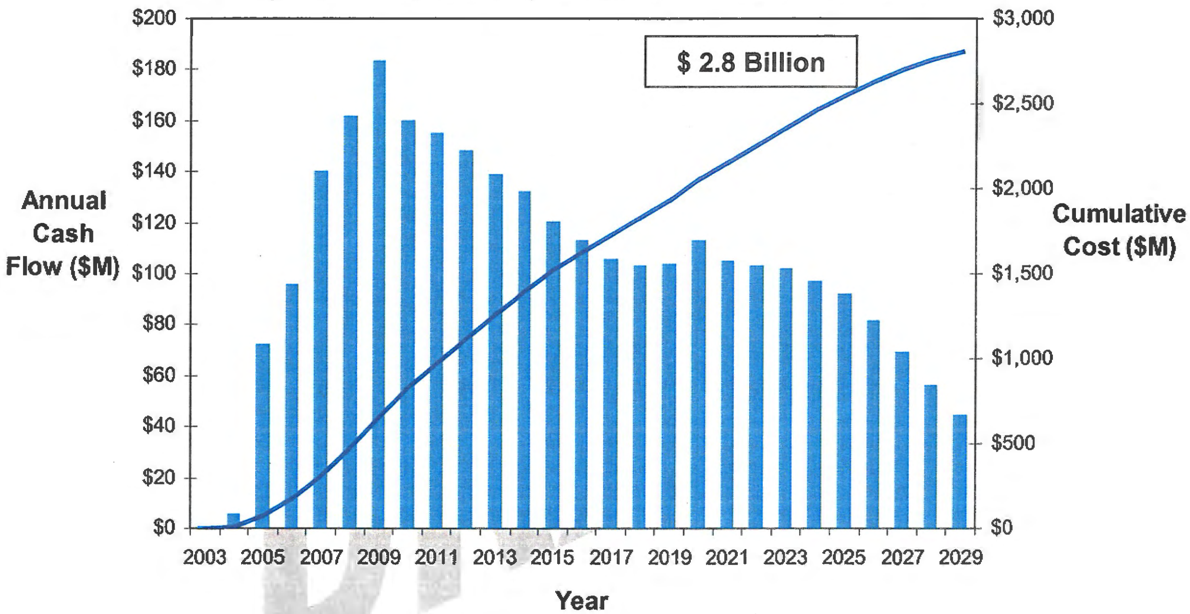
Table ES-1
Estimated Cost for Proposed Projects

Project Group	Project Description	Capital Cost ($1,000)
I. Leakage Management Projects	Washout Valve Inspection	$ 150
	Valve and Hydrant Inspection and Maintenance	$ 5,720
	Pilot District Metering Area (four areas) Implementation	$ 1,440
	Leakage Management Program	$ 5,950
	Inflation	*$ 990*
	Subtotal	**$ 14,250**
II. Structural Rehabilitation	Rehabilitation in Project Area A	$ 181,000
	Rehabilitation in Project Areas B1,B2	$ 158,000
	Rehabilitation in Project Areas C1,C2	$ 142,000
	Rehabilitation in Project Area D	$ 127,000
	Rehabilitation in Project Area E	$ 110,000
	Rehabilitation in Project Areas F1,F2	$ 92,000
	Rehabilitation in Project Area G	$ 131,000
	Rehabilitation in Project Area H	$ 108,000
	Rehabilitation in Project Areas I1,I2,I3	$ 83,000
	Rehabilitation in Project Area J	$ 74,000
	Rehabilitation in Project Areas K1,K2,K3	$ 34,000
	Rehabilitation in Project Areas L1,L2	$ 93,000
	Rehabilitation in Project Areas M1,M2	$ 71,000
	Rehabilitation in Project Areas N1,N2	$ 71,000
	Rehabilitation in Project Area O	$ 78,000
	Rehabilitation in Project Area P	$ 78,000
	Rehabilitation in Project Area Q	$ 54,000
	Rehabilitation in Project Area R	$ 61,000
	Rehabilitation in Project Area S	$ 66,000
	Rehabilitation in Project Area T	$ 57,000
	Rehabilitation in Project Area U	$ 55,000
	Inflation	*$ 836,940*
	Subtotal	**$2,760,940**
III. System Improvement Projects	Customer Meter Inspection and Maintenance Program	$ 16,000
	GIS Data Management Implementation and Update	$ 3,000
	System Optimization and Analysis	$ 1,000
	Water Purification Plants Audit	$ 150
	SCADA Installation and Data Automation	$ 3,750
	Purification Plant Flow Meters Installation	$ 1,000
	Inflation	*$ 8,220*
	Subtotal	**$ 33,120**
	Total Capital Cost	**$2,808,310**

A preliminary planning-level cost estimate was calculated for the benefit associated with recovering leakage over a 20-year period. The potential cost of recovering leakage is estimated up to $1.7 billion. Although this cost savings of water no longer lost to leakage is less than the total capital cost for the recommended projects presented in the CIP, the benefits of recovering leakage still outweigh the cost of the CIP. Benefits such as reducing or eliminating the inconveniences caused by water leaks (e.g., interruption of service, property damage, street failure, etc.) to the public cannot be fully measured in monetary value. Reducing or eliminating the root cause of leakage is also advantageous in the long-lasting impacts to the structural integrity of the distribution systems.

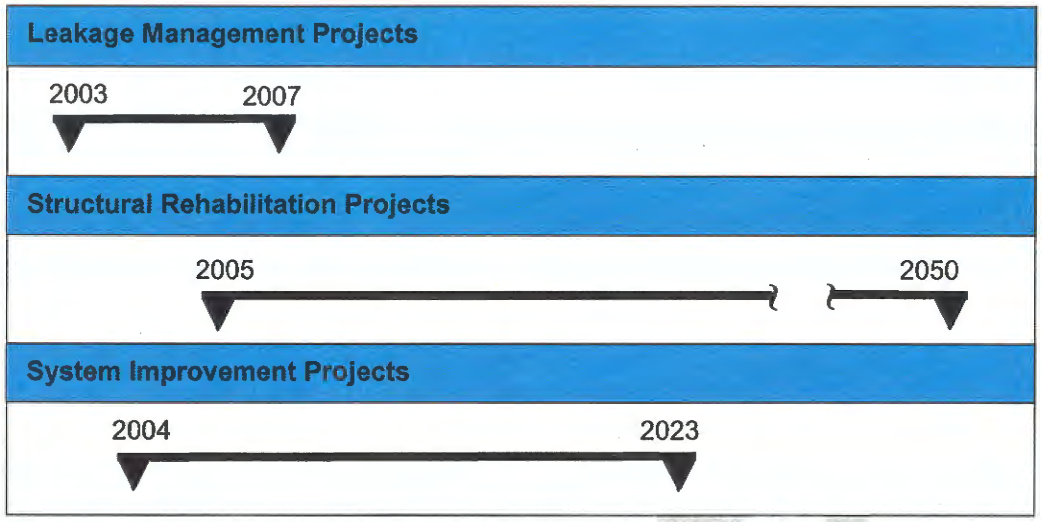
The project schedule for the CIP was used in conjunction with the capital cost estimates for each project to determine a projected cash flow for all recommended improvements. The projected cash flow from 2003 through 2029 for the CIP is shown below in **Figure ES-4**. The annual cash flow peaks in 2009 at $184 million.

Figure ES-4
Projected Capital Improvement Plan Cash Flow



An alternative CIP was developed to evaluate the reduction in the annual capital cost over the duration of the plan. The alternative CIP represents the system structural needs for a 20-year period and recommends implementation of the structural rehabilitation construction projects over a 40-year planning period. The summary schedule for the alternative CIP is shown on the following page in **Figure ES-5**. Implementation of the structural rehabilitation program is scheduled to begin in 2005, with one project area initiated every other year and the last project initiated in 2045.

Figure ES-5
Alternative CIP
Summary Schedule



1 – Not to scale.

The duration for implementation of each project area is estimated to be five (5) years, including design, bid and award, and construction phases. The alternative schedule shows that all activities associated with the capital improvement projects will be completed by 2050. The recommended improvements reflect the 20-year needs of the system; however, implementation for the CIP is scheduled over a 47-year period.

While the alternative CIP reduces the required cash flow on an annual basis, the overall cost is increased due to inflation accrued over an additional 20 years. The estimated cost for each project category is summarized in **Table ES-2** for the alternative CIP. The subtotal for structural rehabilitation projects is increased by approximately $577 million due to inflation.

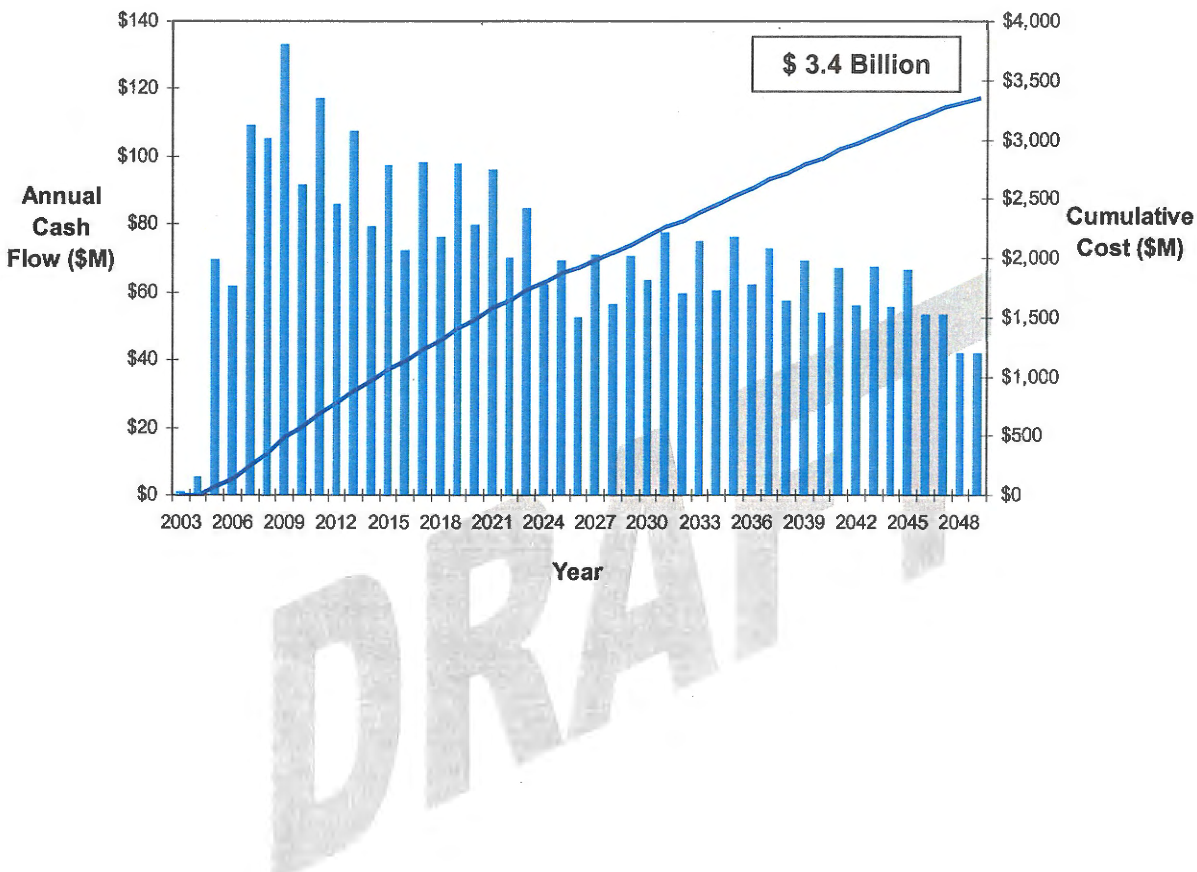
Table ES-2
Alternative CIP
Estimated Cost for Proposed Projects

Project Group	Capital Cost with Inflation ($ M)
I. Leakage Management Projects	$ 14
II. Structural Rehabilitation	$ 3,338
III. System Improvement Projects	$ 33
Total Capital Cost	**$ 3,385**

Similar to the cost estimate calculated for the benefit associated with recovering leakage over a 20-year period, a preliminary planning-level cost was also calculated over a 40-year period. The potential cost of recovering leakage is estimated up to $3.5 billion.

The projected cash flow for the alternative CIP is shown below in **Figure ES-6**. The annual cash flow peaks in 2009 at $134 million.

Figure ES-6
Alternative CIP
Projected Cash Flow



Section 1

MWH

Section 1 – Introduction

1.1 BACKGROUND

The Sewerage and Water Board (S&WB) of New Orleans authorized MWH on January 30, 2002 to perform a Water Distribution System Assessment and Hydraulic Model (Water Master Plan) for the distribution systems on both the East and West Bank of New Orleans.

The goal of the Water Master Plan is to provide a prioritized Capital Improvement Plan (CIP) for the two distribution systems. The CIP identifies areas within the distribution systems that require structural improvements and additional hydraulic capacity. A 20-year needs assessment through the year 2025 is outlined in the CIP, which recommends an implementation schedule over a 27-year period. In addition, an alternative CIP was developed to evaluate the reduction in the annual capital cost required for the 27-year implementation plan. The alternative CIP recommends an extended schedule over a 47-year period for the 20-year needs recommendations.

1.2 OBJECTIVE AND SCOPE OF WORK

The Water Master Plan was initiated to address the condition of the distribution systems as well as current and future capacity requirements. Included in the scope is the evaluation and modeling of the existing water distribution facilities (pump stations storage tanks, transmission and distribution mains) to identify capital improvements required for condition improvements and to meet future demands. Recommendations for capital improvements resulting from the distribution system analysis utilizing the hydraulic model are included in the CIP. Additionally, the Water Master Plan includes the development of an action plan to identify and monitor all potential sources of unaccounted-for water in the system.

The scope of work for the Water Master Plan includes the following tasks:

Task 1 – System Understanding to gather and review available information on existing water facilities and operating practices.

Task 2 – System Characterization to prepare a Technical Memorandum (TM) presenting the understanding of the current operation, capacity and condition of the water distribution systems.

Task 3 – Software Evaluation and Selection to evaluate three hydraulic modeling software packages. Prepare a TM and conduct a workshop summarizing the advantages and disadvantages of each software.

Task 4 – Model Build to review and clean up existing digitized data of the water distribution systems, compare with system maps and drawings, and allocate current water demand.

Task 5 – Model Calibration to collect operation data for hydrant tests and calibrate the model to the actual operating conditions.

Task 6 – Develop Performance Criteria to develop and summarize performance and structural criteria in a TM. Performance criteria will be used to evaluate the system.

Task 7 – Model Simulations to perform extended period simulations utilizing the calibrated hydraulic model under varying water demand conditions and evaluate pressure and flow capacity throughout the system.

Task 8 – Identify Critical Facilities to perform and analyze each system component to determine its criticality to the overall water distribution system and summarize results in a TM.

Task 9 – Establish Condition Assessment to retrieve and analyze samples of existing distribution mains, summarize results in a TM.

Task 10 – Analyze System to Identify Deficiencies to determine deficiencies and identify improvements required in the existing system to meet the performance criteria.

Task 11 – Develop Alternative Analysis Solutions to identify specific improvements needed to meet existing and future system demands based on the criticality of facilities.

Task 12 – Needs Assessment Development (Capital Improvement Plan) to prepare a 20-year needs assessment including project priority, schedule, and capital cost estimates. Conduct a workshop and submit a final report. This was updated during the report preparation to include an alternative CIP, which schedules the 20-year needs over a 40-year implementation period.

Task 13 – Establish Leakage Detection Program to develop an action plan to identify and monitor all potential sources of unaccounted for water including leaks in the water system.

This report serves as fulfillment of all aforementioned tasks as outlined in the scope of work. It summarizes the recommendations for hydraulic capacity and structural improvements, and the leakage detection program.

1.3 PROJECT STAFF

The MWH staff principally involved in the preparation of the Water Master Plan include engineers in the New Orleans area offices. Additional staff from MWH and MWH Soft provided technical support for review of the project. The subconsultants to MWH on the project include Earth Tech, Inc., Essential Environmental Engineering, Inc. (E3), and Integrated Logistical Support, Inc. (ILSI).

1.4 ORGANIZATION OF REPORT

Following is a description of the report organization.

- **Section 1 – Introduction** provides a background, introduction and description of the report organization.
- **Section 2 – Study Area, Land Use and Development** contains a description of the study area, land use, population, and existing and future developments.
- **Section 3 – System Characterization** describes the existing facilities such as the pump stations, water purification plants, storage tanks.
- **Section 4 – Water Production and Demand** summarizes the water audit to estimate water production and consumption data, large users, and unaccounted water.
- **Section 5 – Model Development and Calibration** discusses the model selection, development methodology, and calibration steps.
- **Section 6 – Planning and Evaluation Criteria** presents the capacity and structural performance criteria used to evaluate the water systems.
- **Section 7 – System Evaluation** provides an analysis of the existing systems in comparing the model to the performance criteria.
- **Section 8 – Leakage Management** outlines the action plan for the identifying and monitoring leaks within the system.
- **Section 9 – Capital Improvement Plan (CIP)** details the recommendations for capital improvements with construction schedules, cost analysis, and recommendations.
- **Appendix A—References and Data Sources** provides the details of the information sources utilized during this effort.
- **Appendix B—Diurnal Curves** presents the consumption diurnal curves developed for the large industrial users, for use in the hydraulic model.
- **Appendix C—WDTTE Water Guide** presents a users guide to the customized ArcView editing tools.
- **Appendix D—Field Testing Data** presents the data collected during the field calibration testing.
- **Appendix E—Results of Model Calibration** provides the data correlating the model results with the field conditions.

- **Appendix F—Results of Hydraulic Model Analysis** presents the detailed data related to the analysis of the system utilizing the model.
- **Appendix G—Results of KANEW Analysis** provides the detailed data resulting from the analysis performed.
- **Appendix H—Capital Improvement Projects** presents detailed descriptions of each capital improvement project, including an individual schedule and cost estimate.

1.5 DEFINITIONS

Table 1-1 below presents a list of abbreviations and terms used within the report with their respective definitions.

Table 1-1
Abbreviations and Definitions

Term	Definition
ADD	Average day demand
ALC	Active Leakage Control
Alternative CIP	Capital Improvement Plan addressing the system's 20-year needs implemented over 47 years
AwwaRF	American Water Works Association Research Foundation
BGY	Billion gallons per year
CBD	Central Business District
CD	Cairo Datum (equivalent to 20.43 feet mean sea level)
CIP	Capital Improvement Plan addressing the system's 20-year needs implemented over 27 years
DDD	Downtown Development District
DHH	Department of Health and Hospitals
DMA	District Metering Area
EPS	Extended period simulation
fps	Feet per second
FQ	French Quarter
Ghost node	Node in GIS to hold a curve in a line (equivalent to a vertex)
GIS	Geographic Information System
gpd	Gallons per day
gpm	Gallons per minute
H_2O Map	Hydraulic modeling software
ILI	Infrastructure Leakage Index

Table 1-1
Abbreviations and Definitions
(cont'd.)

Term	Definition
HANO	Housing Authority of New Orleans
HGL	Hydraulic gradient line
Junction	Representation of a physical cap, cross, tee, or reducer in GIS
KANEW model	Structural analysis software
Link	Representation of a water main in GIS
MDD	Maximum day demand
MGD	Million gallons per day
MGY	Million gallons per year
MSL	Mean sea level
MWH	Montgomery Watson Harza
Node	Representation of all points in GIS including junctions, fire hydrants, and valves
NOMC	New Orleans Medical Complex
NPSH	Net Positive Suction Head
PAN	Priority Action Number
psi	Pounds per square inch
PVC	Polyvinyl chloride
rpm	Revolutions per minute
S&WB	Sewerage and Water Board of New Orleans
SSERP	Sewer System Evaluation and Rehabilitation Program
SCADA	Supervisory Control and Data Acquisition
TIGER lines	Topographically Integrated Geographic Encoding and Referencing (2000 U.S. Census)
TIN	Triangulated Irregular Network
TIRL	Technical Indicator for Real Losses (expressed in gallons per service connection per day)
UARL	Unavoidable Annual Real Losses (expressed in gpd)
UFW	Unaccounted for water
VCC	Vieux Carré Commission
Water Demand	Metered and non-metered water consumption
Water Production	Water treated and distributed into the service area
WD	Warehouse District
WDTTE Water	Customized ArcView editing tool
WTC	World Trade Center

Section 2

Section 2

MWH

Section 2 – Study Area, Land Use and Development

2.1 STUDY AREA

The study area is Orleans Parish, Louisiana, which is divided by the Mississippi River into the East and West Banks. The City of New Orleans shares the same boundary as Orleans Parish.

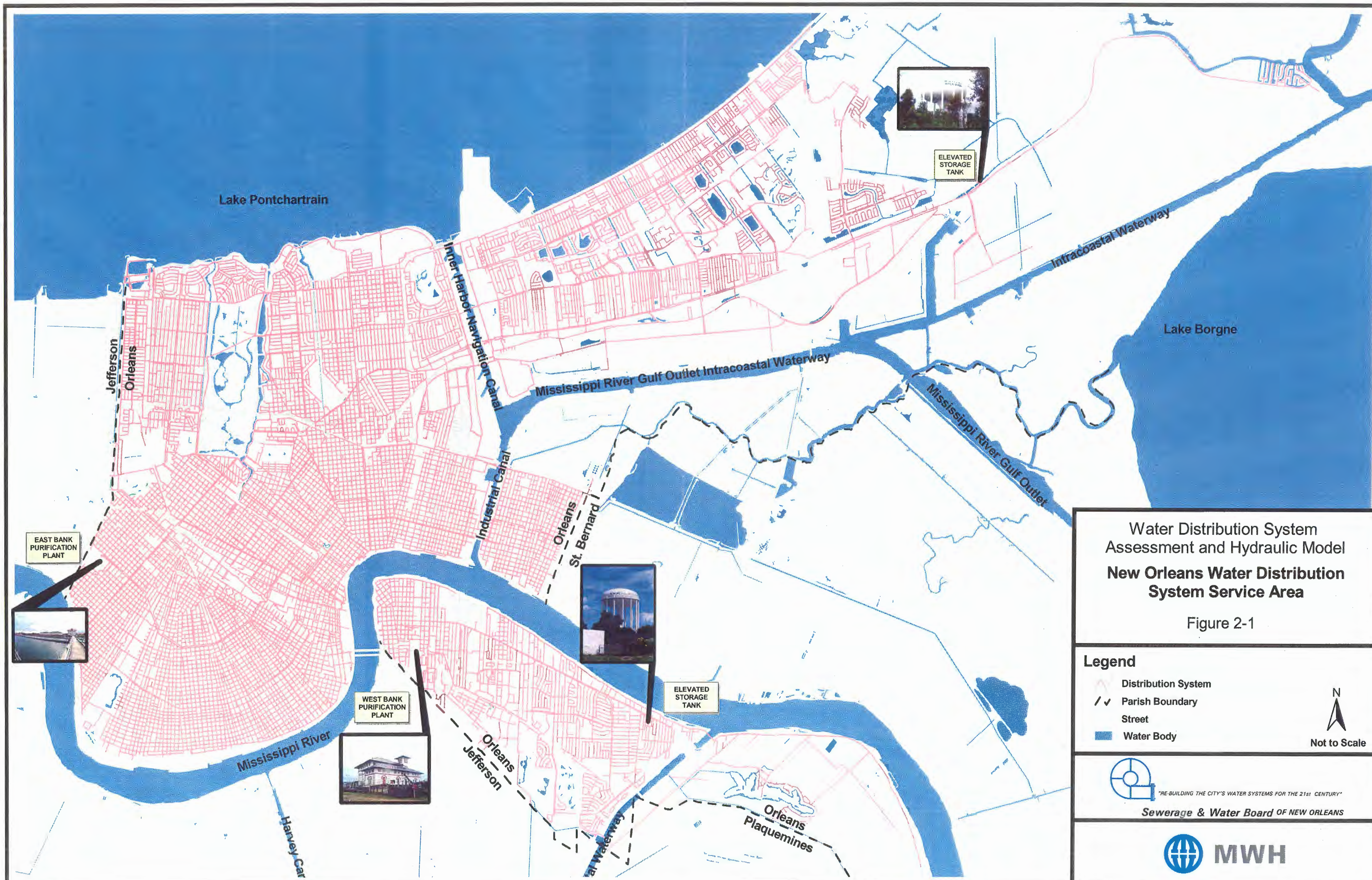
The S&WB maintains two water distribution systems with one water purification plant for each system on the East and West Banks. Both distribution systems receive raw water for treatment from the Mississippi River. **Figure 2-1** shows water distribution service areas as well as the boundaries of Orleans Parish (East and West Banks). The East and West Bank systems distribute water to service areas totaling approximately 43,980 and 8,770 acres, respectively.

2.2 AREA TOPOGRAPHY

The topography of the area is relatively flat, and the ground level is typically at or below Mean Sea Level (MSL). For this reason, elevation information is typically expressed in terms of Cairo Datum (CD), a datum that allocates positive ground elevations. Cairo datum of 20.43 feet is equivalent to MSL.

The Mississippi levees on both the East and West Bank are built up to a height of 40 feet CD (20.43 feet MSL). The highest point within the city is approximately 28 feet CD (7.57 feet MSL) and the lowest point dips to approximately four feet CD (-16.43 feet MSL).

Figure 2-2 shows a typical cross section of the East Bank with a range in ground elevation from the Mississippi River levee to the Lake Pontchartrain levee. **Figure 2-3** shows elevation contours for New Orleans.

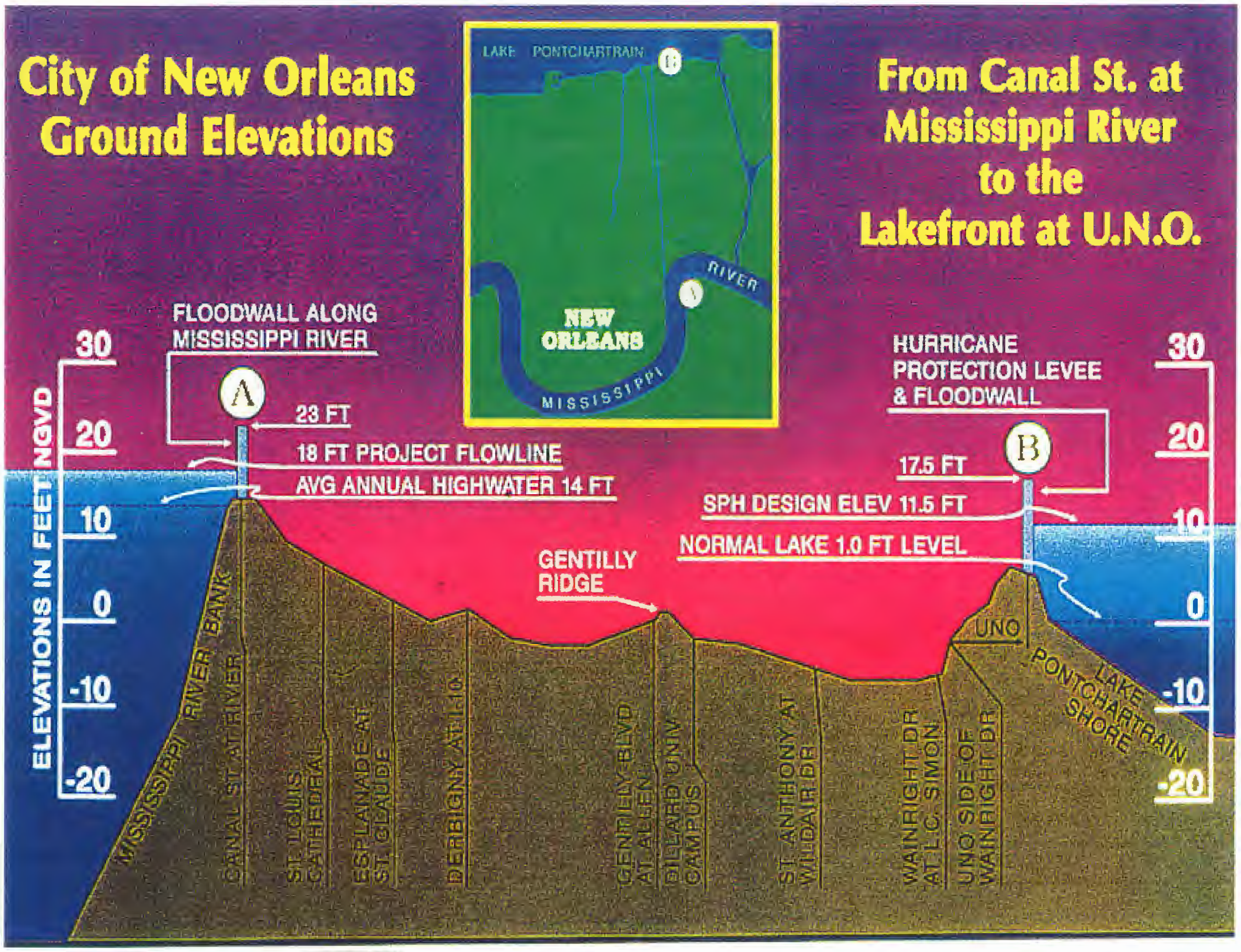


Water Distribution System Assessment and Hydraulic Model

New Orleans Water Distribution System Service Area

Figure 2-1

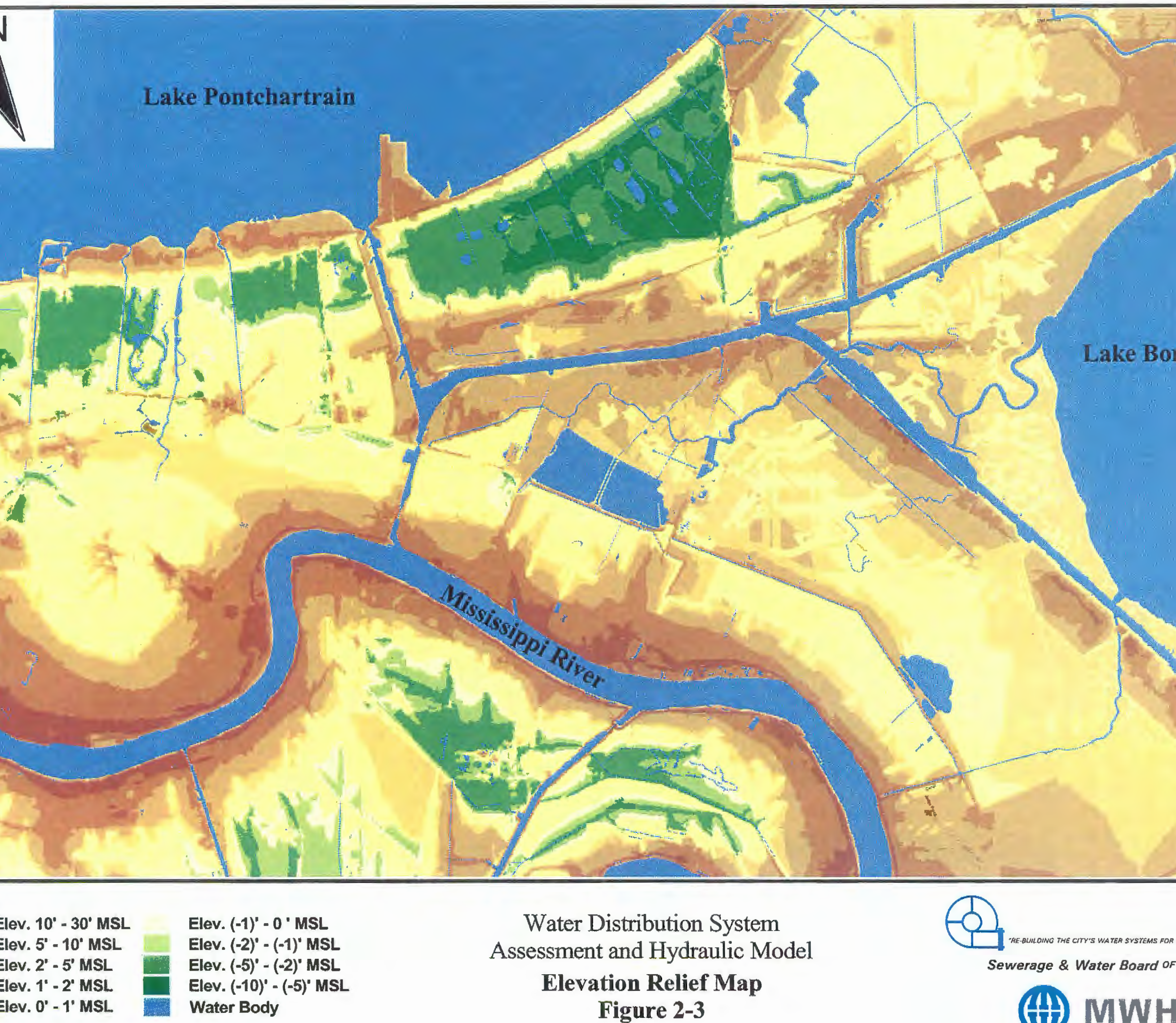
Figure 2-2
Typical Cross Section of New Orleans



2.3 ENVIRONMENTAL CONDITIONS AND LAND USE

Most of the land area currently occupied by Orleans Parish is marshland or swamp, which has been reclaimed over time. Due to its formation from a swamp area, much of the soil in the city contains a high percentage of organic matter. Organic soils are more readily compressed than the alluvial deposits adjacent to the River. As a result, subsidence of the organic soils continuously occurs throughout the city. The fluctuation in the water table causes additional subsidence. The water table frequently fluctuates due to peak and low rainfalls. These dynamic soil conditions subject underground structures such as pipes to significant amounts of stress, resulting in the continuous development of cracks, fractures and displaced joints.

With respect to land use, an ArcView shapefile was obtained from the City Planning Commission showing the breakdown of land uses within the City of New Orleans. The land use in the city is divided into the following nine categories:



Water Distribution System
Assessment and Hydraulic Model

Elevation Relief Map
Figure 2-3

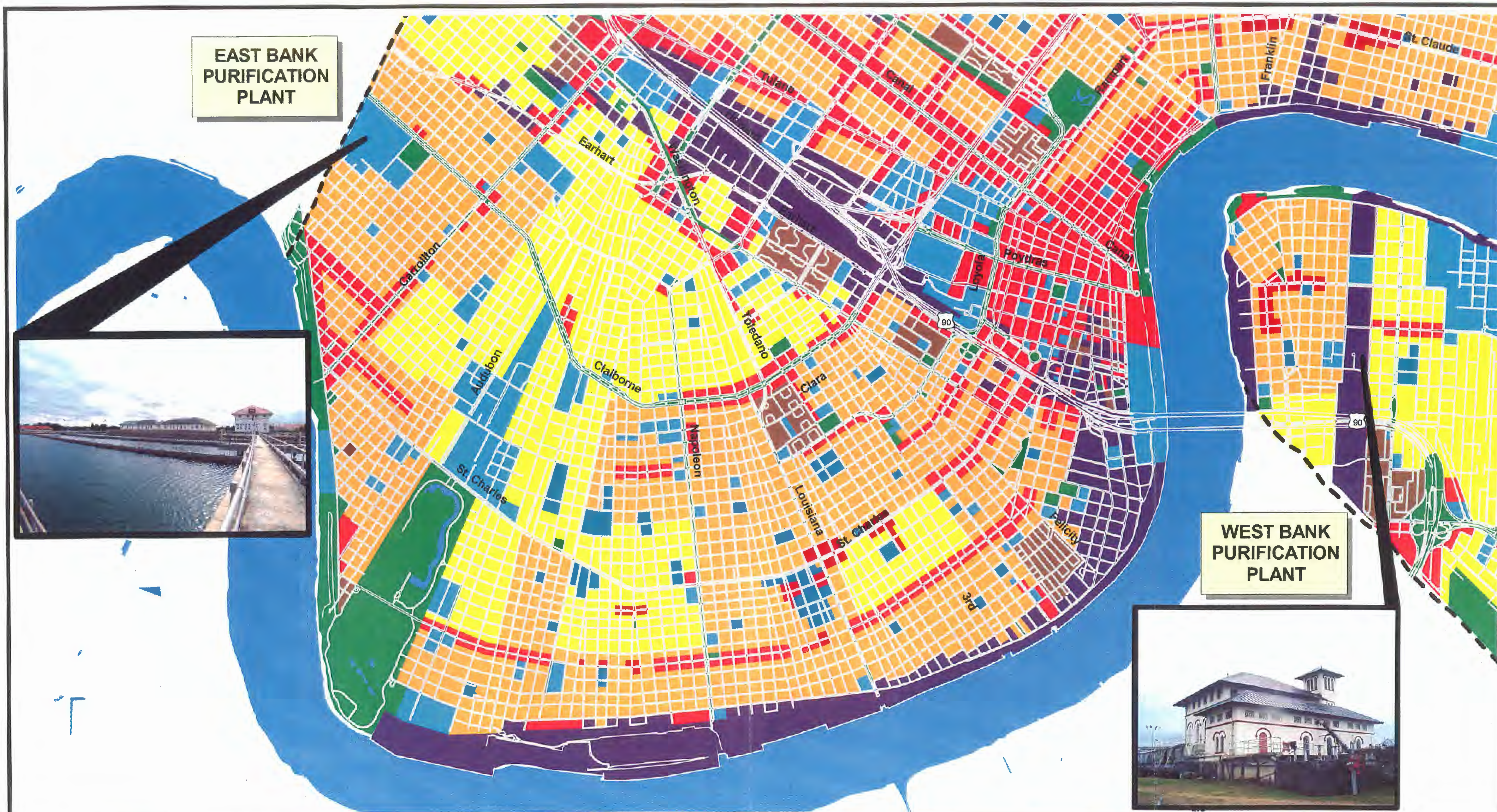
"RE-BUILDING THE CITY'S WATER SYSTEMS FOR
Sewerage & Water Board OF

MWH

- Single Family Residential
- Residential/Commercial
- Residential/Marine
- Multi Family Residential
- Commercial
- Wetland
- Recreational
- Public
- Industrial

The land area consists primarily of residential, commercial, wetlands, and light industrial developments, as well as open recreational space. Wetland areas comprise 45 percent of the total land area on the East Bank (47,700 acres) and 15 percent of the total land area on the West Bank (1,600 acres). Recreational areas include parks as well as major roads with wide median strips. Public areas include hospitals, cemeteries, and college campuses. **Figures 2-4** through **2-11** show the generalized land use zoning for the East and West Bank as defined by the City Planning Commission.

The service areas for the water distribution system were assessed to determine the percentage of land currently developed, undeveloped, and available for future development. The status of land available for future development is discussed later in this section. **Tables 2-1** and **2-2** summarize the existing land use and total developed area for the East and West Bank, respectively. Although wetlands constitute a large percentage of the total land area, they are considered to be areas that are not developable and are not included in the statistics summarized in these tables. Approximately 62 percent of the developable land area on the East Bank is currently developed (including fully developed, re-developed, and partially developed areas). Of the developed area on the East Bank, 56 percent is zoned as either single family residential or mixed residential/commercial.



Legend

Single Family Residential	Recreational	Water Body
Residential/Commercial	Public	
Multi Family Residential	Industrial	
Commercial	Parish Boundary	
Wetland	Street	

N

1 Inch = 1/2 Mile

Water Distribution System
Assessment and Hydraulic Model

Existing Land Use
Uptown

Figure 2-4

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

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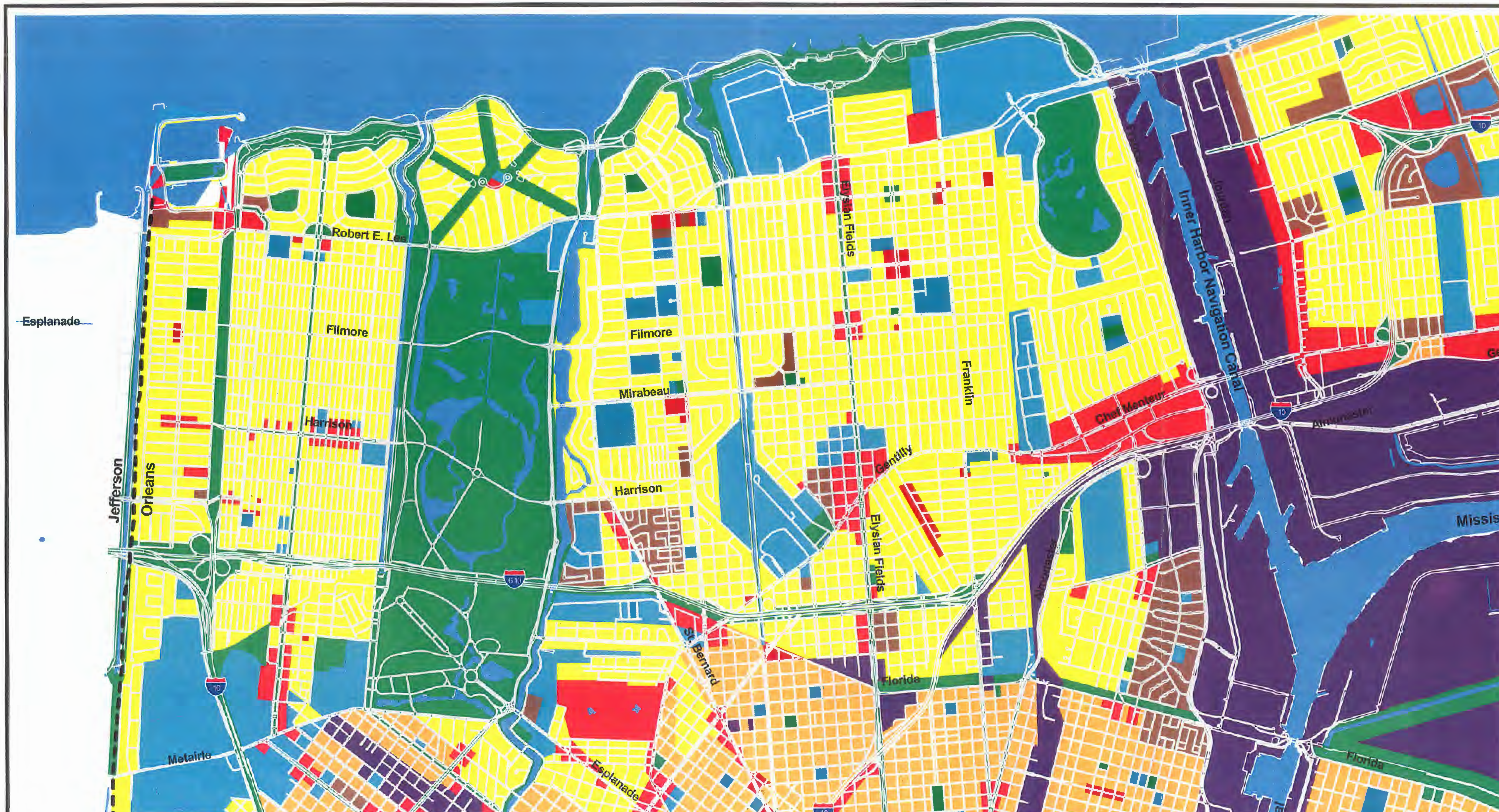

Legend

N

1 Inch = 1/2 Mile

- Single Family Residential
- Residential/Commercial
- Multi Family Residential
- Commercial
- Wetland
- Recreational
- Public
- Industrial
- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Existing Land Use
Lakefront

Figure 2-5

Location
By Council District

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

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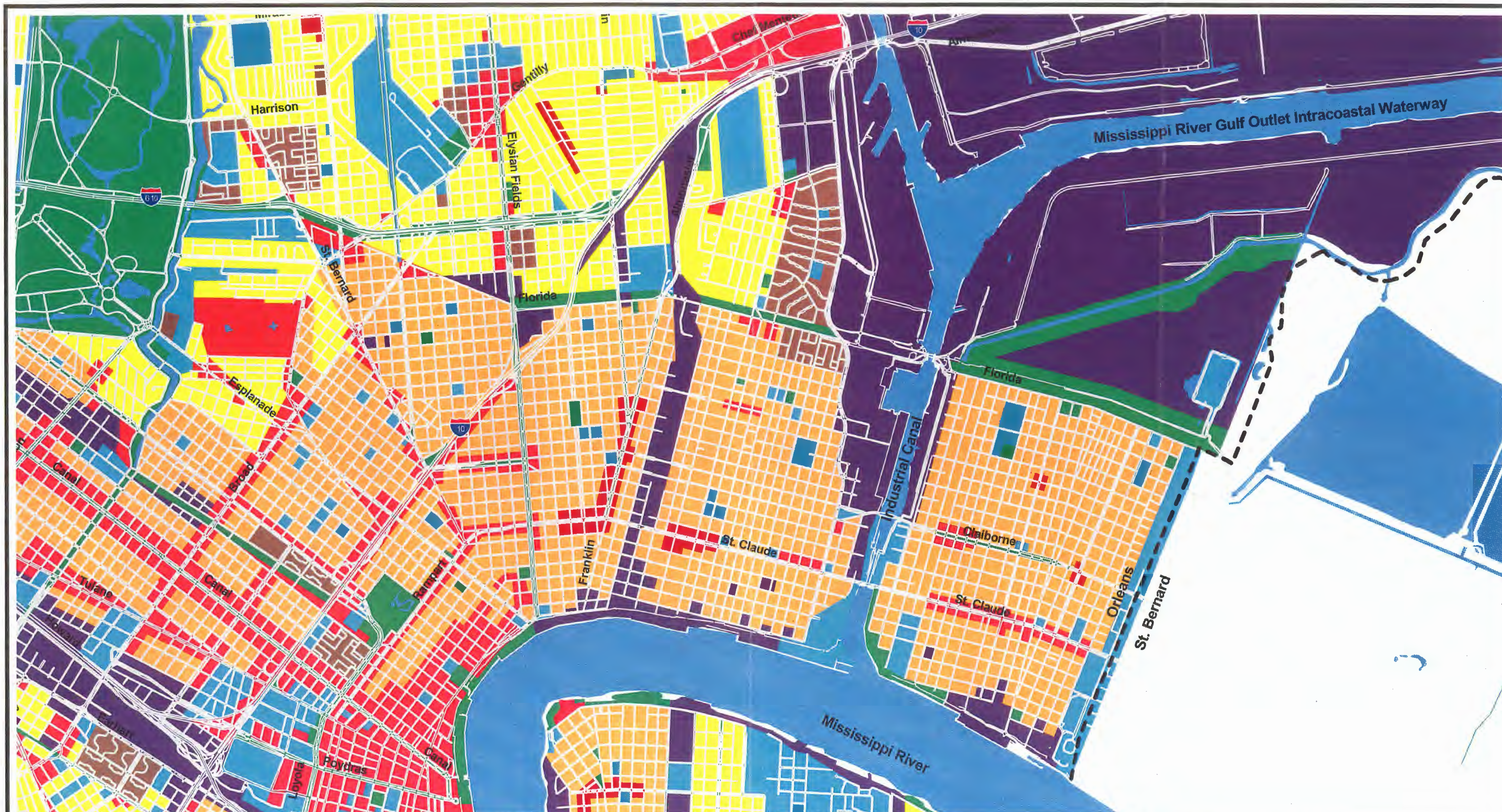

Legend

N

1 Inch = 1/2 Mile

- Single Family Residential
- Residential/Commercial
- Multi Family Residential
- Commercial
- Wetland
- Recreational
- Public
- Industrial
- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Existing Land Use
Ninth Ward

Figure 2-6

Location
By Council District

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

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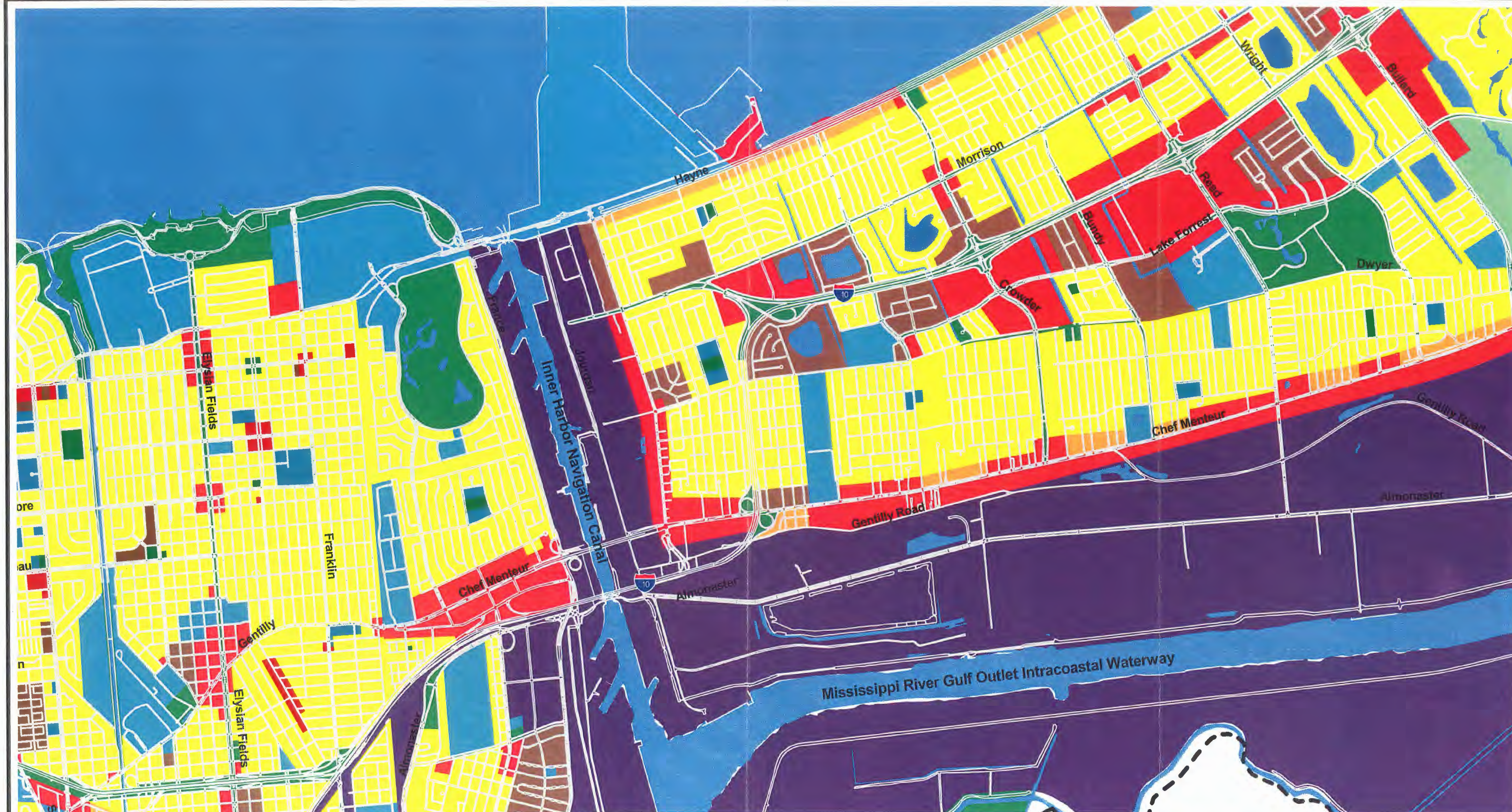

Legend

N

1 Inch = 1/2 Mile

Single Family Residential	Recreational	Water Body
Residential/Commercial	Public	
Multi Family Residential	Industrial	
Commercial	Parish Boundary	
Wetland	Street	

Water Distribution System
Assessment and Hydraulic Model

Existing Land Use
New Orleans East

Figure 2-7

Location
By Council District

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

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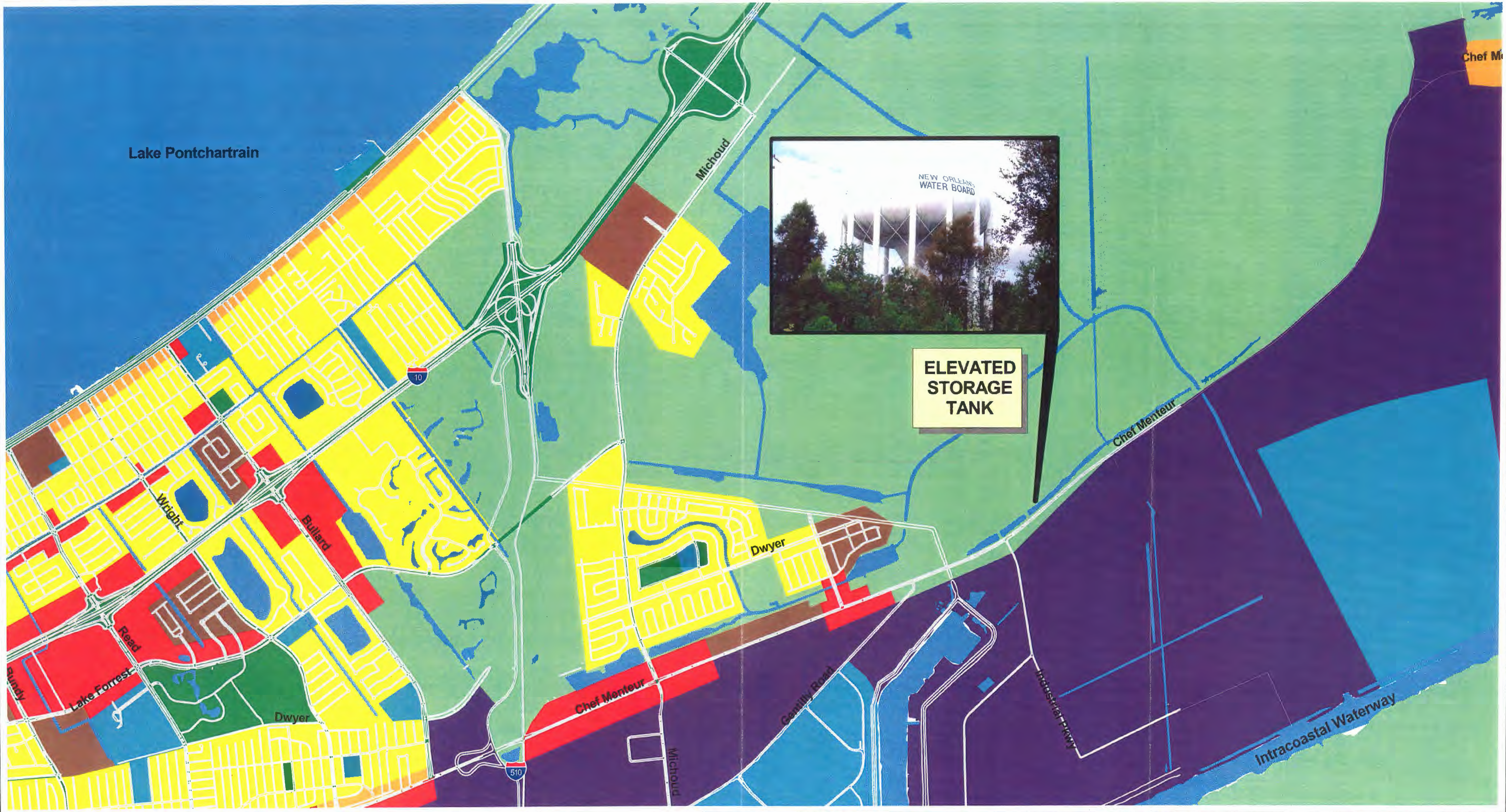

Legend

N

1 Inch = 1/2 Mile

- Single Family Residential
- Residential/Commercial
- Multi Family Residential
- Commercial
- Wetland
- Recreational
- Public
- Industrial
- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Existing Land Use
Chef Menteur

Figure 2-8

Location
By Council District

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

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Legend

N

1 Inch = 1/2 Mile

- Single Family Residential
- Residential/Commercial
- Multi Family Residential
- Commercial
- Wetland
- Recreational
- Public
- Industrial
- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Existing Land Use
Venetian Isles

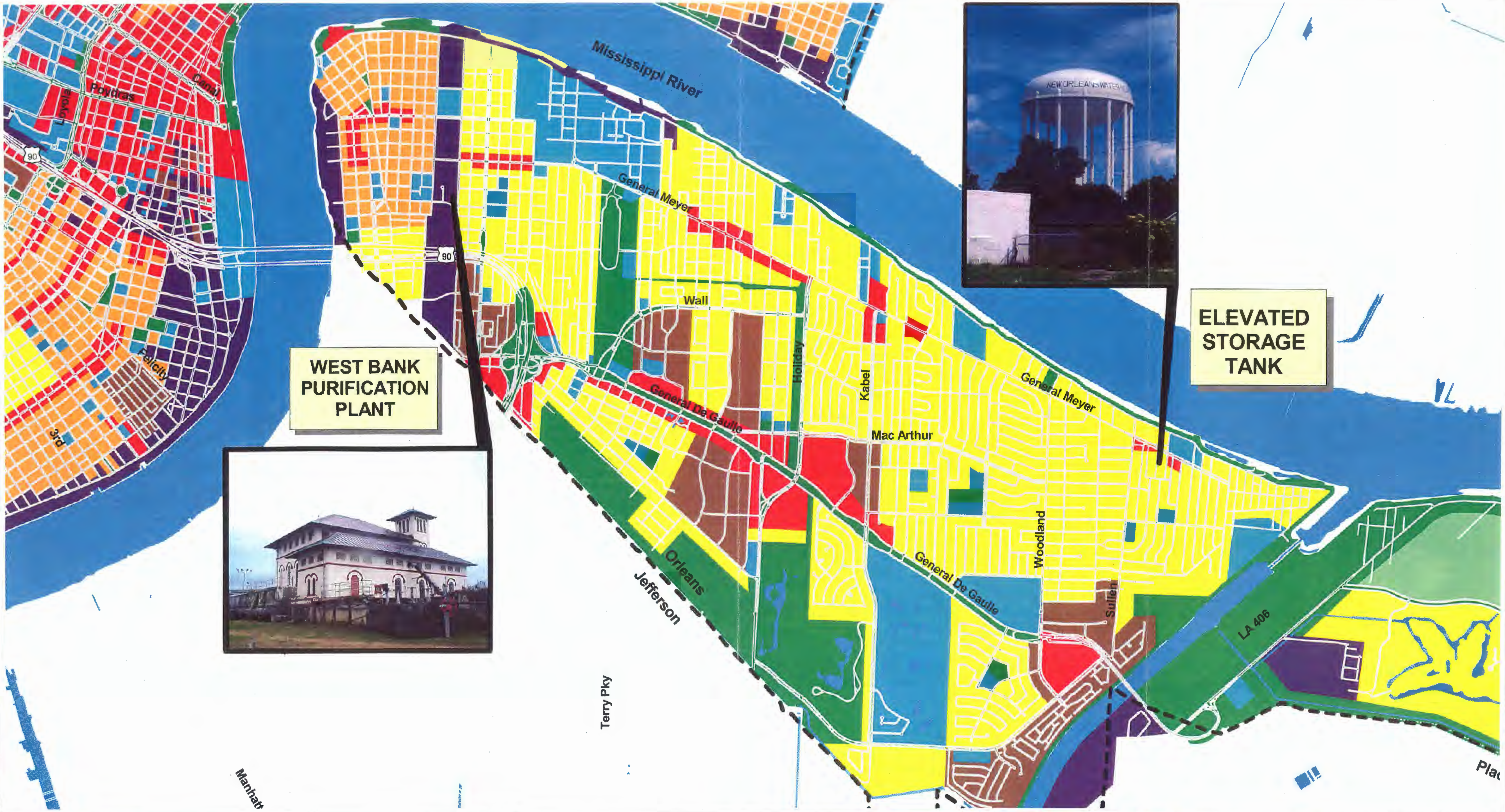
Figure 2-9

Location
By Council District

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

MWH



Legend

- Single Family Residential
- Residential/Commercial
- Multi Family Residential
- Commercial
- Wetland
- Recreational
- Public
- Industrial
- Parish Boundary
- Street
- Water Body

N

1 Inch = 1/2 Mile

Water Distribution System Assessment and Hydraulic Model

Existing Land Use
Algiers

Figure 2-10

Location
By Council District

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

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Legend

N

1 Inch = 1/2 Mile

- Single Family Residential
- Residential/Commercial
- Multi Family Residential
- Commercial
- Wetland
- Recreational
- Public
- Industrial
- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Existing Land Use
Lower Coast

Figure 2-11

Location
By Council District

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

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Table 2-1
Land Use of Developed Area
East Bank

Land Use Category	Area (acres)	Percent of Total Area	Area Developed (acres)	Percent of Developed Area	Developed Area as Percent of Total Area
Industrial	16,700	29 %	4,700	13 %	8 %
Single Family Residential	13,300	23 %	12,900	36 %	22 %
Residential/ Commercial	7,100	12 %	7,100	20 %	12 %
Recreational	6,100	11 %	2,300	6 %	4 %
Public	6,000	10 %	3,700	10 %	6 %
Commercial	4,300	7 %	3,900	11 %	7 %
Residential/ Marine	3,200	6 %	100	<1 %	<1 %
Multi-Family Residential	1,400	2 %	1,300	4 %	2 %
Total	**58,100**	**100 %**	**36,000**	**100 %**	**62 %**

Note:
1 – Land use excluding wetlands

Approximately 66 percent of the developable land area on the West Bank is currently developed (including fully developed, re-developed, and partially developed areas). Single family residential areas comprise approximately 45 percent of the total land area on the West Bank and more than 50 percent of single family residential areas are developed. Of the developed area on the West Bank the majority, over 80 percent, is zoned as either single family residential, recreational, public, or multi-family residential.

Table 2-2
Land Use of Developed Area
West Bank

Land Use Category	Area (acres)	Percent of Total Area	Area Developed (acres)	Percent of Developed Area	Developed Area as Percent of Total Area
Single Family Residential	4,200	45 %	3,200	53 %	34 %
Recreational	2,600	28 %	600	10 %	7 %
Public	800	9 %	600	10 %	7 %
Multi-Family Residential	600	7 %	600	10 %	7 %
Commercial	400	4 %	400	6 %	4 %
Industrial	400	4 %	400	6 %	4 %
Residential/ Commercial	300	3 %	300	5 %	3 %
Residential/ Marine	0	0 %	0	0 %	0 %
Total	**9,300**	**100 %**	**6,100**	**100 %**	**66 %**

Note:
1 – Land use excluding wetlands

2.4 CURRENT POPULATION AND FUTURE POPULATION PROJECTION

In order to identify the future water demand, the population and development growth was determined for the city. According to the 2000 U.S. Census, the overall population of New Orleans is 484,700. The population density for the area is estimated by the U.S. Census to be 2,700 people per square mile with 1,200 housing units. The majority of the area has been developed and there is not much land available for new development. For this reason, the city is not expected to have a significant increase in population over the next twenty years. The population projection for the year 2020 is reported by the Louisiana Population Data Center (of Louisiana State University, Department of Sociology) as 524,000.

2.5 EXISTING AND FUTURE DEVELOPMENTS

In order to accurately model the water distribution system with future demand conditions, it was important to understand the potential for growth and change that may occur. Future growth projections for New Orleans were based on a year 2025 planning horizon. MWH conducted meetings, in conjunction with the SSERP, with city departments to characterize plans for development and new construction within the study area. A key source of information was the 1999 Land Use Plan produced by the New Orleans City Planning Commission. This Plan outlines the types of land use in the area and highlights key future developments.

Information was also more recently obtained during the refinement of the Central Business District/French Quarter/Warehouse District (CBD/FQ/WD) sewer model extension. A complete coverage of future development and redevelopment locations was obtained through meetings with local agencies and organizations to gather information on any known future growth plans specifically within the CBD/FQ/WD basin. Listed below are the groups that were contacted as part of this effort followed by the results of these contacts and meetings, including explanations of information received.

- Canizaro Group (River 2000 Project)
- City Planning Commission
- Convention Center
- Downtown Development District (DDD)
- Housing Authority of New Orleans (HANO)
- New Orleans Medical Complex (NOMC)
- Office of Safety and Permits
- Regional Planning Commission
- Vieux Carré Commission (VCC)
- World Trade Center (WTC) Building Hotel Development

Canizaro Group (River 2000 Project)

Representatives from the Canizaro Group provided information on proposed future developments for the River 2000 Project. Details included amount of development, land use, and projected implementation schedule for the area bounded by Annunciation Street, the Crescent City Connection, the Mississippi River, and Race Street.

City Planning Commission of New Orleans

Representatives from the City Planning Commission of New Orleans were interviewed on projecting future flows for the CBD/FQ/WD basin. In addition to providing information from the City Planning Commission, they also obtained and provided information from the DDD and the City's Office of Safety and Permits.

The provided information included detailed maps showing development along Canal Street, current spreadsheets from the DDD listing all known projects within the CBD/FQ/WD area and spreadsheets from the Office of Safety and Permits listing permit applications.

Convention Center

The Convention Center was contacted to determine any plans for expansion or development. Representatives referred MWH to Schrenk and Peterson Consulting Engineers, Inc., which serves as the consultant for the Convention Center.

Schrenk and Peterson Consulting Engineers, Inc. was contacted concerning the proposed layout and development of the Phase IV Convention Center expansion and related local developments. Information was provided on the size and location of the Convention Center expansion and a related major hotel to be built as part of the development. Current plans call for the construction of an additional 1.5 million square feet of convention center floor space as well as a 1,250-room hotel.

Downtown Development District (DDD)

Information concerning existing, proposed, and future development was obtained from the DDD via the City Planning Commission. The information included an extensive spreadsheet that identified specific projects, such as new hotels and condominiums along with their estimated size (i.e., number of rooms or condominium units) and timeframe for implementation.

Housing Authority of New Orleans (HANO)

A meeting was conducted with HANO to review future development impacts on the water distribution and sewerage systems. HANO advised that they currently have plans that will result in the de-densification of five present housing developments in the city. The plan is part of a multi-phase program to comply with directions from the Department of Housing and Urban Development (HUD).

The main impact this plan has is due to the demolition of the St. Thomas Housing Development, bounded by Felicity Street, Laurel Street, Josephine Street and Tchoupitoulas Street. The demolition of this housing development and subsequent development of fewer single family and multi family residential units will result in a significant decrease in the water demand from this area.

New Orleans Medical Complex (NOMC)

The NOMC includes representatives from Tulane University Health Sciences Center, LSU Health Sciences Center, and Finnin & Associates, Inc. (consultant to the New Orleans Medical Complex). A meeting with NOMC representatives provided information on the development of numerous future facilities that are planned within the complex. The NOMC has created a Master Plan to define the existing complex facilities and to describe future plans for the complex. The NOMC representatives provided information on the size and use of each proposed facility.

The information obtained included figures from the most recent NOMC Master Plan update showing existing and proposed future facilities within the complex. In addition, an excerpt was included from the NOMC Master Plan that describes each of the proposed facilities. Some of the more significant proposed facilities included a hotel with a conference center and meeting space and several new wet labs that tend to be large water consumers.

Office of Safety and Permits

A complete listing of all available permit applications received from 1999 through 2001 was obtained from the Office of Safety and Permits via the City Planning Commission. The information obtained was similar to the spreadsheet from the DDD that identified specific projects, such as new hotels and condominiums along with their estimated size and timeframe for implementation.

Regional Planning Commission

Information collected from the Regional Planning Commission provided projections of future land use throughout the City of New Orleans.

Vieux Carré Commission (VCC)

The VCC, which focuses on development within the French Quarter, was interviewed about any known developments within their jurisdiction. The VCC indicated that the majority of projects they track within the French Quarter are very minor in scope, such as the remodeling of residential dwellings. They indicated no foreseeable new development or redevelopment in the French Quarter that would be classified as a major future water consumer.

World Trade Center (WTC) Building Hotel Development

There is currently a plan to convert the WTC Building from commercial office space to a hotel development. Specific information regarding the extent of development and building plumbing plans was acquired during an interview with the WTC Facility & Security Manager. Floors one through seventeen 17 are anticipated to be converted to a hotel, resulting in approximately 300 rooms.

2.5.1 Development Status

With the development information received from the agencies listed above, land areas were delineated and identified as one of the categories defined below. The development categories identify which land areas would expect an increase in water demand with new or re-development and those land areas with no predicted change in water demand that are fully developed. Land area characterizations were accomplished by using aerial photography to determine the amount of vacant land available for development and performing site visits to check possible development. The land areas were characterized as follows:

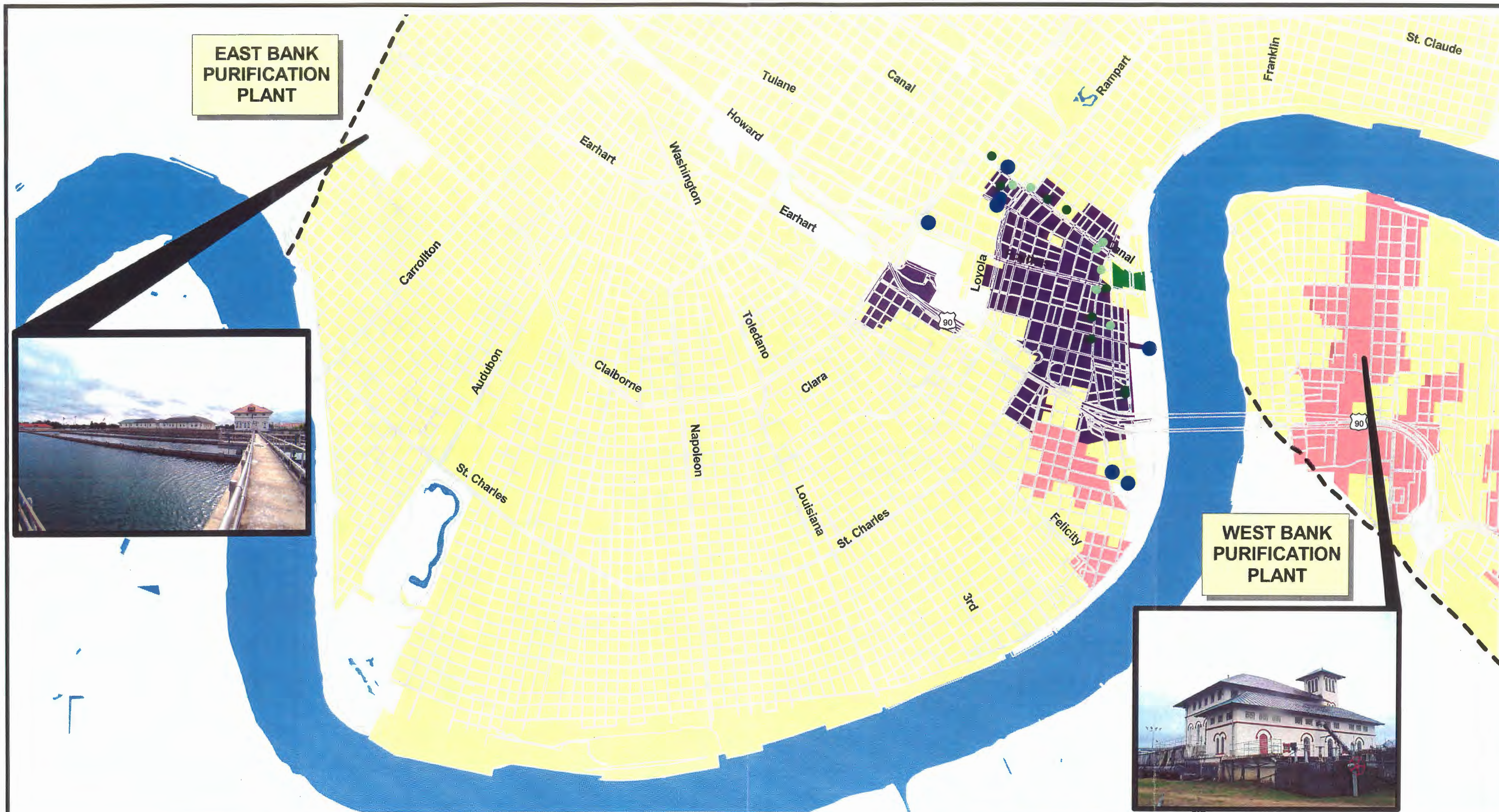
- **Full Development:** Land area is fully developed and no change in either development or water demand is expected.
- **Re-Development:** Land area where new development is planned to replace the existing development. Potential change in water demand can be expected.

- **Partial Development:** Existing development is a percentage of the land area and a portion of the area is available for new development. Potential increase in water demand can be expected.
- **New Development:** Construction of new development in a land area that is currently not developed. Increase in water demand is expected.
- **No Development:** No existing development in a land area and no development expected in the future. No increase in water demand is expected.

The characterized land areas were then plotted in ArcView to identify where the future development projects were likely to occur in relation to the existing water distribution system. **Figures 2-12** through **2-19** show the existing land use areas by the development status along with the projected flow from future water consumers. Two areas on the East Bank were identified as predominant areas for new and re-development and four areas were identified on the West Bank for new or partial development:

- Land area east of Industrial Canal (East Bank)
- Central Business District/French Quarter (East Bank)
- Land adjacent to the Intracoastal Waterway (West Bank)
- Algiers Point (West Bank)
- English Turn (West Bank)
- Garden Oaks (West Bank)

Based on the future population and development expected in the service areas, future water demand was estimated. The future water demands estimated for the planning year 2025 are discussed in **Section 3**.



Legend

- New Development
- Re-Development
- Partial Development
- Full Development
- Parish Boundary
- Street
- Water Body
- 100,000 - 300,000 Gal/Day
- 10,000 - 100,000 Gal/Day
- 0 - 10,000 Gal/Day

N

1 Inch = 1/2 Mile

Water Distribution System
Assessment and Hydraulic Model

Future Water Consumers & Future Development
Uptown
Figure 2-12

Location
By Council District

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

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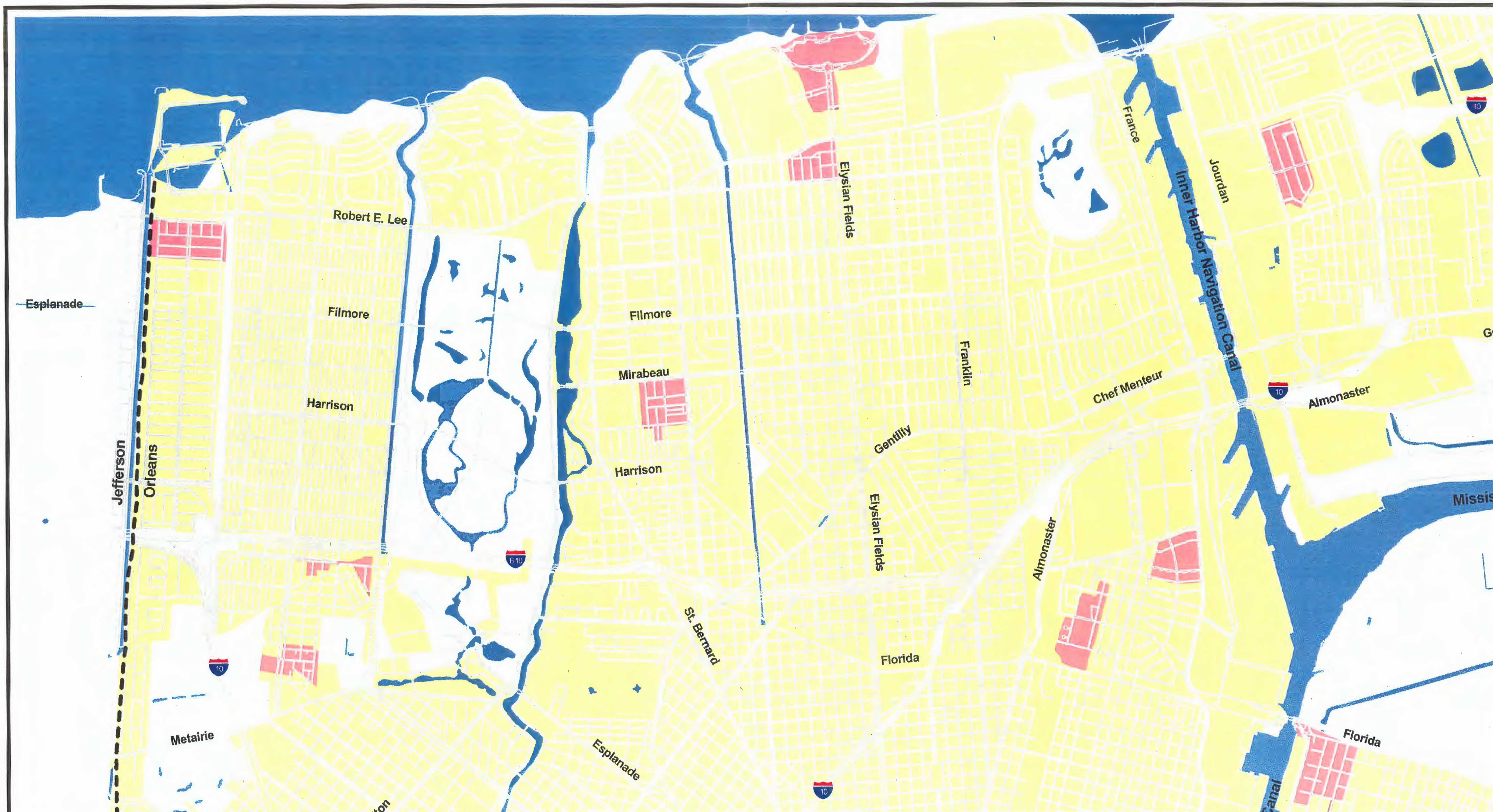


Legend

N

1 Inch = 1/2 Mile

New Development	Street
Re-Development	Water Body
Partial Development	100,000 - 300,000 Gal/Day
Full Development	10,000 - 100,000 Gal/Day
Parish Boundary	0 - 10,000 Gal/Day

Water Distribution System
Assessment and Hydraulic Model

Future Water Consumers & Future Development Lakefront

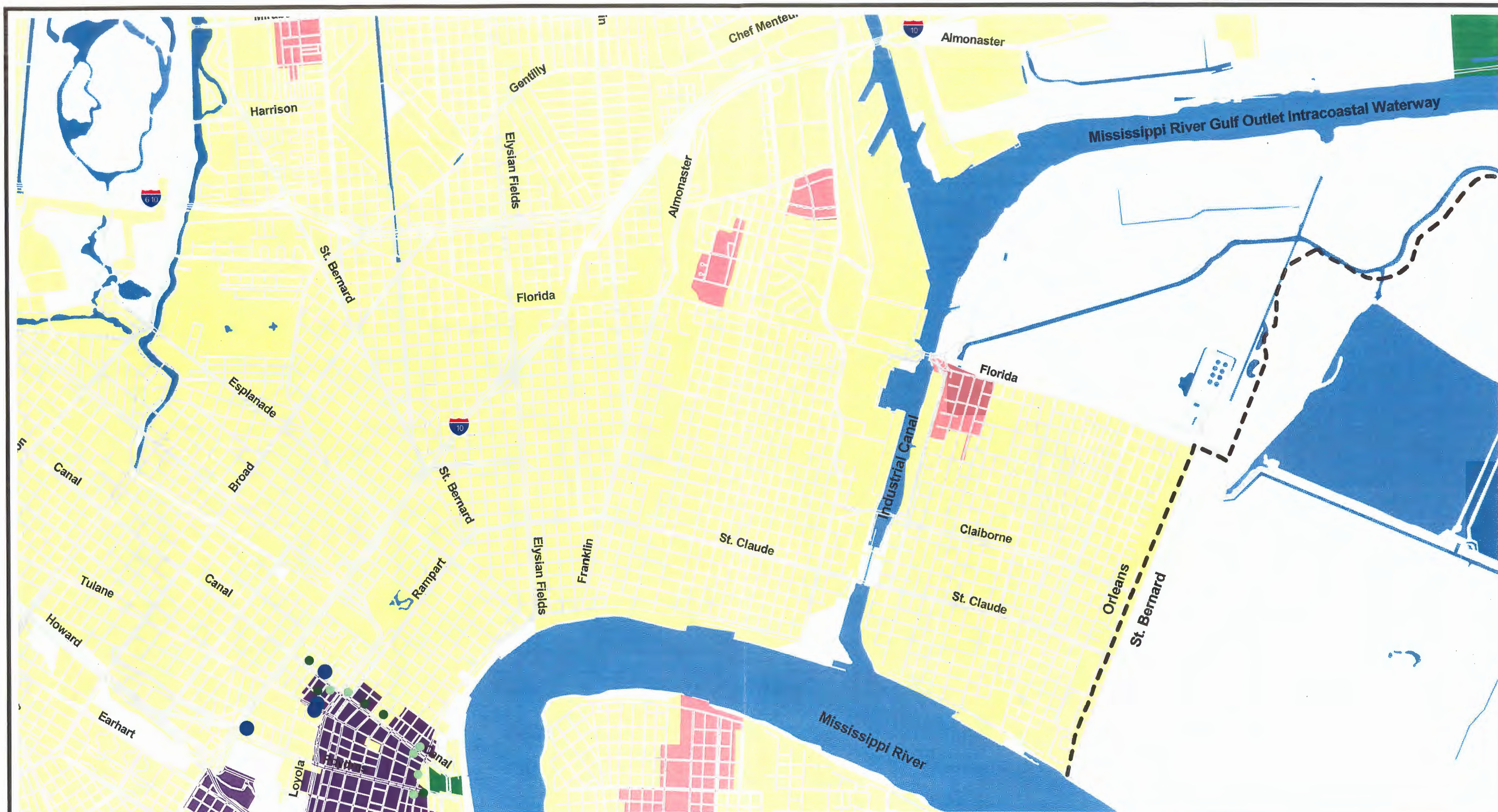
Figure 2-13

Location
By Council District

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

MWH



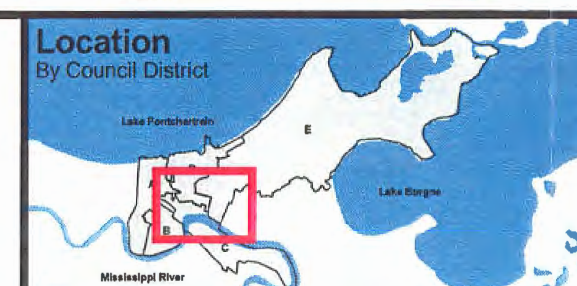
Legend

N	New Development	Street	
1 Inch = 1/2 Mile	Re-Development	Water Body	
	Partial Development	100,000 - 300,000 Gal/Day	
	Full Development	10,000 - 100,000 Gal/Day	
	Parish Boundary	0 - 10,000 Gal/Day	

Water Distribution System
Assessment and Hydraulic Model

Future Water Consumers & Future Development
Ninth Ward
Figure 2-14

Location
By Council District



"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"
Sewerage & Water Board OF NEW ORLEANS

MWH

Legend

N

1 Inch = 1/2 Mile

New Development
Re-Development
Partial Development
Full Development
Parish Boundary

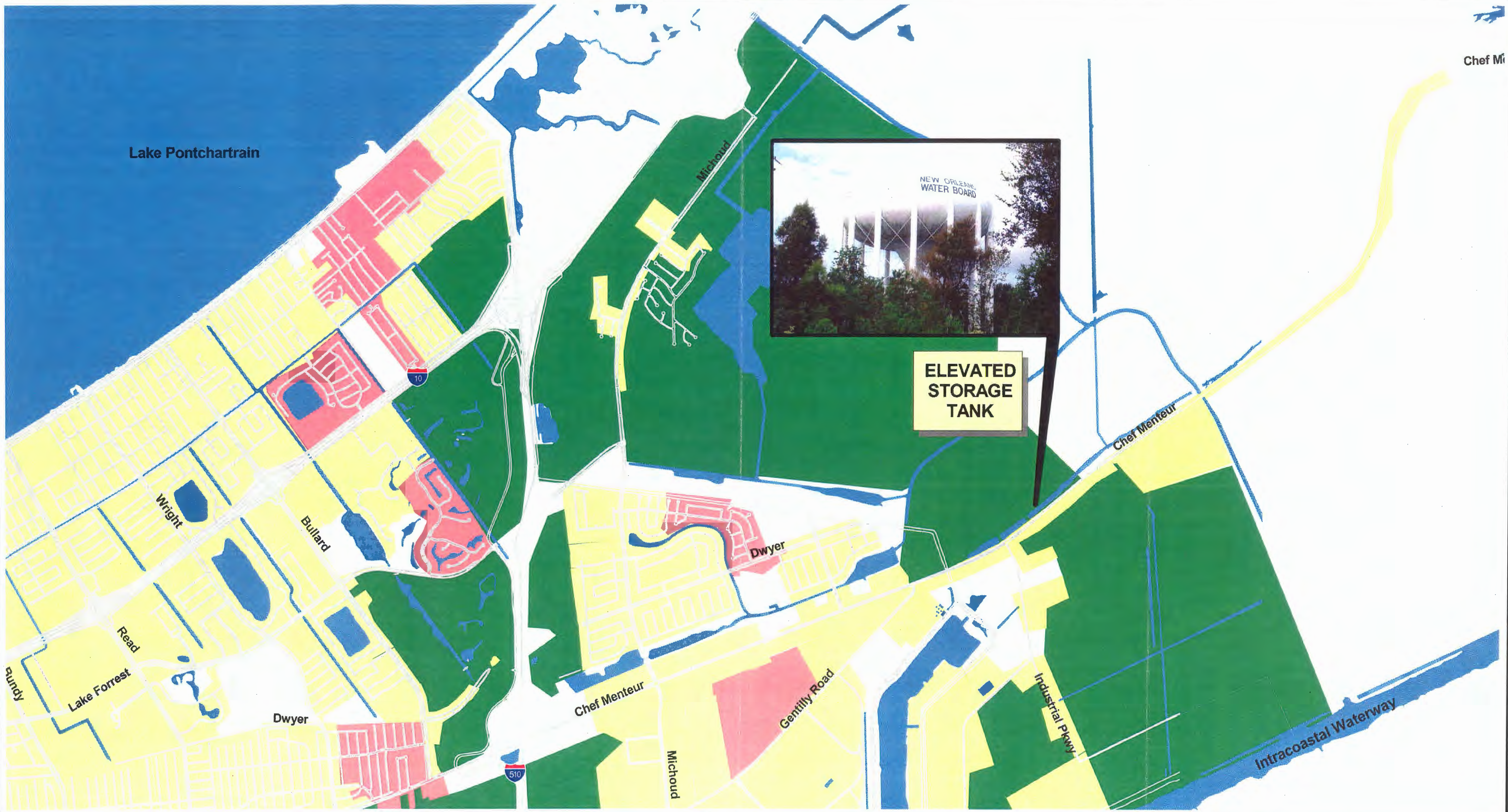
Street
Water Body
100,000 - 300,000 Gal/Day
10,000 - 100,000 Gal/Day
0 - 10,000 Gal/Day

Water Distribution System
Assessment and Hydraulic Model
Future Water Consumers
& Future Development
New Orleans East
Figure 2-15

Location
By Council District

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"
Sewerage & Water Board OF NEW ORLEANS

MWH



Legend

N

1 Inch = 1/2 Mile

- New Development
- Re-Development
- Partial Development
- Full Development
- Parish Boundary
- Street
- Water Body
- 100,000 - 300,000 Gal/Day
- 10,000 - 100,000 Gal/Day
- 0 - 10,000 Gal/Day

Water Distribution System
Assessment and Hydraulic Model

Future Water Consumers
& Future Development
Chef Menteur

Figure 2-16

Location
By Council District

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board of New Orleans

MWH

Legend

N

1 Inch = 1/2 Mile

- New Development
- Re-Development
- Partial Development
- Full Development
- Parish Boundary
- Street
- Water Body
- 100,000 - 300,000 Gal/Day
- 10,000 - 100,000 Gal/Day
- 0 - 10,000 Gal/Day

Water Distribution System
Assessment and Hydraulic Model

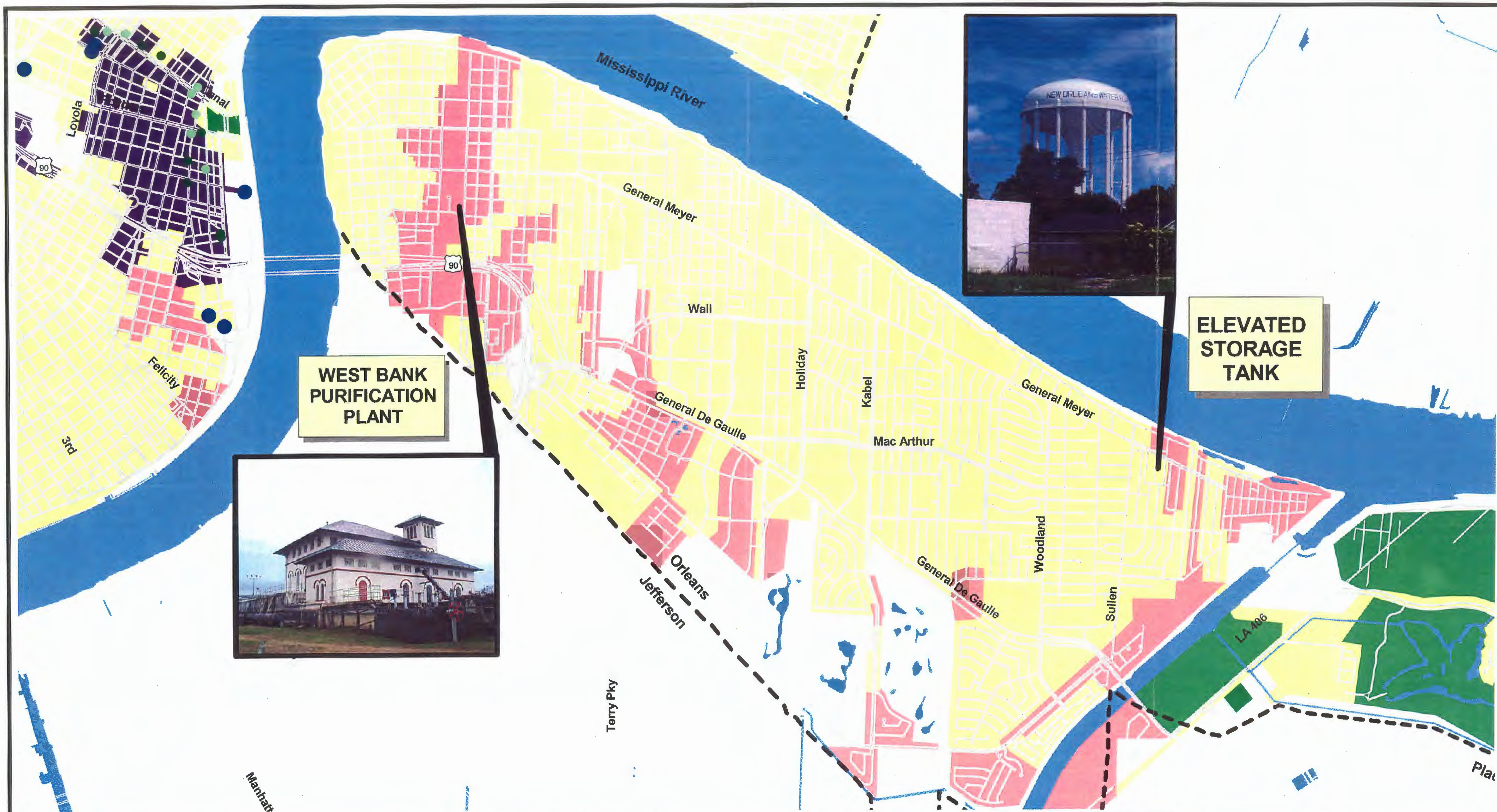
Future Water Consumers
& Future Development
Venetian Isles

Figure 2-17

Location
By Council District

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"
Sewerage & Water Board OF NEW ORLEANS

MWH



Legend

N

1 Inch = 1/2 Mile

- New Development
- Re-Development
- Partial Development
- Full Development
- Parish Boundary
- Street
- Water Body
- 100,000 - 300,000 Gal/Day
- 10,000 - 100,000 Gal/Day
- 0 - 10,000 Gal/Day

Water Distribution System
Assessment and Hydraulic Model

Future Water Consumers & Future Development Algiers

Figure 2-18

Location
By Council District

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

MWH

Legend

N	New Development	Street	
1 Inch = 1/2 Mile	Re-Development	Water Body	
	Partial Development	100,000 - 300,000 Gal/Day	
	Full Development	10,000 - 100,000 Gal/Day	
	Parish Boundary	0 - 10,000 Gal/Day	

Water Distribution System
Assessment and Hydraulic Model

Future Water Consumers
& Future Development
Lower Coast

Figure 2-19

Location
By Council District

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

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Section 3

Section 3

MWH

Section 3 – System Characterization

3.1 DESCRIPTION OF DISTRIBUTION SYSTEMS

This section describes the existing system facilities and provides an understanding of existing system operations. All references and sources of data for the system characterization are listed in **Appendix A**.

There are two completely separate water distribution systems operated by the S&WB; one serves the population on the East Bank of the Mississippi River and one serves the West Bank. Beginning in 1899, the water distribution system was developed on the East Bank, the most populated area of the city. The West Bank distribution system dates back to 1906, and both systems have evolved through many additions and improvements. The existing facilities are listed according to distribution system in **Table 3-1**. Each system consists of a purification plant, multiple ground-level storage tanks, pumping stations at the purification plant, water transmission and distribution mains, and an elevated storage tank. **Figures 3-1** through **3-8** show the configuration of the distribution systems and depict the location of the existing facilities.

Table 3-1
Water Facilities by Distribution System

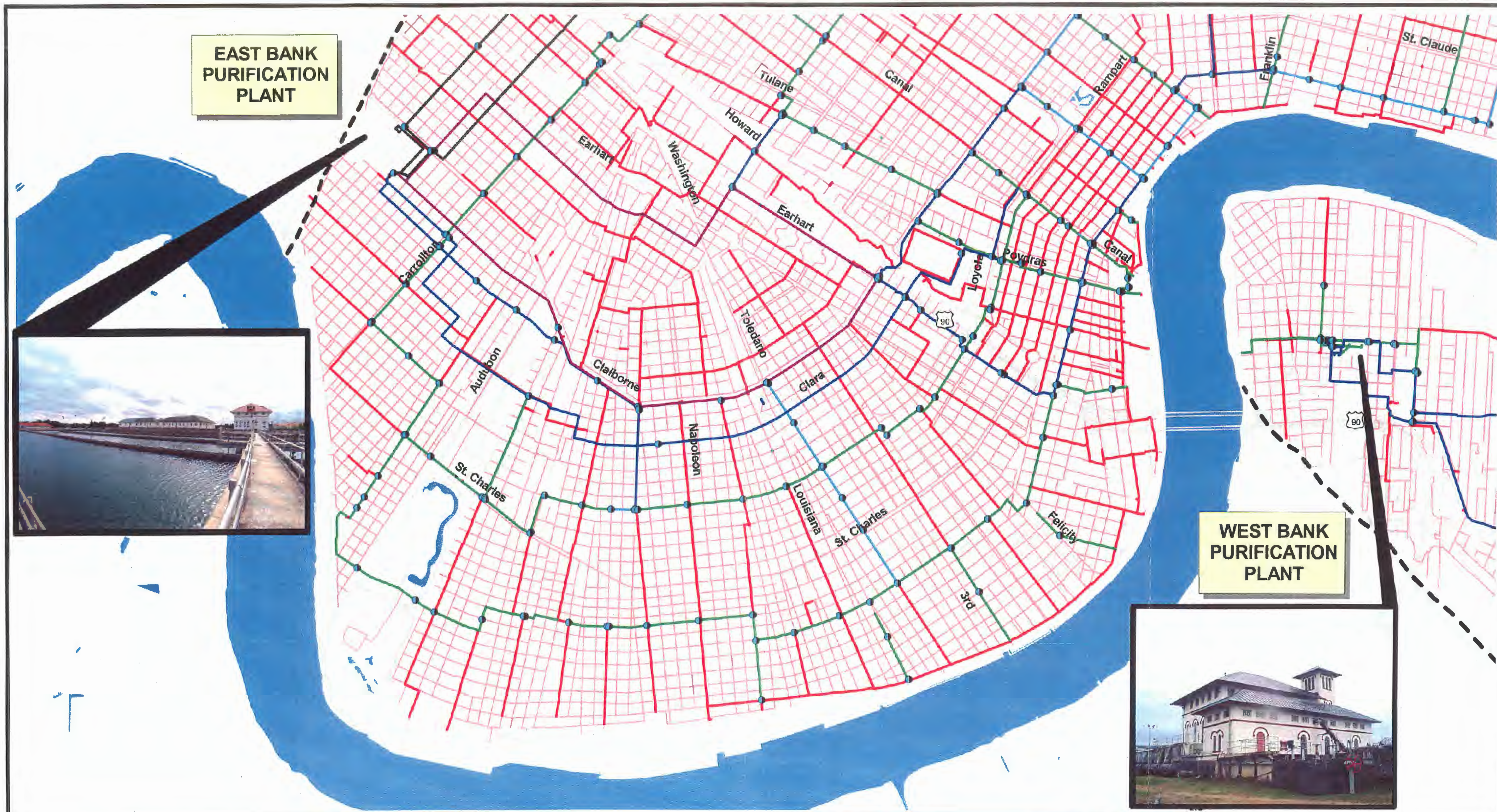
Facility Type	East Bank	West Bank
Water Purification Plant	1	1
Ground-Level Storage Tank	10	2
Elevated Storage Tank	1	1
Pipeline (miles)	1,334	195
Valve	12,600	1,700
Fire Hydrant	13,500	2,100
Pumping Station	3	2
Pump	8	10

Note:

1 – Data compiled from GIS and rounded to the nearest hundred for pipelines, valves, and hydrants

Five pumping stations maintained by the S&WB distribute water from the two water purification plants. Combined, the systems consist of over 1,500 miles of water transmission and distribution mains ranging in size from two inches to 54 inches in diameter. Water is delivered to approximately 160,000 residents, businesses, and industries on the East and West Banks.

The age of the East Bank system varies in age up to 100 years, and the age of the West Bank system varies up to 96 years. The actual expected life of the components of the distribution systems will depend on specific conditions such as pipe material, age, type of installation and soil conditions.



Legend

- Valve (16" & Larger)
- Diameter (> 50")
- Diameter (40" - 50")
- Diameter (30" - 40")
- Diameter (24" - 30")
- Diameter (16" - 24")
- Diameter (12" - 16")
- Diameter (0 - 12")
- Parish Boundary
- Street
- Water Body

N

1 Inch = 1/2 Mile

Water Distribution System
Assessment and Hydraulic Model

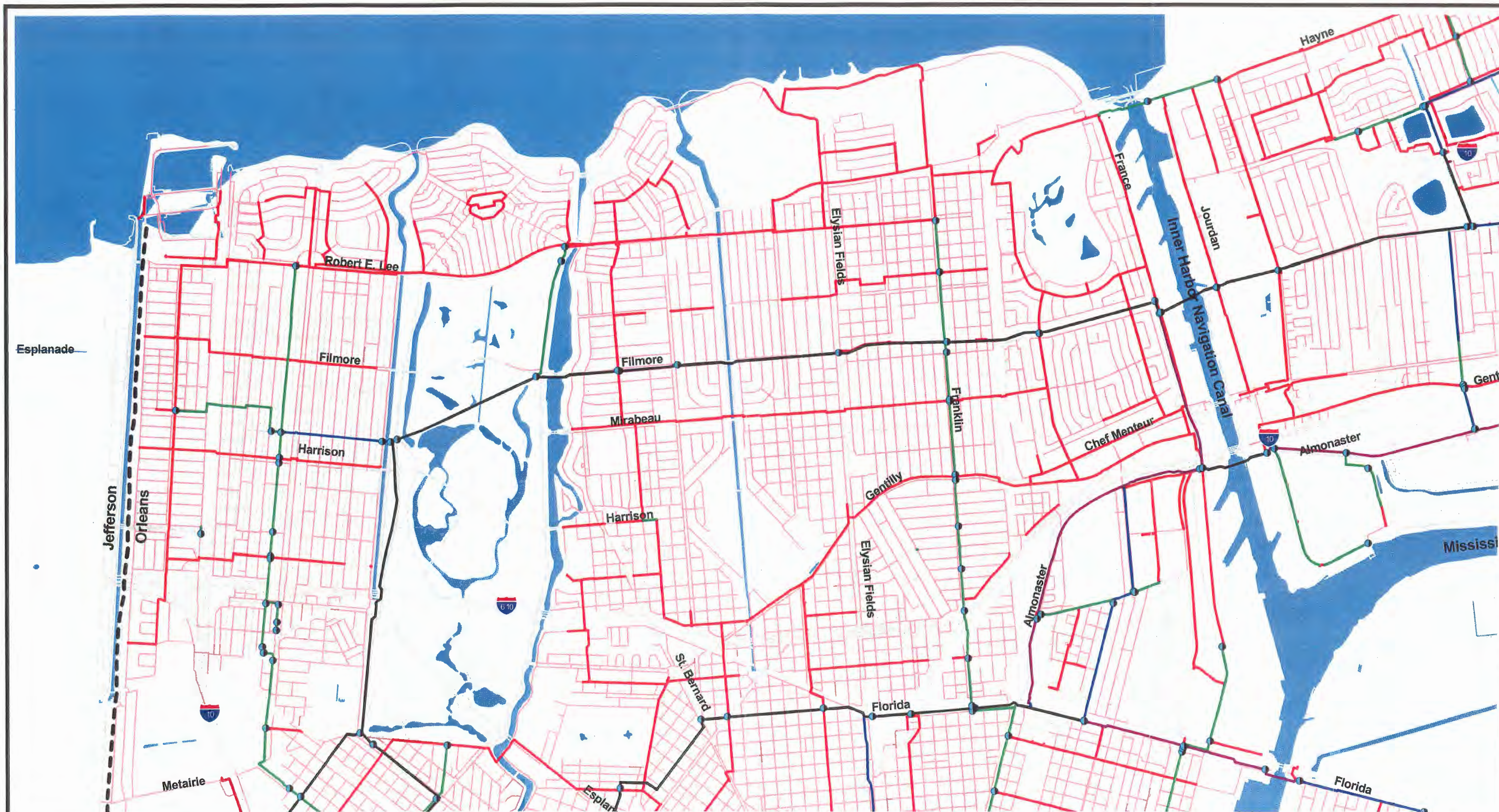
Distribution by Pipe Diameter
Uptown

Figure 3-1

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

MWH



Legend

N

1 Inch = 1/2 Mile

- Valve (16" & Larger)
- Diameter (> 50")
- Diameter (40" - 50")
- Diameter (30" - 40")
- Diameter (24" - 30")
- Diameter (16" - 24")
- Diameter (12" - 16")
- Diameter (0 - 12")
- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Distribution by Pipe Diameter
Lakefront

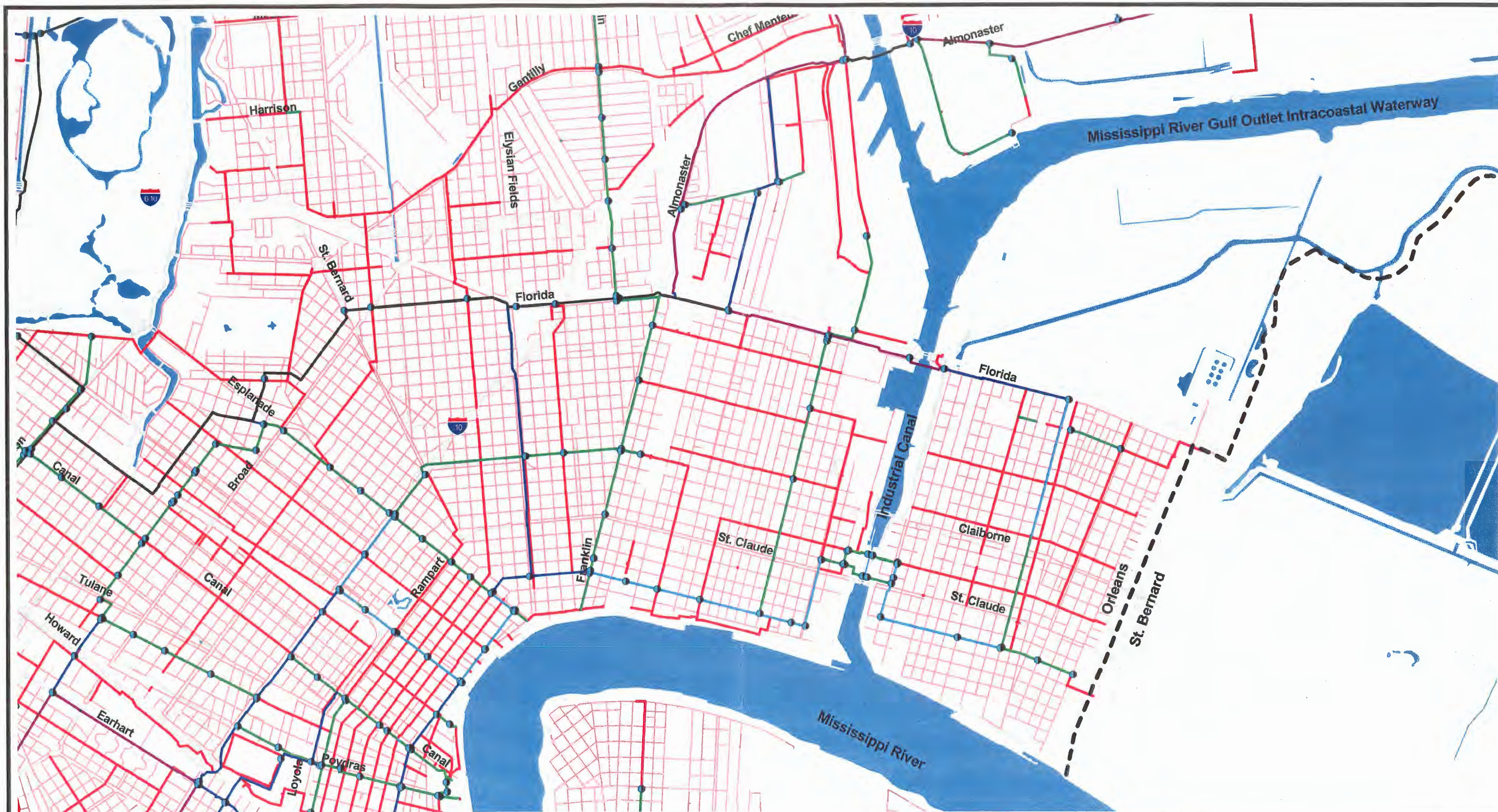
Figure 3-2

Location
By Council District

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

MWH



Legend

N

1 Inch = 1/2 Mile

- Valve (16" & Larger)
- Diameter (> 50")
- Diameter (40" - 50")
- Diameter (30" - 40")
- Diameter (24" - 30")
- Diameter (16" - 24")
- Diameter (12" - 16")
- Diameter (0 - 12")
- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Distribution by Pipe Diameter
Ninth Ward

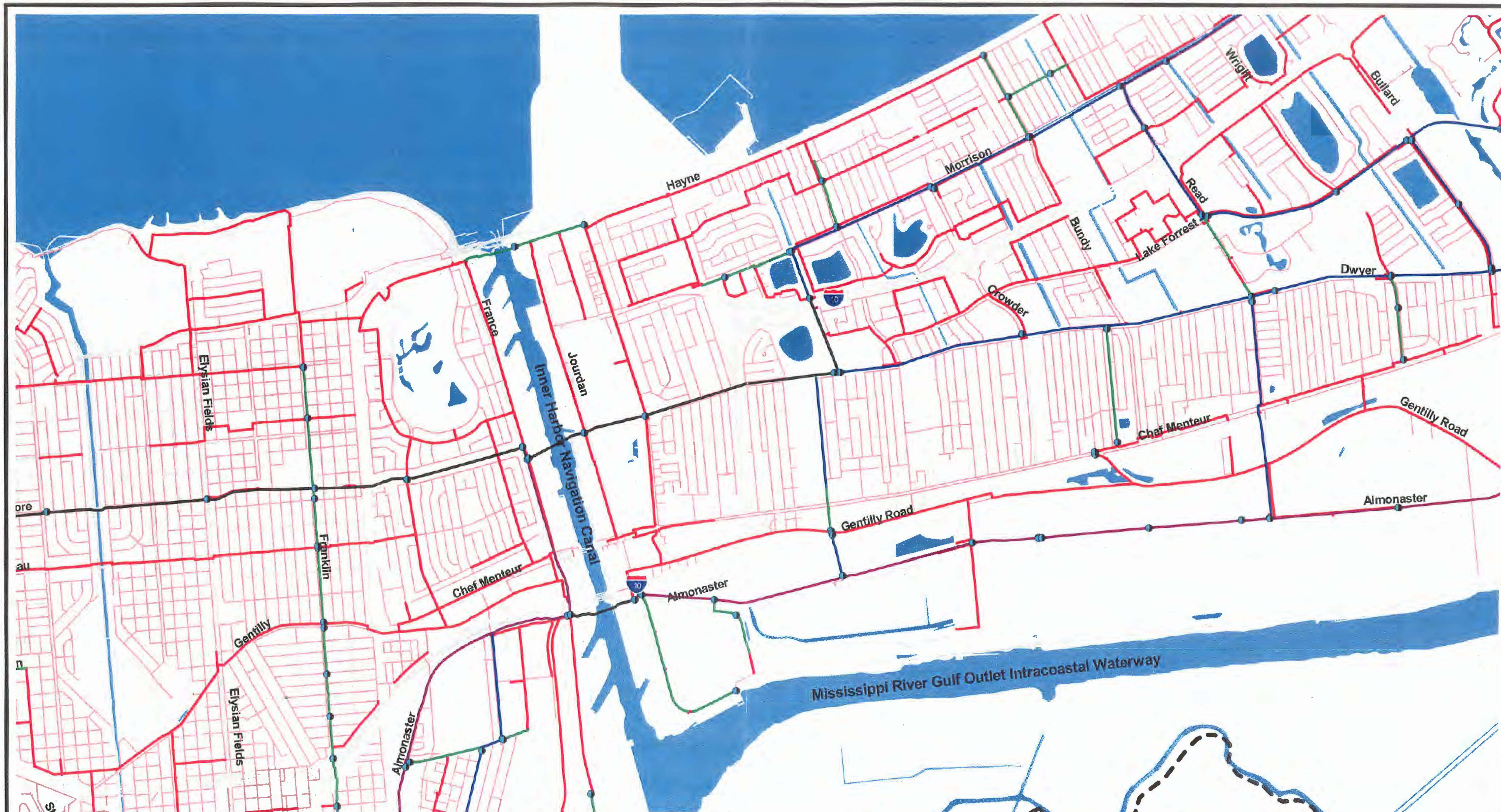
Figure 3-3

Location
By Council District

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

MWH



Legend

N

1 Inch = 1/2 Mile

- Valve (16" & Larger)
- Diameter (> 50")
- Diameter (40" - 50")
- Diameter (30" - 40")
- Diameter (24" - 30")
- Diameter (16" - 24")
- Diameter (12" - 16")
- Diameter (0 - 12")
- Parish Boundary
- Street
- Water Body

Water Distribution System Assessment and Hydraulic Model

Distribution by Pipe Diameter New Orleans East

Figure 3-4

Location
By Council District

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board *OF NEW ORLEANS*

MWH

Legend

N

1 Inch = 1/2 Mile

- Valve (16" & Larger)
- Diameter (> 50")
- Diameter (40" - 50")
- Diameter (30" - 40")
- Diameter (24" - 30")
- Diameter (16" - 24")
- Diameter (12" - 16")
- Diameter (0 - 12")
- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Distribution by Pipe Diameter
Chef Menteur

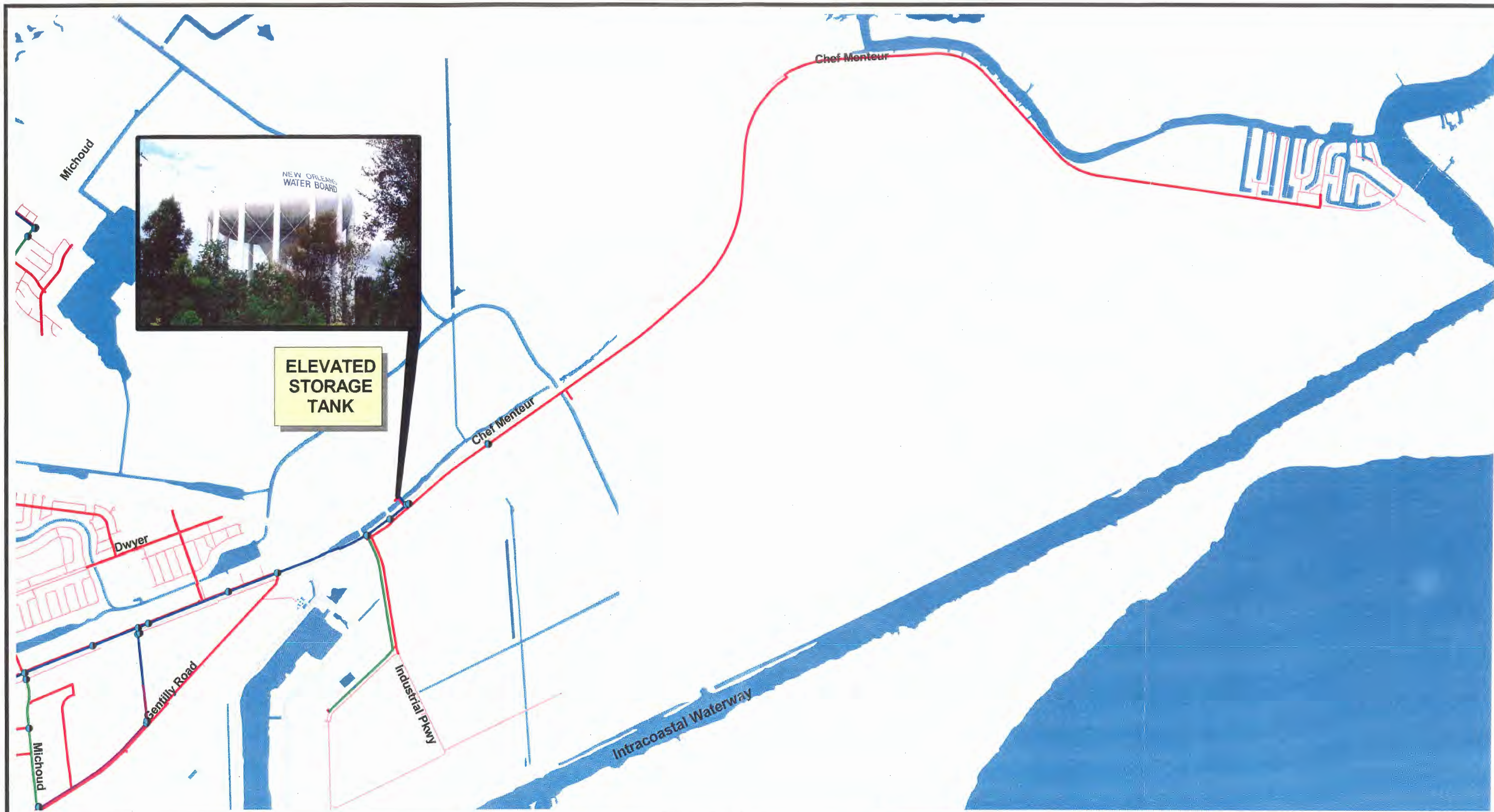
Figure 3-5

Location
By Council District

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

MWH



Legend

N

1 Inch = 1/2 Mile

- Valve (16" & Larger)
- Diameter (> 50")
- Diameter (40" - 50")
- Diameter (30" - 40")
- Diameter (24" - 30")
- Diameter (16" - 24")
- Diameter (12" - 16")
- Diameter (0 - 12")
- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Distribution by Pipe Diameter
Venetian Isles

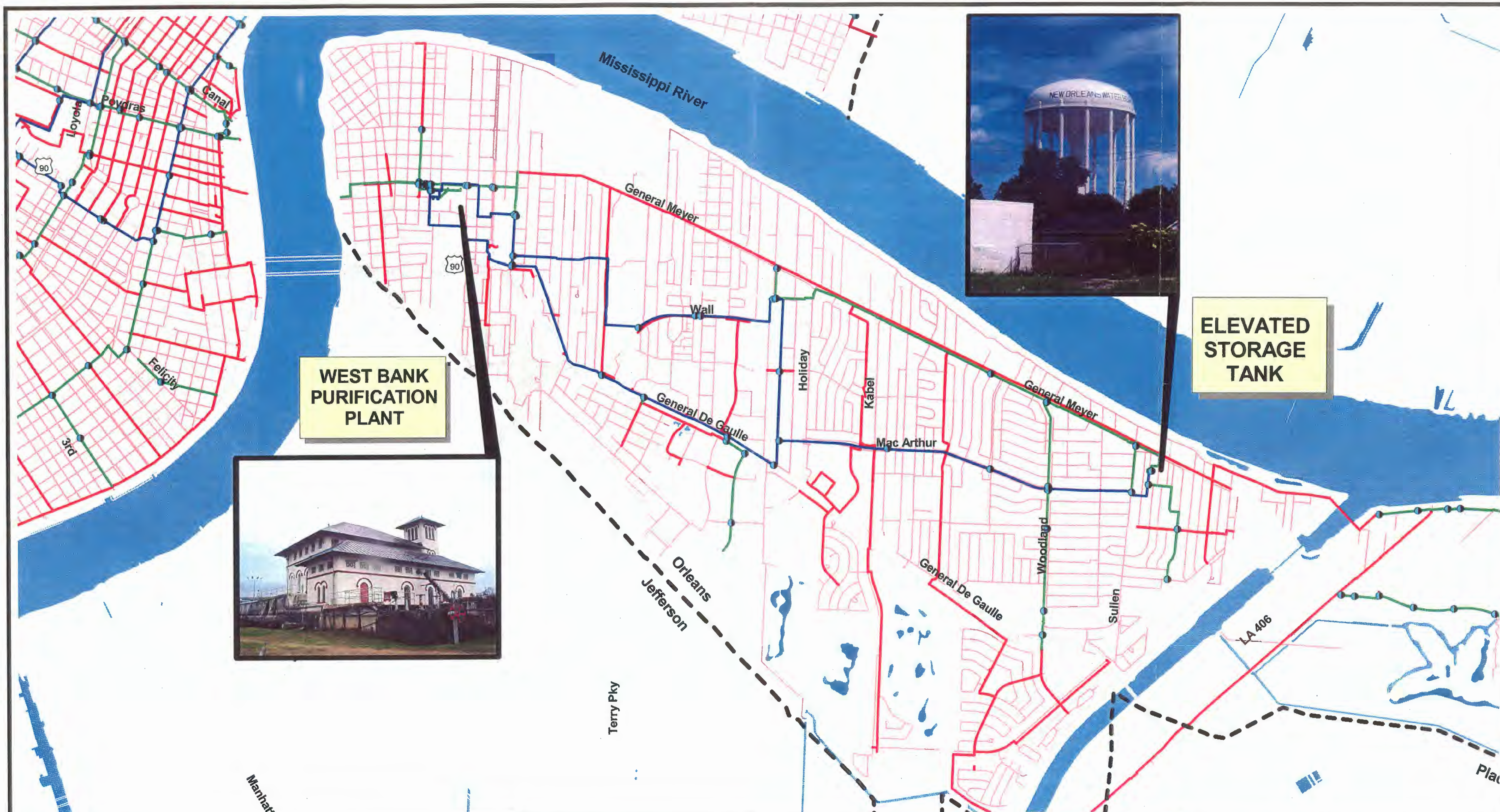
Figure 3-6

Location
By Council District

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

MWH



Legend

N

1 Inch = 1/2 Mile

- Valve (16" & Larger)
- Diameter (> 50")
- Diameter (40" - 50")
- Diameter (30" - 40")
- Diameter (24" - 30")
- Diameter (16" - 24")
- Diameter (12" - 16")
- Diameter (0 - 12")
- Parish Boundary
- Street
- Water Body

Water Distribution System Assessment and Hydraulic Model

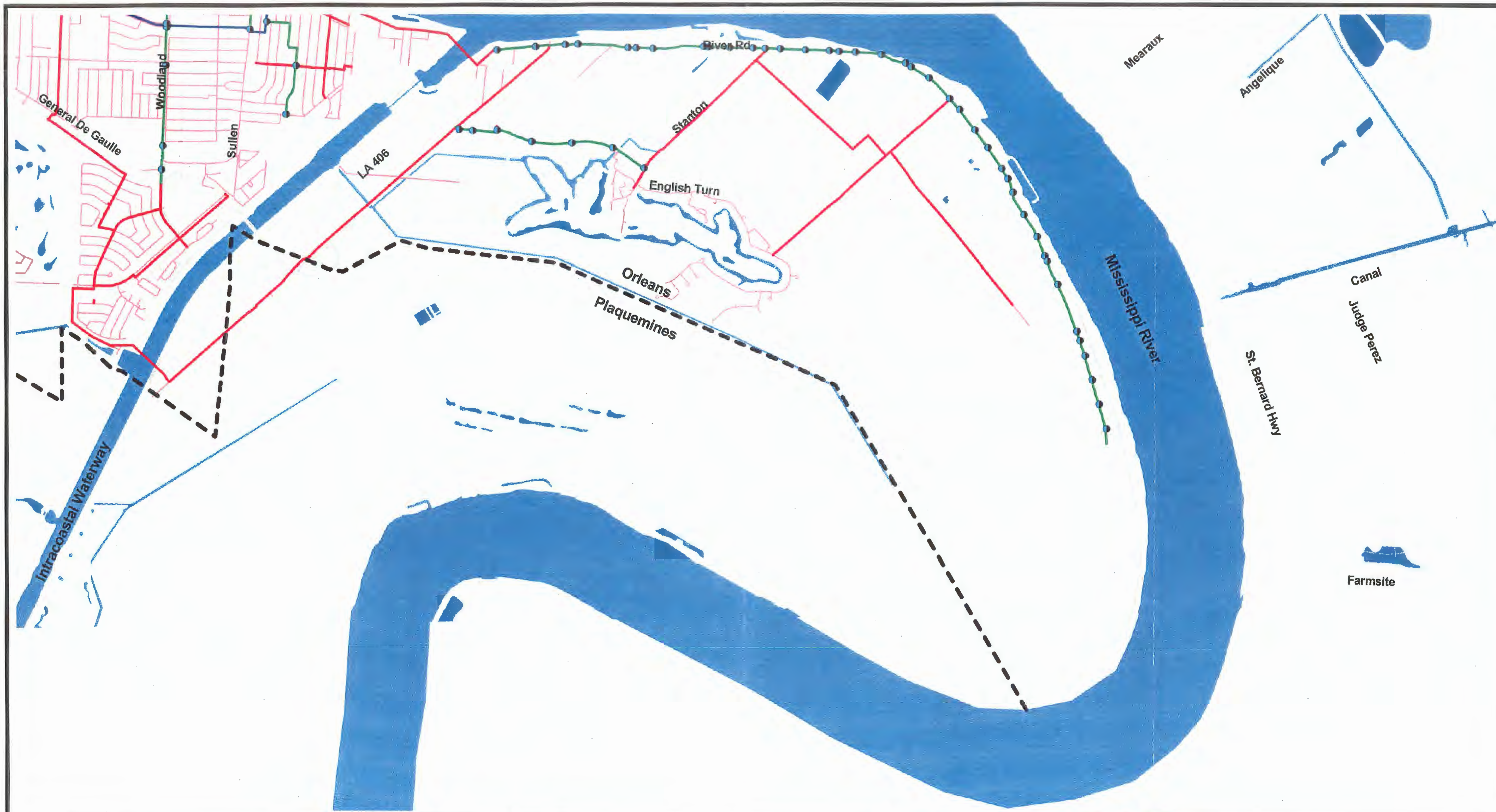
Distribution by Pipe Diameter Algiers

Figure 3-7

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

***Sewerage & Water Board** OF NEW ORLEANS*

MWH



Legend

N

1 Inch = 1/2 Mile

- Valve (16" & Larger)
- Diameter (> 50")
- Diameter (40" - 50")
- Diameter (30" - 40")
- Diameter (24" - 30")
- Diameter (16" - 24")
- Diameter (12" - 16")
- Diameter (0 - 12")
- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Distribution by Pipe Diameter
Lower Coast

Figure 3-8

Location
By Council District

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

MWH

3.1.1 Water Purification Plants

There are two purification plants that provide service to the East Bank system (Carrollton Water Purification Plant) and the West Bank system (Algiers Water Purification Plant). The Carrollton Plant is located in the Uptown area on Claiborne Avenue and Leonidas Street near the Jefferson and Orleans Parish boundary. In the past five years, the secondary settling basins at the Carrollton Plant have been rehabilitated. According to the S&WB staff, the Carrollton Plant has a design treatment capacity and hydraulic capacity of 232 million gallons per day (MGD).

The Algiers Plant is located in Algiers Point on Diana Street and Elmira Avenue. The majority of the Algiers Plant has been upgraded and the New High Lift Pump Station at the Algiers Plan has been constructed over the past ten years. The Algiers Plant has a design treatment capacity and hydraulic capacity of 40 MGD.

3.1.2 Pipelines

The S&WB's CassWorks database contains an inventory of the existing water distribution systems and has been used for recording and tracking construction and maintenance performed on the water distribution systems since July 1993. The database includes a work order system driven by service requests. CassWorks is also used to track the day-to-day system maintenance and repair activities.

The database includes information such as pipe size, pipe length, pipe material, installation date, valve and hydrant locations, and work performed on the system (e.g., rebuild water manhole, repair water valve, exercise water valve, replace water meter, etc.). According to CassWorks, there are approximately 14,000 valves and 15,000 hydrants on the East and West Banks combined.

Tables 3-2 and 3-3 summarize the water main pipe lengths by diameter and pipe material type for the East and West Bank systems, respectively. This information was compiled from the CassWorks database. The CassWorks data is somewhat different from the GIS data shown in **Table 3-1**. This difference occurs because the GIS data is primarily derived from the Sewer and Water Maps (maintained by the S&WB), which may not reflect the current CassWorks data. As with CassWorks, the GIS data will require continuous updating as facilities are added, removed, replaced or relocated.

As shown in **Table 3-2**, over 70 percent of the pipes in the East Bank water distribution system are 8 inches in diameter or smaller. Approximately 57 percent of the pipes in the water distribution system are cast iron. Asbestos cement pipe accounts for approximately 28 percent of the water mains. A combination of pipe materials such as PVC, steel, prestressed concrete, ductile iron, and others account for the remaining 15 percent of the water mains in the East Bank distribution system.

Table 3-2
Summary of Water Main Lengths (Linear Feet) and Materials
East Bank[1,2]

Pipe Material	Pipe Diameter (Inches)					Total (Linear Feet)	Percent (%)
	8 or under	9-16	18-27	30-48	48-54		
Cast Iron	3,219,700	757,600	128,400	74,900	2,600	4,183,200	57.3
Asbestos Cement	1,558,700	429,000	13,600	17,700	8,200	2,027,200	27.7
PVC/Plastic	358,000	107,400	5,700	6,900	-	478,000	6.5
Other[3]	256,600	47,100	18,300	58,300	12,300	392,600	5.4
Steel	300	600	800	70,200	94,600	166,500	2.3
Prestressed Concrete	-	-	-	41,300	-	41,300	0.6
Ductile Iron	5,400	2,300	7,400	-	-	15,100	0.2
Total (Linear Feet)	5,398,700	1,344,000	174,200	269,300	117,700	7,303,900	100
Percent (%)	73.9	18.4	2.4	3.7	1.6	100.0	

Notes:
1 - Data compiled from CassWorks and rounded to the nearest hundred feet
2 - Data excludes pipe segments at the Carrollton Plant
3 - "Other" pipe material not identified

Table 3-3
Summary of Water Main Lengths (Linear Feet) and Materials
West Bank[1,2]

Pipe Material	Pipe Diameter (Inches)				Total (Linear Feet)	Percent (%)
	8 or under	9-16	18-27	30-36		
Asbestos Cement	439,800	116,800	3,200	8,300	568,100	54.1
Cast Iron	178,500	60,400	1,000	-	239,900	22.9
PVC/Plastic	91,700	17,300	300	-	109,300	10.4
Other[3]	70,400	5,200	4,900	4,900	85,400	8.1
Prestressed Concrete	-	-	9,800	26,300	36,100	3.4
Steel	-	-	-	6,300	6,300	0.6
Ductile Iron	4,300	400	-	-	4,700	0.4
Total (Linear Feet)	784,700	200,100	19,200	45,800	1,049,800	100.0
Percent (%)	74.7	19.1	1.8	4.4	100	

Notes:
1 - Data compiled from CassWorks and rounded to the nearest hundred feet
2 - Data excludes pipe segments at the Algiers Plant
3 - "Other" pipe material not identified

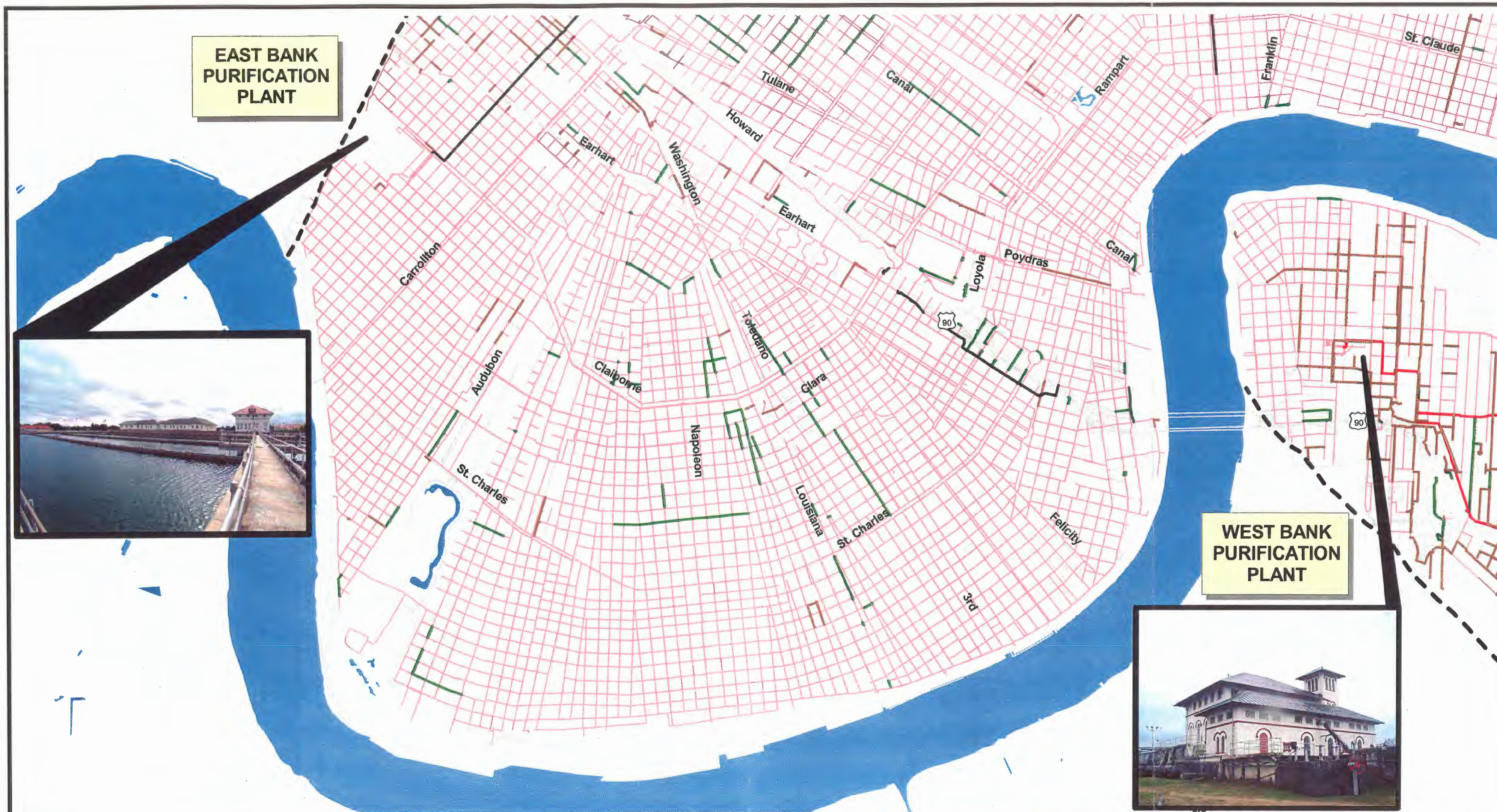
As shown in **Table 3-3**, approximately 75 percent of the pipes in the West Bank water distribution system are 8 inches in diameter or smaller. Approximately 54 percent of the pipes in the water distribution system are made of asbestos cement. Cast iron accounts for approximately 23 percent of the water mains. A combination of pipe materials such as PVC, prestressed concrete, steel, ductile iron, and others account for the remaining 23 percent of the water mains in the West Bank distribution system.

Figures 3-1 through **3-8** illustrate the water mains for the East and West Bank systems by diameter. **Figures 3-9** through **3-16** illustrate the water mains by pipe material.

3.1.3 Pumping Stations

The S&WB currently operates and maintains five water distribution pumping stations. Three pumping stations are located on the East Bank at the Carrollton Plant: A & B, Claiborne, and Panola. The A & B and Claiborne stations operate continuously. Panola station serves as a backup for operation when A & B or Claiborne stations are out of service for maintenance or emergencies. Two pumping stations are located on the West Bank at the Algiers Plant: Station C and the New High Lift Station. Both Station C and the New High Lift Station operate continuously. **Table 3-4** provides details about the pump information according to pumping station and distribution system.

Information on the pumps and pumping stations were obtained from the S&WB. Head-capacity, horsepower, and efficiency data are not available for all pumps. Some pumps have been modified over time, and original design information may not always be valid; detailed records of such modifications are not always available. Where information was not available, it was noted as 'unknown'. The capacity of the pumps was typically obtained from manufacturers' pump curves. All other pump capacities were obtained from pump curves as previously tested by the S&WB. The pumps were not field tested to verify their capacities or operating speeds.



Legend

- Asbestos Concrete
- Cast Iron
- Copper
- Ductile Iron
- Prestressed Concrete
- Polyvinyl Chloride
- Steel
- Parish Boundary
- Street
- Water Body

N

1 Inch = 1/2 Mile

Water Distribution System Assessment and Hydraulic Model

Distribution by Pipe Material Uptown

Figure 3-9

Location
By Council District

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

MWH

Legend

N

1 Inch = 1/2 Mile

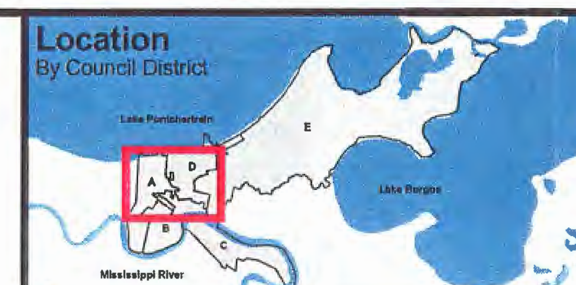
- Asbestos Concrete
- Cast Iron
- Copper
- Ductile Iron
- Prestressed Concrete
- Polyvinyl Chloride
- Steel
- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Distribution by Pipe Material
Lakefront

Figure 3-10

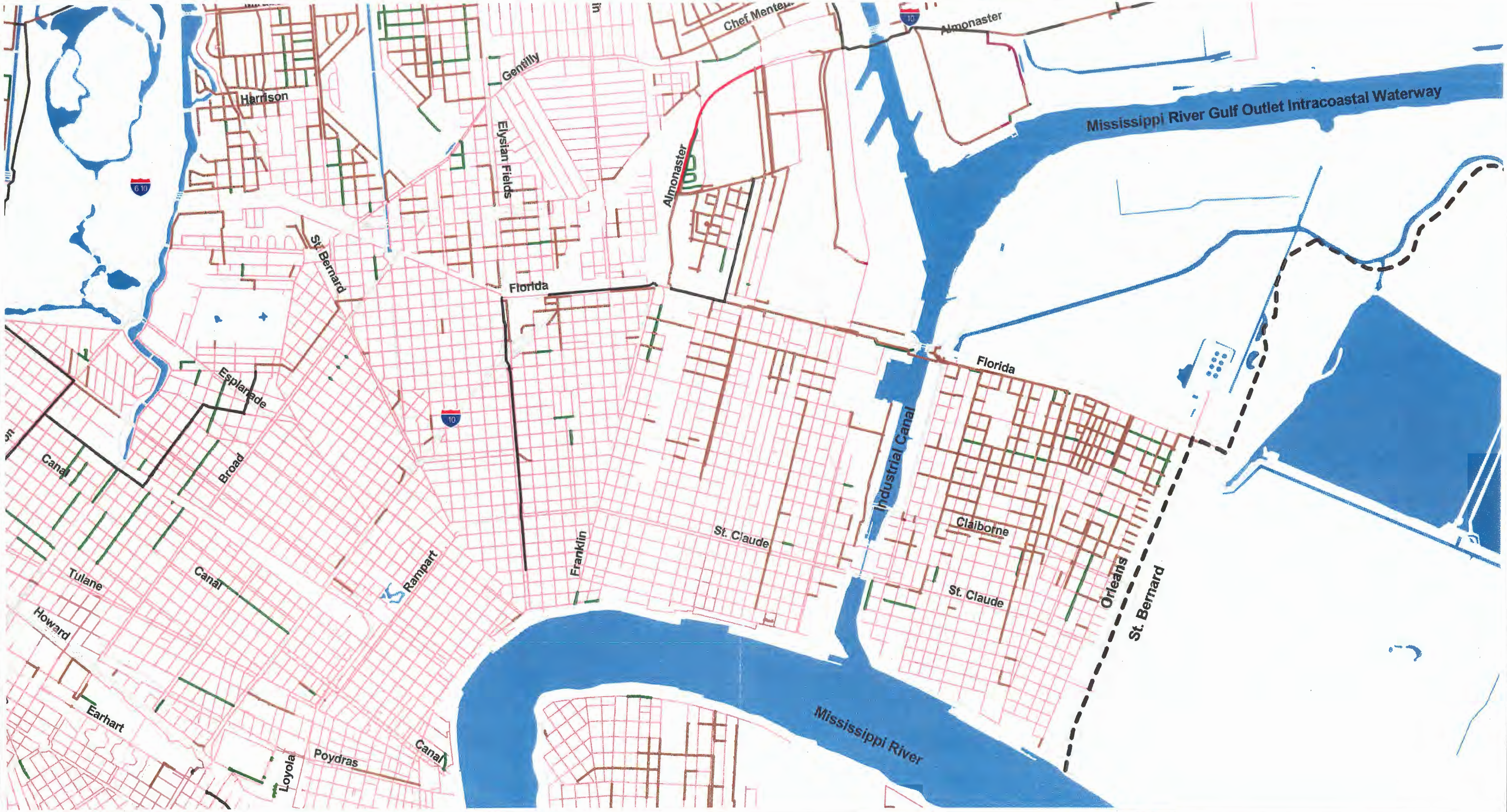
Location
By Council District



"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

MWH



Legend

N

1 Inch = 1/2 Mile

- Asbestos Concrete
- Cast Iron
- Copper
- Ductile Iron
- Prestressed Concrete
- Polyvinyl Chloride
- Steel
- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Distribution by Pipe Material
Ninth Ward

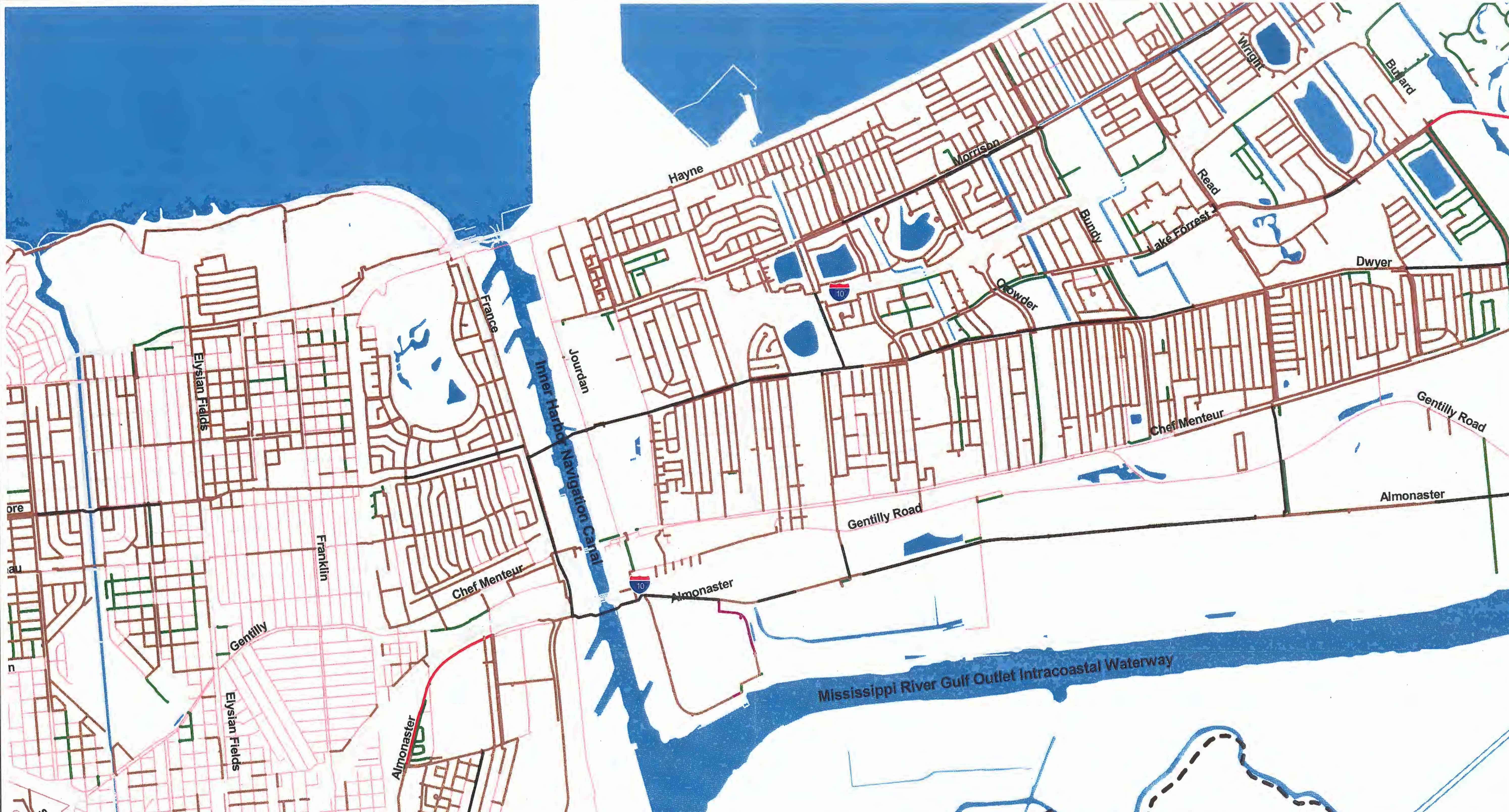
Figure 3-11

Location
By Council District

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

MWH



Legend

N

1 Inch = 1/2 Mile

- Asbestos Concrete
- Cast Iron
- Copper
- Ductile Iron
- Prestressed Concrete
- Polyvinyl Chloride
- Steel
- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Distribution by Pipe Material
New Orleans East

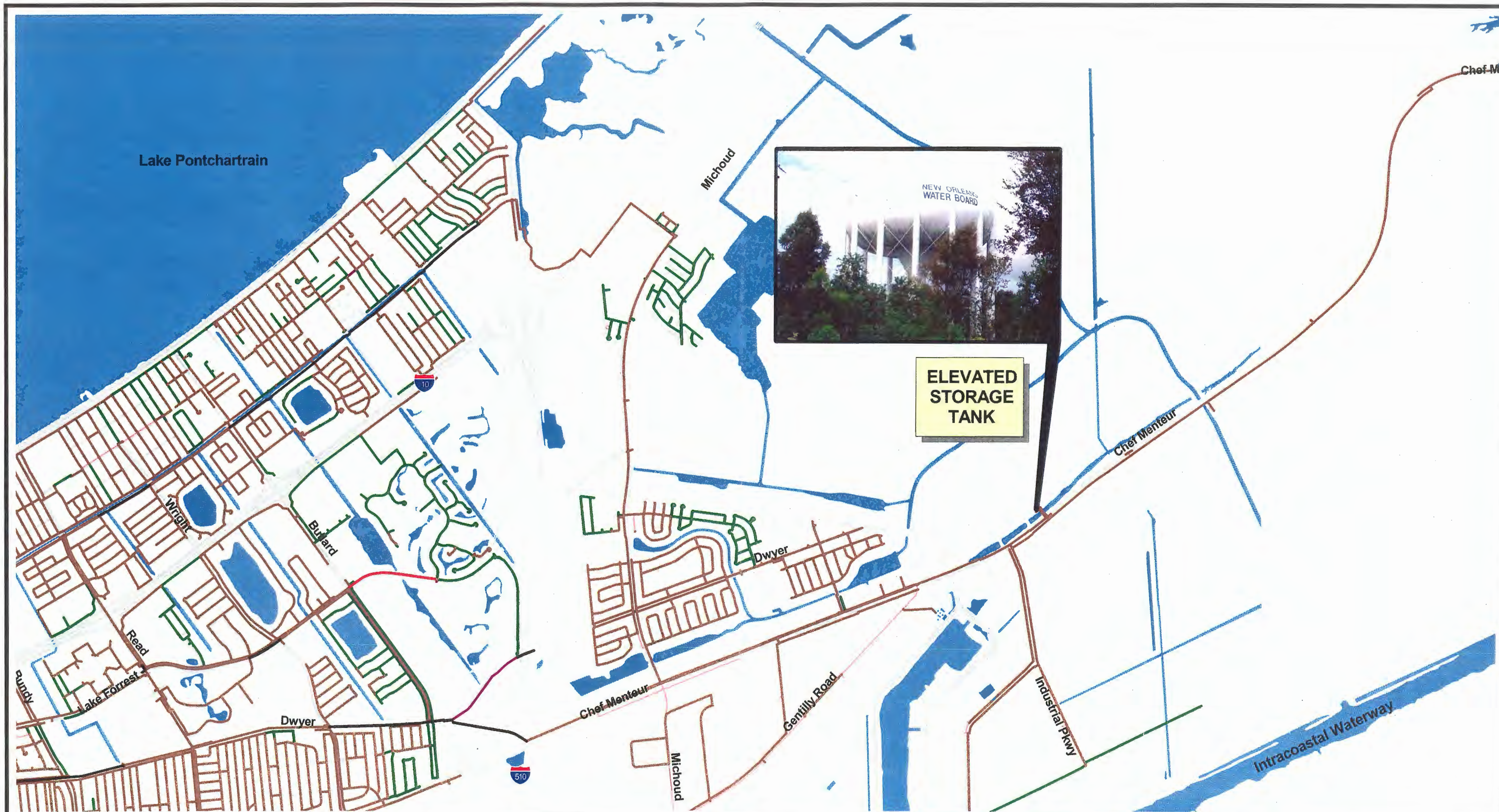
Figure 3-12

Location
By Council District

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

MWH



Legend

N

1 Inch = 1/2 Mile

- Asbestos Concrete
- Cast Iron
- Copper
- Ductile Iron
- Prestressed Concrete
- Polyvinyl Chloride
- Steel
- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Distribution by Pipe Material
Chef Menteur

Figure 3-13

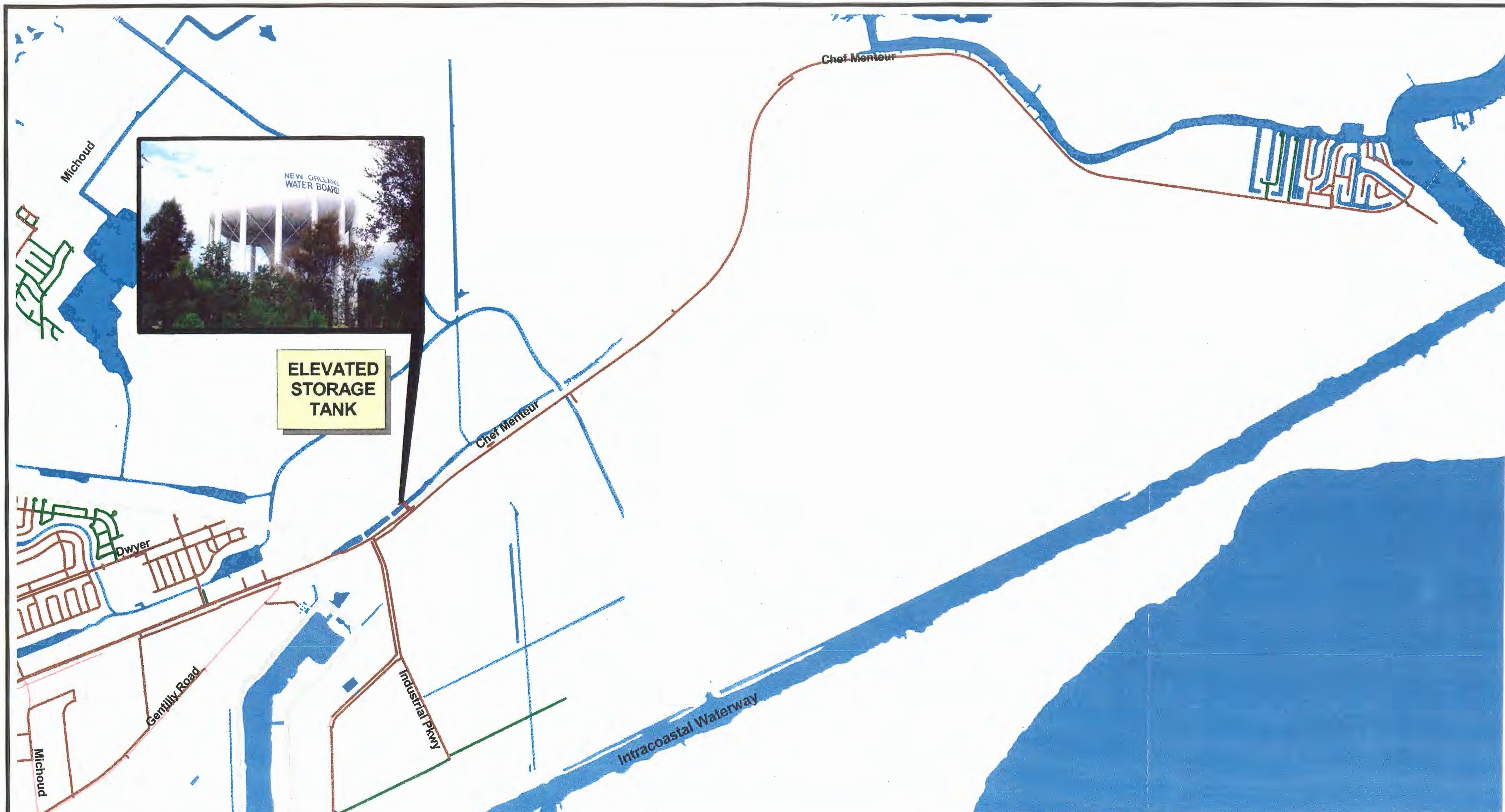
Location

By Council District

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

MWH



Legend

N

1 Inch = 1/2 Mile

- Asbestos Concrete
- Cast Iron
- Copper
- Ductile Iron
- Prestressed Concrete
- Polyvinyl Chloride
- Steel
- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Distribution by Pipe Material
Venetian Isles

Figure 3-14

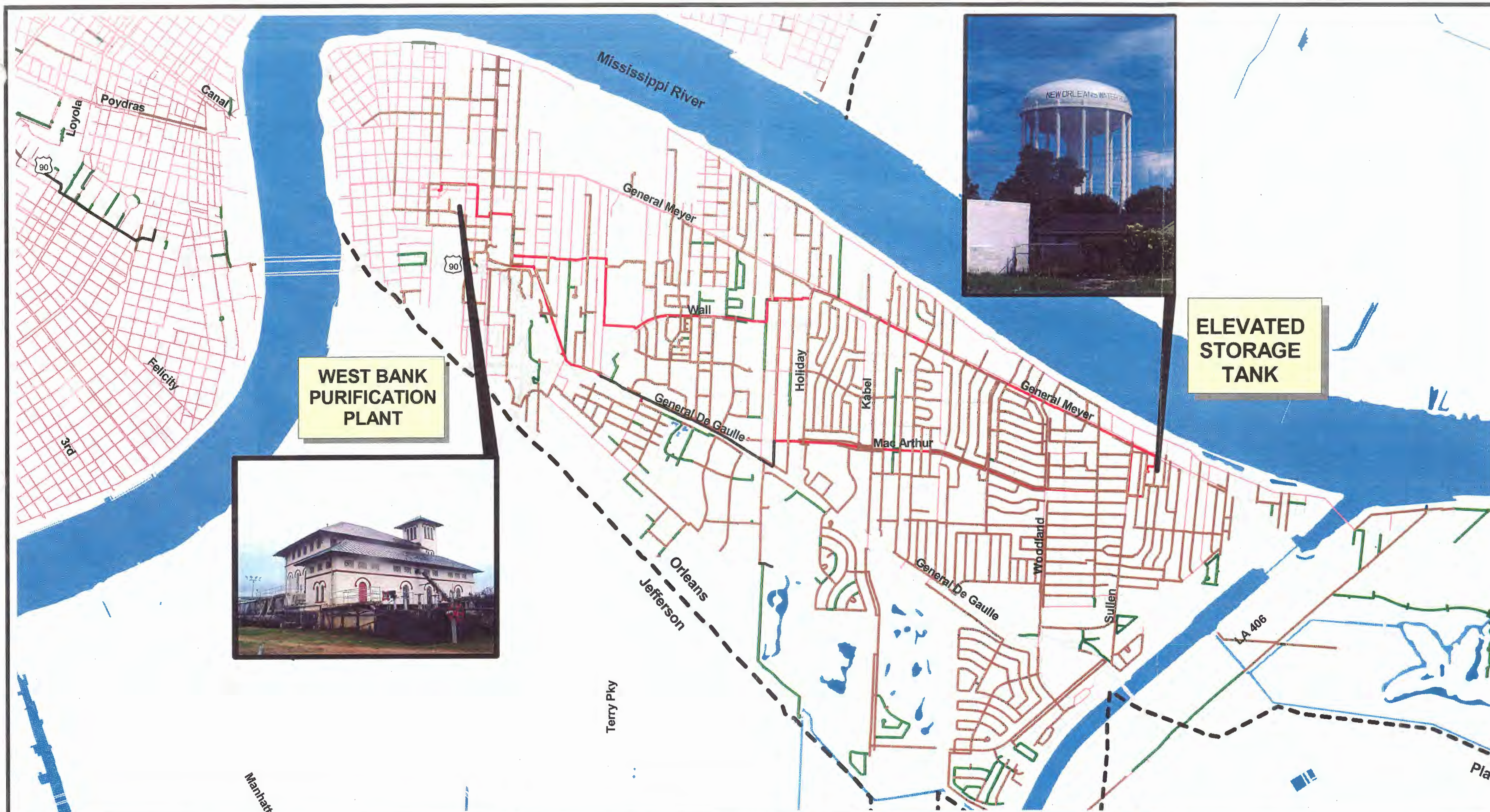
Location

By Council District

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

MWH



Legend

N

1 Inch = 1/2 Mile

- Asbestos Concrete
- Cast Iron
- Copper
- Ductile Iron
- Prestressed Concrete
- Polyvinyl Chloride
- Steel
- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Distribution by Pipe Material
Algiers

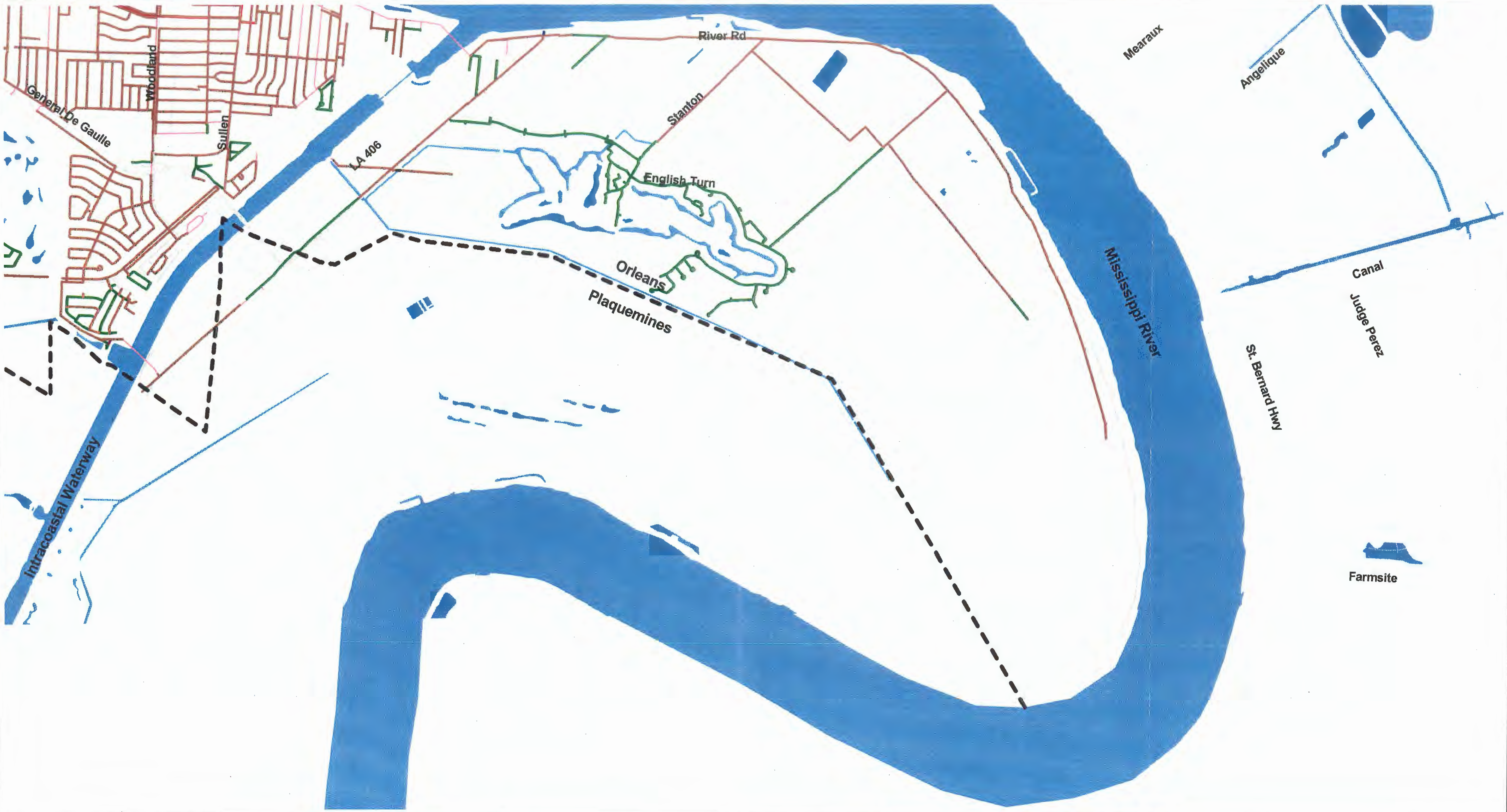
Figure 3-15

Location
By Council District

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

MWH



Legend

N

1 Inch = 1/2 Mile

- Asbestos Concrete
- Cast Iron
- Copper
- Ductile Iron
- Prestressed Concrete
- Polyvinyl Chloride
- Steel
- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Distribution by Pipe Material
Lower Coast

Figure 3-16

Location
By Council District

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

MWH

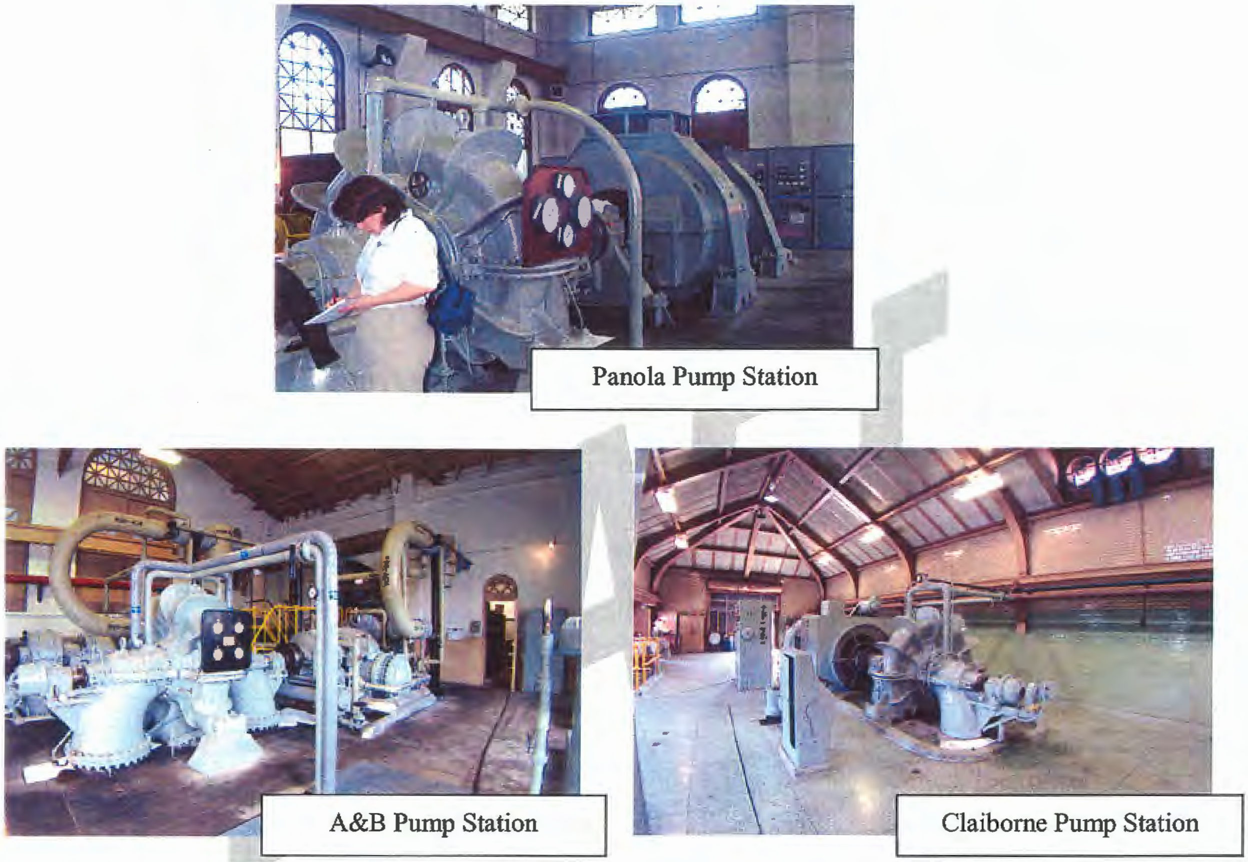
Table 3-4
Pump Information

Distribution System	Pump Name	Pump Size (in)	Speed (rpm)	Impeller Diameter (in)	Capacity (MGD)
East Bank	*Claiborne Pump Station*				
	Pump 1	Unknown	660-740	Unknown	40
	Pump 2	Unknown	750	Unknown	40
	Pump 3	Unknown	750	Unknown	40
	Pump 4	Unknown	750 (5 speeds)	Unknown	40
	A&B Pump Station				
	Pump A	Unknown	750	Unknown	40
	Pump B	Unknown	750	Unknown	40
	Panola Pump Station				
	Pump 1	Unknown	720/750	Unknown	50
	Pump 2	Unknown	720/750	Unknown	50
West Bank	*Pump Station C*				
	Pump 1	10	1150/1750	Unknown	6
	Pump 2	10	1150/1750	Unknown	6
	Pump 3	8	1750	Unknown	4
	Pump 4	10	1150/1750	Unknown	6
	Pump 5	10	1150/1750	Unknown	6
	Pump 6	10	1150/1750	Unknown	6
	New High Lift Pump Station				
	Pump 7	Unknown	490/872	28.2	7
	Pump 8	Unknown	490/872	28.2	7
	Pump 9	Unknown	885	25.2	7
	Pump 10	Unknown	885	25.2	7

All of the distribution pumping stations are maintained and operated by the S&WB Pumping and Power Department. The S&WB operators exercise the valves in the pumping stations on a monthly basis. All pumping stations are monitored on the hour and inspected at least daily. The inspecting personnel complete pumping station inspection reports each day. These reports include information regarding pumping station equipment status and problems or defects. Pumps that are not in continuous operation are tested approximately once a week.

Figure 3-17 shows the three pumping stations located at the Carrollton Plant on the East Bank. Pumping stations A&B, Claiborne, and Panola (when utilized) on the East Bank are manned 24 hours per day.

Figure 3-17
Carrollton Plant Pumping Stations



Panola Pump Station

A&B Pump Station

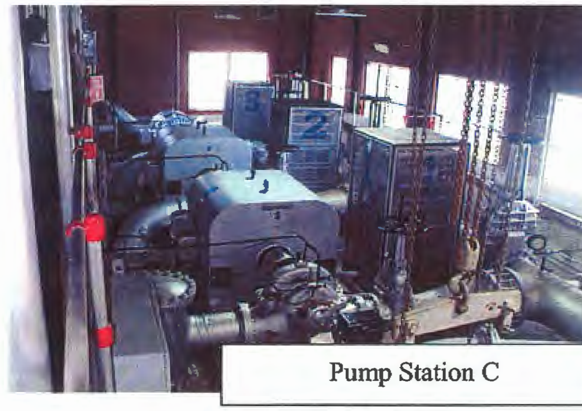
Claiborne Pump Station

Figure 3-18 shows the two pumping stations located at the Algiers Plant on the West Bank. The New High Lift Pump Station and Pump Station C on the West Bank are manned 24 hours per day.

Existing record drawings have been reviewed for the pumping stations. Pumping station record drawings indicate the date the drawings were prepared, pump layout, hydraulic schematics, plan and profile of the pumping station with dimensions, and piping elevations.

Figure 3-18
Algiers Plant Pumping Stations

New High Lift Pump Station



Pump Station C

Figures 3-19 and **3-20** on the following pages present schematics of the East and West Bank water distribution pumping stations, respectively. The schematics illustrate the pumping stations at each purification plant, the diameter and location of the discharge lines, and the connectivity of the pumping stations.

Figure 3-19 shows the six discharge lines at the Carrollton Plant. The discharge lines range in size from 30 to 50 inches. Claiborne Station discharges to two 50-inch lines; A & B Station discharges to four lines at 48 inches, approximately 43 inches, 36 inches, and 30 inches in diameter. Panola Station is capable of pumping to all six discharge lines. Claiborne Station has four pumps each with a capacity of 40 MGD, and Panola Station has two pumps each with a capacity of 50 MGD. There are two pumps located at A & B Station, each with a capacity of 40 MGD.

Figure 3-19
Schematic of Pumping Stations
Carrollton Plant

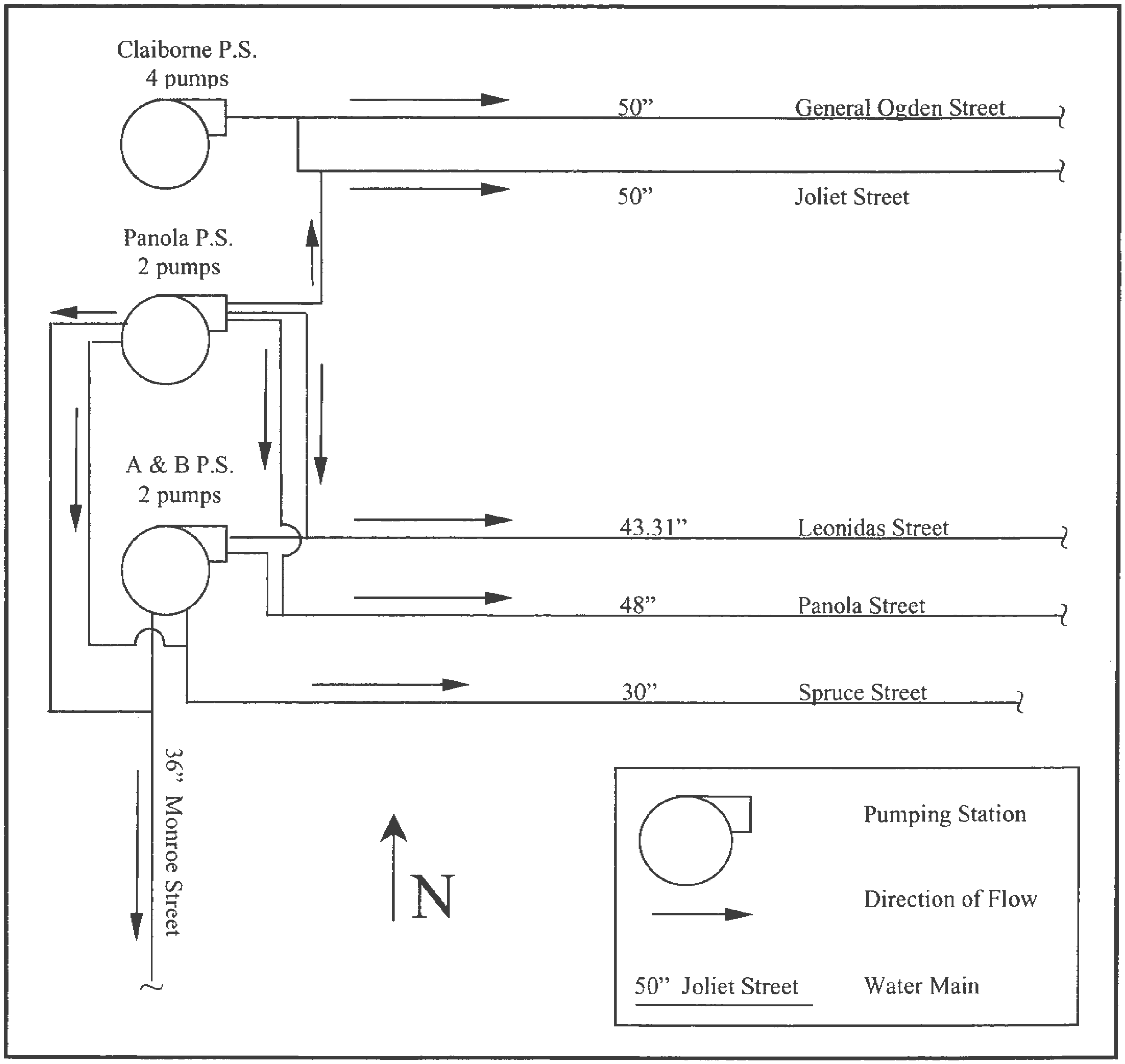
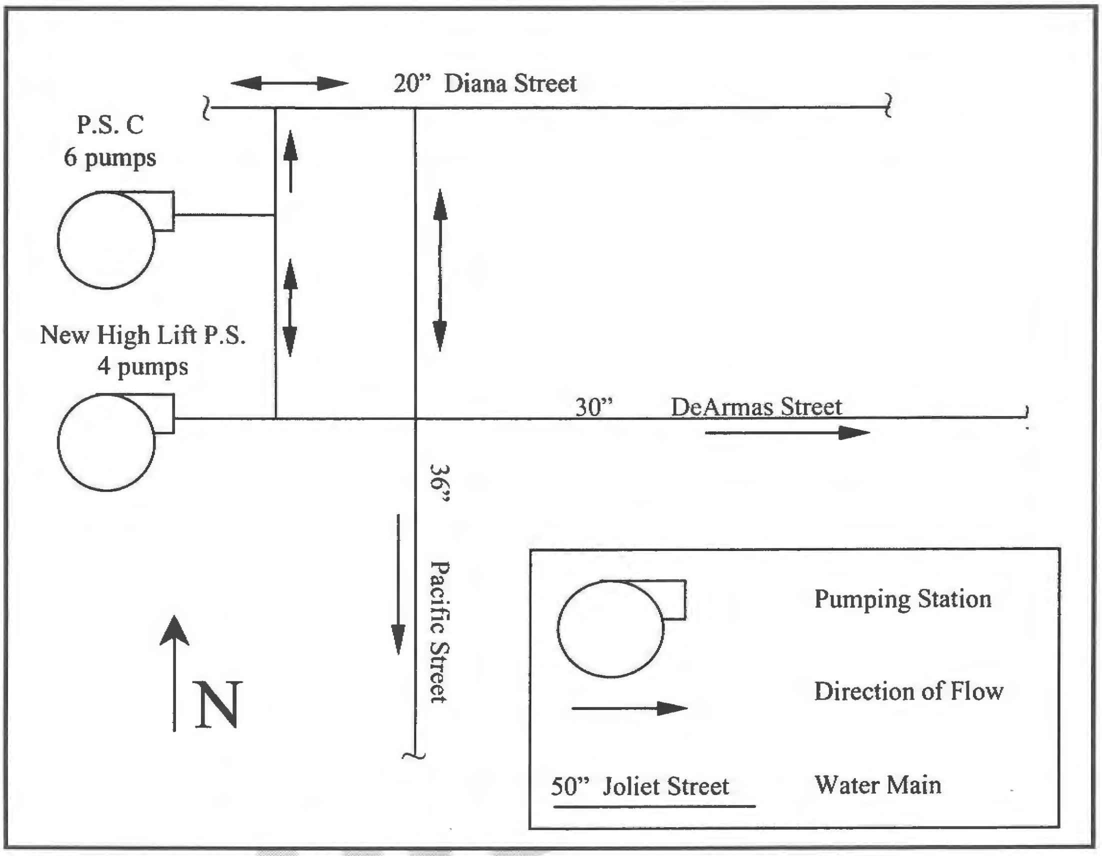


Figure 3-20 shows the three discharge lines at the Algiers Plant. The discharge lines range in size from 20 to 36 inches. The New High Lift Station discharges directly to two lines at 30 inches and 36 inches in diameter; Pump Station C discharges directly to one 20-inch line. Both stations are capable of pumping to all three discharge lines for redundancy. Pump Station C has six pumps, one with a capacity of 4 MGD and five pumps with a capacity of 6 MGD. The New High Lift Station has four pumps, each with a capacity of 7 MGD.

Figure 3-20
Schematic of Pumping Stations
Algiers Plant



3.1.4 Storage Tanks

On the East Bank, there are ten ground-level storage tanks: four concrete tanks, each with a capacity of 4.1 MG and six steel tanks, each with a capacity of 3.4 MG, for a total storage capacity of approximately 37 MG. Several of the tanks have been refurbished within the past five years. According to the S&WB staff, all of the tanks are inspected approximately every two years.

The ground-level storage tanks, located on-site at the Carrollton Plant, are operated to provide filter backwash and to maintain steady flow during the peak demand hours to the water distribution pumping stations. The water level of the storage tanks fluctuates daily by approximately 25 to 30 percent of the tank capacity. During low demand hours, the tanks are filled to approximately 75 percent capacity. This procedure changes seasonally; during warmer months the tanks store less water in order to increase the turnover rate. All ten tanks fill simultaneously, having the same approximate hydraulic gradient.

Figure 3-21
Carrollton Plant and Ground-Level Storage Tanks

The East Bank has one elevated storage tank located in the eastern area of the city with a capacity of 2 MG. The elevated storage tank serves to maintain pressure in the water mains to the Venetian Isles service area. This area of the city is the furthest distance from the Carrollton Plant. The water elevation in the storage tank typically does not fluctuate on a daily basis. During the summer months, the elevated tank is flushed approximately weekly for maintenance. Water quality sampling, including chlorine residual, is conducted weekly at the East Bank elevated tank. **Figure 3-22** shows the 2 MG elevated storage tank serving the East Bank.

Figure 3-22
East Bank Elevated Storage Tank

On the West Bank, there are two ground-level storage tanks each with a capacity of 5 MG, for a total storage capacity of 10 MG. Both of the tanks are inspected approximately every two years. Similar to the ground-level storage tanks on the East Bank, the ground-level storage tanks on the West Bank, located at the Algiers Plant, are

On the West Bank, there are two ground-level storage tanks each with a capacity of 5 MG, for a total storage capacity of 10 MG. Both of the tanks are inspected approximately every two years. Similar to the ground-level storage tanks on the East Bank, the ground-level storage tanks on the West Bank, located at the Algiers Plant, are operated to maintain a steady flow during the peak demand hours to the pumping stations for distribution. The water level in the storage tanks fluctuates daily, and during low demand hours the tanks are filled to approximately 75 percent capacity. Both tanks fill simultaneously, or have the same approximate hydraulic gradient.

Algiers has one elevated storage tank in the southeastern area with a capacity of 2 MG. The elevated storage tank was recently rehabilitated and is currently in service. The tank serves to maintain pressure in the water mains throughout the Algiers distribution system. Once the tank is in service, the water level does not fluctuate over a wide range daily. Water sampling is conducted weekly at the West Bank elevated tanks for chlorine residual.

Table 3-5 provides details on the storage tanks for both the East and West Bank service areas.

Table 3-5
Storage Tank Information

Distribution System	Tank Name	Tank Volume (MG)	Tank Diameter (ft)	Ground Elevation, CD (ft)	Min. Water Elevation/ Level (ft)	Max. Water Elevation/ Level (ft)
East Bank	Chef Menteur Elevated Tank	2	Variable	22.5	107.5/0	142.5/35
	Steel Tanks 1 – 6	3.4	140	19.7	19.7/0	49.3/29.6
	Concrete Tanks 7 – 10	4.1	154	19.7	19.7/0	49.2/29.5
West Bank	Algiers Elevated Tank	2	Variable	4.12	114.7/0	149.7/35
	Steel Tanks 1 - 2	5	160	25.5	25.5/0	58.8/33.3

3.1.5 System Maintenance

Data related to flushing, construction, and repairs of the water distribution system is also maintained in the CassWorks database. CassWorks provides records of service requests received by the S&WB Phone Center. When the S&WB Phone Operator receives a service request, it is sent electronically to the S&WB Dispatcher. A service request may be submitted by the S&WB operators, personnel, or the public. This information is managed in the CassWorks database and is processed into work orders for completion by the maintenance crews.

A summary of selected work activities associated with water maintenance from 1994 through December 2002 is presented in **Table 3-6**. The data in **Table 3-6** was compiled from the CassWorks database, including archived work activities. Nearly 65,000 maintenance requests were received for these work activities during this time period.

Table 3-6
Summary of Work Activities
East and West Bank
(1994 – 2002)

Work Activity Category		Total	Percent (%)
Abbreviation	**Description**		
WHSF	Water Leak - Hydrant Flowing	40	< 0.1
WVBO	Water Valve Broken Open	260	0.4
WVBCL	Water Valve Broken Closed	310	0.5
WLPR	Water - Low Pressure	440	0.7
WVLK	Water Leak – Valve	1,270	2.0
WHLK	Water Leak – Hydrant	3,720	5.7
WMTLK	Water Leak – Meter	8,670	13.3
WOLK	Water Leak - Outlet Service	11,100	17.1
WMLK	Water Leak – Main	12,270	18.9
WILK	Water Leak - Inlet Service	26,880	41.4
Total		64,960	100.0

Notes:
1 – Data compiled from CassWorks and rounded to the nearest tens.

Of these entries, approximately 60 percent of the work activities are related to water leaks from either inlet or outlet services. Leaks from water mains and meters account for another 30 percent of the work activities listed above for the water distribution systems.

To address the water supply availability during fire flow demand, the S&WB has initiated a hydrant exercising and maintenance program. As a result of the hydrant maintenance program the S&WB has repaired malfunctioning hydrants and improved the reliability of the system to supply fire flow demand.

In addition, to address the low pressure complaints, the S&WB has recently initiated a valve exercising and maintenance program similar to the hydrant maintenance program.

The S&WB has repaired and/or opened valves that were malfunctioning or left closed and has since received fewer pressure complaints in these areas.

The S&WB is also continuing an undersized main replacement program to replace water pipelines less than 6 inches in diameter. These mains are considered undersized and can not typically deliver fire flow. All 6-inch pipe identified for replacement due to breaks or leaks is replaced with 8 inch diameter pipe.

3.2 PRESSURE ZONES

There is one pressure zone within each distribution system. The maximum pressure anticipated from the S&WB during the average day demand is 65 psi on the East Bank and 64 psi on the West Bank.

On the East Bank the mean elevation is 20 feet with a low elevation of 4 feet and a high elevation on the Mississippi River levee of 40 feet, Cairo Datum (CD). On the West Bank the mean elevation is 21 feet with a low elevation of 2 feet and a high elevation of 33 feet CD. As shown in **Section 2**, **Figure 2-2** illustrates a typical cross section of the city. A summary of the range of elevations assigned to the water distribution system is discussed in detail in **Section 5**.

Section 4

Section 4

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Section 4 – Water Production and Demand

An analysis of the existing and historical water production, water demand, along with the projection of future water requirements is summarized in this section.

The term "water production" refers to the amount of water treated and distributed into the service area. "Water demand" is comprised of two components: metered and non-metered water consumption (billed and unbilled). Non-metered water consumption includes water use for extinguishing fires, cleaning streets, flushing sewers, drains, and gutters, cleaning markets and other public buildings, and under registration of meters. "Unaccounted-for water" (UFW) is defined as non-metered water use and leaks in the distribution system.

4.1 EXISTING WATER PRODUCTION

The Mississippi River provides 100 percent of the raw water for the East and West Bank systems. The S&WB maintains and operates two water purification plants: Carrollton Plant (East Bank) and Algiers Plant (West Bank). The Carrollton Plant has a treatment design capacity and a hydraulic capacity of 232 MGD. The Algiers Plant has a treatment design capacity and a hydraulic capacity of 40 MGD. **Table 4-1** on the following page summarizes the average and maximum production data for each plant from 1991 through 2001, as published in the *S&WB 2001 Comprehensive Annual Financial Report.*

The peak-to-average ratios (maximum flow to average flow) for the Carrollton and Algiers Water Purification Treatment Plants are 2.0 and 1.6, respectively. Over the eleven-year period, the average daily production at the Carrollton Plant decreased by 0.3 percent, and the maximum daily flow occurred in 1996 at approximately 198 MGD. Over the eleven-year period from 1991 to 2001, the average daily production at the Algiers Plant increased by 12 percent and the maximum daily flow occurred in 1998 at approximately 23 MGD. Both water purification plants are currently operating below their design capacities.

4.1.1 Production Diurnal Curve Development

For analysis of water demand in the hydraulic model, a 24-hour flow pattern is required. Hourly plant production estimates were not previously available from *S&WB Comprehensive Annual Financial Report*. The Carrollton and Algiers Plants report average daily production by separate methods. Water distributed to the East Bank service area is directly measured by venturi meters; however, the meters are believed to be inaccurate. The Carrollton Plant therefore records production by calculating the quantity of water treated by the filter galleries and subtracting the process water used for backwash. The Algiers Plant records average daily production with venturi meters.

Hourly flows were calculated for the water production from the two treatment plants for 2001 and 2002. Daily filter gallery log sheets from January 1, 2001 through December 31, 2002 were obtained for the Carrollton Plant. Daily venturi meter log sheets were obtained for the Algiers Plant from January 1, 2001 through November 4, 2002. The hourly flow data for approximately 90 days (chosen randomly) from each year was entered into an electronic spreadsheet. All holidays were selected, as well as one weekend for each month and one weekday for each week. By evaluation of the data that was captured for the two-year period, minimum and maximum production days were identified. An average production day was determined from the 2002 data. Production data was also entered for the days during which field calibration testing on fire hydrants was conducted.

Table 4-1
Summary of Production Data at
Carrollton and Algiers Water Purification Plants
(1991 – 2001)

Year	Carrollton Purification Plant		Algiers Purification Plant	
	Average Daily Flow (MGD)	Maximum Flow (MGD)	Average Daily Flow (MGD)	Maximum Flow (MGD)
1991	115	133	10	13
1992	115	139	10	14
1993	117	140	10	15
1994	114	129	11	17
1995	121	143	12	18
1996	129	198	11	18
1997	129	157	12	19
1998	127	153	12	23
1999	140	168	15	22
2000	128	153	12	19
2001	115	148	11	16
Eleven Year	123 (average)	198 (maximum)	11 (average)	23 (maximum)

Note:

1 – Values rounded to nearest one.

The following hourly information was obtained for selected days from the daily log sheets at the Carrollton Plant:

- Flow rates from old and new filter galleries
- Backwash rates for old and new filter galleries
- Water level readings in storage tanks
- Status of balance valve (open/closed) downstream of storage tank

At the Carrollton Plant, there are 28 filters at the old filter gallery (Sycamore Station) and 16 filters at the new filter gallery (Claiborne Station). Recorded flow rates for each of the new and old filter galleries were summed to provide an aggregate hourly treated water flow rate expressed as MGD from each filter gallery. The hourly data from the daily log sheets indicated a rise or fall in the storage tank water level from one hour to the next. When the water level falls, that water is discharged from the tanks for either filter backwash or distribution. The status of a balance valve downstream of the storage tanks indicates whether water is discharged for backwash or distribution. When the balance valve is open water is used for distribution; when the balance valve is closed water is used for filter backwash. Water discharged from the storage tanks was added or subtracted from the flow rate from the filter galleries, accordingly.

At the Carrollton Plant, the overall water balance is generally described by the following three derived equations:

$Q_D = Q_F - Q_S$ *(Storage tanks are filling up)*
$Q_D = Q_F$ *(Storage tanks are emptying to backwash)*
$Q_D = Q_F + Q_S$ *(Storage tanks are emptying to distribution)*

Where,

Q_F = *flow of treated water from the filter galleries*
Q_S = *flow of treated water from the ground-level storage tanks*
Q_D = *flow of water pumped (i.e., high lift pumpage) into the distribution system*

Figure 4-1 shows a schematic of the Carrollton Plant with the general flow direction of treated water from the filter galleries through the distribution pump stations.

Based on the days selected for data analysis during the year 2002, the diurnal curve developed for the Carrollton Plant is shown in **Figure 4-2.** Average daily flows were calculated for weekend days (125 MGD), and weekdays (124 MGD) that were not holidays. The average day demand curve is relatively flat with an average constant production at approximately 123 MGD. This estimate is the same as the eleven-year average of daily flow reported in the *S&WB 2001 Comprehensive Annual Financial Report*, which indicates good correlation. In addition, raw water intake flows as compiled by the S&WB were used to validate production flows.

Legend

N

Not to Scale

Parish Boundary	Production	Direction of Flow
Facility Building	Water Intake	Backwash Flow
Facility Boundary	Distribution	

Water Distribution System
Assessment and Hydraulic Model

Carrollton Plant Schematic

Figure 4-1

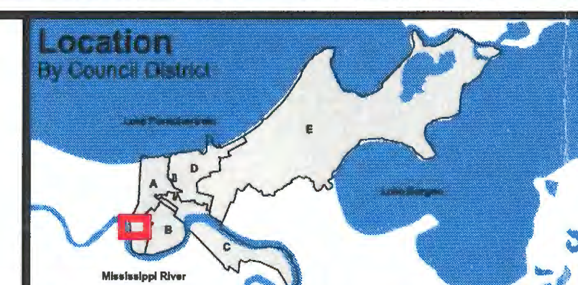

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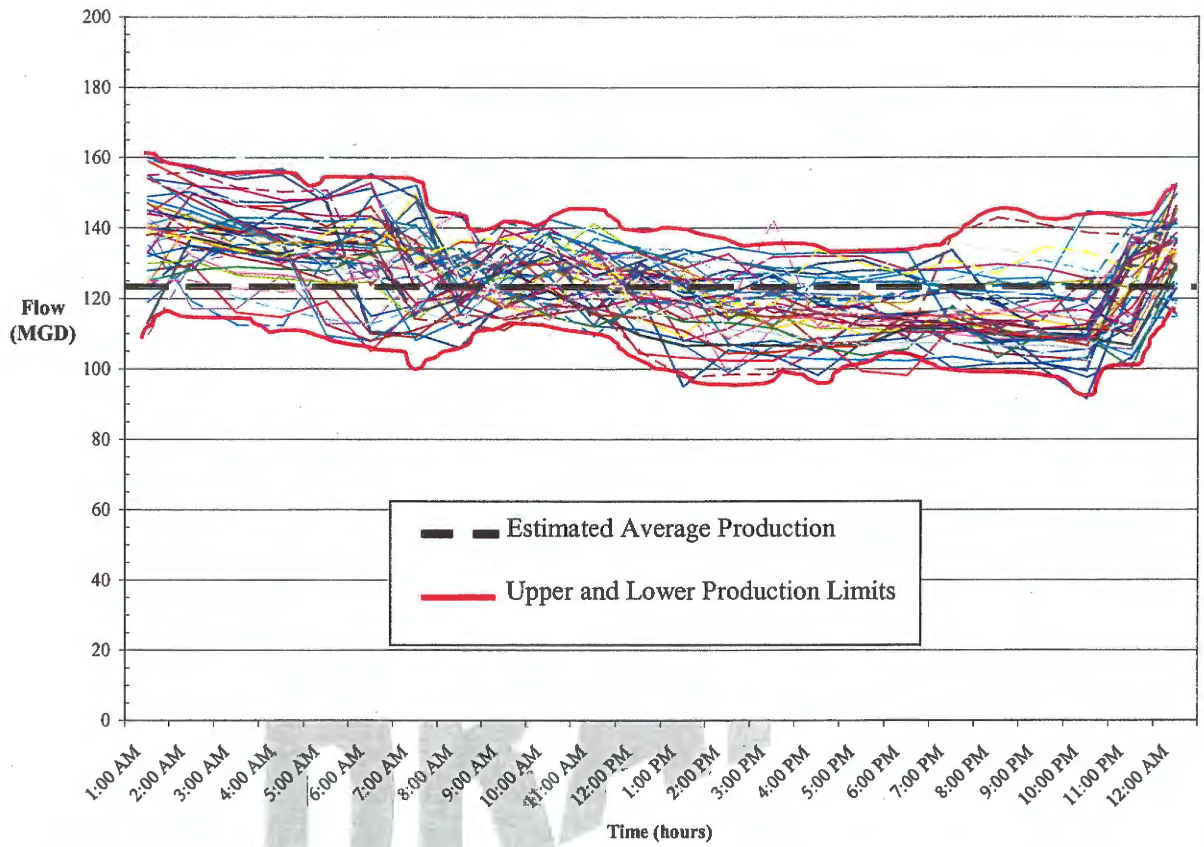
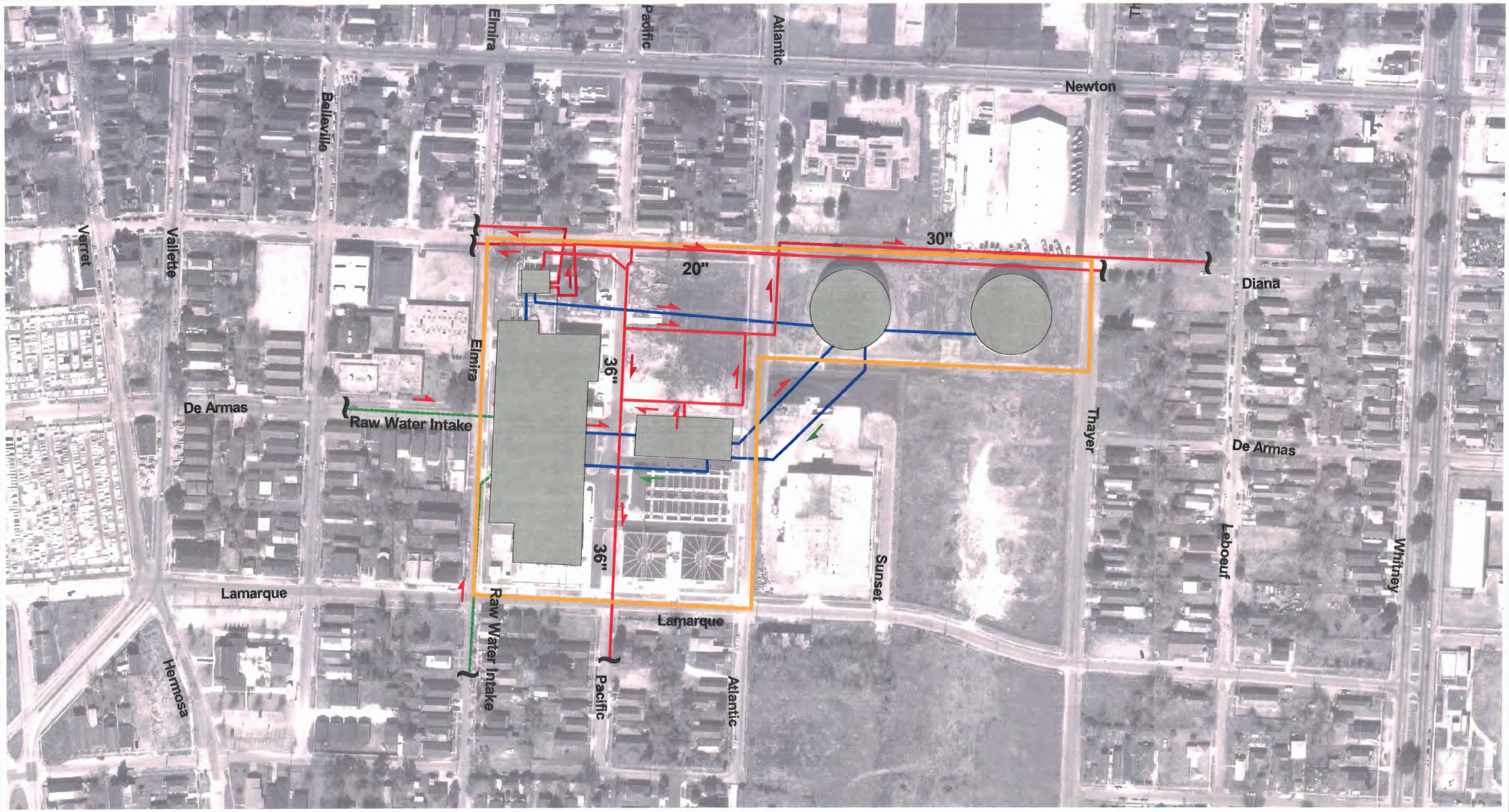
Figure 4-2
Carrollton Plant Diurnal Curve



One possible reason that the diurnal curve for the Carrollton Plant does not represent fluctuation during the day (as production diurnal curves typically do) may be due to significant water losses from the distribution system.

The Algiers Plant production was analyzed with the data recorded by three venturi meters, which totalize the water distributed. The venturi meters account for water leaving the ground-level storage tanks for distribution since the meters are located downstream of the tanks. **Figure 4-3** shows a schematic of the Algiers Plant with the general flow of treated water from the filter galleries through the distribution pump stations.

Based on the days selected for data analysis during the year 2002, the diurnal curve developed for the Algiers Plant is shown in **Figure 4-4.** Average daily flows were calculated for weekend days (10.9 MGD), and weekdays (10.3 MGD) that were not holidays. Also shown is the diurnal curve for maximum demand from the days selected in 2001 and 2002. The maximum production day occurred on January 4, 2001 during a freeze event. The average day demand curve is relatively flat with an increase in production from approximately 7:00 a.m. to 9:00 p.m.. The increase in production during these hours represents the typical increase in demand from consumers during the day.



Legend

N
Not to Scale

Parish Boundary
Facility Building
Facility Boundary
Production
Water Intake
Distribution
Direction of Flow
Backwash Flow

Water Distribution System Assessment and Hydraulic Model

Algiers Plant Schematic

Figure 4-3

Location
By Council District

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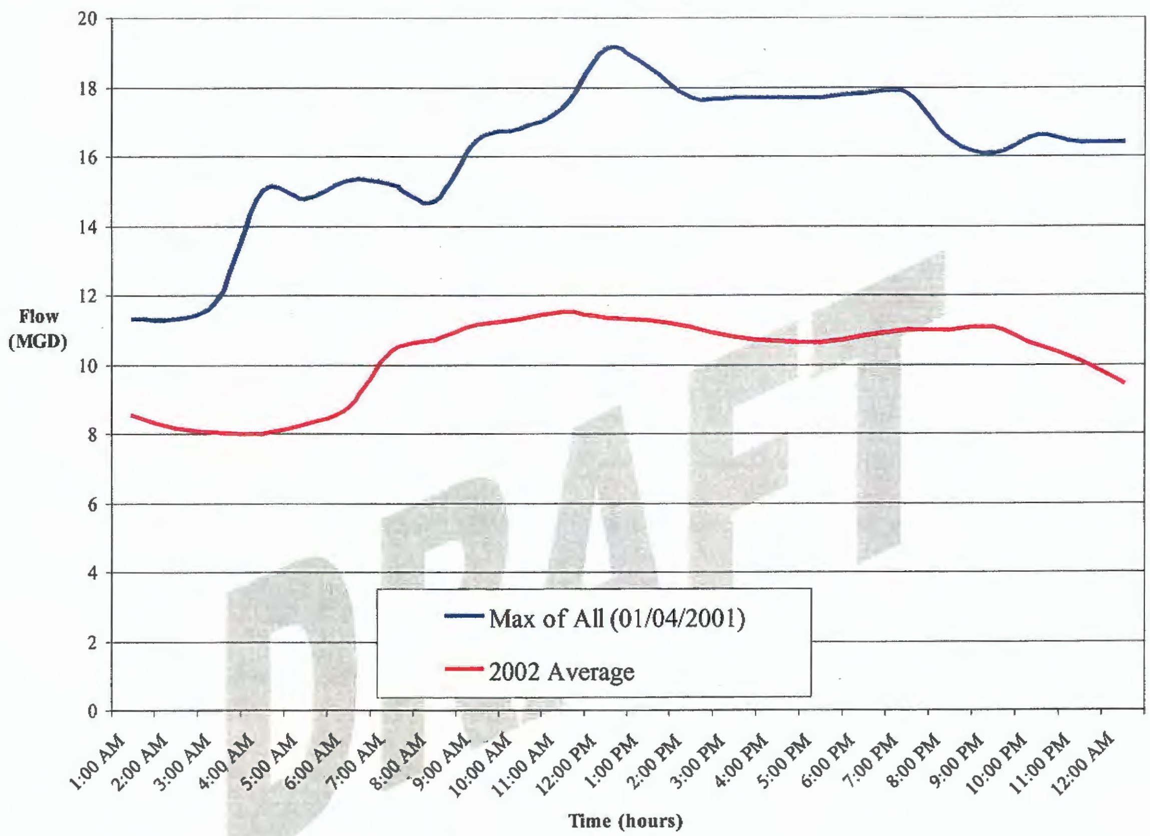
The average day demand is approximately 11 MGD. This estimate is four 4 percent less than the eleven-year estimate for average daily flow reported in the *S&WB 2001 Comprehensive Annual Financial Report*, which indicates good correlation.

Figure 4-4
Algiers Plant Diurnal Curve



4.2 EXISTING WATER DEMAND

Data for metered water consumption was received from the S&WB Computer Center. The metered water data consists of water billed to customers and a portion of public water consumption, which is unbilled. Not all public water consumption is metered; the non-metered public water is included in the estimate of UFW as described below. The metered water consumption information includes the monthly water consumption for each billing account, location of the water meter, and type of consumer (residential, commercial, industrial, public water, etc.). The water consumption data from 1997 to 2001 is presented in **Table 4-2**. The average daily consumption has been fairly consistent over the five years evaluated. The maximum day for consumption occurred on the East Bank in 1999 at approximately 66 MGD and on the West Bank in 1999 at approximately 7 MGD.

Table 4-2
Metered Water Consumption
(1997-2001)

Year	Average Daily Consumption (MGD)				
	East Bank	Percent Change	West Bank	Percent Change	Total
1997	64.00	-	6.76	-	70.75
1998	65.21	1.9%	6.88	1.8%	72.09
1999	66.32	1.7%	6.92	0.6%	73.24
2000	64.36	-3.0%	7.27	4.8%	71.63
2001	63.25	-1.7%	6.83	-6.1%	70.08
5-Year Average	**64.63**	**-**	**6.93**	**-**	**71.56**

The metered water consumption data was analyzed to determine water demand according to the type of consumer classification, as defined by the S&WB. **Figures 4-5** and **4-6** on the following pages show the water consumption by billing classification for the East and West Bank, respectively. Mixed residential and commercial consumers account for the majority of both service areas, 91 percent for the East Bank and 96 percent for the West Bank. The remaining customers represent hospitals, hotels, mixed residential/ commercial, industrial, mixed industrial/ residential/ commercial, school board, and other. Other billing classification types include bars, medical facilities, motels, office buildings, and restaurants.

For comparison, **Table 4-3** shows the average daily water production, metered water consumption, and wastewater flows for the same five-year period for both the East and West Bank systems. Average daily flow estimates for the water system includes water treated and distributed from the water purification plants (production), metered water (consumption) and the estimate of water consumed that would be discharged (returned) to the wastewater collection system (90 percent of water consumption). The average wastewater flows were estimated in conjunction with the development of the sewer system hydraulic model as part of the SSERP.

Figure 4-5
Water Consumption by Billing Classification
(1997-2001) East Bank

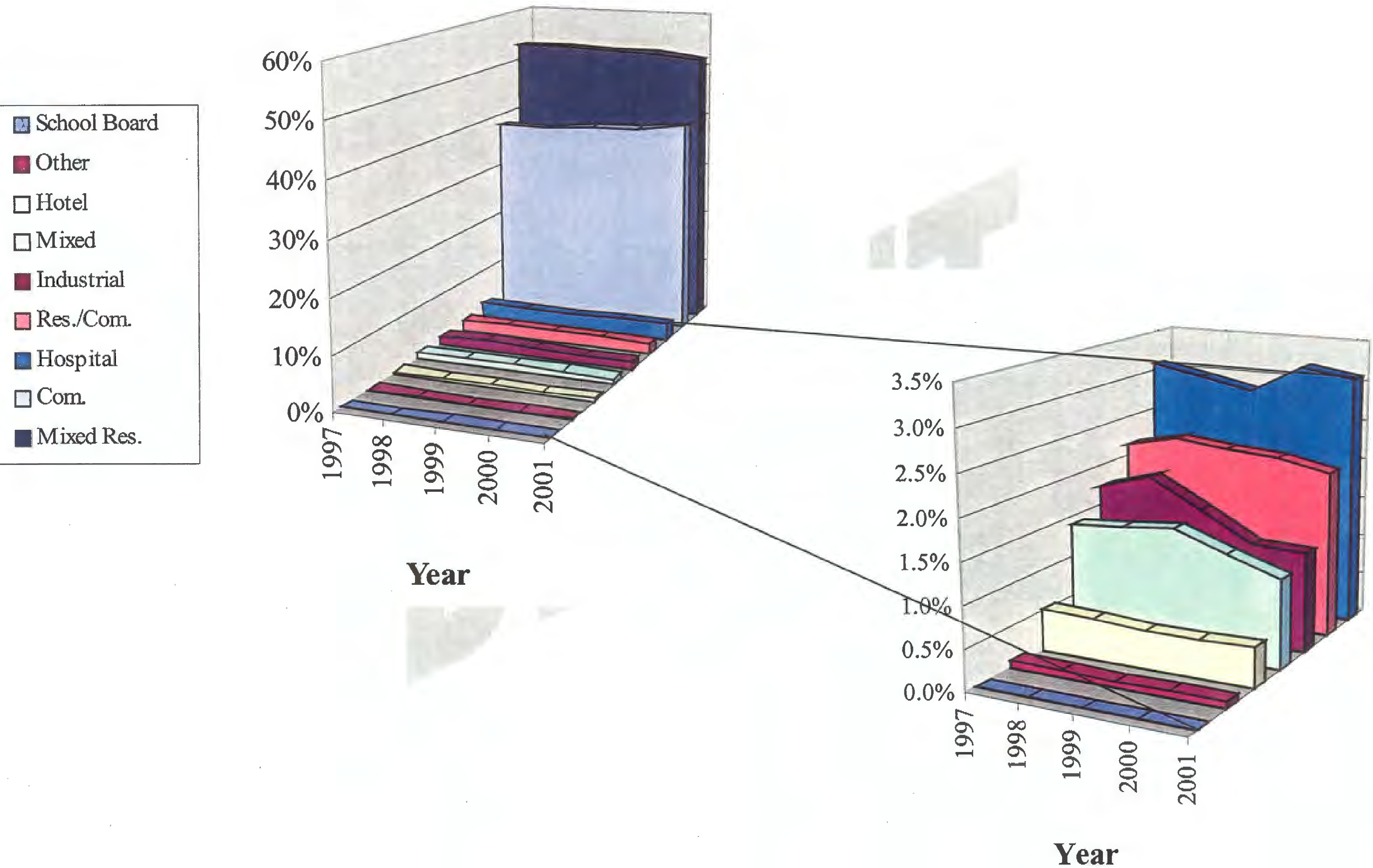


Figure 4-6
Water Consumption by Billing Classification
(1997-2001) West Bank

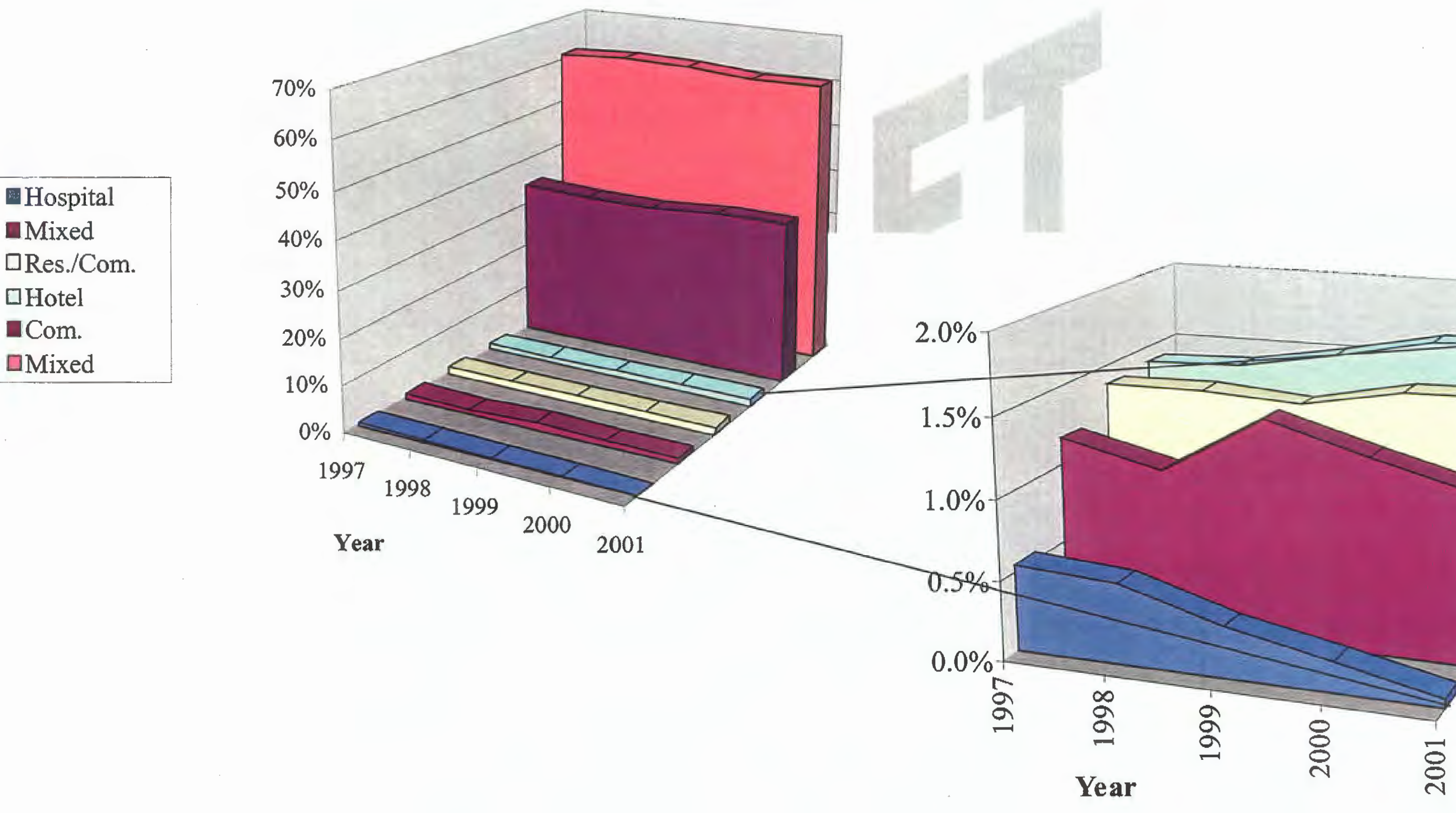


Table 4-3
Comparison of Water Production, Consumption and Wastewater Collection (1997-2001)

Water System	Water Flow (MGD)			Wastewater Flow (MGD)
	Production	Consumption	Returned	Generation
East Bank	127.7	64.6	58.1	58.0
West Bank	12.5	6.9	6.2	4.8
Total	**140.2**	**71.5**	**64.3**	**62.8**

Assuming that approximately 90 percent of metered water consumption is discharged to the wastewater collection system, the average daily water consumption is relatively similar to the estimates for wastewater contributed by consumption. On the East Bank, 90 percent of the average daily consumption is approximately 0.1 MGD greater than the estimated wastewater collected. On the West Bank, 90 percent of the average daily consumption is approximately 1.4 MGD greater than the estimated wastewater collected.

The comparison of the flow data recorded at the East and West Bank Sewage Treatment Plants and the percentage of consumed water assumed to be discharged to the sewage system validates the water consumption flows. With validated consumption flows and production flows, the comparison therefore adds confidence to the estimated UFW, as described further in this section.

4.2.1 Consumption Diurnal Curve Development

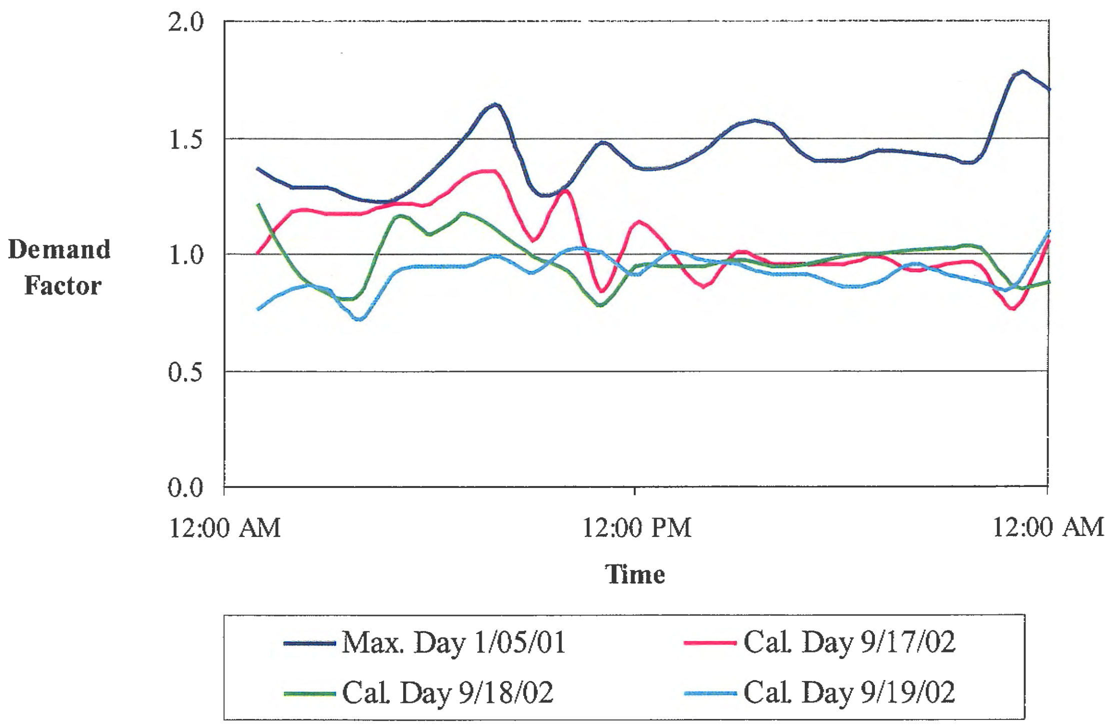
As previously stated, a 24-hour flow pattern is required for the analysis of water demand in the hydraulic model. A production diurnal curve was developed for both the East and West Bank Purification Plants. Due to the difference in production and metered consumption values, a consumption diurnal curve was developed to more accurately represent the metered consumption demand.

A five-year average from 1997 to 2001 was calculated for the metered consumption data and the UFW based on plant production data reported in the *S&WB 2001 Comprehensive Annual Financial Report*. To calculate the diurnal consumption, the percentage of UFW was subtracted from the average production. A consumption diurnal curve was then calculated based on the ratio of diurnal consumption (known as the demand factor), not including UFW, on the maximum day demand to the average day demand. Consumption diurnal curves were also calculated for the days during which field calibration testing on fire hydrants was conducted.

Figures 4-7 and 4-8 represent the consumption diurnal patterns for maximum day demand and calibration days on the East and West Bank, respectively. The maximum day demand occurred on January 5, 2001, which was during a recorded freeze event.

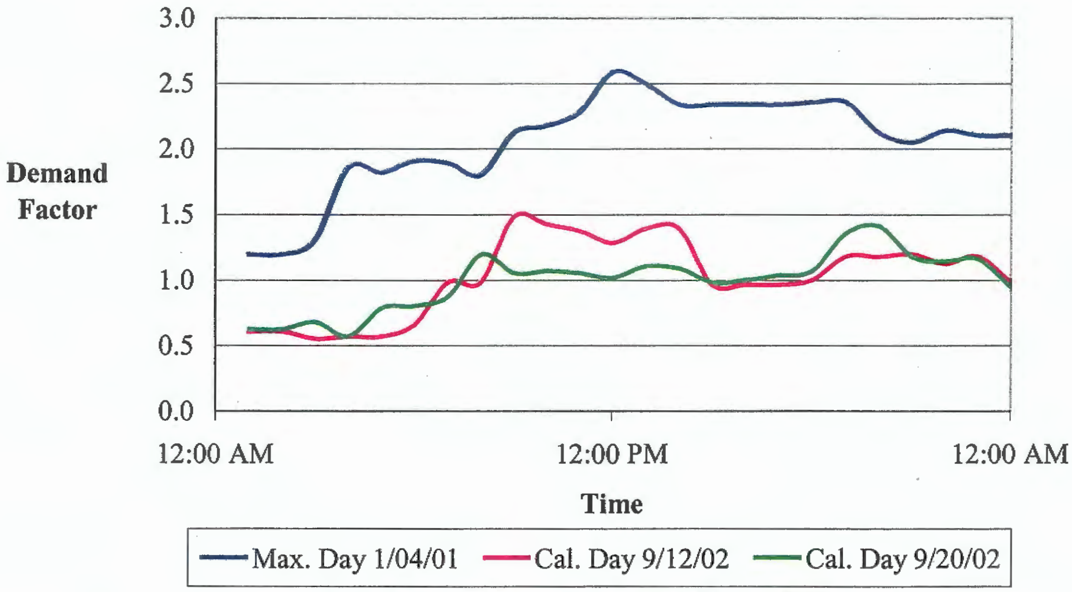
These diurnal curves were used in the hydraulic model to represent a consumption pattern for the majority of the metered water consumers during the hydraulic performance analysis. Large industrial water consumers, as discussed below, were assigned diurnal patterns specific to the industry's daily operations. **Figure 4-7** shows that the demand factor for the three East Bank calibration days ranges from 0.7 to 1.3 of average daily demand. The demand factor for the East Bank maximum demand day ranges from 1.2 to 1.8 of average day demand.

Figure 4-7
Consumption Diurnal Pattern
East Bank



As shown in **Figure 4-8**, the demand factor for the two West Bank calibration days ranges from 0.6 to 1.5 of average daily demand. The demand factor for the West Bank maximum demand day ranges from 1.2 to 2.6 of average day demand.

Figure 4-8
Consumption Diurnal Pattern
West Bank



4.2.2 Public Consumption

The metered consumption data for a portion of the public water usage (unbilled water) was also made available by the S&WB Computer Center. The water distributed for public consumption is non-revenue generating water provided by the S&WB. Public water use is also presented in the S&WB report *Water Contributed during 2001 for Public Purposes*. City departments that receive public water are listed in **Table 4-4** and include the Parks and Parkways Department, Fire Department, and Recreation Department.

As previously discussed, not all public water is metered and is considered to be a percentage of the UFW. Approximately 75 percent of the public water accounts in 2001 were metered. Accounts without a listed consumption volume in the S&WB report were considered to be non-metered and were not accounted for. In 2001, there were 836 metered and non-metered public accounts in the East Bank and 90 public accounts in the West Bank, for a total of 926 accounts systemwide.

The two following types of non-metered public accounts were identified.

1. Non-metered accounts that assign a nominal monetary value for consumed water (NM-type); and
2. Non-metered accounts that do not assign a value to the consumed water (NV-type).

According to the *S&WB 2001 Comprehensive Annual Financial Report*, NM-type accounts represented 22 percent of the public water accounts. NV-type accounts represented the remaining three percent. Water use for the non-metered accounts was estimated so an overall total of public water use could be established. The mean and average water use during 2001 for each department with a public water consumption account was estimated and is presented in **Table 4-4**.

Table 4-4
Comparison of Median and Mean Values for Public Consumption during 2001

Public Department	Million Gallons (MG)	
	Median Consumption	Average Consumption
Type A: Fountains	0.92	2.27
Type B: Fire Departments	0.21	0.30
Type C: Swimming Pools	1.18	2.47
Type D: Libraries	0.07	0.25
Type E: Cemeteries	0.15	0.18
Type F: City of New Orleans	0.79	3.94
Type G: Department of Health	0.11	0.16
Type H: Property Management	0.04	0.76
Type I: Safety and Permits	0.04	0.15
Type J: Sanitation Department	0.06	0.07
Type K: Public Works	0.01	0.20
Type L: Department of Welfare	2.86	3.13
Type M: Municipal Miscellaneous	0.16	1.62
Type N: City Parks	5.58	12.06
Type O: Museum of Art	3.36	3.36
Type P: Audubon Park	7.20	16.85
Type Q: Parks & Parkways	0.04	0.51
Type R: Recreation Department	0.07	0.73
Type S: Criminal Sheriff	7.37	22.05
Type T: New Orleans Police Dept.	0.17	2.98
Type U: Schools	0.72	1.32
Type V: Sewerage & Water Board	0.32	4.21

Note:
The median is the value in an ordered set of values such that there is an equal number of values above or below it. The median corresponds to the middle rank. If there is no one middle value, the median is the average of the two middle values.

As shown in **Table 4-4**, the average consumption values are significantly greater than the median values for all public departments. The median consumption value mitigates the arithmetic impact of the largest consumption values that appear in the average consumption estimate. The median consumption value for each public department is a more reasonable factor than the average value to apply to non-metered accounts. The median, therefore, was used as a basis for calculating water consumption for non-metered public accounts. **Table 4-5** on the following page summarizes the metered and estimated non-metered water on the East and West Bank for public usage for the year 2001.

Table 4-5
Water Contributed for Public Consumption during 2001

Public Department	East Bank (MG)				West Bank (MG)				Total (MG)	Percent of Total (%)
	Metered Water Use	Non-Metered Accounts		Total Water Use	Metered Water Use	Non-Metered Accounts		Total Water Use		
		NM Water Use	NV Water Use			NM Water Use	NV Water Use			
Type A: Fountains	15.89	1.83	-	17.72	-	-	-	-	17.72	0.8%
Type B: Fire Department	9.75	0.43	-	10.18	0.92	-	-	0.92	11.11	0.5%
Type C: Swimming Pools	31.31	2.35	-	33.66	0.78	2.35	-	3.13	36.79	1.6%
Type D: Libraries	2.85	0.07	-	2.92	0.16	-	-	0.16	3.08	0.1%
Type E: Cemeteries	1.60	0.15	-	1.75	0.03	-	-	0.03	1.78	0.1%
Type F: City of New Orleans	68.98	7.11	-	76.09	9.89	-	-	9.89	85.97	3.8%
Type G: Department of Health	1.75	0.11	-	1.86	-	0.11	-	0.11	1.97	0.1%
Type H: Property Management	2.29	-	-	2.29	-	-	-	-	2.29	0.1%
Type I: Safety and Permits	0.57	0.04	-	0.61	0.03	-	-	0.03	0.64	0.0%
Type J: Sanitation Department	0.27	0.40	-	0.67	-	-	-	-	0.67	0.0%
Type K: Public Works	3.63	0.01	-	3.64	-	-	-	-	3.64	0.2%
Type L: Department of Welfare	12.53	2.86	-	15.39	-	-	-	-	15.39	0.7%
Type M: Municipal Miscellaneous	6.49	0.16	-	6.65	-	-	-	-	6.65	0.3%
Type N: City Parks	144.76	5.58	-	150.33	-	-	-	-	150.33	6.7%
Type O: Museum of Art	3.36	-	-	3.36	-	-	-	-	3.36	0.1%
Type P: Audubon Park	185.30	14.40	-	199.70	-	-	-	-	199.70	8.9%
Type Q: Parks & Parkways	20.43	0.96	0.02	21.41	9.25	-	0.00	9.26	30.67	1.4%
Type R: Recreation Department	38.02	4.12	0.01	42.16	9.95	0.15	-	10.09	52.25	2.3%
Type S: Criminal Sheriff	418.86	81.09	-	499.95	-	-	-	-	499.95	22.2%
Type T: New Orleans Police Dept	83.46	1.02	-	84.48	0.06	0.17	-	0.23	84.71	3.8%
Type U: Schools	200.72	28.81	0.07	229.60	25.98	2.88	-	28.86	258.46	11.5%
Type V: Sewerage & Water Board	488.12	6.63	0.14	494.89	287.38	2.21	-	289.59	784.49	34.8%
Total	**1,740.94**	**158.13**	**0.25**	**1,899.31**	**344.43**	**7.87**	**0.00**	**352.31**	**2,251.6**	**100.0%**

Notes:
1 – Non-metered accounts that assign a nominal value for consumed water (NM)
2 – Non-metered accounts that do not assign value for consumed water (NV)

Approximately 2,250 million gallons of the metered water consumption were contributed by the S&WB to public usage for the year 2001. On average, the daily consumption for public water in 2001 was 6.2 MGD. The largest user for public water is the S&WB with over 770 million gallons (over 35 percent) used for operation of the sewage, water, and drainage systems such as process water at the purification plants and pumping stations.

4.2.3 Large Users

The largest water consumers were identified based on metered consumption records for the years 1997 through 2001 and are shown in **Table 4-6** for the East Bank and **Table 4-7** for the West Bank. Since the East Bank service area has a higher demand and is larger than the West Bank service area, the thirty largest users were identified for the East Bank and the twenty largest users were identified for the West Bank. The thirty largest users on the East Bank together use an average of 5.66 MGD, which represents nine percent of the total consumption. The largest users on the West Bank together use an average of 1.21 MGD, which represents 16 percent of the total consumption. **Tables 4-6** and **4-7** also summarize the user type (residential, commercial, or industrial) and the demand curve assigned to each user (industrial, East or West Bank consumption).

The Orleans Parish Prison was the largest water consumer on the East Bank accounting for approximately one percent of the total demand. The S&WB was the largest water consumer on the West Bank accounting for approximately nine percent of the total demand.

The majority of the large consumers on the East and West Banks are commercial users; four of the large users on the East Bank are industries. The large industrial users were contacted to determine specific daily water usage patterns at the individual facility. All other consumers within the service areas have been assigned a consumption demand pattern calculated for the East and West Bank consumers, as defined above. The diurnal curves developed for the large industrial users are included in **Appendix B.**

Table 4-6
Top Thirty Consumers - East Bank

Consumer	Address	User Type	Diurnal Pattern	Average Demand (MGD)						% of Total Demand
				1997	1998	1999	2000	2001	5 Year Avg.	
Sheraton Hotel	520 Canal St.	Commercial	East Bank Consumption	0.10	0.11	0.11	0.12	0.13	0.11	0.17
CS&M Associates	520 Canal St.	Commercial	East Bank Consumption	0.11	0.12	0.12	0.10	0.10	0.11	0.17
City Park	5709 Orleans Ave.	Commercial	East Bank Consumption	0.05	0.08	0.12	0.17	0.14	0.11	0.17
Hearthwood East Association	5555 Bundy Rd.	Commercial	East Bank Consumption	0.10	0.09	0.11	0.14	0.12	0.11	0.17
Jazz Casino Company	4 Canal St.	Commercial	East Bank Consumption	-	-	0.11	0.12	0.10	0.11	0.17
Canal Street Hotel	614 Canal St.	Commercial	East Bank Consumption	0.11	0.11	0.12	0.14	0.13	0.12	0.19
Association of Hospital Services	7639 Townsend Pl.	Commercial	East Bank Consumption	0.13	0.12	0.14	0.11	0.09	0.12	0.19
Housing Authority of New Orleans	WM J Guste Housing Projects	Residential	East Bank Consumption	0.11	0.11	0.12	0.12	0.13	0.12	0.19
Royal Orleans Omni	621 St. Louis St.	Commercial	East Bank Consumption	0.13	0.13	0.13	-	0.11	0.13	0.20
Levee Commission	Hayne Blvd.	Commercial	East Bank Consumption	0.23	0.13	0.10	0.10	0.08	0.13	0.20
US Gypsum Company	5701 Lewis Rd.	Industrial	Industrial	0.13	0.13	0.13	0.12	0.12	0.13	0.20
Air Products & Chemicals Inc.	14700 Intracoastal Dr.	Industrial	Industrial	0.10	0.13	0.17	0.15	0.14	0.14	0.22
Housing Authority of New Orleans	Desire Housing Projects	Commercial	East Bank Consumption	0.01	0.02	0.01	0.21	0.45	0.16	0.25
Tulane University	7000 Plum St.	Commercial	East Bank Consumption	0.14	0.14	0.17	0.20	0.19	0.17	0.26
Tulane University	1426 Tulane Ave.	Commercial	East Bank Consumption	0.14	0.19	0.25	0.21	0.15	0.19	0.30
Audubon Park Commission	Audubon Park	Commercial	East Bank Consumption	0.17	0.23	0.17	0.19	0.23	0.20	0.31
Sewerage & Water Board	Eagle St./Spruce St.	Commercial	East Bank Consumption	0.21	0.24	0.20	0.24	0.14	0.21	0.33
Veterans Hospital	1613 Perdido St.	Commercial/ Hospital	East Bank Consumption	0.28	0.26	0.27	0.19	0.12	0.22	0.34
University of New Orleans	Lakeshore Dr.	Commercial	East Bank Consumption	0.07	0.13	0.27	0.30	0.32	0.22	0.34
Fairmont Hotel	123 Baronne St.	Commercial	East Bank Consumption	0.28	0.25	0.22	0.20	0.20	0.23	0.36
Hyatt Regency of New Orleans	1300 Poydras St.	Commercial	East Bank Consumption	0.26	0.23	0.27	0.25	0.25	0.25	0.39
New Orleans Hilton Hotel	100 Poydras St.	Commercial	East Bank Consumption	0.30	0.28	0.28	0.23	0.23	0.27	0.42
Marriott Hotel	555 Canal St.	Commercial	East Bank Consumption	0.33	0.35	0.34	-	0.32	0.34	0.53
Folgers Coffee	14601 Old Gentilly Rd.	Industrial	Industrial	0.42	0.43	0.41	0.43	0.43	0.42	0.65
NASA Michoud	13800 Old Gentilly Rd.	Industrial	Industrial	0.57	0.70	0.64	0.38	0.48	0.55	0.86
Orleans Parish Prison	2700 Tulane Ave./Gravier St. /Perdido St.	Commercial	East Bank Consumption	0.60	0.60	0.70	1.01	1.04	0.79	1.23
Average Daily Demand for Large Consumers (MGD)				**5.08**	**5.31**	**5.68**	**5.43**	**5.94**	**5.66**	
Average Daily Demand for East Bank (MGD)				**63.48**	**64.76**	**65.81**	**63.92**	**62.86**	**64.16**	
Percent of Total Demand (%)				**8.0**	**8.2**	**8.6**	**8.5**	**9.4**	**8.8**	

Note:
1 – Orleans Parish Prison, Criminal Courts, and Criminal Sheriff considered one consumer

Table 4-7
Top Twenty Consumers - West Bank

Consumer	Address	User Type	Diurnal Pattern	Average Demand (MGD)						% of Total Demand
				1997	1998	1999	2000	2001	5 Year Avg.	
No Open Account on File	4400 Woodland Dr.	Commercial	West Bank Consumption	0.03	0.02	0.03	-	-	0.02	0.27
Sterik Company	4001 General de Gaulle Dr.	Commercial	West Bank Consumption	0.01	0.01	0.01	0.09	0.01	0.02	0.27
Holly Park Apartments	3300 Preston Pl.	Commercial	West Bank Consumption	0.03	0.03	0.02	0.02	0.03	0.03	0.41
Port of New Orleans	3000 Patterson Dr.	Commercial	West Bank Consumption	0.02	0.07	0.03	0.01	0.02	0.03	0.41
New Orleans Towers	3601 Texas Dr.	Commercial	West Bank Consumption	0.03	0.03	0.03	0.04	0.04	0.03	0.41
Shadow Lake Management	3200 Rue Parc Fontaine	Commercial	West Bank Consumption	0.03	0.03	0.03	0.02	0.03	0.03	0.41
New Orleans Recreation Dept.	2500 General Meyer Ave.	Commercial	West Bank Consumption	0.05	0.05	0.02	0.02	0.03	0.03	0.41
Housing Authority of New Orleans	2030 Whitney Ave.	Commercial	West Bank Consumption	0.04	0.04	0.04	0.03	0.05	0.04	0.54
Tribaut Prop. Corporation	6101 Tullis Dr.	Commercial	West Bank Consumption	0.04	0.04	0.04	0.04	0.04	0.04	0.54
Live Oak Builder	5501 Tullis Dr.	Commercial	West Bank Consumption	0.04	0.04	0.04	0.04	0.04	0.04	0.54
Shadowbrook Apartments	2100, 2200 Westbend Pkwy.	Commercial/ Single Family Residential	West Bank Consumption	0.04	0.05	0.04	0.06	0.06	0.05	0.68
Southwood Ltd.	4300 Sullen Pl.	Commercial	West Bank Consumption	0.06	0.04	0.04	0.05	0.05	0.05	0.68
Naval Support Activity	General Meyer Ave.	Commercial	West Bank Consumption	0.20	0.02	0.02	0.03	0.03	0.06	0.81
Forrest Park Association	3700 Garden Oaks Dr.	Commercial	West Bank Consumption	0.08	0.09	0.10	0.09	0.10	0.09	1.22
Sewerage & Water Board	Pacific Ave./ Socrates St./ Tall Spruce Dr.	Commercial	West Bank Consumption	0.63	0.64	0.63	0.65	0.68	0.65	8.75
Average Daily Demand for Large Consumers (MGD)				**1.33**	**1.20**	**1.12**	**1.19**	**1.21**	**1.21**	
Average Daily Demand for West Bank (MGD)				**7.26**	**7.32**	**7.41**	**7.70**	**7.21**	**7.38**	
Percent of Total Demand (%)				**18.3**	**16.4**	**15.1**	**15.4**	**16.8**	**16.3**	

Note:
1 – Sewerage & Water Board accounts summarized for three locations

4.3 WATER AUDIT

The purpose of the water audit performed as part of the Water Master Plan was to estimate the following:

- Unaccounted-for water (UFW)
- Known water losses
- System leakage

UFW may be attributed to under estimated usage by city departments for public consumption, "under" representation of service meters, "over" representation of production meters, and leaks in the distribution system. The water audit was conducted for the distribution systems utilizing two methods. The difference in the two is defined by the level of detail included and the additional assumptions made (for non-metered public water consumption and known water losses). The methods utilized are discussed below along with their respective results.

Method 1

The first method utilized for the water audit was to estimate UFW with the available data for water production and metered consumption. The following equation was used to determine the quantity of UFW:

UFW = [Water Production (Distributed into System) – Metered Water Use]

The water production was estimated for the Carrollton and Algiers Plants as previously discussed. Metered water consumption represents both revenue generating accounts and public water accounts.

Figures 4-9 and **4-10** graphically represent the average daily production in MGD for water pumped into the East and West Bank distribution systems for the years 1997 to 2001, compared to the estimated metered water consumption. As shown in **Figure 4-9**, the five-year average from 1997 to 2001 for daily consumption and production on the East Bank distribution system is 64.6 MGD and 127.7 MGD, respectively. Annually, the metered consumption on the East Bank accounts for approximately 50 percent of the daily production. In comparison, the average daily flow of wastewater collected attributed to daily consumption (not including infiltration) is 58 MGD.

Figure 4-9
Average Daily Production and Average Daily Consumption (1997 – 2001) East Bank

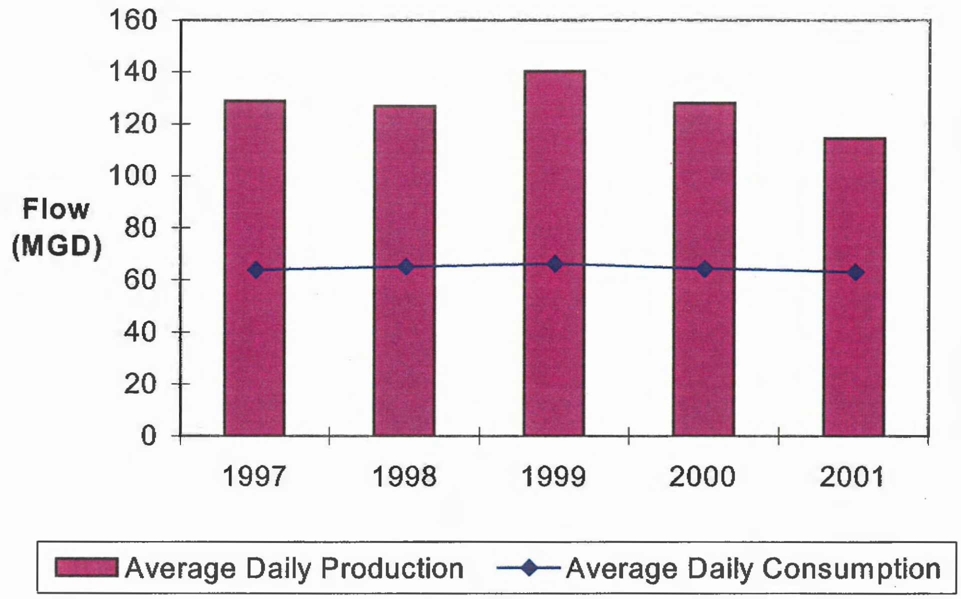
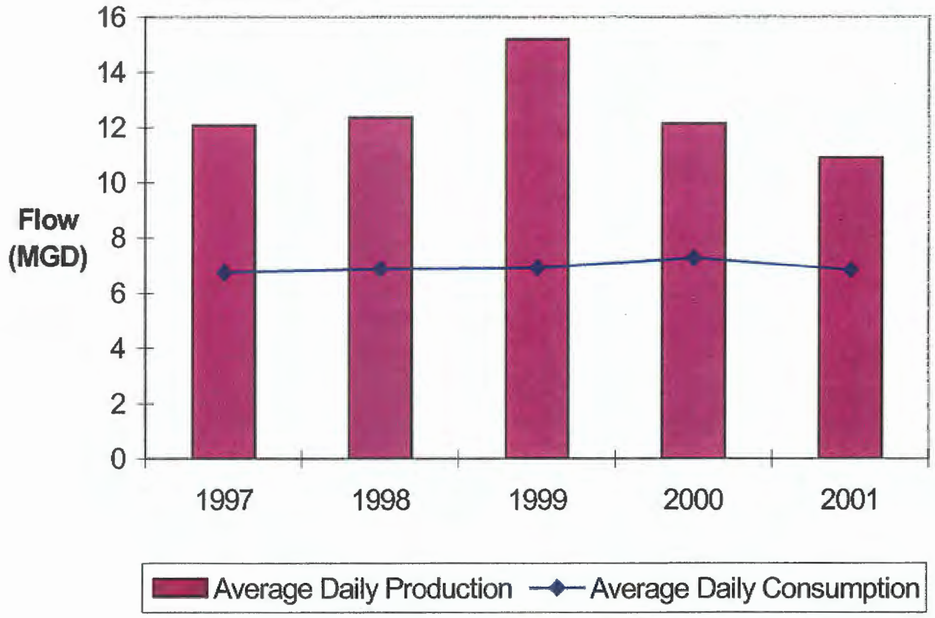


Figure 4-10 shows the five year average from 1997 to 2001 for daily consumption and production on the West Bank distribution system at 6.9 MGD and 12.5 MGD, respectively. Annually, the metered consumption on the West Bank accounts for approximately 45 percent less than the daily production. In comparison, the average daily flow of wastewater collected attributed to daily consumption (not including infiltration) is 4.8 MGD.

Figure 4-10
Average Daily Production and Average Daily Consumption
(1997 – 2001) West Bank



Method 2

The second method utilized for the water audit was to estimate UFW with a more detailed approach which included an estimate of known water losses. The guidelines for performing a water audit as presented in American Water Works Association (AWWA) manual, *Water Audits and Leak Detection (AWWA M36)*, were followed. The following equation was used to compute the extent of UFW:

UFW = [Water Production (Distributed into System) –
Metered and Estimated Public Water Use – Known Water Losses]

The water production was estimated for the Carrollton and Algiers Plants as previously discussed. Metered water consumption represents both revenue generating and public water. Non-metered water consumption is typically public water use that is not metered. Non-metered water consumption was estimated as previously discussed and summarized in **Table 4-5**.

Known water losses include water loss on private property and leaks located during 2001. The *S&WB 2001 Comprehensive Annual Financial Report* estimates water loss on private property at 1.2 BG. For this water audit, the volume of breaks and leaks for East Bank and West Bank systems is reported according to the number of accounts in each area.

The S&WB performed a leak detection survey in 2001. Based on this survey, leaks with an estimated volume of 4.8 BG were located in 2001. For the water audit, the identified leaks were apportioned between East Bank and West Bank systems on the basis of water distributed into each system. **Table 4-8** summarizes the estimate of known water losses in 2001.

Table 4-8
Summary of 2001 Known Water Losses

System	Leaks on Private Property (BG)	Detected Leaks (BG)	Total (BG)
East Bank	1.1	4.4	**5.5**
West Bank	0.1	0.4	**0.5**
Total	**1.2**	**4.8**	**6.0**

A possible source of UFW may be attributed to the washout or "dump-off" valves that typically discharge into the drainage system. During the hydraulic model build task, a number of these valves were identified in the distribution system. The washout valves are used to discharge water from isolated water mains during maintenance and repairs. Upon investigation of one such washout valve immediately downstream of the Carrollton Plant, it was discovered that this valve was open.

The water audit analysis was based on an annual data, specifically for the year 2001. The results are therefore presented as billion gallons (BG) for that year.

The analysis for 2001 (utilizing Method 2) is summarized in **Table 4-9**.

Table 4-9
2001 Water Audit

Description	East Bank (BG)		West Bank (BG)		East & West Bank (BG)	
Water Production	43.9		3.8		47.7	
Water Consumption						
Revenue Generating Water	20.6	47 %	1.8	47 %	22.4	47 %
Public Water	1.9	4 %	0.4	11 %	2.3	5 %
Known Water Losses						
Water Losses on Private Property	1.1	3 %	0.1	3 %	1.2	3 %
Estimate of Water Loss from Leaks Located during 2001	4.4	10 %	0.4	11 %	4.8	10 %
UFW (Production – Consumption – Known Water Losses)	**15.9**	**36 %**	**1.1**	**28 %**	**17.0**	**35 %**

It is estimated that approximately 36 percent of the water distributed to the East Bank, and 28 percent for the West Bank, respectively, are currently identified as UFW and may represent system leakage. The total percentage of known water losses and UFW is approximately 48 percent for both the East and West Bank systems.

Table 4-10 summarizes the potential water loss from leakage for 2001 including water loss on private property, actual leaks located in the system, and estimated UFW. The estimated water loss is also shown as a percentage of the water production for each system.

Table 4-10
Potential Water Loss from Leakage for 2001

Description	East Bank (BG)		West Bank (BG)		East and West Bank (BG)	
Water Production	43.9		3.8		47.7	
Water Loss on Private Property	1.1	3 %	0.1	3 %	1.2	3 %
Located Leaks	4.4	10 %	0.4	11 %	4.8	10 %
UFW	15.9	36 %	1.1	29 %	17.0	36 %
Total	**21.4**	**49 %**	**1.6**	**42 %**	**23.0**	**48 %**

The two methods utilized in conducting the water audit yielded similar results for water loss in comparison to average daily production, demonstrating good correlation. For the East and West Bank systems approximately 49 percent and 42 percent water loss is estimated, respectively.

4.4 FUTURE WATER DEMAND TO YEAR 2025

The existing distribution systems and water demand were used as a base model to further understand and compare the capacity requirements related to future water demand. A water demand analysis was conducted for the study area in conjunction with the model development for the wastewater collection system as part of the SSERP to identify capacity upgrades in the sewer system. Recently, the CBD/FQ/WD sewer model extension was refined with updated information on development in this basin. The information obtained in conjunction with the model build efforts for the sewer system (references listed in **Section 2**) was reviewed and utilized for the water distribution system.

The future demand projections were estimated based on the projection of service area growth and development, as described in **Section 2**. The development status of the service area or change in zoning provided an assumption of additional water supply required for new customers. Future demands from the service areas were loaded into the model at existing nodes.

To quantify the water demand expected for future development, projections were calculated using commonly accepted practices (i.e., projections based on population, land use and area size). For example, in partially developed land areas where development is expected to occur, the existing water demand within the land area was distributed to the areas of the existing development. This provided a rate of water demand per acre of developed land. The remaining undeveloped percentage of the land area was then multiplied by the demand factor to determine projected demand. An assumption was made that land areas would be fully developed by 2025. For land areas with no existing water demand, standard demand projections were used based on the type of planned development and zoning. The locations and general sizes of expected future water consumers for the service areas were previously presented in **Figure 2-12** through **2-19.**

The anticipated future demand required by the identified development and re-development for the East and West Bank service areas is summarized in **Tables 4-11** and **4-12**, respectively.

Table 4-11
Future Demand Summary for 2025
East Bank

Development Status	Number of Sub-basins	Area (acres)	Existing Consumption (MGD)	2025 Consumption (MGD)
Developed				
Fully Developed	613	31,400	47	47
Re-Developed	75	2,500	16	28
Partially Developed	26	2,300	2	3
Subtotal	*714*	*36,200*	*65*	*78*
Undeveloped				
New Development	15	6,700	0	10
No Development	N/A	62,900	0	0
Subtotal	*15*	*69,600*	*0*	*10*
Total	**729**	**105,800**	**65**	**88**

Future demand on the East Bank is projected to be 88 MGD. The additional consumption will result in an increase of approximately 35 percent of the existing water consumption.

Table 4-12
Future Demand Summary for 2025
West Bank

Development Status	Number of Sub-basins	Area (acres)	Existing Consumption (MGD)	2025 Consumption (MGD)
Developed				
Fully Developed	104	4,600	6	6
Partially Developed	27	1,500	1	2
Subtotal	*131*	*6,100*	*7*	*8*
Undeveloped				
New Development	4	2,600	0	4
No Development	N/A	2,200	0	0
Subtotal	*4*	*4,800*	*0*	*4*
Total	**135**	**10,900**	**7**	**12**

The future consumption on the West Bank is projected to be 12 MGD. The additional demand will result in an increase of approximately 71 percent of the existing water demand.

Section 5

Section 5

MWH

Section 5 – Model Development and Calibration

5.1 MODEL SELECTION

Computer models of water distribution systems are effective tools for predicting system behavior under a wide range of demand loading and operating conditions. They make use of laws of conservation of mass and energy to determine pressure and flow conditions for specified system characteristics and operating conditions. The predictive capabilities of models provide powerful tools for evaluating system response to various management alternatives. These tools include the evaluation of the performance of water distribution systems under various planning scenarios for current and future demand loadings, and investigation of system vulnerability to emergency situations. The model can then be used to identify system deficiencies and develop remedial measures to address the identified deficiencies.

In order to create the best model possible, it was necessary to select from the competitive software packages which best meet the needs of the modeling effort. A summary of the advantages and disadvantages of selected hydraulic modeling software was presented to the S&WB. The evaluation criteria are listed below followed by a summary of the capabilities of each software package in relation to the criteria. A score was assigned to each criterion and each software package was ranked according to its score. H_2O Map version 3.0, which operates with ArcView GIS, was recommended and selected as the model software for this project.

5.1.1 Modeling Software Evaluated

There are several network-analysis software models with a variety of features and capabilities. MWH evaluated the following four model software packages, which are widely used and accepted in the industry: WaterCAD, EPANET, H2O Net and H2O Map. Each of the model software packages evaluated are Windows based programs that run either within AutoCAD or as stand-alone applications.

WaterCAD is written and sold commercially by Haestad Methods. Haestad Methods, located in Waterbury, Connecticut, has been writing hydraulic software for the past 20 years. The newest version of WaterCAD, version 5.0, was evaluated.

EPANET is public domain software developed by the Water Supply and Water Resources Division (formerly the Drinking Water Research Division) of the U.S. Environmental Protection Agency's National Risk Management Research Laboratory. EPANET version 2.0 was evaluated.

H2O Net and H2O Map are developed by MWH Soft, Inc. of Broomfield, Colorado. MWH Soft, Inc. was founded in 1996 as a subsidiary of the environmental engineering firm MWH Global, Inc. H2O Net version 3.x and H2O Map Water GIS 2.5 were evaluated.

5.1.2 Software Selection Criteria

To select the appropriate modeling software, evaluation criteria were defined and used to score each software package. The operating criteria for the model are grouped into the following five categories:

- Model Setup
- Model Simulation
- Model Output
- Model Information
- Advanced Features

5.1.2.1 Model Setup

The first step in creating a hydraulic model is the model setup. Model setup includes importing existing GIS or CAD data into the modeling software and converting the data to a usable model consisting of pipes, tanks, and other water facilities. The categories in the model setup selection criteria include network creation, facilities, controls, demands, scenarios, data exchange, and database management.

Network Creation

Network creation must be accomplished by at least the following two methods:

- Convert imported GIS or CAD data to a hydraulic model (including the ability to remove unnecessary nodes).
- Manually create and edit the model according to graphics.

Facilities

Facilities required in the model include:

- Pipes
- Valves (check, pressure reducing, pressure sustaining, flow control, pressure breaker, throttle control, float, user-defined)
- Tanks (fixed head, cylindrical, variable head, variable area, single and multiple inlet/outlet)
- Pumps (constant power, multiple data points, variable speed)
- Flow Totalizers (meters)

Controls

Operational controls must be included for variable operating equipment (i.e., a pump starts when the discharge pressure is less then a setting). Controls should be based on:

- Pressure, flow, time switches, grade, valve settings, tank settings

Demands

Demands must allow the following:

- Multiple demands to be assigned to nodes in the model.
- Multiple demand curves (or patterns) to be described in a stepwise or continuous (linear) fashion for the simulation period.

Scenarios

Alternatives (scenarios) can be developed for differing conditions. The user must be able to change demands (peak hour, peak day, etc.), pipe diameter or status, pump power, etc. in each scenario. The scenarios must be managed so that:

- Multiple scenarios are saved in the same file, so the results of one scenario can easily be compared to other scenarios.
- Each scenario can be run with only the selected facilities (facility management).
- The user can mix and match demands, facilities, controls, etc. in the scenarios.

Data Exchange

The software must allow the sharing of data extracted from GIS and CAD software applications. Software formats used for importing/exporting data must include:

- GIS – Shapefile (ArcView) and Generate (e.g. ArcInfo)
- CSV (comma-delimited text)
- CAD – DXF, DWG, and DGN

Database Management

A database is typically used to store the physical characteristics of the facilities in the water system and other model information. The database must have the ability to perform the following:

- Allow the user to easily cut-and-paste to/from the database.
- Add user-specified database tables and fields to support various engineering and planning applications.
- Perform mathematical operations (addition, subtraction, etc.) on the database columns.

5.1.2.2 Model Simulation

The model provides information regarding the system conditions under various system parameters through model simulation. The criteria included in this category include simulation time, fire flow analysis, and water quality.

Simulation Time

In addition to allowing the user to model a steady-state run (a snapshot of the conditions at one point in time with unchanging system parameters), the model must allow:

- Extended Period Simulation (EPS), allowing the simulation of system performance over time. An EPS is essential for evaluating water quality dynamics and the performance of storage tanks in response to extended fire demands, specific pump operating schedules, or a basic 24-hour diurnal-demand pattern.

Fire Flow Analysis

Fire flow analysis consists of applying fire demands to selected locations in a model. Residual pressures, available flows, and design flows are calculated. The model must be able to:

- Perform system-wide analysis at each fire flow node.
- Analyze single and multiple simultaneous fire flows along with their expected duration in a dynamic environment.

Water Quality

A model needs to have EPS capabilities to model most water quality issues. For the S&WB system, the water quality model must include:

- Water Age – Determine water age characteristics.
- Source Tracing – Compute the percentage of water originating from a specified node over time.

5.1.2.3 Model Output

Various tools assist in the analysis model simulation results (model output). The model output selection criteria includes the categories of database queries, tabular output, and graphical output.

Database Queries

Query tools allow a user to probe the model database for specific information. Advanced query tools can greatly assist in the decision making process for network asset inventory, rehabilitation requirements, and financial planning. Query tools must have the ability to:

- Build intelligent queries on any database and modeling attributes (both input and output data) to meet a single criterion or multiple criteria simultaneously.
- Display query results graphically, in tabular format, printed, or exported to a standard spreadsheet or word processor.

Tabular Output

The model must allow the user to view output results in a table. Options should include:

- Report tables that can be customized by selecting the variables to display, the order in which they appear along with the desired units, display precision, column width, and format, and the corresponding hydraulic time period.
- Display of the results for the entire network, portions, or selected elements.
- Sorting according to any variable and filtered based on any search criteria.
- Maximum, minimum, and average values for all variables, automatically calculated and reported for EPS runs.

Graphical Output

It is often easier for a model user to analyze and view trends through graphical output, as opposed to tabular output reports. Graphical output options should include:

- Group Graphs – Graphs that include (and compare) several facilities in the same graph.
- Time Series Graphs – Time-series graphs visually show how user-specified variables change throughout an EPS. Variables such as pipe flow rates, velocities, headlosses, nodal pressures, hydraulic grades, water age, quality concentrations, pump operations, and others should be viewed on time-series graphs. Graphs are especially useful for model calibration.
- Color Mapping – Color-coded facilities based on pipe sizes, flowrates, etc.
- Pipeline Profile – Display to show the profile of a series of selected with the hydraulic grade line (HGL) and ground profiles.
- Contours – Color-coded contours for attributes including elevation, pressure, HGL, demand, chemical concentration, water age, percent source contribution, fire flow, and other pertinent modeling parameters. The contours should allow for the contouring of sections of the network or the entire network and should allow the option of displaying the maximum, minimum, or average values for a simulation.
- Annotations – Display of annotations (flow direction arrows, text showing pipe diameters, etc.) on selected facilities.
- Exporting – Graphs and charts exported through Windows Metafiles or in various image formats.

5.1.2.4 Model Information

The model information category includes criteria that are related to the software package on a more general or basic level. These categories include the hydraulic engine utilized, allowances for head loss, ease of use of the model, cost of the software and software maintenance and support.

Hydraulic Engine

The stability and reliability of the algorithm employed to analyze the hydraulics of the water distribution system are of great importance and are a critical consideration when selecting a model. The methods used by the software packages being evaluated include:

- Hybrid (or Gradient) Method – Original method used by EPANET and WaterCAD
- Modified Hybrid Method – The original Hybrid Method has been enhanced to explicitly account for analytical gradient derivation of bounded nonlinear elements. As a result, the modified hybrid method exhibits superior convergence characteristics of any other method for nonlinear network analysis. In short, the method is more reliable and, in systems that contain pumps and/or control valves, will run the analyses significantly faster, eliminate nonlinear divergence conditions, and produce accurate results.

Head Losses

To model friction head losses in pipes, the model must allow:

- Selection of the formula used for calculating head losses: Hazen-Williams, Darcy-Weisbach, or Chezy-Manning.
- Minor (local) head losses to be added for bends, meters, fittings, valves, etc.

Ease of Use

Ease of use of the model will affect how well engineering and operations staff will be able to utilize the model after it has been set up. This is a relatively subjective assessment and can best be determined based on a demonstration of each software package. In general, ease of use covers three separate areas:

- Data Entry – Items that affect the ease of data entry include:
  - ASCII vs. Graphical – Data entry methods can range from simple editing of an ASCII file (text) to highly graphical CAD-based data entry. Graphical methods allow the user to change network data directly on-screen and have the changes automatically reflected in the data set, thus eliminating the need to manually perform the required changes back into the data set.
  - Spreadsheet – When performing massive data entry for a large distribution system, a spreadsheet-type interface can greatly increase the speed of input.
- Model Operation – Ease of model operation is related to the actions taken by an operator to run the model after all data has been entered and debugged. Some models incorporate graphical "click on" features to simplify model operation while others require preparing and running a complicated job control file. When weighing the relative importance of data entry versus model

operation, it is important to consider that data is only entered once, while the model may be run hundreds of times.

- Data Output and Analysis – Data output and analysis describes the manner in which the voluminous data developed by a model is presented to the user (e.g., tables, graphs, and maps) and is analyzed. In some cases, tabular output can be very difficult to interpret. Again, since the model may be executed several times, it is important that data output be presented in a form that is easy to understand and evaluate. The ability to easily generate on-screen and printed graphics of the model results greatly simplifies model output interpretation, and provides a valuable resource for relating results to individuals unfamiliar with the inner workings of hydraulic and water quality computer modeling.

Cost

Model software package costs normally vary with the following items:

- Number of links to be included in the model
- Features included in the model
- Add-on modules

The modeling of a distribution system using less sophisticated software packages carries with it a number of issues associated with model maintenance and support, data management, calibration complexity, operational variables, and interpretation of output that results in increased labor requirements. These labor requirements, and their associated costs, may be minimized through the use of more sophisticated, higher cost, modeling software. A balance must be struck, however, between software sophistication, software flexibility, required model performance criteria, labor cost, and software cost.

Maintenance and Support

Availability of sound maintenance and support is an important consideration with regard to continued use and upgrading of the model. Turnover in the computer industry is quite common. Thus, there is an increased risk that the continuity, as well as the quality, of vendor support can be affected if the software is relatively new and untested. Even if the model is established, the level of vendor support for that software package should be investigated.

5.1.2.5 Advanced Features

The following features offer advanced functions in the modeling effort.

Logical Controls

Logical controls include a highly sophisticated rule-based logical control language (If, Elseif, Else, And, Or, Not) for defining decision rules (PLC emulation) to precisely simulate the hydraulic behavior of the water system. The user can automatically control the status of pipes, pumps, and valves based on time (time switch), tank water levels (grade switch), node pressures (pressure switch), pipe flow rates (flow switch), and any of their combinations. Rule-based controls allow link status and settings to be based on a combination of conditions that might exist in the network after an initial hydraulic state of the system is computed.

SCADA Interface

A SCADA interface allows the user to extract real-time modeling data directly from a SCADA system. The data consist of tank water levels, pipe status, pump status and settings, and various demand scaling options. Recorded pressure and flow readings can be imported for model calibration/verification purpose. Alarm settings for tank level, node pressure, and pipe velocity may also be fully supported. Such on-line modeling and monitoring capability is helpful for operator training (emergency response), confirmation of normal system performance, projection of operating scenarios, system trouble-shooting, and improvement of overall operations.

Pumping Energy and Cost

Costing routines compute pumping energy and cost based on variable electricity and demand charges.

Energy Management

Energy management capabilities assist the user in identifying the most energy-efficient and cost-effective pump scheduling and operational policies. An energy management module handles time-varying energy rates and demand charges, as well as constant efficiency and variable pump efficiency (efficiency vs. flow data) curves for any pump in the system. This capability can be effectively used to optimize storage/pumping trade-offs, evaluate rate schedules, and monitor cost of operations.

Net Positive Suction Head (NPSH)

The model may calculate NPSH requirements to ensure cavitation free operation. These items include:

- NPSH Calculation
- Cavitation Index

5.1.3 Modeling Software Comparison

The four software packages (WaterCAD, EPANET, H2O Net and H2O Map) were evaluated by comparing the criteria they support. Based on the criteria supported, a score was assigned to each software package. Evaluating and scoring the software is subjective by nature. In order to rank the software more objectively, each criterion was given a score, rather than each category. **Table 5-1** shows a summary for the scores of the software packages by category. Each category was weighted as shown in **Table 5-1** according to the perceived importance compared to the other categories.

Table 5-1
Modeling Software Comparison

Category and Weighting	WaterCAD	EPANET	H2O Map	H2O Net
Model Setup (25%)	78	41	100	97
Model Simulation (20%)	100	83	83	100
Model Output (25%)	82	40	100	100
Model Information (20%)	81	58	100	96
Advanced Features (10%)	73	55	100	100
Overall Score	**83**	**53**	**97**	**98**

The results of the scoring indicate that both H2O Net and H2O Map are top choices for creating a model of the S&WB's water distribution system. H2O Map has the advantage of a wide range of features and a relatively low cost for the software and support. H2O Map also has a particular advantage in its ability to directly interface with GIS as a stand-alone application, which works especially well in light of the S&WB's existing GIS system, both from the standpoint of familiarity with GIS as well as the associated cost savings by not requiring the purchase of additional software for graphic interface (i.e., AutoCAD). H_2O Map version 3.0 was recommended and selected as the model software for this project.

5.2 MODEL COMPONENTS

A spatial data management system was used to efficiently analyze and model the water distribution systems. The hydraulic model components consist of ArcView GIS files, customized GIS tools, and H_2O Map modeling software. **Figure 5-1** shows a schematic data flow diagram of the model components and data management system implemented for this project. This system allows easy access to data and also provides the flexibility of being able to quickly move data between GIS and H_2O Map for model simulations and viewing of results graphically through GIS. The data management system also preserves the integrity of system data through numerous model simulations.

5.2.1 ArcView GIS

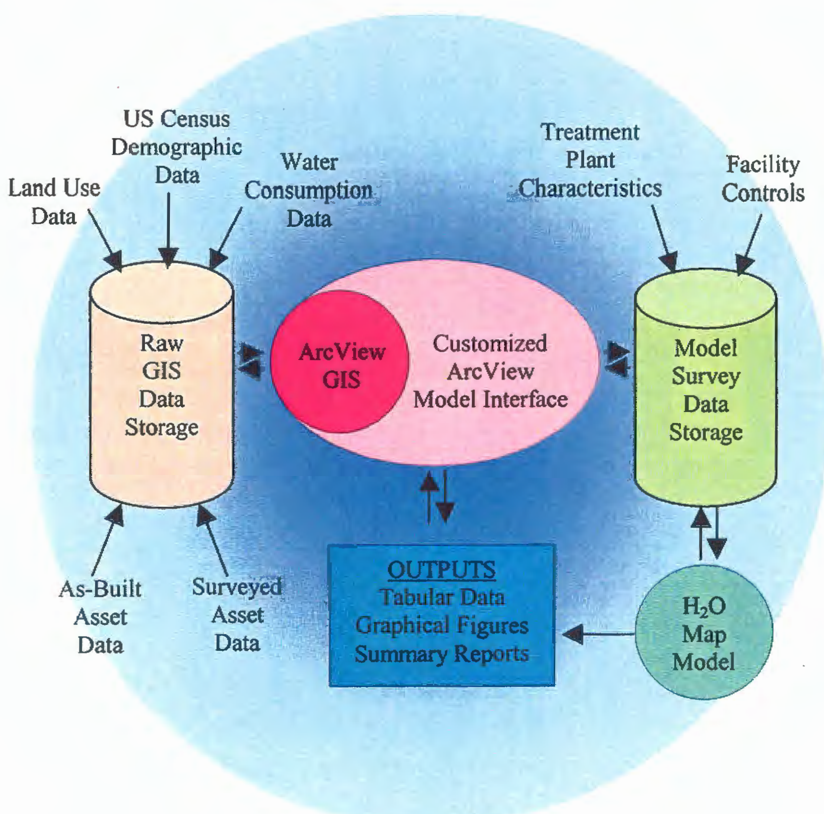
The water hydraulic model implemented a GIS/Data Management System based upon the ESRI ArcView 3.x software platform for all data management activities. The purpose of the GIS files is to include all facilities within a spatial database. Locating all facilities within one database allows for improved management of data and an easily accessible data source.

5.2.2 Customized GIS Tools

Model build activities were carried out through the use of an ArcView Model Extension customized by MWH. Similar extension tools were developed by MWH for the SSERP hydraulic model of the wastewater collection system. The tools were developed in ArcView programming language, Avenue, to help assure quality and prevent errors in the model build process. The tools typically automate a manual process that may have associated user errors. A detailed users guide for the customized tools is provided in **Appendix C**. These customized GIS tools are briefly described as follows:

- WDTTE Water: Records changes made to the GIS files in order to trace all data used in the model to their sources. Provides access to overlay aerial photography for the network system. The WDTTE Water tool provides flexibility in moving data from GIS to the model software.
- Simplify: Simplifies pipe segments based on pipe criteria (material, age, diameter) and specified node type (junction, check valve, calibration hydrant) for input into H_2O Map. Analyzes pipe characteristics that do not vary on the connecting pipes, and merges pipes together as a single pipe. Returns output reference tables to link simplified and extended networks to update information between files.
- Valve Trace: Traces a pipe segment (based on user selection) to the nearest upstream and downstream valves. Identifies the minimum number of valves that should be closed to isolate the pipe segment for maintenance or repair. An extended valve trace identifies the pipe segments downstream of the isolated pipe that would not receive water supply during maintenance activities. Customers who would not receive water supply may then be identified based on the results of the valve tracer.

Figure 5-1
Data Management System
Flow Diagram



5.2.3 H_2O Map

H_2O Map version 3.0 was used as the primary hydraulic analysis simulation platform. Additional software modules purchased by the S&WB include the following:

- H_2O Map Skeletonizer: Simplifies and reduces large GIS models to a manageable size ready for hydraulic analysis. Automatically reduces excessive pipe segmentation (caused by valves, fire hydrants, and data capture process) by dissolving interior nodes based on any specified combinations of physical characteristics (e.g., series pipes of similar diameter, material or age), removes pipes less than a specified diameter, and trims short pipe segments including dead ends and hydrant leads.

- H_2O Map Allocator: Geocodes meter billing data to determine the demand at each junction node by identifying and summing all the customers/meters in its associated demand area polygon. Calculates demands based on a direct spatial intersection between demand categorization polygons (e.g., land use polygons, population polygons, pressure zone polygons, and others) and demand area coverage polygons. Calculates demand nodes by summing individually assigned consumption category polygons. Locates the junction closest to the billing meter by using advanced search algorithms and then allocates nodal demands. Locates the closest pipe to each meter, then assigns demands to the nearest junction node on either side of the pipe or divided based on a distance-weighted approach.

- H_2O Map Calibrator: Uses Genetic Algorithms and Global Search control strategies to optimally adjust pipe roughness coefficient, link status, and demand distribution to provide a calibrated model and best reflect what is actually occurring in the system. The program minimizes the difference between observed field data and model predictions considering all test data simultaneously to provide the best calibration possible. Ability to disaggregate the network model into separate logical calibration groups based on the known physical characteristics of the associated pipes (e.g., material, age, diameter, location) and evaluate their fitness under various demand loading and operating conditions and to maximize efficiency.

5.3 MODEL DEVELOPMENT METHODOLOGY

The modeling methodology follows a logical progression of events including data acquisition, model construction, and assumptions made for the model build process.

5.3.1 Data Acquisition

In order to develop a hydraulic model and evaluate the distribution systems, it was necessary to gather available data for the distribution systems and the Water Purification Plants. The majority of the data was obtained from the Sewer and Water Maps, which are maintained by the S&WB. Other sources of information for the water system facilities were collected and used to help verify asset information.

The principal sources of data include the following:

- New Orleans City Planning Commission Land Use Reports - In conjunction with the SSERP, MWH obtained information on a population study and the future land use and growth for the City of New Orleans through the year 2020. Land Use Reports compiled by New Orleans City Planning Commission were made available to MWH. These reports and maps identify potential areas of growth or re-development in the city. Additional information was received from the Planning Commission in 2002 to update the areas in the city identified for re-development.

- S&WB Comprehensive Annual Financial Reports - MWH reviewed the *S&WB Comprehensive Annual Financial Reports* from 1996 to 2001. The annual reports provide information for both the East Bank and West Bank water distribution systems including quantity of water treated, quantity of water consumed, quantity of free water (water provided for public use), power usage, and revenue from water charges.

- Water Billing Data - The S&WB Computer Center provided monthly water consumption data for the East and West Bank. This information included the quantity of metered water and water use category (i.e., residential, commercial, and industrial). The S&WB Computer Center also provided information on free water annually contributed to the public, including the quantity of water consumed, and estimated cost to the S&WB to provide water and sewer services.

- Leak Detection Reports - Leak detection reports for the distribution systems are completed weekly and submitted to the S&WB by Earth Tech. These reports were available to use to identify the areas of the distribution systems where leaks have been detected.

- S&WB Maps - MWH received maps and plans of the water systems (including mains and pump stations) which are maintained by the S&WB. Sewer and Water Location Maps, drawn to scales of 1"=60' and 1"=100', detail the sewer collection and water distribution systems and include pipe location, pipe size, general valve and hydrant location and reference numbers. Valve and Hydrant Maps (not drawn to scale) contain information related to the water systems and provide information on the location, pipe size, general valve and hydrant location and reference numbers.

- S&WB Construction Field Books - Handwritten construction field books prepared by S&WB inspectors are frequently referenced on the Sewer and Water Location Maps. The field books include information such as location, record or "as-built" dimensions and notes, dates of installation, location of house connections, and names of contractors performing the work. These field books are stored at the S&WB and were available to MWH.

- Pitometer Engineering Associates Drawings - Drawings completed by Pitometer Engineering Associates (1988) were obtained from the S&WB. These drawings include the location, flow, pressure, and size of the major water transmission and distribution mains (12 inches and larger). Additional "as-built drawings" of the water purification plants, pump stations, and storage tanks were also made available to MWH.

Additional sources of information include complaint data and asset inventory from CassWorks, U.S. Census data, zoning maps, digital 2-lined street maps, digital contour mapping, digital aerial ortho-photographs, future consumption estimates from the sewer model, and daily logsheets from the Water Purification Plants. All references and sources of data for the Water Master Plan are listed in **Appendix A**.

5.3.2 Conversion of Water Maps to GIS Format

All of the system Sewer and Water Maps were originally digitized in 1997 during the sewer model build process for the SSERP. The sewer and water systems were digitized on separate layers. The location and attributes of the nodes and pipes of the water distribution systems were shown on 616 Sewer and Water Maps. The maps were not based on any regular grid and were at varying orientations. In order to convert this data to electronic format, the locations of the water nodes and pipes were digitized. This was accomplished by scanning each map to create an electronic image and then downloading the scanned image into AutoCAD software.

Once aligned, the outline of the map was traced onto one layer of an AutoCAD drawing, the pipes were traced onto a second layer, the nodes were transferred to a third layer, and any written notes or other annotations were added to a fourth layer. Nodes are defined as valves, hydrants, corporation cocks, junctions (caps, crosses, or tees), and reducers. The AutoCAD drawings were then transferred into a GIS system. One GIS file was constructed for both the East Bank and West Bank systems.

When noted on the maps, reference data was entered for pipes including material, diameter, and the upstream and downstream nodes. The majority of pipes had no diameter or material indicated. As each node was digitized, a full reference was attributed to it. The node naming convention followed the same general naming convention as on the Sewer and Water Maps. Each node was identified with a letter for the node type followed by a "-", the map number followed by a "-", and a three digit sequential number. For example, the node ID for the first fire hydrant, node type F, on map number 253 is indicated as F-253-001.

5.3.3 Network Editing in GIS

Once the GIS files were retrieved, the East and West Bank systems were separated into two files. As the two water distribution systems operate separately, one model was constructed for each system. Separating the two systems in GIS also allowed more than one person to edit the networks at the same time. Creating, editing, and managing of the water links and nodes in the GIS files was conducted using the customized model build application developed by MWH, WDTTE Water.

When the Sewer and Water Maps were digitized in GIS, "ghost" nodes were created to hold a curve in a line, which is typically accomplished by vertices in a pipe segment. The "ghost" nodes created an extensive network with many small pipe segments that actually represented fewer pipe segments according to similar pipe characteristics. H_2O Map Skeletonizer was used to simplify out the "ghost" nodes and create vertices in the network systems. The skeletonized networks more accurately represent the actual distribution systems.

Network editing in GIS included checking and editing the water facilities in the GIS files in comparison to the available data sources before importing the model structure into H_2O Map. The GIS files for the water nodes and links were checked against the Sewer and Water Location Maps for accuracy and made consistent with the maps. The Valve and Hydrant Maps were used to verify network information not available on the Sewer and Water Location Maps. The following is an overview of the procedures taken to check and edit the GIS files for the water nodes and links.

Database characteristics for pipelines include 'From' and 'To' nodes, length, diameter, roughness, date of construction, and data sources for each characteristic. Database characteristics for nodes include identification (ID), node type, x and y coordinates, elevation, demand node for model purposes, and data sources for each characteristic. Numerous checks were conducted on the pipeline and node information, including the following:

- All pipe segments and nodes were verified to show location; some pipes and facilities were redrawn to more accurately show their locations.
- Connectivity was checked for each pipeline for the correct 'From' and 'To' nodes.
- All pipe segments were also verified for diameter, material, and age of construction.
- Nodes were checked to verify node types and location.

Assumptions made for purposes of network editing in GIS included the following:

- A separate pipeline is defined wherever two or more pipes intersect and wherever a pipeline changes size.
- Pipe length was calculated in ArcView.
- When pipe material or diameter was not available from the maps, the CassWorks inventory database was utilized. CassWorks was the main source of age information. Some pipe segments did not have material, diameter, or facility age information on the maps or CassWorks. In these cases assumptions were made, as discussed in the following subsection.
- Node types include valves, fire hydrants, corporation cocks, and junctions.
- Junction node types were defined as a dead-end (cap), the intersections of two or more pipelines (cross or tee), or at the location where any pipeline changes size (reducer) or material.

Scripts available in ArcView were also used to perform quality assurance checks for the manual network editing in GIS. The function of the scripts is similar to the customized GIS tools created by MWH. The scripts automate a manual process that may have associated user errors. The following scripts were used in ArcView during the GIS cleanup process:

- Get Covered Lines: checks for polylines (as drawn in ArcView) completely covered and hidden by other polylines
- Getdupes: identifies duplicate values for pipe and node IDs

- Frenchman's Connectivity: checks the connectivity of the 'From' and 'To' nodes for each line segment based on proximity

The final GIS files include all pipelines two inches in diameter and larger, other than private pipelines not maintained by the S&WB.

5.3.3.1 Assumptions for Network Editing

Following are the general assumptions made when information for the water facilities was not available. All data sources were listed in the GIS files for documentation and future reference. Information entered into the hydraulic model based on assumptions is identified as such. If the assumptions were later verified, the data source was modified accordingly.

Missing pipe diameters were derived from known pipe sizes upstream and downstream of the pipe segment in question. If there was no change in known pipe diameter values, then all pipes between the known values were assumed to be that size. For pipe segments that did not have diameters identified upstream or downstream, the diameter was assumed by matching the diameter of pipes within the same general location. For example, if the majority of pipes within a neighborhood were six inches in diameter, that pipe segment was also assigned a diameter of six inches.

Unless otherwise noted on maps or CassWorks, the material of the pipe was assumed based on the date of construction. As defined by the S&WB, the date of construction and associated pipe material are as described in **Table 5-2**.

Table 5-2
Pipe Material According to Date of Construction

Date Constructed	Pipe Material
1900 to 1950	Cast Iron
1950 to 1970	Asbestos Cement
1970 to Present	Polyvinyl Chloride

If the date of construction was not available, the pipe material was estimated by matching the material of pipe within the same general location. For example, if the majority of pipes within a neighborhood were constructed of cast iron and one pipe segment did not have a designated material, that pipe segment was also assigned cast iron for material.

The CassWorks database provided 64 percent, by length, of the installation years of water mains. To determine the remaining ages, the Sewer and Water Location Maps provided some pipe age information. The Sewer and Water Location Maps also reference construction field books, which contain actual field recorded construction information and the time period during construction. When field books were referenced on the maps, the installation year of the water main was determined based on the time period the field books were in use. Using this method, 13 percent, by length, of the water main installation dates were determined. The remaining water main installation dates were assumed based on all available data of surrounding pipes.

As a node was named, renamed, or a new node was added, the format for the ID was created as "Map number"- "Next largest number". For example, if a new node was added to map number 327, and the largest node ID currently on that map was 327-299, then the new node ID was created as 327-300. All subsequent nodes that were named, renamed or added were given the next largest number.

5.3.4 Network Simplification

The GIS networks contain large data sets with very detailed information of the distribution systems. The detailed GIS data was processed to exclude excess information not required for the hydraulic model. A skeletonized, or simplified, version of the GIS files was used in H_2O Map for the purpose of running a model with a manageable sized network. The customized GIS tool, Simplify, was used to simplify the GIS networks. All junctions, check valves, and select hydrants used for field testing were kept in the simplified networks. All other valves and hydrants were skeletonized out of the networks for the purpose of a simplified hydraulic model. If the pipe criteria for diameter, material, and installation date did not vary on the connecting pipes, they were merged together as a single pipe. **Table 5-3** provides a summary of the system components in GIS and in the simplified network used for H_2O Map. The module H_2O Map Skeletonizer was not be used for this step since all nodes are deleted permanently from the networks utilizing this module.

Table 5-3
GIS and H_2O Map
Network Components

Network Component	GIS Network		H_2O Map Network (Simplified)	
	East Bank	West Bank	East Bank	West Bank
Pipe Segments	44,600	6,200	18,200	2,600
Nodes	40,100	5,700	13,800	2,100

Note:
1 – Data from GIS and H_2O Map and rounded to the nearest hundred

5.4 MODELING SYSTEM ASSETS

Modeling water assets involves the input of relevant data into the model to describe the specific characteristics of the water assets. This includes assigning elevations, allocating water demand, and assigning operating controls.

The location of water assets including pipes, nodes, pump stations, and storage tanks were modeled based on Sewer and Water Maps to include pipe layout and connectivity. Model inputs from the GIS files for pipelines include 'From' and 'To' nodes, diameter, and roughness. The pipeline length is calculated in H_2O Map. Model data for nodes includes node ID from the GIS files, demand, and elevation. Ground-level storage tanks are modeled as reservoirs and elevated storage tanks are modeled as variable area tanks. Model input for storage tanks include diameter, elevation, operations, and maximum and minimum level. Pump information required for the model includes pump curves (exponential 3-point curves, when available) and operations. Detailed information about operational data for the existing water facilities is described in **Section 4**.

5.4.1 Elevation

Elevations were assigned to all nodes within the GIS network. Elevation information was expressed in terms of Cairo Datum (CD), a datum that allocates positive ground elevations. Cairo datum of 20.43 feet is equivalent to MSL.

A GIS script was used to update the node shapefile with elevations from a digital contour model. Three separate contour models from local and state data sets were generated to allocate elevation data. The primary elevation model generated was based upon contour shapefiles acquired from the City Planning Commission. The contour data was converted to an elevation Triangulated Irregular Network (TIN) model for New Orleans shown in **Figure 5-2**. These contours were originally constructed through plannimetric processes from aerial survey and tied down using set monument reference points to a second order level of accuracy. All nodes located in the West Bank system and the majority of the East Bank system were assigned elevations using the contour-based TIN model.

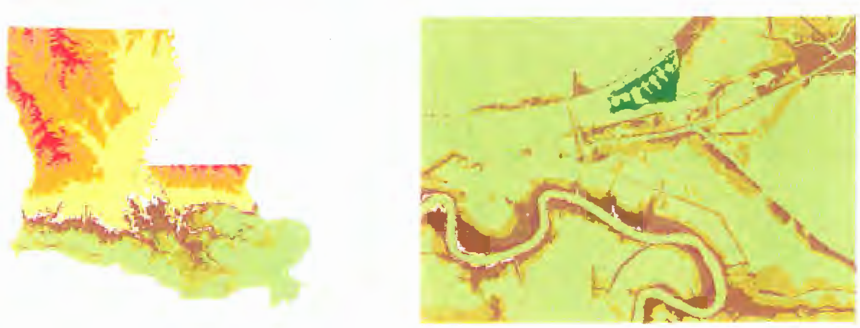
Figure 5-2
Primary Elevation TIN Model
East and West Bank

Venetian Isles, an area of the East Bank water distribution system was not allocated elevation data using the primary TIN model due to lack of contour coverage for this area. A secondary elevation TIN model was generated based upon the point elevation data collected during the sanitary sewer system survey in conjunction with the SSERP, as shown in **Figure 5-3**. All sanitary manholes with connecting sewer diameter greater than or equal to 12 inches in diameter were assigned elevation values through conventional survey methods.

Figure 5-3
Secondary Elevation TIN Model
Venetian Isles

In order to provide a single quality assurance check on the assigned elevation data, a state-based elevation grid was used as a baseline to identify any nodes that did not agree within a reasonable variance. The state-based elevation grid does not have the level of accuracy that the local TIN elevation maps contain. The state-based elevation grid is shown in **Figure 5-4**. The comparison, however, proved useful in identifying several nodes with large differences in the estimated elevation.

Figure 5-4
Louisiana Grid Elevation



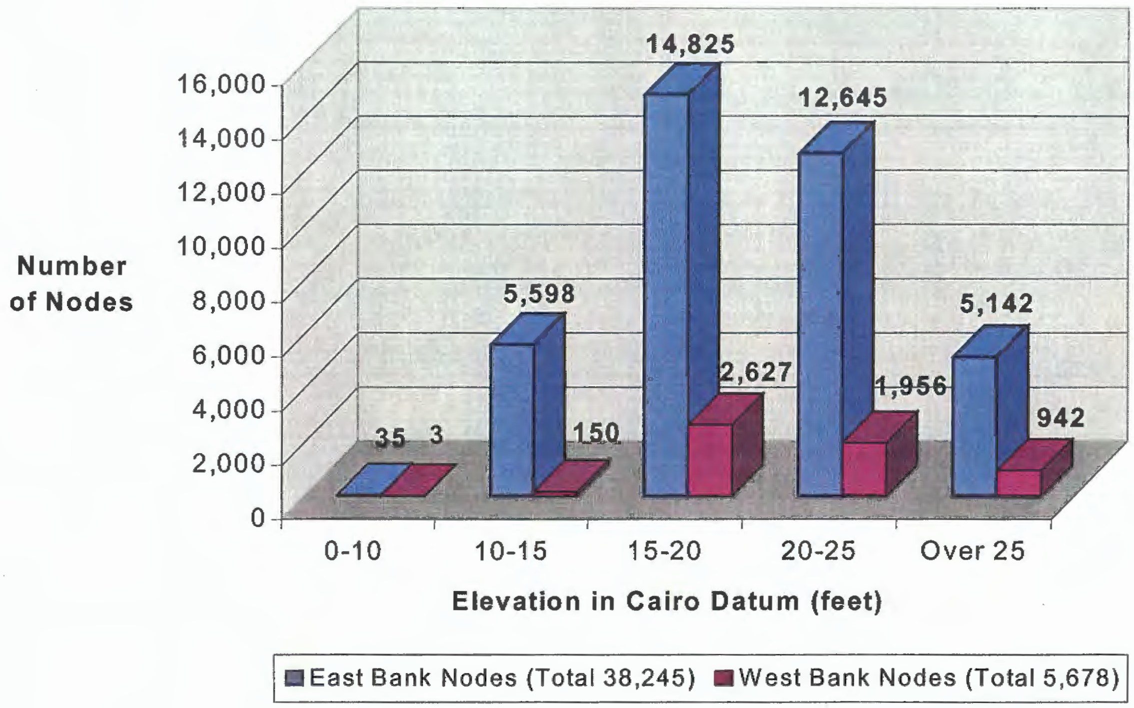
All pipe segments that cross drainage or navigational canals were identified in the Sewer and Water Maps and field inspected to determine whether the pipes cross over or under the canal. Elevations were estimated for those pipe segments that cross over canals and ground-level elevation was assigned to those pipe segments crossing under canals. Photographs were taken of each known canal crossing and linked to the GIS and H_2O Map databases for reference. An example of a water main canal crossing is shown in **Figure 5-5.** Approximately 110 canal crossings were identified on the East Bank and 20 crossings on the West Bank.

Figure 5-5
Water Main Canal Crossing

Additional elevation data was retrieved from record drawings available from the S&WB for larger pipes, typically greater than or equal to 12 inches. All elevation values, when estimated for pipe segments, were assigned to nodes.

Figure 5-6 summarizes the range of elevations estimated for the model nodes by distribution system. Approximately 39 percent of the East Bank nodes and 46 percent of the West Bank have an elevation between 15 to 20 feet CD. Most of the nodes with elevation over 20 feet CD are located near levees or drainage canals, where the ground level is artificially built up for flood control.

Figure 5-6
Range of Elevations



Note:
1 – Nodes in GIS include valves, hydrants, and junctions

5.4.2 Demand Allocation

The Water Master Plan model build effort included a water consumption analysis task to facilitate demand allocation throughout the distribution system. The water demand allocation was divided into two sub-tasks: spatial allocation and consumption analysis. This section addresses all efforts related to demand allocation including a comparison of the Thiessen Polygon process to the H_2O Map Allocator module process.

The distribution system arrangement and the locations of the junctions were evaluated to determine which junctions would be designated as demand junctions. Demand junctions are nodes to which a portion of the total system water demand has been allocated, based on their areas of influence. The demand junctions were selected based on the pipe size that would typically have associated service connections. All junctions on pipe segments less than or equal to 20 inches in diameter were therefore selected as demand nodes.

Existing demands were distributed using the monthly metered water consumption data provided by the S&WB from 1997 through 2001. The metered consumption data consisted of all user accounts with monthly water consumption by volume, meter date, billing address, zip code, and billing classification information. There are approximately 150,000 meter locations for the East and West Banks, including multiple customers at single addresses. The total water consumption and spatial allocation was determined for each user account.

After reviewing the metered consumption files for completeness and uniformity, the following assumptions were made:

- Negative consumption values indicated that the previous reading exceeded actual consumption (overbilling).
- 'Zero' address numbers and 'zero' zip codes represent water consumption location at fountains, commercial wharves, or construction sites.

Two tables were generated from the metered consumption data in a Microsoft Access database: an address table and a consumption table. The address table consisted of address data for the spatial allocation task, while the consumption table consisted of monthly volume data for the consumption analysis task.

5.4.2.1 Spatial Allocation

Spatial allocation is the process where a spatial graphic is created based on address data in tabular form and a spatial reference theme. The spatial allocation task consisted of geocoding the address information for the water consumption data set. The address data table was used to geocode the unique consumer accounts to a location relative to New Orleans street coverage. User accounts that could not be accurately geocoded by street address were allocated with the 5-digit zip code area associated with the address.

The ArcView geocoding engine was implemented for the geocoding procedure. Geocoding accuracy is a function of the completeness and accuracy of the tabular address data and spatial reference theme. The City Planning Commission provided street centerline data set for a local spatial reference. After review of the street centerline data theme, it was identified that effective geocoding results could be produced by geocoding all user accounts to the corresponding city block versus the exact address. This spatial accuracy is acceptable taking into account both the desired detail level of the model and the level of detail held within the distribution system network data.

A second spatial reference theme, 2000 Census Topographically Integrated Geographic Encoding and Referencing (TIGER) files, was used for geocoding user accounts that could not be accurately geocoded to the City Planning Commission street centerline data set. The U.S. Census Bureau created TIGER lines, a set of digital maps containing most streets in the United States. These files were obtained for the city of New Orleans with street data consisting of name and address information. Street centerline attributes of interest included street name, high/low address range, and zip code.

Each unique meter account was geocoded as a point relative to the street GIS shape files with one of four procedures: (1) Centerlines or TIGER lines with street and zip code, (2) Centerlines or TIGER lines with streets only, (3) zip code only, or (4) individually geocoded.

The geocoding methods (1) through (3) were utilized based on available data for the location of the water consumers. The first procedure represents a higher level of accuracy in comparison to the third procedure. If a water consumer record did not have the required criteria for the first geocoding procedure, the second or third procedure was followed.

The geocoding method (4) was utilized for large water consumption user accounts. This method is the most accurate by assigning the users to their actual spatial location based on the exact street address. Users with an assigned average monthly water consumption value greater than one (1) liter per second (approximately 23,000 gpd) (MWH Model Standard) were identified as large users.

The geocoding effort produced graphics with a database link containing a record for each user account and associated data fields including address information, geocoding match status and confidence scoring factor. A sensitivity analysis was conducted on the matched accounts addressing the correct spatial allocation relative to the confidence-scoring factor. After review, a baseline level match score was set for acceptance where all accounts scoring less than were considered spatially unmatched.

Unmatched user accounts records were scored low for geocoding confidence typically due to slight differences in address spelling or other discrepancies between the address data sets. Common examples included alternative street name or spelling conventions, address with two street directions, numerical street name, house numbers spelled out, and ambiguous addresses. Many of these were verified and adjusted as matched records.

The following table summarizes the results and confidence level from the geocoding process. In **Table 5-4** the overall system (East Bank and West Bank) results are shown. Of the 150,541 meter locations, approximately 99 percent (149,498 accounts) were geocoded with confidence to an accurate street block location. These accounts represent 69.4 MGD, 99.3 percent, of water consumption.

Table 5-4
Summary of Metered Water Consumption
East and West Bank (1997 to 2001)

Geocoding Process	Accounts	1997 Demand (MGD)	1998 Demand (MGD)	1999 Demand (MGD)	2000 Demand (MGD)	2001 Demand (MGD)	5-Year Avg Demand (MGD)	Final Demand (MGD)
New Orleans Centerlines (street/zip)	137,314	58.73	60.04	60.71	59.00	58.01	59.30	58.12
U.S. Census TIGER lines (street/zip)	10,971	5.58	5.92	5.87	5.85	5.56	5.76	5.70
New Orleans Centerlines (street only)	119	0.03	0.03	0.04	0.01	0.05	0.03	0.03
TIGER lines (street only)	482	0.38	0.22	0.35	0.36	0.33	0.33	0.39
Individually Geocoded	612	5.24	5.03	5.42	5.58	5.29	5.31	5.12
Subtotal Verified	*149,498*	*69.95*	*71.22*	*72.39*	*70.80*	*69.24*	*70.72*	*69.36*
Subtotal Unverified	*1,043*	*0.80*	*0.87*	*0.85*	*0.83*	*0.84*	*0.84*	*0.86*
Total	150,541	70.75	72.09	73.24	71.63	70.08	71.56	70.22
Verified (%)	99.3%	98.9%	98.8%	98.8%	98.8%	98.8%	98.8%	98.8%
Unverified (%)	0.7%	1.1%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%

The 1,043 metered accounts for which locations were not verified and thus, allocated separately represent approximately one percent (approximately 0.86 MGD) of the total water consumption. This water consumption data was geocoded by zip code and is shown in **Table 5-5**.

Table 5-5
Metered Water Consumption Geocoded by Zip Code
East and West Bank (1997 to 2001)

Zip Code	Accounts	1997 Demand (MGD)	1998 Demand (MGD)	1999 Demand (MGD)	2000 Demand (MGD)	2001 Demand (MGD)	5-Year Avg Demand (MGD)	Final Demand (MGD)
70112	3	0.003	0.002	0.000	0.000	0.000	0.003	0.000
70113	13	0.028	0.026	0.026	0.028	0.024	0.027	0.027
70114	9	0.001	0.001	0.002	0.001	0.002	0.002	0.002
70115	9	0.006	0.014	0.016	0.013	0.007	0.012	0.012
70116	5	0.005	0.004	0.005	0.004	0.004	0.005	0.004
70117	14	0.016	0.004	0.003	0.003	0.006	0.021	0.007
70118	37	0.042	0.033	0.029	0.027	0.030	0.032	0.030
70119	14	0.000	0.001	0.000	0.000	0.001	0.002	0.001
70122	15	0.008	0.015	0.009	0.005	0.008	0.012	0.009
70124	116	0.027	0.025	0.028	0.029	0.026	0.028	0.027
70125	24	0.015	0.018	0.011	0.010	0.012	0.016	0.012
70126	90	0.078	0.100	0.158	0.146	0.158	0.139	0.132
70127	177	0.223	0.242	0.233	0.207	0.221	0.231	0.219
70128	64	0.061	0.072	0.058	0.060	0.060	0.079	0.070
70129	77	0.073	0.103	0.074	0.066	0.088	0.103	0.092
70130	27	0.034	0.036	0.029	0.029	0.023	0.035	0.034
70131	349	0.178	0.171	0.174	0.206	0.177	0.191	0.186
Total	**1,043**	**0.798**	**0.867**	**0.855**	**0.834**	**0.847**	**0.938**	**0.863**

5.4.2.2 Demand Analysis

As a part of the consumption analysis task, statistical averages were estimated of all recorded consumption volumes for each user account from 1997 through 2001. Each user account contained 24 fields grouped in 12 field pairs (monthly readings) of recorded water meter consumption and meter reading date. The data set contained some records that did not include meter readings for each month. In order to assign an average monthly consumption per account, the following assumptions were made:

- The average monthly consumption was calculated by taking the total volume divided by the total number of meter readings.
- Meter readings equal to zero were not included in the average calculation.
- Meter readings shown as negative volumes were included in the average calculation in order to account for overbilling cycles.
- Demand allocated to nodes on pipes less than or equal to 20 inches in diameter.

The results of the consumption analysis included total water consumed and total number of meter readings for each customer account per year. This allows for monthly and yearly comparison and quality assurance checks. Each user account record was assigned a total consumption volume, total number of readings per year, an average daily consumption based on monthly readings, an average daily demand for each year, and a five-year average demand. Some accounts had unusually high, low, or even negative consumption values for certain years, resulting in an inaccurate demand average. The data was analyzed to remove outliers, such that a more accurate average demand could be calculated based only on the "reliable" readings, called Final Demand. The results of the consumption analysis are shown in **Table 5-4.**

After water consumption accounts were geocoded and represented spatially, the associated consumption could be allocated as demand to the system based on their location relative to the network components of interest (pipes vs. junctions). While several procedures can be used to allocate demand, two methods were performed and compared for the verified water consumption accounts: Thiessen Polygon process and H_2O Map Allocator. The unverified water consumption accounts were allocated by zip code. The Thiessen Polygon process utilizes the closest junction allocation method, where geocoded demand was assigned to the junction (demand node) that was closest to the consumer location. The H_2O Map Allocator module allocates demand to the closest pipe then splits the demand to the upstream and down stream junctions of that pipe segment.

In comparison, the closest pipe concept assigned demand to a more accurate location of water consumers. The H_2O Map Allocator module was therefore used for the final demand analysis. Both methods are described below.

Thiessen Polygon Process

Metered consumption values were allocated to model junctions specified as demand. There were a total of 6,356 designated demand nodes, 5,679 out of 13,045 junctions on the East Bank and 669 out of 1,774 junctions on the West Bank. Allocating both verified and unverified accounts required the creation of Thiessen polygons around demand nodes.

Thiessen Polygons were created for each demand node to define the demand coverage area. Thiessen Polygons are unique shapes that create boundaries around all points within an area closest to the demand node without overlapping with other polygon boundaries. Each Thiessen Polygon represents the coverage area of water consumers for each demand node.

An ArcView script, Calculate Demographics, was used to allocate the unverified consumption accounts. The script allocates demand to the nodes based on the percent of the zip code polygon's area contained within the Theissen Polygon. For example, if a Thiessen Polygon contained 10 percent of the area of a zip code polygon, then the demand node would be assigned 10 percent of the consumption associated with that zip code.

Demand from major consumers was allocated separately. Major consumers were previously determined to be those records with consumption for the year 2001 greater than 1 liter per second (approximately 23,000 gallons per day). For these 326 major consumer accounts, the associated consumption value was allocated to the nearest junction using an ArcView script, Nearest Feature. Those nearest junctions were then assigned the consumption value for the particular major user.

Each demand node contained within the Thiessen Polygons represents the sum of demands allocated by street geocoding, allocated by zip code, and those large users individually geocoded.

H_2O Map Allocator Module

The H_2O Map Allocator module assigns geocoded water consumption points to the closest pipe by geographic proximity. The demand assigned to a pipe segment is then evenly divided and allocated to the upstream and downstream junctions. In final comparison, this method provided a more accurate allocation of demand based on proximity and was used for the final system analysis.

To allocate demand for large water consumers, the nearest demand node was assigned all of the demand instead dividing this value to the upstream and downstream junctions of the pipe. The 17 major user accounts on the East Bank accounts for approximately 7 percent (4.3 MGD) of flow, while the seven major user accounts on the West Bank accounts for approximately 15 percent (1.02 MGD) of flow. Because these few accounts make up a large percent of flow, these major accounts were specifically checked for accuracy in geocoding and moved when necessary. Therefore, the demand was allocated more accurately to a single, closest junction on the closest pipe.

The H_2O Map Allocator module was not used to allocate the unverified water consumption. The unverified water consumption was allocated by zip code to pipes less than or equal to 20 inches in diameter. Each pipe within a zip code was allocated a percentage of that consumption based on pipe length, then evenly divided to the upstream and down stream nodes. The consumption allocated by zip code was designated as a separate demand within H_2O Map. The Allocator module directly assigns demand to the hydraulic model, which can store up to 10 demand values and patterns. The following demand fields were designated for specific demand types and diurnal pattern (discussed further below):

- Demandl = General consumption for East Bank and West Bank
- Demand2 = Large consumer demand
- Demand3 = Unverified demand allocated by zip code
- Demand4 = UFW loss
- Demand5 = Calibration day hydrant flow
- Demand6 = Future demand

Each demand node identified in the hydraulic model therefore had up to six demands and diurnal patterns assigned. The total demand allocated to one node is calculated by summing the values in all six demand fields.

Unaccounted-for Water

Upon comparison of the total water production with the metered water consumption data, a significant daily flow for UFW was identified, as discussed in **Section 4**. The UFW was assumed to represent non-metered water demand and leakage throughout the distribution system. In order to accurately predict system hydraulics for the model calibration and analysis, all water demand, including UFW, must be accounted for and allocated within the model. Without knowledge of the exact location of UFW, assumptions were made to represent the water usage on a system-wide basis. Several methods were utilized to allocate UFW, as discussed below.

The first method utilized to allocate UFW was to apply a single system-wide demand factor to each pipe segment. The demand factor represented the percentage of UFW according to the water audit conducted for the distribution systems. This demand factor did not take into account the potential for some pipe segments to be distributing UFW at a different flow rate based on pipe capacity or potential for pipe failure. Upon further investigation, it was determined that pipe characteristics should be used as criteria to more accurately estimate UFW.

The UFW water was allocated throughout the distribution system based on physical pipe characteristics. General assumptions were made to prioritize pipe characteristics by material, date of installation (age), and length. Based upon engineering experience and history, certain known pipe deterioration assumptions were chosen as factors for allocation of UFW. **Table 5-6** shows the pipe material and pipe age factors used to allocate UFW.

Table 5-6
Unaccounted-for Water Allocation Factors

Criteria	Factor
Material	
Cast Iron	0.20
Copper	0.10
Asbestos Cement	0.25
PVC/Plastic	0.05
Steel	0.10
Prestressed Concrete	0.10
Ductile Iron	0.15
Concrete	0.25
Age (Years)	
0	1.0
25	1.2
50	1.4
75	1.8
100	2.0

Each pipe segment was assigned an allocation factor based upon length, material, and date of installation. The allocation factor was calculated as a combination of the pipe material and age factors with heavier weighting placed upon the pipe material. More weighting was applied to the pipe material. Once the pipe allocation factor was calculated, each pipe was allocated flow as a percentage of total system UFW flow based upon pipe length. Using this method, twice as much flow is allocated to a pipe segment 100 feet in length versus a pipe of 50 feet in length, assuming all other pipe characteristics are identical.

Each of the factor based weighting schemes applied the assigned factor to the pipe segment length as a percentage of the total system pipe length. The allocation of UFW to each pipe segment in the distribution system was calculated with the following derived equations.

- $\textit{Length Based Flow} = \textit{UFW} \times \dfrac{\textit{Water Main Length}}{\sum (\textit{Length})}$

- $\textit{Material Based Flow} = \textit{UFW} \times \dfrac{\textit{Water Main Length x Material Factor}}{\sum (\textit{Length x Material Factor})}$

- $\textit{Age Based Flow} = \textit{UFW} \times \dfrac{\textit{Water Main Length x Age Factor}}{\sum (\textit{Length x Age Factor})}$

- $\textit{Weighted Flow} = \textit{UFW} \times \dfrac{\textit{Water Main Length x (Weighted Material Flow + Weighted Age Flow)}}{\sum (\textit{Length x (Weighted Material Flow + Weighted Age Flow)})}$

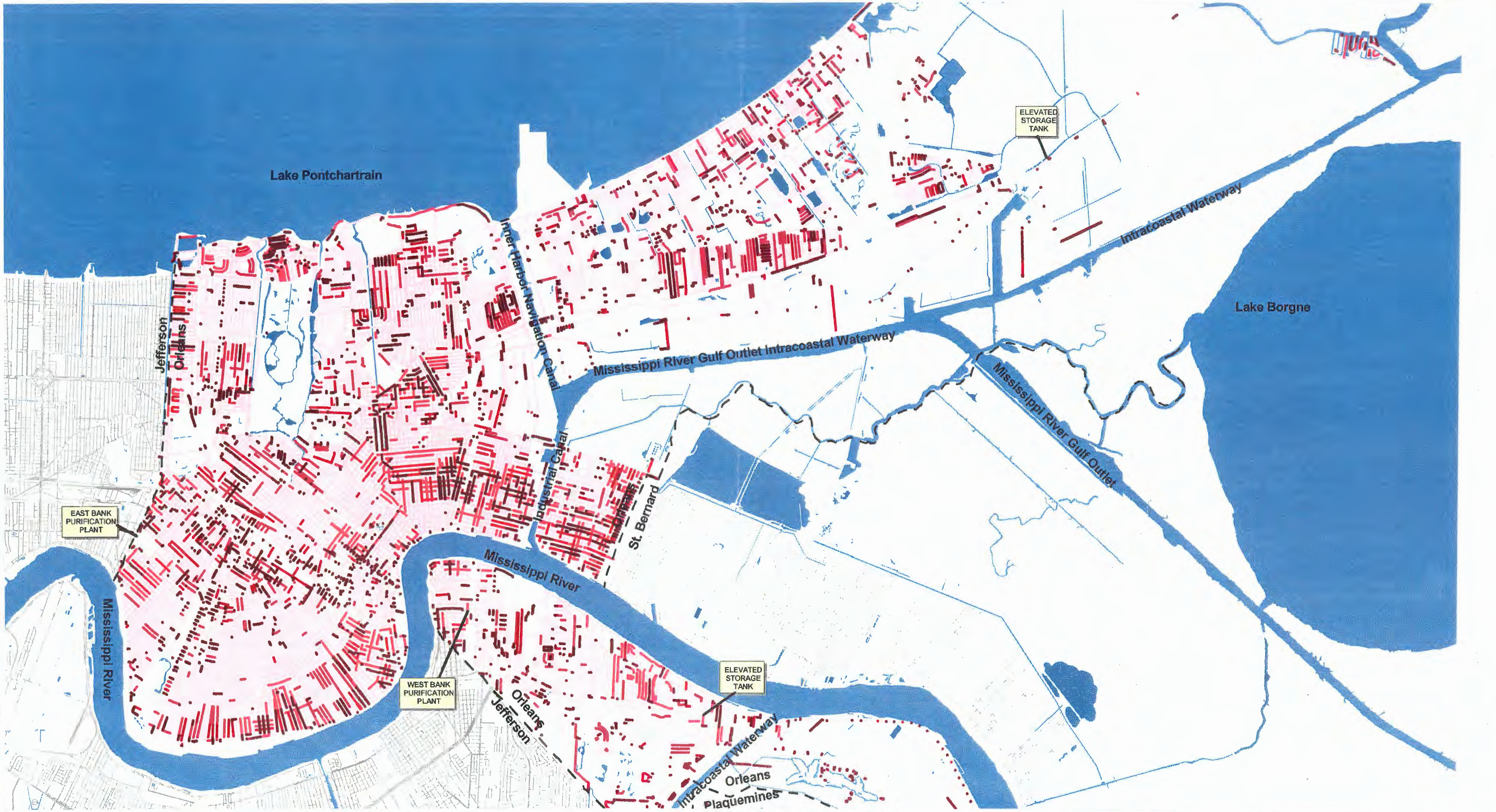
The weighted flow was used as the UFW value allocated to each pipe. **Table 5-7** shows an example calculation of UFW allocated to a 6-inch pipe. The weighted flow was assigned to the upstream and downstream junctions of each pipe segment for modeling purposes. **Figure 5-7** shows the allocation of UFW for the East and West Bank systems, respectively, based on a percentage of demand in each pipe segment.

Table 5-7
Unaccounted-for Water Allocation Example

Pipe Characteristic				UFW Allocation Based on Pipe Characteristic (gpm)			Weighted Flow (gpm)
Diameter (inches)	Length (feet)	Material	Date of Installation	Length	Material	Age	
6	100	AC	1972	0.39	0.47	1.42	0.81

5.4.3 Diurnal Pattern

The existing system model was created as a 24-hour extended period simulation (EPS) model. A 24-hour EPS model is one which simulates various demands during different hours of the day, with greater demands during peak hours. Hourly flow summaries are determined for the contributions to the distribution system from pump stations and storage tanks. The production diurnal curve was created, as discussed in **Section 3**, based on data gathered from the water



Legend

N

Not to scale

Percentage of Leakage

- < 25 %
- 25 - 50 %
- 50 - 75 %
- > 75 %

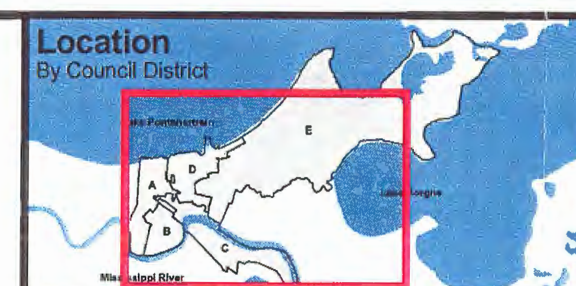
- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Allocation of Unaccounted for Water East & West Bank

Figure 5-7

Location
By Council District



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MWH

purification plants and metered demand for 2001 through 2002. The estimated hourly production was adjusted with the metered demand to account for water losses. Using this data, a consumption diurnal curve was created with factors for each hour representing the demand for that hour compared to the average for the entire day. Diurnal patterns were also developed specifically for the days during which field testing was conducted in order to compare the field testing data to the model results.

The demand curves assigned to the East and West Bank systems are discussed in **Section 3** and shown in **Figures 3-7** and **3-8**. The specific diurnal curves assigned to the four large industrial users on the East Bank are shown in **Appendix B.** The UFW loss was assigned a constant demand over a 24-hour period. Demand curves assigned to the hydrants used for field testing represent constant demand over a 15-minute period to model the flows run for static and residual pressures, as described below in model calibration field testing.

5.5 MODEL CALIBRATION

Model calibration is a process that is implemented to verify that the computer representation of the distribution system responds to hydraulic parameters in the same manner as the existing physical system. The general purpose of model calibration is to determine the actual operating conditions that occur in the water distribution system in comparison with the computer model predictions. The comparison serves as a check for the model results so that the model reflects the response of the physical system to various conditions.

5.5.1 Field Testing

The objective of the field testing is to obtain instantaneous flow and pressure data at various locations throughout the distribution system. Outlined below is the testing protocol and specific locations where testing was performed. Twenty sites were tested to obtain sufficient data for calibration. Generally, each test provides the following information at the time that the test was performed:

- All inflows into the system - including flow from pumps and tanks
- All outflows from the system - including water use from customers and test hydrant flows
- Pressure at various points throughout the system

The calibration tests should "stress" the distribution system so that the data will reflect the system's reactions to a range of operating conditions. To accomplish this, water is released during each test from one or more hydrants until a minimum pressure drop of 5 psi is experienced at the test location. The pressure drop provides a range in operating conditions to simulate "stress" on the system.

Several activities were accomplished prior to conducting the field tests. Each hydrant that was opened during testing was inspected to see that they were operational without significant leakage. All test equipment including pressure gauges, flow meters, pitometers, etc. were checked for operation, accuracy and differences in readings were recorded for reference.

The following equipment was used for the hydrant testing:

- Radios for each of the testing personnel
- Two pressure gauges (0-100 psi range) for use on 2½-inch hydrant nozzles. Pressure gauges were provided by the S&WB and MWH. The two gauges were calibrated against each other and the difference in readings was recorded as shown below.
- Two hydrant flow meters (pitot tube diffusers) for use on 2½-inch hydrant nozzles. Flow meters were provided by the S&WB and MWH. The two flow meters were calibrated against pressure gauge #2 and the difference in readings was recorded as shown below.
- Four hydrant wrenches
- Pressure loggers (three were available and utilized on the West Bank and six were available and utilized on the East Bank)

Following is the calibration data for the pressure gauges and pitot diffusers used for data collection. Pressure gauge #2 was used to record all pressure readings at the residual test hydrants. For the purpose of comparing the pressure data collected, pressure gauge #2 is considered the standard pressure against which all other gauges are calibrated. The variances in pressure readings for each pressure gauge and pitot diffuser are listed below in **Table 5-8.**

Table 5-8
Variance in Pressure Readings
for Field Equipment

Test	Pressure Gauge/ Diffuser	Pressure (psi)	Variance from Pressure Gauge #2 (psi)
1	#2	62	N/A
1	#5	60	-2
2	#2	15	N/A
2	Red diffuser (MWH)	12	-3
3	#2	20	N/A
3	Grey diffuser (S&WB)	17	-3

Notes:
1 - N/A = Not Applicable

At least three MWH staff were present in the field to conduct the hydrant tests. One person monitored the pressure and flow from the test hydrant and coordinated readings from the flow hydrants and pump stations. One person monitored the flow and pressure at each of the flow hydrants (up to two hydrants were used to provide a pressure drop at the test hydrant). One person was present at each of the East Bank pump stations that were in operation (Station A&B and Claiborne Station) to record operating data. The S&WB staff at the West Bank pump station provided assistance to record operating data during the hydrant tests.

Available pump curves were obtained from the S&WB for all of the distribution pumps at both the Claiborne and Algiers Purification Plants (except Algiers Pump 3). During the field collection on the East Bank, Claiborne Pumps 1, 2, and 3 as well as Pump B were in operation.

The S&WB staff indicated that the pump stations at the Claiborne Plant currently have no type of meter to accurately record flow data (the existing venturi meters are not accurately functioning).

Following is a summary of the procedure followed while conducting the field tests. The testing was conducted from September 11 through September 20, 2002. Each test followed the step-by-step instructions listed below. All data and comments were recorded on data collection forms provided by MWH.

- Step 1 – watches were synchronized.
- Step 2 - flow monitors were installed on distribution pumps and pitot diffusers on flow hydrants (remove cap from 2½-inch nozzle and open hydrant valve to flush barrel before attaching pitot diffusers).
- Step 3 – pressure gage was installed at the residual hydrant test site (remove cap from 2 ½-inch nozzle and open hydrant valve to flush barrel before attaching pressure gauge).
- Step 4 - static pressure and time of test were recorded at test site hydrant.
- Step 5 - by radio, the test coordinator instructed both people stationed at the flow hydrants to begin the test flow until a minimum of 5 psi pressure drop was observed at the test site hydrant. If sufficient pressure drop was not obtained, the test was relocated to a new site.
- Step 6 - when pressure at the test site and flow from the hydrants stabilized (usually three to five minutes), the coordinator called for and recorded the flows from each hydrant and recorded the pressure at the test site hydrant. The coordinator also instructed the remaining personnel to take pressure flow and/or level readings at the pump stations. Readings at the pump stations were recorded on separate field forms for documentation. The location of each hydrant was recorded as well as its flow rate.
- Step 7 - the coordinator instructed the flow hydrants to be closed. All field personnel understood the importance to close the hydrants very slowly (over about a one minute period) to prevent the rupture of pipes caused by water hammer.
- Step 8 - the coordinator again read and recorded the static (rebound) pressure at the test location.
- Step 9 - test was concluded (equipment removed and hydrant caps replaced). Field personnel moved to the next site.

Sixteen (16) hydrant tests were performed on the East Bank and four hydrant tests were performed on the West Bank for a total of 20 field tests conducted throughout the City of New Orleans. Initial readings from the pump stations and the residual hydrant were recorded after the residual hydrant was opened for each test. Once the flow hydrants were open and a pressure drop of at least 5 psi was detected at the residual hydrant, a residual reading was recorded at the pump stations, residual hydrant, and flow hydrants. A total of two readings were recorded for the flow hydrants and the pump stations during each test. A rebound pressure was recorded at the residual hydrant once the flow hydrants were closed and pressure stabilized (approximately five minutes). A total of three readings were recorded for each of the residual hydrants.

Data collected during the hydrant tests is summarized in **Appendix D**.

5.5.1.1 East Bank Distribution System

Six (6) pressure loggers were provided by the S&WB to obtain residual pressure readings during the hydrant tests. The pressure logger data is summarized in **Appendix E**. The pressure loggers recorded hydrant pressure at the following locations (as shown in **Figure 5-8**):

1. Choctaw & N. Galvez - # 02172288
2. Lake Forest & Louis Prima - # 02200280
3. Sumpter & Elysian Fields - # 02200288
4. Euphrosine & S. Dupre - # 02172289
5. Calhoun between Camp & Perrier - # 02172283
6. Leonidas & Pritchard - # 02200297

Figure 5-8
Pressure Logger Sites
East and West Bank

Flow, pressure, and wet well water level data were collected from the pump stations that were in operation during each of the 16 tests conducted on the East Bank.

The following information was recorded for the pump stations:

- Time of the reading
- Discharge totalizer volume (gallons)
- Flow rate (gpm) and velocity (fps)
- Pressure (psi)
- Wet well water level (ft) for Pump Station A&B only
- Pump speed (rpm) for Claiborne Pump Station, Pump 1 only

Portable, ultrasonic flow meters were installed on three of the four pumps in operation at the Carrollton Purification Plant. Due to the configuration of the discharge piping and valves, there is a very limited amount of space available to install the flow monitors. The sensors for the flow monitors were attached to the discharge pipes, downstream of the valves, which were exposed below ground-level in the valve pits. Following in **Table 5-9** is a summary of the pumps that were in operation during the tests and the location of the flow meters.

Table 5-9
Pump Station Operating Data
East Bank

Pump Station	Pump	Operating	Flow Meter
Claiborne	1	Yes	Yes
	2	Yes	No
	3	Yes	Yes
	4	No	No
A&B	A	No	No
	B	Yes	Yes
Panola	1	No	No
	2	No	No

At A&B Pump Station a portable, ultrasonic flow meter was attached to the 36-inch discharge line from Pump B. The discharge flow and velocity were recorded with this meter. Pressure was read from a permanent pressure gauge installed on the pump discharge. The wet well water level was read from a gauge in the pump station.

At the Claiborne Pump Station two portable, ultrasonic flow meters were attached to Pumps 1 and 3. The discharge volume, flow, and velocity were recorded for each pump with the flow meters. Pressure was read from a permanent pressure gauge installed on the discharge for each pump. The speed of Pump 1 was read from a gauge in the pump station and Pumps 2 and 3 are constant speed pumps. Pumps 2 and 3 are similar pumps; therefore, one flow meter was installed on the discharge of Pump 3. The discharge flow from Pump 2 will be estimated in comparison with the data collected for Pump 3. The ground-level storage tanks were maintained at a constant water level during testing. All bypasses were closed during the testing.

5.5.1.2 West Bank Distribution System

At the time the West Bank hydrant tests were conducted, only three pressure loggers were available from the S&WB to obtain residual pressure readings. The pressure loggers were installed during two of the four tests performed on the West Bank. Two of the sites were re-tested due to no drop in pressure during the first test. The pressure loggers were not used when the sites were re-tested. The pressure logger data is summarized in **Appendix E**. Three pressure loggers recorded hydrant pressure at the following locations (as shown in **Figure 5-8**).

1. Diana & Pacific - # 02200297
2. Blair & Patterson - # 02172283
3. Mercedes & Copernicus - # 02172289

Flow meters were not required for the West Bank distribution pumps at the Algiers Water Purification Plant. The facility has accurate flow meters that provide instantaneous readings for all distribution pumps. **Table 5-10**, on the following page, is a summary of the pumps that were in operation during the tests. Two pumps were in operation for all tests performed on the West Bank.

Table 5-10
Pump Station Operating Data
West Bank

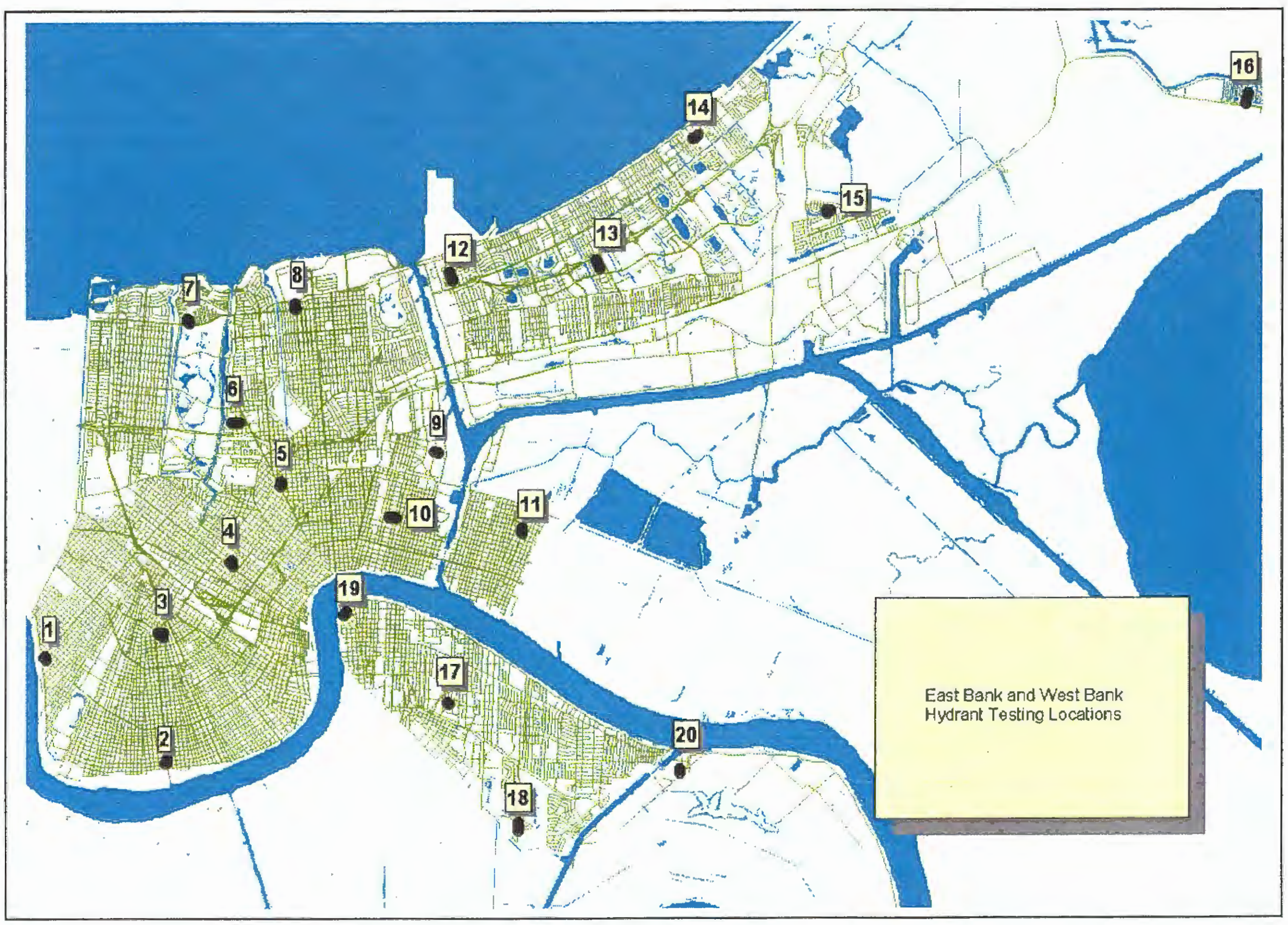
Pump Station	Pump	Operating
Station C	1	Yes
	2	No
	3	No
	4	No
	5	No
	6	No
New High Lift	7	Yes
	8	No
	9	No
	10	No

Twenty (20) hydraulic tests were conducted. All tests followed the procedure outlined above. **Figure 5-9** shows the general location of each of the tests. A map of each test site is shown in **Appendix D.** The location maps are included for each test site to indicate which hydrants were residual (pressure reading only) and flow hydrants (pressure and flow). Following are the specific location of the test sites:

1. Napoleon Ave. at Annunciation St.
2. Short St. at St. Charles Avenue
3. S. Rocheblave St. at Milan St.
4. S. Tonti at Canal St.

5. Republic St. at Rocheblave St.
6. Cadillac St. at Milton St.
7. Robert E. Lee Blvd. at Bluebird St.
8. Robert E. Lee Blvd. at St. Anthony St.
9. Alvar St. at Benefit St.
10. N. Derbigny St. at Louisa St.
11. N. Galvez St. at Tupelo St.
12. Alabama St. between Curran Blvd. and Morrison Rd.
13. Tara St. at Wendy Ln.
14. Curran Rd. at Windward Ct.
15. Lemans St. at Cannes St.
16. Lucrino Rd. at Alba Rd.
17. Vespasian Blvd. at Elizardi Blvd.
18. Lenox St. at Lakewood Estates Dr.
19. Pelican St. between Seguin and Bouny
20. Oliver St. at Woodland Highway (406)

Figure 5-9
Location of Hydrant Testing
East and West Bank



5.5.2 Model Calibration Runs

Calibration of a water distribution model is performed at the end of an extensive data collection and model build process in order to validate the model's depiction of the existing distribution system. As part of the hydraulic model build effort, this task includes an element of subjectivity that must be weighed against the purpose and the function of such a tool. Typically, model calibration can be simply described as comparing data collected from the existing physical system and comparing it with model results based on a set of similar conditions in both the field and model simulations.

The model calibration data collection effort for the Water Master Plan focused on obtaining instantaneous flow and pressure data at various locations throughout the distribution system. The purpose of calibration field testing was to determine the actual operating conditions that occurred in the water distribution system for comparison with the computer model predictions. The comparison of field data served as a check for the model results.

For the purpose of calibrating the hydraulic model, all pump curves were used to verify the field data. Field data collected for the pumps with the portable flow meters did not correlate with the operating data provided by the pump curves. The pump curves were, therefore, used to calibrate the model. The flow monitoring data collected was utilized with appropriate technical discretion, realizing that the configuration of the discharge piping on the pumps did not provide an ideal situation for application of the flow monitors. The data collection effort was completed to obtain the best possible estimate for operating information.

The comparison of the pressure tests conducted in the field and the pressure loggers from the field and the model runs is provided in **Appendix E**. Additional pressure data in the distribution systems was provided by the S&WB from tests conducted in 1997 by the Property Insurance Association of Louisiana which conducted over 50 hydrant pressure tests throughout the East and West Bank system. This data was used to further evaluate the hydraulic model results.

During the hydraulic model build task, a number of washout or "dump-off" valves were identified in the distribution system. The washout valves are used to discharge water from isolated water mains during maintenance and repairs. The majority of the 108 washout valves are located on water mains larger than or equal to six inches in diameter and discharge to underground drainage canals. Upon investigation of a washout valve immediately downstream of the Carrollton Plant, it was discovered that this valve was fully open and discharging approximately 2 MGD to the drainage system. Based on this information, the washout valves may be a significant source of UFW.

The pressure results for the East Bank system ranges from 23 to 90 percent difference (between field readings and model results) for static pressures. The pressure results for the West Bank system are closer than the results of the East Bank, ranging from 2 to 5 percent difference for static pressures.

Numerous factors affect the results derived from a computerized model. For this effort, the following factors, each which can effect the model results independently, have been identified as possible causes for the discrepancies between the model and field data:

- Temporal variance in demand between various days. The diurnal curve created for calibration day was used to determine demand over a 24-hour period based on hourly production data from the purification plants. However, demands change from day to day.
- Spatial variance in demand between various days. The demand allocation spatially distributed the demand using monthly average billing data. All demand nodes, except for large users were assigned the same diurnal curve. Yet, demand varies spatially from day to day.
- Ultrasonic flow meters work best when located on a "straight run" (free from bends) of pipe, the distance of which is recommended by the flow meter manufacturer. Because of the limited amount exposed discharge pipe (at the East Bank pump stations) on which to locate the flow meters, the amount of "straight run" of pipe was less than that recommended by the manufacturer, which may have resulted in inaccuracies in flow estimations. Therefore, the flow in these cases was therefore assumed based on available pump curves.
- Pressure meters and flow meters used for the field testing have some level of inaccuracy, both in measuring and in reading such meters.
- It was determined that a significant number of valves located throughout the system may be closed or inoperable. These valves could not be identified and included in the model. Identifying closed valves, specifically on large transmission lines would change the hydraulic performance within the model.
- A significant percentage of water production is considered to be UFW. In order to account for the UFW in the distribution system, this demand was allocated based on assumptions made for pipe characteristics. The system-wide allocation could not represent point sources of water consumption, which would significantly change the hydraulic performance within the model.
- Washout valves that discharge to the drainage system may be a significant source of UFW. If open, these valves would be considered a large point source of water consumption. Which could change the hydraulic performance within the model.

Understanding these discrepancies, the hydraulic models of the East and West Bank water distribution systems sufficiently serve as tools in the analysis and evaluation required.

5.6 RECOMMENDATIONS

The following recommendations are based on a better understanding of the distribution systems as well as lessons learned during model build process:

- It is recommended that the GIS networks be continuously updated with future improvements and rehabilitation of the distribution systems. Future updates to the GIS files may then be readily linked to H_2O Map for model results.
- As a part of the S&WB's valve exercising and maintenance program, closed valves (including washout valves) will be identified throughout the system and valves will be

opened and/or repaired. All valve improvements and status updates should be included in the hydraulic model.

- With the implementation of the recommended Leakage Management Plan discussed in **Section 8**, an understanding of UFW will further refine and define water consumption point sources previously considered as UFW. The model should be updated to represent these point sources of water consumption to reduce the amount of UFW allocated on a system-wide basis.
- Install flow meters at discharge of Carrollton Plant pump stations.
- Implement a meter testing and replacement program for flow meters within the water purification plants as well as the water customer meters.
- Streamline and develop a data collection system for the water purification plants and distribution systems including installation of SCADA.
- Continue and expand metering public water consumption and identification of UFW.

Section 6

Section 6 – Planning and Evaluation Criteria

The purpose of the planning and evaluation criteria is to evaluate the existing distribution system in comparison to performance goals established for the system. The evaluation process identified deficiencies in the system defined as those components that did not meet the performance criteria.

Hydraulic (capacity) performance criteria were developed to use as standards for the evaluation of the capacity of existing facilities and for development of proposed improvements. Capacity criteria cover capacity, operation, and reliability requirements for piping, pumping, and storage facilities. Additional structural (service level) criteria were developed to evaluate the physical condition of the system.

The criteria described in this section were developed with the S&WB staff during several workshops.

6.1 HYDRAULIC PERFORMANCE CRITERIA

The evaluation for hydraulic performance criteria was performed utilizing the hydraulic model and included all system components, i.e., the transmission and distribution systems and storage components. Improvements required for the existing system to meet the performance criteria were identified, and alternative analysis solutions were developed utilizing the criteria. A summary of the hydraulic criteria is provided in **Table 6-1** on the following page. The criteria are based on adopted state and local regulations, industry standards, and local and national operations experience.

In the State of Louisiana, the Department of Health and Hospitals (DHH) regulates the design and construction of public drinking water systems. The DHH has adopted the "Ten-State Standards" to use as guidelines, with some modification. Neither the City of New Orleans nor the Sewerage and Water Board of New Orleans have adopted, by ordinance or code, any other water system development standards that would supersede Louisiana rules or regulations.

In the following discussion, the hydraulic performance criteria have been grouped by facility type:

- Pipe criteria – distribution network
- Pumping criteria – transmission facilities
- Storage criteria – ground and elevated facilities

A discussion of the capacity criteria associated with each facility type follows.

Table 6-1
Hydraulic Performance Criteria

Facility Type	Criteria	Value/Description
Pipe Criteria	**Diameter**	
	Required size	Greater of: peak hourly flow or average of MDD + fire flow
	Minimum size	8 inches
	Fire Flow	
	Residential (Single-family)	1000 gpm, 2 hrs. duration
	Residential (Multi-family)	2500 gpm, 2 hrs. duration
	Commercial	3000 gpm, 3 hrs. duration
	Industrial	4000 gpm, 4 hrs. duration
	Institutional	5000 gpm, 4 hrs. duration
	Pressure	
	Maximum pressure (East Bank)	65 psi at ground level
	(West Bank)	64 psi at ground level
	Minimum pressure	40 psi at ground level
	Minimum pressure during fire flow	20 psi at ground level
	Velocity	
	Maximum operational	
	Existing pipe	10 fps
	Design pipe	5 fps
	Minimum flushing	2.5 fps
	Headloss	
	Pipe diameter < 16-inch	10 ft/ 1000 ft
	Pipe diameter ≥ 16-inch	3 ft/ 1000 ft
	Hazen-Williams Friction Coefficient, C	
	PVC Pipe/Plastic	140
	AC Pipe	140
	Ductile Iron, Cement Lined	130
	Cast Iron, Unlined	130
	Steel, Unlined	120
	Concrete, includes pre-stressed	130
	Other (Unknown)	100
	Reliability	
	Distribution	Looping of dead-ends
	Transmission	Two source feeds to all hydraulically isolated areas
	Valve Spacing	Maximum of 1,000 ft
	Hydrant Spacing	Maximum of 350 ft

Table 6-1
Hydraulic Performance Criteria
(cont'd.)

Facility Type	Criteria	Value/Description
Pumping Criteria	**Capacity (Required Flow)**	Greater of: peak hourly flow or average of MDD + fire flow
	Reliability	
	Equipment	Firm capacity (sufficient to deliver minimum capacity with largest pump out of service). Minimum of 2 pumps.
	Power	Electric pumps must have at least two different power sources + emergency generator
Storage Criteria	**Capacity**	
	Fire protection storage	1,200,000 gallons (5000 gpm * 4 hour duration)
	Operational storage	Average of MDD (daily consumption only)

6.1.1 Pipe Diameter

6.1.1.1 Required Size

Pipe capacity was evaluated under peak hour flow conditions. Current peak hour conditions were determined from the water purification plants' production records. The diurnal consumption pattern developed for the maximum day was applied to the future maximum day demand (MDD) in order to determine the future peak hour flow.

The peak hour flow conditions may be superseded by fire flow conditions. Pipe capacity was evaluated under fire flow demand, which was defined as the average of MDD plus fire flow requirements for zoning districts. Required fire flow is defined in **Table 6-1**.

The required size criterion is the greater of peak hourly flow or fire flow demand.

6.1.1.2 Minimum Size

The criteria for pipe diameter is typically based on peak domestic flow, fire flow, and pressure requirements of hydraulic analysis as well as other hydraulic criteria. In addition, minimum diameter requirements have been established by the Ten-State Standards, which states: "The minimum size of water main for providing fire protection and serving fire hydrants shall be six inches in diameter". The exception defined by the Ten-State Standards state: "The minimum size of water main in the distribution system where fire protection is not to be provided should be a minimum of three inches in diameter".

The S&WB has adopted a minimum water pipeline diameter of eight inches. Currently, all pipes with a diameter less than six inches requiring replacement or repair are replaced with eight inch diameter pipe. This design criterion was established approximately 20 years ago. As a part of the system improvements, all pipe under eight inches in diameter were identified and evaluated for potential replacement.

6.1.1.3 Fire Flow

The required pipe capacity was evaluated under fire flow conditions, as previously mentioned. The Ten-State Standards refer to the Insurance Service Office's Fire Suppression Rating Schedule for determination of fire flow requirements. According to the Fire Suppression Rating Schedule, fire flow conditions include an average of maximum day domestic demands plus "Needed Fire Flow". Current and future maximum day domestic demand was determined as discussed in **Section 3**. Fire flow criteria, to be used for evaluation and future planning, were estimated based upon typical fire flow values for each of four categories of development served: residential, commercial, industrial, and institutional. The required duration of fire flow is also based on Fire Suppression Rating Schedule requirements. Fire flow and duration are defined for these zoning districts in **Table 6-1**.

6.1.2 Pipe Pressure

Pressure criteria include maximum, minimum, and fire flow requirements.

6.1.2.1 Maximum

The pressure class of pipe and other appurtenances dictates maximum distribution system pressure in the distribution system. Static pressure above 100 psi is not advisable because of the increased leakage rate, an increased risk of pipe failure, and the required installation of pressure reducing valves on distribution mains or on service connections.

The S&WB operates the distribution pump stations at the Carrollton Plant (East Bank) between 68 and 72 psi. In order to protect the aged pipes within the distribution system, the maximum pressure is 65 psi on the East Bank. The Algiers Plant (West Bank) maintains pressure at the distribution pump stations between 62 and 65 psi. The West Bank elvated storage tank overflows above 64 psi; therefore, the maximum pressure within the distribution system on the West Bank is 64 psi.

6.1.2.2 Minimum

A minimum distribution system pressure is required to avoid customer complaints and prevent contamination from backflow. The Ten-State Standards require that a minimum pressure of 20 psi, measured at ground level, be maintained at all points in the distribution system under all conditions of flow (including fire flow). However, it is recommended that a minimum pressure of 35 psi be maintained at all points in the distribution system to avoid customer complaints.

The S&WB continues to receive complaints from large consumers (e.g., from Children's Hospital on the East Bank) if pressure is maintained at 35 psi or lower. A minimum pressure of 40 psi to reduce customer complaints and prevent backflow.

6.1.3 Pipe Velocity

There are no regulations governing velocity of flow in pipes (other than flushing velocity of 2.5 fps). Criteria for evaluation and design are provided by way of recommendation rather than requirement.

6.1.3.1 Maximum Operational

For evaluation of existing pipes, a maximum velocity of ten fps under peak hour flow conditions is suggested. For design or sizing of recommended pipe improvements, a maximum velocity of five fps under peak hour flow conditions is suggested. By maintaining pipe velocities below five fps, the system can, in most cases, avoid the necessity of surge protection devices. The recommended design velocity was used for the analysis of alternative solutions for the water distribution system.

6.1.3.2 Minimum Flushing

For evaluation of existing pipes, a minimum velocity of 2.5 fps under peak hour flow conditions is recommended for flushing.

6.1.4 Pipe Headloss

6.1.4.1 Maximum Design Rate

As with velocity, a headloss criterion is recommended as an indicator of sufficient capacity and energy efficiency. It is recommended that a maximum design headloss rate of 10 ft/1000 ft under peak hour flow conditions be used for pipes less than 16 inches in diameter. For pipes greater than and equal to 16 inches in diameter, a headloss rate of 3 ft/1000 ft is recommended.

6.1.4.2 Hazen-Williams C Factor

The Hazen-Williams equation was used for the hydraulic model to determine friction-related headloss. The friction coefficient "C" is required in the headloss equation for each pipe segment in the model. Some C factors are provided on the West Bank network from a study completed in 1989 by *Pitometer and Associates*. For all other pipes, the value of C was assumed based on pipe material, lining, and age.

Hazen-Williams equation:

$$h_L = \frac{[V^{1.85} L]}{[(1.318C)^{1.85} R^{1.17}]}$$

Where:

h_L	=	Headloss
V	=	Volume
C	=	C factor for material listed in **Table 6-1**
R	=	Hydraulic radius
L	=	Pipe length

The C factors listed in **Table 6-1** apply to future improvements and to existing pipes. The list includes all pipe materials identified in **Section 4**. The listed C factors were adjusted to account for diameter and age. It is assumed that new pipes initially have lower friction factors and over time the friction factors increase for unlined cast iron and steel pipes.

Diameter Adjustments

Diameter adjustments were made to the C factors (listed in **Table 6-1**) since variations in pipe size can affect headloss. C factor adjustments to account for the change in pipe diameter were estimated using the following formula:

$$C_d = C_i + 0.16d$$

Where:

C_i	=	C factor for material listed in **Table 6-1**
C_d	=	C factor adjusted for diameter
d	=	Pipe diameter in inches

Age Adjustments

Age adjustments were also made for unlined cast iron and steel pipes. C factors for cast iron and steel pipes deteriorate over time as corrosion adds to the roughness of the pipe wall. The C factor adjustment for age follows the adjustment for diameter and were made using the following relationship:

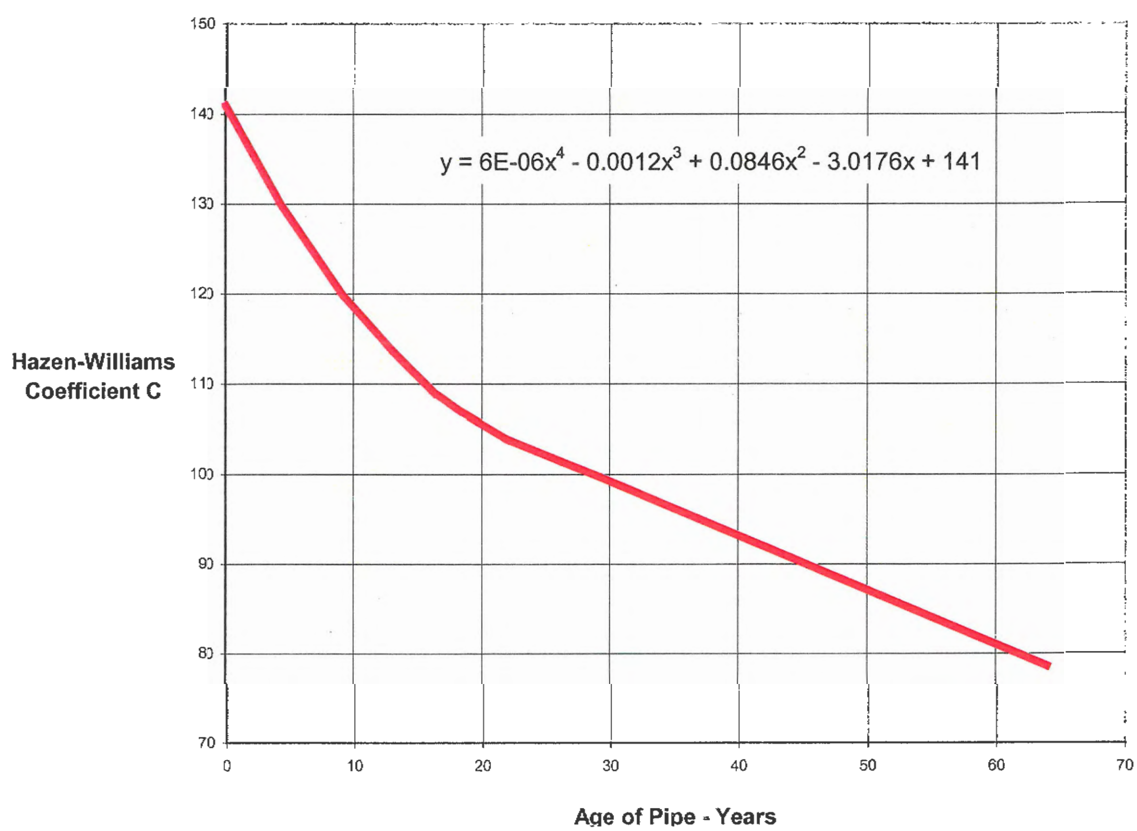
$$C_a = C_d + 0.000006x^4 - 0.0012x^3 + 0.0846x^2 - 3.0176x$$

Where:

C_d	=	C factor adjusted for diameter
C_a	=	C factor adjusted for age
x	=	Pipe age in years

The rate of decline represented in this relationship was taken from trends developed during previous C factor studies performed for the New Orleans system, as reported in the American Water Works Association manual. A graphic of the relationship is presented in **Figure 6-1**.

Figure 6-1
C Factor Trend Curve for New Orleans



6.1.5 Pipe Reliability

6.1.5.1 Distribution

The Ten-State Standards suggest that to increase reliability of service in the distribution system, dead ends should be minimized by making appropriate tie-ins (looping) whenever practical.

6.1.5.2 Transmission

The Ten-State Standards suggest that all hydraulically isolated areas should be provided with two or more feed sources.

6.1.5.3 Valve Spacing

In general, sufficient valves should be provided on water mains to minimize inconvenience and sanitary hazard during repairs. The Ten-State Standards require valves to be spaced at no more than 500-foot intervals in commercial districts and no more than one block or 800-foot intervals in other districts. Where systems serve widely scattered customers, valve spacing should not exceed one mile. Auxiliary valves must also be installed on all hydrant leads.

The S&WB has a design criterion for new valves to be placed no more than 1,000 feet apart. This was used as a maximum spacing criterion for the existing system.

6.1.5.4 Hydrant Spacing

The Ten State Standards and Insurance Services Office (ISO) dictate hydrant spacing requirements. Hydrants should be provided at each street intersection and at intermediate points between intersections. Hydrant spacing may range from 350 to 600 feet depending on the distance to the location being served and the needed fire flow to be provided.

The S&WB has a design criterion for new hydrants to be placed no more than 350 feet apart. This was used as a maximum spacing criterion for the existing system.

6.1.6 Pump Capacity

All pump stations should have sufficient capacity to supply peak water demands without dangerous overloading (within safe operating range of the pump). This is usually the average of maximum day water demand for supply pumps delivering to storage facilities. For pumps delivering to the distribution system, this is either peak domestic flow or the average of maximum day flow plus fire flow, which ever is greater.

6.1.7 Pump Reliability

6.1.7.1 Equipment

All pump stations must be equipped with at least two pumps. The pump station must be able to provide a firm capacity or the maximum pumping demand with the largest of the pumps out of service.

6.1.7.2 Power

Power for each electrically driven pump station shall be supplied from at least two independent sources. As recommended by the Ten State Standards, one power source may be from a standby or an auxiliary source such as an emergency generator.

The S&WB requires at least two independent power sources for each pump station as well as an emergency generator.

6.1.8 Storage Capacity

Storage capacity requirements include provisions for operations, fire and emergencies. Only those sections of clearwells at the water purification plants not required to achieve the necessary disinfection contact time may be considered for storage. The capacity of the storage tanks not required for backwash or process water at the treatment facilities was evaluated for fire, operational, and emergency capacity.

6.1.8.1 Fire

Fire storage capacity must, as a minimum, be equal to the water volume required to serve the largest needed fire flow for the required fire flow duration. For the City of New Orleans, this is equal to 5,000 gpm over a duration of four hours or 1,200,000 gallons. Fire storage capacity should be evaluated at the minimum storage level under average daily demand conditions. Fire storage capacity can only be counted for hydrants or points of delivery where it is hydraulically available at the minimum pressure for the required fire flow duration. Where ground-level storage is to be used as fire storage, only the volume that can be delivered by the pumps during the fire flow duration can be counted.

6.1.8.2 Operational

Operational storage requirements are calculated based on the diurnal water use records of the maximum day. As planning or design criteria for future storage capacity requirements, the same current maximum day diurnal use was applied to the projected maximum day water use of the planning horizon. Elevated storage that is not hydraulically available to the distribution system under normal operating conditions cannot be counted as operational storage.

6.2 STRUCTURAL PERFORMANCE CRITERIA

The primary objective of the structural criteria was to provide guidelines for the long-range water main rehabilitation and replacement strategies. The structural criteria were evaluated utilizing macro (KANEW software) and micro (water main prioritization) analyses. The KANEW model predicts the length of different categories of pipes to be rehabilitated or replaced on an annual basis, based on the inventory of water mains and estimated lifespan. As the KANEW model is a macro model, it does not provide location-specific rehabilitation and replacement information, nor does it consider the physical condition of the pipe and the historical performance (breaks and leaks). The location-specific rehabilitation and replacement information was addressed with the water main renewal/replacement prioritization analysis.

6.2.1 KANEW Analysis

As the S&WB plans for reinvestment into the distribution system, it is important that the annual replacement rates of water mains are established to allow funds to be allocated as needed. It is important that the S&WB understand the level of reinvestment that is required to maintain its level of service and how to prioritize this investment.

The KANEW software used to perform the macro analysis of the water main replacement/rehabilitation rate was developed as part of the American Water Works Association Research Foundation (AwwaRF) project: "Quantifying Future Rehabilitation and Replacement Needs of Water Mains" (1998). A copy of the executive summary of this AwwaRF project is included in **Appendix A**.

The information required to perform the KANEW analysis includes age, diameter, material, and length of the water mains. For each water main category, survival functions are prepared based on the life expectancy for each water main category. The survival function is a mathematical expression, which represents the aging process of the water main. The specific parameters of a survival function indicate the percentage of water mains that will survive beyond a given age. The survival functions are applied to the current inventory of water mains year by year, and calculations are made to determine the length of water mains that have reached the end of their useful life and must therefore be rehabilitated or replaced.

The following subsections describe the details of the KANEW analysis utilized in this assessment.

6.2.1.1 Water Main Categories

The water distribution system was divided into water main categories as presented in **Table 6-2**. The categories were selected based on water main diameter and material. It is important to establish water mains based on categories by diameter and material for the following reasons:

- Large diameter water mains tend to have a longer life expectancy.
- Life expectancy of water mains varies based on material and method of manufacture.

The water main diameter categories are:

1. Between 4 and 12 inches
2. Between 16 and 24 inches
3. Greater than 24 inches

These three diameter categories were established to distinguish between distribution mains (4 to 12 inches), transmission mains (16 to 24 inches), and major transmission mains (greater than 24 inches).

The categories for material were established based on the materials of existing water mains. If information on the type of pipe was not available the type of material was assigned based on the water main age, in accordance with the information presented in **Table 6-2**.

One hobas water main less than 1 mile in length was identified in the East Bank system. A category for hobas material was not developed for structural analysis since this is the only water main constructed of this material. The following categories of water main were not found in the S&WB water system inventory:

- High density poly-ethylene (HDPE)
- Large diameter (greater than 24 inches) PVC
- Large diameter (greater than 24 inches) ductile iron

Table 6-2
Water Main Categories

Category	Material	Installation Date	Diameter (inches)	Description of Category
1A	Cast iron	Before 1910	4 - 12	Pit cast iron pipe with lead joints
1B			16 - 24	
1C			>24	
2A		1910 - 1938	4 - 12	Spun cast iron with lead joints
2B			16 - 24	
2C			>24	
3A		1938 - 1955	4 - 12	Spun cast iron with lead/leadite joints and cement mortar lining
3B			16 - 24	
3C			>24	
4A		1955 - 1972	4 - 12	Spun cast iron with rubber gasket joints and cement mortar lining
4B			16 - 24	
4C			>24	
5A	Ductile iron	All dates	4 - 12	Ductile iron with cement mortar lining
5B			16 - 24	
5C			>24	
6A	Asbestos cement	All dates	4 - 12	Asbestos cement pipe
6B			16 - 24	
6C			>24	
7A	Prestressed concrete	All dates	16 - 24	Prestressed concrete pipe
7B			>24	
8A	Steel	All dates	4 - 12	Coal tar enamel or epoxy lining
8B			16 - 24	
8C			>24	
9A	PVC	All dates	4 - 12	Rubber gasket joints
9B			16 - 24	
9C			>24	
10A	HDPE	All dates	4 - 12	Fusion welded
10B			16 - 24	
10C			>24	
11A	Hobas	All dates	>24	Fiberglass reinforced pipe

6.2.1.2 Water Main Life Expectancies

The water main life expectancies are a key input, as they determine the aging function which defines the lifespan for each water main category. To prepare guidelines on the overall water main rehabilitation/replacement rate for each category of water main, an estimate of the expected life of water mains was established based on a review of literature and a workshop with the S&WB staff. **Table 6-3** presents the life expectancy range for each water main category.

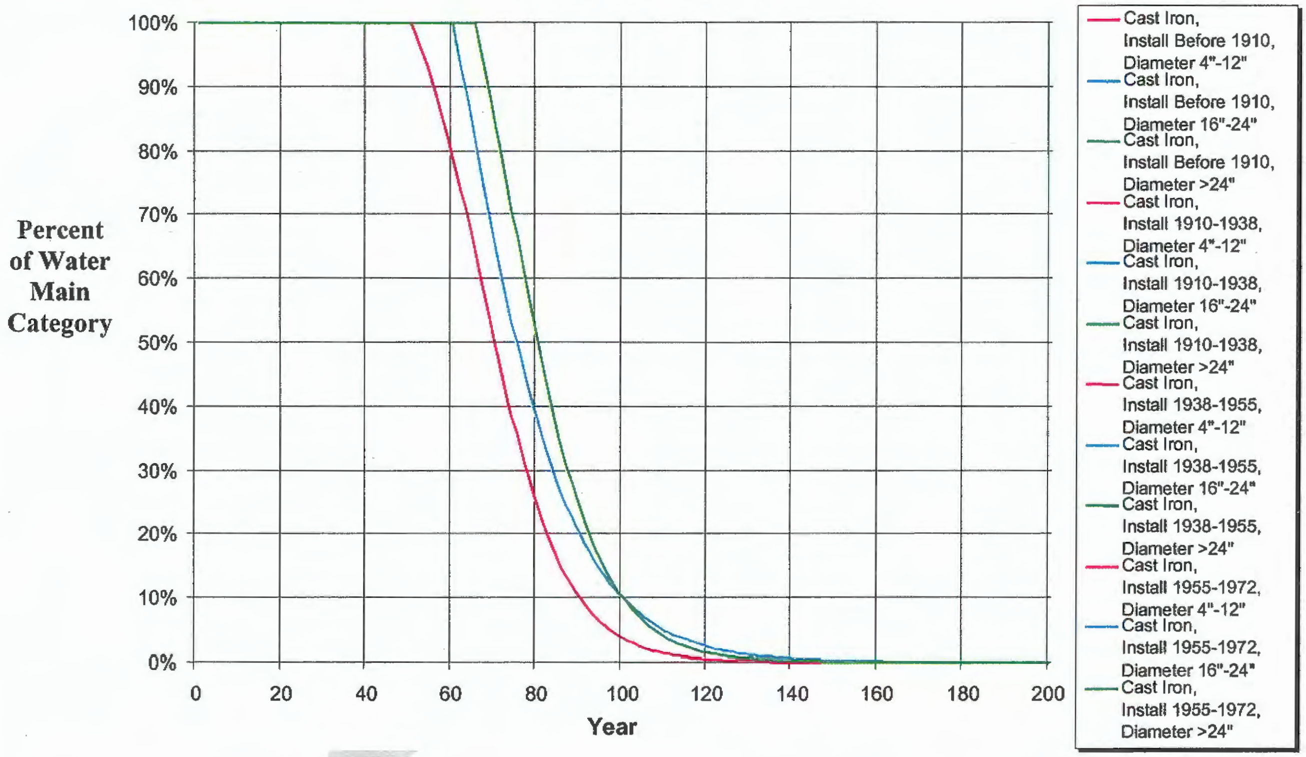
For each water main category a pessimistic (short) and optimistic (long) life expectancy was established. The life expectancy range presented in **Table 6-3** is the lifespan at 100 percent, 50 percent, and 10 percent of a particular pipe type. The life expectancy range was based on the pipe lifespan without rehabilitation or replacement. The lower and upper bounds of the lifespan range are referred to as the "pessimistic" and "optimistic" estimates, respectively. The life expectancy of water mains is dependent on many variables such as quality of installation, soil condition, system pressure, and water quality, and is, therefore, location/utility specific.

Table 6-3
Water Main Life Expectancy

Category	Material	Installation Date	Diameter (inches)	Short and Long Life Expectancy (Years)		
				100%	50%	10%
1A			4 - 12	30 - 50	60 - 70	80 - 90
1B		Before 1910	16 - 24	40 - 60	65 -75	90 - 100
1C			>24	45 - 65	70 - 80	90 - 100
2A			4 - 12	30 - 50	60 - 70	80 - 90
2B		1910 - 1938	16 - 24	40 - 60	65 -75	90 - 100
2C			>24	40 - 65	70 - 80	90 - 100
3A	Cast Iron		4 - 12	30 - 50	60 - 70	80 - 90
3B		1938 - 1955	16 - 24	40 - 60	65 -75	90 - 100
3C			>24	40 - 65	70 - 80	90 - 100
4A			4 - 12	30 - 50	60 - 70	80 - 90
4B		1955 - 1972	16 - 24	40 - 60	65 -75	90 - 100
4C			>24	40 - 65	70 - 80	90 - 100
5A			4 - 12	40 - 50	65 - 75	85 - 100
5B	Ductile iron	All dates	16 - 24	50 - 60	75 - 85	95 - 110
5C			>24	50 - 60	75 - 85	95 - 110
6A			4 - 12	40 - 60	70 - 90	90 - 110
6B	Asbestos cement	All dates	16 - 24	40 - 60	70 - 90	90 - 110
6C			>24	40 - 60	70 - 90	90 - 110
7A	Prestressed concrete	All dates	16 - 24	40 - 60	70 - 90	90 - 110
7B			>24	50 - 60	60 - 80	80 - 110
8A			4 - 12	40 - 50	70 - 80	85 - 100
8B	Steel	All dates	16 - 24	50 - 60	75 - 85	95 - 110
8C			>24	50 - 60	75 - 85	95 - 110
9A			4 - 12	25 - 30	40 - 50	60 - 80
9B	PVC	All dates	16 - 24	25 - 30	40 - 50	60 - 80
9C			>24	25 - 30	40 - 50	60 - 80
10A			4 - 12	45 - 50	60 - 70	70 - 90
10B	HDPE	All dated	16 - 24	45 - 50	60 - 70	70 - 90
10C			>24	45 - 50	60 - 70	70 - 90
11A	Hobas	All dates	>24	40 - 50	60 - 70	70 - 80

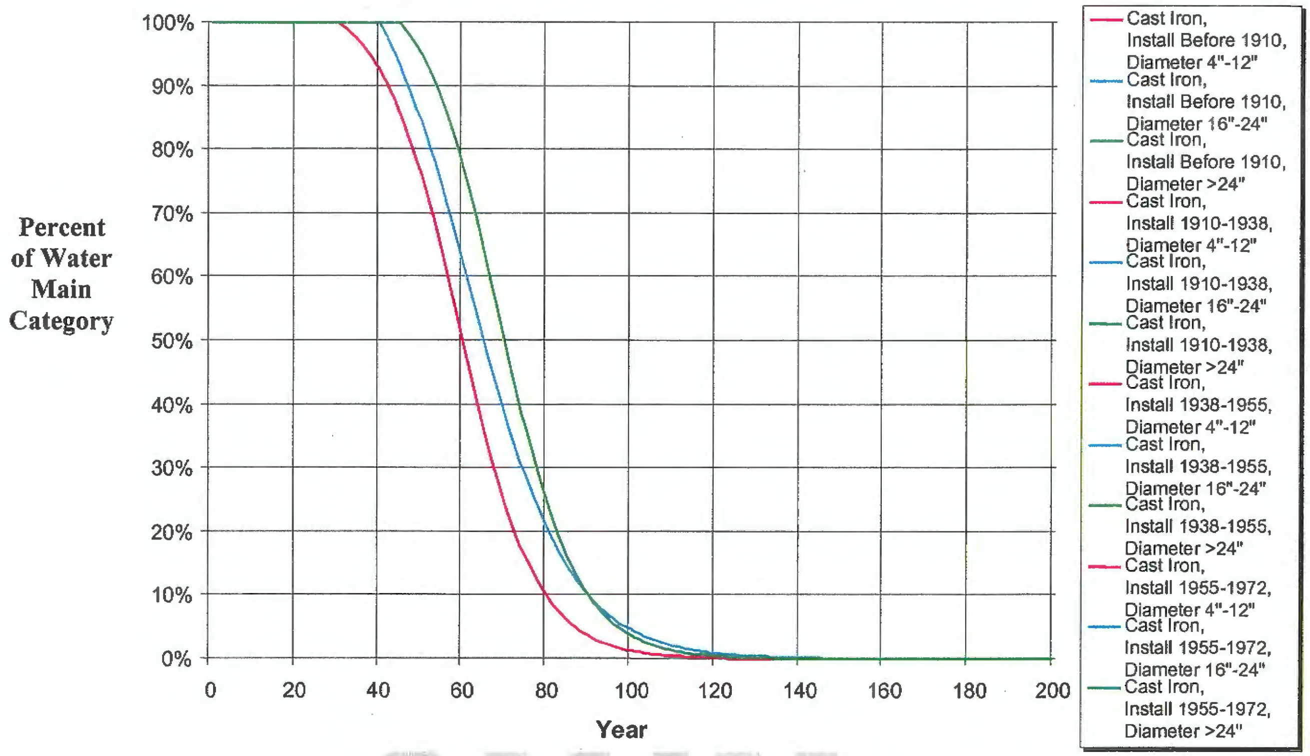
The survival curves for long and short life expectancies of cast iron pipe are presented in **Figures 6-2** and **6-3**, respectively. The life expectancies for the remaining pipe categories are shown in **Appendix G**. The life expectancy of water mains is expected to decrease in time and a smaller percentage of the water main category is estimated to "survive". As shown in **Figure 6-2**, the long life expectancy estimates that 10 percent or less of all cast iron water main categories will survive after being in service for 100 years.

Figure 6-2
Water Main Survival Curve
Long Life Expectancy



In comparison, the short life expectancy shown in **Figure 6-3** estimates that 5 percent or less of all cast iron water main categories will survive after being in service for 100 years.

Figure 6-3
Water Main Survival Curve
Short Life Expectancy



6.2.2 Rehabilitation and Replacement Prioritization

The structural (service level) performance criteria were also used to establish the priority and reinvestment needs for the rehabilitation/replacement of the existing water distribution system. The criteria were based on the structure and ability of the water system to provide S&WB customers with the required level of service.

The methodology to systematically prioritize the water main rehabilitation/replacement program was based on the assignment of an overall Priority Action Number (PAN) to each water main. The overall PAN was derived by summing the individual PANs, based on the ability of the water main to meet the required service criteria. The water main segment with the highest PAN had the highest priority for rehabilitation/replacement.

The service level criteria for the prioritization of water main rehabilitation/replacement of the S&WB water system were divided into primary and secondary service levels. Primary service levels were criteria that directly relate to the ability of the water main segment to perform its design function. Secondary service levels were criteria used as "tie breakers" based on the prioritization analysis using the primary service levels. The criteria and categories are presented in **Table 6-4**.

Table 6-4
Structural (Service Level) Criteria

Category	Criteria
Primary	Age
	Breaks and leaks
Secondary	Material
	Location
	Customer impact

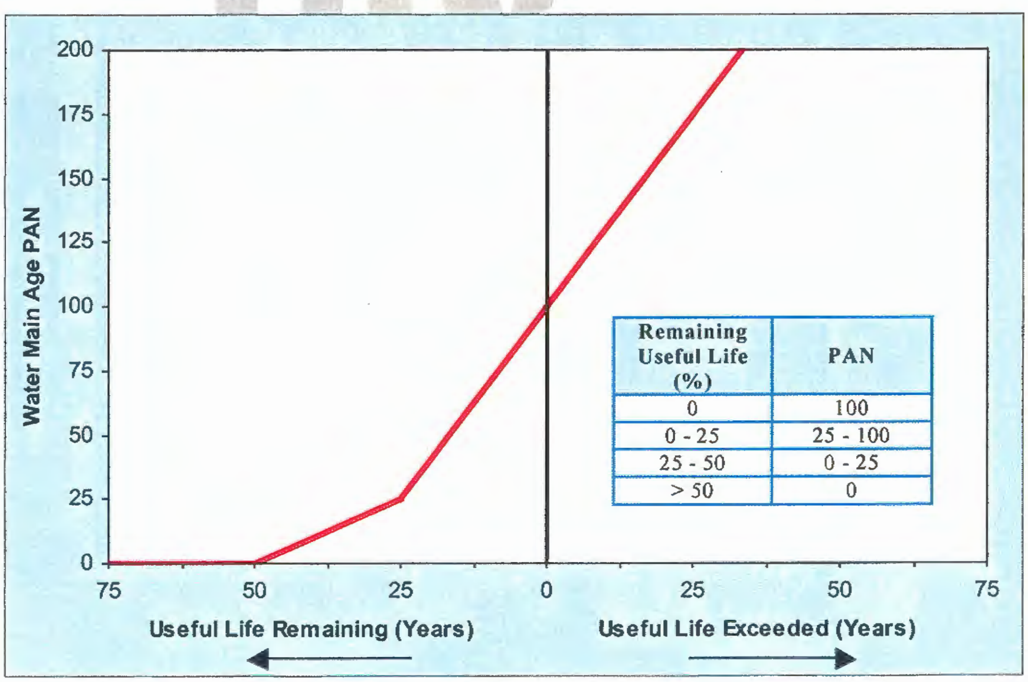
6.2.2.1 Primary Service Level Criteria

Water Main Age

To assist in establishing the guidelines for the rehabilitation/replacement rate for existing water mains and the water main priority, the water distribution system was divided into the categories as presented previously in **Table 6-2.**

The overall philosophy for establishing the water main age PAN is that, in general, water mains deteriorate greater during the latter part of their expected service life. A pipe can be considered to be in the original structural condition if the pipe age is within 50 percent of its anticipated lifespan. **Figure 6-4** illustrates the assumed PANs based on remaining useful life.

Figure 6-4
Water Main Age PAN



The water main prioritization model included a provision to extend the useful life of rehabilitated water main segments. In the event of rehabilitation using a fully structural replacement, the useful life was set to the design life of that technology. Other rehabilitation technologies extended the useful life of the water main by a user-defined period.

Water Main Breaks and Leaks

The history of water main failure (breaks and leaks) is a critical component in the evaluation of water main performance. Guidelines are provided by AwwaRF (Distribution System Performance Evaluation, 1995) for an acceptable number of breaks per 1,000 feet of water main as follows:

- 0.047 to 0.057 breaks per 1,000 feet per year

It is also important to determine the historical time period for the break and leak analysis. For this type of analysis breaks and leaks are typically considered over the last five to ten years. In general, leaks that occurred over ten years ago are not a good indicator of the structural condition of a water main since they do not represent the existing condition. For this analysis, breaks and leaks over the last five years were considered with more weight given to the most recent breaks and leaks.

Each water main break and leak, as well as the date of the event, were assigned to the specific water main where the event occurred. The prioritization model converted the number of breaks for each water main segment to breaks per 1,000 feet per year to calculate the individual PAN. In the case of water main replacement, the model did not allow breaks and leaks earlier than the water main installation date.

The information on breaks and leaks was compiled from the CassWorks system maintained by the S&WB and the database of leaks maintained by Earth Tech. A break or leak was included only if it originated from the water main. Breaks and leaks occurring on services and fire hydrants were not included in the analysis since they do not represent the condition of the water main.

Breaks and leaks that occurred over 5 years ago are less indicative of the water main condition (unless they have re-occurred) than recent breaks or leaks. More weight was, therefore, assigned to the most recent breaks and leaks and determined as follows:

1. The number of breaks and leaks in Year 1 multiplied by a weighting factor of 1.
2. The number of breaks and leaks in Year 2 multiplied by a weighting factor of 0.8.
3. The number of breaks and leaks in Year 3 multiplied by a weighting factor of 0.6.
4. The number of breaks and leaks in Year 4 multiplied by a weighting factor of 0.4.
5. The number of breaks and leaks in Year 5 multiplied by a weighting factor of 0.2.
6. Sum the number of breaks and leaks multiplied by the appropriate weighting factor for the past five years.

7. Divide the sum by the length of water main and convert to breaks and leaks/1,000 feet/year for the past five years.
8. PAN for breaks and leaks were determined based on the relationship listed in **Table 6-5**.

Table 6-5
Water Main Breaks and Leaks PAN

Breaks and Leaks / 1,000 feet / Year	PAN
< 0.02	0
0.02 - 0.4	50
> 0.4	100

6.2.2.2 Secondary Service Level Criteria

Water Main Material

Frequently, utilities place a higher priority on the replacement of pipes manufactured from a certain material. This is certainly true with asbestos cement pipe, as the water industry as a whole is moving toward replacement of this type of pipe due to potential adverse health risk. Some utilities also choose to replace cast iron pipes installed during certain time periods due to the high failure rates.

Each water main segment was assigned a PAN based on the material of construction. **Table 6-6** summarizes the proposed PANs applied to differing materials of construction.

Table 6-6
Water Main Material PAN

Material of Construction	PAN
Prestressed concrete	100
Asbestos cement	90
Cast iron before 1910	80
Cast iron 1910 - 1938	80
Cast iron 1938 - 1955	80
Cast iron 1955 - 1972	50
Ductile iron	50
Steel	30
HDPE	30
Hobas	30
PVC	30

Location of Water Main

An important element when considering the prioritization of water main rehabilitation/replacement is the area of the city that a water main serves. To assist in assigning a PAN to the water main, relevant to its location, the service area was evaluated to develop general service location categories. The division of the service area and the associated PANs are listed in **Table 6-7**. A land use zoning map was utilized to assign the appropriate PAN to each water main.

Table 6-7
Water Main Location PAN

Location	PAN
French Quarter	100
Central Business District	100
Downtown	80
Industrial	70
Institutional	70
Major thoroughfares	60
Commercial	50
Residential	40
Other areas not defined above	20

Customer Impact

An important element when considering the prioritization of water main rehabilitation /replacement is to determine the effect on the customer of a failure of each water main. The critical customers for the S&WB were determined to include the top 50 large water users and the customers with a fire service, as identified by the S&WB billing records. Therefore, a customer impact PAN of 100 was assigned to water mains with a fire service and/or serving a large water user. Customers with a four inch combination connection or larger are assumed to have a fire service for the purpose of this analysis. **Table 6-8** shows the PAN for the customer impact criteria.

Table 6-8
Customer Impact PAN

Service Connection	PAN
Top fifty large water consumer	100
Fire service	100
4-inch and larger combination service	100
Others	0

The larger water users, the fire service water mains, and 4-inch and larger combination service locations were provided by the S&WB.

Construction Schedule

For economic reasons, rehabilitation of water mains is often performed in conjunction with a street replacement program, sidewalk construction, streetscape project, highway widening or other utility project. Coordination of the other construction activity with the water main program is, therefore, critical to prevent undue disturbance to traffic. Construction scheduling was not a direct service level criterion, but is an economical condition for prioritizing. The construction scheduling subroutine allowed the model to list the proposed construction projects of other entities and show the water main priority listing with associated water main consolidated PAN. This allowed for a direct comparison of water main priority to proposed construction work for the five-year horizon and assist S&WB with capital improvement planning.

6.2.3 Weighting Factors

Once the service level criteria were established, the level of importance (weighting) of each service level criteria was determined. The assignment of weighting factors is subjective and is based on experience and local knowledge. The prioritization model allowed the weighting factors to be changed globally for each category of water mains or individually. The weighting factors are shown in **Table 6-9**.

Table 6-9
Service Level Weighting Factors

Category	Service Level	Weighting Factor
Primary	Breaks and leaks	0.4
	Age	0.3
Secondary	Customer impact	0.3
	Location	0.2
	Material	0.2

Section 7

Section 7 – System Evaluation

The purpose of this section is to describe the evaluation performed on the existing water distribution systems and present the findings of the evaluation along with recommended improvements to address existing deficiencies and meet future demands for a twenty-year (2025) planning effort.

The hydraulic capacity of the water systems was evaluated using the hydraulic model and performance criteria described in **Section 6**. This evaluation included analysis of pressures, velocities, fire flow, storage volumes, and existing conditions. The hydraulic model results are based on existing system conditions, including a significant percentage of UFW, and should not be considered as final results. The hydraulic model should be further refined during the implementation of the recommended improvements. Supporting information for the hydraulic performance criteria analysis is included in **Appendix F**.

The structural condition of the water systems was evaluated using the KANEW analysis and the prioritization analysis with respect to the performance criteria such as water main age, material, and history of breaks as described in **Section 6**. Supporting information for the structural condition analysis is included in **Appendix G**.

7.1 HYDRAULIC ANALYSIS

The hydraulic capacity analysis of the East and West Bank systems was conducted utilizing ArcView and the hydraulic model in H_2O Map. The hydraulic model was run under existing maximum day demand conditions, unless otherwise noted, with the existing network configuration. This section presents a summary of the analysis results with regard to pipe diameter, system pressure, fire flow, velocity, headloss, system reliability, and storage capacity. The result of the analysis suggests that the systems, in general, appear to have sufficient capacity to supply the existing water demand, therefore requiring no immediate or future upgrades to meet the planning horizon for the year 2025.

Given the age of the systems, it is recommended at this time to focus on the structural condition of the distribution systems and initiate a leakage management program. Implementation of the recommendations made for structural improvements will further improve the hydraulic capacity characteristics of the system such as pipe velocity and system pressure.

As previously stated, the hydraulic model results are based on existing system conditions, including a significant percentage of UFW, and should not be considered as final results. As the structural recommendations are made to the distribution systems and leakage levels are reduced, the hydraulic model should be refined to represent the system improvements. The hydraulic capacity and performance criteria of the system should continue to be evaluated utilizing the refined hydraulic model.

7.1.1 Pipe Capacity

All pipes were evaluated, based on pipe flow and diameter, to determine whether the pipes are sized appropriately to supply the existing water demand. The performance criteria for pipe capacity are as previously outlined in **Table 6-1**. Specifically, the pipes were evaluated by the ability to supply the maximum of peak hourly demand or average of maximum day demand (MDD) plus fire flow. In addition, the pipes were evaluated based on the minimum diameter requirement identified by the S&WB.

7.1.1.1 Pipe Flow

All pipe segments were evaluated to determine if they are capable of supplying the existing water demand at peak hour and MDD plus fire flow conditions. The analysis of pipe segment flow capacity was based on the pressure at peak flow conditions. Pipe segments that met the minimum pressure criteria of 20 psi during peak flow conditions are considered to meet the pipe flow criteria. The detailed list of all pipe segments that did not meet flow conditions is summarized in **Appendix F**. **Figures 7-1** and **7-2** show the pipe segments that did not meet the pipe flow criteria on the East and West Bank, respectively.

Further action to address these results should not be taken until the structural rehabilitation program and the leakage management program have been completed and the system re-evaluated.

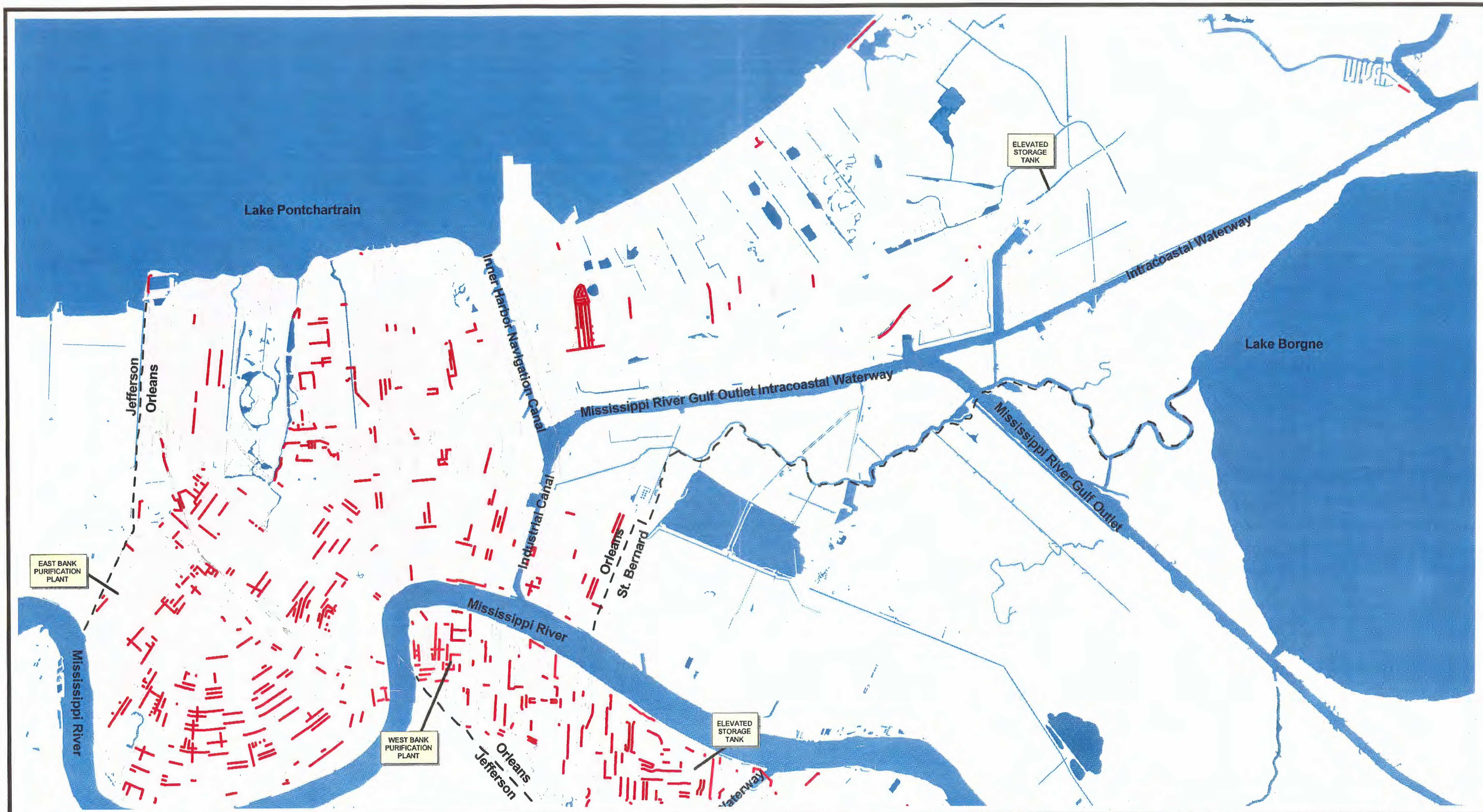
7.1.1.2 Pipe Diameter

The results of the pipe diameter analysis, shown in **Table 7-1**, indicate that approximately 50 percent of the East and West Bank systems are comprised of pipe segments equal to six inches in diameter. The existing policy of the S&WB is to install pipes eight inches in diameter and larger when replacement is needed.

Table 7-1
Pipe Diameter Analysis

Pipe Diameter Category (Inches)	East Bank		West Bank	
	Length (Linear Feet)	Percent of Total (%)	Length (Linear Feet)	Percent of Total (%)
> 6	1,090,000	15	45,000	< 5
6	3,397,000	50	482,000	50
8 to 54	2,556,000	35	502,000	50
Total	**7,043,000**	**100**	**1,029,000**	**100**

On a systemwide basis, some 62 percent of the pipes are less than or equal to six inches in diameter. Given this fact, a significant increase in pipe sizes on a systemwide basis may improve the hydraulic capacity to supply demand under fire flow conditions, but may adversely effect water age and quality. The recommendations for pipe replacements



Legend

N

Not to scale

Pipe Capacity Criteria

Segments to be Further Evaluated

Segments Capable of Meeting Peak Flow Conditions

Parish Boundary

Street

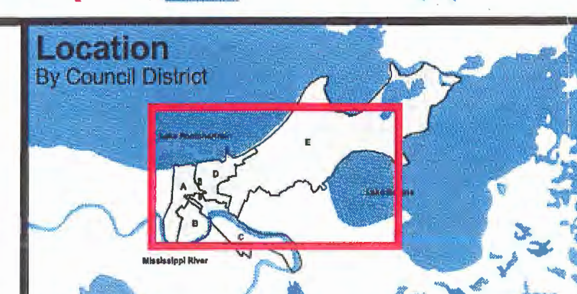
Water Body

Water Distribution System
Assessment and Hydraulic Model

Performance Criteria
Pipe Capacity
East Bank

Figure 7-1

Location
By Council District



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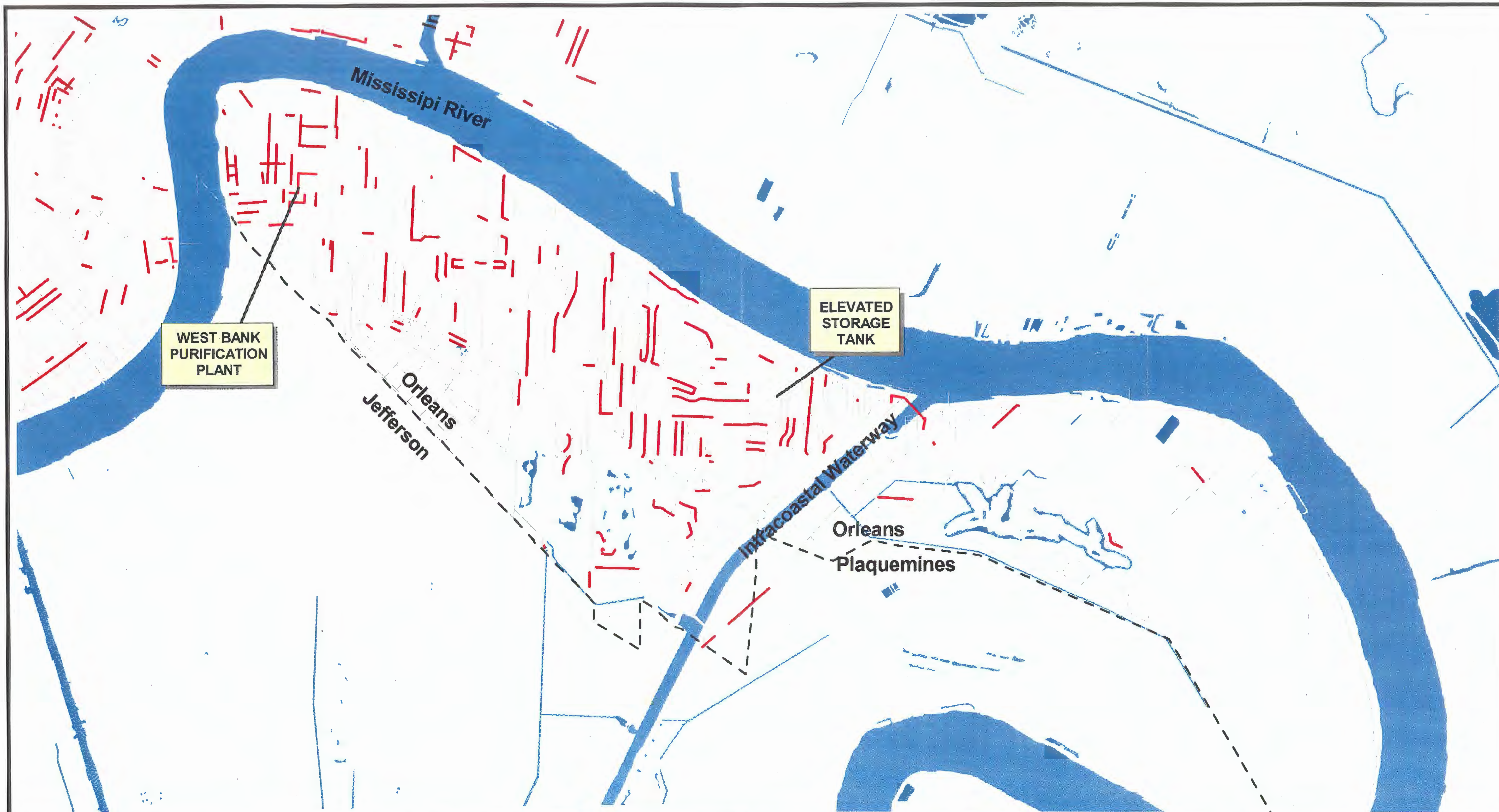

Legend

N

Not to scale

Pipe Capacity Criteria

- Segments to be Further Evaluated
- Segments Capable of Meeting Peak Flow Conditions
- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Performance Criteria
Pipe Capacity
West Bank

Figure 7-2

Location
By Council District

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resulting from the structural analysis include the increase of pipe diameter to the 8-inch minimum size. The effect on water age and quality should be evaluated further as the structural rehabilitation program and the leakage management program have been initiated.

7.1.2 System Pressure

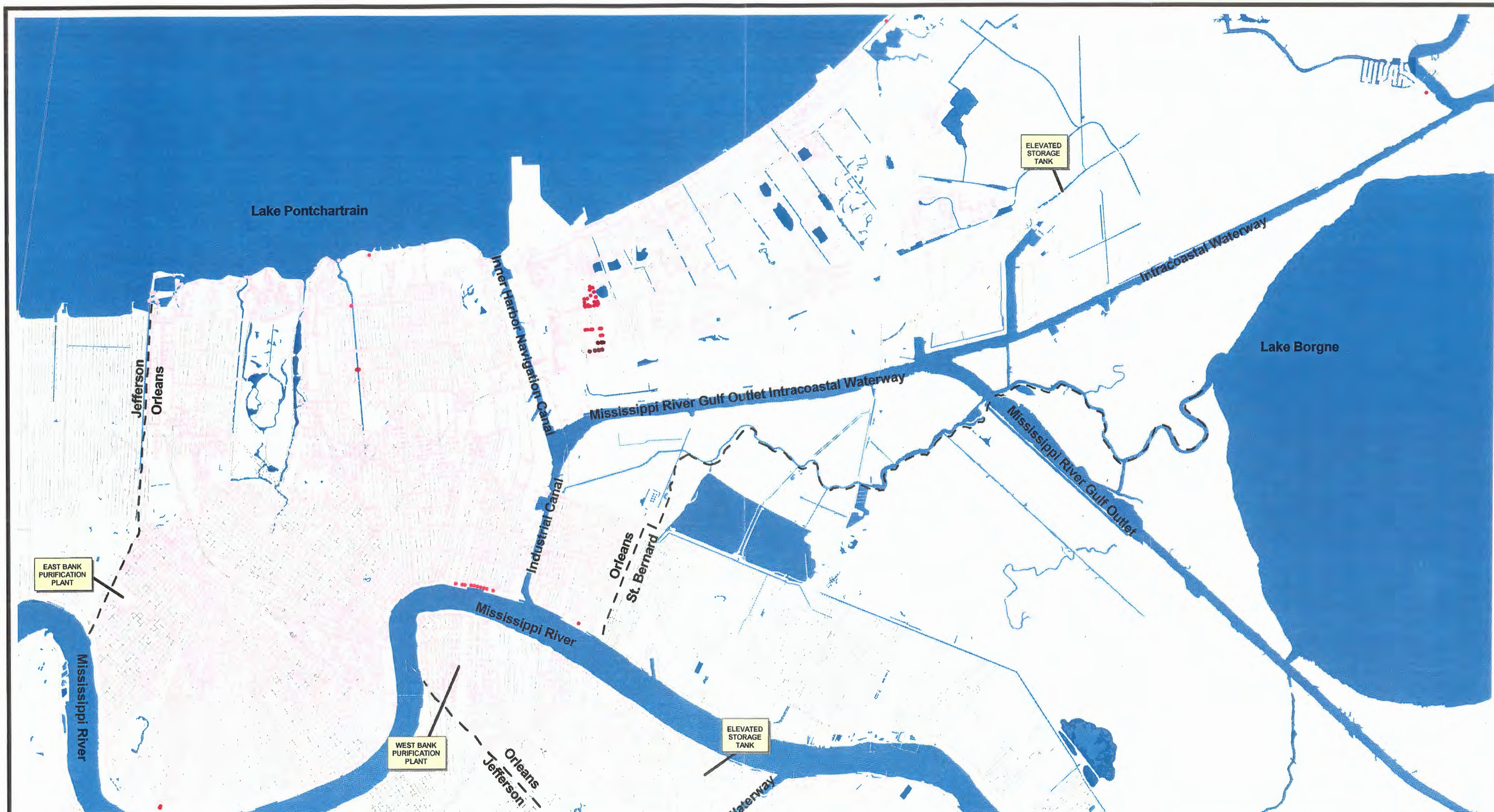
The pressure analysis was conducted on the network nodes, as the hydraulic model records the system pressures on nodes. As mentioned in **Section 5**, the nodes included in the hydraulic model consist of junctions (caps, crosses, tees, or reducers), check valves, and select hydrants used for field testing. Minimum pressures were evaluated during peak hourly demand of MDD conditions, since critical pressures occur at the highest demand. Maximum pressures were evaluated over the 24-hour period of MDD conditions.

A summary of the number of nodes on the East Bank that do not meet the minimum pressure of 40 psi and maximum pressure of 65 psi is shown in **Table 7-2**. The locations are shown in **Figures 7-3** and **7-4**. On the East Bank, the nodes that do not meet minimum pressure are typically located adjacent to levees and in Venetian Isles. All nodes that exceed maximum pressure are located immediately downstream of the purification plant. The East Bank system has less than one percent of the nodes not meeting the minimum pressure criteria at peak hour demand and less than two percent exceeding the maximum pressure criteria during MDD conditions. Of the nodes that exceed maximum pressure, the highest pressure is 70 psi.

Table 7-2
Pressure Analysis during Maximum Day Conditions

Pressure Criteria (psi)	East Bank		West Bank	
	Number of Nodes	Percent of Total (%)	Number of Nodes	Percent of Total (%)
≤40	157	1	0	0
>65 (64 for West Bank)	264	2	2,118	100
Total	**12,923**	**100**	**2,118**	**100**

As discussed in **Section 6**, the West Bank elevated storage tank overflows above 64 psi; therefore, the maximum pressure within the distribution system on the West Bank is 64 psi. A summary of the number of nodes on the West Bank exceeding the maximum pressure of 64 psi is shown in **Table 7-2**. The locations are shown in **Figure 7-5**. All nodes in the West Bank system met the minimum pressure criteria at peak hour demand. All of the nodes exceed the maximum pressure criteria over a 24-hour period during MDD conditions. The highest projected pressure in the system is 85 psi.



Legend

N

Not to scale

Pressure (psi)

●	<= 35	/ ✓	Parish Boundary
●	36 - 39		Street
	>= 40	▬	Water Body

Water Distribution System
Assessment and Hydraulic Model

Performance Criteria
Pressure Less Than or Equal to 40 psi
East Bank

Figure 7-3

Location
By Council District

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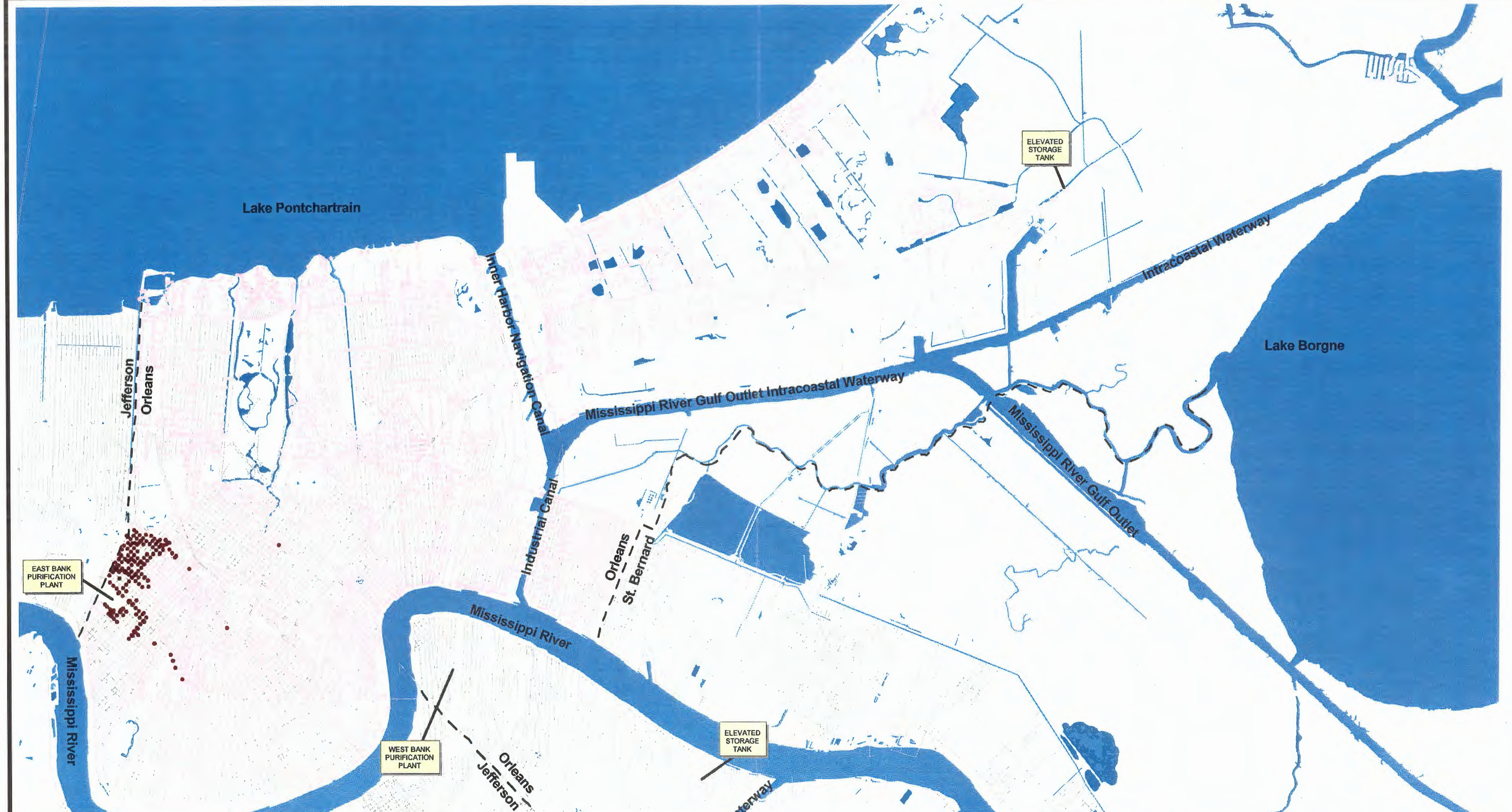

Legend

N

Not to scale

Pressure (psi)

● > 65

<= 65

Parish Boundary

Street

Water Body

Water Distribution System
Assessment and Hydraulic Model

Performance Criteria
Pressure Greater Than 65 psi
East Bank

Figure 7-4

Location
By Council District

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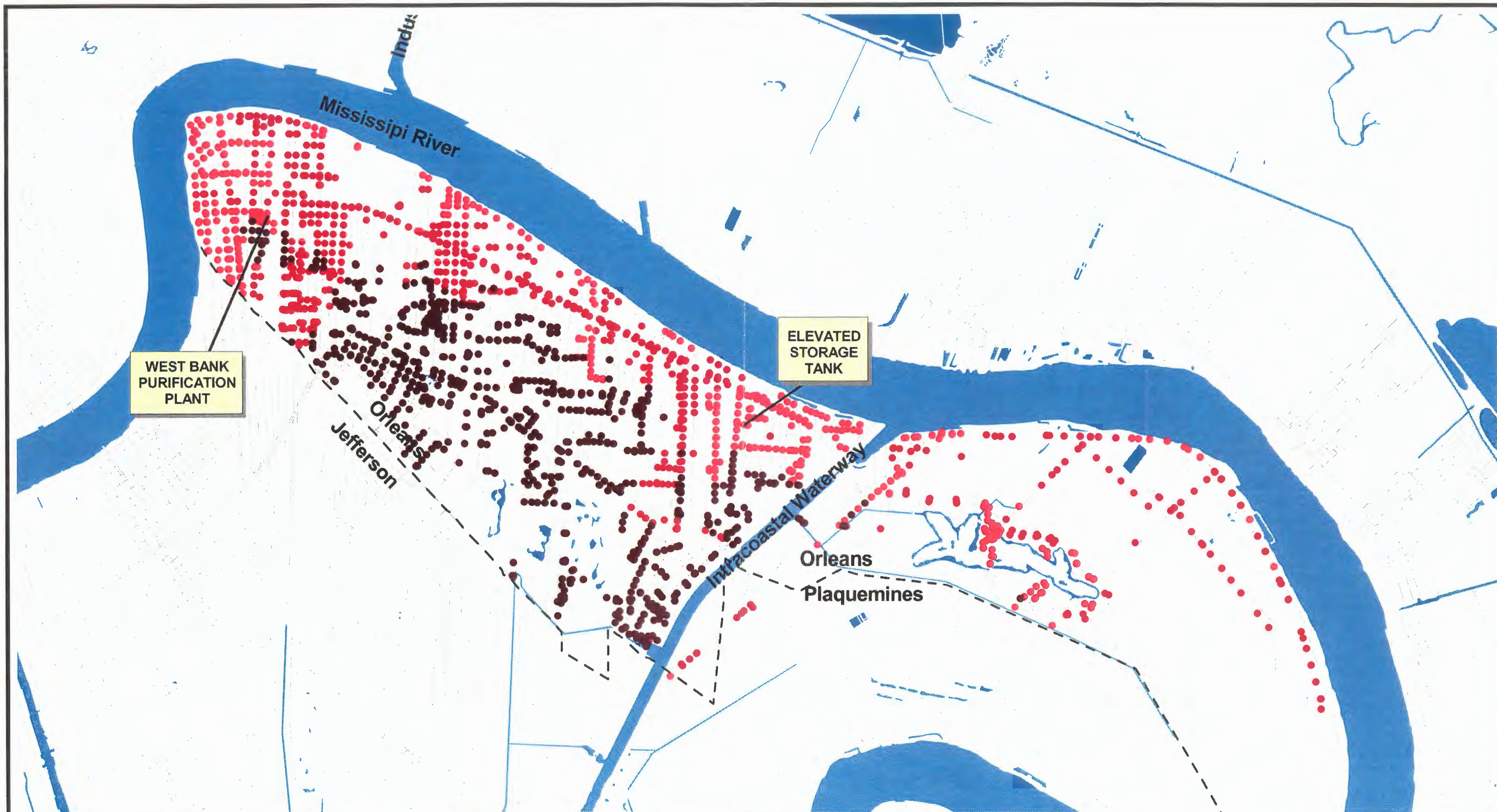


Legend

Pressure (psi)

- >= 80
- 64 - 80

- Parish Boundary
- Street
- Water Body

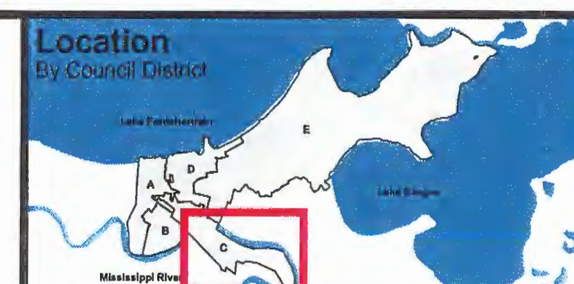
N

Not to scale

Water Distribution System
Assessment and Hydraulic Model

Performance Criteria
Pressure Greater Than 64 psi
West Bank

Figure 7-5



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At this time, it is not recommended that action be taken to address these deficiencies beyond implementation of the rehabilitation and leakage management programs since the flow and pressure may be improved by the structural recommendations. Evaluation of the system pressure should continue after completion of the recommended programs discussed in **Section 9**.

7.1.3 System Pressure During Fire Flow Conditions

The distribution systems were also evaluated under a demand condition of maximum day plus required fire flow. The fire flow results are categorized by land use zoning since fire flow criteria is different for each land use type, as discussed in **Section 6**. Utilizing GIS, the land use zoning was identified as residential, commercial, industrial or institutional for each hydrant to be tested for fire flow conditions. Each land use zone and associated hydrant was then imported to H_2O Map to run the fire flow analysis. The analysis for each zone was performed in H_2O Map for the average of maximum day demand with the required fire flow.

Tables 7-3 and **7-4** summarize the number of hydrants that do not meet fire flow requirements at 20 psi under MDD conditions for the East and West Bank, respectively.

Table 7-3
Pressure Analysis during Fire Flow Demand
East Bank

Landuse Zone		Number of Fire Hydrants	Flow Criteria (gpm)	Number of Hydrants Below 20 psi	Percent of Total (%)
Residential	Single-Family Residential	5,608	1,000	355	6 %
	Multi-Family Residential	483	2,500	165	34 %
	Other	764	2,500	43	1 %
	Subtotal	**6,855**	-	**563**	**8 %**
Commercial	Commercial	1,775	3,000	823	46 %
	Residential/ Commercial	47	3,000	42	89 %
	Subtotal	**1,822**	-	**865**	**47 %**
Industrial		830	4,000	492	59 %
Institutional		762	5,000	621	81 %
Total		**10,269**	-	**2,541**	**25 %**

Twenty-five (25) percent of the fire hydrants tested on the East Bank did not meet the performance criteria of 20 psi during fire flow demand. Eighteen (18) percent of the fire hydrants tested on the West Bank did not meet the performance criteria of 20 psi during fire flow demand. The majority of the hydrants that do not meet the minimum pressure criteria are located in non-residential areas for both the East and West Bank systems.

Additional supporting information is provided for each hydrant not meeting the performance criteria in **Appendix F,** which includes a summary of the available flow at each hydrant at a minimum pressure of 20 psi.

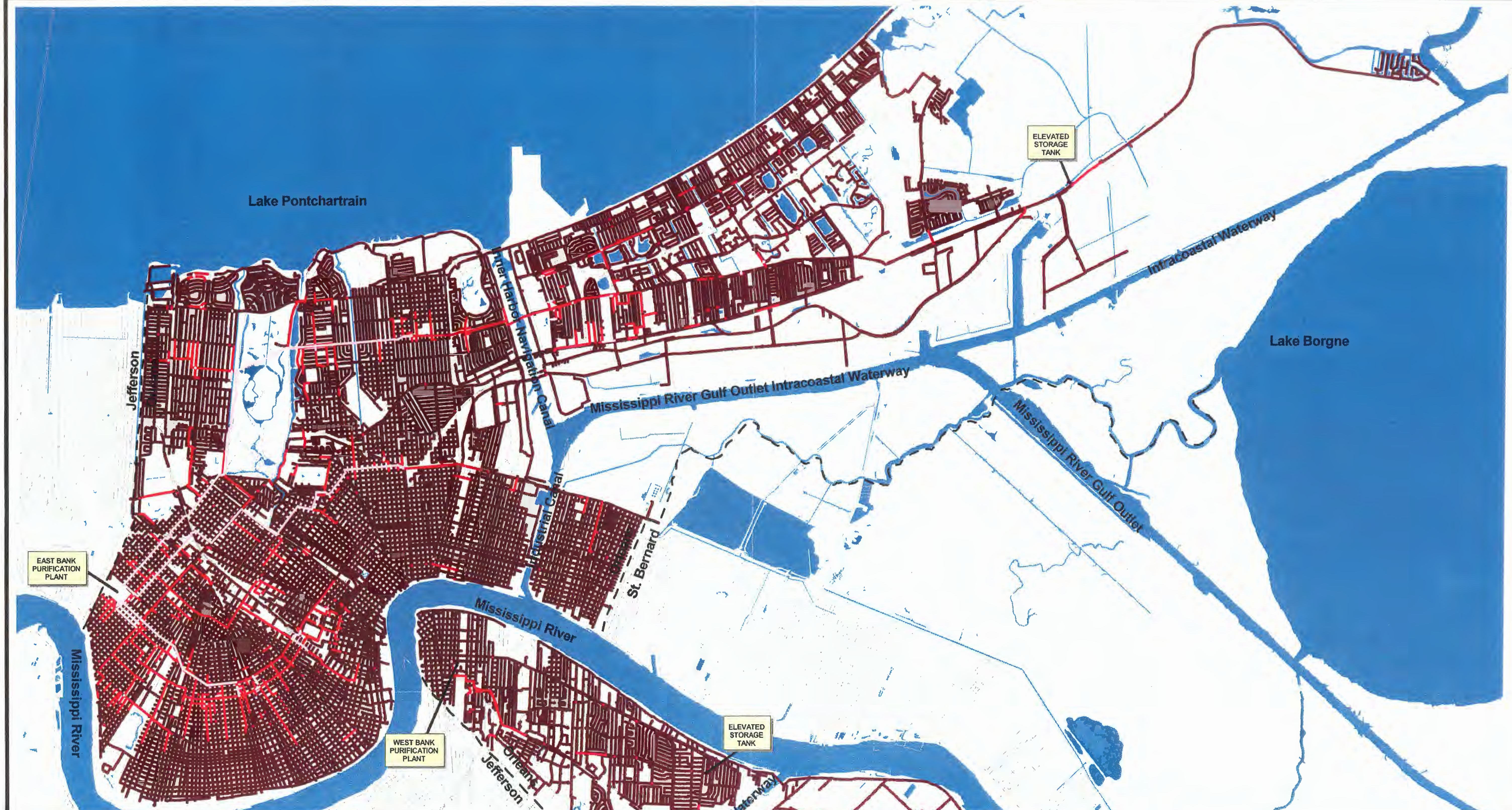
Table 7-4
Pressure Analysis during Fire Flow Demand
West Bank

Landuse Zone		Number of Fire Hydrants	Flow Criteria (gpm)	Number of Hydrants Below 20 psi	Percent of Total (%)
Residential	Single-Family Residential	1,327	1,000	52	4 %
	Multi-Family Residential	226	2,500	70	31 %
	Other	142	2,500	5	4 %
	Subtotal	**1,695**	-	**127**	**7 %**
Commercial	Commercial	147	3,000	54	37 %
	Residential/ Commercial	124	3,000	75	60 %
	Subtotal	**271**	-	**129**	**48 %**
Industrial		37	4,000	36	97 %
Institutional		115	5,000	96	83 %
Total		**2,118**	-	**388**	**18 %**

As previously stated, the system analysis will change as the hydraulic model is refined with updates from the recommended structural improvements. Those fire hydrants that are currently not capable of providing the required pressure during fire flow demand are recommended for continued evaluation after the model refinement.

7.1.4 Pipe Velocity

The systems were evaluated for the established velocity criteria for all pipe segments. **Table 7-5** on the following page presents the velocity criteria, the total number of pipes that fall below the minimum velocity, and the number of pipes that exceed the maximum velocity. **Figures 7-6** and **7-7** show the pipe segments on the East Bank not meeting minimum and those exceeding maximum velocity, respectively. **Figures 7-8** and **7-9** show the pipe segments on the West Bank not meeting minimum and those exceeding maximum velocity, respectively.



Legend

N

Not to scale

Velocity (fps)

- <= 1.0
- 1.1 - 2.4
- >= 2.5

- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Performance Criteria
Velocity Less Than 2.5 fps
East Bank

Figure 7-6

Location
By Council District

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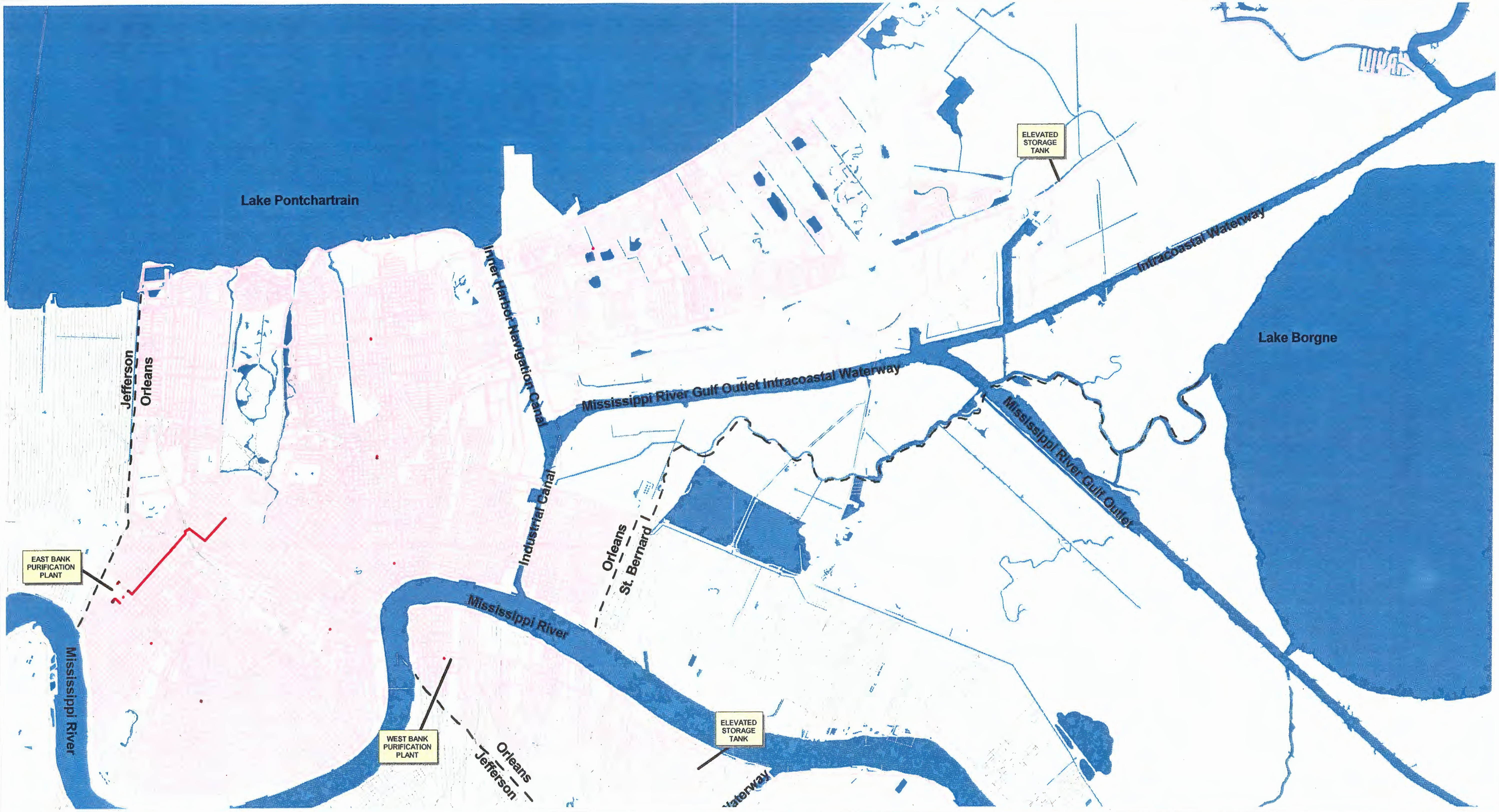

Legend

N

Not to scale

Velocity (fps)

- >= 10
- 6 - 9
- <= 5

- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Performance Criteria
Velocity Greater Than 5 fps
East Bank

Figure 7-7

Location
By Council District

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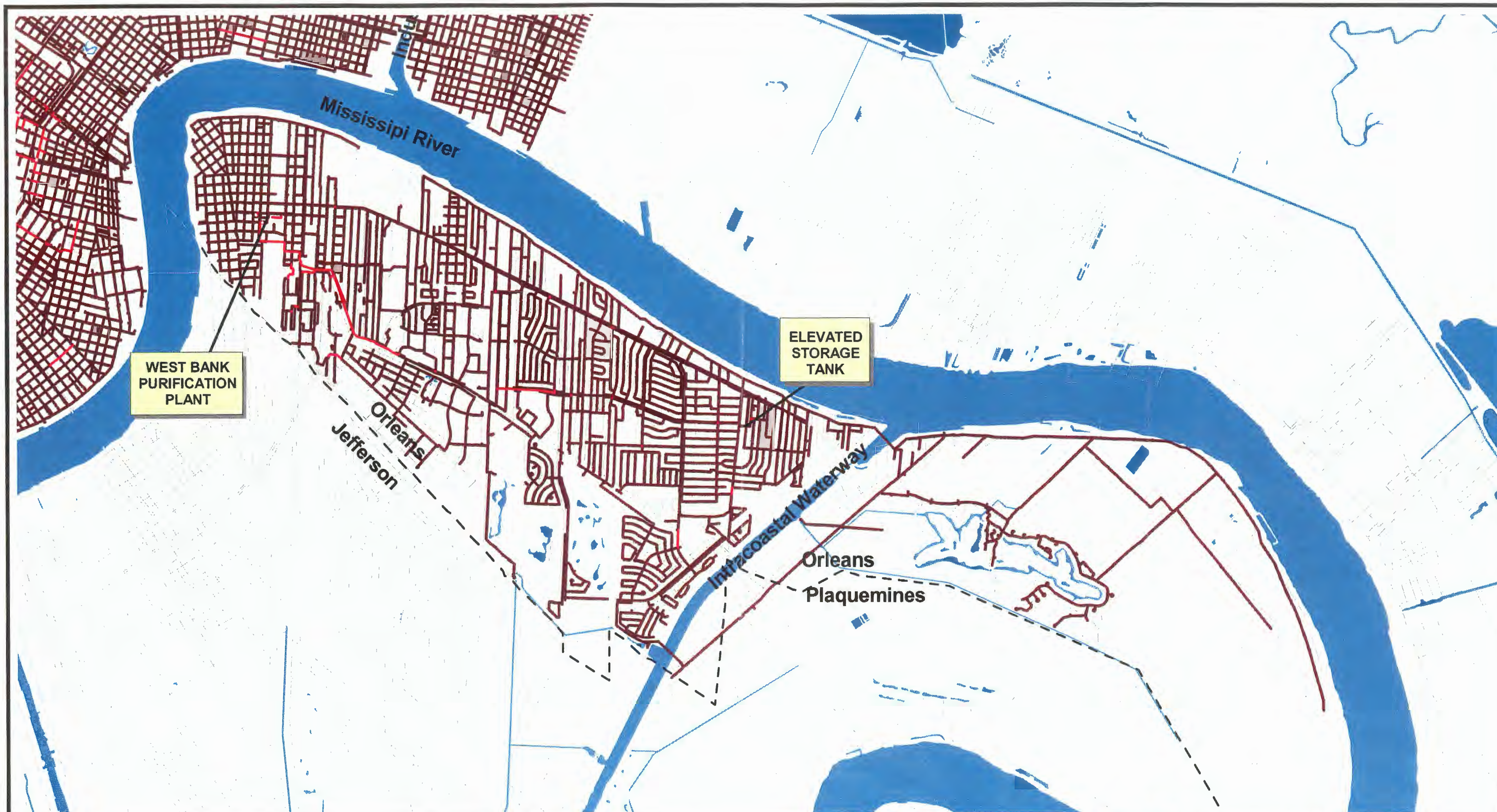

Legend

N

Not to scale

Velocity (fps)

- <= 1.0
- 1.1 - 2.4
- >= 2.5

- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Performance Criteria
Velocity Less Than 2.5 fps
West Bank

Figure 7-8

Location
By Council District

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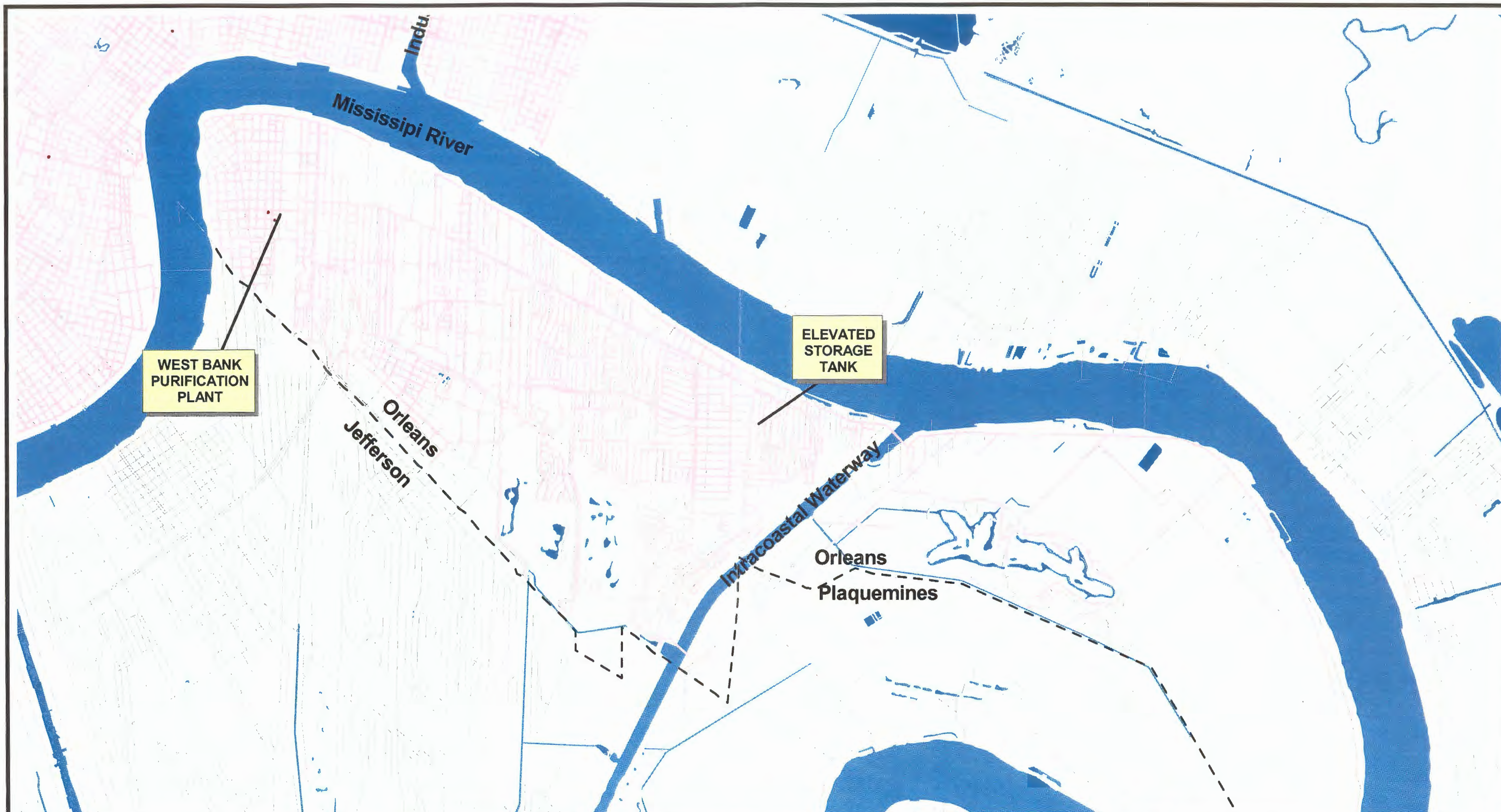

Legend

N

Not to scale

Velocity (fps)

- >= 10
- 6 - 9
- <= 5

- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Performance Criteria
Velocity Greater Than 5 fps
West Bank

Figure 7-9

Location
By Council District

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Table 7-5
Velocity Analysis during Maximum Day Conditions

Velocity Criteria (fps)	East Bank		West Bank	
	Number of Pipes	Percent of Total (%)	Number of Pipes	Percent of Total (%)
≤2.5	17,124	99	2624	99
> 5.0	33	< 1	3	< 1
Total	**17,303**	**100**	**2,627**	**100**

In both systems, the velocity exceeds the maximum in less than one percent of the pipe segments (by number). This typically occurs immediately downstream of the purification plants. Of the pipes that exceed maximum velocity, the highest projected velocities on the East and West Bank are 17 fps and 8 fps, respectively. In both systems, the projected velocity in essentially all pipe segments falls below the minimum recommended velocity for flushing. As discussed in **Section 6**, however, there are no regulations governing velocity of flow in pipes and the velocity criteria is provided by way of recommendation rather than requirement.

As previously stated, with the implementation of the recommended structural improvements and the associated hydraulic model refinement, the system analysis will change. Those pipe segments that do not currently fall within the recommended minimum and maximum velocities are recommended for continued evaluation after the model refinement.

7.1.5 Pipe Headloss

Pipe headloss was evaluated in all pipe segments and categorized by those pipes less than 16 inches in diameter and pipes greater than or equal to 16 inches in diameter. **Table 7-6** presents the headloss criteria and the total number of pipes that exceeds maximum headloss.

Table 7-6
Headloss Analysis during Maximum Day Conditions

Pipe Diameter Category (Inches)	Headloss Criteria (Liner Foot/ 1,000 feet)	East Bank		West Bank	
		Number of Pipes	Percent of Pipe Category (%)	Number of Pipes	Percent of Pipe Category (%)
< 16	> 10	97	< 1	8	< 1
≥16	> 3	46	3	1	< 1

In both systems, the headloss in the majority of pipe segments falls below the maximum recommended headloss. In the East Bank system, the headloss exceeds the maximum in less than three (3) percent of the pipe segments. Of the pipes that exceed the maximum criteria, the highest headloss is approximately 50 linear feet per 1,000 feet.

Figures 7-10 and **7-11** show the headloss for pipes on the East Bank for smaller pipes (less than and equal to 16 inches in diameter) and larger pipes (exceeding 16 inches in diameter), respectively. **Figures 7-12** and **7-13** show the headloss for pipes on the West Bank for smaller pipes and pipes exceeding 16 inches in diameter, respectively. Smaller pipes exceeding the maximum headloss are typically short pipe segments. Larger pipes exceeding maximum headloss are typically closer to the purification plants.

Although no action is recommended at this time with respect to pipe headloss results, this criteria should be further refined and re-evaluated during the implementation of the replacement and leakage program.

7.1.6 System Reliability

The system reliability analysis included the evaluation of performance criteria for the pipe network reliability, pumping capacity, and pumping reliability.

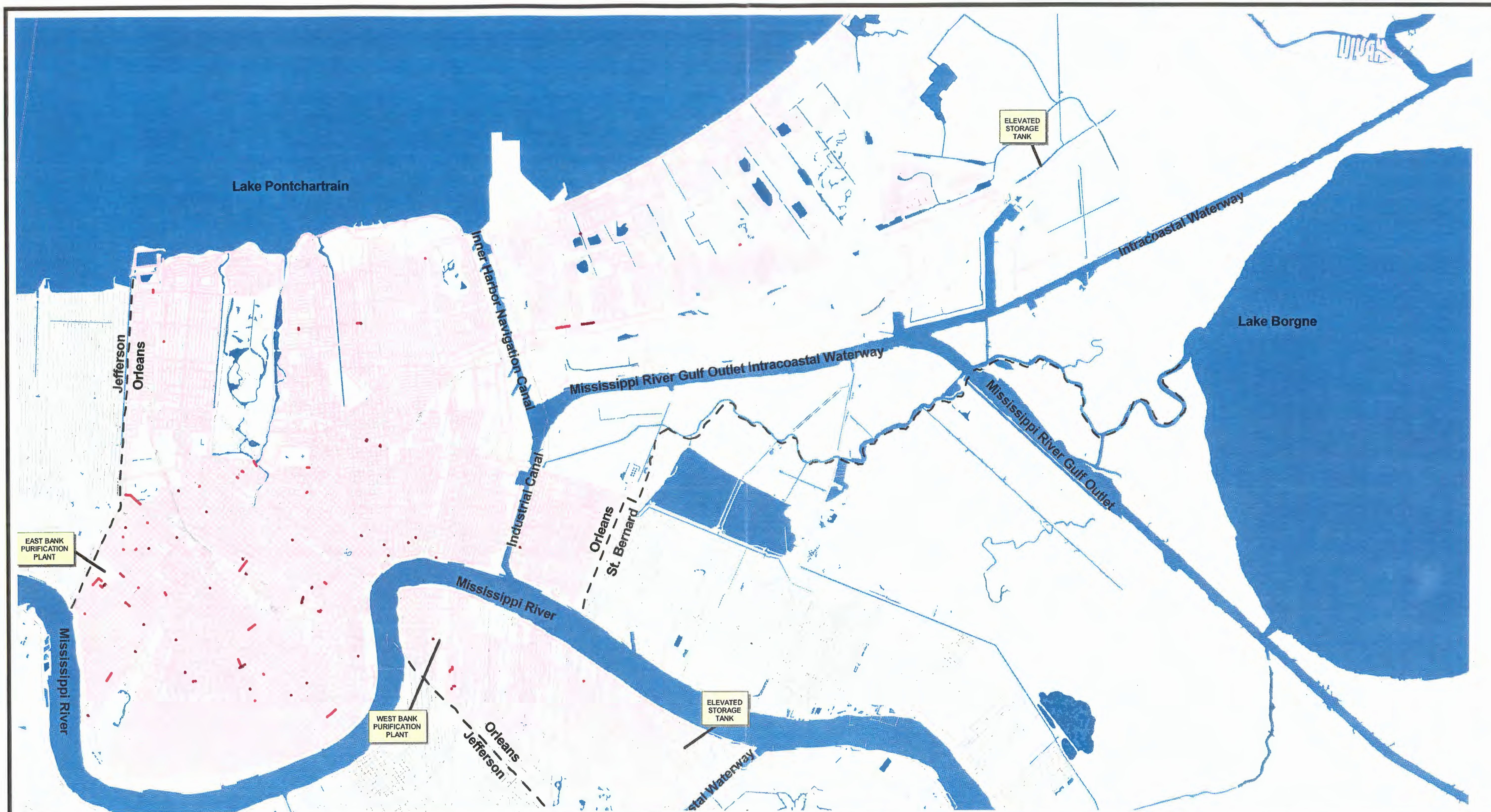
7.1.6.1 Pipe Network Reliability

Pipe network reliability includes distribution and transmission criteria to identify areas within the system that have dead-ends and are hydraulically isolated. Pipe reliability also includes valve and hydrant spacing criteria.

Areas within the distribution systems identified as having dead-ends or are hydraulically isolated are summarized in **Appendix F**. Location maps are included for each area identified.

The majority of the East and West Bank systems are sufficiently looped, providing two sources of water distribution for most areas. Areas identified with network deficiencies include Venetian Isles on the East Bank and English Turn on the West Bank. Venetian Isles has one 12-inch distribution line over five miles in length. This area is considered to be hydraulically isolated. English Turn is on the opposite side of the Intracoastal Waterway from the Algiers Plant, with two 12-inch water mains crossing under the waterway. Although this area has two sources of water distribution, it is reported that the water mains require frequent repairs from breaks due to waterway traffic.

Currently, the isolated areas of Venetian Isles and English Turn have sufficient sources for water distribution. If additional development projects are proposed or the water demand increases in these areas, the distribution networks should be further evaluated to determine if additional water mains are required to improve the system reliability.



Legend

Head Loss (ft/1000 ft)

- >= 21
- 10 - 20
- <= 10

- Parish Boundary
- Street
- Water Body

N

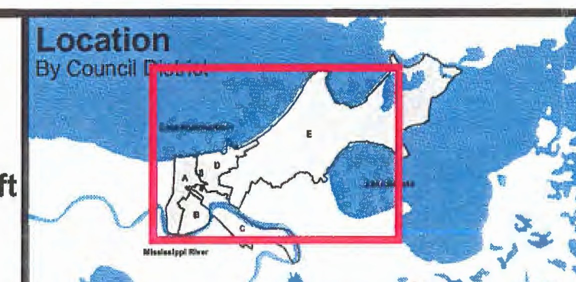
Not to scale

Water Distribution System
Assessment and Hydraulic Model

Performance Criteria
Smaller Pipes & Headloss Greater Than 10ft/1000ft
East Bank

Figure 7-10

Location
By Council District



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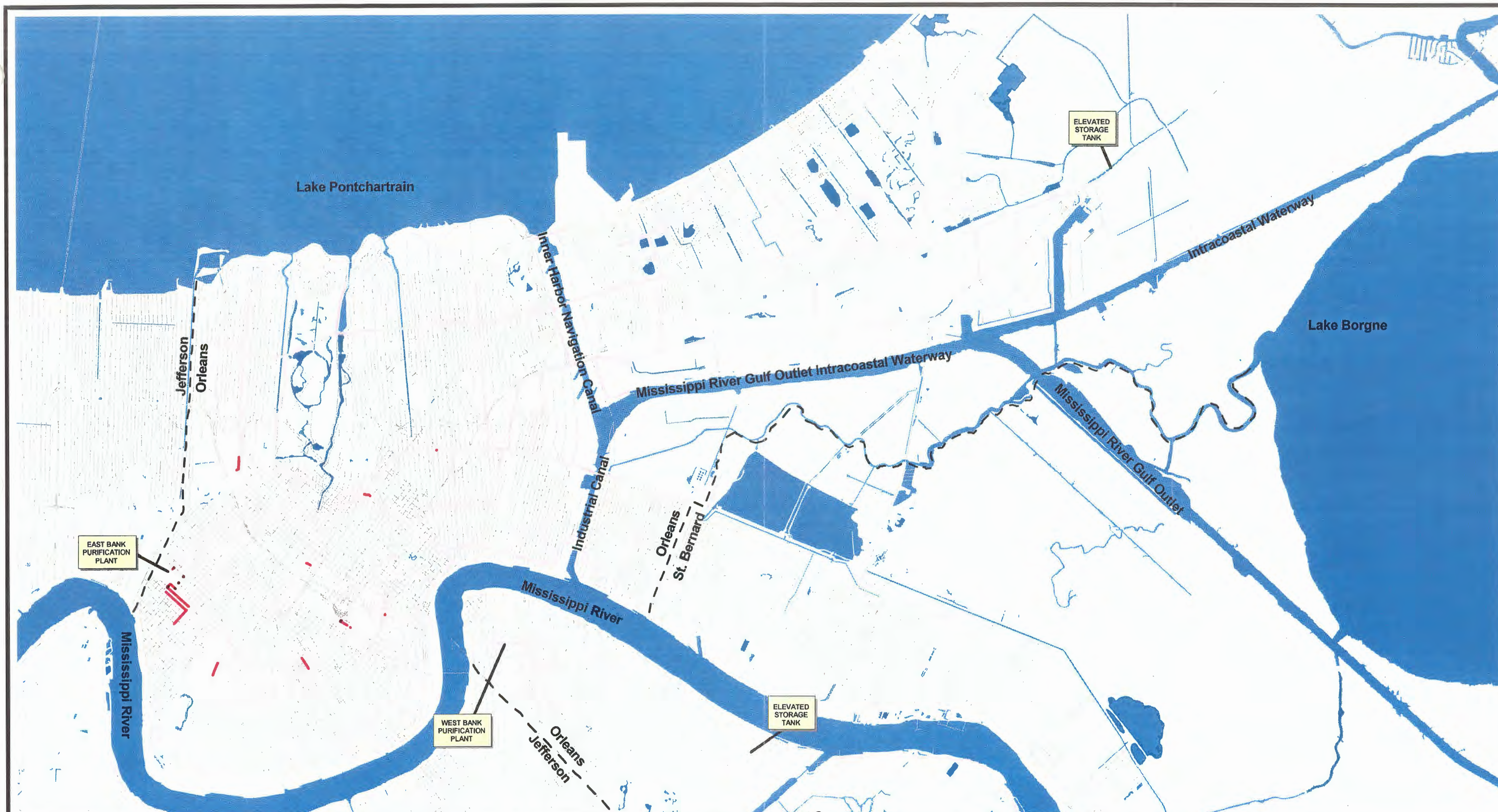

Legend

N

Not to scale

Head Loss (ft/1000 ft)

- >= 11
- 4 - 10
- <= 3

- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Performance Criteria
Larger Pipes & Headloss Greater Than 3ft/1000ft
East Bank

Figure 7-11

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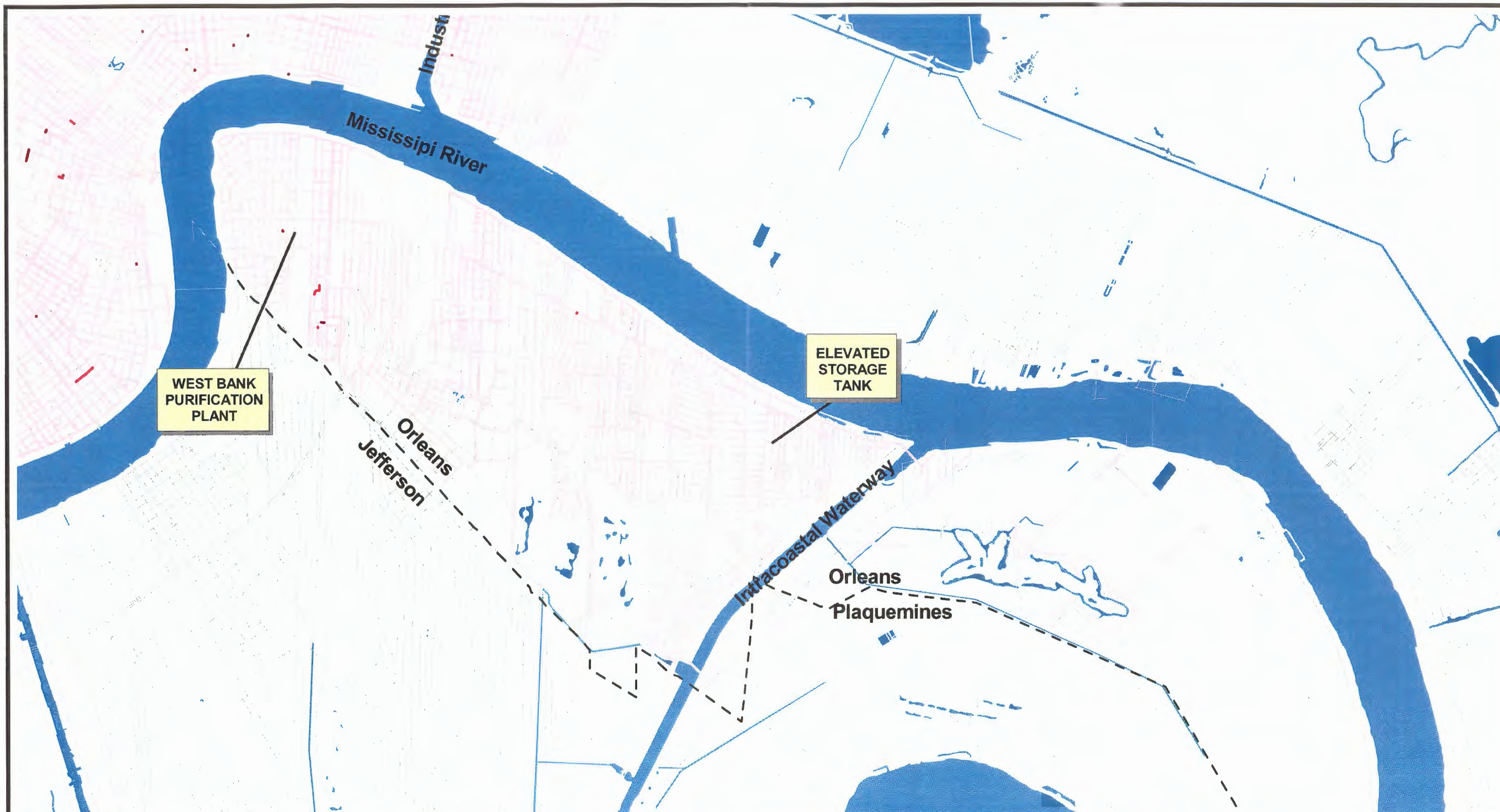


Legend

N

Not to scale

Head Loss (ft/1000 ft)

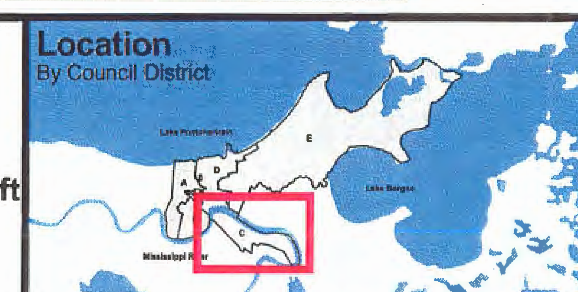
- >= 21
- 10 - 20
- <= 10

- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Performance Criteria
Smaller Pipes & Headloss Greater Than 10ft/1000ft
West Bank

Figure 7-12



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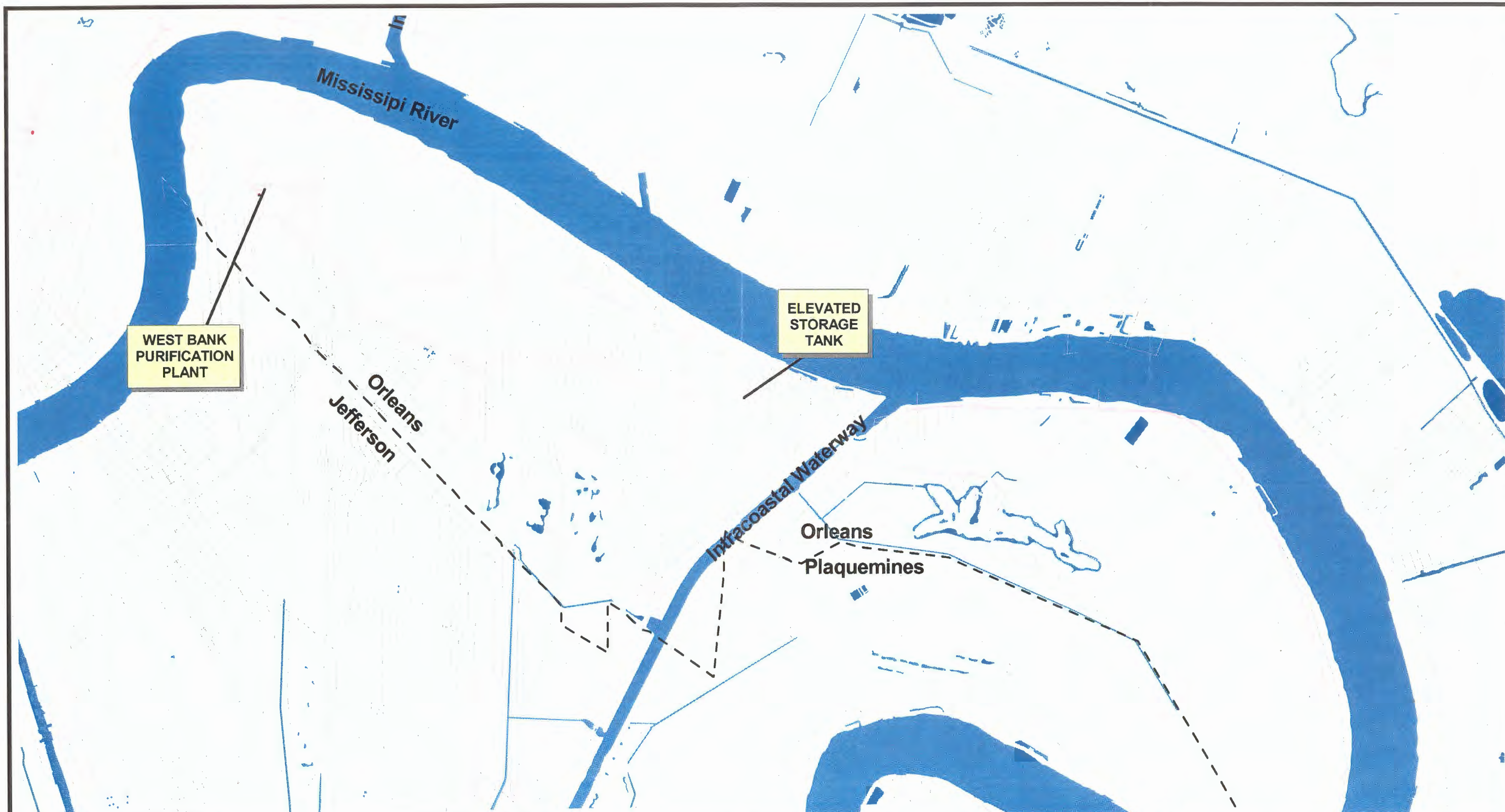

Legend

N

Not to scale

Head Loss (ft/1000 ft)

- >= 11
- 4 - 10
- <= 3

- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Performance Criteria
Larger Pipes & Headloss Greater Than 3 ft/1000 ft
West Bank

Figure 7-13

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

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Fire hydrants and valves in the distribution system were evaluated for maximum spacing criteria of 350 feet and 1,000 feet, respectively. The spacing between fire hydrants was measured by the linear distance over land. The maximum distance for fire hydrants is defined to provide an accessible water source within a range of potential fire hazards at ground level; this is measured more accurately by the distance over land. In contrast, the spacing between valves was determined by the linear distance along water mains. A maximum distance for valve spacing is defined to assist with the operations and maintenance of the pipe network; this is measured more accurately by the distance along water mains.

A listing of hydrants and valves not meeting the criteria are provided in **Appendix F**. Approximately 60 percent of the fire hydrants on both the East and West Banks do not meet the maximum spacing criteria of up to 350 feet. In comparison, approximately 80 percent of the hydrants for both systems are spaced up to 700 feet.

Approximately 24 percent and 28 percent of the valves on the East and West Bank, respectively, do not meet the maximum spacing criteria of up to 1,000 feet. In comparison, approximately four percent and six percent of the valves on the East and West Bank, respectively, are spaced at over of 2,000 feet.

With respect to the existing system layout, network reliability can be improved with the addition of new valves and hydrants. The recommendations for pipe replacements resulting from the structural analysis include installation of new valves and hydrants to meet the maximum spacing criteria.

7.1.6.2 Pump Capacity and Reliability

The pumping capacity was evaluated to determine if the required flow could be supplied with the existing pumps. The required flow is the greater of either peak hourly flow or the average of MDD plus fire flow. Based on a preliminary evaluation, both the East and West Bank pumping stations have the capacity to deliver the maximum criteria. Each of the stations has a minimum of two pumps, which meets the pumping reliability criteria for firm capacity. The East and West Bank pumping stations are sufficiently interconnected and have the capability of distributing water to each of the main transmission lines leaving the treatment plants.

The pumping reliability was also evaluated in terms of power sources. The S&WB purchases power from Entergy and the S&WB also generates and supplies power from their power plant on the East Bank. Entergy and the S&WB power plant supply power to both purification plants and each plant also has an emergency generator on site. The S&WB power plant supplies power to the West Bank via power lines that run under the Mississippi River. Although each treatment plant has dual power sources, one pump station does not have a second power source: A&B Pump Station on the East Bank.

As mentioned previously, the East and West Bank pumping stations were assessed to have adequate capacity and power sources to supply the existing water demand. The water demand and required capacity should be further evaluated as recommended structural improvements are made to the system. Regarding A&B Pump Station, which does not have dual power sources, adequate capacity is available from the other pumping stations to supply water demand when this station is not in operation.

The water purification plant pumping stations along with the treatment units are recommended for evaluation to better account for the capacity and actual flow. During the system evaluation of the Water Master Plan, the availability of the operations data from the water purification plants and distribution systems was limited. It is, therefore, recommended that the data collection and reporting procedures be evaluated.

7.1.7 Storage Capacity

The S&WB has ground-level storage tanks for both the East and West Bank systems that were evaluated for capacity. The operational storage requirement is defined as 20 percent of MDD. The fire flow storage is defined as the volume of water required for an institutional fire demand of 5,000 gpm over a duration of four hours. Typically MDD conditions are used to define emergency storage. The Vulnerability Assessment conducted in 2002 identified no emergency storage requirements for the S&WB.

Table 7-7 details the existing storage volume and compares to the recommended storage volume as outlined by the performance criteria.

Table 7-7
Storage Capacity with Existing Demands

Description/Criteria	East Bank	West Bank
Demand		
ADD – Metered Consumption (MGD)	61.2	5.6
MDD – Metered Consumption (MGD)	87.4	11.5
Fire Flow Required (gpm)	5,000	5,000
Fire Flow Duration (hours)	4	4
Operational Storage – 20% of ADD (MG)	12.2	1.1
Fire Storage (MG)	1.2	1.2
Emergency Storage – MDD (MGD)	87.4	11.5
Total Volume Required (MG)	*100.8*	*13.8*
Existing Storage		
Ground-Level Storage Tanks (MG)	37	10
Required Storage for Backwash (MGD)	1.2	0.5
Total Storage Available (MG)	*35.8*	*9.5*
Storage Deficiency (MG)	**65**	**4.3**

Note:
Storage does not include elevated storage tanks

For the purpose of this report and in order to develop a preliminary estimate of additional storage requirements, the emergency storage was defined as MDD in addition to that volume needed for operational and fire flow. The total available storage capacity for the East and West Banks is approximately 35 and 70 percent of the recommended storage, respectively.

It is recommended that the ground-level storage tanks be evaluated further as a part of a Water Audit study. The Water Audit should include a detailed assessment of the hydraulic conditions of all storage facilities and future storage requirements.

7.2 STRUCTURAL ANALYSIS

The primary objective of the structural analysis is to provide guidelines for the rehabilitation and replacement of water mains. The structural analysis was conducted utilizing KANEW computer software as a macro model and a prioritization process as a micro model. The KANEW model predicts the length of different categories of pipes that should be rehabilitated or replaced annually based on the inventory of water mains and estimated life expectancy.

The KANEW macro model does not provide recommendations for rehabilitation and replacement of specific water mains. The KANEW model is recommended by the AwwaRF project, which developed the analysis, to establish procedures for prioritizing water main replacement. The micro model was conducted to supplement the KANEW analysis with prioritization recommendations. The prioritization analysis considers the physical condition of the pipe, the historical performance (breaks and leaks), and the ability of the system to meet the service level criteria discussed in **Section 6**.

7.2.1 KANEW Analysis

The KANEW analysis was conducted based on water main characteristics including age, diameter, material, length, and life expectancy. Survival functions were calculated for each water main category described in **Section 6**. The survival function is a mathematical expression that represents the aging process of a water main and indicates the percentage of water mains that will survive beyond a given age as well as the remaining years of service. The survival functions are estimated on the basis of aging behavior, failure, and rehabilitation and replacement rates of pipe categories.

The cast iron pipes are typically older pipes, 43 to 97 years old, and are near the end of their survival function. Cast iron pipes have a residual life (remaining years of service) ranging from 9 to 38 years, based on short and long life expectancies. The ductile iron pipes are typically newer pipes, 19 to 24 years old, and have the longest residual life (41 to 67 years). The age of PVC pipes range from 17 to 22 years; however, they have a shorter residual life (21 to 37 years) due to the shorter life expectancy of PVC pipe.

Based on the survival functions for short and long life expectancies, the KANEW model simulates the aging process to determine the length of pipe that has reached the end of its useful life for each water main category. **Tables 7-8** and **7-9** on the following pages show the length recommended for replacement of cast iron and other pipe material categories, respectively, based on long life expectancy. Additional information for the length of water main replacement based on short life expectancy is included in **Appendix G.**

As shown in **Table 7-8**, the cast iron water main category requiring the most replacement was installed prior to 1920 ranging in diameter from 4 to 12 inches. Over 40 miles of this cast iron pipe category is recommended for replacement within the first year of structural rehabilitation.

Table 7-8
Water Main Replacement Length
Cast Iron Categories

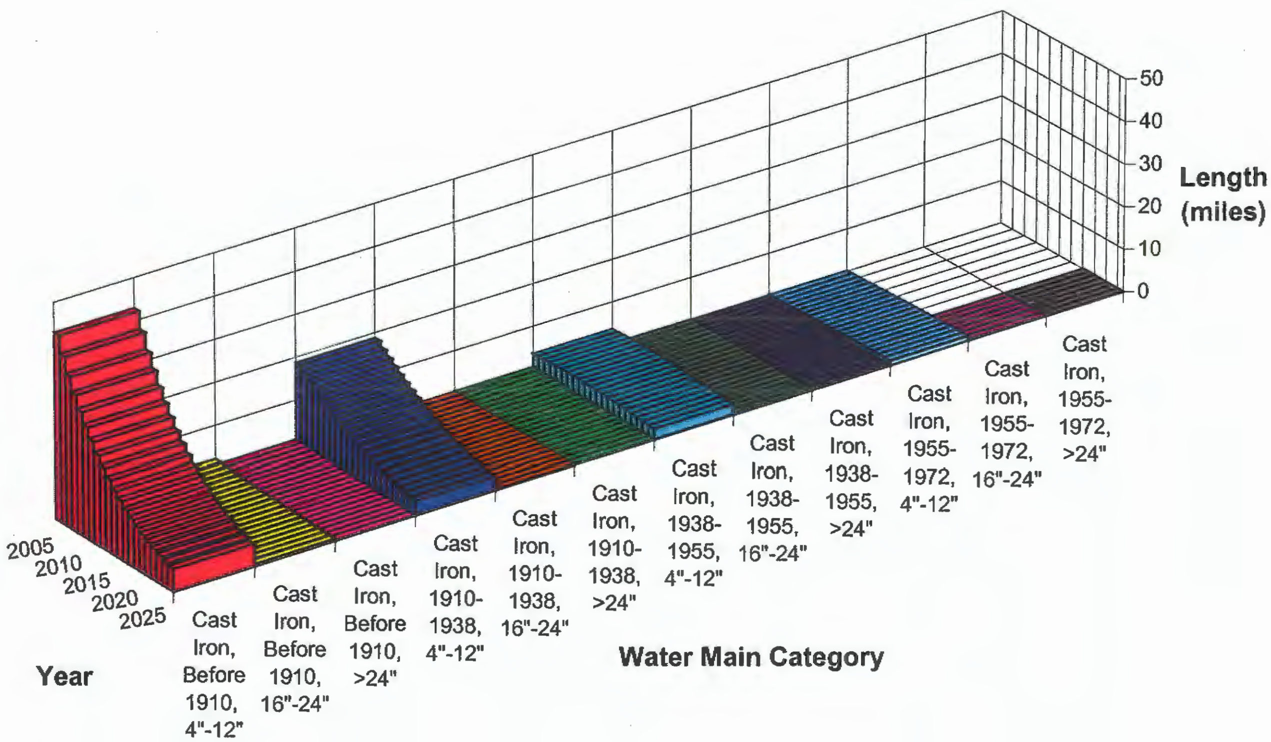
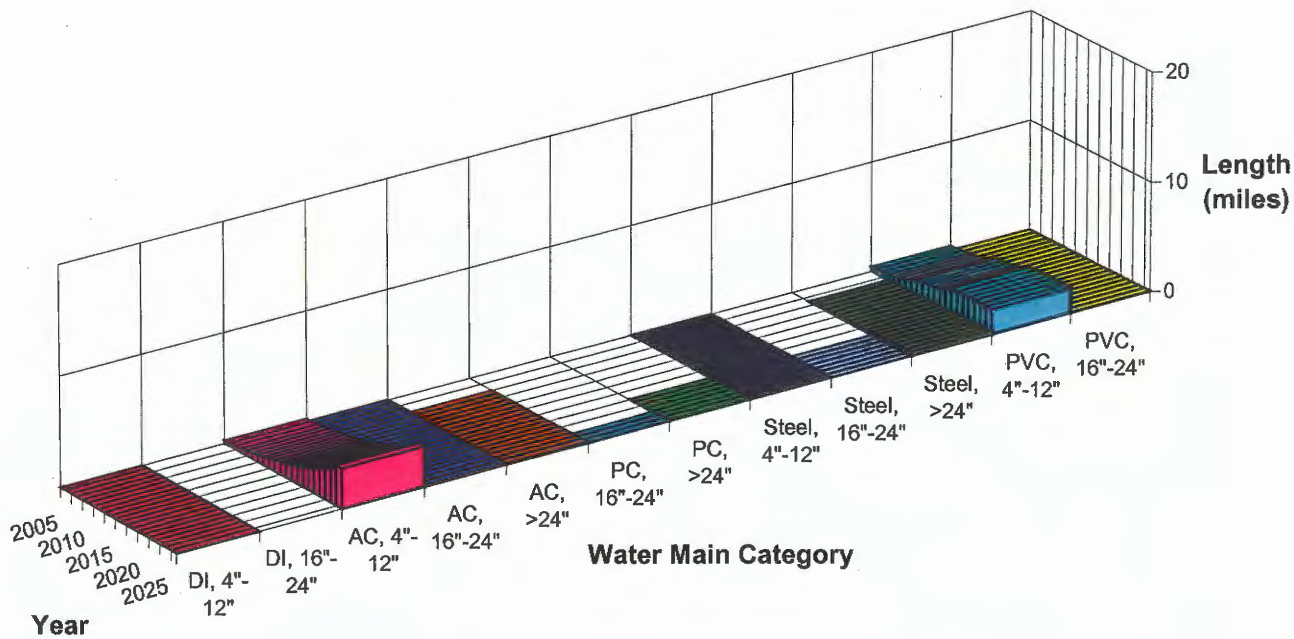


Table 7-9 shows the remaining water main categories (mixed material categories) other than cast iron. Less than 5 miles of each mixed material pipe category is recommended for replacement on an annual basis.

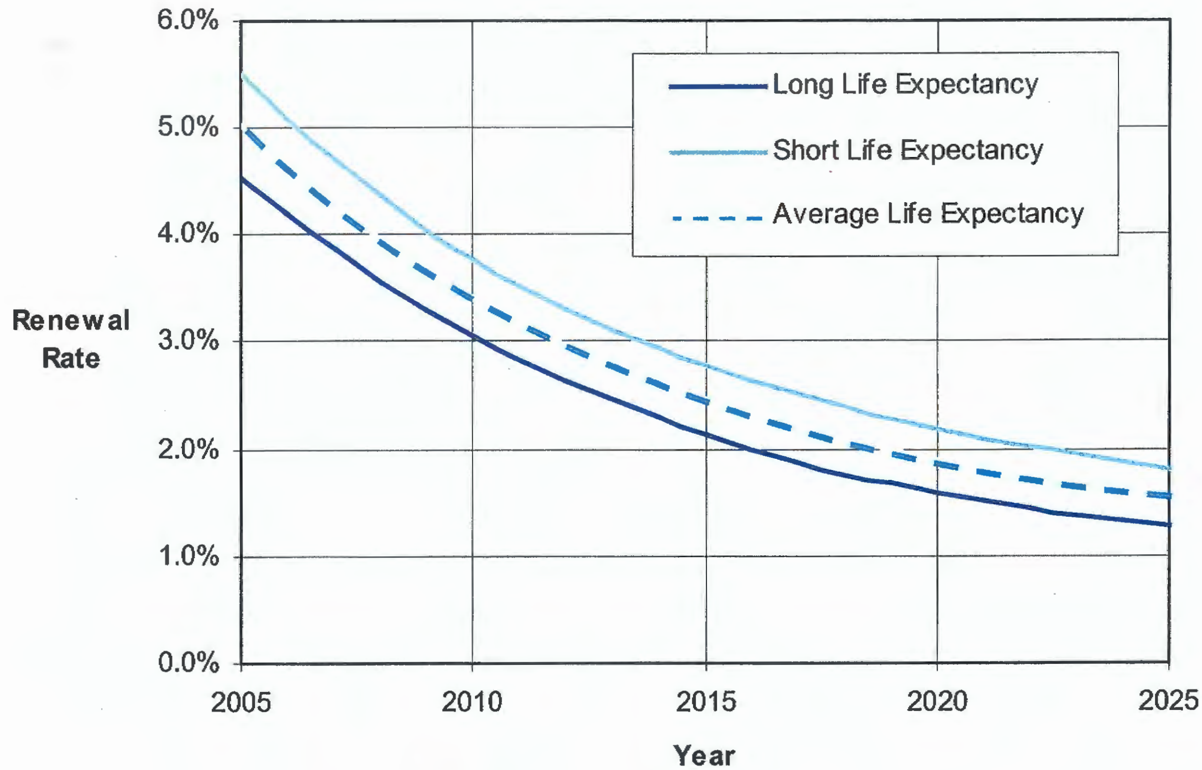
Table 7-9
Water Main Replacement Length
Mixed Material Categories



Note:
DI = Ductile iron; AC = Asbestos Cement; PC = Prestressed concrete

The water main replacement rates, based on each water main category, were compiled to determine the overall renewal rate for the entire system. Renewal rates were developed for long life expectancy, short life expectancy, and average life expectancy. The average life expectancy was derived from the long and short life expectancies. **Figure 7-14** shows the annual water main renewal rates for the entire system calculated by the KANEW analysis.

Figure 7-14
Annual Water Main Renewal Rates



The recommendations of the water main replacement analysis are based on the average life expectancy renewal rate. **Table 7-10** on the following page summarizes the recommendations for renewal rate and length of water main replacement on an annual basis. A total of 891 miles, approximately 58 percent of the system, is recommended for replacement over the 20-year planning period.

Table 7-10
Recommended Water Main Renewal Rate

Year	Annual Renewal Rate (%)	Total Length (miles)
2005	5.0%	77
2006	4.6%	71
2007	4.3%	66
2008	4.0%	61
2009	3.7%	57
2010	3.4%	53
2011	3.2%	49
2012	3.0%	46
2013	2.8%	43
2014	2.6%	40
2015	2.5%	38
2016	2.3%	36
2017	2.2%	34
2018	2.1%	32
2019	2.0%	31
2020	1.9%	29
2021	1.8%	28
2022	1.7%	27
2023	1.7%	26
2024	1.6%	25
2025	1.5%	24
Total	**57.8%**	**891**

Results and findings of the KANEW analysis are summarized below.

1. The S&WB water distribution system is old; approximately 42 percent of the water mains were installed prior to 1930.
2. The recommended replacement rate in the first five (5) years of the planning period (2005 to 2010) is an average of 66 miles, or four (4) percent of the system annually.
3. The average replacement rate over the remainder of the planning period (2010 to 2025) is approximately 35 miles, or two (2) percent of the system annually.
4. The oldest cast iron water mains have the highest initial replacement rate of approximately 10 percent annually.

The water main replacement analysis for the water system provides the annual replacement rates for each water main category based on long ("optimistic") and short ("pessimistic") life expectancies, age of water mains, and material of the water mains.

7.2.2 Rehabilitation and Replacement Prioritization

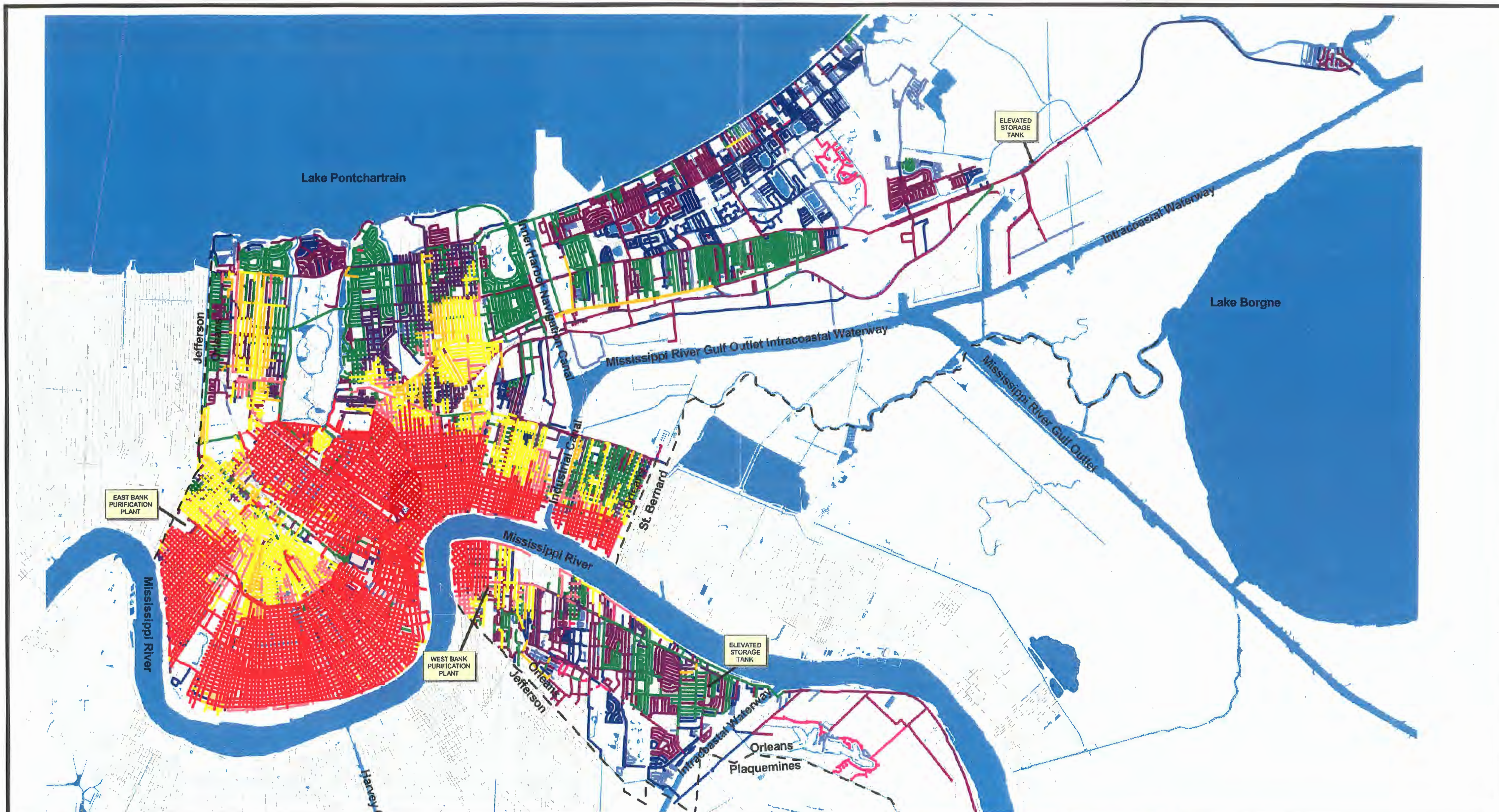
The methodology used to prioritize the water mains recommended for rehabilitation and replacement was based on assigning a priority action number (PAN) to each water main. The results of the water main prioritization analysis provide information on the order in which water mains should be replaced or rehabilitated based on performance criteria. Water main characteristics including age, history of breaks and leaks, material, customer impact, and location were used to conduct the prioritization analysis. **Figures 7-15** through **7-17** show the water main characteristics used for the prioritization analysis for water main age, location of breaks and leaks, and the location of large water users, respectively. The service level criterion of customer impact was analyzed based on the large water users. The large water users, shown in **Figure 7-17**, include the top 50 water users according to the S&WB billing records, water users with fire protective systems, and users with a service connection larger than (4) four inches in diameter.

Table 7-11 shows the parameters and characteristics for the prioritization analysis of a sample water main. The sample water main (ID 161364) is located on the East Bank and is a 12-inch diameter cast iron pipe, approximately 130 feet in length.

Table 7-11
Sample Water Main Characteristics

Parameter	Value
Water Main ID	161364
Distribution System	East Bank
Installation Year	1909
Diameter	12 inches
Material	Cast iron
Length	130 feet
Leaks and Breaks (date)	07/29/1999
Critical Customers	Fire service and service 4 inches or larger
Location of Water Main	French Quarter

Each water main was evaluated according to the service level criteria described in **Section 6**. Based on the ability of the water main to meet each service criterion, a PAN was assigned to that criterion. A weighting factor was applied to each criterion and an overall PAN for each water main was derived by summing the individual PANs for weighted criteria. The water main segment with the highest PAN signifies a higher priority for rehabilitation or replacement. A sample PAN calculation for a water main is shown in **Table 7-12**. The overall PAN for this water main is 179 and the criterion with the most influence is the age of the pipe.



Legend

N

Not to scale

Water Main By Age

- 1900s
- 1910s
- 1920s
- 1930s
- 1940s
- 1950s
- 1960s
- 1970s
- 1980s
- 1990s

- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Water Main Age

Figure 7-15

Location
By Council District

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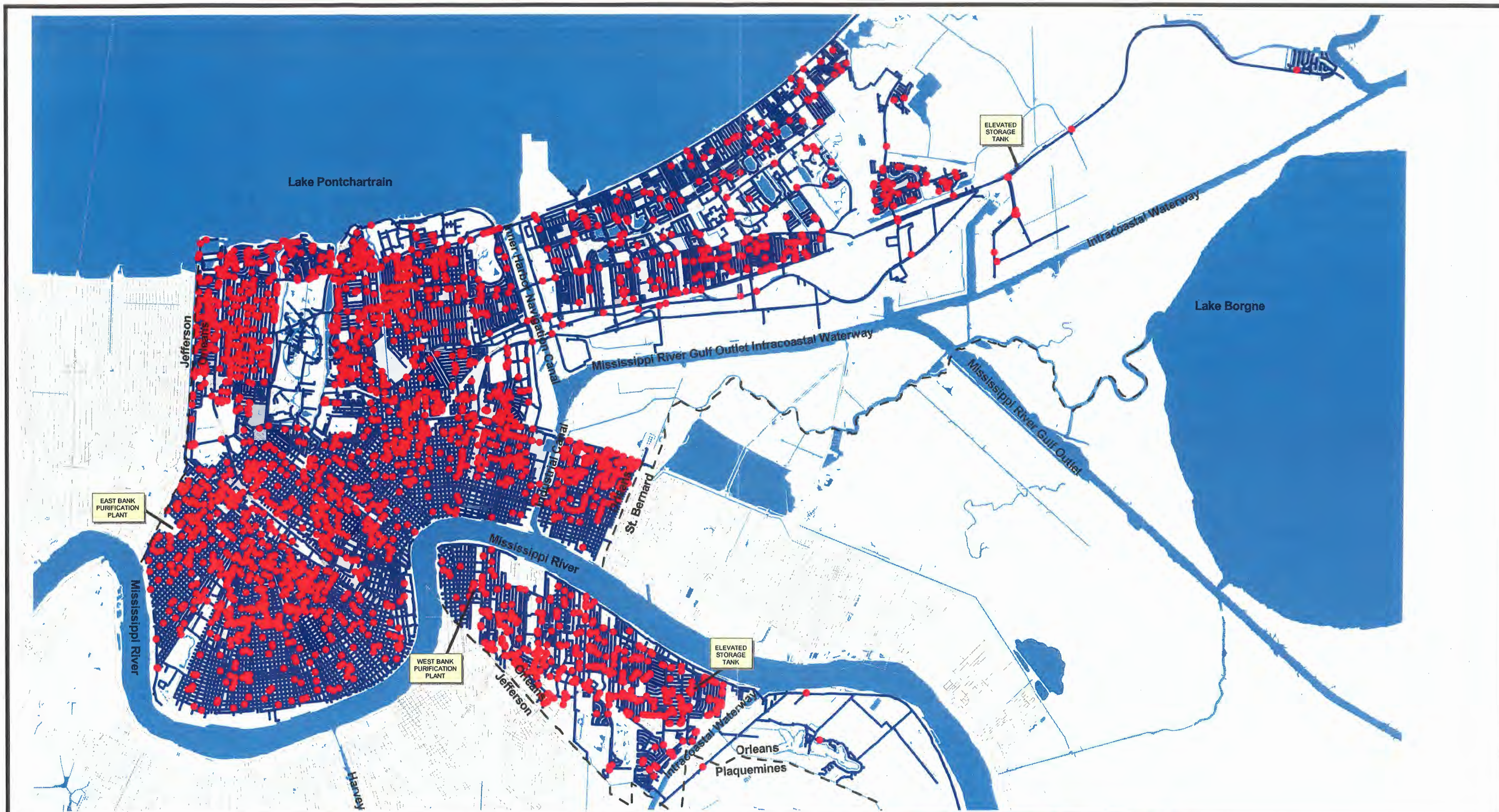

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Not to scale

Location of Leaks & Breaks

- Leaks & Breaks
- Water Main
- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Location of Leaks and Breaks

Figure 7-16

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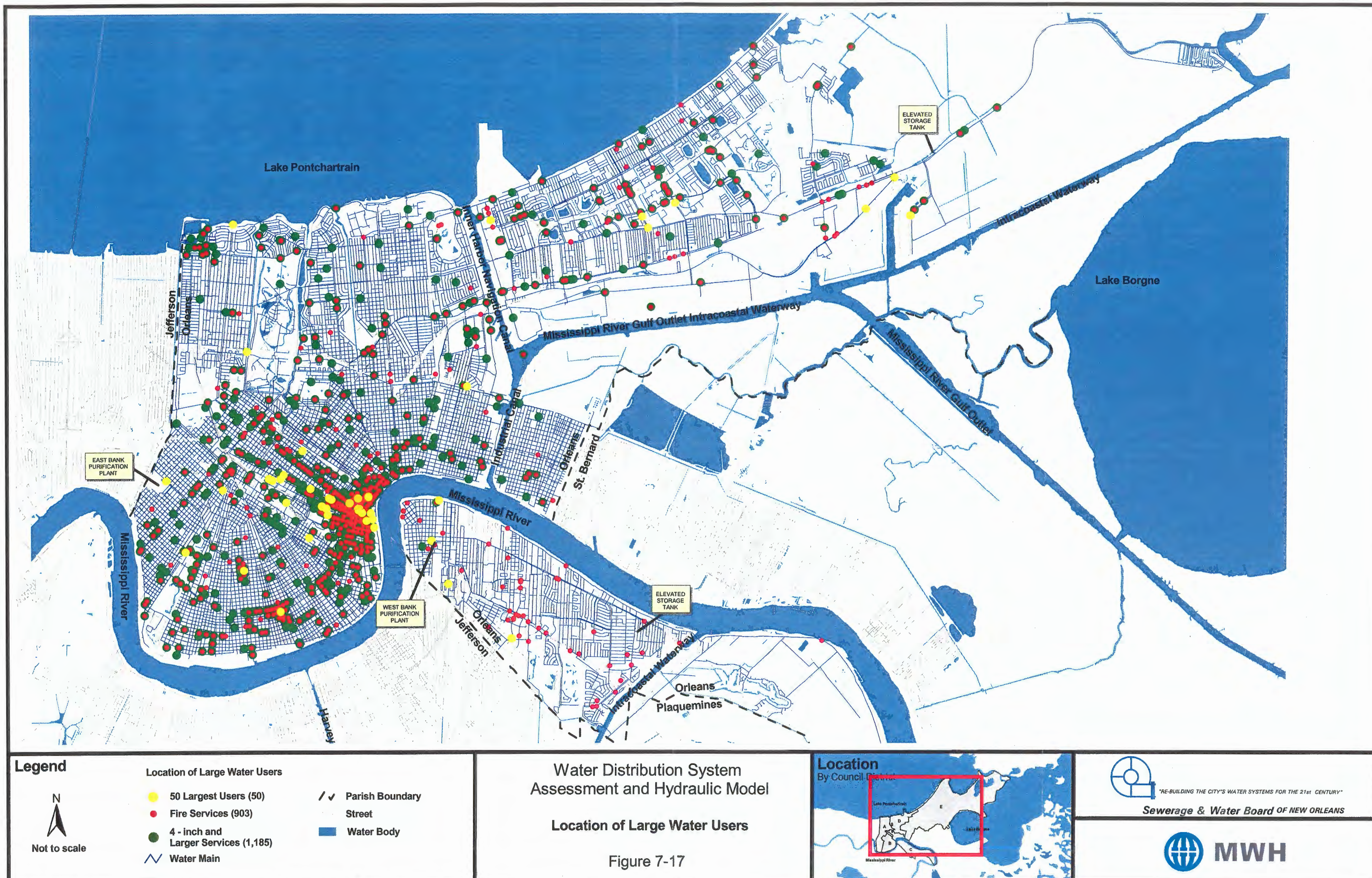


Water Distribution System Assessment and Hydraulic Model

Location of Large Water Users

Figure 7-17

Table 7-12
Sample PAN Calculation

Service Level Criteria	Individual PAN Calculations			Weighting Factor	PAN
Water Main Age	Exceeds useful life by 48%	=	243	0.3	72.9
Water Main Breaks and Leaks	0.62 breaks/1,000 ft/year	=	100	0.4	40
Water Main Material	Cast iron before 1910	=	80	0.2	16
Location of Water Main	French Quarter	=	100	0.2	20
Customer Impact	Critical customer	=	100	0.3	30
Final PAN					**178.9**

After each water main was assigned a PAN, the water mains recommended for replacement were grouped into construction project areas. It is recommended that structural rehabilitation be scheduled within contiguous areas to reduce the mobilization requirements during construction rather than schedule replacement of short water main segments throughout the city. In general, construction should occur within a localized area and scheduled with other utility work or streets projects. The water main project areas were identified by the water mains that would likely be replaced or rehabilitated within the same time frame.

The water mains were grouped into 21 unique project areas over the 20-year planning period. Each project area was assigned a PAN based on the PAN assigned to the individual water mains. The PAN for a water main project area was calculated using the equation derived below.

$$\textit{Project Area PAN} = \frac{\sum(\textit{Water Main PAN x Water Main Length})}{\sum(\textit{Length})}$$

Project areas were determined based on the following criteria:

1. Water mains with varying PANS but within a contiguous area were grouped within the same project year, e.g., water mains with a PAN of 160 and 33 were identified for replacement within the first year of construction since both pipes are within the French Quarter area.
2. All water mains identified in the 20-year prioritization analysis were included in a project area.

Although the water main project area prioritization changes the priority rank of some water mains, the higher priority water main segments still require rehabilitation or replacement within the first five (5) years. Preliminary cost estimates have been assigned to the water main replacement program based on conservative, "open cut" construction methods. The unit price cost estimates are presented in detail in **Section 9**.

The results of the prioritization analysis for the replacement and rehabilitation of water main project areas is summarized in **Table 7-13**. A total of 929 miles, or 60 percent of the system, is recommended for replacement based on the prioritization analysis.

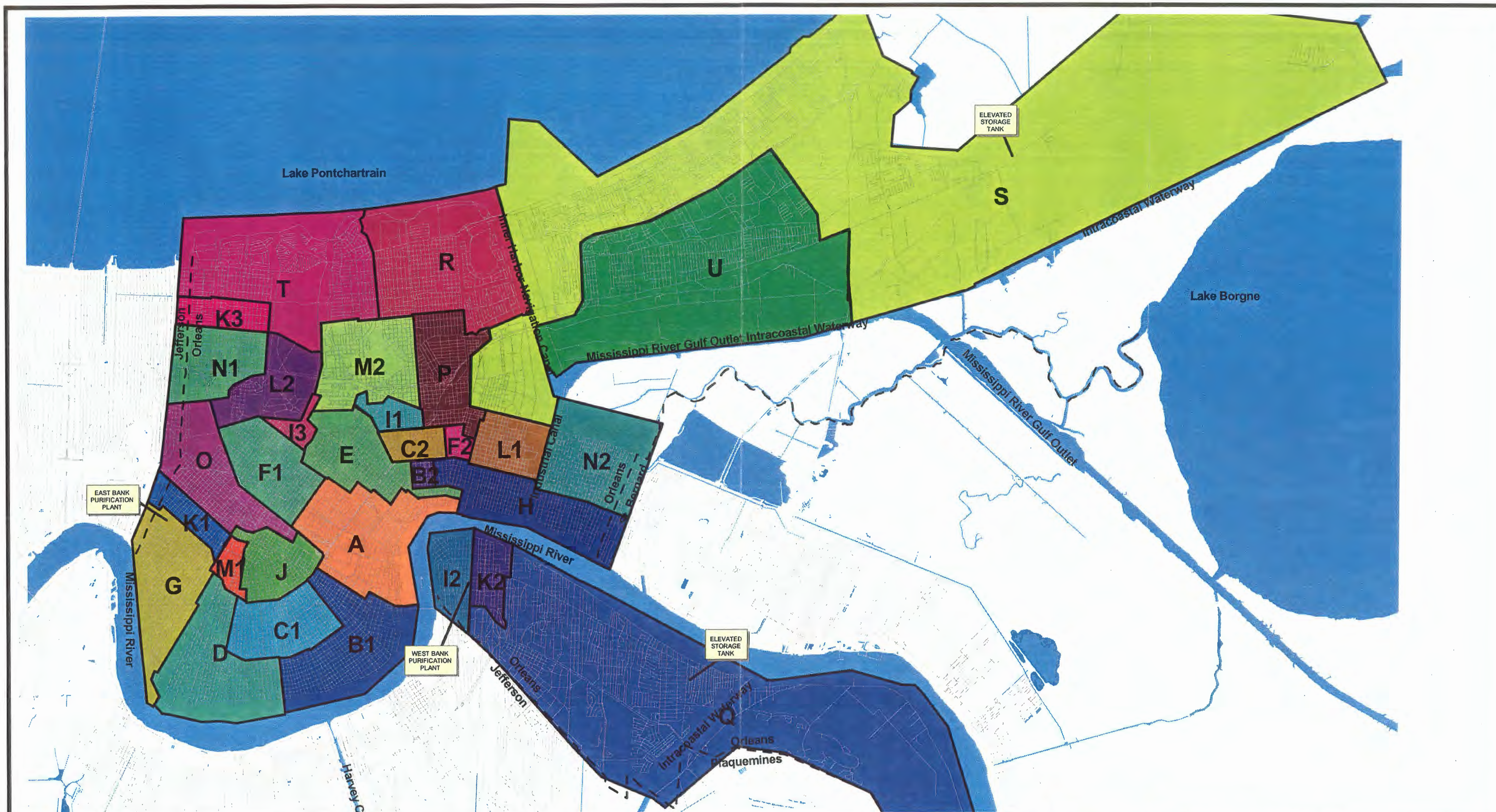
Table 7-13
Project Area Prioritization

Project Area	Year of Project	Length of Water Main to be Replaced (miles)
A	2005	85
B1, B2	2006	77
C1, C2	2007	68
D	2008	62
E	2009	54
F1, F2	2010	50
G	2011	55
H	2012	53
I1, I2, I3	2013	41
J	2014	36
K1, K2, K3	2015	32
L1, L2	2016	31
M1, M2	2017	35
N1, N2	2018	35
O	2019	37
P	2020	38
Q	2021	27
R	2022	30
S	2023	29
T	2024	28
U	2025	26
Total		**929**

The prioritization of the 21 water main project areas is illustrated in **Figure 7-18**. **Appendix H** includes a figure and table summarizing the project area PAN, total length of water main recommended for rehabilitation, and capital cost for each of the project areas.

7.3 FACILITY OPERATIONS

In conjunction with the condition assessment of the distribution systems, the operation and maintenance procedures of the system facilities (fire hydrants, valves, and meters) were reviewed with the S&WB, although not assessed in detail.



Legend

N

Not to scale

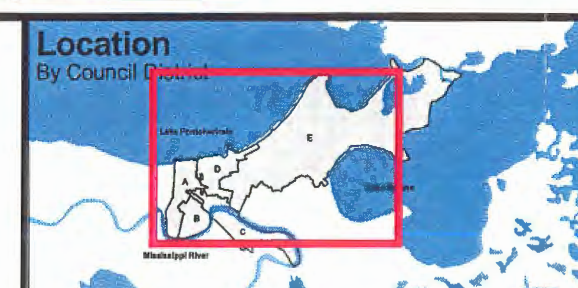
Structural Improvements Project Area

- Project Areas
- Project Boundary Area
- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Structural Improvement Project Areas

Figure 7-18



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The S&WB has initiated a fire hydrant inspection and maintenance program in 2002. Approximately 10,000 hydrants are inspected annually under this program. Hydrants are tested to ensure they function; functional hydrants receive maintenance including grease, paint, and replacement of small parts. Pressure is recorded at each location as well. If the hydrant is not functioning, it is replaced. According to the S&WB, approximately five (5) to ten (10) percent of the hydrants inspected are in need of replacement.

In 2003 the S&WB intends to initiate a valve inspection and maintenance program similar to the hydrant maintenance program. During the hydrant inspections, valves were utilized to isolate water mains or inspected if low pressure was recorded in the area. If the valve was not functioning or needed maintenance, the valve was repaired as needed.

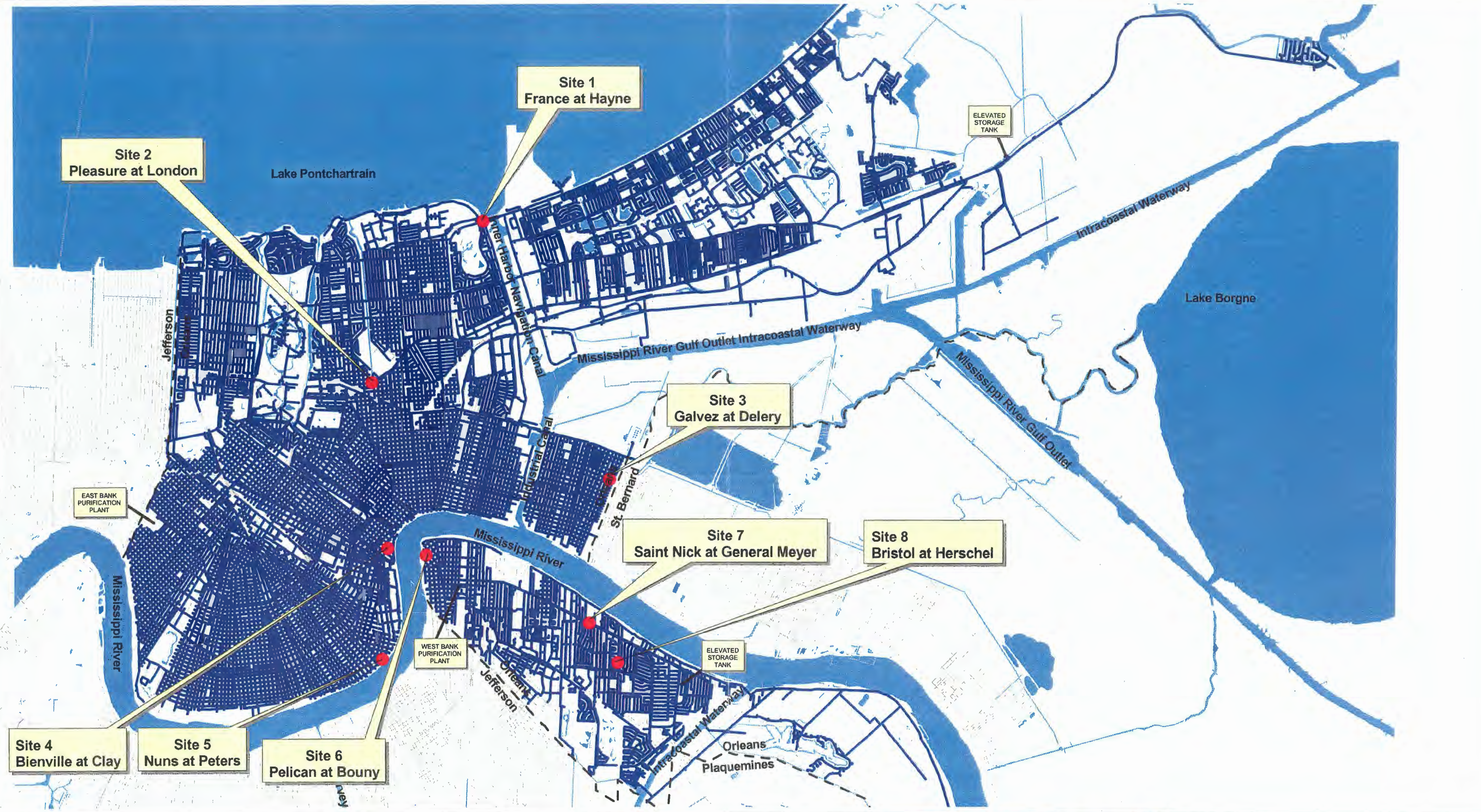
Circa 1990, the S&WB initiated a routine schedule for inspection and maintenance of all residential customer water meters. Each commercial meter is inspected and maintained once every 20 years as well as on an as needed basis. Typically, a residential meter can be rebuilt and re-installed for use. Once a meter has been in use for 20 years, or if a meter is not functioning, the meter is sent to the manufacturer to be rebuilt and is replaced with a rebuilt meter. Commercial meters are inspected and maintained on an "as needed" basis. Commercial meters that are larger than one (1) inch in size are tested and rebuilt in the field by S&WB operators.

Recommendations are made in **Section 9** to continue and further expand the operation and maintenance programs for fire hydrants, valves, and meters.

7.4 WATER MAIN SAMPLE TESTING

The purpose of the sample testing was to perform a limited analysis of water mains varying in age located throughout the distribution system. The condition assessment included analysis of the soil characteristics and metallurgical testing of core water main samples to evaluate the potential for corrosion.

Eight water mains were selected for the condition assessment. The pipes were selected based on a range of age, a diameter greater than six (6) inches and less than or equal to 12 inches, and a material capable of withstanding core sampling (e.g., cast iron and ductile iron). In addition, the locations were selected to minimize disruption to traffic and other utilities during site excavation. **Table 7-14** summarizes the details of each location selected, and **Figure 7-19** illustrates the location of the water mains selected for condition assessment.



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N

Not to scale

Condition Assessment Sites

- Survey Sites
- Water Main
- Parish Boundary
- Street
- Water Body

Water Distribution System
Assessment and Hydraulic Model

Location of Water Main
Condition Assessment Sites

Figure 7-19

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

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Table 7-14
Condition Assessment
Water Main Locations

Site No.	Site Location	Diameter (inches)	Material	Installation Date
1	France at Hayne	12	Cast Iron	1954
2	Pleasure at London	12	Cast Iron	1950
3	Galvez at Delery	12	Cast Iron	1950
4	Bienville at Clay	8	Cast Iron	1909
5	Nuns at Peters	8	Cast Iron	1924
6	Pelican at Bouny	10	Cast Iron	1908
7	Saint Nick at General Meyer	12	Cast Iron	1963
8	Bristol at Herschel	12	Cast Iron	1956

The procedure for the water main condition assessment is outlined as follows:

1. Locate and excavate the water main at selected location.
2. Determine the depth of cover, pipe material, approximate age, and diameter of pipe.
3. Inspect the exterior condition of the pipe.
4. Obtain soil samples for chemical analysis.
5. Measure the in-situ soil resistivity.
6. Obtain core samples from each pipe for metallographic examination.

Corrpro Companies, Inc. conducted the metallurgical testing and prepared a report to summarize the findings. The report, *Pipe Condition Survey, City of New Orleans, Buried Water Pipelines, September 2002,* is included in **Appendix A**. **Figure 7-20** shows the water main excavation and a core sample retrieved from a cast iron water main.

Figure 7-20
Water Main Excavation

Water Main Excavation

Cast Iron Core Sample

Table 7-15 provides a summary of the results from the pipe survey. The findings of the metallurgical testing revealed that six (6) of the eight (8) water mains show no evidence of corrosion. The two water mains that did show evidence of corrosion were slightly corroded (evidence of graphic corrosion and/or pits). Although the majority of the core samples tested indicated no corrosion, this may not be indicative of the condition of the complete water main segment. All core samples were retrieved from the upper portion of the pipe and represent a small section of the water main.

Regarding the soil analysis, the interrelationship of soil moisture, pH, conductivity, sulfide concentration, chloride concentration, and soil resistivity is used to determine the rate of corrosion. Soil moisture content measures the anticipated rate of corrosion with values over 20 percent moisture considered high. The results for the eight (8) samples range from 26 to 91 percent. The soil conductivity measures the loss of metal with values over 350 micromhos per centimeter considered high. Each of the eight (8) samples measured over 350 micromhos per centimeter. Soil resistivity is a common parameter for evaluating the corrosiveness of the soil and is also related to the concentration of salts. Low resistivity indicates high levels of salt and high corrosion. Resistivity ranged from 460 to 2,000 ohm per centimeter.

According to the soil testing results, all the sites tested indicated that the soil is potentially corrosive to cast iron water mains. The analysis also indicated that there is no existing corrosion protection. To reduce corrosion on new water mains, the selection of water main material and corrosion protection should be assessed during project design of the recommended structural rehabilitation program.

Table 7-15
Water Main Condition Assessment Summary

Site No.	Site Location	Age (years)	Material	Diameter (inches)	Sample No.	Soil Moisture Content (%)	pH	Chloride (ppm)	Sulfide (ppm)	Soil Conductivity (micromhos)	Soil Resistivity (Ohm-cm)	Soil Type	Corrosive Soil	Metallographic Analysis
1	France at Hayne	48	Cast Iron	12	4	25.99	7.7	21	0	510	1,961	Clay Loam	Yes	No evidence of corrosion
2	Pleasure at London	52	Cast Iron	12	5	53.01	6.9	16	0	670	1,493	Clay Loam	Yes	No evidence of corrosion
3	Galvez at Delery	52	Cast Iron	12	7	89.04	6.8	540	0	2,340	427	Clay Loam	Yes	No evidence of corrosion
4	Bienville at Clay	93	Cast Iron	8	6	32.04	8.1	10	0	864	1,157	Clay Loam	Yes	No evidence of corrosion
5	Nuns and Peters	78[1]	Cast Iron	8	1	25.53	8.8	17	0.5	499	2,004	Clay & Rocks	Yes	Evidence of graphic corrosion and pits
					2	27.34	8.4	6	0	599	1,670			
6	Pelican at Bouny	94	Cast Iron	10	8	42.04	8.6	26	0	517	1,934	Clay Loam	Yes	Evidence of graphic corrosion
7	Saint Nick at General Meyer	39	Cast Iron	12	9	68.86	7.1	16	0	625	1,600	Clay Loam	Yes	No evidence of corrosion
8	Bristol at Herschel	46	Cast Iron	12	10	91.42	6.8	440	Trace	2,187	457	Clay Loam	Yes	No evidence of corrosion

Note:
1 – Age of water main considered inaccurate due to good condition of fitting and bolts.

7.5 RECOMMENDATIONS SUMMARY

In general, the East and West Bank distribution systems were evaluated to have an adequate supply of raw water and capacity to deliver sufficient water to meet existing demand scenarios. The system has sufficient capacity to supply the existing demand. No capacity upgrades are recommended at this time. With a goal for reduction in breaks and leaks, the system demand should be re-evaluated with the hydraulic model in the future. A leakage management program is recommended as a priority as well as network replacement and rehabilitation.

A summary of the recommendations discussed in **Sections 5** and **7** is as follows:

- Implement a water main rehabilitation and replacement program.
- Continue and expand the fire hydrant, valve, and customer meter maintenance programs initiated by the S&WB and inspect all washout valves.
- Replace flow meters at the discharge of Carrollton Plant pump stations.
- Conduct a Water Audit at the purification plants.
- Continue and expand metering public water consumption and identification of UFW.
- Streamline and develop a data collection system for the Carrollton and Algiers Plants and distribution systems including installation of SCADA.
- Implement asset data management utilizing GIS and CassWorks.
- Refine the hydraulic model with future system improvements in order to continue assessment of capacity upgrade needs.
- Implement a leak management program (outlined in **Section 8**), including pressure and flow monitoring.

Section 8

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Section 8 – Leakage Management

A plan for leakage management within a distribution system is essential to identify and monitor potential sources of unaccounted for water (UFW). A summary of the typical procedures utilized for leakage control by the water industry is provided in this section. These procedures were evaluated for potential implementation as a leakage management plan for the S&WB. The recommended plan outlines future efforts for determining UFW and ties the repairs identified from leakage detection to the systemwide renewal plan.

8.1 ACTIVE LEAKAGE CONTROL

Active Leakage Control (ALC) is the framework of strategies that may be used to control leaks within a distribution system. Leakage control strategies vary in level of effort, cost, and subsequent outcome or results. The leakage control strategies considered for the S&WB's water distribution systems included the following and are listed by increasing level of effort and cost:

1. **Reactive Leakage Control**: limited to only fixing leaks that can be seen surfacing. No proactive activities are performed to identify leaks.
2. **Leak Detection and Sounding**: uses equipment to listen for leaks, including the use of noise correlation to pinpoint the leak location. The S&WB is currently utilizing this strategy.
3. **District Metering Areas (DMAs)**: relies on measuring the flow into isolated areas of the distribution system. By examining the flow (especially during the low flow/night hours) into each DMA in comparison to the amount of water consumed in the DMA, an assessment of the level of leakage can be made. Once the level of leakage in each DMA has been established, a priority can be set for leak detection and sounding.
4. **Step Testing**: consists of isolating smaller areas within each DMA. This method of leakage control, which can pinpoint increasingly smaller leaks, is expensive and labor intensive.

ALC alternatives which utilize one or more of the leakage control strategies described above are summarized in **Table 8-1**. These ALC alternatives and the corresponding leakage control strategies were considered for the S&WB water systems.

Table 8-1
Summary of ALC Alternatives

ALC Alternatives	Reactive Leakage Control	Leak Detection and Sounding	District Metering	Step Testing
A	✓			
B	✓	✓		
C	✓	✓	✓	
D	✓	✓	✓	✓

The selection of the most effective ALC alternative included an analysis of the economic benefits of the various leakage strategies. In order to identify the most cost-effective ALC alternative, the existing leakage levels were defined for the water distribution systems.

8.2 LEAKAGE LEVELS

The UFW and leakage level for the S&WB distribution systems was previously estimated as a percentage of water production. A percentage of leakage does not, however, provide an accurate assessment of overall leakage when compared to other communities or when the baseline value for water consumption or production fluctuates.

To illustrate how misleading it is to use a percentage to define leakage levels, **Table 8-2** was duplicated from *Managing Water Leakage, Economic and Technical Issues* prepared by Allan Lambert, Stephen Myers, and Stuart Trow for the Financial Times Energy. **Table 8-2** shows the extent to which variations in consumption or production can influence the reported percentage of water loss when the real loss leakage rates are identical. Although the value of water loss is consistent for each country, the percentage of water loss ranges from 44 percent to nine percent simply because of variations in water consumption and production.

Table 8-2
Influence of Per Capita Consumption on Percentage of Water Loss

Per Capita Consumption (gallons/capita/day)	Metered and Non-Metered Consumption (MGD)	Water Losses (MGD)	Water Production (MGD)	Percent Loss (%)
13.2 (Jordan)	3.30	2.64	5.94	44
26.4 (Czeck Rep)	6.60	2.64	9.24	29
39.6 (UK, France)	9.90	2.64	12.54	21
79.3 (Japan)	19.83	2.64	22.47	12
105.7 (US)	26.42	2.64	29.06	9

The economic regulator of the water industry in England and Wales provides the following in their 1996/1997 report on leakage and water efficiency:

"The Office of Water Service does not favor percentage of water into supply as a measure of leakage. This can be misleading. For instance, a reduction in the volume water into a supply may occur as a result of a water company's successful promotion of water efficiencies by its customers but would make its leakage performance worse."

Expressing leakage as a percentage of total water supplied is reasonable to use only when evaluating a system under static consumption and production rates. Rather than present the leakage levels based on percentages, the S&WB leakage levels will be discussed in the more representative term of gallons per service connection per day.

The system leakage for the S&WB distribution systems was therefore redefined in terms currently utilized in the water industry with respect to system leakage: Unavoidable Annual Real Losses (UARL), Technical Indicator for Real Losses (TIRL), Infrastructure Leakage Index (ILI), and economical level of leakage. These terms are described in the following subsections.

8.2.1 Unavoidable Annual Real Losses (UARL)

The water industry has long recognized that it is impossible to achieve zero leakage. The term UARL has been introduced to define the level of leakage which could be achieved at the current operating pressure if there was no financial or economic constraint for leakage control. In simple terms, the UARL is the level of leakage that cannot be economically recovered.

An estimate of UARL for a distribution system consists of the following types of leaks:

1. Background losses from undetectable leaks
2. Losses from reported leaks
3. Losses from unreported leaks

Using an approach adopted in the United Kingdom, an average UARL is calculated for infrastructure components based on published international data for typical flow rates and breakage frequencies. The average industry values of the UARL for each infrastructure component are shown in **Table 8-3**. The total UARL is the sum of background losses, reported leaks, and unreported leaks.

Table 8-3
Average Parameters of UARL

Infrastructure Component	Background Losses	Reported Leaks	Unreported Leaks	UARL Total
Water Mains (gallons/ mile of mains/ day/ psi)	2.87	1.74	0.78	**5.39**
Service Connections, Meters at Edge of Street (gallons/ service connection/ day/ psi)	0.11	0.01	0.03	**0.15**
Underground Pipes Between Edge of Street and Customer Meters (gallons/ mile of pipe/ day/ psi)	4.79	0.57	2.13	**7.49**

The values presented in **Table 8-3** were used in the following equation to estimate the overall UARL for the S&WB distribution systems.

$$UARL = [(5.39 \times Lm) + (0.15 \times Nc) + (7.48 \times Lp)] \times P$$

Where:

UARL = gallons per day
Lm = length of water mains in the distribution system (miles)
Nc = number of service connections
Lp = total length of pipe from the street edge to the customer meter (miles)
P = average operating pressure (pounds per square inch)

The following characteristics of the S&WB distribution systems were used to calculate the UARL:

1. Approximately 1,580 miles of water main
2. Approximately 164,000 service connections
3. Average length of service connection between street and water meter of 30 feet
4. Average system pressure of 60 psi

The total UARL for New Orleans was calculated to be 15 gallons per service connection per day, or 880 million gallons per year (MGY).

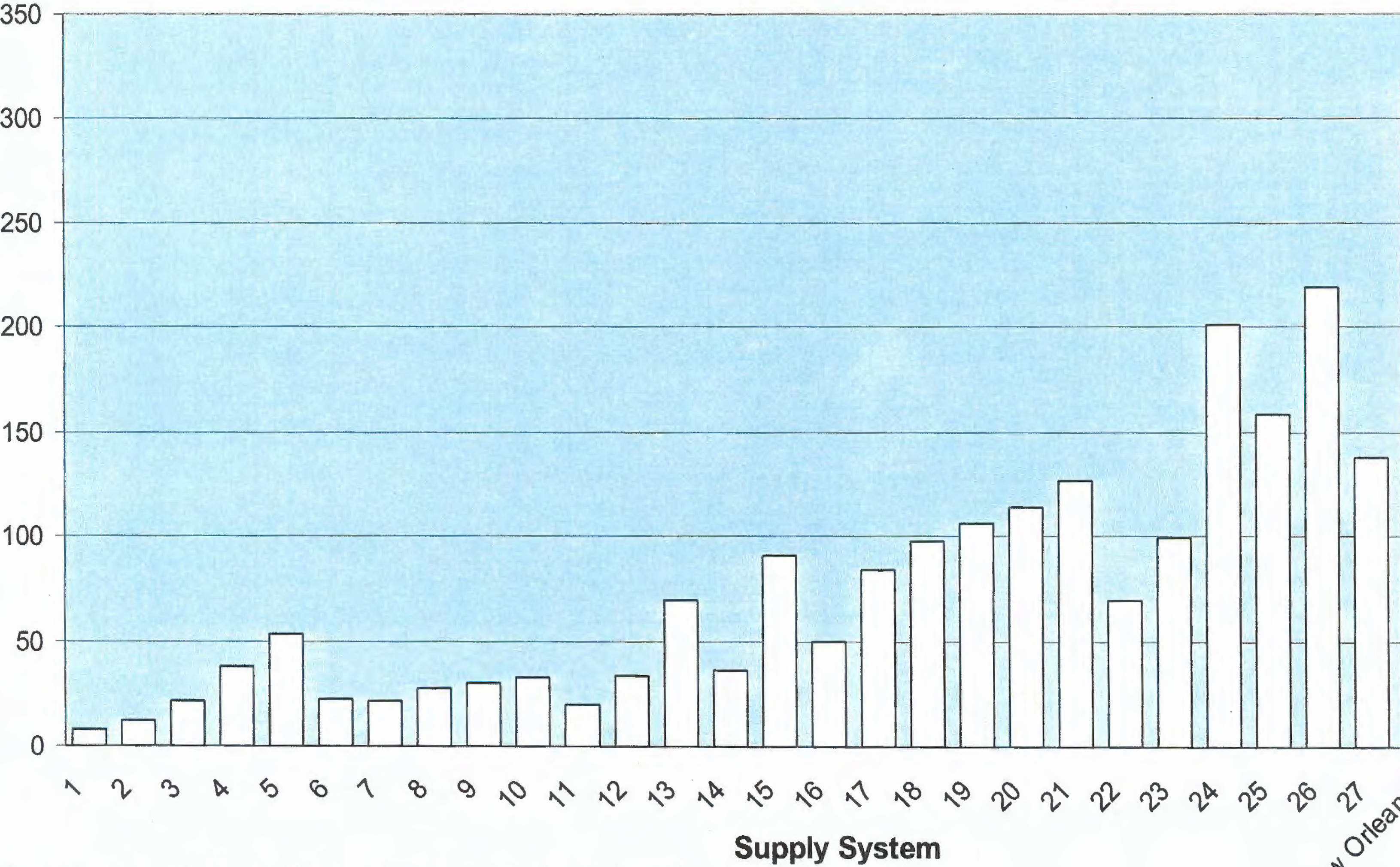
The preliminary estimate of UARL should be used only as a guide to define leakage. Once the recommended ALC is implemented, the background losses, reported and unreported leaks can be further defined and a more accurate UARL should be calculated to represent the actual leakage.

8.2.2 Technical Indicator for Real Losses (TIRL)

The TIRL is the performance indicator of the total volume of losses in a water distribution system. The TIRL is defined by gallons per service connection per day.

It is difficult to determine the existing level of leakage within the S&WB distribution systems. According to the water audit, UFW and system leakage is approximately 48 percent of total water production. Known leakage within the system is approximately 13 percent, so the TIRL is within the range of 13 to 48 percent. No other source of non-metered water use other than public consumption was identified during the water audit. It is assumed that most of the UFW is, therefore, leakage. For the purpose of this analysis, TIRL is estimated at approximately 40 to 48 percent of water production.

However, as previously discussed, expressing leakage as a percentage of total water supplied is not an accurate indicator of the performance of a water distribution system. The TIRL is therefore expressed in terms of gallons per service connection per day. Converting from a percentage to these units, the TIRL for New Orleans is approximately 319 to 382 gallons per service connection per day. **Figure 8-1** compares the TIRL estimated for New Orleans with other international communities. The level of real losses in the S&WB water systems is shown at the upper end of those communities surveyed.



ly systems composed of 27 systems surveyed in 20 countries

rce: Lambert, A. O., T.G. Brown, M. Tkizawa, and D. Weimers, *A Review of Performance Indicators for Real Losses from* *er Supply Systems*, IWSA, J Water SRT - Aqua 48, 227-237, 1999.

Water Distribution System
Assessment and Hydraulic Model
Technical Indicator for Real Losses
Figure 8-1

"RE-BUILDING THE CITY'S WATER SYSTEM"
Sewerage & Water Boar

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8.2.3 Infrastructure Leakage Index (ILI)

The ILI is a non-dimensional numeric value which provides a method of comparing leakage between communities. This is a more accurate indicator for comparison than the percentage of leakage based on water production. The ILI is the ratio of TIRL to UARL.

Figure 8-2 illustrates the results of a survey of the ILI calculated for international communities. The higher ILI value represents a system with higher leakage rates and the lower ILI value represents a system with comparatively lower leakage rates. The ILI for the S&WB distribution systems is approximately 23 to 27. Similar to the TIRL, the S&WB distribution systems has an ILI at the upper end of those communities surveyed.

8.2.4 Economic Level of Leakage

The economic level of leakage is defined as the amount of leakage with the lowest annual cost (considering the cost of lost water and implementing ALC). Although this is commonly construed as a purely financial equation, other social, political, and environmental costs can be included in the savings through a reduction of water losses.

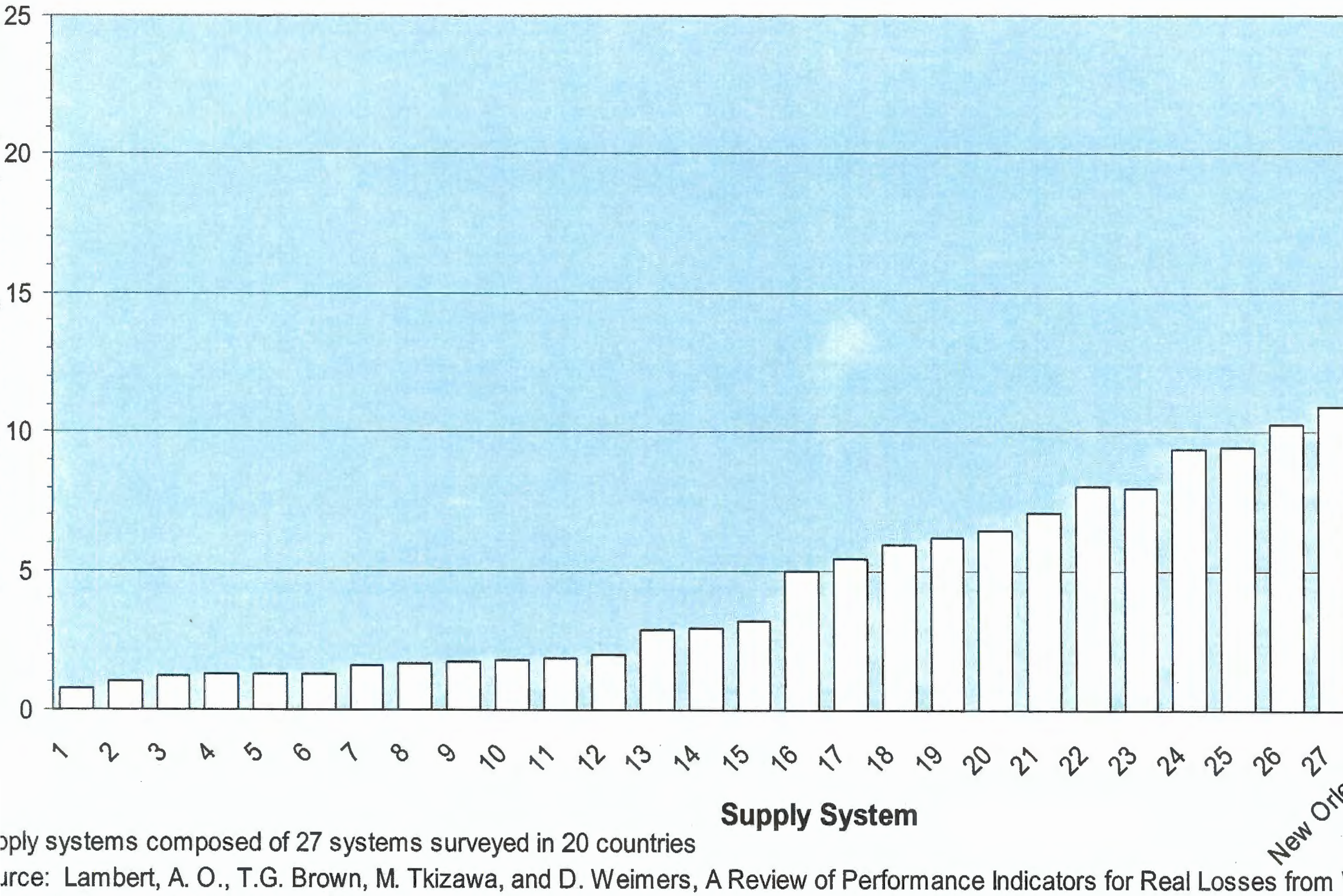
The concept of an optimum level of leakage is illustrated graphically in **Figure 8-3**. The following three parameters are shown in **Figure 8-3** as a function of the annual real losses in the system:

1. Cost of lost water
2. Annual cost of implementing ALC
3. Total cost of lost water and annual cost of implementing ALC

Figure 8-3 illustrates, as would be expected, that as leakage increases the cost of water lost increases. This figure also illustrates that if more stringent forms of ALC, which have a higher annual cost (A>B>C), are implemented the volume of leakage decreases. As the volume of leakage decreases, the cost of leakage (or cost of lost revenue) decreases. Adding the cost of lost water and the cost of implementing ALC results in the total cost curve (upper curve, A'B'C'). The minimum point on the curve represents the most cost-effective level of leakage control, that is the level of leakage with the lowest overall annual cost (B').

8.2.5 Target Leakage Levels

To select the most appropriate ALC alternative, as described in **Table 8-1**, it is necessary to establish a target goal to reduce leakage levels within the distribution system. The target reduction in leakage for the distribution systems was established by first evaluating the ALC alternatives A through D for the potential to reduce leaks. The potential to reduce leaks was estimated and described by the TIRL factor. The ILI was then calculated (as the ratio of TIRL to UARL) and used as an indicator to compare each of the ALC alternatives. The estimated UARL of 15 gallons per day was used to calculate the ILI.



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ɔply Systems, IWSA, J Water SRT - Aqua 48, 227-237, 1999.

Water Distribution System
Assessment and Hydraulic Model
Infrastructure Leakage Index
Figure 8-2

"RE-BUILDING THE CITY'S WATER SYSTEM"
Sewerage & Water Boar

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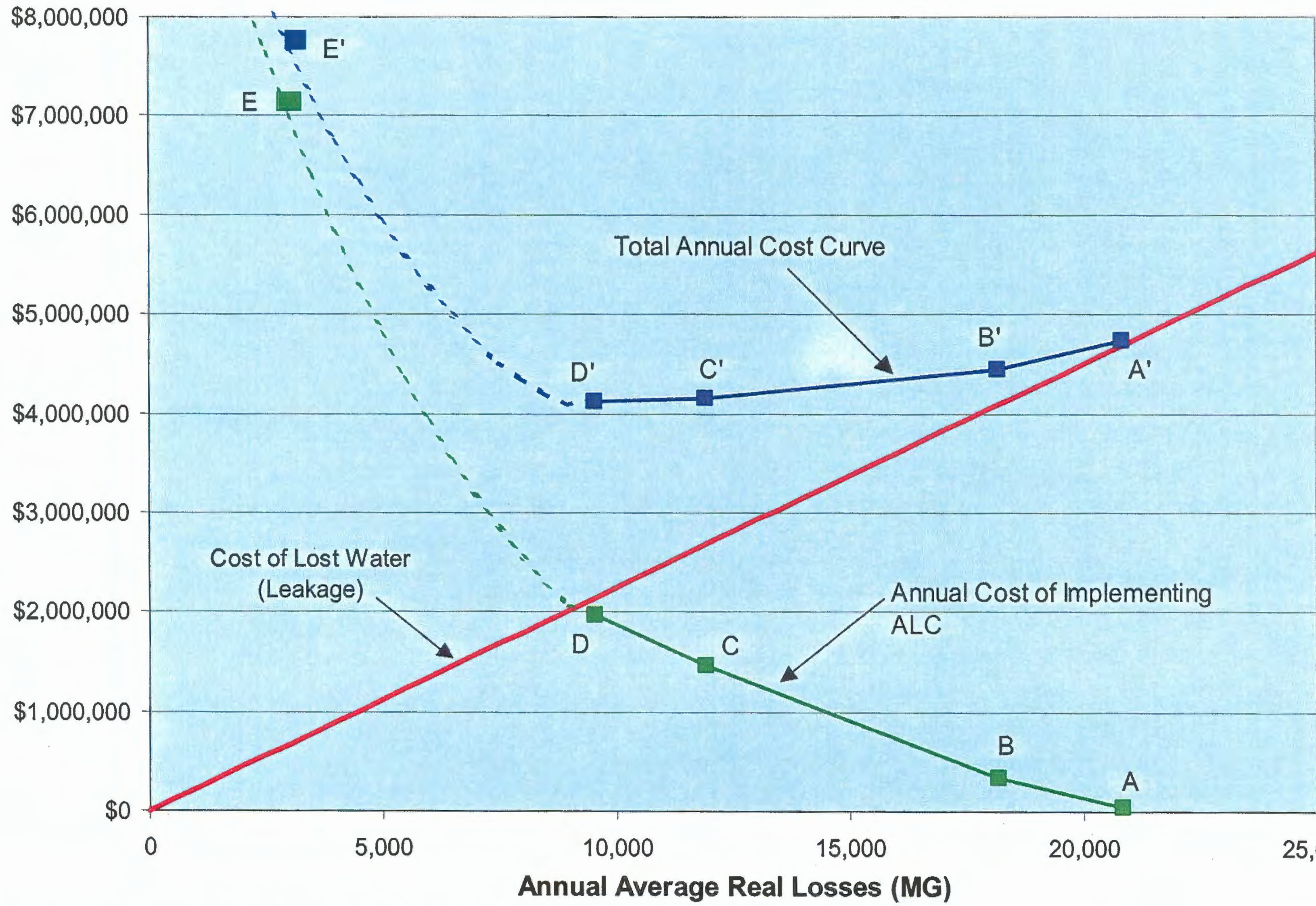


Cost of ALC to achieve UARL cannot be determined with information available.

Water Distribution System
Assessment and Hydraulic Model

Determination of Economic Level of Leakage

Figure 8-3

Sewerage & Water Board

ALC Alternative A: Reactive Leakage Control

The method of reactive leakage control identifies only those leaks that have surfaced. According to the leak detection survey conducted in 2001, approximately 2,150 MGY of leaks were surfacing. It is therefore assumed that reactive leakage control has the potential to reduce TIRL by 2,150 MGY. The ILI ranges from 19 to 23.

ALC Alternative B: Leak Detection Survey and Reactive Leakage Control

The total volume of leakage located during the leak detection survey conducted in 2001 was estimated at 4,800 MGY. This volume was used as an estimate of the reduction in TIRL that could be achieved by a combination of reactive leakage control and leak detection survey. The ILI ranges from 16 to 20.

ALC Alternative C: District Metering, Leak Detection Survey, and Reactive Leakage Control

No formal guidelines are available for quantifying the reduction of leakage by the implementation of district metering. For the purpose of this analysis, it was assumed that leakage would be reduced to 25 percent. This reduction in leakage results in an ILI of 14, which is at the median range in comparison to other communities presented in **Figure 8-2.**

ALC Alternative D: Step Testing, District Metering, Leak Detection Survey, and Reactive Leakage Control

No formal guidelines are available for quantifying the reduction of leakage by the implementation of step testing. For the purpose of this analysis, it was assumed that leakage would be reduced to 20 percent. This reduction in leakage results in an ILI of 12, which is at the low range in comparison to other communities presented in **Figure 8-2**.

The existing S&WB distribution system has an estimated ILI of 23. The ILI estimated for the ALC alternatives is used as an indicator of potential reduction in leakage if the alternative is implemented as a part of a Leakage Management Plan. The estimated ILI factors range from 23 (similar to the existing ILI) to 12 (an aggressive reduction in leakage rates) as summarized below:

- ALC Alternative A: 19 to 23
- ALC Alternative B: 16 to 20
- ALC Alternative C: 14
- ALC Alternative D: 12

The target leakage level selected for the S&WB is between an ILI of 14 to 12, which is achievable by implementing ALC alternatives C or D.

8.3 COST ANALYSIS OF ACTIVE LEAKAGE CONTROL

The selection of the most appropriate ALC considers the cost analysis of the water saved by the ALC and the cost of implementing the ALC alternatives. The cost analysis includes an estimate for the cost benefit from recovered leakage, cost of implementing the ALC alternatives, and the determination of the economic level of leakage and appropriate ALC.

8.3.1 Cost Benefit from Recovered Leakage

The cost benefit of recovered leakage was calculated according to the guidelines provided by AWWA in the manual *Water Audits and Leak Detection (AWWA M36)*. The annual cost benefit from recovered leakage was calculated as well as the cost benefit over the duration of 20-year and 40-year periods. Water production and potential leakage values for the year 2001, as discussed in the water audit in **Section 4**, were used to estimate the cost of leakage. The *S&WB 2001 Comprehensive Annual Financial Report* provided additional data summarizing the unit production cost. The cost benefit of recovering leakage was calculated with the following equation:

Annual Cost Benefit of Recoverable Leakage = Unit Production Cost x Recoverable Leakage x 2.5

Where:

2.5 = factor representing the total benefit of repairing a leak including the reduction in damage to streets, property, and the water main network.

The following characteristics of the S&WB distribution systems were used to calculate the total cost benefits from potentially recoverable leakage:

1. Unit production cost = $2,310 per MG
2. Recoverable leakage (assuming 65 percent of existing potential leakage) = 0.65 x 23,000 MGY = 14,950 MGY

Due to the large quantity of leakage identified within the distribution system, it is assumed that a large portion, 65 percent, can be recovered by implementing the recommended ALC. The annual cost benefit of recoverable leakage was estimated up to $86 million.

The cost benefit for recoverable leakage was also calculated for a 20-year and 40-year duration. An annual increase of 3 percent was included to represent inflation and calculated to the mid-point of the time period. The benefit of recovered leakage is up to $1.7 billion for a 20-year duration and up to $3.5 billion for a 40-year duration.

8.3.2 Cost Analysis of ALC Alternatives

The annual cost of reactive leakage control was estimated to be $50,000 as it only includes administrative type costs, and does not require additional equipment or manpower.

The S&WB is currently conducting leak detection and sounding, which can be performed at an estimated annual capital cost of $300,000.

With respect to DMAs, there are four options:

- permanent DMAs with fixed meters;
- permanent DMAs with temporary insertion meters;
- temporary DMAs with fixed meters; or
- temporary DMAs with temporary insertion meters.

The descriptions, advantages, and disadvantages of these options are summarized in **Table 8-4**.

Table 8-4
Permanent and Temporary DMA Options

DMA Option	Description	Advantages	Disadvantages
Permanent DMAs with fixed meters	• DMA boundary valves always closed. Flow into the DMA continuously monitored.	• Continuous information on flow into DMA. • Earliest detection of leaks.	• Highest cost. • Permanently closed valves can compromise system hydraulics.
Permanent DMAs with temporary insertion meters	• DMAs boundary valves always closed. Flow continuously monitored into DMAs using insertion meters.	• DMAs are always ready for monitoring. • Earliest detection of leaks.	• Permanently closed valves can compromise system hydraulics. • Labor intensive to move meters to each DMA.
Temporary DMAs with fixed meters	• Boundary valves closed when flow into DMA is monitored. • Flow monitored into DMA using fixed meters on a regulated schedule.	• Limited compromise to system hydraulics (only when boundary valves are closed).	• Labor intensive to close boundary valves. • High cost of permanent metering stations.
Temporary DMAs with temporary insertion meters	• Boundary valves closed when flow into DMA is monitored. • Flow monitored into DMA using insertion meters on a regulated schedule.	• Limited comprise to system hydraulics (only when boundary valves are closed). • Reduced number of meters required.	• Labor intensive to close boundary valves. • Labor intensive to move meters to each DMA.

As previously defined, the economic level of leakage is the amount of leakage that corresponds to the lowest annual cost for implementation of an ALC. **Figure 8-3** illustrates the economic level of leakage for the S&WB systems in terms of annual cost versus level of leakage. The following three parameters are shown in **Figure 8-3** for the S&WB distribution systems as a function of the annual real losses in the system:

1. Annual cost of lost water
2. Annual cost of implementing ALC (Alternatives A through C)
3. Total cost of lost water and implementing ALC

For the purpose of this analysis, the capital cost of the DMA program has been annualized over 20 years. The cost of implementing the ALC alternatives shown in **Figure 8-3** does not include the cost to repair any leaks detected. As illustrated in **Figure 8-3**, the minimum annual cost approaches the ALC alternatives of C and D.

For comparison, **Figure 8-4** illustrates the economic level of leakage including the repair of leaks in the analysis.

The economic level of leakage, the target level of leakage, and the potential reduction in leakage was taken into consideration for each ALC alternative. The ALC alternatives C and D were closest in comparison of target ILI and cost effectiveness. At this point in time, the recommended option for the S&WB is ALC alternative C. Alternative C includes reactive leakage control, leak detection and sounding, and district metering procedures to control leakage. Alternative D, which includes step testing for smaller leaks, may be considered in the future as larger leaks have been detected, repaired and controlled within the distribution system.

8.4 RECOMMENDED LEAKAGE MANAGEMENT PLAN

The Leakage Management Plan is the guidance document for implementation of Active Leakage Control (ALC). The analysis of leakage levels indicated the most appropriate form of ALC for the S&WB is Alternative C, which includes the implementation of DMAs and continuation of leak detection and sounding. The leakage management plan includes guidelines for the implementation of the recommended ALC and procedures for management and operation of the DMAs.

8.4.1 District Metering Areas

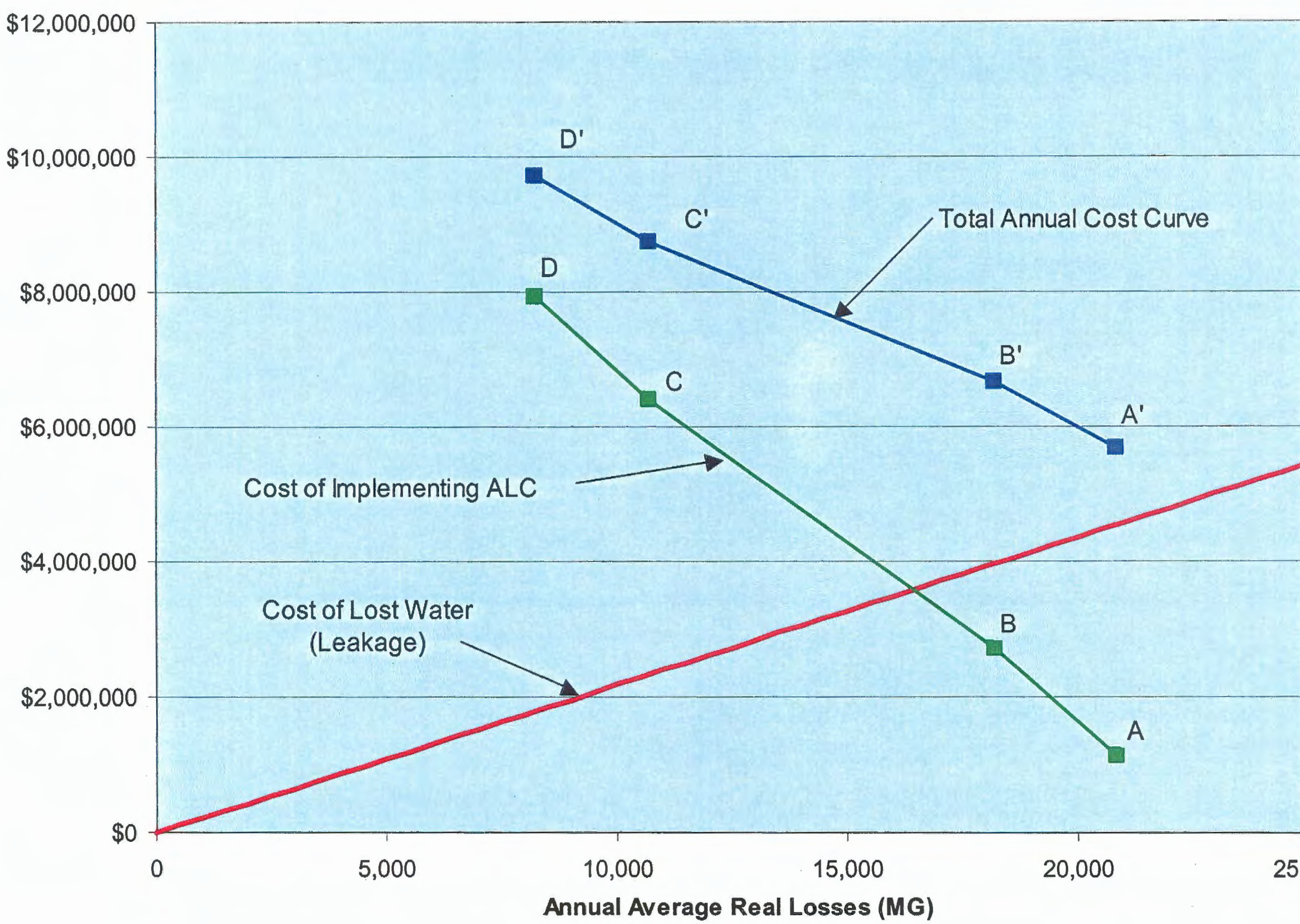
The implementation of district metering requires the installation of metering stations, selection of boundary valves, hydraulic analysis, monitoring large water consumers, flow within a district, and night flow. It is also recommended to conduct a pilot study of four selected DMAs prior to a full-scale installation of DMAs throughout the distribution systems.

Metering Stations

The use of temporary insertion meters installed in manholes is the most cost-effective means of metering. **Figure 8-5** shows a typical arrangement for a district metering station. The preliminary location for each of the 43 recommended district metering stations is shown in **Appendix H**. During initial implementation of this plan, the exact location for the DMA metering station needs to be confirmed.

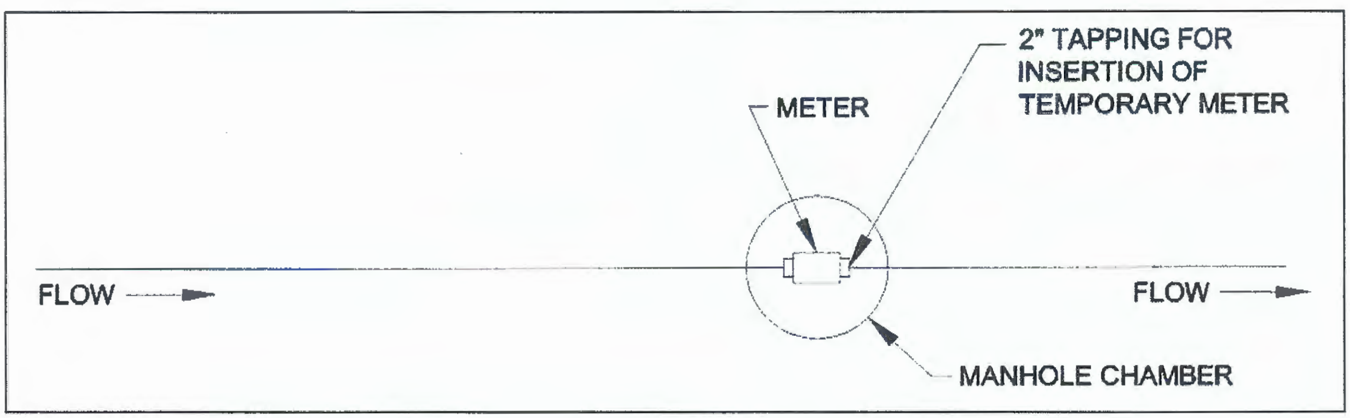
DMA Boundary Valves

In order for metering stations to accurately measure all flow entering or leaving the DMA, flow needs to be restricted with the use of boundary valves. Existing valves within the water distribution system must be identified and closed to ensure that this is achieved. Figures are included in **Appendix H** to show the locations of the DMAs; however, specific boundary valves are not identified. Prior to implementation, the S&WB must select the DMA boundary valves and repair as necessary.



Water Distribution System
Assessment and Hydraulic Model
Determination of Economic Level of Leakage with Repair Cost
Figure 8-4

Sewerage & Water Board



Water Distribution System
Assessment and Hydraulic Model
Metering Station Layout (Insertion Meter)
Figure 8-5

"RE-BUILDING THE CITY'S WATER SYSTEM"
Sewerage & Water Board

Hydraulic Analysis

The effect of closing boundary valves on the overall system hydraulics needs to be evaluated to determine whether the valves can be permanently closed (to perform continuous monitoring) or can only be closed during the monitoring period. The hydraulic model, developed as part of this study, should be used to evaluate the effect on system pressures and fire flows due to the closure of the boundary valves. Based on this analysis it can be determined if some or all of the boundary valves can be kept in a permanent closed position. Identifying valves that can be kept in a permanent closed position reduces the overall operational efforts and costs.

Large Water Users

The DMAs are used to assist in identifying the overall night flow and how it relates to system leakage. It is important, therefore, to identify any source of large water consumption that occurs during the night. Once large nighttime users are identified, they should be monitored in conjunction with the overall flow monitoring into the DMAs.

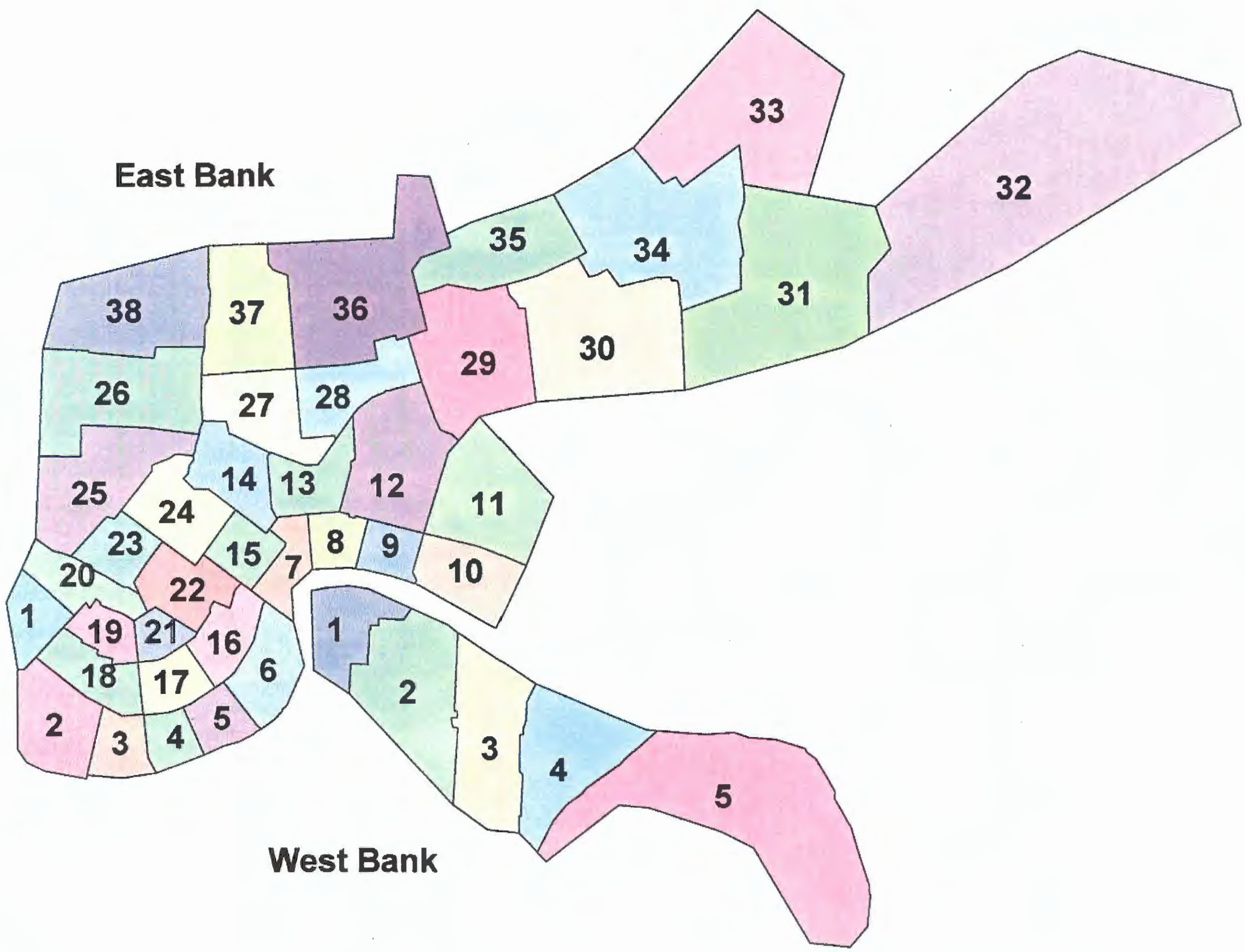
Flow Monitoring within DMAs

DMAs are used to measure the minimal night flow into an area. This minimal night flow is made up of a number of different components such as background losses from undetected leaks, average consumer night use, large consumer night use, and leaks represented as breaks. The flow into the DMAs should be continuously monitored and the results recorded (ideally transmitted utilizing telemetry to a central station). If the boundary valves cannot be permanently closed, the DMAs should be isolated for at least seven days to establish an overall pattern of night flow and normal water consumption. It is likely that the minimum night flow will occur at different times in different DMAs depending on the overall water use in each DMA. Typically, the minimum night flow occurs between the hours of 2:00 a.m. and 4:00 a.m., but in areas such as the French Quarter the hours of minimum night flow could be dramatically different.

Pilot Study

Figure 8-6 presents the recommended location and boundary for each of the 43 DMAs throughout the distribution system; there are 38 DMAs on the East Bank and five (5) DMAs on the West Bank. It is recommended that four DMAs be selected as the first to be implemented as a pilot study. This will allow key design and operation criteria to be established prior to the installation of all DMAs. Specifically, the implementation of these four (4) DMAs will allow the S&WB to establish the following:

1. Type of insertion meter
2. Standard design for metering stations
3. Extent of repair needed for boundary valves
4. Standard operating procedures



Water Distribution System
Assessment and Hydraulic Model
District Metering Areas
Figure 8-6

Sewerage & Water Board

The initial four (4) DMAs were selected because they have key characteristics that are representative of the overall water system of New Orleans. The locations of the four (4) pilot DMAs are shown illustrated in **Figures 8-7** through **8-10**. The characteristics of the four (4) DMAs selected for the pilot program are summarized in **Table 8-5.**

Table 8-5
Pilot Program DMA Characteristics

DMA	DMA Characteristics
East Bank District 16	Highest estimated annual cost of savings by reduction of leakage
East Bank District 18	Highest number of service connections per mile
East Bank District 32	Lowest number of service connections per mile
West Bank District 4	Representative DMA of the West Bank system

It is estimated that implementation of this leakage detection pilot study will take approximately two (2) years to complete. The cost estimate breakdown for the pilot DMAs is included in **Appendix H**.

8.4.2 Leak Detection Survey

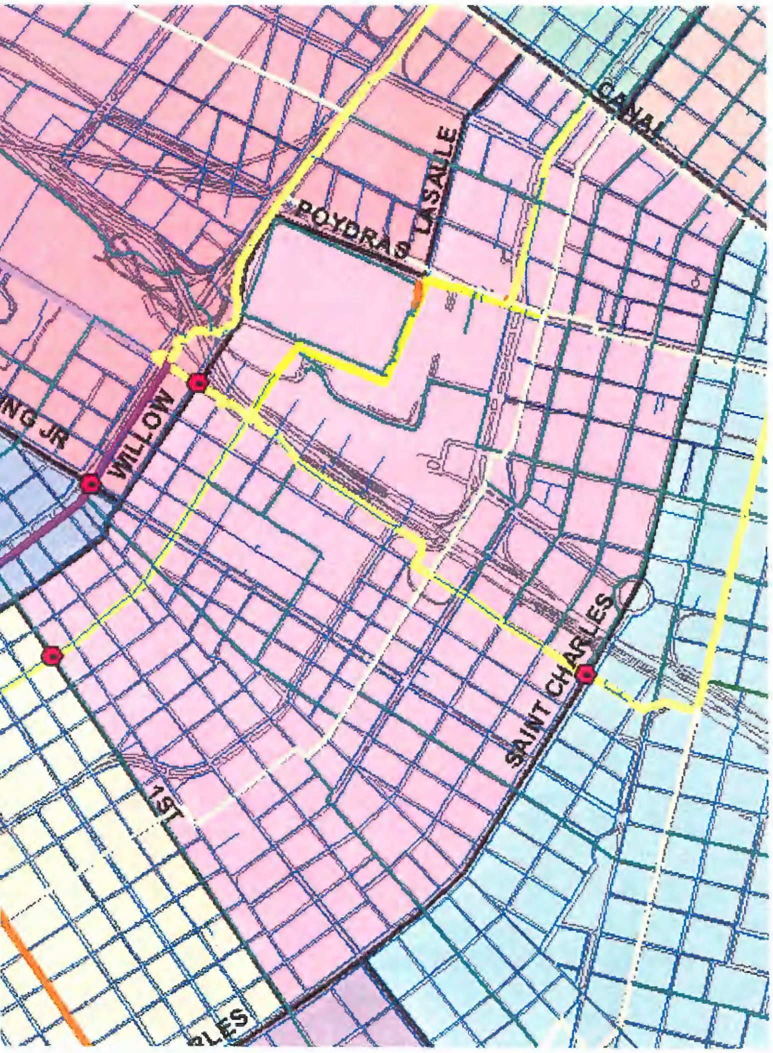
Once the level of leakage in each DMA has been estimated with flow monitoring, a leak detection survey should be performed within the DMA to locate specific leaks. The goal of the ALC is to reduce leakage below the current level. As a result of the initial leak detection, it is anticipated that a large number of leaks will be identified. The frequency of leak repairs will most likely reduce as the backlog of leaks is addressed. When all of the known leaks are repaired, the night flow should be re-measured to establish a base level of undetected leakage.

8.5 SUMMARY

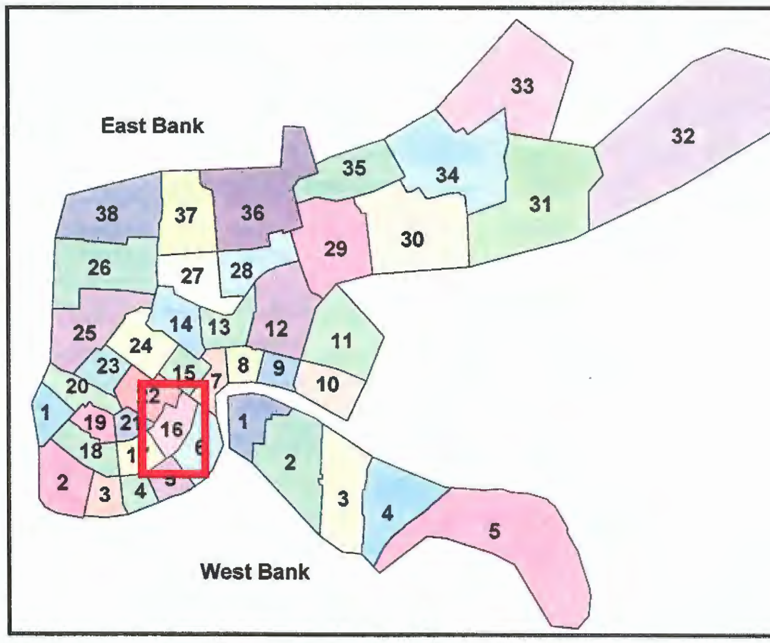
The leakage management plan recommended for the S&WB includes continuation of the existing leak detection and sounding program as well as implementation of DMAs. Additional supporting information for the DMAs is included in **Appendix H**. Once the DMA program has been implemented, step testing should be considered in the future for additional leakage control. The evaluation of ALC alternatives indicates an increased level of ALC may be cost effective.

As a planning level effort, the preliminary cost estimate for the benefit associated with recovering leakage was compared to the total cost of the recommended ALC. Comparing the benefit of recovering leakage over a 20-year period (ranging from $211.1 million to $700.4 million) to the cost of ALC ($7.4 million) indicates that implementation of the recommended leakage control projects is financially beneficial and justified.

As leaks are detected and broken water mains are repaired within the distribution system, the GIS files and subsequently the hydraulic model should be updated. With the use of the GIS database files, all repairs conducted as part of the leakage management plan can



East Bank District 16	
Length of Water Main	37 miles
Number of Service Connections	2,555
Density of Service Connections	70 service connections/mil
Number of Closed Valves	56
Number of District Meters	3
Average Daily Demand (1997-2001)	5.0 MGD



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Boundary Valve
DMA Boundary
Water Main
Streets

Water Distribution System
Assessment and Hydraulic Model
East Bank District 16
Figure 8-7

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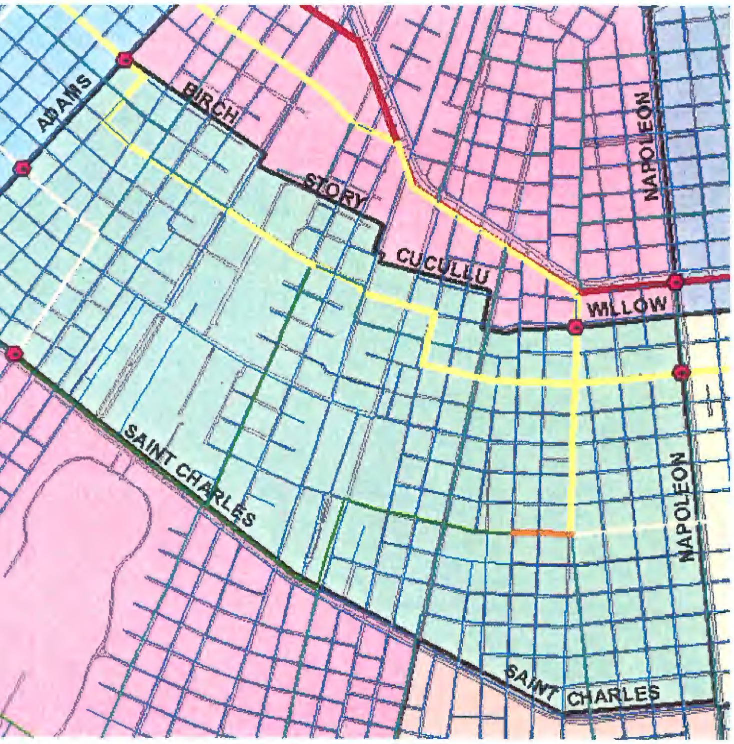
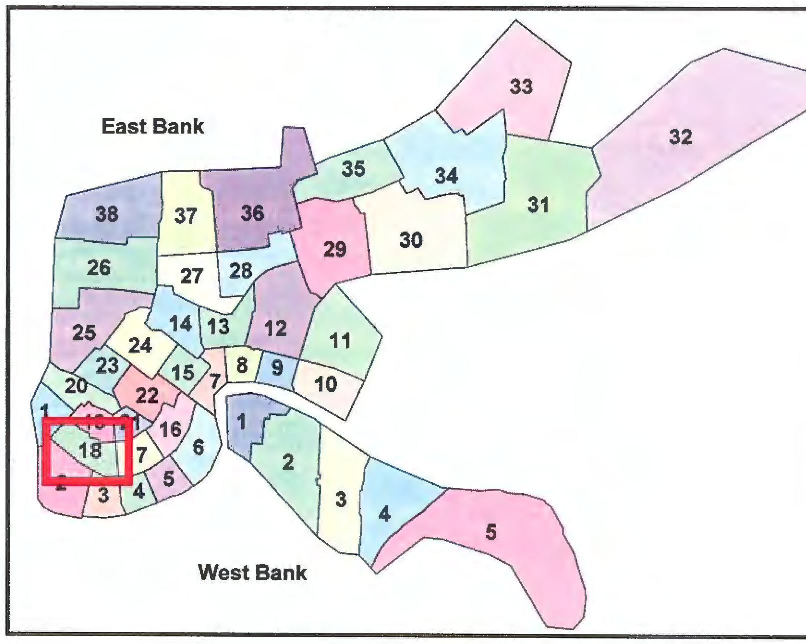


East Bank District 18	
Length of Water Main	32 miles
Number of Service Connections	4,718
Density of Service Connections	145 service connections/mile
Number of Closed Valves	67
Number of District Meters	5
Average Daily Demand (1997-2001)	1.9 MGD



Boundary Valve
DMA Boundary
Water Main
Streets

Water Distribution System
Assessment and Hydraulic Model
East Bank District 18
Figure 8-8

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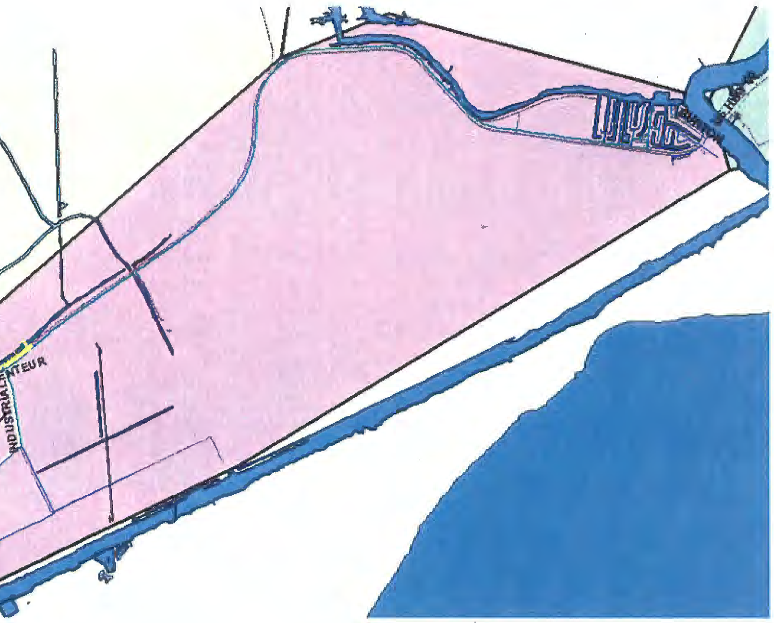
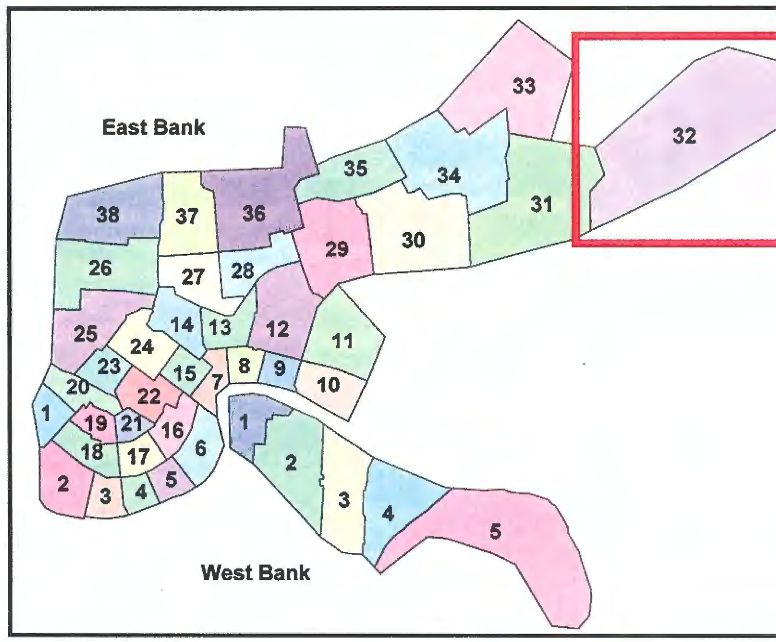


East Bank District 32	
Length of Water Main	17 miles
Number of Service Connections	435
Density of Service Connections	26 service connections/mil
Number of Closed Valves	0
Number of District Meters	1
Average Daily Demand (1997-2001)	0.3 MGD



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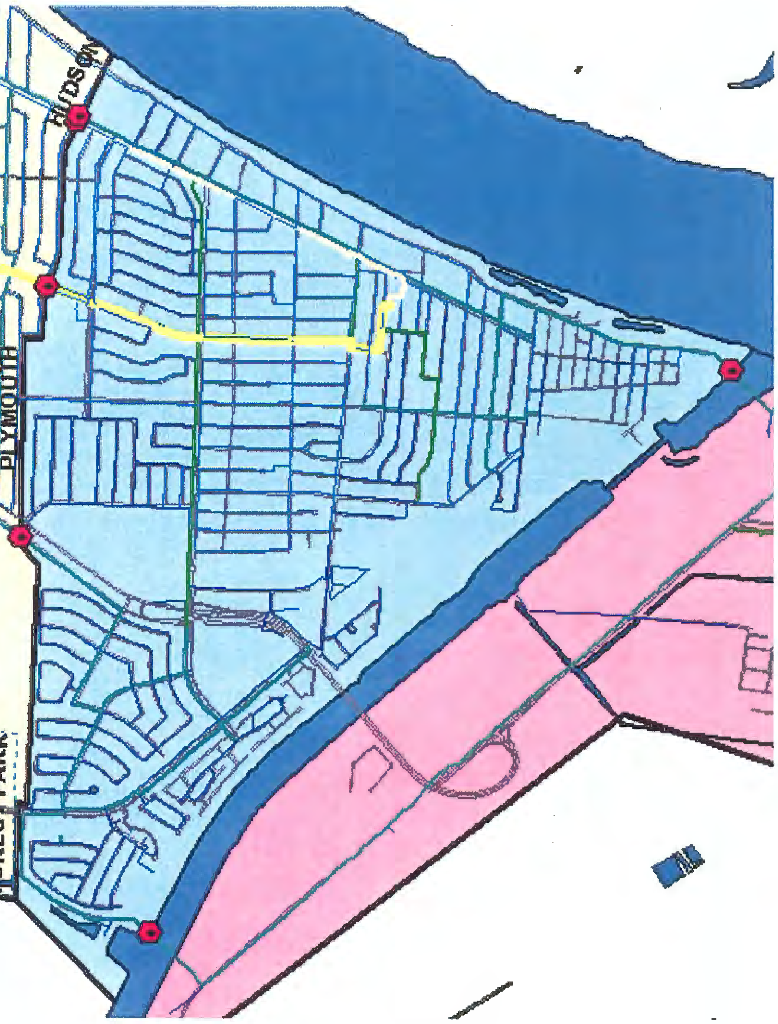
Boundary Valve
DMA Boundary
Water Main
Streets

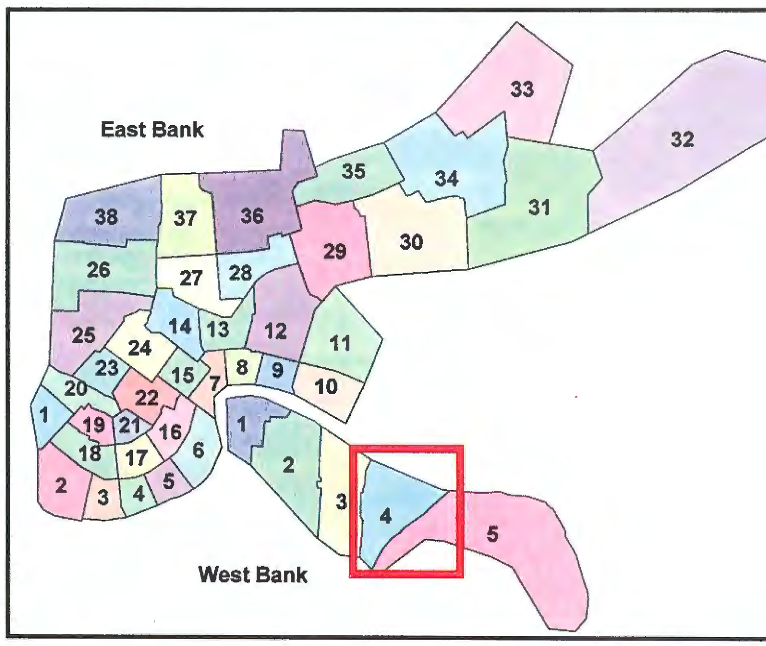
Water Distribution System
Assessment and Hydraulic Model
East Bank District 32
Figure 8-9

"RE-BUILDING THE CITY'S WATER SYST
Sewerage & Water Boa

MW



West Bank District 4	
Length of Water Main	52 miles
Number of Service Connections	4,156
Density of Service Connections	81 service connections/mi
Number of Closed Valves	5
Number of District Meters	6
Average Daily Demand (1997-2001)	1.8 MGD



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Boundary Valve
DMA Boundary
Water Main
Streets

Water Distribution System
Assessment and Hydraulic Model
West Bank District 4
Figure 8-10

"RE-BUILDING THE CITY'S WATER SYST
Sewerage & Water Boa
MV

be compared to the recommendations for the systemwide structural rehabilitation program. In order to prevent overlapping efforts from the leakage repairs and the rehabilitation, the GIS files should be updated on a continuous and frequent basis. The updated hydraulic model can be used to evaluate the system performance as a result of system improvements.

Section 9

Section 9

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Section 9 – Capital Improvement Plan

This section discusses the criteria and assumptions employed in the development of the Capital Improvement Plan (CIP). Three (3) project groups recommended to address the deficiencies identified in the water distribution systems are also presented in this section. Details of the specific projects in each group are discussed, including the 20-year implementation schedule and planning level capital cost estimates. Finally, presented in this section is an alternate CIP, utilizing a 40-year implementation plan in comparison to the 20-year implementation plan for the structural rehabilitation program.

9.1 CRITERIA AND ASSUMPTIONS

The criteria utilized for the development of the CIP include hydraulic and structural conditions for the distribution systems, as discussed in **Section 6**, as well as improvements for the operation of the systems.

Structural rehabilitation projects were scheduled for a 20-year implementation period starting in 2005. Recommended projects that do not involve construction activities were scheduled to start as soon as possible to positively improve the operations of the distribution systems.

9.2 RECOMMENDED CAPITAL IMPROVEMENT PLAN

This section outlines the recommended improvement projects that were identified as a result of the system evaluation. The improvement projects are grouped into one of the following:

I. **Leakage Management**
II. **Structural Rehabilitation**
III. **System Improvements**

It is recommended that leakage management and structural rehabilitation be addressed as priorities. Hydraulic criteria and capacity system improvements should be re-evaluated once structural rehabilitation projects are implemented and leakage levels are reduced.

I. Leakage Management Projects

Four (4) leakage management projects are recommended as a result of the water leakage analysis to identify and reduce leakage levels within the distribution systems. These projects are scheduled for immediate implementation since they should provide significant improvements to the water systems as well as better accountability of the water produced. The duration for these projects ranges from one (1) to three (3) years.

Project No. 1. Washout Valve Inspection

As a potential source of UFW, the washout valves used to drain water mains during maintenance should be inspected and repaired, if necessary. Site visits are recommended to physically inspect the condition of the valves to determine if they are functioning properly. Repairs should be conducted on the valves as necessary. Location maps for the washout valves identified are located in **Appendix H**. The inspection of the washout valves should be conducted within the first six (6) months of the CIP. After all valves have been inspected it is recommended that a procedure be developed for routine inspection and maintenance. The estimated cost for this project includes the staff required for inspection and the replacement of approximately ten (10) percent of the valves.

Project No. 2. Valve and Fire Hydrant Inspection and Maintenance Program

The water distribution valve and fire hydrant maintenance programs currently underway should be continued to identify valves and hydrants requiring maintenance and repair. The inspection of the valves and hydrants should continue and be completed within a three (3) year period.

The cost for the valve and hydrant inspection and maintenance program is based on the replacement of approximately ten (10) percent of the existing valves. The S&WB has inspected the majority of the hydrants and approximately ten (10) percent of the hydrants were found to require replacement. All defective hydrants identified by the SW&B have been replaced thus the cost for replacement of hydrants is not included in this program cost.

Project No. 3. Pilot District Metering Areas (DMAs) Implementation

It is recommended that four (4) DMAs be implemented for a pilot study, as described in **Section 8**. This will allow key design and operation criteria as well as standards and staffing requirements to be established prior to permanent installation of district metering on a systemwide scale. The pilot DMAs are recommended for immediate implementation over a two (2) year period. The cost breakdown for the pilot study is included in **Appendix H**.

Project No. 4. Leakage Management Program

The recommendations from the leakage management analysis include the implementation of Active Leakage Control (ALC) utilizing DMAs and leak detection and sounding. The implementation of district metering requires the installation of metering stations, selection of boundary valves, hydraulic analysis, plus monitoring of large water consumers, flow within a district, and night flow. The installation of systemwide DMAs is recommended once the pilot DMAs have begun. Details of the leakage management program are discussed in **Section 8**. Supporting information and details for the DMAs is included in **Appendix H**. The cost for the leakage management program includes the cost of 39 DMAs (excluding the four (4) pilot DMAs) as well as the leak detection and sounding program.

II. Structural Rehabilitation Projects

Projects included in the structural rehabilitation group were identified as a result of the structural analysis of the distribution systems with the KANEW model and the replacement prioritization process. Twenty-one (21) project areas were identified and scheduled based on the priority replacement of water mains within the project area. Each structural rehabilitation project area is scheduled for a duration of five (5) years including design, bid and award, and construction phases, with all of the projects distributed over a 20-year period. The cost estimate of the structural rehabilitation projects includes the cost for design, bid and award, and construction phases.

Unit costs were estimated for the replacement of water mains including the cost to install new hydrants and valves. Although the S&WB has an existing hydrant and valve maintenance program, it is anticipated that new hydrants and valves will be installed as a part of the structural rehabilitation program. Inclusion of new hydrant and valve installation yields a more conservative cost estimate for the CIP.

In developing the construction cost estimates, assumptions were made for the spacing of fire hydrants and valves. The number of fire hydrants estimated for the structural rehabilitation is similar to the number of existing hydrants. Fire hydrant spacing is assumed at approximately one per 500 linear feet on water mains less than or equal to 12-inches in diameter, one per 1,000 linear feet on water mains from 16 to 20-inches in diameter, and one per 2,000 linear feet on water mains greater than 20-inches in diameter. In comparison, the system reliability criterion for hydrant spacing is a maximum of 350 linear feet.

Valve spacing is assumed at approximately one per 200 linear feet on water mains less than or equal to 20-inches in diameter, one per 500 linear feet on water mains 24-inches in diameter, and one per 1,000 linear feet on water mains greater than 24-inches in diameter. In comparison, the system reliability criterion for valve spacing is a maximum of 1,000 linear feet along water mains.

A detailed cost breakdown for the water main rehabilitation is included in this section. Details of the structural rehabilitation project areas are provided in **Appendix H** including location maps, project schedules and planning level capital cost. Following is a listing of the structural rehabilitation area projects.

Project No. 5. Rehabilitation in Project Area A
Project No. 6. Rehabilitation in Project Areas B1 and B2
Project No. 7. Rehabilitation in Project Areas C1 and C2
Project No. 8. Rehabilitation in Project Area D
Project No. 9. Rehabilitation in Project Area E
Project No. 10. Rehabilitation in Project Areas F1 and F2

Project No. 11.	Rehabilitation in Project Area G
Project No. 12.	Rehabilitation in Project Area H
Project No. 13.	Rehabilitation in Project Areas I1, I2, and I3
Project No. 14.	Rehabilitation in Project Area J
Project No. 15.	Rehabilitation in Project Areas K1, K2, and K3
Project No. 16.	Rehabilitation in Project Areas L1 and L2
Project No. 17.	Rehabilitation in Project Areas M1 and M2
Project No. 18.	Rehabilitation in Project Areas N1 and N2
Project No. 19.	Rehabilitation in Project Area O
Project No. 20.	Rehabilitation in Project Area P
Project No. 21.	Rehabilitation in Project Area Q
Project No. 22.	Rehabilitation in Project Area R
Project No. 23.	Rehabilitation in Project Area S
Project No. 24.	Rehabilitation in Project Area T
Project No. 25.	Rehabilitation in Project Area U

III. System Improvements Projects

Five (5) projects were identified for system improvements as a result of the overall system analysis. These projects include improved data retrieval and management. System improvement projects, excluding installation of SCADA and purification plant flow meters, do not require time for design, bid, and construction and are therefore recommended for early implementation. The duration for the system improvements projects ranges from one (1) to 20 years.

Project No. 26. Customer Meter Inspection and Maintenance Program

It is recommended to continue and expand the existing meter inspection and maintenance program for the customer billing meters. As meters age, they tend to move out of calibration and will either over or under represent actual flow data. Currently, the S&WB routinely tests and maintains residential meters. Commercial meters are currently tested and repaired on an as needed basis only. Since many commercial users are larger water users in comparison to residential users, it is important that commercial meters are accurately accounting for consumed water. In this project it is assumed that commercial meters are routinely inspected and maintained once every ten (10) years at a minimum. The cost for the meter inspection and replacement program is based on the replacement of all customer meters at an average replacement cost for rebuilt meters, provided by the S&WB.

Project No. 27. GIS Data Management Implementation and Update

With the existing GIS developed in conjunction with the hydraulic model, all construction, improvements, repairs, and maintenance to the distribution systems can be tracked in one central location available for access by multiple users. Area maps can be generated from the GIS to represent any portion of the system. The GIS is structured so that it may be linked to CassWorks for information and updates on repairs and maintenance. The customized GIS tool, WDTTE Water, also allows for direct updates within ArcView with the capability to track all changes in the database structure.

Subsequent to the construction of the GIS, improvements were made within the distribution systems and tracked on the Sewer and Water Maps by the S&WB. The existing GIS files were constructed based on the distribution system inventory available at the time. The GIS should continue to be updated with the most recent system inventory and should be conducted over the duration of the CIP. All future improvements to the distribution systems should be tracked in GIS. The hydraulic model should also be updated as information is added and refined. The cost estimate includes the engineering fee required to implement this project.

Project No. 28. System Optimization and Analysis

System optimization is recommended utilizing the hydraulic model updated with information from ongoing system improvements. As the hydraulic model is updated, additional system analyses should be conducted to develop sufficient hydraulic parameters and to evaluate future capacity requirements.

The system optimization and analysis should be conducted as structural improvement projects are performed (starting in 2005), over a five (5) year period to optimize future construction projects. The hydraulic model should be updated with information from ongoing construction projects in order to continue the refinement of the hydraulic performance of the system. The hydraulic performance should be evaluated to understand the effect of subsequent construction projects. The cost estimate includes the engineering fee required to implement this project.

Project No. 29. Water Purification Plants Audit

Based on the difficulty experienced in acquiring flow data from the purification plants during this study, a Water Audit is recommended to better establish the capacity and UFW at both the Carrollton and Algiers Plants. The audit should include an analysis of the data collection methods, water entering the plants, treated water at unit processes, and water distributed to determine the leakage and UFW within the plants. A detailed assessment of the capacity of all distribution pumps, storage facilities, future storage requirements, and existing power sources should be conducted as well.

The Audit should take into consideration the existing configuration of the West Bank distribution system is such that water can be supplied to the City of Gretna and the Industrial Park area in Plaquemines Parish. The audit is recommended for immediate implementation and the project duration is estimated over a one (1) year period. The cost estimate includes the engineering fee required to conduct the audit.

Project No. 30. SCADA Installation and Data Automation

Recommendations are made for installation of a Supervisory Control and Data Acquisition (SCADA) system for use at the purification plants and the distribution systems. Collection and recording of operational data is most efficiently provided by a fully implemented SCADA system. A SCADA interface within the hydraulic model also allows real-time modeling data to be downloaded directly from the SCADA system.

The system will consist of process control instruments installed in the field, control panels and cabinets, control and power wiring, telemetry equipment, and a distribution of Programmable Logic Controllers (PLC) and operator workstations, or Man Machine Interface (MMI).

SCADA is also recommended within the Carrollton Plant, at the East Bank raw water intake, and the recommended East and West Bank DMAs. The Algiers Plant has an existing data collection system that is currently being refurbished. The cost breakdown for SCADA installation is included in **Appendix H**. SCADA installation will require design, bid, and construction phases, which is estimated over a three (3) year period. The cost estimate includes the design, installation and equipment cost.

Project No. 31. Purification Plant Flow Meters Installation

The existing venturi meters and manometers for the water purification plants should be evaluated for operability and accuracy. Reliable flow meters at the purification plants are essential in order to understand the hourly production and distribution of water. Upon evaluation of the existing plant meters, a recommendation will be made for repairs or replacement as necessary. A procedure for regular calibration and maintenance of the new and existing flow meters is also recommended. The installation of flow meters will require design, bid, and construction phases, which is also estimated over a three (3) year period. The cost estimate includes the installation and equipment cost of flow meters.

9.3 CIP SCHEDULE

Capital improvement projects are sequenced according to system needs. Projects addressing exiting system deficiencies are scheduled over the next 20 years, with projects having the greatest impact listed first.

A schedule for each project, including start date, duration, and end date was developed using Primavera's SureTrak scheduling software. An overall 20-year master schedule for the CIP was also developed. Some projects require work to be performed immediately (to conduct initial inspections) while others are on a continuous basis (for annual maintenance programs). Each construction project schedule is comprised of the following major activities:

- **Design** – includes pre-design, preliminary design, and final design phases. Pre-design and preliminary design consist of developing a detailed design scope of work, contract negotiation, establishing the basis of design, surveying, water main route selection, value engineering and permits identification. Final design includes generation of construction documents (specifications and plans) including traffic maintenance plans after specific field conditions are assessed and incorporated.

- **Bid and Award** – includes responding to inquiries from prospective bidders, pre-bid meetings, bid openings, developing required addenda, bid evaluation, and contract document execution.

- **Construction** – includes the physical implementation of all tasks associated with the project from mobilization to project close-out including engineering services during construction (ESDC) and construction management (CM).

The duration of each activity was assigned based on experience from similar projects, including projects performed by the S&WB. **Table 9-1** shows the durations assumed for the major project activities.

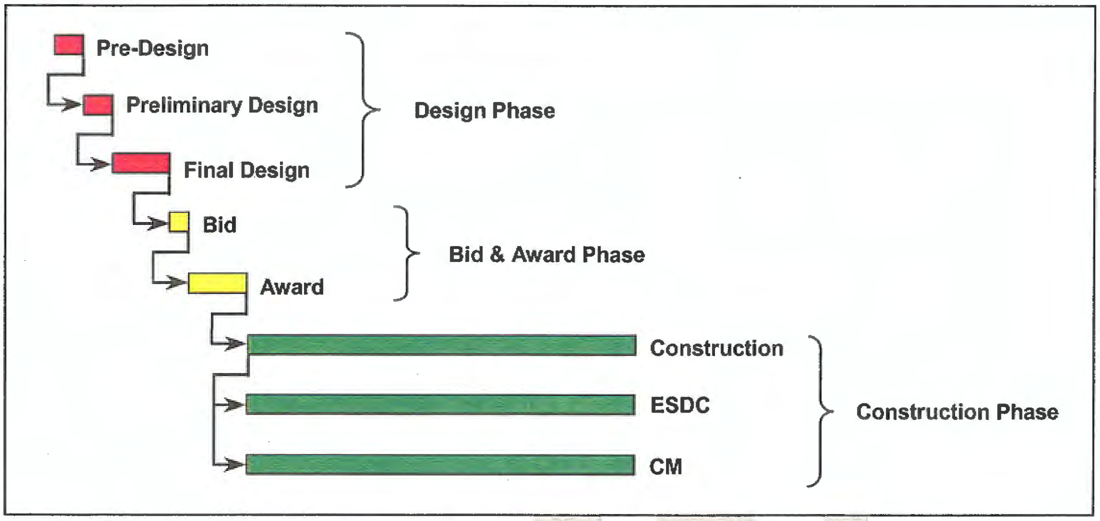
Table 9-1
Duration of Project Area Construction Activities

Activity	Duration[1]
Design Phase	12 months
Bid and Award	6 months
Construction	40 months

Note:
1 – Duration of each activity is for an entire project area.

Within each project, relationships were established between tasks to ensure optimal project flow. A typical project schedule is shown in **Figure 9-1**.

Figure 9-1
Typical Project Schedule



A master schedule summary of all recommended improvement projects from pre-design through construction activities is shown in **Figure 9-2**. The master schedule shows that all activities associated with the capital improvement projects will be completed by 2030.

9.4 COST ASSUMPTIONS

Planning level capital cost estimates were developed for the projects proposed in this CIP. The capital cost consists of estimates for construction, engineering, construction management, contingency, and legal/administration fees.

Unit costs for water main repair were developed to estimate project costs. An estimated capital cost breakdown for the planned improvement projects is provided as well as the cost distribution over the 20-year implementation schedule.

9.4.1 Unit Costs

Unit costs were established for each of the water facilities including new water main installation, valves, fire hydrants, and surface restoration in order to standardize cost calculations. A detailed breakdown of all unit costs is shown in **Table 9-2**. A number of sources were investigated to compile the cost data that was used to establish the unit costs. Actual construction costs from similar S&WB projects were obtained, local contractors were contacted and other similar projects throughout the southeastern United States were researched. The data was reviewed and compared, and engineering judgement was applied to develop the unit costs shown in **Table 9-2**.

Description	Start	Finish
I. Leakage Management Projects		
City-Wide		
Washout Valve Inspection	01SEP03	29FEB04
Valve and Hydrant Inspection and	01SEP03	31AUG06
Pilot DMA (four areas) Implementation	01JAN04	30DEC05
Leakage Management Program	01JAN05	30DEC07
II. Structural Rehabilitation Project Areas		
A		
Structural Rehabilitation Design	01JAN05	31DEC05
Bid/Award	01JAN06	30JUN06
Construction	01JUL06	31DEC09
+B1, B2		
	01JAN06	31DEC10
+C1, C2		
	01JAN07	31DEC11
+D		
	01JAN08	31DEC12
+E		
	01JAN09	31DEC13
+F1, F2		
	01JAN10	31DEC14
+G		
	01JAN11	31DEC15
+H		
	01JAN12	31DEC16
+I1, I2, I3		
	01JAN13	31DEC17
+J		
	01JAN14	31DEC18
+K1, K2, K3		
	01JAN15	31DEC19
+L1, L2		
	01JAN16	31DEC20
+M1, M2		
	01JAN17	31DEC21
+N1, N2		
	01JAN18	31DEC22
+O		
	01JAN19	31DEC23
+P		
	01JAN20	31DEC24
+Q		
	01JAN21	31DEC25
+R		
	01JAN22	31DEC26
+S		
	01JAN23	31DEC27
+T		
	01JAN24	31DEC28
U		
Rehab Design, bid, award, construction	01JAN25	31DEC29
III. System Improvements		
+Customer Meter Inspection and Maintenance		
	01JAN04	01JAN24
+GIS Data Management Implementation and Updating		
	01JAN04	01JAN24
+System Optimization and Analysis		
	01JAN05	31DEC09
+Water Purification Plants Audit		
	01JAN04	31DEC04
+SCADA Installation and Data Automation		
	01JAN05	31DEC07
+Purification Plant Flow Meters Installation		
	01JAN04	31DEC06

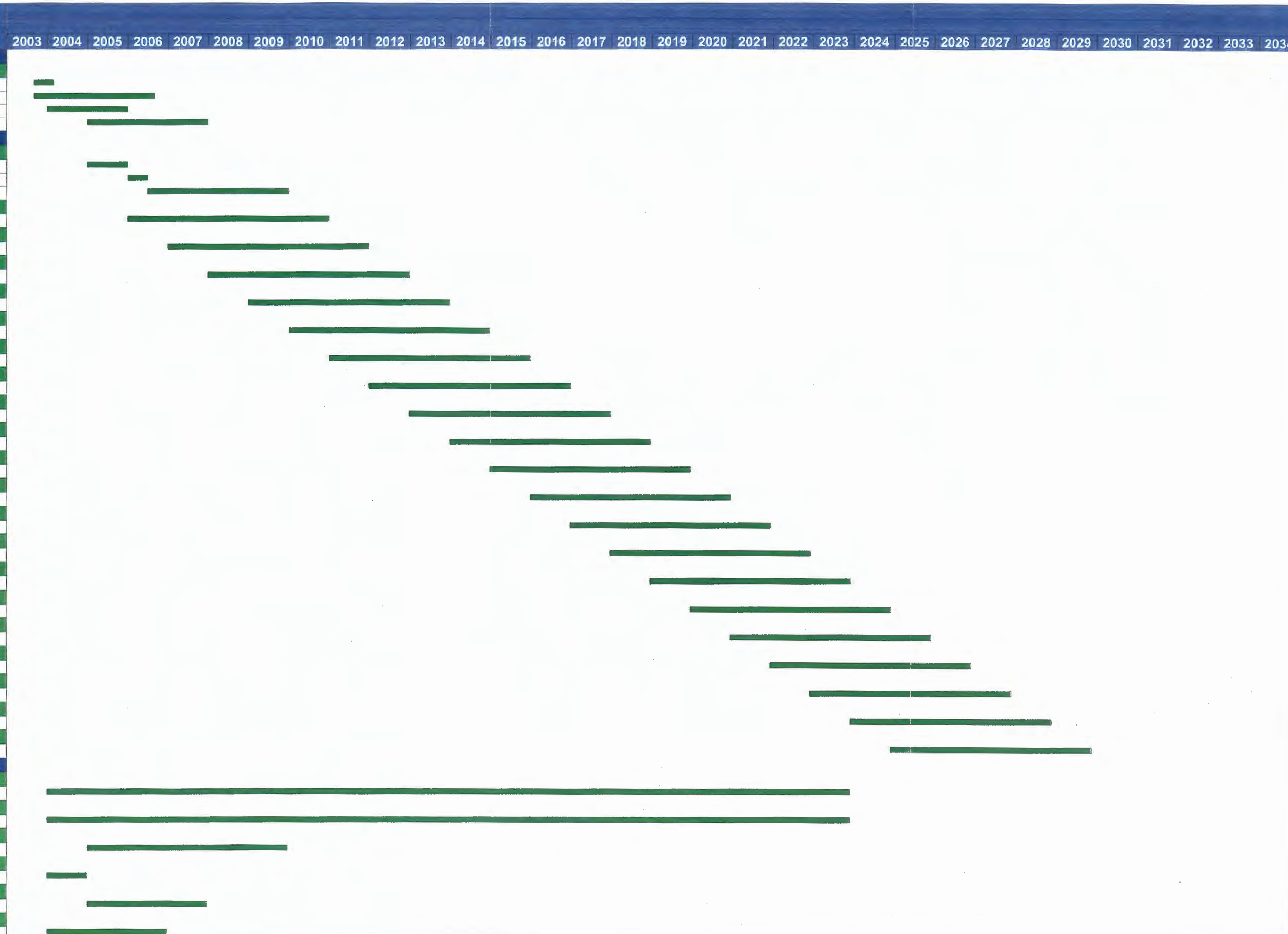


Figure 9-2
Capital Improvement Plan Schedule

Table 9-2
Water Main Unit Costs per Linear Foot

Cost Element	8-inch PVC	10-inch PVC	12-inch PVC	16 to 20-inch DI	24-inch DI	30 to 36-inch DI	42-inch DI	48-in DI
Water Main	$70	$76	$84	$102	$132	$150	$210	$24
Service Connections	$32	$32	$32	$32	$32	-	-	-
Fire Hydrant	$7	$7	$7	$4	$3	$3	$3	$3
Valve	$16	$23	$36	$49	$45	$72	$40	$42
Site Preparation and Restoration	$113	$113	$113	$113	$113	$207	$207	$20
Raw Construction Cost	*$240*	*$260*	*$280*	*$300*	*$330*	*$440*	*$460*	*$50*
Construction Allowances and Contingency (30%)	$72	$78	$84	$90	$99	$132	$138	$15
Design and Engineering Services (10%)	$24	$26	$28	$30	$33	$44	$46	$50
Construction Management (10%)	$24	$26	$28	$30	$33	$44	$46	$50
Legal and Administrative (1%)	$3	$3	$3	$3	$4	$5	$5	$5
Support from S&WB for System Operation (1%)	$3	$3	$3	$3	$4	$5	$5	$5
Capital Cost	**$370**	**$400**	**$430**	**$460**	**$510**	**$670**	**$700**	**$76**

Notes:

1 - One fire hydrant per 500 feet on mains 12-inches in diameter and less; one fire hydrant per 1,000 feet on mains from 16 to 20-inches in diameter; one fire hydrant per 2,000 feet on mains greater than 20-inches in diameter.

2 - One valve per 200 feet on mains 20-inches diameter and less; one valve per 500 feet on mains 24-inches in diameter; one valve per 1,000 feet on mai greater than 24-inches in diameter.

3 - Fifty percent of road width (16 feet) replaced up to 24-inch diameter; 100 percent of road width replaced greater than 24-inch diameter.

4 - Construction and capital cost rounded up to the nearest tens.

5 - Allowances and contingency include temporary restoration, chlorination and testing, temporary services, traffic management, bypass pumping, confli resolution, and damage claims.

9.4.2 Cost Structure

Several steps were performed in order to develop the capital cost for all proposed capital improvements. First, a capital cost structure was developed which outlines and provides a standard process for developing cost estimates. Second, construction unit costs were established for water main repair using cost data from similar S&WB projects as well as other similar projects in the region. Finally, total cost estimates were generated for each water main by size.

The process for estimating the capital cost for structural improvement projects is outlined in the following steps and summarized in **Table 9-3**:

1. **Estimate the Raw Construction Cost** – The quantity of materials (or units) needed for upgrading an existing water facility multiplied by the unit cost of each item.

2. **Apply a Construction Allowance and Contingency** – A 30 percent construction allowance and contingency were applied to reflect the planning level of the identified improvements and to add a provision for additions or changes that may occur as the project proceeds through design. Some of the costs covered under allowances may include the tasks of temporary restoration, chlorination and testing, temporary services, traffic management, bypass pumping, conflict resolution, and damage claims.

3. **Estimate Engineering Related Services** – The cost of preliminary design, final design, bid and award and engineering services during construction. These services are estimated as ten (10) percent of the raw construction cost (step 1 above).

4. **Estimate Construction Inspection and Management Services** – Activities include submittal review, shop drawing approval, response to requests for information and project start-up, contract administration, progress payments, and inspection. These services are estimated as ten (10) percent of the raw construction cost (step 1 above).

5. **Estimate Legal and Administration Costs** – Costs associated with the bid and award phase, project closeout, public meetings associated with the project, etc. These services are estimated as one (1) percent of the raw construction cost (step 1 above).

6. **Estimate S&WB Support** – Costs associated with the support from the S&WB for system operations in relation to project activities. These services are estimated as one (1) percent of the raw construction cost (step 1 above).

7. **Calculate the Capital Cost Subtotal** – The capital cost subtotal is determined by summing the cost from Steps 1 through 6.

8. **Determine the Inflation** – Future cost estimated using three (3) percent annual increase to account for inflation. Inflation was calculated based on the subtotal of all leakage management projects, structural rehabilitation projects, and system improvement projects and projected to the mid-point duration for each project group.

9. **Calculate the Total Capital Cost** – The total capital cost is determined by summing the costs from Steps 7 and 8.

Table 9-3
Water Main Replacement Capital Cost Structure

Step	Cost Item Description	Cost Item Calculation
1.	Raw Construction Cost	(Quantity) x (Unit Cost)
2.	Construction Allowances and Contingency	30% of Step 1
3.	Design and Engineering	10% of Step 1
4.	Construction Management	10% of Step 1
5.	Legal / Administration	1% of Step 1
6.	Support from S&WB	1% of Step 1
7.	Capital Cost Subtotal	SUM of Steps 3, 4, 5, & 6
8.	Inflation	3% of Step 7 to mid-point of project duration
9.	**Total Capital Cost**	**SUM of Steps 7 & 8**

9.4.3 Project Capital Cost

Based on the cost structure and unit costs outlined above, a capital cost estimate was derived for each of the proposed capital improvement projects. A summary of the capital cost estimate for the entire CIP is shown in **Table 9-4**. **Appendix H** includes detailed project descriptions with a capital cost breakdown for each of the 21 structural improvement projects.

Table 9-4
Estimated Cost for CIP Projects

Project Group	Project Description	Capital Cost ($1,000)
I. Leakage Management Projects	Washout Valve Inspection	$ 150
	Valve and Hydrant Inspection and Maintenance[1]	$ 5,720
	Pilot DMA (four areas) Implementation	$ 1,440
	Leakage Management Program	$ 5,950
	Inflation	*$ 990*
	Subtotal	**$ 14,250**
II. Structural Rehabilitation	Rehabilitation in Project Area A	$ 181,000
	Rehabilitation in Project Areas B1,B2	$ 158,000
	Rehabilitation in Project Areas C1,C2	$ 142,000
	Rehabilitation in Project Area D	$ 127,000
	Rehabilitation in Project Area E	$ 110,000
	Rehabilitation in Project Areas F1,F2	$ 92,000
	Rehabilitation in Project Area G	$ 131,000
	Rehabilitation in Project Area H	$ 108,000
	Rehabilitation in Project Areas I1,I2,I3	$ 83,000
	Rehabilitation in Project Area J	$ 74,000
	Rehabilitation in Project Areas K1,K2,K3	$ 34,000
	Rehabilitation in Project Areas L1,L2	$ 93,000
	Rehabilitation in Project Areas M1,M2	$ 71,000
	Rehabilitation in Project Areas N1,N2	$ 71,000
	Rehabilitation in Project Area O	$ 78,000
	Rehabilitation in Project Area P	$ 78,000
	Rehabilitation in Project Area Q	$ 54,000
	Rehabilitation in Project Area R	$ 61,000
	Rehabilitation in Project Area S	$ 66,000
	Rehabilitation in Project Area T	$ 57,000
	Rehabilitation in Project Area U	$ 55,000
	Inflation	*$ 836,940*
	Subtotal	**$2,760,940**
III. System Improvement Projects	Customer Meter Inspection and Maintenance Program[2]	$ 16,000
	GIS Data Management Implementation and Update	$ 3,000
	System Optimization and Analysis	$ 1,000
	Water Purification Plants Audit	$ 150
	SCADA Installation and Data Automation	$ 3,750
	Purification Plant Flow Meters Installation	$ 1,000
	Inflation	*$ 8,220*
	Subtotal	**$ 33,120**
	Total Capital Cost	**$2,808,310**

Notes:

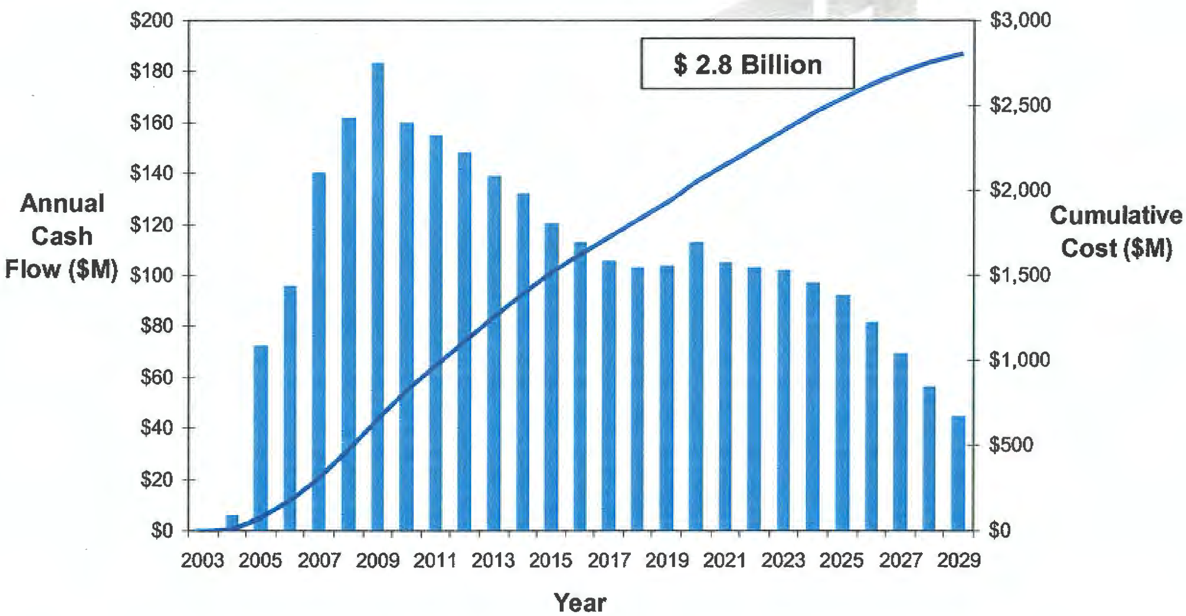
1 – Cost based on the replacement of ten (10) percent of the existing valves, at an average replacement cost of $4,000 per valve. The cost for replacement of hydrants is not included.

2 – Cost based on the replacement of all meters at an average replacement cost of $100 per meter.

9.5 COST PROJECTION AND DISTRIBUTION

A 20-year planning schedule was used along with the cost estimates for individual projects to determine a projected distribution for all recommended improvements. To accomplish this, each activity within a project was up-loaded in the scheduling program along with the estimated project costs. The scheduling software automatically distributes the costs associated with a particular activity over the duration of that activity, thus enabling a cost distribution to be generated. The projected capital improvement cash flow for the CIP is shown in **Figure 9-3**. The projected cash flow peaks in the year 2009 at $183 million.

Figure 9-3
Projected Capital Improvement Cash Flow



9.6 ALTERNATIVE CAPITAL IMPROVEMENT PLAN

As requested by the S&WB, an alternative CIP was developed in order to evaluate the reduction in the required annual capital cost. In order to accomplish this, only the recommended structural rehabilitation projects were scheduled over a longer period of time, specifically a 40-year planning schedule. This alternative CIP does not include an analysis of the system for additional structural rehabilitation recommendations beyond the 20-year condition analysis included in this study. Each of the water mains and project areas that are recommended in the 20-year CIP are included in the alternative CIP. That is, the rehabilitation program addresses the system's 20-year structural needs and scheduled over a 40-year period.

Based on the cost structure and unit costs outlined previously, a summary of the capital cost estimate for the alternative CIP is shown in **Table 9-5**. The breakdown of the individual project costs is shown previously in **Table 9-4**. As shown in **Table 9-5**, the subtotal for structural rehabilitation projects increases from $2.8 billion in the 20-year implementation to $3.4 billion for the alternative implementation plan. This increase is due to the cost of inflation estimated over the additional 20 years.

Table 9-5
Estimated Cost for Alternative CIP Projects

Project Group	Capital Cost ($ 1,000)
I. Leakage Management Projects	
Subtotal with Inflation	*$ 14,250*
II. Structural Rehabilitation	
Subtotal	$ 1,924,000
Inflation	$ 1,414,140
Subtotal with Inflation	*$ 3,338,140*
III. System Improvement Projects	
Subtotal with Inflation	*$ 33,110*
Total Capital Cost	**$ 3,385,500**

The master schedule summary for the CIP alternative is shown in **Figure 9-4**. Implementation of the CIP is scheduled from 2005 through 2045, with one project area initiated every other year. The duration for implementation of each project area remains at five (5) years, including design, bid and award, and construction phases. The alternative schedule shows that all activities associated with the capital improvement projects will be completed by 2050. The projected capital improvement cash flow for the alternative CIP is shown in **Figure 9-5**. Similar to the 20-year CIP, the projected cash flow for the alternative CIP peaks in the year 2009, but at a lower estimate of $133 million.

Description	Early Start	Early Finish
I. Leakage Management Projects		
City-Wide		
Washout Valve Inspection	01SEP03	29FEB04
Valve and Hydrant Inspection and	01SEP03	31AUG06
Pilot DMA (four areas) Implementation	01JAN04	30DEC05
Leakage Management Program	01JAN05	31DEC07
II. Structural Rehabilitation Project Areas		
A		
Structural Rehabilitation Design	01JAN05	31DEC05
Bid/Award	01JAN06	29JUN06
Construction	30JUN06	31DEC09
+B1, B2		
	01JAN07	31DEC11
+C1, C2		
	01JAN09	31DEC13
+D		
	01JAN11	31DEC15
+E		
	01JAN13	31DEC17
+F1, F2		
	01JAN15	31DEC19
+G		
	01JAN17	31DEC21
+H		
	01JAN19	31DEC23
+I1, I2, I3		
	01JAN21	31DEC25
+J		
	01JAN23	31DEC27
+K1, K2, K3		
	01JAN25	31DEC29
+L1, L2		
	01JAN27	31DEC31
+M1, M2		
	01JAN29	31DEC33
+N1, N2		
	01JAN31	31DEC35
+O		
	01JAN33	31DEC37
+P		
	01JAN35	31DEC39
+Q		
	01JAN37	31DEC41
+R		
	01JAN39	31DEC43
+S		
	01JAN41	31DEC45
+T		
	01JAN43	31DEC47
+U		
	01JAN45	31DEC49
III. System Improvements		
+Customer Meter Inspection and Maintenance		
	01JAN04	01JAN24
+GIS Data Management Implementation and Updating		
	01JAN04	01JAN24
+System Optimization and Analysis		
	01JAN05	31DEC09
+Water Purification Plants Audit		
	01JAN04	31DEC04
+SCADA Installation and Data Automation		
	01JAN05	31DEC07
+Purification Plant Flow Meters Installation		
	01JAN04	31DEC06

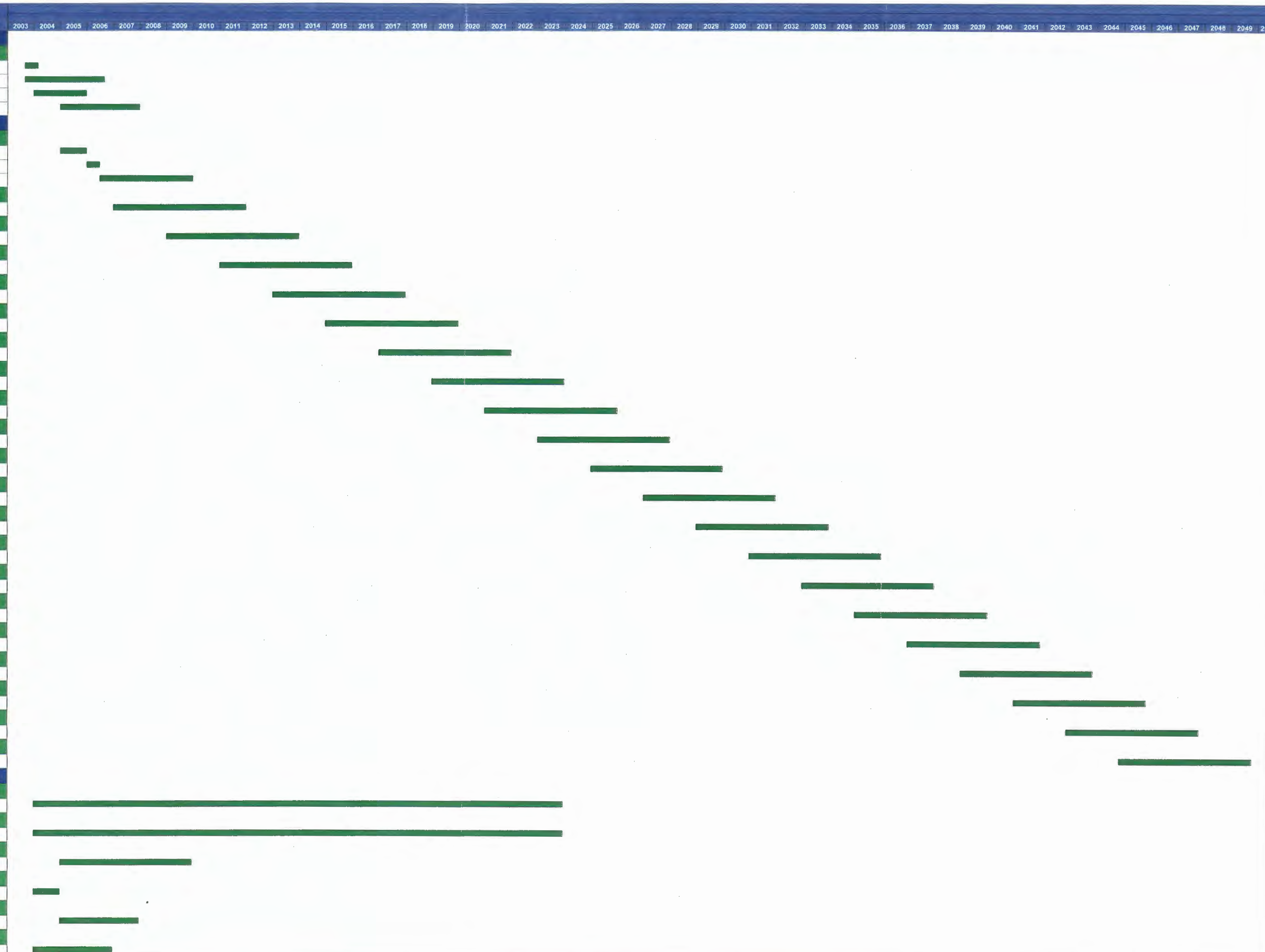
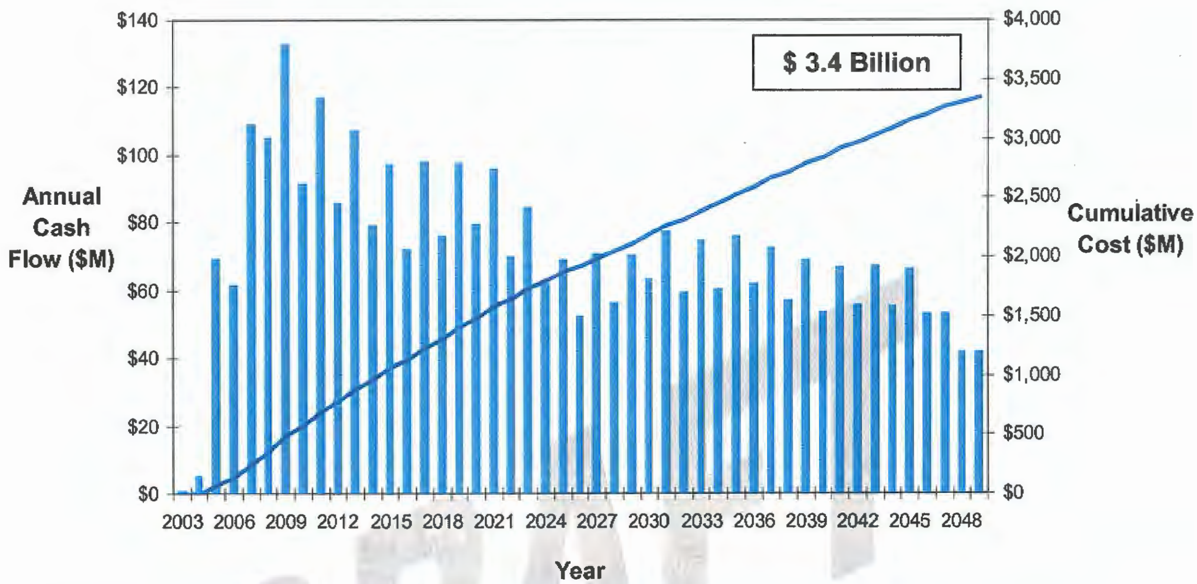


Figure 9-4
Alternative Capital Improvement Plan Schedule

Figure 9-5
Alternative CIP
Projected Capital Improvement Cash Flow



The cash flow shown in **Figure 9-5** is a preliminary projection for the alternative CIP. If the CIP alternative is selected, MWH will further refine the projected annual cash flow to level the peak cash distribution requirements and further assist with budget planning.

Appendix A

MWH

Appendix A – References and Data Sources

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KANEW Model Executive Summary

EXECUTIVE SUMMARY

INTRODUCTION AND OBJECTIVES

Due to the aging of the water distribution systems and the lack of timely maintenance on the part of most water utilities, there is an urgent need for the development of a predictive distribution system condition assessment model. This model should consider factors such as age, material, joints, and environmental conditions in identifying and estimating rehabilitation and replacement needs of a water distribution system. The American Water Works Association Research Foundation (AWWARF) contracted Roy F. Weston, Inc., (WESTON) to provide North American water utilities with such a model. The specific objectives of this study were the following:

- Develop a user friendly software suitable for use by North American water utilities to forecast water main rehabilitation and replacement needs, and develop long-term cost-effective strategies for water main rehabilitation and replacement.
- Demonstrate the effectiveness and applicability of this software by testing it at four North American and one British water utility.
- Develop a user manual for the easy use of the software.
- Identify and define the characteristics of the North American water distribution systems in terms of rehabilitation and replacement needs.

BACKGROUND AND SCOPE

To date, few if any, standardized techniques are available for North American water utilities to evaluate distribution systems and to develop proactive procedures. Water utility operators, in general, manage and operate distribution systems in a reactive mode by responding to emergency breaks and water main leaks. In Europe, however, Raimund K. Herz, a faculty member at Dresden University of Technology, and formerly at Karlsruhe University, Germany, developed the Karlsruhe model (KAMODEL) and applied it successfully at more than ten European utilities (Herz 1996).

WESTON teamed with Raimund K. Herz to develop a user friendly software (KANEW) for North American utilities and to enhance KAMODEL's capabilities.

As detailed input from water utilities was crucial to the development of KANEW, WESTON also teamed with the Philadelphia Water Department (PWD), and worked with Boston Water and Sewer Commission (BWSC), Los Angeles Department of Water and Power (LADWP), Fort Worth Water Department (FWWD), and Severn Trent Water, Ltd., (STW) United Kingdom, (UK) to test the software. Additional utilities participated by responding to a survey.

CHARACTERIZATION OF NORTH AMERICAN WATER DISTRIBUTION SYSTEMS

In order to provide a frame of reference for water utilities using the model, a study of available distribution system data was conducted to characterize North American water distribution systems. The goal was to determine "typical" distribution system characteristics for systems of various sizes and in different geographic regions. Three primary data sources were utilized for this purpose:

- American Water Works Association (AWWA) Water Industry Database (WIDB)
- Questionnaire developed for this project
- Previous AWWARF projects

In examining the data, North America was divided into seven geographic regions, six for the U.S., and one for Canada. It was found that in both countries, the use of both types of cast iron pipe, lined and unlined, is similar - in the range of 43% to 48%. However, in the U.S., the percentage of lined and unlined cast iron pipe are almost equal, in the range of 22% to 26%. In contrast, Canadian systems have substantially more unlined cast iron pipe than lined cast iron pipe (35% unlined versus 9% lined). Regional differences showed that the generally older sections of the country represented by the Northeast and Midwest have the highest percentages of cast iron pipe at 62% and 57%, respectively. The Northwest and West both have significant quantities of steel pipe (10% and 14%, respectively) compared to the rest of the country. The West region also has a substantial percentage (45%) of asbestos cement (AC) pipe, which is much higher than any other region of the country. Also the average percentage of the distribution system pipe that is replaced annually in the U.S. and Canada is 0.5% and 0.6%, respectively. Within the U.S. the annual replacement rates vary from 0.4% in the Midwest region to 0.7% in the Southeast region. Utilities are expanding their distribution systems at annual rates of 1.5% and 0.9% in the U.S. and Canada, respectively. Expansion rates vary from 1.0% in the South Central and Northwest regions to 2.3% in the Southeast region.

MODEL DESCRIPTION

The primary objective of KANEW is to provide water utilities with a tool to develop their long range pipe rehabilitation and replacement strategies. Based on the historical inventory of water main and the estimated life-span data, KANEW predicts the length of different categories of pipe to be rehabilitated or replaced on an annual basis. KANEW is a macro model and does not provide location specific rehabilitation and replacement information.

The process involves importing data on the water distribution network to the model, differentiated according to year of installation or rehabilitation and pipe categories which are defined with respect of aging behavior and data availability. Most important criteria for the definition of types of water mains are age, material, diameter and bedding quality.

For each type of water main survival functions must be determined. Survival functions are mathematical expressions of the life expectancies of each water main category, and are defined based on three ages, "low", "medium" and "high". These functions are estimated on the basis of failure, rehabilitation and replacement rates in the past and, particularly for modern pipe materials, through expert estimates of the useful life-span of the different water main categories. These estimates are used by the software to determine the parameters of the survival function for each pipe category. The model then simulates the aging process. The survival functions are applied to the current inventory of water mains year by year, and calculations are made to determine the lengths of water mains which reach the end of their useful lives and must therefore be rehabilitated or replaced.

There is considerable uncertainty in estimating future events, so, for each pipe category pessimistic and optimistic estimates of the useful life-spans are made. This results in a pessimistic survival function based on short life expectancies and an optimistic survival function based on long life expectancies of each pipe category.

The KANEW model developed in this study is user friendly and capable of providing 13 different sets of graphical and tabular outputs primarily showing percent or length of water mains of each category to be rehabilitated or replaced each year during a specified planning period.

CASE STUDIES

KANEW was applied to four U.S. and one UK water utility. The project team worked with each utility to select water main categories for modeling and to estimate life expectancies for each category. In some cases, the project team also worked closely with the utility to collect the data necessary to complete the water main inventory for modeling.

Each water utility was unique in terms of data availability. Some had detailed computerized databases with which the water main inventory could be readily generated. Others had more limited data available and relied on known information about the distribution system and assumptions by personnel familiar with the system. In one case, the utility had enough historic data available to calculate aging functions for several of its water main categories. Regardless of the level of detail available, the model was shown to provide valuable guidance for utilities in planning long-term rehabilitation and replacement programs. The results of the case studies and the characterization of North American water utilities indicate that due to lack of availability of a detailed inventory of pipes for water utilities, inventory of each separate group of pipes cannot be developed. Rather, several groups of pipes can be consolidated to compromise with the lack of data. Additionally, it was found that the unlined cast iron water mains were the predominant type of mains in North American water utilities, and required most of the replacement or rehabilitation. For the test case utilities the following observations were made:

1. Under optimistic assumptions for PWD, the rehabilitation and replacement rate is fairly constant at approximately 0.6% to 0.8% of water mains per year. Under pessimistic assumptions, about 1.2% rehabilitation and replacement is required at the beginning of the planning period with this rate dropping during the latter part of the

planning period. Small diameter cast iron mains are the predominant pipes for rehabilitation and replacement.

2. Under optimistic assumptions LADWP would require rehabilitation and replacement rates of approximately 2.3% of its water main annually, gradually declining to 1.1% by year 2015. Under pessimistic assumptions, the predicted rehabilitation and replacement rates start at the rate of 4.4% annually and then decline to 1.1% by year 2015. LADWP's actual rehabilitation and replacement rate of 2.7% for fiscal year 1995 fell between the optimistic and pessimistic assumptions. Again, most of the water mains that are rehabilitated or replaced are cast iron mains.
3. BWSC water systems require about 2% per year (optimistic assumptions) to about 6.5% per year (pessimistic assumptions) at the beginning of the planning period. Most of these candidates mains are 8 inch to 12 inch unlined cast iron mains. In recent years the actual replacement and rehabilitation rates at BWSC have been very close to the optimistic estimation.
4. Due to its relatively young age, FWWD's rehabilitation and replacement needs increased with time as the average age of the system increased coming closer to the life-span estimates.
5. Under optimistic assumptions the water main replacement and rehabilitation rate for Nottinghamshire Water System of STW is 1.5% per year. Under pessimistic assumptions, the rate of rehabilitation and replacement starts initially at 3.3% annually and then reduces to about 1.5% by year 2015. Most of the candidate water mains for replacement and rehabilitation are cast iron and gray iron pipes.

RECOMMENDATIONS

To develop good estimates of water main replacement and rehabilitation needs the following recommendations are made for North American water utilities:

1. KANEW should be used by other water utilities for assessing and developing water main replacement and rehabilitation programs.

2. Water utilities should develop better database management systems for their existing distribution system inventories and for capturing historical water main replacement and rehabilitation data.
3. Water utilities should develop geographic information systems (GIS) which would also assist utilities in the use of the model.
4. A workshop should be conducted to discuss and develop consensus on estimation of survival functions for various categories of water mains.

FUTURE WORK

The following are recommended for future work:

1. The present model should be enhanced by incorporating
    - main break functions to predict water main break frequency changes as a result of the implementation of different rehabilitation and replacement strategies
    - the impact of future rehabilitation and replacement work in the development of rehabilitation and replacement strategies
    - the impact of the frequency and cost of failures on rehabilitation and replacement strategies
2. A companion model should be developed. This model would derive survival functions for various water main categories from historical data on main failures, and replacement and rehabilitation data.
3. Additional investigations should be conducted on the prioritization of rehabilitation and replacement work using results from KANEW and other information found in engineering literature.

CORRPRO Pipe Condition Survey

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PIPE CONDITION SURVEY

CITY OF NEW ORLEANS BURIED WATER PIPELINES

FOR

EARTH TECH, INC.

STEVENS POINT, WISCONSIN

BY

CORRPRO COMPANIES, INC.

HOUSTON, TEXAS

SEPTEMBER 2002

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TABLE OF CONTENTS

APPENDICIES

PIPE CONDITION SURVEY
CITY OF NEW ORLEANS
WATER DEPARTMENT

1.0 INTRODUCTION

Corrpro Companies, Inc. was retained by Earth Tech, Inc. of Stevens Point, Wisconsin to perform a pipe condition survey of existing buried cast iron and ductile iron pipe at eight locations for the City of New Orleans Water Department, New Orleans, Louisiana.

The purpose of the study is to determine and evaluate the condition of the buried pipe, diameter and depth of the buried pipe, the soil conditions, the amount and type of corrosion activity on each pipe coupon, the pipe-to-soil potentials and possible DC earth current activity. The evaluation is part of a program for determining the overall system needs assessment for the City of New Orleans.

Eight out of a possible ten locations were selected for excavation and inspection as follows:

1- France at Hayne – 12" – Cast Iron – Installed 1954
2- Omitted
3- Omitted
4- Pleasure at London – 12" - Cast Iron – Installed 1950
5- Galvez at Delery – 12" – Cast Iron – Installed (unknown)
6- Bienville at Clay – 8" - Cast Iron – Installed 1909
7- Nuns at Peters – 8" – Cast Iron – Installed 1924
8- Pelican at Bounty – 10" – Cast Iron – Installed 1908
9- Saint Nick at General Meyer – 12" Cast Iron – Installed 1963
10- Bristol at Hershel– 12" – Cast Iron – Installed - 1956

The survey scope-of-work was to include but not be limited to the following:

1- Locate and excavate the candidate pipe at each of eight pre-selected locations.
2- Expose completely and clean the selected pipe section.
3- Determine the depth of cover, pipe material, approximate age and diameter of pipe.
4- Inspect for evidence of any dielectric coating, evidence of corrosion and measure the depth of any significant corrosion pits and document their location on the excavated pipe section.
5- Obtain a sample of the soil next to the pipe and a second sample from unexcavated soil for chemical analysis.
6- Obtain water samples of any water found next to the excavated pipe.
7- Measure and record the in-situ soil resistivity of the soil next to the pipe and unexcavated soil.

8- Measure and record the pipe-to-soil potential of the pipe section as well as the adjacent pipe joints.
9- Determine the electrical continuity across the joints to adjacent pipe sections.
10- a half days to complete this site due to delays Obtain two core samples of the specimen pipe at pre-selected locations for metallurgical examination for corrosion. The size of core samples will be 2-inch for 8-inch diameter pipe and 4-inch for 10-inch and larger diameter pipe.
11- Obtain photographs to document the excavation and any pertinent features.
12- It was expected that the survey would proceed at the rate of two locations per day.

Pipe excavation and survey work started on September 9, 2002 at site No 7 – Nuns & Peters. It required one and and breakdowns of the excavation contractor's equipment. It was determined, due to cost constraints, Corrpro's field inspection portion of the project would be discontinued and the remaining sites would be excavated and that only a soil sample, pipe core sample and photographs would be obtained at each site by the Earth Tech representative.

The resulting field data is complete only for Site No. 7. Soil and pipe core analysis and photographs have been completed for all eight sites.

This report presents the results of the Pipe Condition Survey.

2.0 CONCLUSIONS

2.1 Pipe Core Samples

Metallographic examination of the eight core samples indicates that all samples were gray iron (cast iron) type pipe and that two of the samples, one from site 7 and one from site 8, showed some graphitic corrosion. The remaining specimens showed no significant corrosion.

2.2 Soil Analysis

The soil surrounding each pipe is corrosive with respect to cast iron and ductile iron pipe. The soil resistivities at the elevation of each pipe section inspected are indicative of corrosive conditions with 100% of the measurements less than 3,000 ohm-cm and 16% less than 1,000 ohm-cm.

2.3 Pipe-To-Soil Potentials

Pipe-to-soil potentials recorded at site seven, -0.555 volts with respect to a copper/copper sulfate reference electrode, are indicative of typical buried cast iron pipe in a corrosive environment. There was no indication of cathodic protection on this pipe section. Pipe-to-soil potentials were not measured at the remaining sites.

2.4 Corrosion Coating and Corrosion Pits

There was no evidence of a dielectric coating on any of the excavated pipe sections. There were no corrosion pits on the 8" cast iron pipe at site No.7. Corrosion pits were not indicated and/or measured on the remaining seven pipe excavations.

3.0 **RESULTS AND ANALYSIS**

3.1 Field and Laboratory Testing

Field and laboratory testing were performed to collect chemical and electrical data pertaining to the corrosivity of the soil of at each of the eight excavation sites with respect to cast iron water pipelines. The test procedures employed are described in Appendix "A".

In-situ soil resistivity measurements were recorded at Site No 7. Specific soil resistivities were determined from the soil samples obtained at each of the eight site excavations. All resistivity data is tabulated in Appendix "B".

Pipe-to soil potential measurements were made on the 8-inch cast iron pipe section at site No. 7. Potentials were not obtained on the remaining seven sites. These potentials are tabulated in Appendix "B".

Soil samples collected at pipe depth at each of the eight site excavations were tested in the laboratory for pH, chloride ion concentration, sulfide ion concentration, conductivity, and resistivity. This data is tabulated in Appendix "B".

Considering each of the chemical and electrical soil properties that are tested in the field and the laboratory, general guidelines for interpreting the results are as follows:

- Soil Moisture - The higher the soil moisture content, the greater the anticipated rate of corrosion. Moisture contents can range from 1% (very dry sands) to 40% (clays holding a great deal of moisture). Typical values are 10 to 15% with over 20% moisture considered high.

- pH - Acid soils and groundwater are more conducive to galvanic corrosion of ferrous materials than alkaline soils.

- Conductivity - For a given corrosion cell with a fixed potential difference between the anode and cathode, the higher the conductivity, the greater the metal loss. Conductivities over 350 micromhos/centimeter (equivalent to a resistivity of 2,850 ohm cm) are considered high.

- Sulfide Concentration - Any detectable concentrations of sulfide ions are indicative of anaerobic conditions that may support high rates of metal dissolution due to microbiologically influenced corrosion.

- Chloride Concentrations - Chloride ions are cathode depolarizers which enhance the rate of corrosion. The higher the concentration, the greater the rate of corrosion. Many soils have chloride concentrations less than 10 ppm. Concentrations over 50 ppm are significant.

- Soil Resistivity - Resistivity is a common parameter for evaluating the corrosiveness of the soil. Resistivity is the inverse of conductivity and is measured in units of ohm-centimeters. Corrosivity is often an inverse function of resistivity with low resistivity soils usually more corrosive than high resistivity soils. Resistivity is also related to the concentration of salts with a low resistivity indicating high levels of salt.

  It should be stressed that there is no single chemical or electrical property of the soil or groundwater that determines the rate of corrosion. Consideration of the interrelationship of all of the above factors is important to an accurate assessment of the potential rates of corrosion and the design of corrosion protection systems.

	Soil Resistivity (ohm-cm) **Eight excavation sites**
Minimum	427
Maximum	2,004
Percent < 1000	16
Percent < 3000	100

With respect to the chemical properties of the soil, the test results of the samples obtained at the eight excavation sites indicate:

- A pH range from a minimum of 6.8 to a maximum of 8.8.

- Chloride ion concentrations from 6.0 to 540 ppm.
- Sulfide ion concentration of 5-ppm was found in the sample from site No. 7.
- Conductivities ranged from 499 to 2,340 micromhos.

3.2 Metallographic Analysis of Pipe Core Samples

At least one core sample was retrieved from each excavated pipe section and sent to Metallurgical Consultants, Inc. for analysis. The results of the analysis are contained in Appendix "B" and are summarized as follows:

- The sample from Site No. 8 showed graphitic corrosion 0.035-inch deep on the outside surface.
- The sample from Site No. 7 showed graphitic corrosion on the outside surface extending a maximum of 0.025-inch across the pipe wall thickness.
- No evidence of graphitic corrosion was observed on the remaining pipe specimens.
- The metallographic analysis of the core samples from all eight pipe sections were typical of gray cast iron.

3.3 Photographs

Photographs were taken at each pipe excavation site providing a visual record of the excavation, soil conditions and apparent pipe condition. All photographs are contained in Appendix "C"

APPENDIX A

TEST PROCEDURES

TEST PROCEDURES

PIPE CONDITION SURVEY

WATER PIPING

The collection of accurate corrosion data requires attention to test procedures and equipment to ensure the recording of reproducible data. Test methods incorporated during this pipe condition survey for the underground water piping include the following:

Soil Resistivity
Pipe-to-Soil Potential
Stray Current
pH
Chloride Ion
Sulfide Ion
Moisture Content
Conductivity
Pit Depth Measurements
Metallographic examination of pipe core samples.

Soil resistivity, structure-to-soil potential and stray current data are collected in situ in the field. Soil samples are collected and tested in the laboratory for the other parameters listed. Any corrosion pits were cleaned and the depth of significant pits measured. A core sample of each pipe section was removed and metallographically examined for evidence of significant corrosion.

I. SOIL RESISTIVITY

Resistivity is a common parameter for evaluating the corrosivity of soil. Resistivity is the inverse of conductivity and is measured in the units of ohm-centimeters. Corrosivity is often an inverse function of resistivity with low resistivity soils usually more corrosive than high resistivity soils. Serious corrosion can also be associated with high resistivity soils, particularly where the soil composition is not uniform. Variations in resistivity indicate variations in composition which are conducive to galvanic corrosion.

Resistivity measurements were conducted using the Collins Single Probe instrument. This instrument measures the resistivity of the soil at the tip of the probe in ohm-cm.

II. PIPE-TO-SOIL POTENTIAL

Pipe-to-soil potentials are DC voltages used to evaluate the corrosion pattern along underground pipelines. Properly interpreted and correlated with other measurements, pipe-to-soil potentials give an indication of the severity of both galvanic and electrolytic corrosion cells.

Measurements must be recorded with a high input impedance voltmeter. The negative terminal of the meter is connected to an underground structure and the positive terminal to a saturated copper/copper sulfate reference electrode placed in contact with the soil. Copper sulfate half-cells are used for underground corrosion testing because they are stable and yield reproducible results.

Pipe-to-soil potentials were recorded using a Beckman, Model HD 110 digital voltmeter. This instrument is designed for corrosion testing and has an internal resistance of 22 megohms.

III. STRAY CURRENT

Stray DC earth currents can emanate from the operation of DC transit systems, cathodic protection rectifiers, welding and DC motors. When discharged from the surface of ferrous piping, these currents will consume approximately 1 gram of metal per ampere-hour. Concentrated electrolytic corrosion can cause rapid deterioration of underground piping.

The presence of stray current is detected through the use of pipe-to-soil potential measurements. The pipe-to-soil potentials are taken and recorded over a period of time. Fluctuations in potential indicate the presence and magnitude of exposure to stray current.

IV. pH

pH is the negative logarithm of the hydrogen ion concentration. For piping of ferrous materials construction, a pH in the range of 4 to 10 has little effect on the rate of corrosion under oxidizing conditions at ambient temperatures. At pH values above 10, the steel readily polarizes which tends to passivate the corrosion cells.

Acid soils are more conducive to ferrous corrosion. Hydrogen ions present act as cathode depolarizers increasing the corrosion reaction rate. At pH values below 4, the rate of corrosion accelerates rapidly.

The method used to measure pH is ASTM Standard Test Method D2976-71 that has an accuracy of plus or minus 0.01. Soil samples collected from soil borings are dissolved in distilled water and placed in a centrifuge to remove the suspended solids. The supernatant liquid is then tested with a glass-calomel pH electrode in conjunction with an Orion Research Model 601 A meter.

V. CHLORIDE ION

Chloride ions are depolarizing agents and cause corrosion pitting of many common materials of construction. ASTM Standard Test Method D5 12-81 is used to measure the chloride ion concentration with an accuracy of +0.5 ppm. This method utilizes an ion selective electrode and an Orion Digital Ionalyzer. The chloride ion concentration for soil samples is measured from the supernatant fluid prepared for the pH testing.

VI. SULFIDE ION

Sulfide ions present in the soil are indicative of anaerobic conditions. Under these conditions, sulfate-reducing bacteria can greatly accelerate the rate of corrosion of ferrous materials. The bacteria reduce sulfates to sulfides and in the process oxidize iron. Soil samples are tested for the presence of sulfide ions to an accuracy of plus or minus 1 ppb. The solution extracted from the soil sample is tested through the use of a specific ion probe (silver/sulfide electrode) in conjunction with an Orion Research Digital Ionalyzer. The test procedure meets or exceeds the requirements of EPA Standard Test Method 376.1.

VII. MOISTURE CONTENT

When soil samples are collected, they are immediately sealed to prevent evaporation and/or contamination. Moisture content of the samples is determined using ASTM Standard Test Method D22 16-80. A part of the soil sample is weighed, dried for 24 hours in an oven at 110^0C, then weighed again. The moisture content is calculated from the weight loss to an accuracy of plus or minus 0.1%.

The moisture content is a significant parameter in defining the corrosivity of a soil environment. For underground pipeline evaluations, test borings allow for a determination of the moisture content at the depth of burial.

VIII. CONDUCTIVITY

For a given corrosion cell with a fixed potential difference between the anode and cathode, the higher the conductivity, the greater corrosion current flow and the corresponding metal loss.

The conductivity of the soil samples are measured in the laboratory on a precise water extract using a YSI Model 32 conductance meter and a platinized platinumiridium electrode. In the 10 to 200 micromho/cm range, the resolution is 0.1 micromho/cm. Test procedures are in accordance with ASTM DI 125.

APPENDIX B

LABORATORY AND FIELD TEST DATA

METALLURGICAL CONSULTANTS, INC.

October 1, 2002

Ref: 0650-02-14636
Sub: Examination of Cast Iron Pipe Samples

Mr. Ken Evans (3)
Corrpro Companies
7000 Hollister, S-8
Houston, Texas 77040

Dear Mr. Evans:

As you requested, we have metallographically examined specimens from four samples reportedly trepanned from cast iron pipe. The four samples were identified as Site 1, Site 4, Site 6 and Site 7. The purpose of our examination was to determine if the specimens showed significant corrosion, specifically graphitic corrosion.

SUMMARY

One of the four specimens, from Site 7, showed graphitic corrosion on the outside surface, which extended a maximum of 0.025 inch across the pipe wall thickness. The other specimens showed no significant corrosion.

LABORATORY EXAMINATION

Two of the samples, from Site 1 and from Site 4, were 2-7/8-inch O.D. x 1-inch I.D., whereas the two other samples, from Site 6 and Site 7 were 1-inch O.D. x 1/8-inch I.D. The larger samples had been cut from thicker pipe than the smaller samples.

Each sample was sectioned along its circumferential axis, and the sections were encapsulated for metallographic preparation and examination. Each specimen showed a microstructure consisting of graphite flakes, ferrite, cementite (iron carbide) or steadite (iron phosphide) and pearlite (a mixture of ferrite and cementite). The proportions of the above constituents varied from one specimen to the other and within each specimen across the wall thickness. The microstructures were typical of gray cast iron.

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Visit us on the World Wide Web: www.metallurgical.com

The outside and inside surfaces of each specimen showed superficial corrosion except for the outside surface of the specimen from Site 7, which showed irregular patches of corrosion attack. Islands of cementite or steadite and graphite flakes were visible within the corrosion product. Figure 1 is a representative view of the attack, which was characteristic of graphitic corrosion.

* * *

Please call if you have questions about this information or if we may serve you further. Samples will be held for 30 days from the issuance of this report, after which they will be discarded unless we are informed otherwise.

Sincerely,

Mark Buehler

W. M. Buehler

WMB:ec

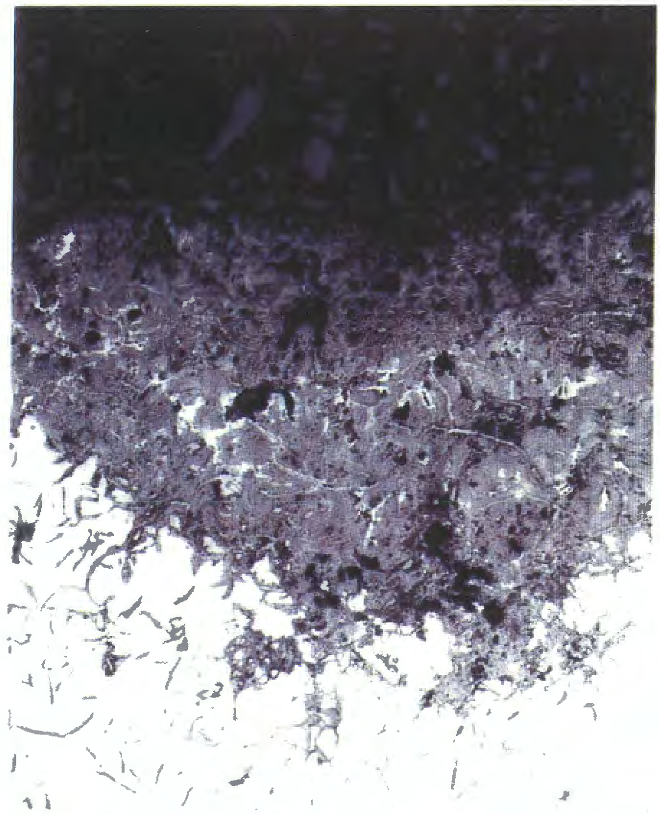

Figure 1 Nital Etch 100X

Photomicrograph of graphitic corrosion on the specimen from Site 7.

METALLURGICAL CONSULTANTS, INC.

October 18, 2002

Ref: 0705-02-14636
Sub: Examination of Trepanned
Coupons from Sites 3, 8, 9 and 10

Mr. Ken Evans (3)
Corrpro Companies
7000 Hollister, S-8
Houston, Texas 77040

Dear Mr. Evans:

As you requested, we have metallographically examined four additional samples reportedly trepanned from municipal cast iron pipes in New Orleans. The results of a previous examination of four other samples by Metallurgical Consultants, Inc. were submitted to you in our report, Ref.: 0650-02-14636, issued October 1, 2002.

The four samples were removed from locations identified as Site 3, Site 8, Site 9 and Site 10. All coupons were 2-7/8-inch O. D. x 1-inch I. D. The purpose of the examination was to determine if the samples showed significant corrosion, specifically graphitic corrosion.

SUMMARY

One of the four samples, from Site 8, showed graphitic corrosion 0.035-inch deep on the outside surface. No evidence of graphitic corrosion was observed on the other samples.

LABORATORY EXAMINATION

Each of the four samples was saw cut circumferentially for preparation of a metallographic specimen. The four specimens were polished, then etched with a weak solution of nitric acid in ethanol.

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There was no significant corrosion on the surfaces of specimens from Sites 3, 9 and 10, but the specimen from Site 8 showed patches of graphitic corrosion on the outside surface. The deepest corrosion penetration was 0.035 inch on the specimen we examined.

The specimens from Sites 9 and 10 showed a microstructure consisting of very fine graphite flakes, ferrite and pearlite (a mixture of ferrite and iron carbide). The specimen from Site 3 showed a similar microstructure, but with much coarser graphite flakes. The specimen from Site 8 showed many shrinkage voids from casting, and the microstructure included large apparent islands of steadite (iron phosphide) in addition to graphite flakes and ferrite. The microstructures were characteristic of different forms and vintages of gray iron.

* * *

Please call if you have questions about this information or if we may serve you further. Sample remnants will be held for 30 days from the issuance of this report, after which they will be discarded unless we are informed otherwise.

Sincerely,

Mark Buehler

W. M. Buehler

WMB:my

PIPE INVESTIGATION DATA FORM

Data Type: Dig Up

City, State: Nuns & Peters, New Orleans, LA. Inspection Site No. 7

Pipe Type: Cast Iron

Pipe Size: 8"

Date Installed: Reported to be 1924

Pipe Age: 78-yrs.

Date Inspected: September 9, 2002

Type of encasement: None

Soil Samples: No. 1 – Next to 8" pipe
No. 2 – Undisturbed soil

Pipe-to-soil potentials: Fixed Cell – 8" pipe -0.555 volts
8" pipe south side –0.555 volts
spool north side –0.555 volts

Type of joints: Bolted flanges

Soil resistivity: At surface – 1,500 ohm-cm
At pipe depth – 2,000 ohm-cm

Length of test pipe section: 32"

Depth of cover: 7'-3"

Pit depths: No pits found on the inspected pipe section

Core sample: 1
Comments:

1. The contractor had a difficult time excavating the pipe at this location due to the location, depth of pipe and continuous intrusion of ground water.

2. **An attempt was made to retrieve 2 core samples but both were lost in the pipe. A subsequent attempt was made the next day and was successful in obtaining one sample.**

3. **The specified age of the inspected pipe section is questionable as the actual appearance of the pipe was similar to new pipe. The flanges and bolts were in excellent condition and did not show any significant corrosion.**

LABORATORY ELECTROLYTE ANALYSIS

NT: Earth Tech
JECT: Pipe Condition Survey
E RECEIVED: 9-17-02

JOB NUMBER: 331295
OFFFICE: Houston
DATE OUT: 9-19-02

ENGINEER: Dave Bauer
TECHNICIAN: Nancy Jacob

PLE ID	LOCATION	MOISTURE %	pH	CHLORIDE ppm	SULFIDE ppm	CONDUCTIVITY micromhos	RESISTIVITY ohm-cm	SOIL TYPE	SOIL COL
1	Site # 7 Undisturbed soil	25.53	8.8	20	0.5	499	2,004	Clay & Rocks	Gray
2	Site # 7 Next to pipe	27.34	8.4	6	0	599	1,670	Clay & Rocks	Gray
3	Site # 7 Water in Manhole	100	8.5	17	192 (Sulfate)	630	1,587	Water	clear

LABORATORY ELECTROLYTE ANALYSIS

IT: Earth Tech | JOB NUMBER: 331295 | ENGINEER: Dave Bauer

ECT: Pipe Condition Survey | OFFFICE: Houston

RECEIVED: 9/20/02 | DATE OUT: 9/24/02 | TECHNICIAN: Nancy Jacob

LE ID	LOCATION	MOISTURE %	pH	CHLORIDE ppm	SULFIDE ppm	CONDUCTIVITY micromhos	RESISTIVITY ohm-cm	SOIL TYPE	SOIL COLC
4	France at Haynes	25.99	7.7	21	0	510	1,961	Clay Loam	Gray
5	Pleasure at London	53.01	6.9	16	0	670	1,493	Clay Loam	Gray
6	Bienville at Clay	32.04	8.1	10	0	864	1,157	Clay Loam	Gray

LABORATORY ELECTROLYTE ANALYSIS

NT: Earth Tech
JECT: Pipe Condition Survey
E RECEIVED: 10/14/02

JOB NUMBER: 331295
OFFFICE: Houston
DATE OUT: 10/16/02

ENGINEER: Dave Bauer
TECHNICIAN: Nancy Jacob

PLE ID	LOCATION	MOISTURE %	pH	CHLORIDE ppm	SULFIDE ppm	CONDUCTIVITY micromhos	RESISTIVITY ohm-cm	SOIL TYPE	SOIL COL
7	Galvez at Delery Next to pipe	89.08	6.8	540	0	2,340	427	Clay Loam	Gray Yell
8	Pelican at Bounty Next to pipe	42.04	8.6	26	0	517	1,934	Clay Loam	Gray Yell
9	St. Nick at General Meyer Next to pipe	68.86	7.1	16	0	625	1,600	Clay Loam	Yelloy Gr
10	Bristol at Herschel Next to pipe	91.41	6.8	440	Trace	2,187	457	Clay Loam	Gray

APPENDIX C

PHOTOGRAPHS

SITE NO. 1 LOCATION - FRANCE AT HAYNE

SITE NO.1
12" CAST IRON PIPE

SITE NO. 1
EXCAVATION

SITE NO. 1
SETTING UP TO OBTAIN CORE SAMPLE

SITE NO. 4 LOCATION - PLEASURE AT LONDON

SITE NO. 4
12" CAST IRON PIPE

SITE NO. 4
SETTING UP TO OBTAIN PIPE CORES

SITE NO. 5 LOCATION - GALVEZ AT DELERY

SITE NO. 5
12" CAST IRON PIPE

SITE NO. 5
12" CAST IRON PIPE WITH SADDLES AND STOPPS

SITE NO. 6 LOCATION - BIENVILLE AT CLAY

SITE NO. 6
8" CAST IRON PIPE

SITE NO. 6
SETTING UP TO OBTAIN CORE SAMPLES

SITE NO. 6
PRIOR TO POURING CONCRETE

SITE NO. 7

SITE NO.7 -
OBTAINING SOIL SAMPLE

SITE NO. 7
EXCAVATING 8" CAST IRON WATERLINE

SITE NO. 7
PLACING SHORING AND ACCESS LADDER

SITE NO.7
DE-WATERING HOLE & CLEANING PIPE

SITE NO. 7
8" CAST IRON PIPE READY FOR TESTING

SITE NO. 7
PERFORMING TESTS ON 8" CAST IRON PIPE

SITE NO. 7
CONDITION OF BOLTS AND FLANGE ON SOUTH END OF PIPE SECTION

SITE NO. 7
CONDITION OF BOLTS AND FLANGE ON NORTH END OF PIPE SECTION

SITE NO. 7
CONDITION OF 8" CAST IRON PIPE SECTION

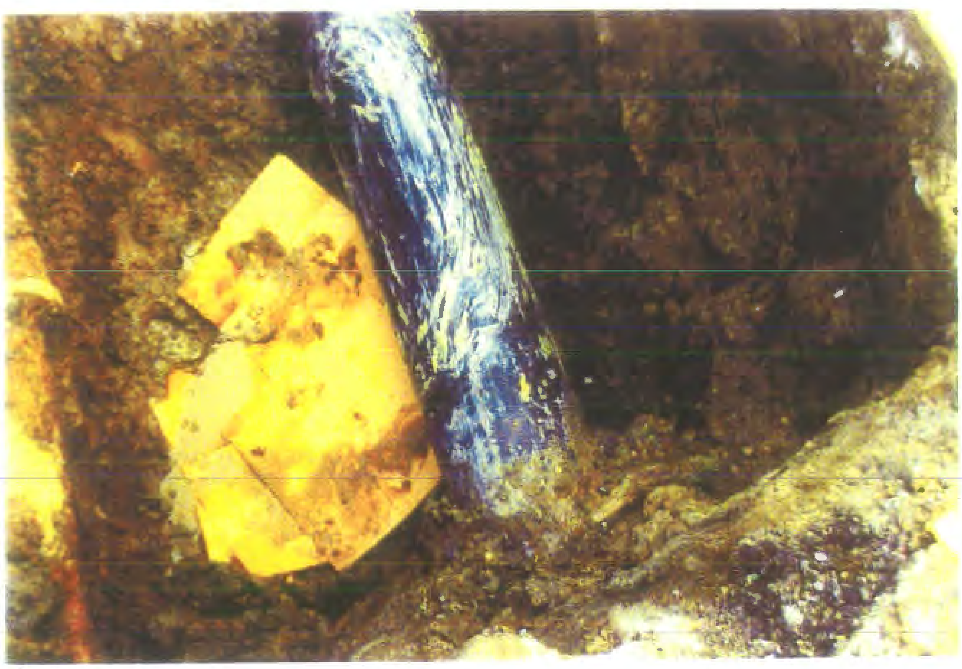
SITE NO. 7
SETTING UP TO OBTAIN CORE SAMPLES

SITE NO. 7
CUTTING THE FIRST CORE SAMPLE

SITE NO. 8 LOCATION - PELICAN AT BOUNY

(NO OTHER PHOTOGRAPHS OF THE EXCAVATED 10" CAST IRON PIPE AVAILABLE)

SITE NO. 9 LOCATION - SAINT NICK AT GENERAL MEYER



SITE NO. 9
12" CAST IRON PIPE

SITE NO. 9
SETTING UP TO OBTAIN CORE SAMPLES

SITE NO. 9
READY FOR BACK FILLING

SITE NO. 10 LOCATION - BRISTOL AT HERSCHEL

SITE NO. 10
12" CAST IRON PIPE

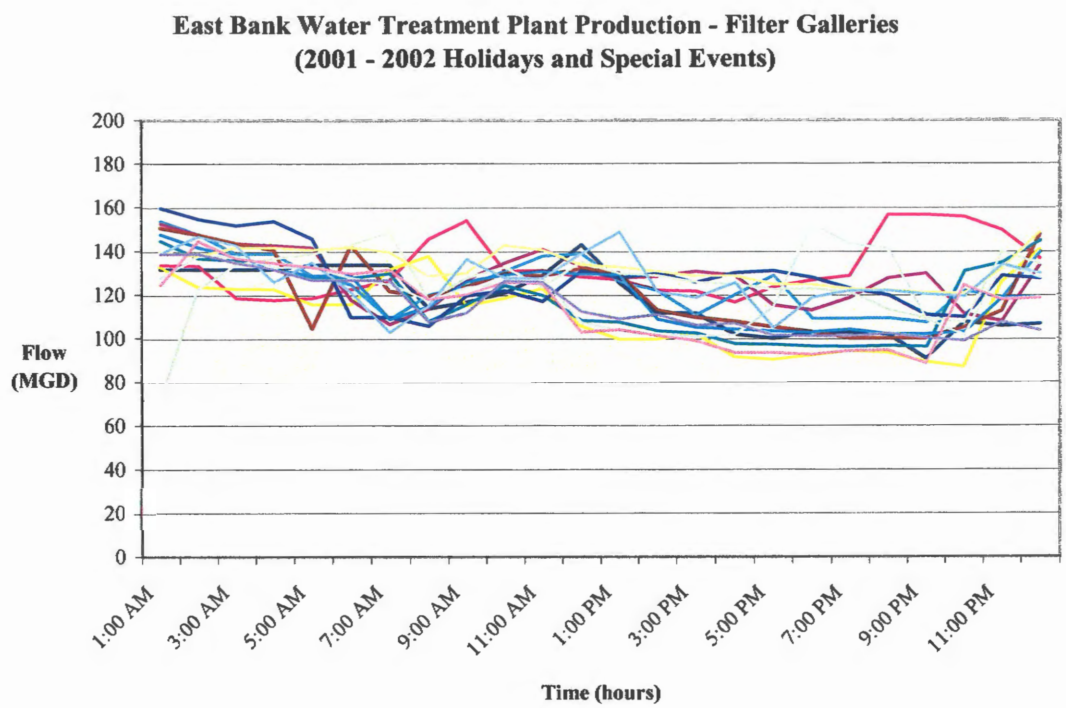
SITE NO. 10
READY FOR BACK FILLING

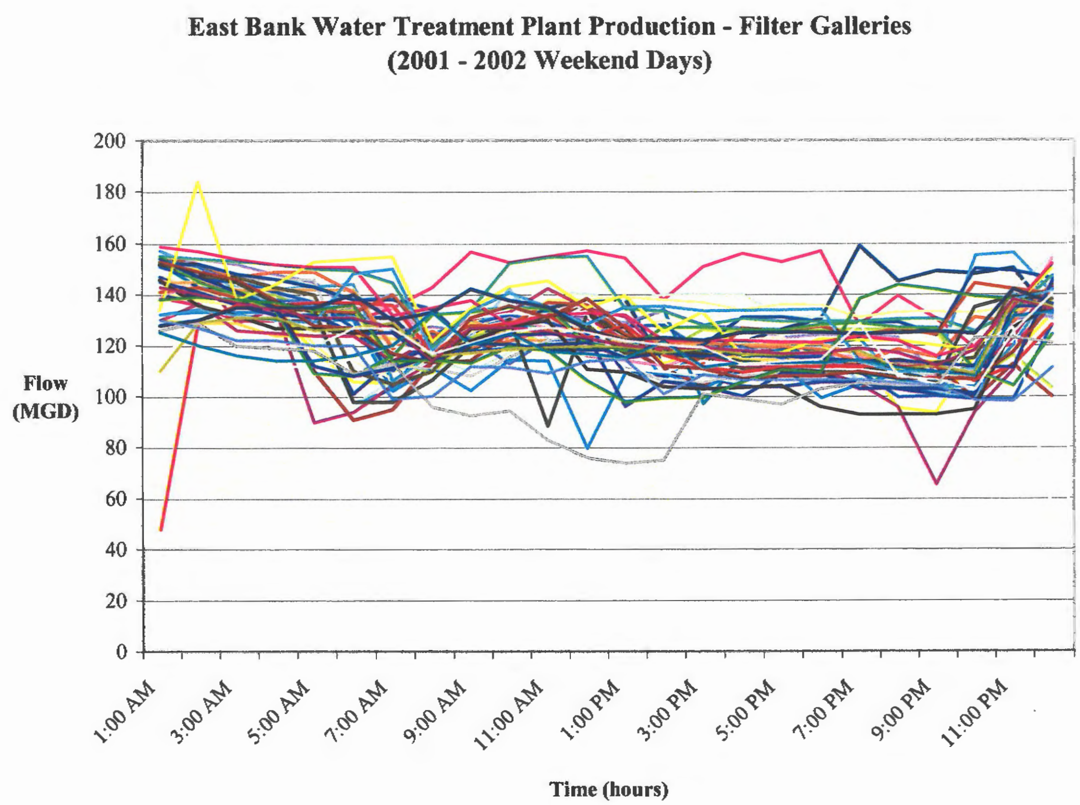
Appendix B

Appendix B

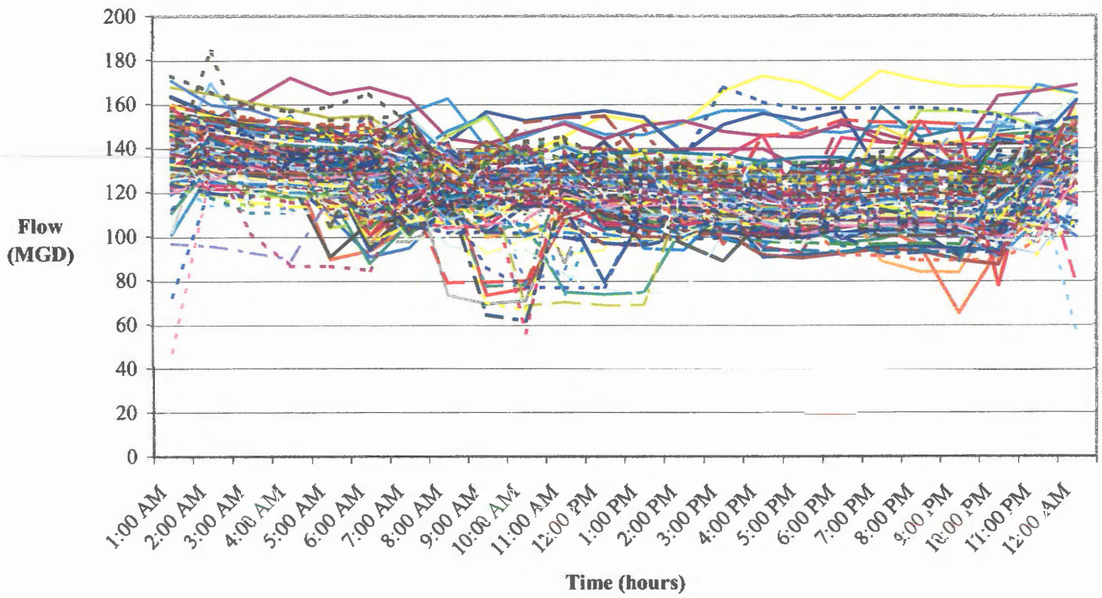
MWH

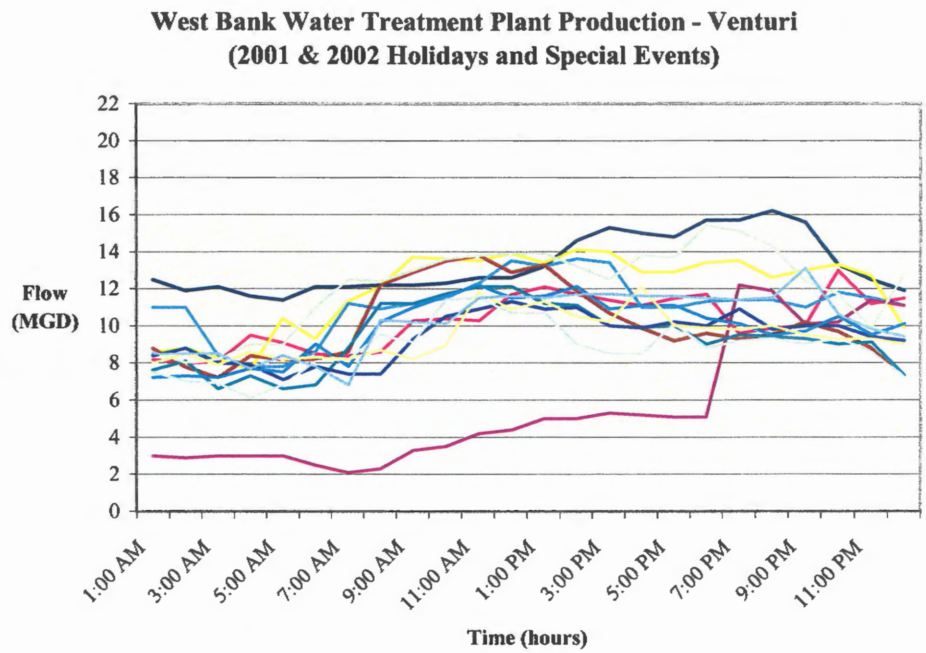
Appendix B – Diurnal Curves

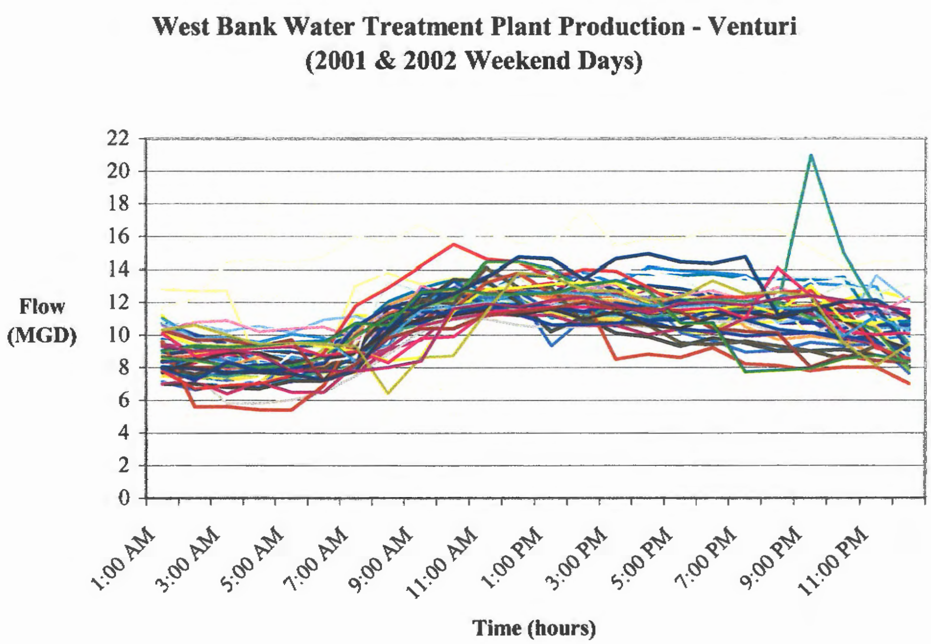

East Bank Water Treatment Plant Production - Filter Galleries
(2001 - 2002 Holidays and Special Events)
200
180
160
140
120
100
80
60
40
20
0
Flow
(MGD)
1:00 AM
3:00 AM
5:00 AM
7:00 AM
9:00 AM
11:00 AM
1:00 PM
3:00 PM
5:00 PM
7:00 PM
9:00 PM
11:00 PM
Time (hours)

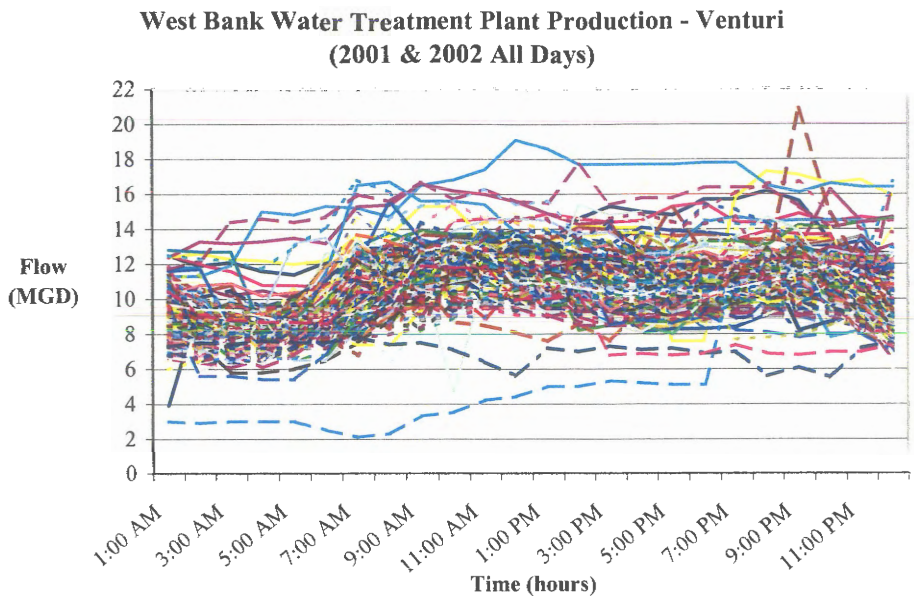

East Bank Water Treatment Plant Production - Filter Galleries
(2001 - 2002 Weekend Days)
200
180
160
140
120
100
80
60
40
20
0
Flow
(MGD)
1:00 AM
3:00 AM
5:00 AM
7:00 AM
9:00 AM
11:00 AM
1:00 PM
3:00 PM
5:00 PM
7:00 PM
9:00 PM
11:00 PM
Time (hours)

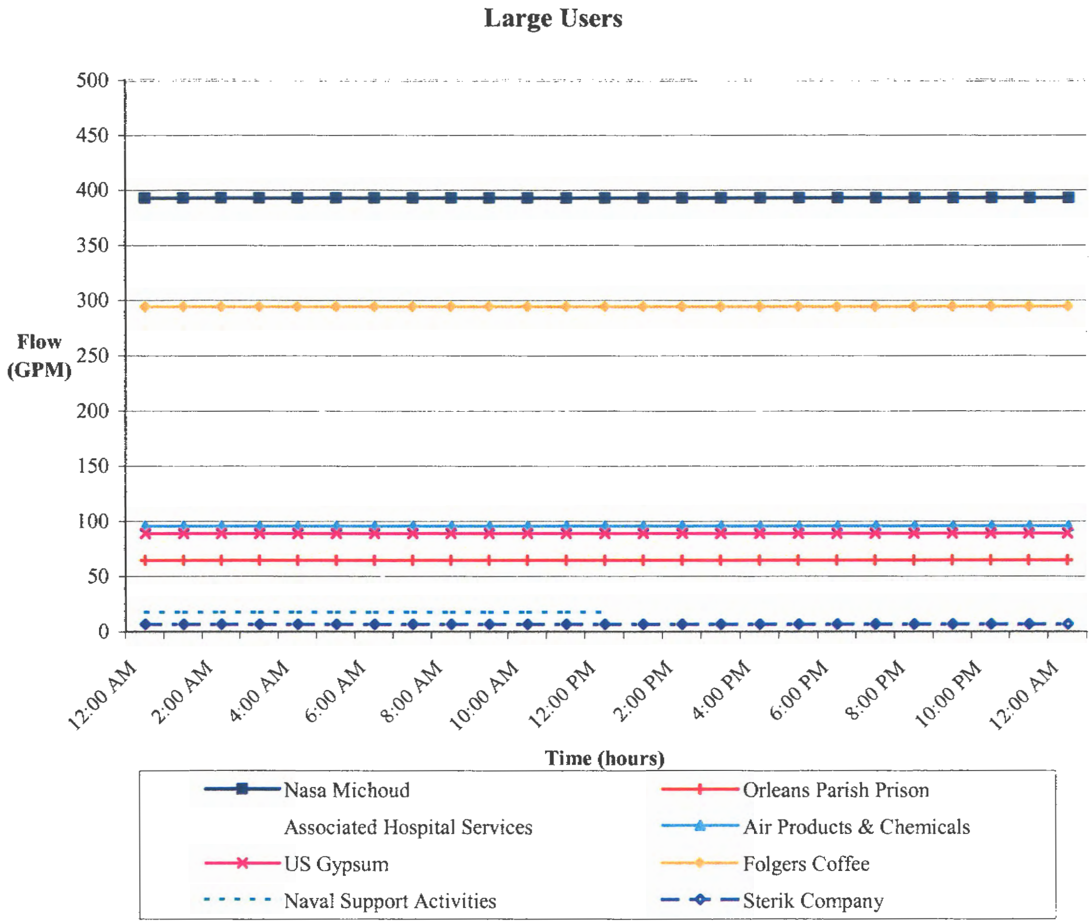
East Bank Water Treatment Plant Production - Filter Galleries
(2001 - 2002 All Days)




West Bank Water Treatment Plant Production - Venturi
(2001 & 2002 Holidays and Special Events)
22
20
18
16
14
12
10
8
6
4
2
0
Flow
(MGD)
1:00 AM
3:00 AM
5:00 AM
7:00 AM
9:00 AM
11:00 AM
1:00 PM
3:00 PM
5:00 PM
7:00 PM
9:00 PM
11:00 PM
Time (hours)


West Bank Water Treatment Plant Production - Venturi
(2001 & 2002 Weekend Days)
22
20
18
16
14
12
10
8
6
4
2
0
Flow
(MGD)
1:00 AM
3:00 AM
5:00 AM
7:00 AM
9:00 AM
11:00 AM
1:00 PM
3:00 PM
5:00 PM
7:00 PM
9:00 PM
11:00 PM
Time (hours)


West Bank Water Treatment Plant Production - Venturi
(2001 & 2002 All Days)
Flow
(MGD)
22
20
18
16
14
12
10
8
6
4
2
0
1:00 AM
3:00 AM
5:00 AM
7:00 AM
9:00 AM
11:00 AM
1:00 PM
3:00 PM
5:00 PM
7:00 PM
9:00 PM
11:00 PM
Time (hours)


Large Users
500
450
400
350
300
250
200
150
100
50
0
Flow (GPM)
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM
Time (hours)
Nasa Michoud
Orleans Parish Prison
Associated Hospital Services
Air Products & Chemicals
US Gypsum
Folgers Coffee
Naval Support Activities
Sterik Company

Appendix C

MWH

Appendix C

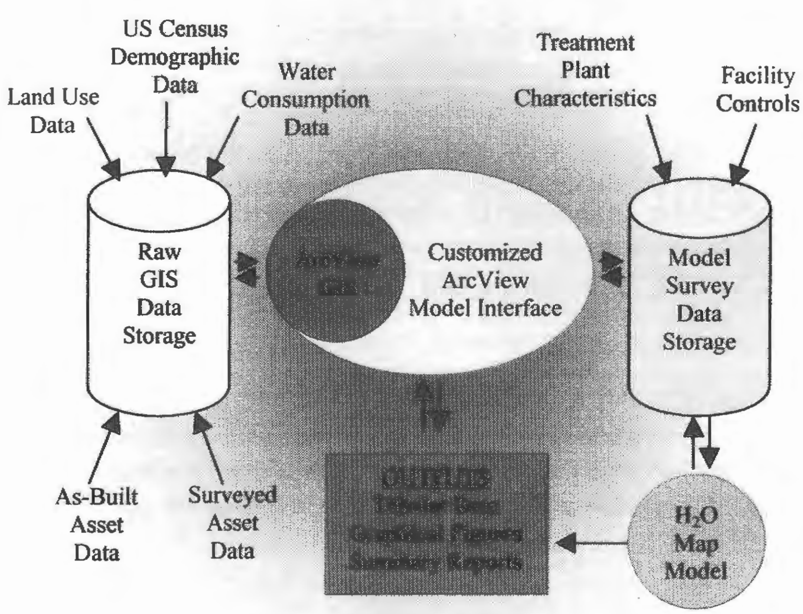
Appendix C – WDTTE Water Guide

S&WB of New Orleans
ArcView GIS Data Management Tools: WDTTE Water Users Guide

In conjunction with the Water Master Plan conducted for the S&WB, MWH developed a geographical information system (GIS) in ESRI ArcView 3.x software platform for the East and West Bank water distribution systems. The GIS network is intended for all data management activities and will include all facilities within a spatial database. Locating all facilities within one database allows for improved management of data and an easily accessible data source. The GIS network contains large data sets with detailed information of the distribution systems including water main installation year, size, material, as well as valves, hydrants, crosses, caps, and tees. The GIS network also serves as a platform for the hydraulic model of the distribution systems developed with H_2O Map computer software.

The hydraulic model components consist of ArcView GIS files, customized GIS tools, and H_2O Map modeling software. **Figure 1** shows a schematic data flow diagram of the model components and data management system implemented for this project. This system allows easy access to data and also provides the flexibility of being able to quickly move data between GIS and H_2O Map for model simulations and viewing of results graphically through GIS. The data management system also preserves the integrity of system data through numerous model simulations.

Figure 1
Data Management System
Flow Diagram



As shown in **Figure 1**, the core of the data management system is the Customized ArcView Model Interface. The ArcView Model Interface is a collection of tools in ArcView that analyze, reformat, translate, display, export, and import model-related data. These tools are stored as computer scripts in ArcView programming language (Avenue) under the extension, named WDTTE Water (WDTTE Water.avx). The extension also provides a suite of tools for data entry, manipulation, and analysis within ArcView GIS. WDTTE Water provides the user with tools that are easy to use and enhance the integrity of the database and data sharing.

Similar extension tools were developed by MWH as part of the SSERP for the hydraulic model of the wastewater collection system. The tools were developed to help assure quality and prevent errors with data management. The tools typically automate a manual process that may have associated user errors.

In addition to the WDTTE Water tools, MWH developed a customized ArcView script to simplify the GIS network. The detailed GIS data was processed to exclude excess information not required for the hydraulic model. A skeletonized, or simplified, version of the GIS files was used in H_2O Map for the purpose of running a model with a manageable sized network. This was accomplished by using the customized GIS tool, Simplify, to simplify the GIS network. All junctions, check valves, and select hydrants used for field testing were retained in the simplified network. All other valves and hydrants were skeletonized out of the networks for the purpose of a simplified hydraulic model. The Simplify tool is described below.

- Simplify: Simplifies pipe segments based on pipe criteria (material, age, diameter) and specified node type (junction, check valve, calibration hydrant) for input into H_2O Map. Analyzes pipe characteristics that do not vary on the connecting pipes, and merges pipes together as a single pipe. Returns output reference tables to link simplified and extended networks to update information between files.

REQUIREMENTS

The WDTTE Water extension requires ESRI ArcView 3.x software platform. The WDTTE Water.avx file can either be distributed to each user's computer hard drive, C:\ESRI\av_gis30\arcview\ext32 folder, or centralized in a shared network folder, with each user's $USEREXT environmental variable addressed to the location of the extension.

Additional files are required to use WDTTE Water and should be saved within a shared network folder. An environmental variable named "WDTTE Water" should be created and addressed to the location of the folder. An additional environmental variable named "Basemap" should be created and addressed to the location of the aerial photos and street centerline files.

The additional files include the following tables and executable files.

Tables

Watdatsrc.dbf	data sources look-up table
Watlkfields.dbf	link field definitions table
Watlkmats.dbf	link materials look-up table
Watlktypes.dbf	link types look-up table
Watndfields.dbf	node field definitions table
Watndtypes.dbf	node types look-up table
Watrecnos.dbf	stores last unique record number used

Executables Files

WDTTEWaterForms.EXE	contains the data entry forms
Jpgv.EXE	the photo viewer executable

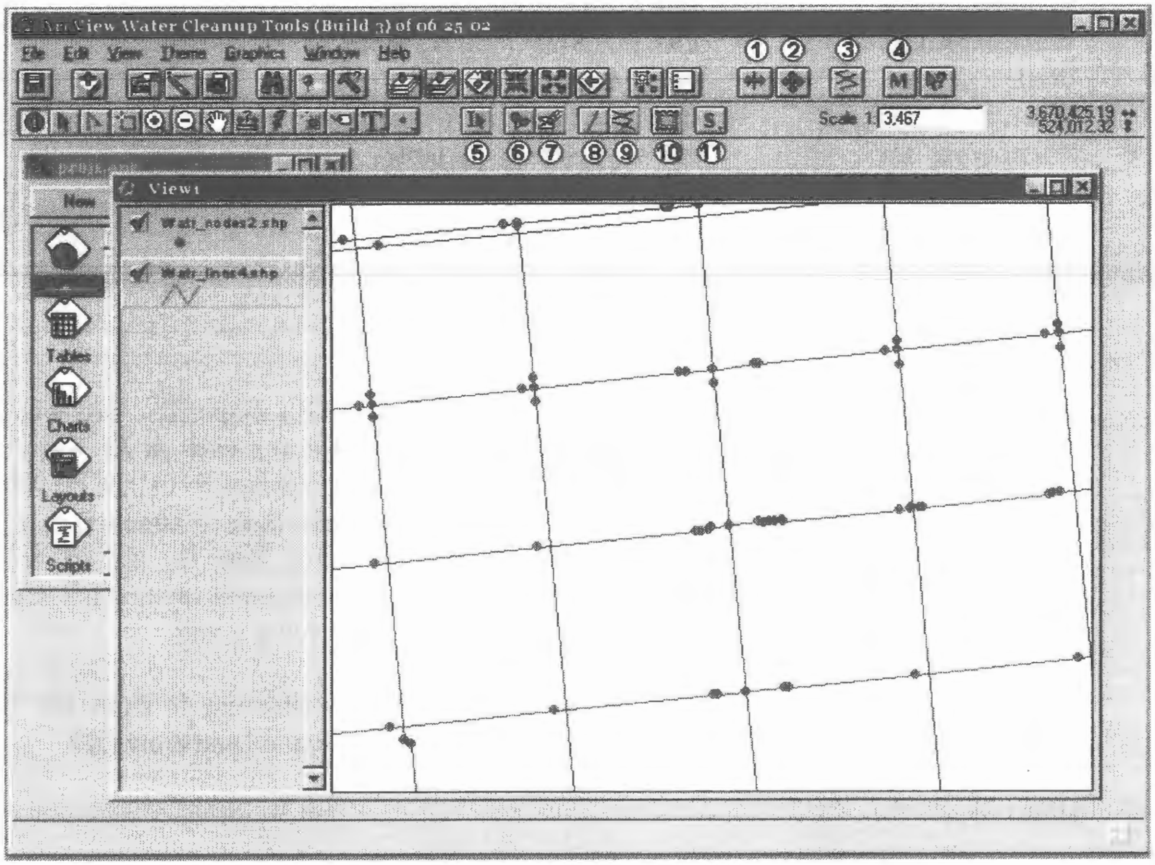
Each user will also require the nodes and links water data GIS shapefiles. No location is specified for these files. Add the nodes and links shapefiles to a view in ArcView in the usual manner. It is important to note that several of the cleanup tools act on both the nodes and the links themes. If there are several water links themes attached to a view, make sure the one to be edited is the first such link theme from the top of the open window when modifying a node. Likewise, if several water node themes are attached, make sure the correct one is at the top when adding or modifying a link.

Activate the WDTTE Water extension to a project by selecting it from the list of available extension under File/Extensions from the main menu of ArcView GIS.

USAGE

Eleven new buttons are available when the WDTTE Water extension is activated. The buttons are numbered 1 through 11, as shown in **Figure 2,** and are described below.

Figure 2
WDTTE Water Extension Buttons in ArcView GIS



1. **Valve Trace** - Select the pipe(s) of interest and press this button to locate the valves that would need to be closed to isolate the pipe(s).

2. **Extended Valve Trace** – Similar to the valve trace (1), but traces further to include all pipes that would be dry if the selected pipe(s) was isolated. This tool can assist in identifying all customers who will not have water services available when a pipe is isolated.

3. **Union Pipes** - Select two pipes to combine into a single pipe and select this button. If materials or sizes are different, a prompt will request the value to use for the composite pipe.

4. **Add Model Fields** - Select the node and link themes and press this button. The fields defined in watndfields.dbf and watlkfields.dbf will be added to the node and link attributes table.

5. **Edit Node or Pipe** - Select the node or link theme and use this tool to bring up an edit form for the feature chosen. The edit form includes information for identification number, pipe material, diameter, "from" and "to" nodes, and node type.

6. **Add Node -** Select the node theme, make it editable, and use this tool to place a new node. Be sure that the link theme is the first water link theme from the top, or the system won't modify the correct links theme. Links can be split if a node is added on the links and "Yes" is answered to the prompt. A node can also be placed on a free link endpoint.

7. **Move Node** - Select the node theme, make it editable, and use this tool to drag a node to a new spot. Again, be sure the first link theme is the first water link theme from the top, or the connected pipes will not be modified.

8. **Add Pipe** - Select the pipe theme, make it editable, and use this tool to lay a new pipe from one node to another. Click on the "from" node and drag to the "to" node with the right mouse button down. Let the mouse button up on the "to" node.

9. **Modify Pipe -** Select the pipe theme, make it editable, and use this tool to grab a pipe and connect it to another node. First click on the pipe once to select it, then drag one end to the desired node.

10. **View Pictures** - Provides access to overlay aerial photography for the network system. Use this tool button to hot-link to JPEG picture files. Click on an element with this tool and the JPEG viewer will launch with the files indicated by the element's PHOTOPATH and PHOTONAME. Note: the viewer tags on a "*.JPG" to the photo name to assist in having multiple photos for an element (e.g., the PHOTONAME = "PS121" would bring up all of the photos whose names start with "PS121").

11. **Fetch Basemap -** This is a drop-down tool button with three choices: Street centerline maps (S), low-resolution aerial photography (L), or high-resolution aerial photography (H). Select the tool and then draw a box on the view (click and drag with the left mouse button down) indicating the extent of background mapping desired to be brought in. A prompt will indicate which files will be added.

Appendix D

Appendix D

MWH

Appendix D –Field Testing Data

Fire Hydrant Field Testing

Site #	Location	Street	Date	Time	Flow & Pressure Readings							Comments
					Initial	Residual					Rebound	
					Test Site (psi)	Test Site (psi)	Hydrant 1 (F1) Flow (gpm)	Hydrant 1 (F1) Pressure (psi)	Hydrant 2 (F2) Flow (gpm)	Hydrant 2 (F2) Pressure (psi)	Test Site (psi)	
1	East Bank	Napolean Ave @ Aunnunciation St.	09/17/02	12:17	48							F1 & F2 open
				12:23		42	785	22.5	530	10		
				12:28							47	
2	East Bank	Short St. @ St. Charles Ave.	09/17/02	11:37	55							F1 & F2 open
				11:43		49	700	20	670	16		
				11:47							55	
3	East Bank	S. Rocheblave St. @ Milan St.	09/17/02	14:59	54							F1 & F2 open
				15:05		42	1010	36	725	21		
				15:10							54	
4	East Bank	S.Tonti @ Canal St.	09/17/02	15:38	52							F1 only
				15:44		42	690	17	820	27.5		
				15:52							52	
5	East Bank	Republic St. @ Rocheblave St.	09/17/02	16:50	43							F1 & F2 open
				16:57		30	680	18	500	9		
				17:03							43	
6	East Bank	Cadillac St. @ Milan St.	09/19/02	11:37	42							F1 & F2 open
				11:43		24	640	17	890	28		
				11:50							42	
7	East Bank	Robert E. Lee Blvd. @ Bluebird St.	09/19/02	10:30	51							F1 & F2 open
				10:37		36	820	48	905	29		
				10:45							52	
8	East Bank	Robert E. Lee Blvd. @ St. Anthony St.	09/19/02	9:15	37							F1 & F2 open
				9:20		30	900	32	555	11		
				9:26							38	
9	East Bank	Alvar St. @ Benefit St.	09/18/02	15:00	51							F1 & F2 open
				15:05		43	905	29	970	37		
				15:10							51	
10	East Bank	N. DerbiginySt. @ Louisa St.	09/18/02	15:32	45							F1 & F2 open
				15:39		39	965	33	875	27		
				15:45							45	
11	East Bank	N. Galvez St. @ Tupelo St.	09/18/02	16:21	51							F1 & F2 open
				16:26		45	1050	39	850	29		
				16:30							51	
12	East Bank	Alabama St. between Curran Blvd. and Morrison Rd.	09/18/02	14:03	52							F1 & F2 open
				14:08		45	900	35	950	32		
				14:16							53	
13	East Bank	Tara St. @ Wendy Ln.	09/18/02	11:33	51							F1 only
				11:38		29	775	24	790	22		
				11:45							50	
14	East Bank	Curran Rd. @ Windward Ct.	09/18/02	10:45	50							F1 only
				10:55		45	995	35	1050	43		
				11:00							50	
15	East Bank	Lemans St. @ Cannes St.	09/18/02	9:51	50							F1 & F2 open
				9:56		33	840	28	860	26		
				10:05							49	
16	East Bank	Lucrino Rd. @ Alba Rd.	09/18/02	9:10	50							F1 & F2 open
				9:16		12	500	10	580	12		
				9:25							52	
17	West Bank	Vespasian Blvd. @ Elizardi Blvd.	09/12/02	17:19	65							F1 only
				17:29		60	1170	55	N/A	N/A		
				17:32							66	
18	West Bank	Lenox St. @ Lakewood Estates Dr.	09/20/02	10:10	64							F1 & F2 open
				10:17		32	785	25	820	24		
				10:21							64	
19	West Bank	Pelican St. between Seguin and Bouny	09/20/02	12:11	60							F1 only
				12:19		20	410	6	N/A	N/A		
				12:22							60	
20	West Bank	Oliver St. @ Woodland Highway (406)	09/12/02	15:16	59							F1 only
				15:22		52	1040	42	N/A	N/A		
				15:31							59	

APPENDIX D

East Bank Pump Station Field Testing

Time	Claiborne Station (Pumps 1, 2, 3)													Station A & B (Pu		
	Pump 1					Pump 2				Pump 3				Pump B		
	Volume (gal)	Flow (gpm)	Velocity (fps)	Pressure (psi)	Speed (rpm) analog/ digital	Volume (gal)	Flow (gpm)	Velocity (fps)	Pressure (psi)	Volume (gal)	Flow (gpm)	Velocity (fps)	Pressure (psi)	Volume (gal)	Flow (gpm)	Velocity (fps)
11:37	19,000	28500	8.5	75.5	680/747.5	487,468	24840	7.764	72	487,468	24840	7.764	72.5	4,071,500	31,200	10
11:43	134,400	31900	8.8	75	675/743	686,693	24840	7.764	72	686,693	24840	7.764	72.5	4,219,600	31,500	9.8
12:17	45,500	27300	8.5	75.5	680/748	714,887	24840	7.764	72	714,887	24840	7.764	73	5,244,800	28,800	9
12:23	166,500	26900	9.6	76	680/747	859,733	24588	7.686	72	859,733	24588	7.686	73	5,398,500	29,600	9.7
14:59	17,200	29700	8.9	75.5	675/745	867,887	24840	7.764	72	867,887	24840	7.764	72.5	10,074,300	30,300	9.6
15:04	14,300	28700	8.9	75.5	675/744	988,645	24336	7.764	72	988,645	24336	7.764	72	10,244,400	32,900	10.3
15:38	973,500	27900	8.8	75	675/742	54,171	24840	7.764	72	54,171	24840	7.764	72.5	11,343,300	31,200	9.9
15:44	15,500	28700	8.4	76	675/744	93,360	24588	7.686	72	93,360	24588	7.686	72	11,457,000	31,900	9.4
16:50	298,600	26800	9	76	675/742	739,747	24840	7.843	72	739,747	24840	7.843	73	13,439,000	31,400	9.9
16:57	218,200	25400	8.1	75.5	670/736	930,949	24336	7.686	72	930,949	24336	7.686	72	13,681,300	31,100	11.2
9:10	418,600	25000	9	75	670/735	415,602	24084	7.686	72	415,602	24084	7.686	72	475,900	33,100	10.4
9:15	70,000	27000	8.4	75.5	670/735	424,492	24336	7.843	72	424,492	24336	7.843	72	652,700	33,800	10.4
9:51	1,041,300	27500	9.9	75	680/744	342,425	24588	7.686	72	342,425	24588	7.686	72.5	1,014,600	31,200	9.8
9:56	80,300	27400	9	75.5	680/745	433,118	24336	7.686	72	433,118	24336	7.686	72	1,976,900	32,000	10
10:43	1,347,700	29100	9.3	76	680/745	617,584	24336	7.843	72	617,584	24336	7.843	72	3,539,500	33,400	10.4
10:50	274,500	28700	8.6	76	680/744	91,623	24840	7.843	72	91,623	24840	7.843	72.5	3,876,800	32,600	10.2
11:33	1,063,000	28000	9.3	75.5	670/732	37,254	24336	7.686	72	37,254	24336	7.686	72	5,101,400	31,900	10
11:38	114,000	30500	10.4	75.5	670/735	150,876	24588	7.686	72	150,876	24588	7.686	72	5,226,700	31,100	9.9
14:03	2,655,000	28000	8.5	76	680/745	705,060	25092	7.843	72	705,060	25092	7.843	73	9,798,400	31,300	9.9
14:08	148,200	27600	8.4	76	670/741	759,663	24336	7.686	72	759,663	24336	7.686	72	9,968,400	30,800	9.7
15:00	461,800	26800	7.9	76	675/742	936,831	24336	7.843	72	936,831	24336	7.843	73	11,514,800	29,900	9.4
15:05	107,800	28600	8.1	75.5	675/743	52,160	24588	7.764	72	52,160	24588	7.764	72.5	11,710,700	31,400	9.9
15:34	796,900	29700	8.6	76	675/742	748,982	23832	7.529	72	748,982	23832	7.529	72.5	12,556,700	29,800	9.3
15:40	103,400	32700	7.9	75.5	675/742	858,927	24084	7.686	72	858,927	24084	7.686	72.5	12,730,600	29,800	9.3
16:24	1,200,600	32800	8.6	75.5	675/741	911,497	24588	7.764	72	911,497	24588	7.764	72.5	14,057,600	30,500	9.6
16:26	137,800	29200	8.3	75.5	675/741	44,306	24588	7.686	72	44,306	24588	7.686	72.5	14,198,300	32,600	9.8
9:15	1,008,300	32000	9.6	75.5	690/752	975,587	24840	7.686	72	975,587	24840	7.686	72	1,072,600	31,200	10.2
9:20	173,600	31900	9.4	75.5	690/751	134,498	24336	7.686	72	134,498	24336	7.686	72	1,331,600	33,400	10.5
10:30	1,985,100	35800	9.8	75	685/750	815,776	24588	7.764	72	815,776	24588	7.764	72.5	3,479,800	32,700	10.3
10:37	232,900	26800	8.9	75.5	680/745	13,897	24588	7.686	72	13,897	24588	7.686	72	3,799,500	32,000	10.1
11:36	1,657,700	28400	9.7	75.5	680/746	467,240	24336	7.764	72	467,240	24336	7.764	72	5,687,600	30,400	9.5
11:42	165,600	31000	9.2	75	680/746	620,693	24336	7.686	72	620,693	24336	7.686	72	5,852,200	32,900	9.7

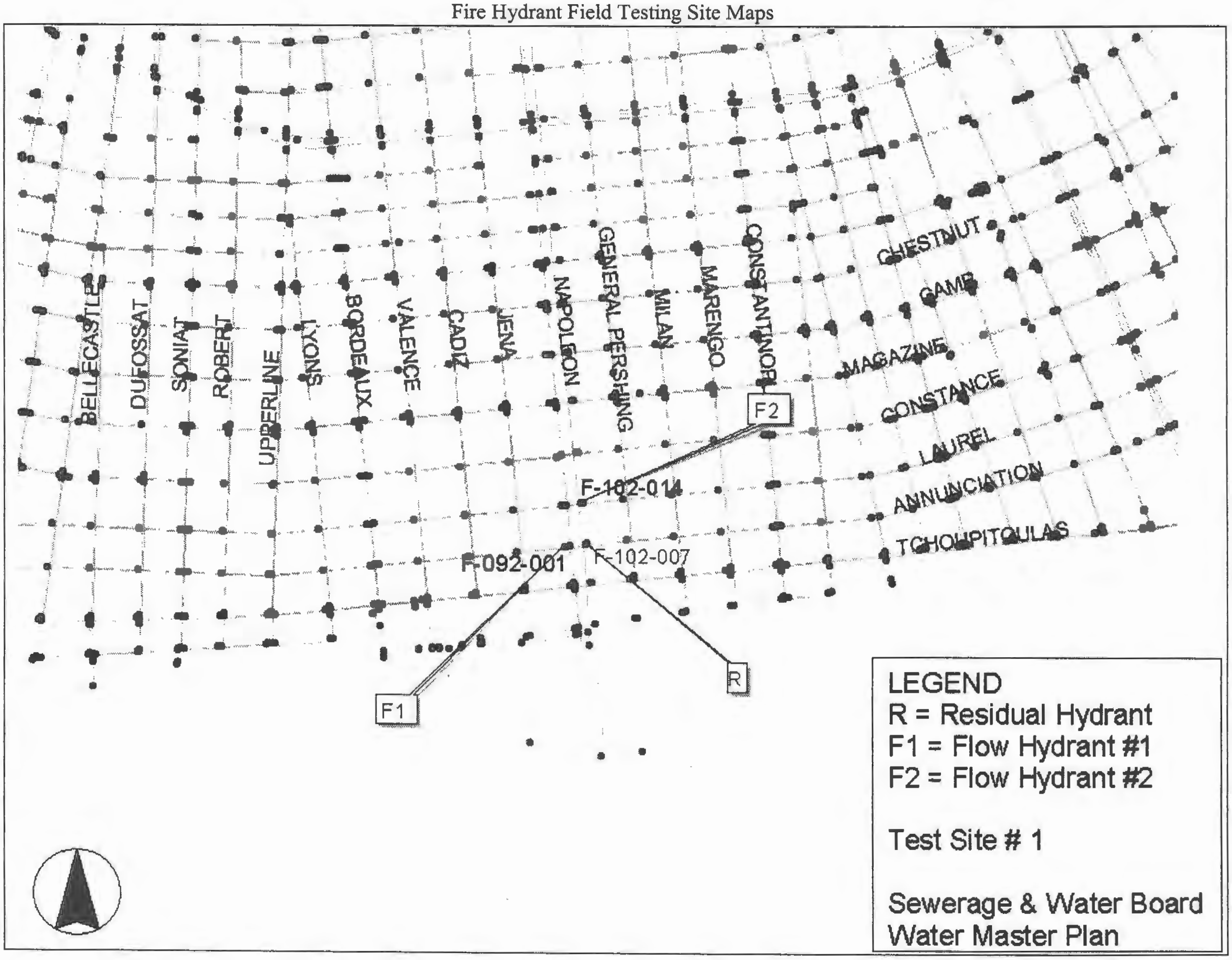
APPENDIX D

West Bank Pump Station Field Testing

Site #	Date	Time	Flow (gpm)			Pressure (psi)	Pump #1 Speed (rpm)	Pump #7 Speed (rpm)	Wet Well Level (ft)	Elev. Tank Level
			24" Venturi	20" Venturi	36" Venturi					
20	09/12/02	15:16	1806	1111	4722	64.5	1610	815	12.1	28.0
		15:25	1806	1111	3750	63.4	1610	815	12.1	28.0
17	09/12/02	17:17	1944	1181	4028	62.7	1610	790	11.8	27.0
		17:27	2014	1250	4097	62.5	1610	790	12.1	26.5
18	09/20/02	10:10	2014	1181	4306	61.7	1675	785	17.9	23.5
		10:17	2014	1111	4306	61.8	1675	785	17.9	23.5
19	09/20/02	12:11	2014	1181	4097	61.9	1675	785	16.7	23.5
		12:19	1944	1250	4236	61.6	1675	785	16.7	23.5

APPENDIX D

Fire Hydrant Field Testing Site Maps



APPENDIX D

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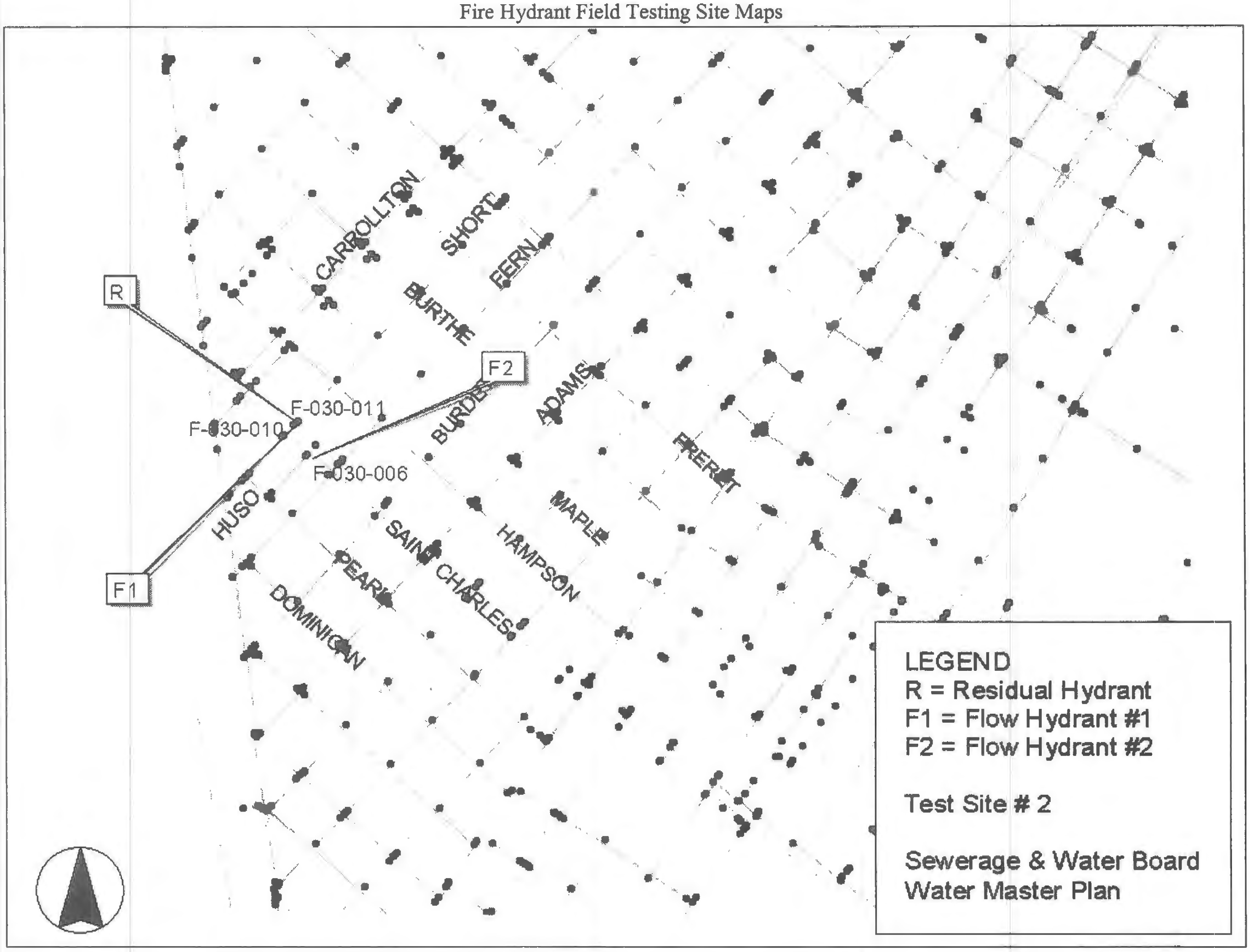
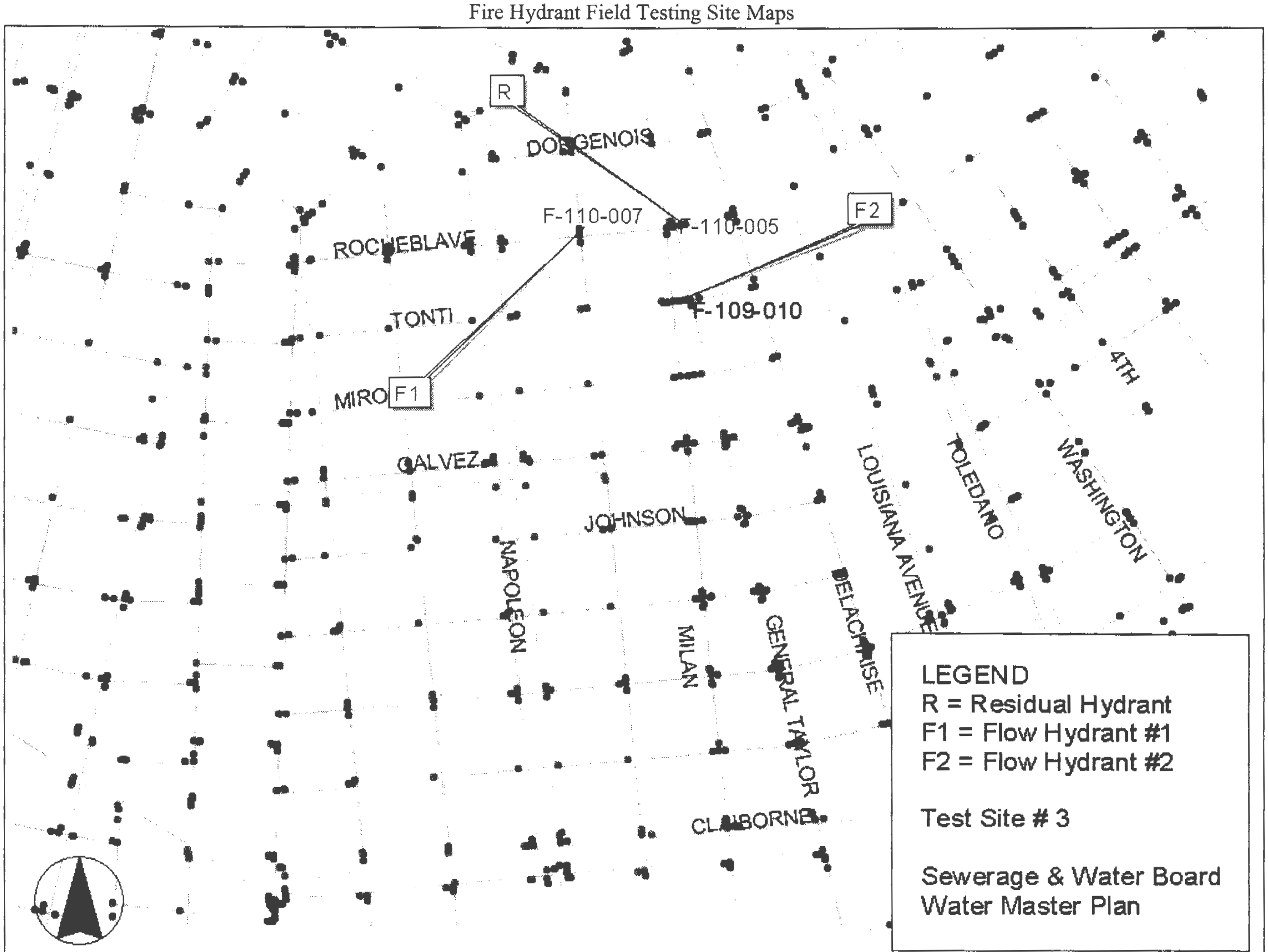


Fire Hydrant Field Testing Site Maps



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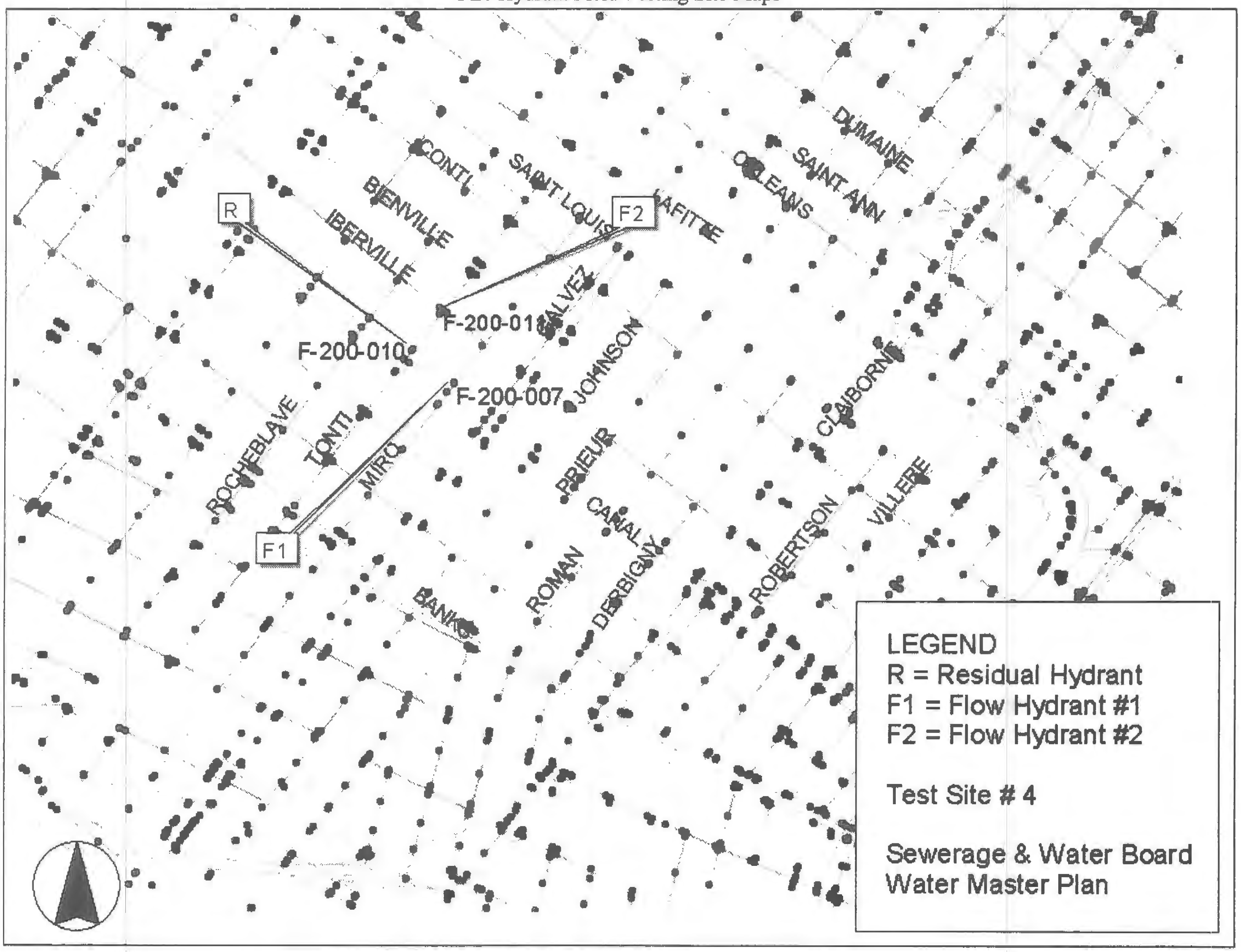

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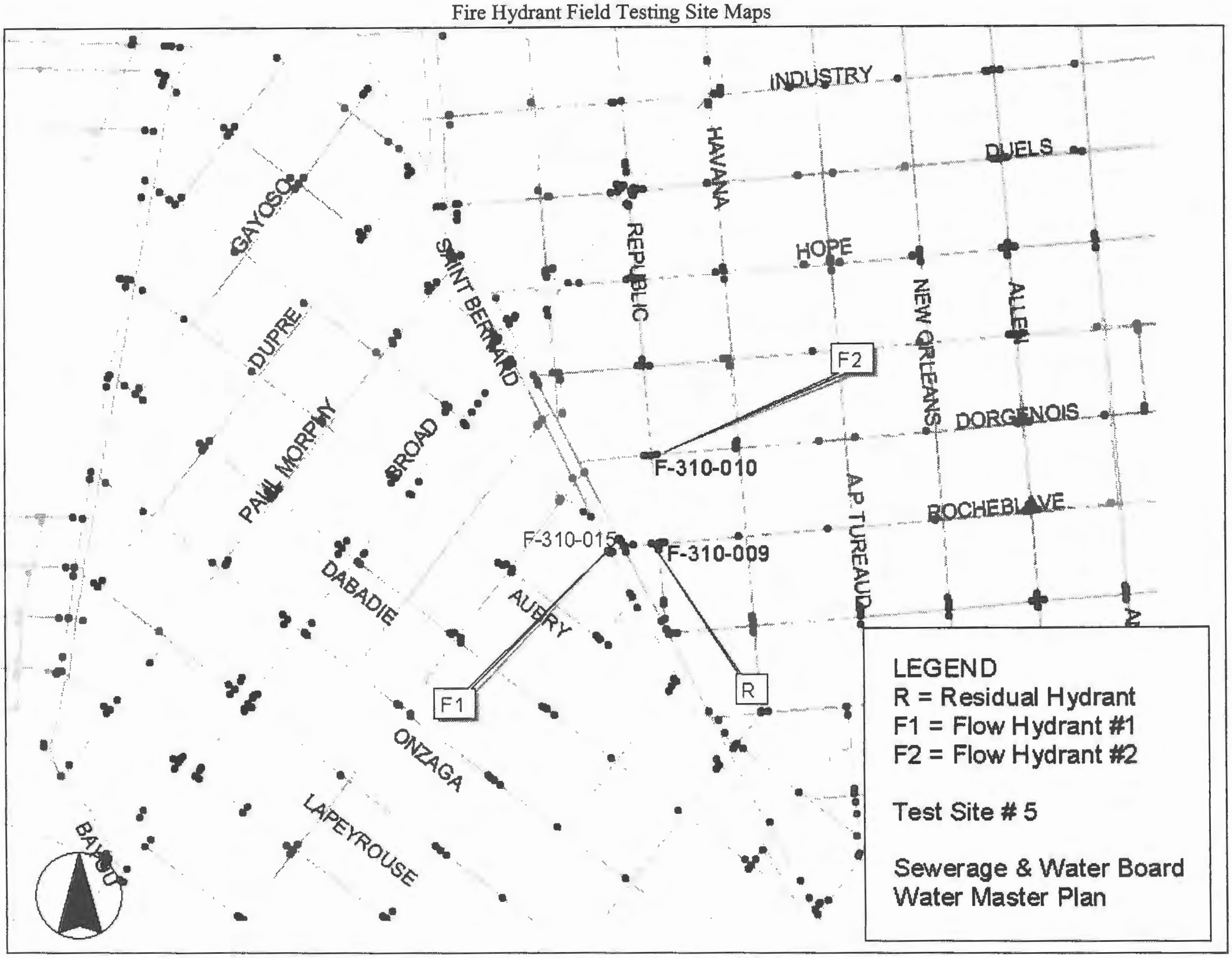
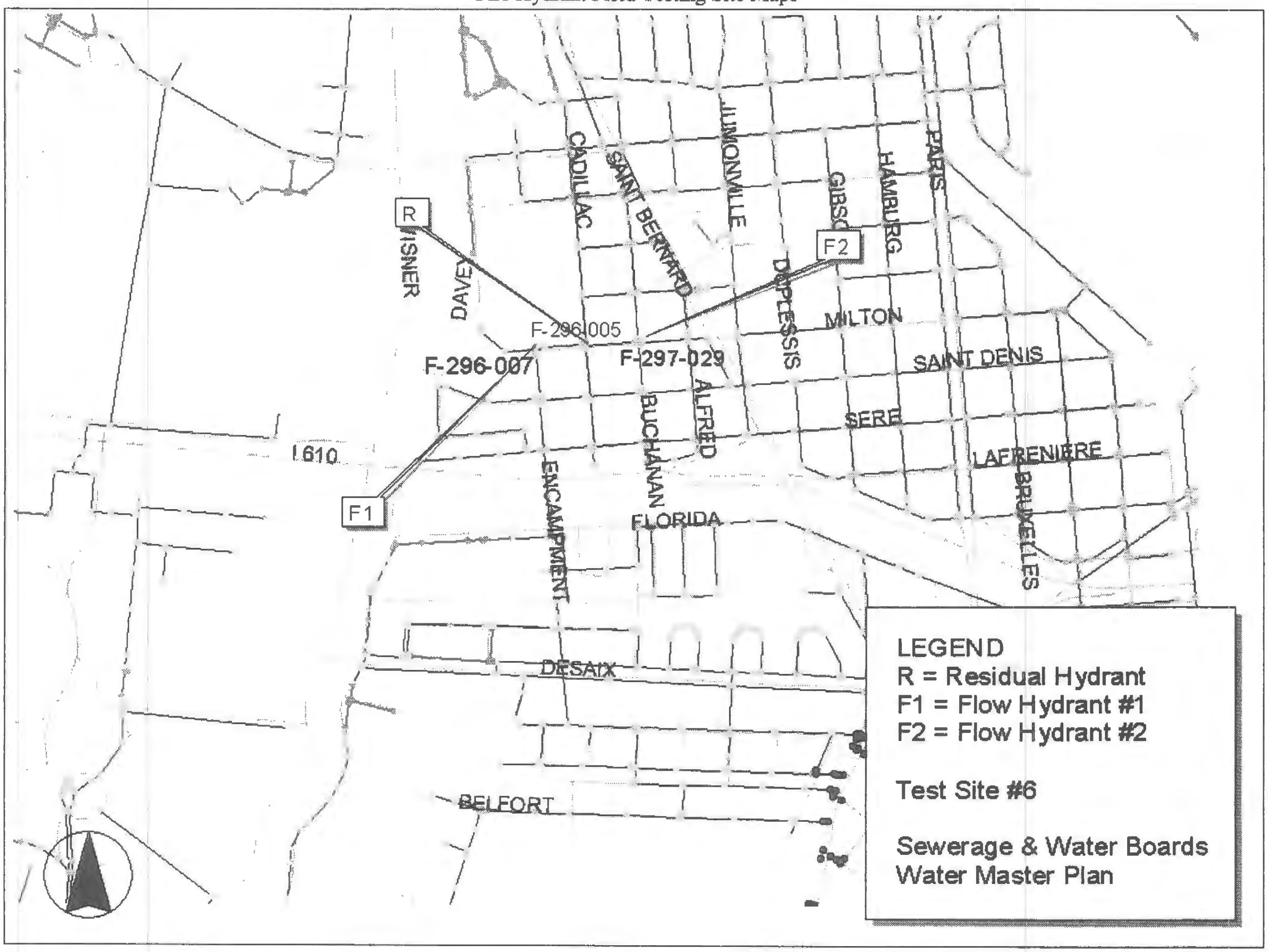


Fire Hydrant Field Testing Site Maps



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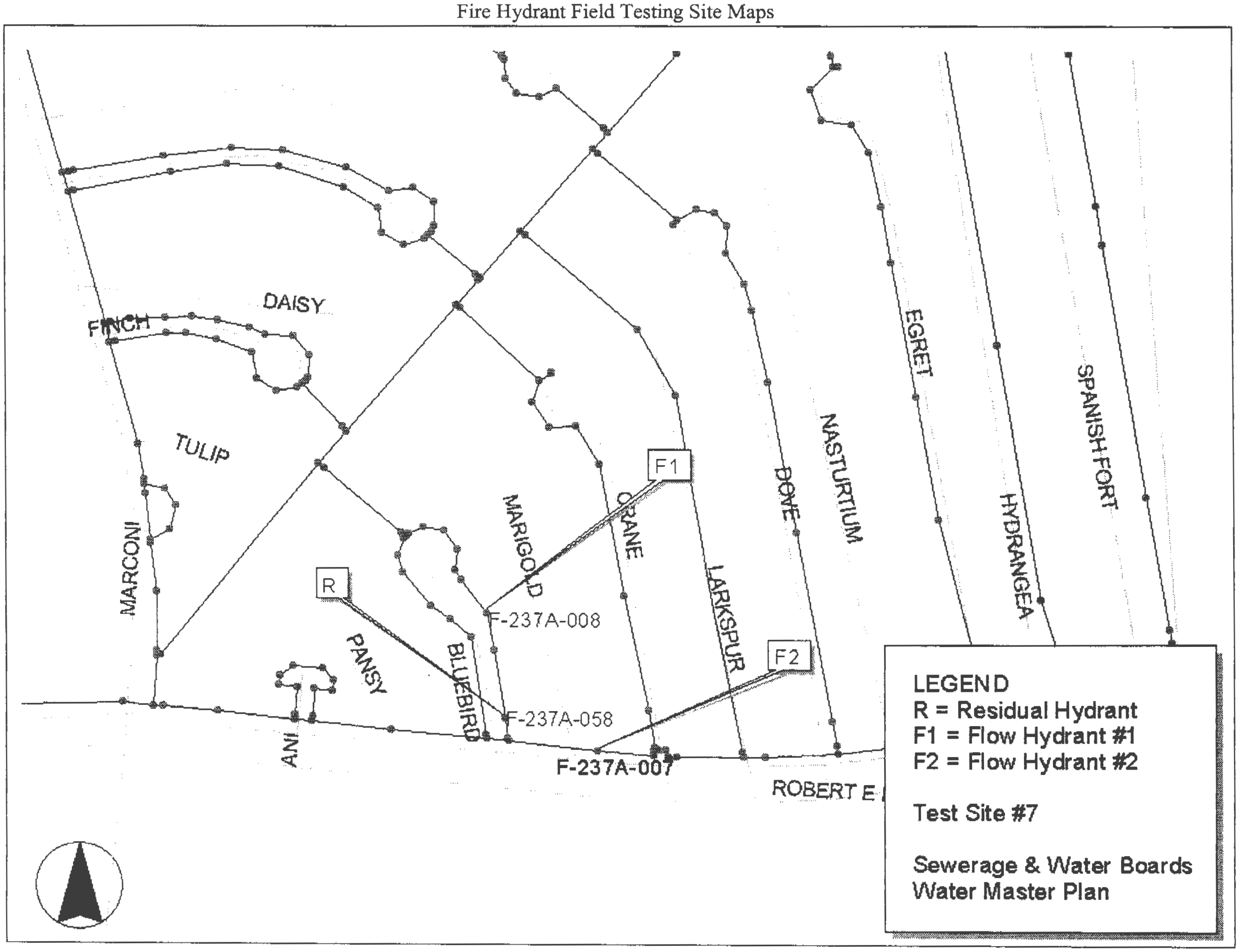

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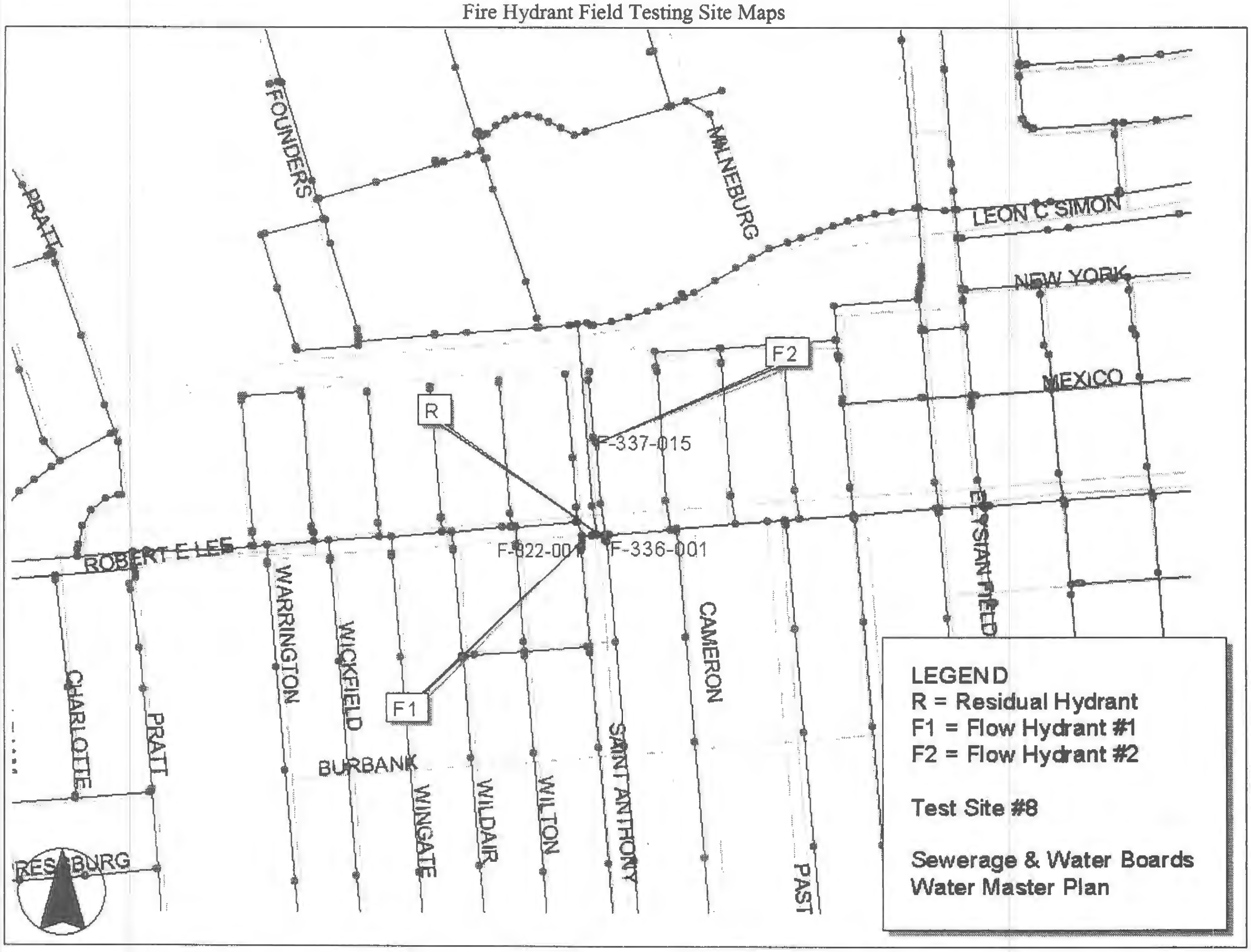

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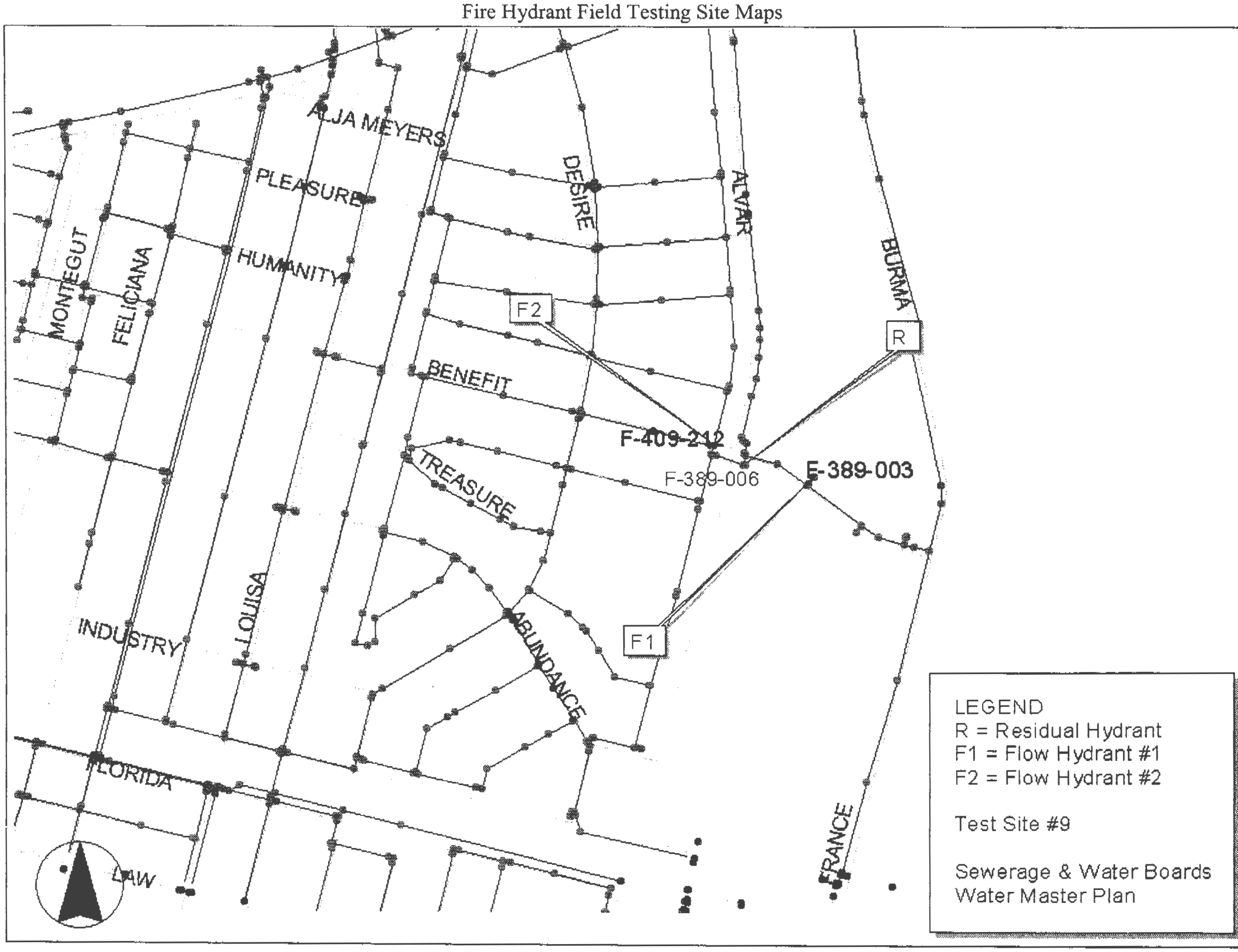

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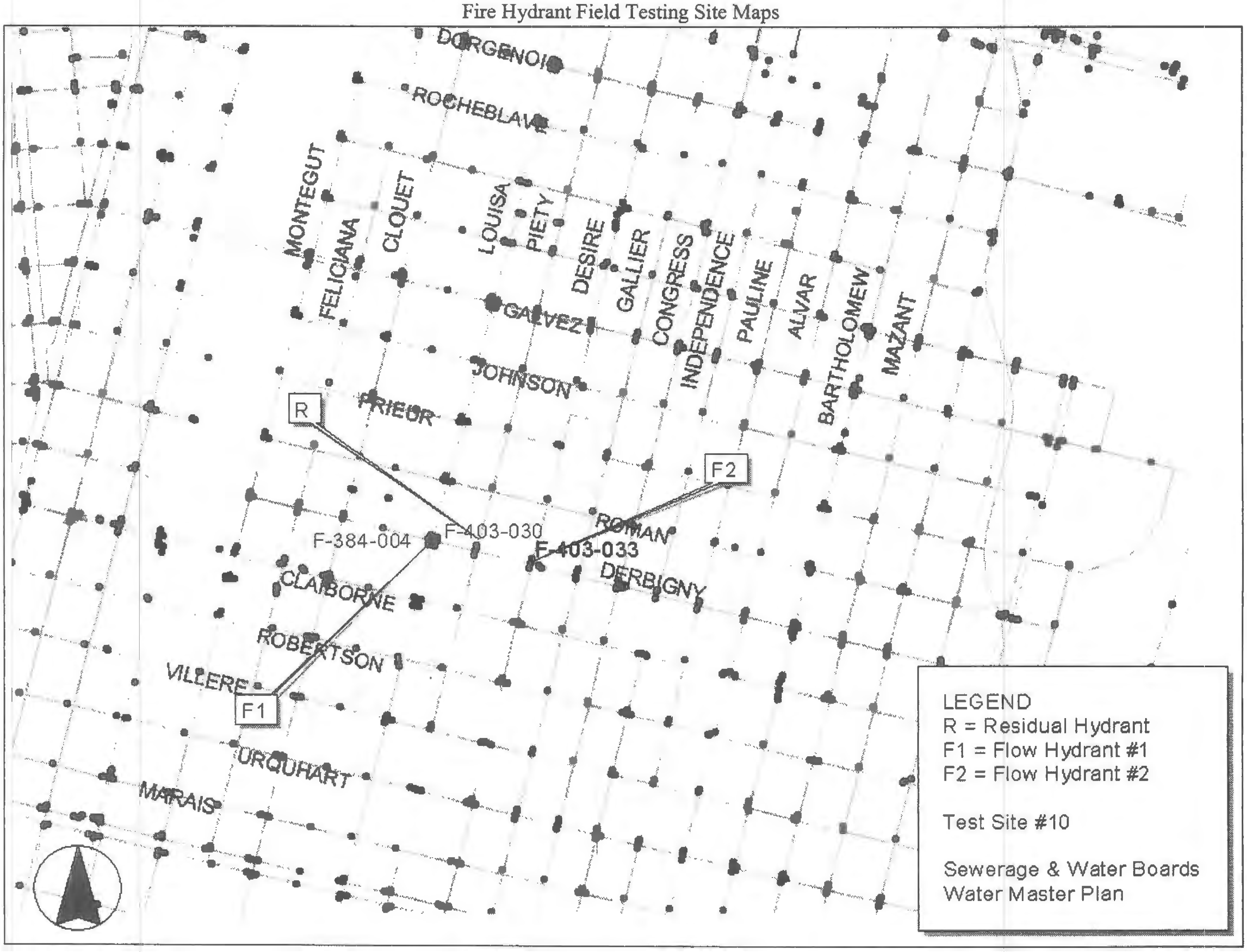

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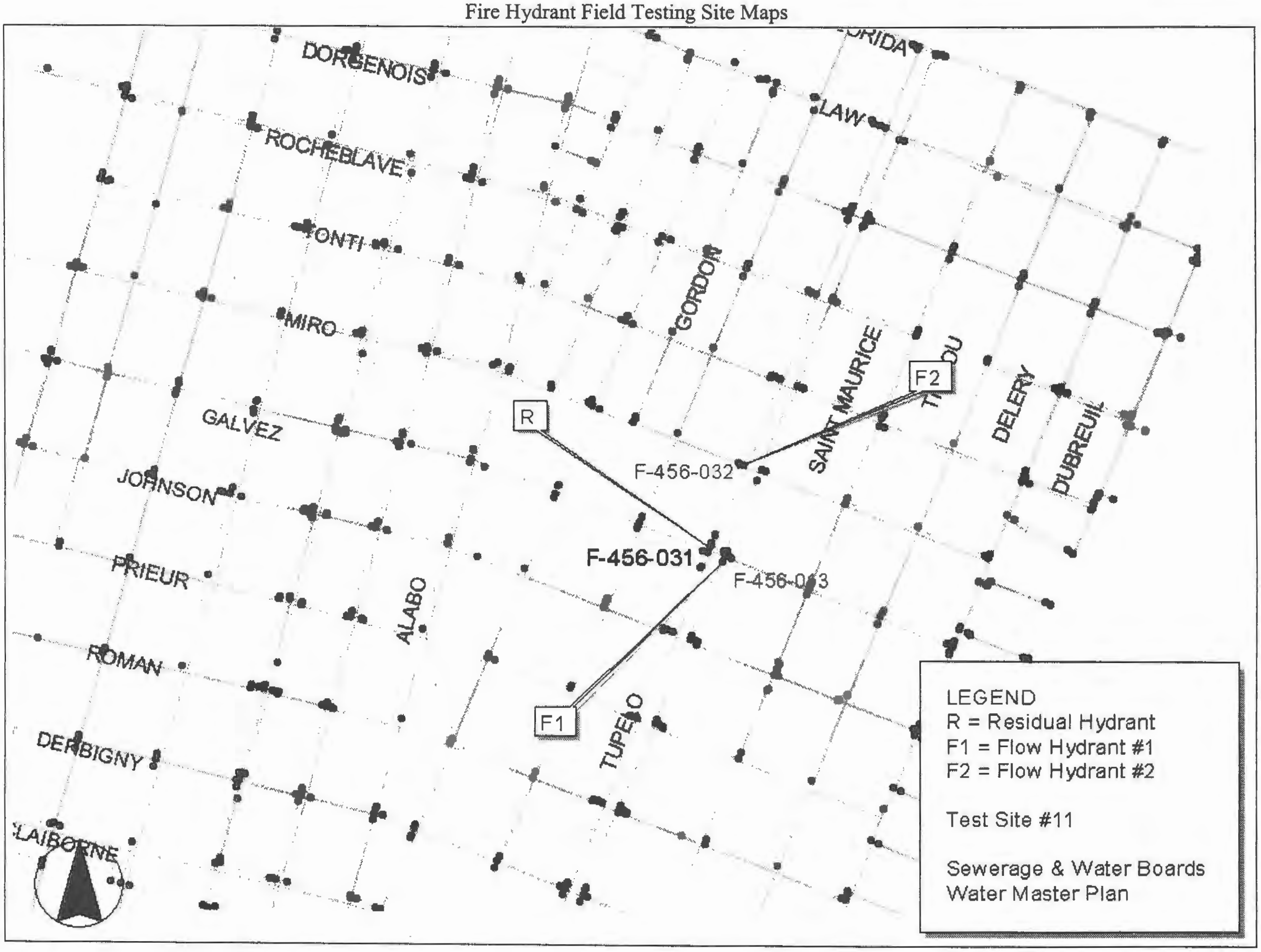

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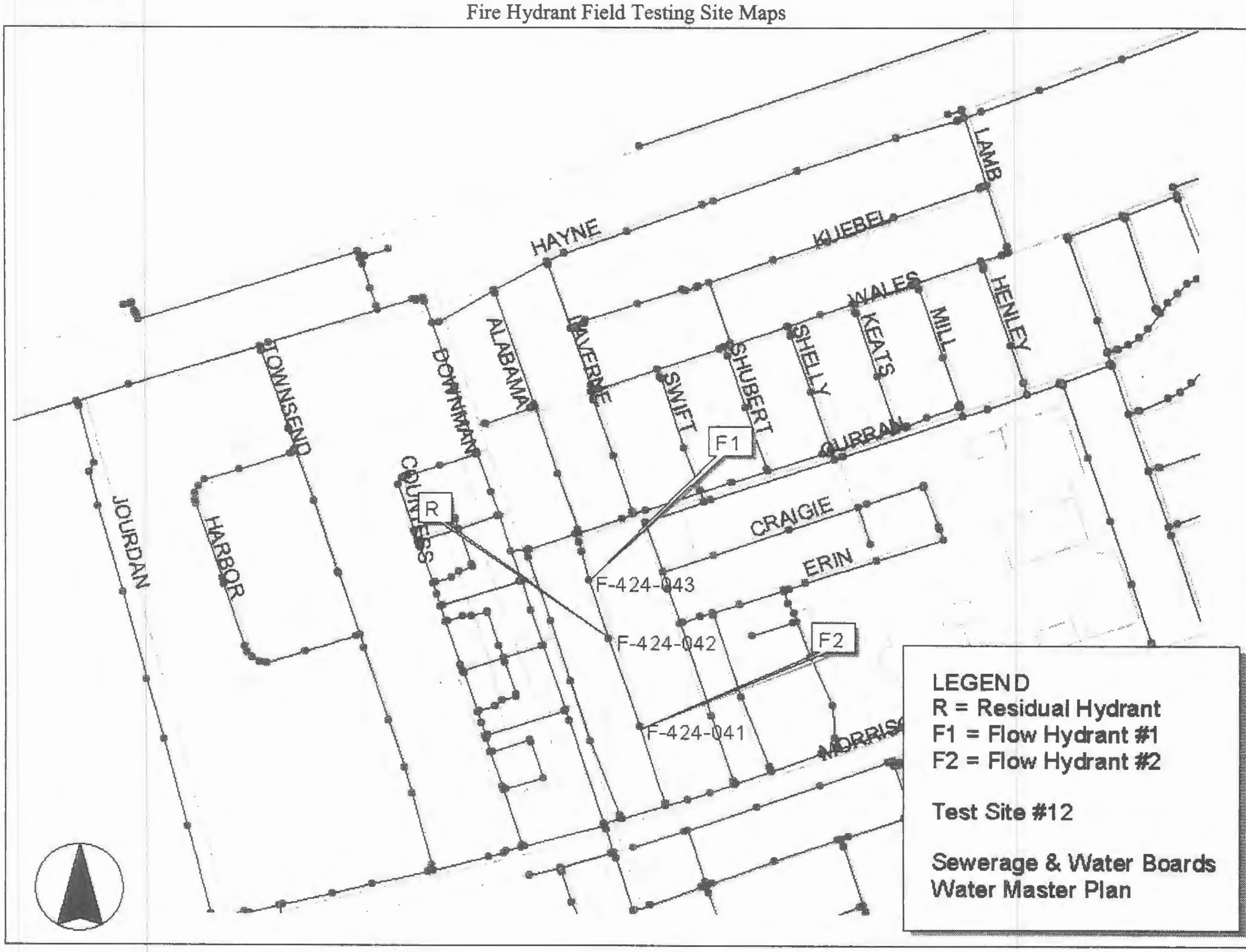

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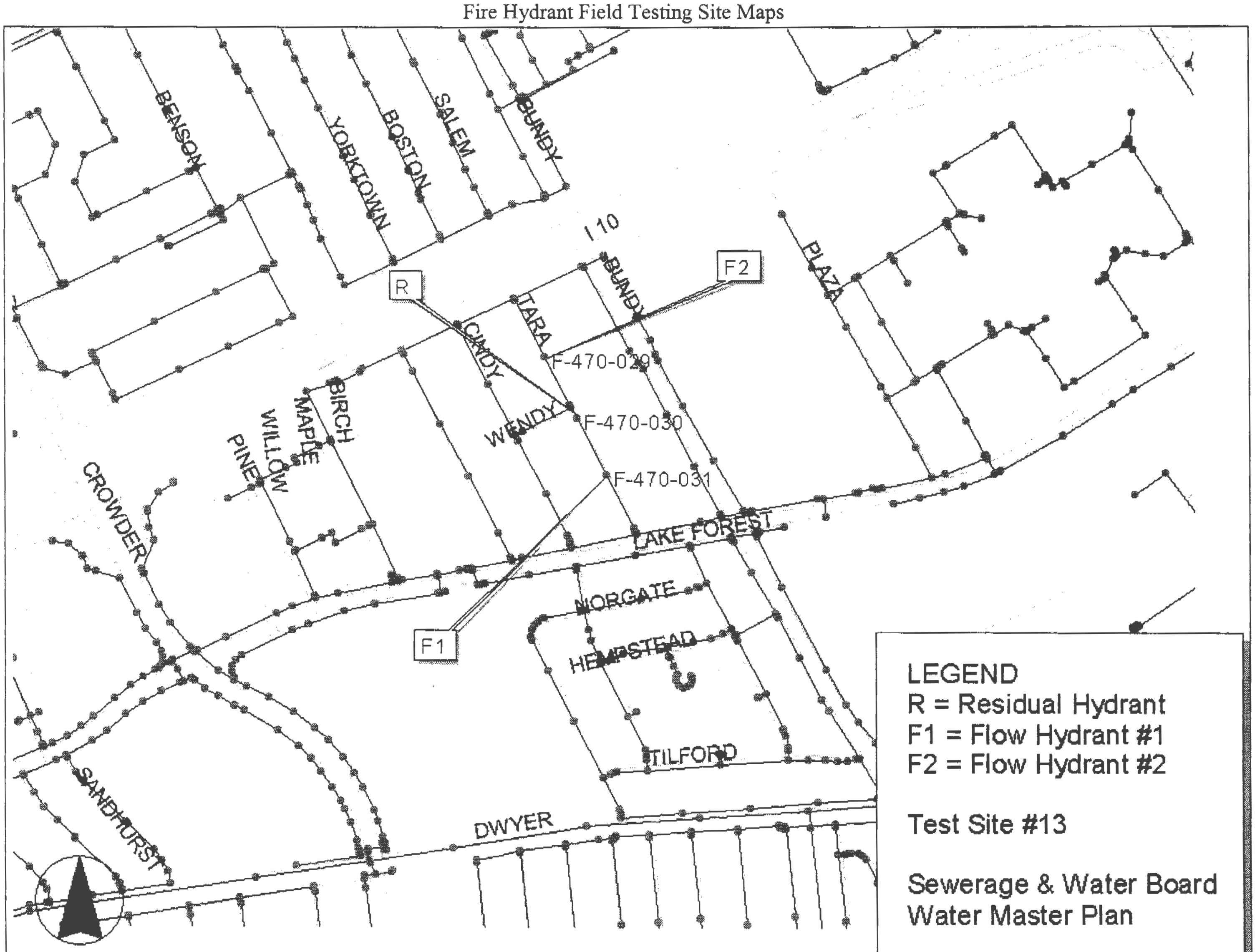

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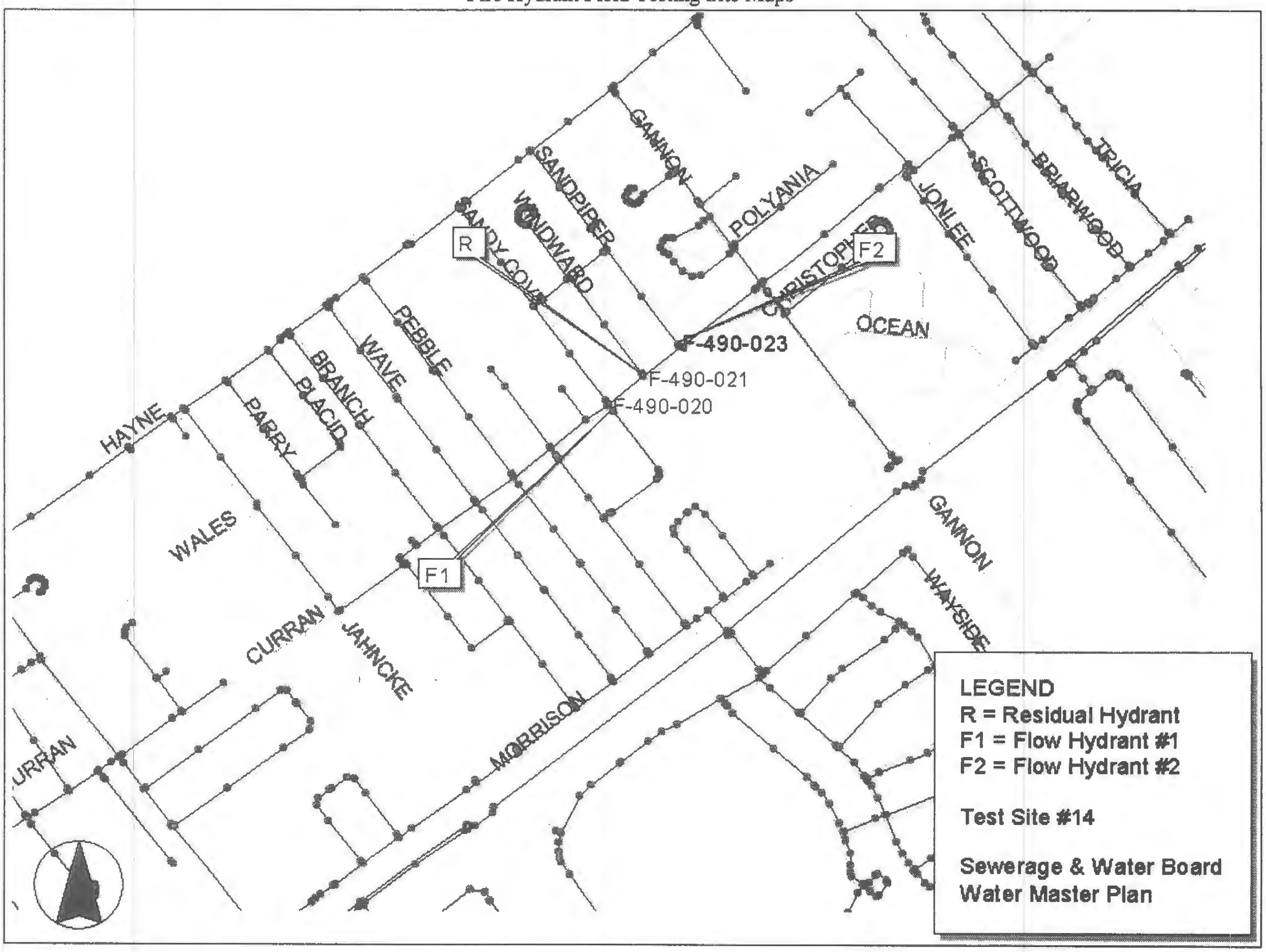
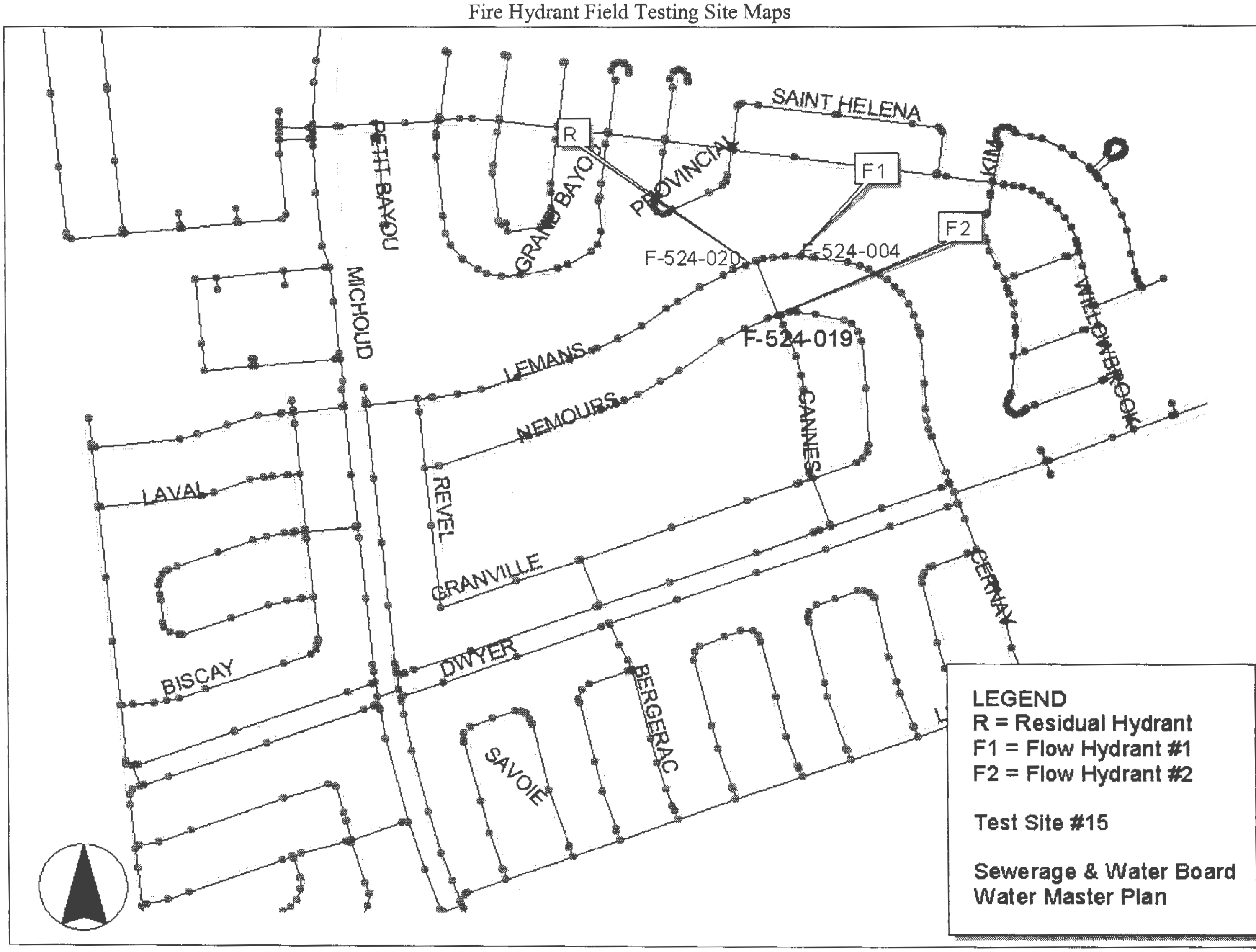


Fire Hydrant Field Testing Site Maps



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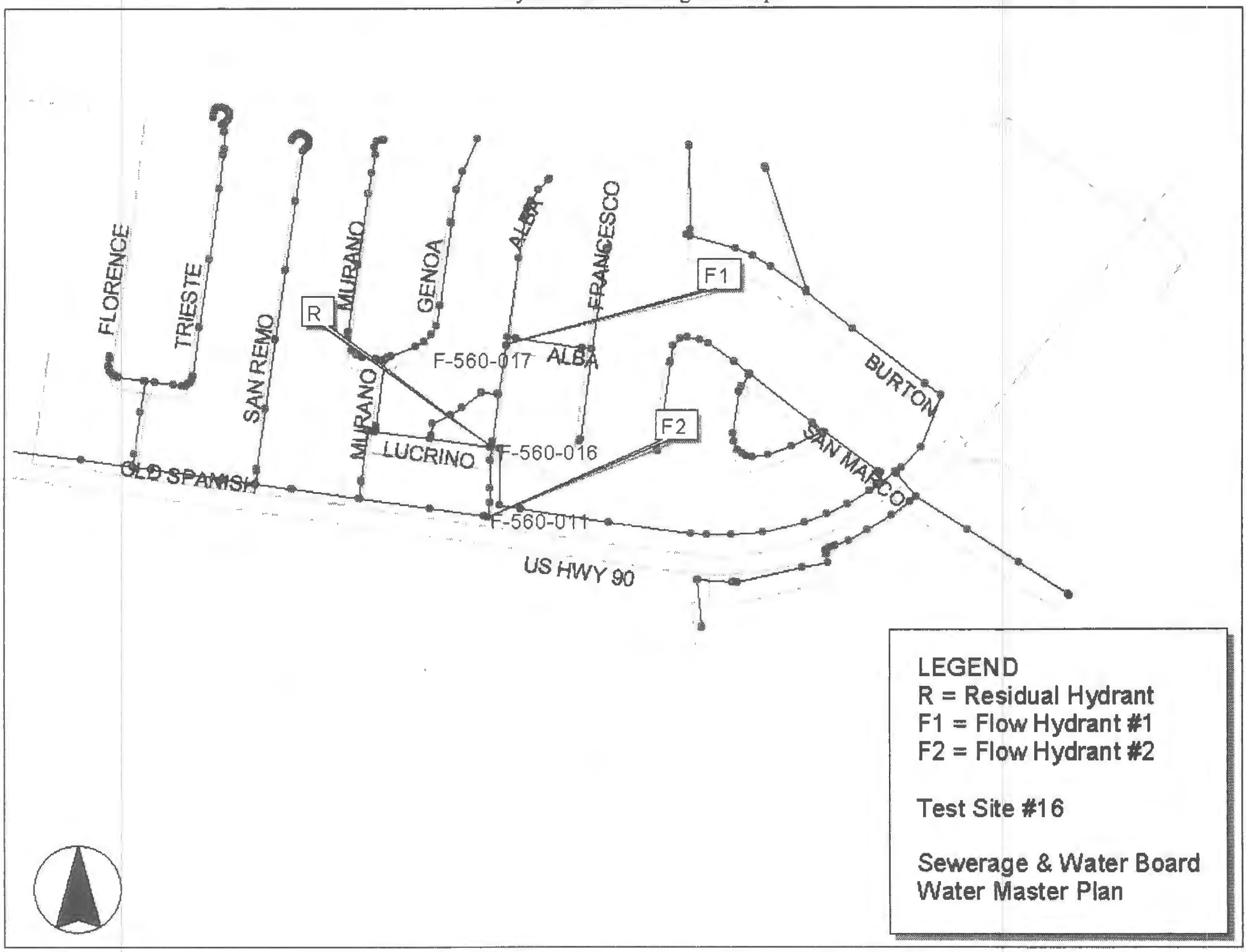

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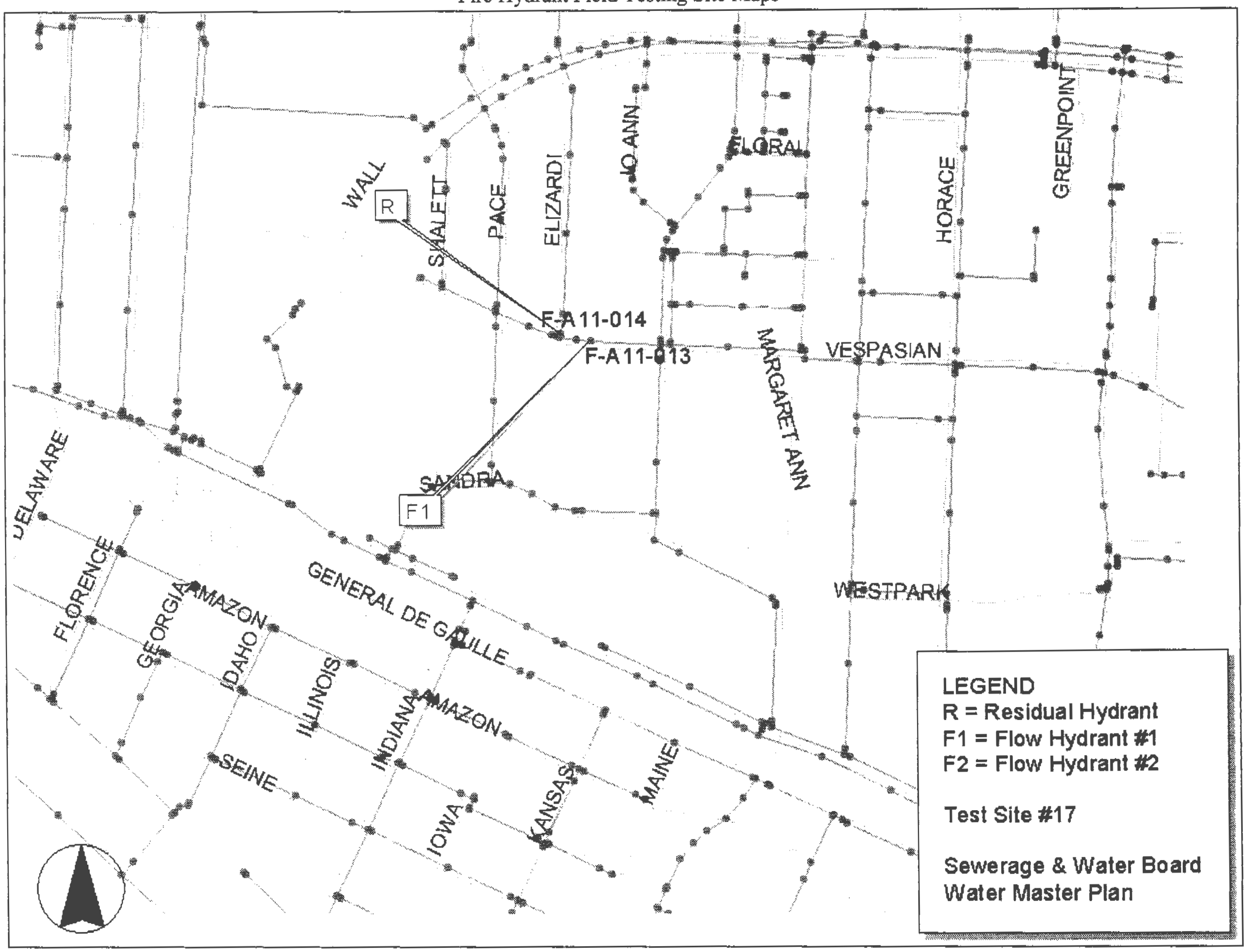

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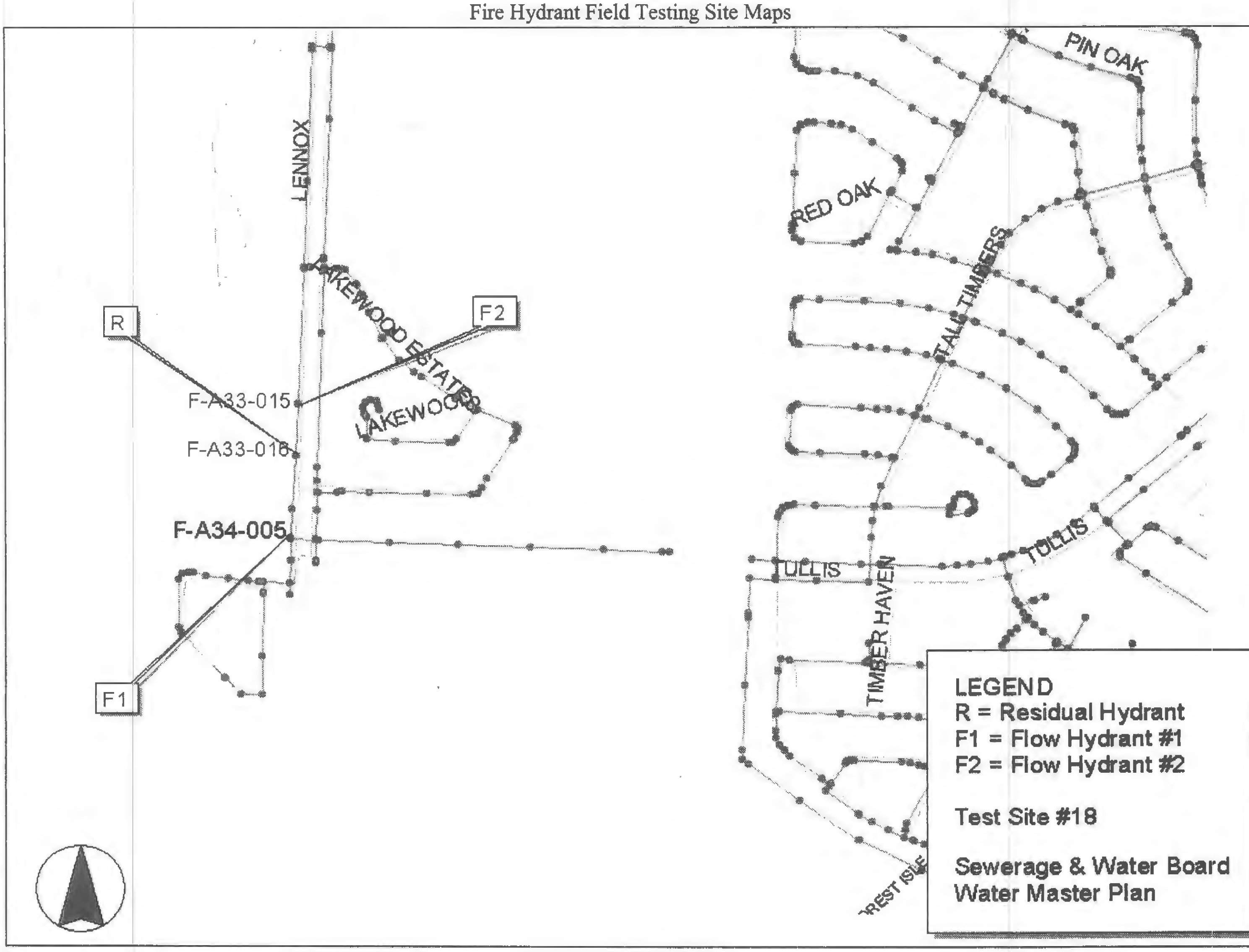

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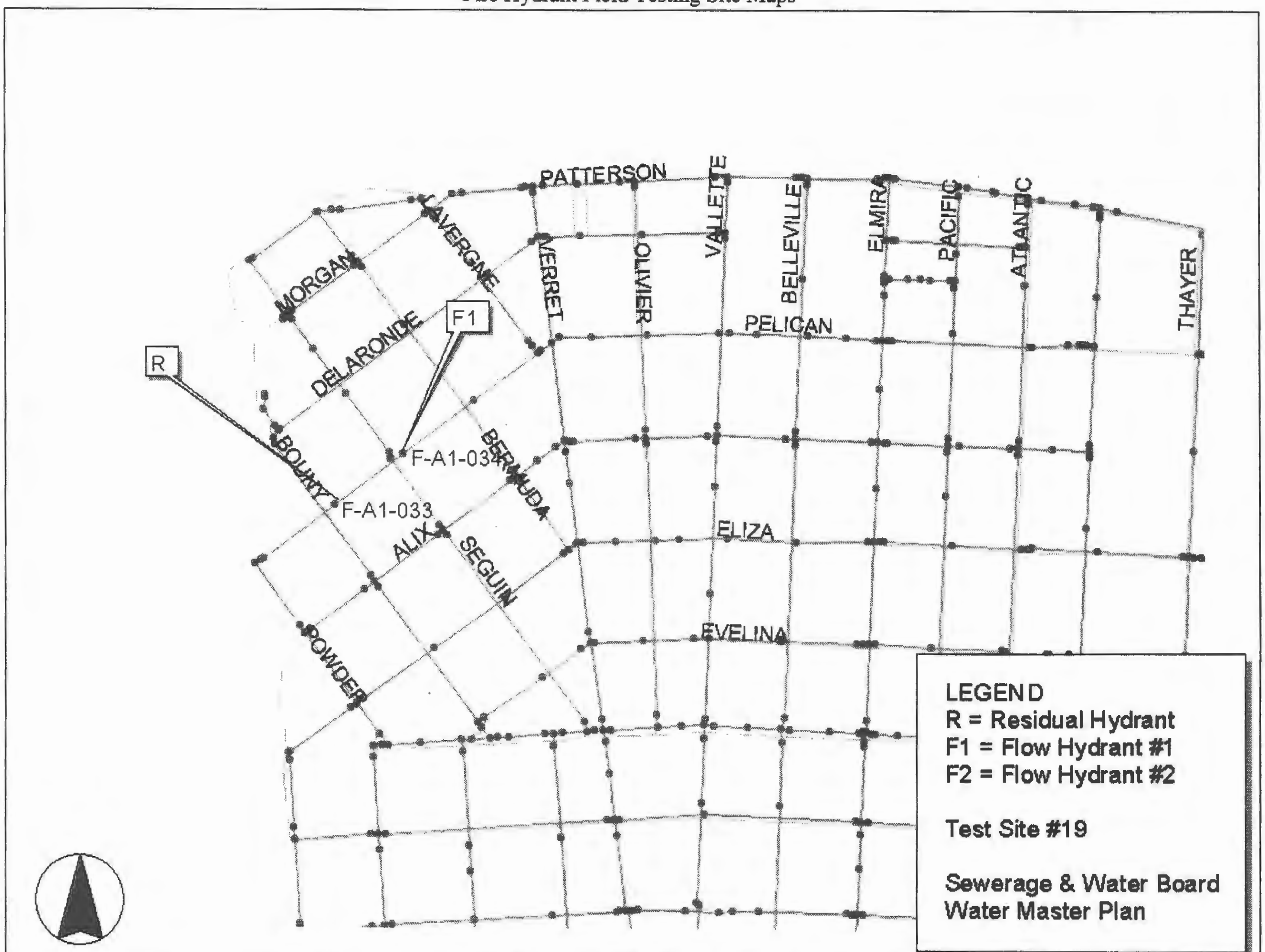

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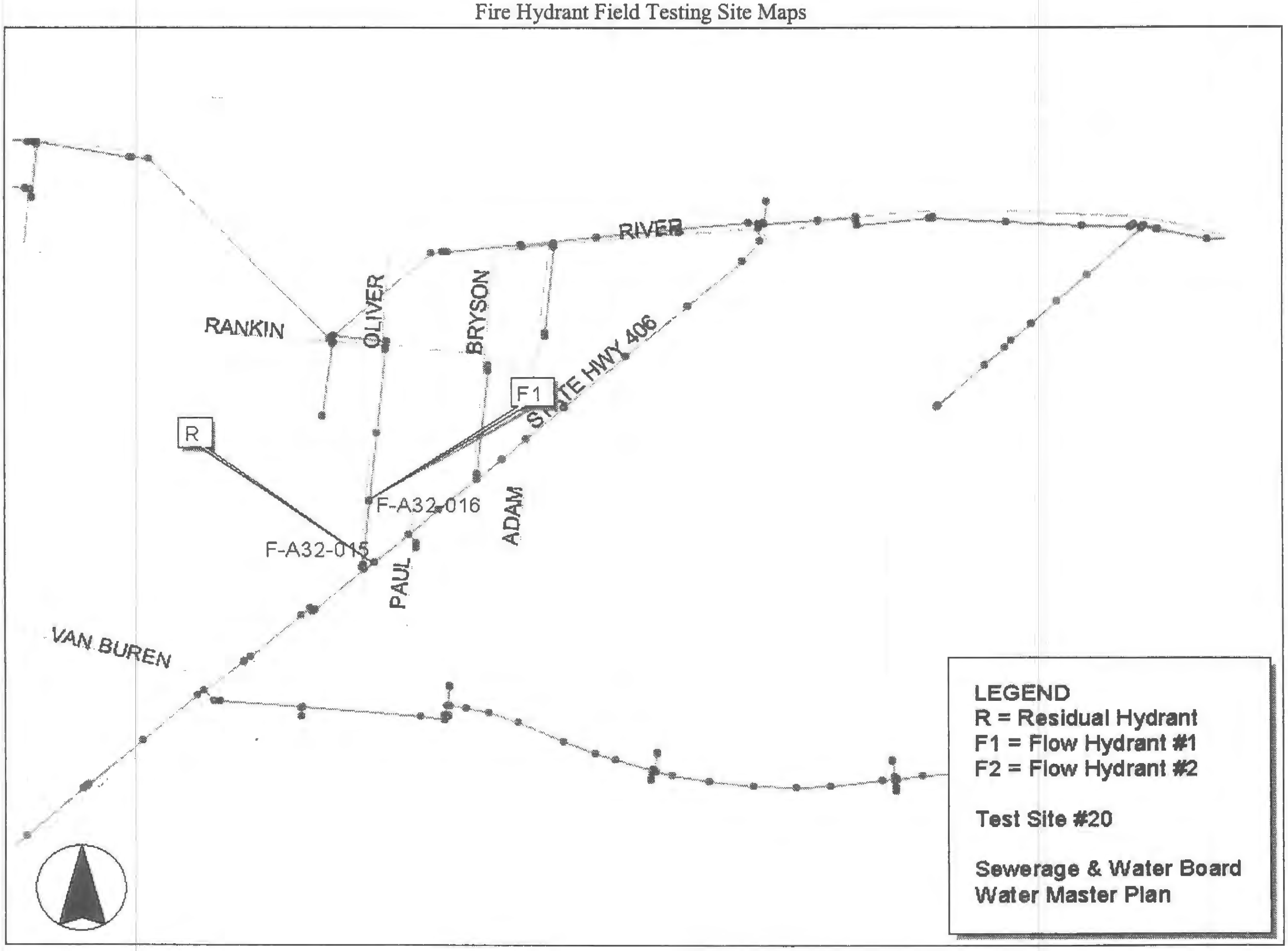

Appendix E

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Appendix E

Appendix E – Results of Model Calibration

East Bank
Pressure Comparison for Property Insurance Association Hydrant Testing

Location	Main Size	Hydrant ID	Static Field Pressure (psi)	Residual Pressure (psi)	Avg. Model Pressure (psi)	Pressure Difference (psi)	Percent Difference (%)
RAYNES & CHARTER	6	F-440-006	42	14	54	12	22%
DOUGLAS & LAMANCHE	6	F-447-004	44	32	55	11	20%
FRENCHMAN & AGRICULTURE	6	F-329-007	47	31	57	10	18%
PRESS & URQUHART	6	F-383-033	47	35	56	9	16%
N. RAMPART & KENTUCKY	6	F-414-002	46	24	55	9	16%
N.GALVEZ & POLAND	12	F-417-003	48	30	57	9	16%
S. PETERS & CALLIOPE	16	F-158-018	46	26	55	9	16%
N. ROMAN & ST. MAURICE	6	F-455-039	48	30	57	9	16%
SENATE & PAUGER	6	F-332-003	48	10	56	8	14%
S. PETERS & MARKET	12	F-146-005	46	23	54	8	15%
BENEFIT & REPUBLIC	12	F-313-021	48	21	56	8	14%
TCHOUPITOULAS & JEFFERSON	6	F-078-007	47	24	54	7	13%
TCHOUPITOULAS & EUTERPE	6	F-151-009	48	21	55	7	13%
ST. CHARLES & GRAVIER	12	F-178-008	51	42	58	7	12%
TULANE & LASALLE	6	F-198-031	51	41	58	7	12%
POYDRAS & S. ROBERTSON	6	F-180-016	52	50	59	7	12%
ST. CHARLES & GIROD	12	F-172-016	50	38	57	7	12%
S. PETERS & GIROD	8	F-171-029	48	42	55	7	13%
ST. ANTHONY & PRENTISS	12	F-322-007	52	28	59	7	12%
DRYADES & FELICITY	6	F-155-030	52	40	59	7	12%
EASTOVER COUNTRY CLUB	12	F-519-016	52	31	59	7	12%
ALMONASTER & ELAINE	12	F-495-001	50	17	56	6	11%
HAYNES & BREVARD	8	F-478-052	50	36	56	6	11%
LEON C. SIMON & FRANKLIN	12	F-375A-002	50	36	56	6	11%
ACADIA & LOTUS	6	F-368-015	51	34	57	6	11%
WASHINGTON & S. WHITE	6	F-133-030	58	38	64	6	9%
DANTE & WILLOW	6	F-032-022	58	42	64	6	9%
TCHOUPITOULAS & HENRY CLAY	6	F-066-006	48	20	54	6	11%
PRYTANIA & ANTONINE	6	F-113-027	52	44	58	6	10%
TCHOUPITOULAS & LOUISIANA	12	F-117-029	49	14	55	6	11%
COLISEUM & ST. MARY	6	F-139-006	52	30	58	6	10%
CANAL & CONVENTION CENTER	16	F-177-025	48	40	54	6	11%
GENTILLY & POUCHE COURT W.	12	F-504-001	50	30	56	6	11%
DECATAUR & TOULOUSE	8	F-266-010	50	45	55	5	9%
ELYSIAN FIELDS & N. MIRO	6	F-346-029	53	26	58	5	9%
CHEF MENTEUR & MICHOUD	12	F-484-018	51	46	56	5	9%
LAKE FOREST & READ	12	F-513-017	54	34	59	5	8%
RESTGATE & PLAINFIELD	8	F-491-004	54	44	59	5	8%
TOWNSEND & HARBOR CIRCLE	12	F-423-019	53	18	58	5	9%
GRAVIER & S. BROAD	6	F-184-011	57	52	62	5	8%
S. BROAD & THALIA	6	F-133-005	58	15	63	5	8%
TCHOUPITOULAS & NAPOLEON	12	F-101-011	50	15	55	5	9%
TCHOUPITOULAS & AUSTERLITZ	12	F-101-012	50	28	55	5	9%

EAST BANK

PRESSURE COMPARISON FOR PROPERTY INSURANCE ASSOCIATION HYDRANT TESTING (CONT'D)

Location	Main Size	Hydrant ID	Static Field Pressure (psi)	Residual Pressure (psi)	Avg. Model Pressure (psi)	Pressure Difference (psi)	Percent Difference (%)
ELYSIAN FIELDS & N. MIRO	6	F-346-029	53	26	58	5	9%
CHEF MENTEUR & MICHOUD	12	F-484-018	51	46	56	5	9%
LAKE FOREST & READ	12	F-513-017	54	34	59	5	8%
RESTGATE & PLAINFIELD	8	F-491-004	54	44	59	5	8%
TOWNSEND & HARBOR CIRCLE	12	F-423-019	53	18	58	5	9%
GRAVIER & S. BROAD	6	F-184-011	57	52	62	5	8%
S. BROAD & THALIA	6	F-133-005	58	15	63	5	8%
TCHOUPITOULAS & NAPOLEON	12	F-101-011	50	15	55	5	9%
TCHOUPITOULAS & AUSTERLITZ	12	F-101-012	50	28	55	5	9%
FOURTH & CLAIBORNE	6	F-131-036	58	45	63	5	8%
IBERVILLE & BOURBON	12	F-196-019	54	48	58	4	7%
BIENVILLE & N. BROAD	6	F-201-015	57	38	61	4	7%
WEST END & ROBERT E. LEE	6	F-214-023	56	21	60	4	7%
MORRISON & MARTIN	16	F-460-047	55	40	59	4	7%
GENTILLY & DALE	12	F-479-009	52	38	56	4	7%
SPANISH FORT & CENTRAL PARK	12	F-237-043	52	24	56	4	7%
BIENVILLE & N. RAMPART	8	F-197-005	55	35	58	3	5%
MIRABEAU & FELICIANA	6	F-248-015	55	16	58	3	5%
BELLAIRE & ETHEL	6	F-007-006	56	10	59	3	5%
GRAVIER & S. CORTEZ	6	F-187-002	60	36	63	3	5%
CHEF MENTEUR & POLAND	8	F-480-014	51	36	54	3	6%
N. CLAIBORNE & ST. LOUIS	6	F-269-033	56	28	59	3	5%
CORTEZ & TOULOUSE	6	F-216-020	64	36	62	2	3%
HARRISON & LOUISVILLE	12	F-222-018	60	50	62	2	3%
WILLOW & McALISTER	12	F-055-005	62	33	64	2	3%
ST. CLAUDE & SPAIN	12	F-344-004	54	48	56	2	4%
GENTILLY & FORTIN	12	F-307-012	58	47	59	1	2%
WEIBLEN & GENERAL DIAZ	6	F-219-013	61	22	60	1	2%
S. CARROLLTON & TULANE	6	F-193-005	64	61	63	1	2%
AUDOBON & EDINBURGH	6	F-048-009	63	52	63	0	0%
S. CARROLLTON & PALM	12	F-037-037	63	54	63	0	0%

West Bank
Pressure Comparison for Property Insurance Association Hydrant Testing

Location	Main Size	Hydrant ID	Static Field Pressure (psi)	Residual Pressure (psi)	Avg. Model Pressure (psi)	Pressure Difference (psi)	Percent Difference (%)
DELARONDE & SEGUIN	6	F-A1-017	68	34	63	5	7%
ATLANTIC & SLIDELL	6	F-A3-037	68	57	65	3	4%
FLANDERS & GENERAL MEYER	6	F-A13-021	68	32	65	3	4%
VESPASIAN & WEST BEND	12	F-A14-031	68	45	67	1	1%
GARDEN OAKS & MEMORIAL PARK	8	F-A15-004	70	38	68	2	3%
GENERAL DEGAULLE & HOLIDAY	12	F-A19-059	70	36	68	2	3%
GENERAL DEGAULLE & WOODLAND	12	F-A36-033	64	13	66	2	3%
ENGLISH TURN & GRAND CYPRESS	8	F-A49-004	68	5	65	3	4%

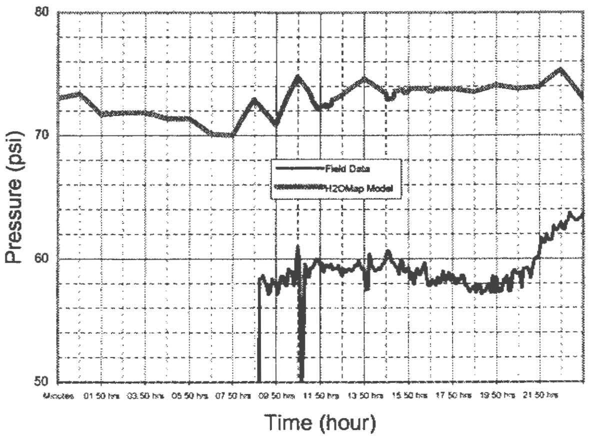
East Bank
Pressure Comparison for Fire Hydrant Field Testing

Site No.	Flow (gpm)		Field Data Pressure (psi)			Model Data Pressure (psi)		Percent Difference (%)
	F1	F2	Initial	Residual	Rebound	Initial	Residual	
1	785	530	48	42	47	63.08	60.3	31%
2	700	670	55	49	55	71.4	66.33	30%
3	1010	725	54	42	54	75.57	72.19	40%
4	690	820	52	42	52	69.97	68.23	35%
5	680	500	43	30	43	69.1	67.19	61%
6	640	890	42	24	42	68.1	62.06	62%
7	820	905	51	36	52	68.63	64.86	35%
8	900	555	37	30	38	70.15	67.11	90%
9	905	970	51	43	51	67.82	63.87	33%
10	965	875	45	39	45	67.49	64.42	50%
11	1050	850	51	45	51	69.3	66.29	36%
12	900	950	52	45	53	69.46	64.25	34%
13	775	790	51	29	50	71.49	68.04	40%
14	995	1050	50	45	50	69.67	65.96	39%
15	840	860	50	33	49	67.95	63.19	36%
16	500	580	50	12	52	61.46	8.03	23%

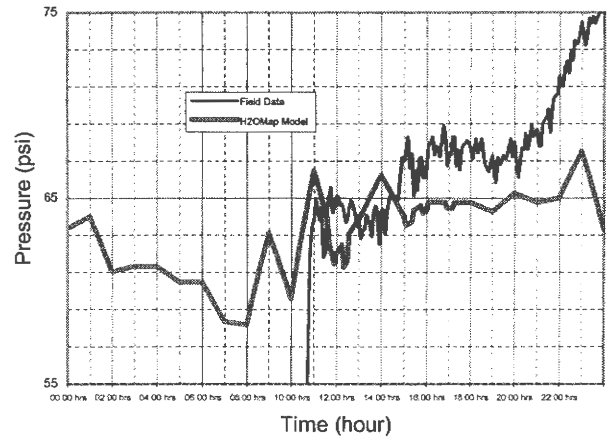
West Bank
Pressure Comparison for Fire Hydrant Field Testing

Site No.	Flow (gpm)		Field Data Pressure (psi)			Model Data Pressure (psi)		Percent Difference (%)
	F1	F2	Initial	Residual	Rebound	Initial	Residual	
17	1170	N/A	65	60	66	68.05	62.13	5%
18	785	820	64	32	64	67.1	60.74	5%
19	410	N/A	60	20	60	62.88	60.06	5%
20	1040	N/A	59	52	59	60.23	51.66	2%

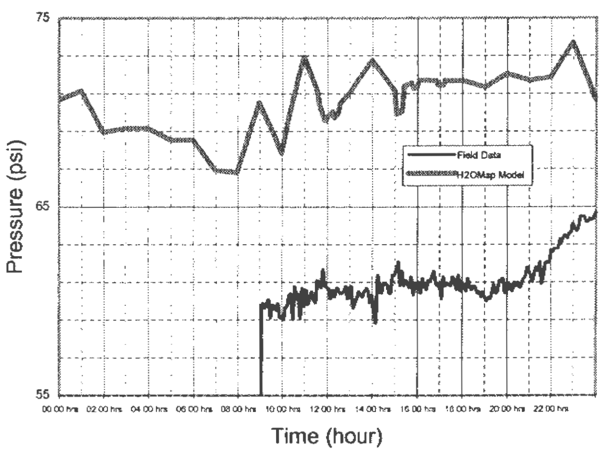
09/17/02 Pressure Logger F-026-026
EastBank



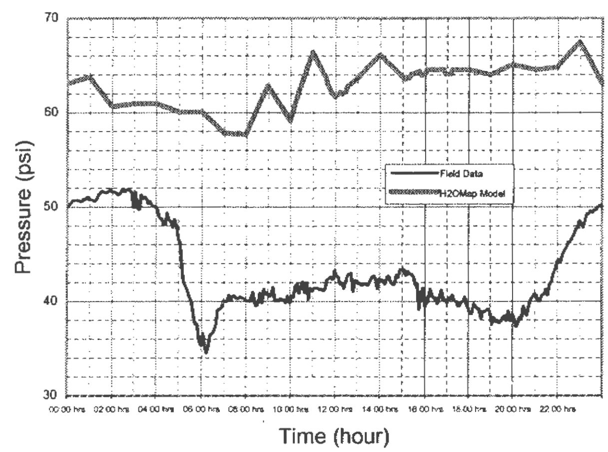
09/17/02 Pressure Logger F-068-019
EastBank



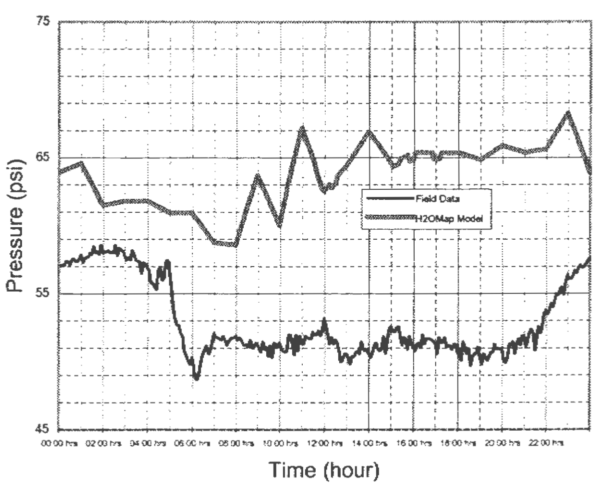
09/17/02 Pressure Logger F-168-014
EastBank



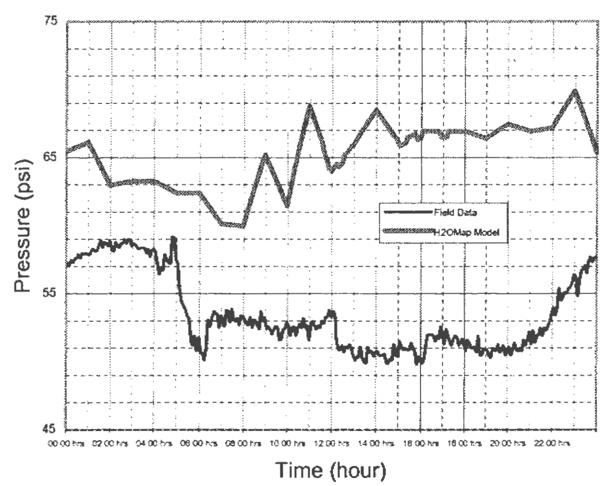
09/17/02 Pressure Logger F-333-003
EastBank



09/17/02 Pressure Logger F-444-009
EastBank



09/17/02 Pressure Logger F-511-005
EastBank



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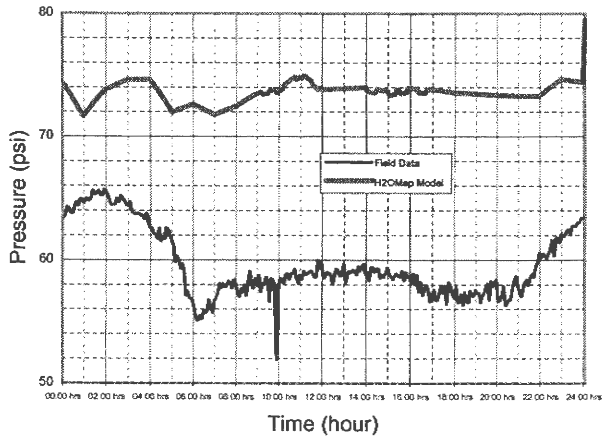
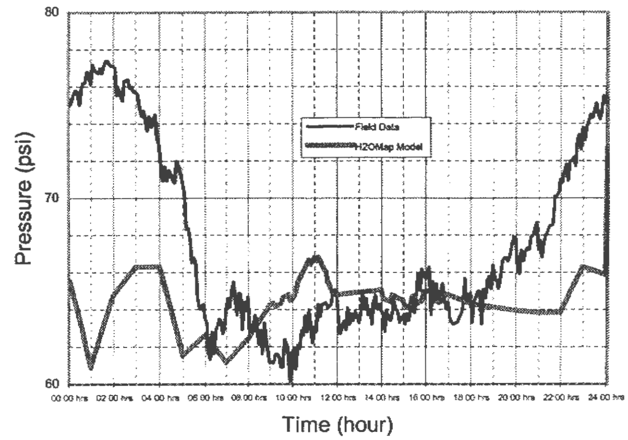
EastBank



09/18/02 Pressure Logger F-068-019
EastBank



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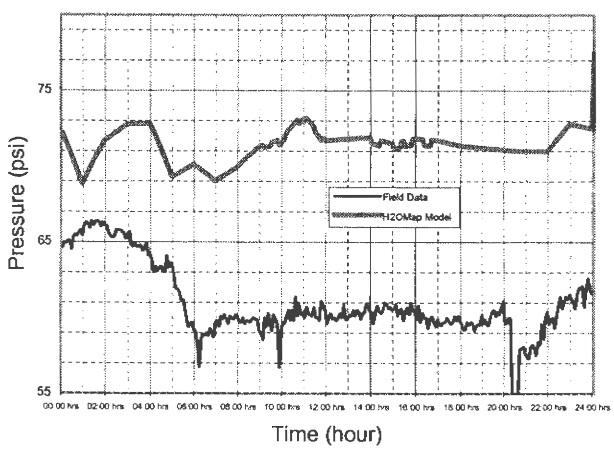
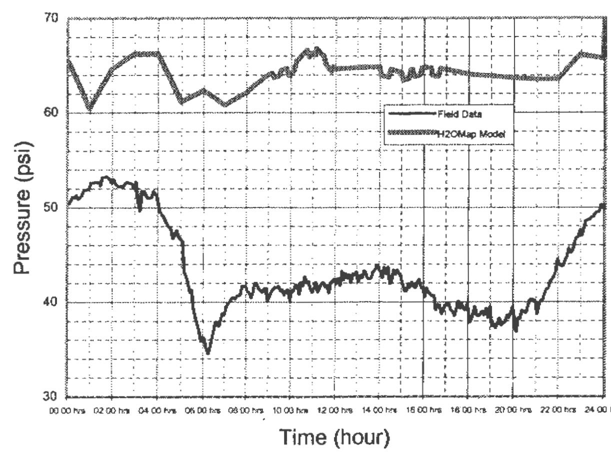


09/18/02 Pressure Logger F-333-003
EastBank



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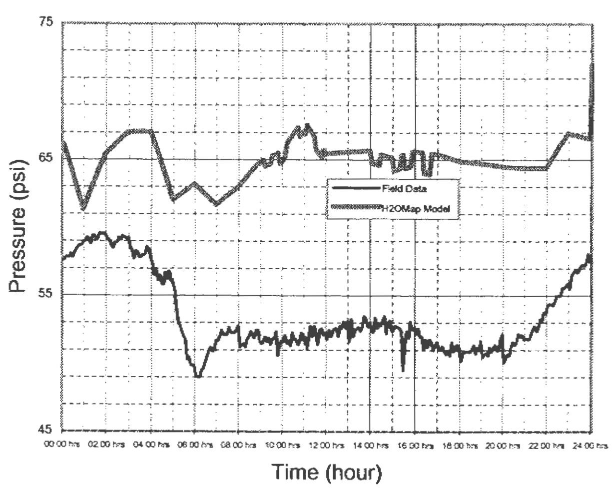
EastBank



09/18/02 Pressure Logger F-511-005
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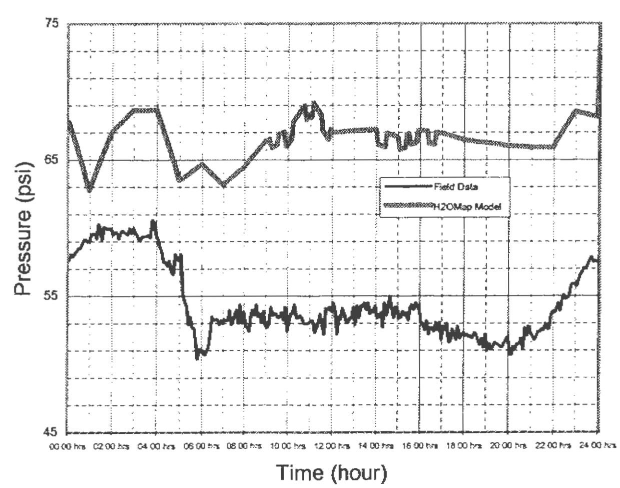
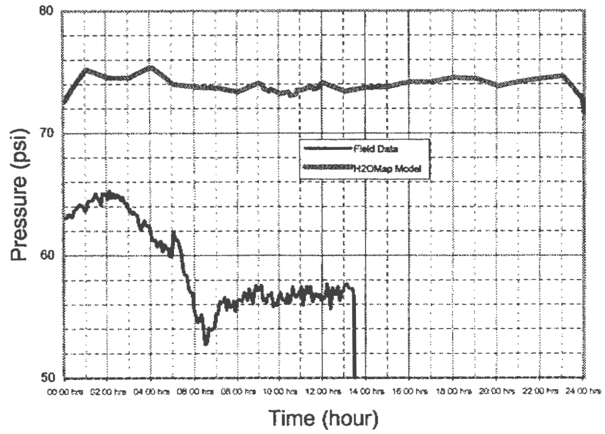
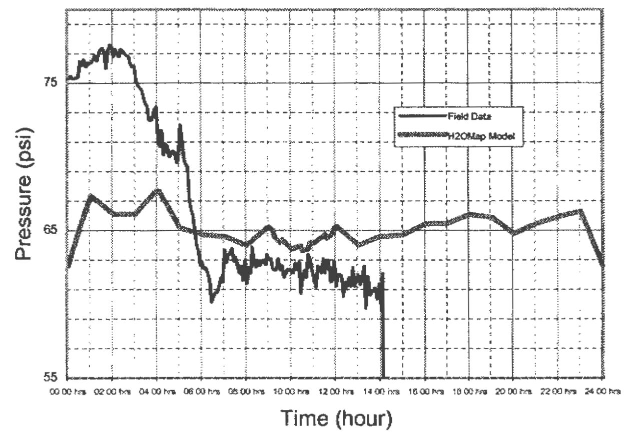


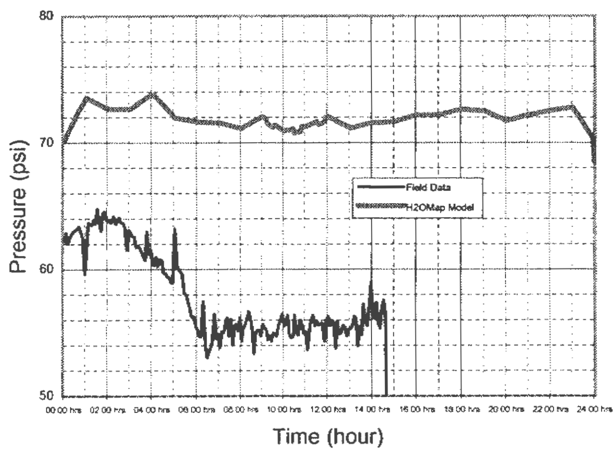
09/19/02 Pressure Logger F-026-026
EastBank



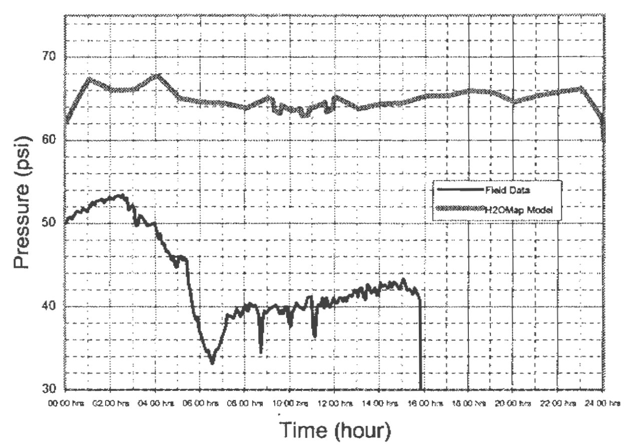
09/19/02 Pressure Logger F-068-019
EastBank



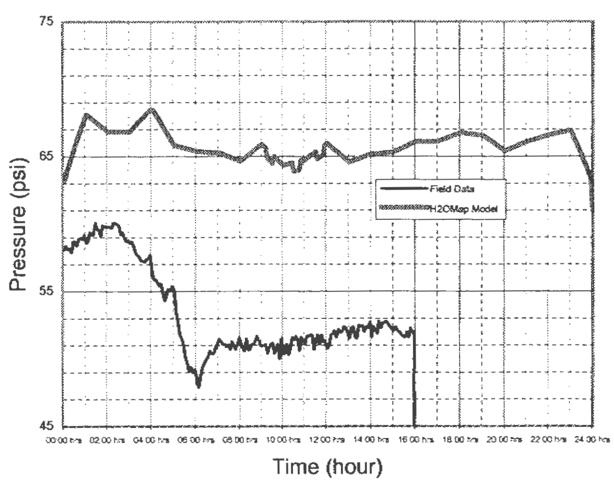
09/19/02 Pressure Logger F-168-014
EastBank



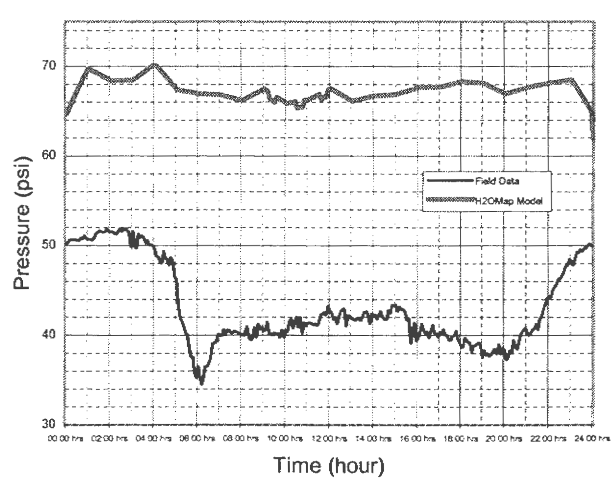
09/19/02 Pressure Logger F-333-003
EastBank

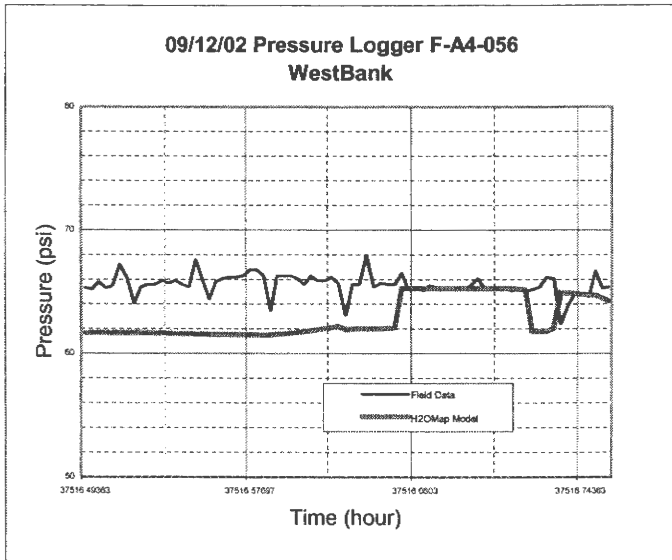


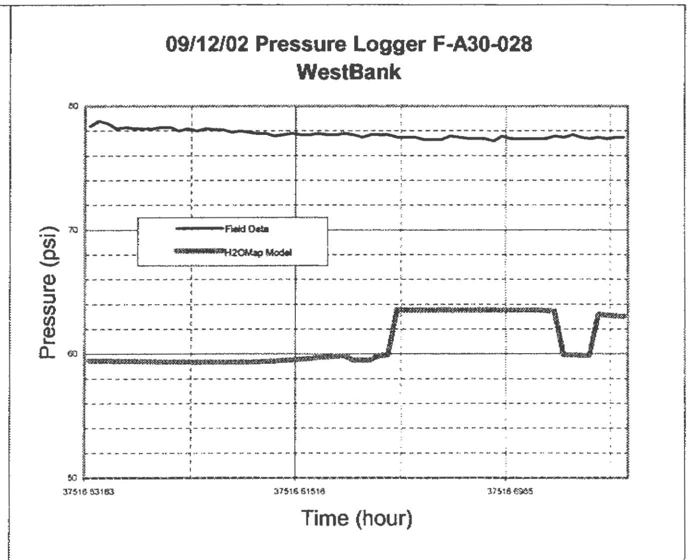
09/19/02 Pressure Logger F-444-009
EastBank

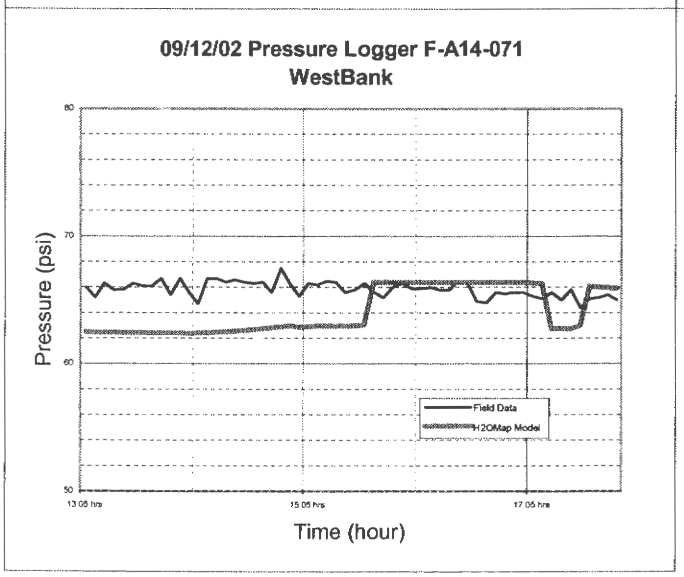


09/19/02 Pressure Logger F-511-005
EastBank




09/12/02 Pressure Logger F-A4-056
WestBank
Pressure (psi)
Time (hour)
Field Data
H2OMap Model


09/12/02 Pressure Logger F-A30-028
WestBank
Pressure (psi)
Time (hour)
Field Data
H2OMap Model


09/12/02 Pressure Logger F-A14-071
WestBank
Pressure (psi)
Time (hour)
Field Data
H2OMap Model

Appendix F

MWH

Appendix F

Appendix F – Results of Hydraulic Model Analysis

Pipe Diameter Criteria

Pipe Capacity - Diameter
Minimum Diameter = 6 inches

Pipe Diameter (Inches)	West Bank		East Bank	
	Length (Linear Miles)	Percent of Total (%)	Length (Linear Miles)	Percent of Total (%)
1	0.11	0.0	0.07	0.0
2	1.46	0.0	4.87	0.0
3	-	-	0.06	0.0
4	6.98	0.0	201.48	0.0
6	91.37	0.0	643.35	0.0
8	43.81	0.0	135.56	0.0
10	1.33	0.0	3.21	0.0
12	27.68	0.0	214.43	0.0
14	0.37	0.0	0.01	0.0
15	-	-	0.06	0.0
16	9.11	0.0	26.68	0.0
18	-	-	0.20	0.0
20	4.16	0.0	24.77	0.0
21	-	-	0.06	0.0
24	0.01	0.0	6.66	0.0
29	-	-	0.02	0.0
30	5.92	0.0	27.57	0.0
36	2.77	0.0	8.52	0.0
41	-	-	0.69	0.0
42	-	-	2.37	0.0
43	-	-	2.53	0.0
48	-	-	11.94	0.0
50	-	-	17.42	0.0
54	-	-	1.44	0.0
Total	**195**	**0.0**	**1,334**	**0.0**

Pressure Analysis During Maximum Day Conditions

Pressure Criteria

East Bank

Pressure	Count	Percent %
• 40 psi	86	0.7%
> 65 psi	264	2.1%
Total Nodes	***350***	***2.7%***

Minimum at 11pm	Count	Maximum Pressure	Count
34	3	46	1
35	5	47	4
36	22	48	15
37	13	49	42
38	1	50	57
39	20	51	70
40	22	52	166
41	64	53	443
42	187	54	868
43	384	55	1528
44	617	56	1670
45	974	57	2275
46	1541	58	1806
47	1797	59	764
48	1900	60	722
49	1604	61	487
50	655	62	581
51	578	63	530
52	493	64	343
53	409	65	222
54	510	66	157
55	377	67	57
56	188	68	33
57	170	69	6
58	123	70	11
59	116	**Total**	**12858**
60	31		
61	32		
62	9		
63	9		
64	4		
Total	**12858**		

West Bank

Pressure	Count	Percent %
• 40 psi	0	0.0%
> 65 psi	2118	100.0%
Total Nodes	***2118***	***100.0%***

Minimum at 12pm	Count	Maximum Pressure	Count
48	2	70	2
51	1	72	1
52	28	73	3
53	35	74	17
54	31	75	46
55	45	76	70
56	101	77	152
57	223	78	288
58	284	79	472
59	316	80	354
60	442	81	437
61	335	82	264
62	216	83	11
63	57	85	1
64	1	**Total**	**2118**
65	1		
Total	**2118**		

Pressure Analysis During Fire Flow Conditions

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - RESIDENTIAL		
Single-Family Residential (355 hydrants)		
Criteria:	1,000 gpm @ 20 psi 2 hr flow	
Statistics:	Flow (gpm)	# Hydrants
	750-1000	151
	500-750	156
	250-500	42
	0-250	6
	Total (< 1,000)	355

FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)
F-471-028	1,000	998.98
F-351-013	1,000	996.57
F-471-021	1,000	995.33
F-132-024	1,000	996.36
F-367-008	1,000	990.93
F-368-003	1,000	1001.08
F-077-022	1,000	991.36
F-059-013	1,000	991.08
F-368-002	1,000	986.98
F-276-013	1,000	986.05
F-088-010	1,000	985.54
F-059-014	1,000	984.44
F-047-013	1,000	984.68
F-471-014	1,000	973.68
F-037-032	1,000	982.38
F-471-016	1,000	973.27
F-230-043	1,000	973.32
F-219-025	1,000	975.77
F-471-029	1,000	968.56
F-471-015	1,000	963.12
F-047-011	1,000	971.96
F-471-032	1,000	959.79
F-471-042	1,000	961.12
F-230-009	1,000	969.99
F-168-022	1,000	972.10
F-144-031	1,000	971.37
F-168-015	1,000	970.10
F-317-021	1,000	964.77
F-471-031	1,000	952.57
F-288-018	1,000	959.11
F-471-030	1,000	953.04
F-369-020	1,000	961

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - RESIDENTIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-230-018	1,000	960.06
F-471-035	1,000	942.94
F-131-024	1,000	959.40
F-007-004	1,000	952.82
F-006-017	1,000	951.65
F-354-019	1,000	951.83
F-047-012	1,000	952.33
F-471-041	1,000	935.68
F-006-010	1,000	939.96
F-372-021	1,000	936.24
F-471-036	1,000	918.54
F-037-025	1,000	941.42
F-371-011	1,000	932.62
F-132-011	1,000	938.08
F-246-016	1,000	933.99
F-471-040	1,000	914.68
F-471-037	1,000	907.71
F-471-039	1,000	908.93
F-230-011	1,000	924.56
F-471-038	1,000	904.17
F-321-028	1,000	921.65
F-230-030	1,000	918.59
F-354-002	1,000	923.34
F-322-012	1,000	920.12
F-057-007	1,000	906.85
F-372-022	1,000	913.54
F-350-019	1,000	906.81
F-083-011	1,000	915.22
F-471-013	1,000	884.34
F-003-025	1,000	921.01
F-368-037	1,000	902.59
F-047-007	1,000	910.62
F-350-022	1,000	893.92
F-002-015	1,000	913.45
F-276-016	1,000	893.54
F-354-014	1,000	897.48
F-007-011	1,000	893.61
F-471-046	1,000	857.98
F-351-012	1,000	871.18
F-240-003	1,000	880.36
F-368-036	1,000	875.7
F-094-030	1,000	870.70
F-315-003	1,000	865.66
F-276-015	1,000	869.8
F-036-008	1,000	880.34

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - RESIDENTIAL (CONT'D)		
FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)
F-559-017	1,000	823.81
F-369-021	1,000	865.22
F-075-021	1,000	882.11
F-292-004	1,000	866.73
F-559-008	1,000	818.61
F-293-009	1,000	857.86
F-559-007	1,000	815.29
F-230-005	1,000	867.82
F-560-028	1,000	813.97
F-007-005	1,000	860.57
F-560-020	1,000	809.17
F-559-001	1,000	807.74
F-367-003	1,000	858.93
F-560-019	1,000	806.24
F-006-011	1,000	850.66
F-560-033	1,000	805.76
F-560-011	1,000	806.92
F-027-014	1,000	869.74
F-559-009	1,000	803.36
F-288-017	1,000	851.28
F-560-016	1,000	790.92
F-559-002	1,000	791.41
F-036-009	1,000	850.33
F-047-021	1,000	849.58
F-560-017	1,000	781.85
F-471-054	1,000	800.94
F-560-024	1,000	779.63
F-559-010	1,000	785.29
F-331-016	1,000	826.08
F-560-022	1,000	786.81
F-133-028	1,000	848.35
F-323-003	1,000	837.99
F-321-029	1,000	835.41
F-323-005	1,000	835.3
F-559-016	1,000	779.39
F-560-023	1,000	772.15
F-006-018	1,000	828.66
F-350-001	1,000	821.48
F-323-006	1,000	831.9
F-560-021	1,000	769.92
F-560-015	1,000	772.56
F-367-006	1,000	826.33
F-007-006	1,000	822.45
F-007-007	1,000	819.02
F-369-022	1,000	811.33

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - RESIDENTIAL (CONT'D)		
FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)
F-219-023	1,000	818.56
F-559-003	1,000	754.41
F-331-003	1,000	798.92
F-559-011	1,000	747.72
F-219-026	1,000	811.04
F-099-015	1,000	825.38
F-027-003	1,000	825.53
F-007-012	1,000	806.21
F-369-024	1,000	793.22
F-369-023	1,000	794.39
F-560-014	1,000	739.14
F-559-004	1,000	733.96
F-471-047	1,000	763.28
F-559-012	1,000	727.88
F-002-005	1,000	818.56
F-231-027	1,000	795.38
F-036-007	1,000	802.33
F-084-005	1,000	802.77
F-337-016	1,000	788.08
F-231-026	1,000	787.27
F-368-021	1,000	777.91
F-559-005	1,000	715.22
F-007-015	1,000	779.54
F-230-020	1,000	785.72
F-559-013	1,000	709.32
F-027-013	1,000	792.45
F-559-006	1,000	717.04
F-471-053	1,000	734.58
F-560-013	1,000	696.6
F-068-017	1,000	762.84
F-321-030	1,000	767.21
F-007-013	1,000	766.07
F-560-025	1,000	693.78
F-132-022	1,000	783.01
F-560-018	1,000	691.44
F-007-014	1,000	760.92
F-431-025	1,000	673.03
F-276-017	1,000	751.45
F-471-048	1,000	723.16
F-004-017	1,000	773.85
F-560-029	1,000	681.11
F-431-061	1,000	672.38
F-431-038	1,000	669.65
F-431-068	1,000	669.11
F-431-037	1,000	667.84

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - RESIDENTIAL (CONT'D)		
FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)
F-560-012	1,000	669.55
F-288-020	1,000	747.45
F-471-052	1,000	707.56
F-230-012	1,000	746.34
F-211-027	1,000	750.07
F-431-026	1,000	653.73
F-350-023	1,000	726.69
F-431-069	1,000	663.61
F-077-013	1,000	757.33
F-560-030	1,000	666
F-431-036	1,000	659.35
F-471-049	1,000	703.05
F-235-025	1,000	747.58
F-431-080	1,000	642.52
F-431-047	1,000	642.15
F-331-018	1,000	713.58
F-471-051	1,000	695.81
F-431-027	1,000	645.2
F-431-039	1,000	652.39
F-431-035	1,000	650.92
F-240-019	1,000	730.19
F-471-050	1,000	694.96
F-431-070	1,000	652.8
F-431-067	1,000	647.79
F-431-060	1,000	647.62
F-431-062	1,000	639.05
F-560-032	1,000	666.17
F-431-052	1,000	632.95
F-560-031	1,000	651.9
F-431-079	1,000	637.2
F-431-046	1,000	635.64
F-391-021	1,000	718.72
F-431-054	1,000	633.53
F-431-053	1,000	630.81
F-368-033	1,000	715.82
F-431-034	1,000	639.1
F-431-028	1,000	633.23
F-431-040	1,000	639.6
F-431-063	1,000	633.88
F-431-071	1,000	642.36
F-431-055	1,000	630.12
F-560-007	1,000	638.56
F-431-078	1,000	632.39
F-431-066	1,000	637.24
F-431-045	1,000	631.01

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - RESIDENTIAL (CONT'D)		
FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)
F-431-059	1,000	636.44
F-431-030	1,000	631.27
F-315-001	1,000	703.26
F-431-033	1,000	630.73
F-431-044	1,000	630.36
F-330-020	1,000	703.4
F-431-041	1,000	630.98
F-431-056	1,000	627.67
F-431-032	1,000	630.37
F-431-043	1,000	631.76
F-431-064	1,000	627.27
F-431-072	1,000	633.87
F-431-042	1,000	630.25
F-431-031	1,000	626.81
F-348-025	1,000	704.87
F-431-057	1,000	627.86
F-431-065	1,000	625.06
F-431-058	1,000	627.71
F-431-077	1,000	625.48
F-084-011	1,000	725.29
F-431-073	1,000	627.36
F-431-074	1,000	627.99
F-431-075	1,000	625.21
F-276-014	1,000	696.01
F-431-086	1,000	621.25
F-027-018	1,000	732.04
F-322-022	1,000	689.94
F-357-002	1,000	710.24
F-560-026	1,000	628.9
F-211-018	1,000	706.61
F-210-008	1,000	708.40
F-036-013	1,000	712.49
F-368-020	1,000	694.55
F-431-029	1,000	613.1
F-560-001	1,000	606.84
F-560-002	1,000	607.17
F-431-076	1,000	603.86
F-246-017	1,000	695.61
F-560-035	1,000	610.87
F-168-021	1,000	702.57
F-560-036	1,000	604.8
F-133-029	1,000	697.12
F-241-018	1,000	680.29
F-036-010	1,000	684.18
F-084-006	1,000	691.13

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - RESIDENTIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-276-018	1,000	659.88
F-560-038	1,000	582.8
F-230-014	1,000	673.48
F-350-024	1,000	649.53
F-144-021	1,000	684.81
F-083-012	1,000	676.97
F-029-006	1,000	691.09
F-075-017	1,000	680.24
F-560-004	1,000	571.88
F-560-008	1,000	569.65
F-560-027	1,000	576.14
F-560-009	1,000	557.8
F-003-006	1,000	669.65
F-068-018	1,000	621.15
F-431-024	1,000	533.64
F-230-048	1,000	628.43
F-292-021	1,000	609.24
F-560-037	1,000	558.76
F-331-019	1,000	599.64
F-560-003	1,000	547.43
F-368-038	1,000	608.98
F-231-028	1,000	619.19
F-536-001	1,000	604.05
F-560-005	1,000	526.76
F-350-020	1,000	594.67
F-368-034	1,000	598.86
F-219-027	1,000	600.86
F-560-010	1,000	517.05
F-134-031	1,000	619.99
F-240-010	1,000	593.6
F-536-003	1,000	579.02
F-368-031	1,000	575.61
F-560-006	1,000	513.75
F-240-020	1,000	564.53
F-100-015	1,000	588.02
F-560-034	1,000	484.12
F-369-031	1,000	550.31
F-331-020	1,000	530.96
F-002-009	1,000	585.44
F-231-025	1,000	550.73
F-230-015	1,000	552.74
F-029-007	1,000	570.91
F-027-030	1,000	569.10
F-332-027	1,000	512.89
F-029-011	1,000	554.80

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - RESIDENTIAL (CONT'D)		
FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)
F-290-001	1,000	519.65
F-368-035	1,000	499.76
F-559-014	1,000	438.47
F-368-032	1,000	490.49
F-369-001	1,000	487.44
F-072-017	1,000	512.17
F-002-007	1,000	515.22
F-073-016	1,000	504.47
F-073-019	1,000	505.13
F-353-001	1,000	475.4
F-072-018	1,000	494.12
F-073-021	1,000	502.90
F-072-008	1,000	493.33
F-076-029	1,000	490.04
F-072-016	1,000	487.84
F-369-002	1,000	453.48
F-076-030	1,000	481.20
F-368-010	1,000	446.99
F-354-003	1,000	449.14
F-003-004	1,000	478.65
F-240-002	1,000	444.17
F-073-018	1,000	461.84
F-056-007	1,000	461.85
F-367-009	1,000	436.43
F-076-033	1,000	454.18
F-055-009	1,000	446.59
F-216-021	1,000	424.91
F-072-006	1,000	436.59
F-075-036	1,000	436.92
F-357-003	1,000	418.07
F-075-033	1,000	433.22
F-240-001	1,000	409.55
F-230-031	1,000	413.23
F-075-035	1,000	411.65
F-071-006	1,000	397.93
F-047-010	1,000	398.59
F-071-008	1,000	379.39
F-070-020	1,000	366.66
F-329-036	1,000	344.76
F-027-019	1,000	375.89
F-029-009	1,000	364.61
F-084-014	1,000	356.80
F-313-014	1,000	325.88
F-047-009	1,000	343.65
F-075-020	1,000	338.67
F-110-001	1,000	326.16

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - RESIDENTIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-351-014	1,000	258.58
F-110-002	1,000	246.43
F-144-026	1,000	204.95
F-110-003	1,000	208.13
F-506-033	1,000	158.84
F-388-036	1,000	158.72
F-559-015	1,000	137.13

Multi-Family Residential (165 Hydrants)

Criteria:	2,500 gpm 2 hr flow	@ 20 psi
Statistics:	Flow (gpm)	# Hydrants
	2000-2500	22
	1500-2000	54
	1500-1000	44
	750-1000	7
	500-750	35
	250-500	3
	Total (< 2,500)	165

FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)
F-116-015	2,500	2,498.10
F-425-045	2,500	2483.28
F-269-032	2,500	2,343.43
F-145-010	2,500	2,354.40
F-294-010	2,500	2,307.73
F-122-025	2,500	2,314.71
F-145-009	2,500	2,317.06
F-145-016	2,500	2,248.40
F-332-002	2,500	2,180.70
F-270-017	2,500	2,211.02
F-158-017	2,500	2,166.79
F-425-043	2,500	2148.52
F-348-016	2,500	2,150.97
F-269-019	2,500	2,144.14
F-295-008	2,500	2,110.62
F-137-005	2,500	2,029.61
F-145-019	2,500	2,087.76
F-198-001	2,500	2,038.16
F-270-016	2,500	2,061.05
F-295-010	2,500	1,996.65
F-122-004	2,500	2,070.21

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - RESIDENTIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-405-006	2,500	2021.27
F-269-020	2,500	2,033.38
F-147-015	2,500	1,983.20
F-333-023	2,500	1,962.52
F-349-015	2,500	1,976.25
F-122-006	2,500	1,954.90
F-198-002	2,500	1,976.19
F-295-009	2,500	1,944.67
F-133-010	2,500	1,990.68
F-198-004	2,500	1,957.03
F-038-018	2,500	1,978.10
F-050-002	2,500	1,861.36
F-348-023	2,500	1,890.04
F-297-017	2,500	1,859.79
F-297-030	2,500	1,865.58
F-004-011	2,500	1,941.05
F-270-005	2,500	1,895.18
F-122-008	2,500	1,846.75
F-122-022	2,500	1,904.93
F-145-013	2,500	1,908.79
F-145-017	2,500	1,899.30
F-138-001	2,500	1,796.41
F-296-014	2,500	1,803.08
F-015-015	2,500	1,789.35
F-171-045	2,500	1,789.65
F-137-006	2,500	1,744.44
F-332-003	2,500	1,728.75
F-349-021	2,500	1729.57
F-418-014	2,500	1752.48
F-297-031	2,500	1,695.12
F-270-010	2,500	1,744.91
F-138-002	2,500	1,609.00
F-297-039	2,500	1,675.34
F-271-004	2,500	1,714.56
F-293-002	2,500	1,649.53
F-297-016	2,500	1,649.86
F-270-003	2,500	1,699.12
F-205-016	2,500	1,709.80
F-333-022	2,500	1,618.62
F-050-004	2,500	1,606.46
F-122-011	2,500	1,678.70
F-349-018	2,500	1,598.45
F-297-038	2,500	1,561.01
F-314-018	2,500	1,541.21
F-271-006	2,500	1,584.22

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - RESIDENTIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-144-006	2,500	1,612.40
F-269-028	2,500	1,572.74
F-268-038	2,500	1,555.32
F-144-005	2,500	1,596.10
F-129-017	2,500	1,584.56
F-138-004	2,500	1,510.68
F-293-004	2,500	1,487.54
F-037-033	2,500	1,603.76
F-138-003	2,500	1,483.79
F-147-014	2,500	1,476.02
F-129-001	2,500	1,543.24
F-405-004	2,500	1489.61
F-349-019	2,500	1,482.37
F-270-006	2,500	1,525.41
F-295-011	2,500	1,443.11
F-145-014	2,500	1,537.63
F-270-011	2,500	1,497.82
F-137-007	2,500	1,392.25
F-314-021	2,500	1,399.85
F-130-010	2,500	1,493.30
F-275-007	2,500	1,424.57
F-271-003	2,500	1,441.22
F-137-009	2,500	1,375.47
F-405-009	2,500	1385.95
F-271-007	2,500	1,430.77
F-137-003	2,500	1,360.65
F-137-010	2,500	1,355.24
F-198-011	2,500	1,399.50
F-197-021	2,500	1,384.82
F-405-005	2,500	1354.48
F-197-026	2,500	1,358.47
F-197-061	2,500	1,361.78
F-198-010	2,500	1,365.88
F-147-013	2,500	1,300.43
F-296-015	2,500	1,298.44
F-137-008	2,500	1,255.54
F-015-016	2,500	1,249.92
F-268-039	2,500	1,272.47
F-349-016	2,500	1,247.99
F-314-020	2,500	1,210.44
F-197-027	2,500	1,241.49
F-406-001	2,500	1222.02
F-116-036	2,500	1,236.32
F-333-027	2,500	1,191.78
F-295-012	2,500	1,182.22

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - RESIDENTIAL (CONT'D)		
FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)
F-349-022	2,500	1185.38
F-348-024	2,500	1,185.26
F-015-017	2,500	1,130.94
F-015-019	2,500	1,121.89
F-332-010	2,500	1,113.31
F-332-009	2,500	1,080.91
F-037-036	2,500	1,144.58
F-122-012	2,500	1,131.62
F-122-013	2,500	1,119.98
F-050-001	2,500	929.86
F-431-022	2,500	694.83
F-431-082	2,500	681.26
F-165-017	2,500	942.74
F-431-023	2,500	678.94
F-431-049	2,500	663.28
F-431-050	2,500	651.33
F-431-048	2,500	658.74
F-431-081	2,500	659.39
F-460-035	2,500	661.59
F-460-033	2,500	664.25
F-460-034	2,500	656.58
F-460-036	2,500	655.34
F-460-032	2,500	657.29
F-431-051	2,500	640.83
F-460-029	2,500	650.59
F-460-024	2,500	650.2
F-460-037	2,500	650.22
F-460-027	2,500	647.52
F-460-048	2,500	647.23
F-460-023	2,500	643.78
F-460-030	2,500	642.76
F-460-022	2,500	640.65
F-460-043	2,500	641
F-460-021	2,500	639.09
F-460-031	2,500	621.76
F-037-027	2,500	843.44
F-166-013	2,500	820.92
F-460-038	2,500	602.81
F-165-019	2,500	813.17
F-167-011	2,500	804.90
F-460-025	2,500	592.56
F-297-018	2,500	763.23
F-167-012	2,500	747.06
F-460-026	2,500	545.19
F-460-039	2,500	542.36

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - RESIDENTIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-165-018	2,500	669.79
F-166-010	2,500	599.47
F-166-014	2,500	591.22
F-166-006	2,500	576.49
F-166-016	2,500	565.09
F-331-002	2,500	500.59
F-050-005	2,500	477.47
F-050-003	2,500	459.54
F-297-015	2,500	347.66

Wetland (0 hydrants)

Recreation (43 hydrants)

Criteria:	1,000 gpm 2 hr flow	@ 20 psi
Statistics:	Flow (gpm)	# Hydrants
	750-1000	30
	500-750	8
	0-500	5
	Total (< 1,000)	43

FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)
F-028-025	1,000	995.82
F-061-001	1,000	988.83
F-037-021	1,000	987.65
F-387-013	1,000	983.15
F-223-011	1,000	982.81
F-195-003	1,000	977.72
F-223-009	1,000	976.45
F-240-005	1,000	974.35
F-216-023	1,000	972.23
F-332B-004	1,000	970.07
F-375G-003	1,000	958.9
F-223-010	1,000	955.92
F-331-017	1,000	942.75
F-007-003	1,000	934.60
F-440-013	1,000	896.96
F-426-023	1,000	871.61
F-375D-001	1,000	886.99
F-211-009	1,000	897.1
F-006-007	1,000	875.37
F-411-001	1,000	875.44

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - RESIDENTIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-237A-012	1,000	849.6
F-325-001	1,000	843.85
F-124-001	1,000	813.72
F-219-019	1,000	834.34
F-331-026	1,000	801.07
F-006-008	1,000	805.35
F-007-002	1,000	789.32
F-007-001	1,000	783.52
F-022-010	1,000	790.65
F-057-004	1,000	778.74
F-330-025	1,000	731.98
F-387-014	1,000	712.67
F-211-010	1,000	723.48
F-226-013	1,000	686.21
F-021-005	1,000	642.40
F-131-010	1,000	624.91
F-331-023	1,000	525.84
F-010-001	1,000	525.46
F-179-009	1,000	466.9
F-028-015	1,000	467.80
F-367-019	1,000	379.55
F-313-015	1,000	242.55

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - RESIDENTIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-300-002	1,000	238.19

EAST BANK

HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - COMMERCIAL

Commercial (823 hydrants)

Criteria: 3,000 gpm @ 20 psi
3 hr flow

Statistics:

Flow (gpm)	# Hydrants
2500-3000	118
2000-2500	163
1500-2000	291
1500-1000	171
500-1000	72
250-500	8
Total (< 3,000)	823

FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)
F-475-057	3,000	2989.73
F-475-058	3,000	2971.6
F-137-011	3,000	2964.31
F-202-003	3,000	2969.28
F-200-002	3,000	2947.29
F-205-008	3,000	2952.37
F-204-008	3,000	2949.37
F-204-011	3,000	2947.42
F-204-004	3,000	2940.99
F-205-012	3,000	2944.63
F-201-003	3,000	2940.65
F-268-002	3,000	2932.05
F-160-009	3,000	2930.46
F-493-021	3,000	2915.14
F-171-021	3,000	2905.88
F-297-024	3,000	2906.74
F-171-044	3,000	2902.64
F-112-024	3,000	2896.41
F-247-002	3,000	2900.54
F-297-019	3,000	2888.34
F-248-041	3,000	2880.04
F-478-095	3,000	2877.97
F-201-027	3,000	2879.59
F-497-017	3,000	2860
F-282-006	3,000	2856.39
F-202-015	3,000	2877.73
F-358-027	3,000	2863.65
F-114-025	3,000	2858.11
F-202-012	3,000	2868.56
F-333-014	3,000	2833.8
F-180-016	3,000	2838.82
F-198-020	3,000	2842.27

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - COMMERCIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-206-013	3,000	2851.18
F-113-030	3,000	2824.77
F-222-003	3,000	2841.89
F-207-010	3,000	2832.78
F-443-024	3,000	2800.81
F-268-006	3,000	2797.51
F-426-081	3,000	2780.01
F-426-084	3,000	2774.87
F-248-040	3,000	2776.57
F-426-083	3,000	2774.88
F-443-023	3,000	2777.37
F-051-015	3,000	2,761.95
F-352-018	3,000	2760.09
F-356-004	3,000	2774.32
F-106-020	3,000	2780.85
F-493-025	3,000	2766.48
F-113-027	3,000	2752.98
F-426-058	3,000	2756.22
F-233-013	3,000	2764.56
F-233-021	3,000	2754.77
F-356-003	3,000	2745.52
F-466-015	3,000	2742.59
F-286-030	3,000	2736.16
F-201-015	3,000	2740.3
F-510-003	3,000	2723.42
F-266-009	3,000	2701.46
F-288-013	3,000	2723.47
F-355-042	3,000	2714.45
F-233-020	3,000	2722.87
F-478-093	3,000	2696.26
F-233-018	3,000	2710.31
F-200-013	3,000	2704.61
F-200-007	3,000	2705.67
F-199-007	3,000	2692.65
F-426-065	3,000	2674.9
F-443-030	3,000	2669.55
F-364-001	3,000	2674.52
F-325-022	3,000	2669.38
F-206-022	3,000	2687.74
F-482-031	3,000	2648.99
F-051-009	3,000	2,646.51
F-199-003	3,000	2660.31
F-201-010	3,000	2663.44
F-199-013	3,000	2644.39
F-204-016	3,000	2654.29
F-173-010	3,000	2630.4

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - COMMERCIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-107-010	3,000	2657.73
F-162-013	3,000	2625.13
F-249-031	3,000	2599.13
F-036-020	3,000	2,639.58
F-203-023	3,000	2637.92
F-291-006	3,000	2606.66
F-455-015	3,000	2586.14
F-212-013	3,000	2613.47
F-207-011	3,000	2627.49
F-107-005	3,000	2624.57
F-420-025	3,000	2557.42
F-282-002	3,000	2564.02
F-466-004	3,000	2576.79
F-202-024	3,000	2612.07
F-198-047	3,000	2579.48
F-198-041	3,000	2578.79
F-325-002	3,000	2549.07
F-199-004	3,000	2577.49
F-204-019	3,000	2601.74
F-203-026	3,000	2598.27
F-179-028	3,000	2562.11
F-203-015	3,000	2594.14
F-269-008	3,000	2563.1
F-298-035	3,000	2531.86
F-495-007	3,000	2520.71
F-479-002	3,000	2527.63
F-030-016	3,000	2,548.87
F-329-006	3,000	2515.19
F-220-027	3,000	2554.08
F-249-032	3,000	2515.67
F-466-019	3,000	2536.76
F-179-019	3,000	2529.26
F-426-062	3,000	2517.68
F-226-038	3,000	2506.85
F-266-017	3,000	2475.68
F-360-012	3,000	2524.11
F-226-039	3,000	2501.69
F-201-016	3,000	2537.12
F-191-007	3,000	2549.61
F-205-024	3,000	2532.11
F-479-006	3,000	2464.67
F-192-015	3,000	2529.54
F-200-016	3,000	2489.75
F-200-026	3,000	2491.18
F-269-009	3,000	2458.48
F-205-021	3,000	2494.93

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - COMMERCIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-030-010	3,000	2,456.83
F-466-016	3,000	2443.09
F-420-026	3,000	2388.04
F-187-005	3,000	2471.93
F-198-036	3,000	2438.57
F-135-008	3,000	2471.8
F-200-019	3,000	2439.31
F-406-006	3,000	2420.09
F-198-018	3,000	2414.23
F-182-007	3,000	2429.52
F-478-096	3,000	2398.03
F-015-014	3,000	2,329.69
F-199-016	3,000	2402.42
F-361-024	3,000	2395.5
F-198-007	3,000	2385.18
F-183-003	3,000	2403.13
F-169-020	3,000	2409.94
F-363A-004	3,000	2345.62
F-460-013	3,000	2363.27
F-048-007	3,000	2,405.34
F-200-030	3,000	2381.67
F-303-012	3,000	2354.19
F-510-002	3,000	2360.16
F-247-028	3,000	2363.66
F-158-020	3,000	2317.85
F-332-005	3,000	2299.34
F-335-005	3,000	2344.23
F-201-024	3,000	2382.88
F-201-004	3,000	2367.45
F-199-022	3,000	2360.13
F-197-059	3,000	2318.73
F-129-023	3,000	2341.96
F-197-028	3,000	2295.19
F-291-009	3,000	2323.6
F-247-001	3,000	2315.12
F-491-052	3,000	2304.5
F-199-010	3,000	2325.44
F-352-027	3,000	2251.42
F-202-004	3,000	2344.32
F-168-019	3,000	2341.65
F-187-001	3,000	2349.78
F-016-001	3,000	2,199.52
F-203-011	3,000	2338.63
F-334-004	3,000	2285.45
F-268-015	3,000	2278.87
F-455-014	3,000	2266.74

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - COMMERCIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-420-027	3,000	2238.85
F-144-019	3,000	2330.37
F-288-021	3,000	2291.15
F-415-024	3,000	2234.1
F-145-002	3,000	2311.58
F-050-007	3,000	2,228.46
F-127-016	3,000	2258.32
F-179-021	3,000	2265.63
F-192-005	3,000	2307.13
F-288-012	3,000	2264.77
F-016-002	3,000	2,161.97
F-363A-007	3,000	2231.96
F-205-011	3,000	2298.19
F-015-013	3,000	2,176.56
F-332-008	3,000	2189.99
F-037-012	3,000	2,293.55
F-197-020	3,000	2230.95
F-171-043	3,000	2207.74
F-038-013	3,000	2,272.80
F-181-027	3,000	2251.24
F-482-032	3,000	2191.62
F-324A-021	3,000	2191.95
F-426-061	3,000	2229.51
F-169-021	3,000	2268.78
F-197-035	3,000	2226.79
F-318A-009	3,000	2204.47
F-077-001	3,000	2,272.42
F-037-013	3,000	2,265.48
F-443-022	3,000	2193.35
F-332B-001	3,000	2174.85
F-325-006	3,000	2189.76
F-216-007	3,000	2259.69
F-495-014	3,000	2163.33
F-325-021	3,000	2194.14
F-306-001	3,000	2202.3
F-133-020	3,000	2239.92
F-167-016	3,000	2251.34
F-198-008	3,000	2207.85
F-464-046	3,000	2132.42
F-352-024	3,000	2131.42
F-200-005	3,000	2207.79
F-181-025	3,000	2200.99
F-016-003	3,000	2,084.18
F-034-010	3,000	2,257.99
F-332-012	3,000	2110.07
F-204-002	3,000	2226.37

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - COMMERCIAL (CONT'D)		
FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)
F-038-014	3,000	2,204.44
F-198-012	3,000	2181.05
F-192-019	3,000	2208.72
F-090-014	3,000	2,190.64
F-420-028	3,000	2091.95
F-138-008	3,000	2126.65
F-426-078	3,000	2136.16
F-510-001	3,000	2148.83
F-332-011	3,000	2081.91
F-032-029	3,000	2,188.90
F-181-028	3,000	2159.14
F-163-004	3,000	2119.79
F-022-001	3,000	2,172.87
F-342-008	3,000	2085.92
F-133-021	3,000	2172.4
F-216-006	3,000	2176.88
F-075-029	3,000	2,181.25
F-343-009	3,000	2091.32
F-455-032	3,000	2093.71
F-016-004	3,000	2,026.48
F-198-005	3,000	2125.5
F-288-010	3,000	2111.27
F-288-031	3,000	2106.17
F-092-022	3,000	2,056.58
F-168-020	3,000	2147.49
F-454-034	3,000	2049.92
F-241-023	3,000	2114.55
F-181-024	3,000	2103.23
F-288-029	3,000	2102.91
F-138-007	3,000	2052.56
F-326-009	3,000	2064.69
F-363-012	3,000	2058.33
F-201-014	3,000	2108.24
F-344-001	3,000	2036.81
F-191-008	3,000	2123.18
F-426-026	3,000	1959.19
F-207-007	3,000	2086.75
F-288-009	3,000	2053.94
F-285-004	3,000	2047.54
F-500-017	3,000	2027.82
F-201-009	3,000	2076.48
F-092-020	3,000	2,006.19
F-479-005	3,000	2016.66
F-143-015	3,000	2099.51
F-106-019	3,000	2086.99
F-270-018	3,000	2054.65

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - COMMERCIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-190-002	3,000	2093.27
F-271-023	3,000	2057.65
F-131-018	3,000	2094.04
F-415-019	3,000	1979.8
F-408-001	3,000	2017.28
F-271-021	3,000	2048.56
F-163-002	3,000	2014.75
F-169-008	3,000	2076.14
F-285-003	3,000	2021.37
F-201-002	3,000	2054.63
F-188-005	3,000	2045.16
F-370-018	3,000	1952.64
F-363A-003	3,000	1976.5
F-426-059	3,000	2014.95
F-184-006	3,000	2052.4
F-269-022	3,000	2010.43
F-200-006	3,000	2022.49
F-036-005	3,000	2,032.70
F-426-082	3,000	1968.79
F-304-001	3,000	1991.39
F-092-019	3,000	1,953.18
F-183-001	3,000	2026.16
F-455-034	3,000	1971.42
F-311-030	3,000	1971.58
F-426-025	3,000	1875.05
F-426-064	3,000	1979.9
F-192-009	3,000	2048.86
F-332-013	3,000	1912.77
F-272-031	3,000	2005.54
F-491-037	3,000	1979.5
F-092-023	3,000	1,926.24
F-102-025	3,000	1932.86
F-181-026	3,000	1990.34
F-154-003	3,000	1954.79
F-197-036	3,000	1974.22
F-268-034	3,000	1966.75
F-344-002	3,000	1930.48
F-454-021	3,000	1929.52
F-180-020	3,000	1976.35
F-198-013	3,000	1972
F-325-031	3,000	1946.07
F-325-004	3,000	1933.97
F-482-033	3,000	1902.8
F-436-005	3,000	1936.18
F-272-012	3,000	1974.07
F-220-028	3,000	1981.64

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - COMMERCIAL (CONT'D)		
FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)
F-272-016	3,000	1974.69
F-193-011	3,000	2011.3
F-285-025	3,000	1938.62
F-269-021	3,000	1947.24
F-205-001	3,000	2004.14
F-288-023	3,000	1965.76
F-406-010	3,000	1943.56
F-032-014	3,000	1,985.70
F-308-001	3,000	1933.53
F-326-027	3,000	1930.26
F-135-002	3,000	1985.61
F-203-004	3,000	1984.56
F-464-042	3,000	1768.84
F-031-031	3,000	1,959.87
F-193-010	3,000	1991.31
F-154-001	3,000	1908.12
F-197-022	3,000	1918.23
F-134-042	3,000	1980.7
F-426-063	3,000	1907.83
F-134-012	3,000	1951.38
F-043-013	3,000	1,926.00
F-188-012	3,000	1922.35
F-154-005	3,000	1872.46
F-201-008	3,000	1925.43
F-173-017	3,000	1905.81
F-026-006	3,000	1,986.58
F-198-045	3,000	1914.82
F-426-086	3,000	1840.04
F-454-020	3,000	1856.91
F-190-010	3,000	1957.02
F-308-010	3,000	1846.25
F-140-009	3,000	1869.12
F-200-001	3,000	1907.76
F-186-001	3,000	1940.46
F-096-012	3,000	1,916.41
F-363A-006	3,000	1856.67
F-191-005	3,000	1940.11
F-092-028	3,000	1,836.78
F-127-023	3,000	1866.15
F-326-011	3,000	1863.44
F-356-013	3,000	1887.82
F-118-019	3,000	1840.76
F-190-011	3,000	1936.03
F-288-033	3,000	1886.14
F-169-007	3,000	1924.29
F-188-014	3,000	1896.47

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - COMMERCIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-219-008	3,000	1873.67
F-203-006	3,000	1932.01
F-415-005	3,000	1844.66
F-383-003	3,000	1830.52
F-188-003	3,000	1891.32
F-198-042	3,000	1875.12
F-286-015	3,000	1855.22
F-163-005	3,000	1876.93
F-219-015	3,000	1861.09
F-102-026	3,000	1804.45
F-133-023	3,000	1896.87
F-051-011	3,000	1,824.03
F-189-009	3,000	1886.65
F-198-046	3,000	1860.61
F-402-007	3,000	1805.01
F-402-033	3,000	1795.79
F-037-009	3,000	1,882.59
F-118-020	3,000	1796.9
F-269-016	3,000	1846.04
F-016A-001	3,000	1,736.26
F-383-008	3,000	1789.72
F-343-010	3,000	1793.59
F-191-004	3,000	1876.44
F-198-037	3,000	1835.43
F-184-001	3,000	1855.51
F-181-012	3,000	1846.47
F-188-002	3,000	1851.17
F-272-013	3,000	1834.23
F-219-010	3,000	1818.1
F-191-003	3,000	1868.35
F-175-008	3,000	1830.22
F-272-015	3,000	1823.6
F-249-029	3,000	1791.83
F-496-004	3,000	1730.12
F-383-001	3,000	1765.98
F-075-038	3,000	1,866.27
F-144-009	3,000	1837.37
F-352-020	3,000	1736.34
F-161-014	3,000	1801.95
F-161-009	3,000	1781.54
F-192-014	3,000	1856.86
F-135-003	3,000	1853.94
F-021-001	3,000	1,834.66
F-102-027	3,000	1744.99
F-198-044	3,000	1807.2
F-479-004	3,000	1757.24

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - COMMERCIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-325-003	3,000	1760.43
F-177-054	3,000	1750.24
F-193-012	3,000	1843.89
F-309-004	3,000	1759.97
F-118-016	3,000	1753.2
F-324-003	3,000	1750.3
F-118-015	3,000	1751.94
F-312-021	3,000	1722.95
F-285-024	3,000	1771.5
F-291-005	3,000	1774.44
F-415-015	3,000	1701.13
F-134-025	3,000	1823.44
F-198-038	3,000	1769.94
F-480-006	3,000	1698.56
F-285-023	3,000	1745.55
F-286-001	3,000	1754.29
F-382-003	3,000	1705.68
F-496-003	3,000	1688.06
F-442-029	3,000	1702.36
F-182-001	3,000	1785.31
F-345-005	3,000	1729.32
F-140-014	3,000	1730.81
F-272-019	3,000	1770.63
F-189-007	3,000	1785.95
F-325-005	3,000	1717.41
F-198-043	3,000	1752.02
F-272-017	3,000	1763.96
F-180-021	3,000	1754.43
F-288-032	3,000	1738.17
F-402-034	3,000	1690.82
F-112-031	3,000	1696.95
F-181-011	3,000	1741.11
F-200-021	3,000	1746.32
F-154-006	3,000	1695.98
F-332-006	3,000	1649.55
F-201-011	3,000	1759.66
F-200-017	3,000	1742.69
F-304-002	3,000	1712.6
F-199-005	3,000	1732.87
F-141-003	3,000	1715.03
F-269-015	3,000	1720.62
F-102-022	3,000	1,675.71
F-360-013	3,000	1719.31
F-311-031	3,000	1682.39
F-405-023	3,000	1701.5
F-051-012	3,000	1,671.20

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - COMMERCIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-272-014	3,000	1709.25
F-272-018	3,000	1715.56
F-113-028	3,000	1645.63
F-125-004	3,000	1659.38
F-079-010	3,000	1,626.87
F-402-008	3,000	1638.65
F-159-027	3,000	1655.56
F-442-028	3,000	1648.47
F-188-001	3,000	1703.47
F-155-003	3,000	1675.37
F-448A-012	3,000	1619.97
F-269-010	3,000	1687.9
F-120-007	3,000	1656.99
F-369-007	3,000	1610.8
F-199-006	3,000	1683.39
F-204-012	3,000	1725.45
F-031-020	3,000	1,689.12
F-473-028	3,000	1638.23
F-443-021	3,000	1636.69
F-132-010	3,000	1706.39
F-326-024	3,000	1646.44
F-107-009	3,000	1712.47
F-370-013	3,000	1594.98
F-500-018	3,000	1627.55
F-211-003	3,000	1671.54
F-288-024	3,000	1672.1
F-205-009	3,000	1708.89
F-201-017	3,000	1679.25
F-448A-011	3,000	1588.57
F-204-009	3,000	1700.47
F-208-016	3,000	1699.86
F-272-008	3,000	1663.16
F-205-013	3,000	1697.61
F-163-003	3,000	1653.64
F-202-013	3,000	1683.58
F-187-006	3,000	1682.45
F-079-029	3,000	1,578.83
F-202-016	3,000	1677.99
F-216-015	3,000	1663.58
F-326-010	3,000	1626.68
F-133-018	3,000	1658.35
F-159-029	3,000	1606.36
F-107-004	3,000	1680.8
F-159-030	3,000	1580.84
F-426-021	3,000	1452.77
F-405-028	3,000	1620.71

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - COMMERCIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-426-022	3,000	1420.53
F-337-003	3,000	1618.54
F-326-026	3,000	1591.86
F-067-021	3,000	1,562.41
F-352-021	3,000	1554.85
F-032-017	3,000	1,660.87
F-204-015	3,000	1676.45
F-192-004	3,000	1649.19
F-140-010	3,000	1579.62
F-187-007	3,000	1647.95
F-363A-008	3,000	1570.1
F-140-002	3,000	1576.79
F-167-014	3,000	1642.93
F-190-006	3,000	1648.86
F-311-019	3,000	1589.91
F-202-002	3,000	1628.09
F-351-022	3,000	1524.06
F-134-013	3,000	1620.71
F-297-023	3,000	1547.24
F-032-024	3,000	1,638.80
F-454-001	3,000	1536.07
F-190-007	3,000	1637.81
F-248-042	3,000	1529.4
F-200-014	3,000	1600.32
F-032-025	3,000	1,629.89
F-312-001	3,000	1510.45
F-133-017	3,000	1614.9
F-102-023	3,000	1,535.37
F-188-011	3,000	1600.75
F-312-006	3,000	1506.53
F-155-004	3,000	1566.07
F-204-013	3,000	1627.87
F-196-035	3,000	1560.9
F-352-026	3,000	1490.95
F-085-002	3,000	1,468.37
F-086-022	3,000	1,517.54
F-333-013	3,000	1502.47
F-085-003	3,000	1,465.85
F-189-003	3,000	1580.28
F-325-034	3,000	1539.65
F-155-005	3,000	1554.15
F-199-002	3,000	1566.22
F-189-005	3,000	1583.39
F-199-008	3,000	1564
F-031-030	3,000	1,579.12
F-160-010	3,000	1536.32

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - COMMERCIAL (CONT'D)		
FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)
F-188-007	3,000	1578.02
F-200-008	3,000	1566.72
F-030-012	3,000	1,570.05
F-199-014	3,000	1560
F-022-009	3,000	1,595.07
F-202-008	3,000	1588.71
F-093-032	3,000	1,523.22
F-096-014	3,000	1,577.91
F-154-008	3,000	1523.64
F-120-009	3,000	1525.57
F-479-003	3,000	1495.4
F-134-016	3,000	1584.56
F-141-004	3,000	1537.86
F-079-030	3,000	1,487.71
F-286-003	3,000	1535.74
F-038-030	3,000	1,612.15
F-190-015	3,000	1593.65
F-326-008	3,000	1513.1
F-125-021	3,000	1498.72
F-154-016	3,000	1516.38
F-164-015	3,000	1560.52
F-351-003	3,000	1448.8
F-201-018	3,000	1552.84
F-189-008	3,000	1553.98
F-309-001	3,000	1489.23
F-184-007	3,000	1557.44
F-272-006	3,000	1539.56
F-298-001	3,000	1480.82
F-272-007	3,000	1533.71
F-155-009	3,000	1497.91
F-285-019	3,000	1504.75
F-351-002	3,000	1429.14
F-309-003	3,000	1477.19
F-138-021	3,000	1469.91
F-201-012	3,000	1535.8
F-197-060	3,000	1494.25
F-201-019	3,000	1527.87
F-189-004	3,000	1525.75
F-198-014	3,000	1502.71
F-134-023	3,000	1541.54
F-191-017	3,000	1551.01
F-188-006	3,000	1520.3
F-038-032	3,000	1,556.96
F-426-024	3,000	1315.32
F-133-022	3,000	1536.1
F-079-009	3,000	1,436.97

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - COMMERCIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-327-006	3,000	1471.66
F-191-013	3,000	1544.5
F-352-025	3,000	1428.3
F-138-005	3,000	1449.29
F-198-009	3,000	1490.66
F-191-015	3,000	1536.7
F-132-019	3,000	1527.7
F-191-010	3,000	1539.52
F-441-004	3,000	1435.23
F-030-009	3,000	1,474.65
F-154-012	3,000	1451.39
F-453-024	3,000	1415.74
F-143-021	3,000	1500.79
F-138-022	3,000	1435.29
F-148-012	3,000	1438.2
F-096-013	3,000	1,490.90
F-190-014	3,000	1515.6
F-332-014	3,000	1391.77
F-127-024	3,000	1440.79
F-286-004	3,000	1445.06
F-188-010	3,000	1476.1
F-282-020	3,000	1377.58
F-127-015	3,000	1429.67
F-479-021	3,000	1388.86
F-189-001	3,000	1475.68
F-454-012	3,000	1401.87
F-286-011	3,000	1431.61
F-285-042	3,000	1432.87
F-495-009	3,000	1373.53
F-079-008	3,000	1,380.77
F-169-023	3,000	1473.98
F-067-022	3,000	1,379.34
F-290-003	3,000	1411.09
F-154-026	3,000	1404.22
F-304-005	3,000	1400.25
F-154-025	3,000	1398.76
F-140-001	3,000	1383.04
F-395-011	3,000	1372.98
F-016-013	3,000	1,299.25
F-270-007	3,000	1414.19
F-038-031	3,000	1,466.56
F-495-008	3,000	1348.43
F-154-002	3,000	1372.23
F-442-011	3,000	1338.01
F-112-027	3,000	1348.83
F-125-024	3,000	1357.6

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - COMMERCIAL (CONT'D)		
FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)
F-329-032	3,000	1348.91
F-420-023	3,000	1330.38
F-188-009	3,000	1414.71
F-270-012	3,000	1390.58
F-127-008	3,000	1346.95
F-285-002	3,000	1359.38
F-143-022	3,000	1406.09
F-133-008	3,000	1410.24
F-408-006	3,000	1332.65
F-271-018	3,000	1378.83
F-312-026	3,000	1294.64
F-043-017	3,000	1,381.66
F-222-005	3,000	1387.72
F-191-011	3,000	1411.02
F-154-019	3,000	1332.32
F-191-016	3,000	1402.68
F-369-004	3,000	1280.33
F-271-002	3,000	1355.34
F-034-036	3,000	1,424.65
F-120-008	3,000	1322.29
F-271-008	3,000	1355.6
F-204-007	3,000	1390.41
F-326-023	3,000	1323.54
F-408-003	3,000	1312.58
F-442-002	3,000	1296.76
F-191-022	3,000	1386.94
F-043-009	3,000	1,356.27
F-031-001	3,000	1,359.42
F-178-001	3,000	1306.61
F-442-007	3,000	1292.3
F-031-008	3,000	1,357.61
F-219-014	3,000	1323.66
F-442-024	3,000	1289.73
F-442-021	3,000	1281.78
F-133-019	3,000	1364.16
F-075-034	3,000	1,369.38
F-272-002	3,000	1343.36
F-442-001	3,000	1279.51
F-442-006	3,000	1278.51
F-043-005	3,000	1,343.18
F-448A-001	3,000	1276.56
F-442-023	3,000	1274.78
F-037-017	3,000	1,364.13
F-442-022	3,000	1266.6
F-370-021	3,000	1248.36
F-036-019	3,000	1,361.43

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - COMMERCIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-284-007	3,000	1286.97
F-125-022	3,000	1271.93
F-454-027	3,000	1257
F-408-005	3,000	1273.86
F-324-002	3,000	1254.61
F-189-015	3,000	1334.09
F-471-056	3,000	1062.44
F-333-021	3,000	1224.16
F-332-007	3,000	1214.35
F-408-004	3,000	1255.09
F-140-007	3,000	1250.95
F-016-023	3,000	1,203.81
F-125-023	3,000	1232.06
F-501-004	3,000	1220.9
F-154-017	3,000	1238.31
F-471-011	3,000	1044.28
F-199-024	3,000	1271.09
F-198-027	3,000	1253.16
F-155-015	3,000	1236.58
F-108-001	3,000	1297.9
F-038-026	3,000	1,283.97
F-479-020	3,000	1191.29
F-351-021	3,000	1170.92
F-329-033	3,000	1192.13
F-471-033	3,000	997.47
F-087-020	3,000	1,189.56
F-385-025	3,000	1196.3
F-471-034	3,000	989.61
F-269-005	3,000	1211.18
F-198-003	3,000	1192.12
F-454-011	3,000	1154.59
F-035-008	3,000	1,265.27
F-471-012	3,000	999.34
F-471-055	3,000	967.43
F-312-018	3,000	1117.1
F-184-008	3,000	1197.77
F-034-037	3,000	1,237.82
F-155-016	3,000	1158.46
F-135-001	3,000	1195.35
F-216-011	3,000	1186.43
F-308-002	3,000	1149.33
F-032-010	3,000	1,205.35
F-155-029	3,000	1149.3
F-032-009	3,000	1,199.45
F-026-012	3,000	1,231.35
F-120-010	3,000	1126.96

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - COMMERCIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-134-011	3,000	1170.46
F-344-015	3,000	1101.68
F-180-017	3,000	977.51
F-132-009	3,000	1164.31
F-496-005	3,000	1053.35
F-037-011	3,000	1,159.58
F-332-019	3,000	1054.44
F-269-001	3,000	1116.41
F-312-024	3,000	1072.74
F-291-015	3,000	1067.36
F-030-008	3,000	1,101.61
F-038-007	3,000	1,134.97
F-032-008	3,000	1,133.43
F-312-027	3,000	1035.42
F-267-028	3,000	1052.41
F-154-009	3,000	1060.21
F-311-004	3,000	1029.54
F-133-025	3,000	1093.53
F-016-015	3,000	985.42
F-036-006	3,000	1,089.34
F-016-016	3,000	976.45
F-144-013	3,000	1078.6
F-369-003	3,000	989.59
F-022-020	3,000	1,049.95
F-420-024	3,000	981.14
F-091-012	3,000	956.20
F-085-004	3,000	944.65
F-037-041	3,000	1,048.61
F-216-012	3,000	1035.46
F-327-013	3,000	996.78
F-291-016	3,000	970.24
F-329-035	3,000	972.3
F-203-012	3,000	1042.83
F-284-008	3,000	983.39
F-311-003	3,000	961.97
F-310-021	3,000	991.81
F-312-023	3,000	963.12
F-030-018	3,000	995.69
F-016-022	3,000	921.83
F-091-006	3,000	910.43
F-312-028	3,000	933.82
F-144-028	3,000	1002.08
F-031-027	3,000	990.22
F-179-027	3,000	960.13
F-292-036	3,000	930.44
F-276-019	3,000	919.47

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - COMMERCIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-026-011	3,000	1,032.53
F-181-021	3,000	945.17
F-332-020	3,000	868.4
F-155-008	3,000	900.39
F-292-003	3,000	880.25
F-207-005	3,000	860.83
F-496-006	3,000	847.8
F-031-022	3,000	909.82
F-495-010	3,000	838.15
F-180-018	3,000	698.33
F-363A-002	3,000	841.22
F-189-006	3,000	890.84
F-228-009	3,000	863.32
F-031-026	3,000	873.41
F-207-001	3,000	810.14
F-030-021	3,000	861.50
F-276-020	3,000	815.18
F-291-001	3,000	815.58
F-496-007	3,000	764.75
F-495-011	3,000	762.33
F-036-004	3,000	840.90
F-201-020	3,000	800.85
F-496-008	3,000	733.41
F-495-012	3,000	734
F-182-015	3,000	771.48
F-181-022	3,000	774.73
F-078-008	3,000	681.24
F-139-001	3,000	721.18
F-344-030	3,000	703.13
F-364-013	3,000	706.16
F-189-002	3,000	729.86
F-324-004	3,000	668.64
F-344-003	3,000	645.05
F-079-012	3,000	630.23
F-182-016	3,000	669.47
F-192-017	3,000	691.14
F-309-025	3,000	647.69
F-144-022	3,000	669.51
F-036-012	3,000	639.38
F-175-011	3,000	627.08
F-216-010	3,000	629.57
F-405-026	3,000	594.6
F-131-020	3,000	606.97
F-173-022	3,000	562.42
F-036-011	3,000	574.27
F-364-005	3,000	537.85

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - COMMERCIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-208-012	3,000	548.49
F-291-002	3,000	499.36
F-290-002	3,000	476.39
F-311-002	3,000	442.64
F-155-007	3,000	447.37
F-131-021	3,000	448.74
F-075-032	3,000	383.95
F-208-007	3,000	371.91
F-454-010	3,000	251.47

Residential/ Commercial (42 hydrants)

Criteria: 3,000 gpm @ 20 psi
3 hr flow

Statistics:

Flow (gpm)	# Hydrants
2500-3000	0
2000-2500	0
1500-2000	1
1500-1000	16
500-1000	25
Total (< 3,000)	42

FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)
F-138-011	3,000	1,964.62
F-120-012	3,000	1,427.31
F-551-011	3,000	1,096.34
F-551-010	3,000	1,112.89
F-551-009	3,000	1,119.55
F-551-008	3,000	1,120.54
F-551-007	3,000	1,117.78
F-551-006	3,000	1,095.53
F-551-005	3,000	1,083.03
F-551-004	3,000	1,072.95
F-551-003	3,000	1,062.45
F-551-002	3,000	1,052.27
F-551-001	3,000	1,025.50
F-552-019	3,001	1,032.26
F-552-018	3,000	1,023.03
F-552-017	3,000	1,010.77
F-552-016	3,000	1,001.35
F-552-015	3,000	992.82
F-552-014	3,000	983.99
F-552-013	3,000	975.66
F-552-012	3,000	967.59

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - COMMERCIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-552-011	3,000	959.29
F-552-010	3,000	951.26
F-552-009	3,000	942.45
F-552-008	3,000	935.01
F-552-007	3,000	927.46
F-552-006	3,000	920.20
F-552-005	3,000	912.76
F-552-004	3,000	905.28
F-552-003	3,000	897.14
F-552-002	3,000	889.27
F-552-001	3,000	881.45
F-559-024	3,000	874.02
F-559-023	3,000	866.47
F-559-022	3,000	859.03
F-559-021	3,000	851.74
F-559-020	3,000	844.76
F-559-019	3,000	837.45
F-559-018	3,009	830.80
F-561-001	3,000	616.23
F-561-002	3,000	595.28
F-561-003	3,000	569.91

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INDUSTRIAL		
Industrial (492 Hydrants)		
Criteria:	4,000 gpm 4 hr flow	@ 20 psi
Statistics:	Flow (gpm)	# Hydrants
	3500-4000	23
	3000-3500	36
	2500-3000	42
	2000-2500	93
	1500-2000	126
	1500-1000	107
	500-1000	56
	0-500	9
	Total (< 4,000)	492
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-502-001	4,000	3901.2
F-164-010	4,000	3898.02
F-389-001	4,000	3864.17
F-384-016	4,000	3846.11
F-158-014	4,000	3833.24
F-159-014	4,000	3837.43
F-366-004	4,000	3846.7
F-171-032	4,000	3817.91
F-525A-016	4,000	3762.9
F-342-015	4,000	3789.39
F-171-034	4,000	3792
F-150-010	4,000	3757.99
F-367-014	4,000	3749.55
F-502-011	4,000	3665.19
F-389-002	4,000	3686.22
F-419-003	4,000	3694.58
F-436-003	4,000	3686.17
F-498-001	4,000	3657.18
F-381-014	4,000	3638.29
F-400-006	4,000	3574.45
F-535A-005	4,000	3585.23
F-525A-015	4,000	3470.78
F-164-008	4,000	3577.64
F-502-002	4,000	3471.1
F-136-001	4,000	3449.38
F-437-007	4,000	3505.85
F-526-002	4,000	3462.43
F-396-003	4,000	3469.12
F-146-010	4,000	3425.49

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INDUSTRIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-147-001	4,000	3421.89
F-480-015	4,000	3424.61
F-123-003	4,000	3366.08
F-217-019	4,000	3497.7
F-502-010	4,000	3389.37
F-502-004	4,000	3342.62
F-437-014	4,000	3373.35
F-187-002	4,000	3448.22
F-525A-013	4,000	3241.49
F-185-012	4,000	3433.24
F-389-003	4,000	3363.27
F-381-010	4,000	3284.19
F-187-004	4,000	3374.98
F-495-004	4,000	3242.91
F-525A-014	4,000	3138.4
F-342-013	4,000	3251.18
F-146-011	4,000	3226.6
F-137-021	4,000	3167.76
F-525A-012	4,000	3059.84
F-158-004	4,000	3176.44
F-366-019	4,000	3221.71
F-167-005	4,000	3238.96
F-147-011	4,000	3092.7
F-183-004	4,000	3190.64
F-158-008	4,000	3110.03
F-272-020	4,000	3186.45
F-416-002	4,000	3116.74
F-417-019	4,000	3123.6
F-525A-011	4,000	2886.06
F-117-003	4,000	2,961.14
F-169-015	4,000	3118.59
F-117-034	4,000	2868.46
F-383-005	4,000	2936.11
F-421-020	4,000	2832.3
F-186-011	4,000	3021.95
F-525A-010	4,000	2713.09
F-382-026	4,000	2887.58
F-342-016	4,000	2814.34
F-497-006	4,000	2852.49
F-165-009	4,000	2899.76
F-525A-009	4,000	2598.81
F-272-032	4,000	2890.04
F-480-016	4,000	2717.24
F-186-008	4,000	2893.8
F-526-005	4,000	2769.08

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INDUSTRIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-158-015	4,000	2751.69
F-272-009	4,000	2845.95
F-497-004	4,000	2773.36
F-169-009	4,000	2827.3
F-417-018	4,000	2740.45
F-366-015	4,000	2762.43
F-525A-008	4,000	2484.61
F-168-011	4,000	2797.68
F-382-013	4,000	2674.09
F-158-018	4,000	2667.11
F-164-016	4,000	2759.04
F-382-020	4,000	2659.98
F-420-016	4,000	2668.78
F-168-007	4,000	2773.45
F-525A-007	4,000	2411.53
F-413-001	4,000	2588.59
F-164-002	4,000	2704.05
F-329-007	4,000	2604.36
F-394-007	4,000	2587.21
F-447-006	4,000	2566.25
F-175-004	4,000	2676.06
F-498-003	4,000	2595.12
F-159-012	4,000	2586.28
F-385-013	4,000	2617.26
F-182-008	4,000	2668.69
F-381-009	4,000	2517.3
F-400-001	4,000	2509.38
F-525A-006	4,000	2301.75
F-036-027	4,000	2,693.70
F-391-028	4,000	2524.37
F-535A-003	4,000	2482.95
F-419-004	4,000	2479.22
F-525A-005	4,000	2229.49
F-136-004	4,000	2418.17
F-495-001	4,000	2433.59
F-413-003	4,000	2395.6
F-420-005	4,000	2385.87
F-525A-004	4,000	2148.26
F-527-008	4,000	2380.63
F-497-005	4,000	2392.4
F-438-012	4,000	2362.34
F-495-002	4,000	2345.8
F-329-011	4,000	2341.49
F-420-019	4,000	2349.96
F-273-017	4,000	2446.6

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INDUSTRIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-159-016	4,000	2359.7
F-049-028	4,000	2,460.76
F-383-019	4,000	2319.29
F-418-003	4,000	2360.43
F-419-006	4,000	2406.14
F-185-011	4,000	2459.62
F-525A-003	4,000	2076.82
F-048-031	4,000	2,459.74
F-437-006	4,000	2349.42
F-167-015	4,000	2448.18
F-036-028	4,000	2,483.52
F-530-003	4,000	2302.91
F-329-005	4,000	2316.54
F-420-022	4,000	2306.31
F-144-002	4,000	2388.62
F-164-009	4,000	2370.47
F-525A-002	4,000	2016.43
F-420-014	4,000	2278.35
F-418-005	4,000	2236.69
F-186-003	4,000	2371.64
F-194-014	4,000	2354.08
F-329-004	4,000	2242.34
F-393-005	4,000	2251.98
F-527-007	4,000	2203
F-048-033	4,000	2,337.73
F-525A-001	4,000	1945.78
F-503-004	4,000	2143.45
F-171-033	4,000	2201.05
F-151-017	4,000	2167
F-528-001	4,000	2175.06
F-383-025	4,000	2171.23
F-217-027	4,000	2307.17
F-159-015	4,000	2191.02
F-526-001	4,000	2188.85
F-550-021	4,000	1893.08
F-171-035	4,000	2152.46
F-527-006	4,000	2141.52
F-383-006	4,000	2147.96
F-528-002	4,000	2136.01
F-049-002	4,000	2,273.79
F-367-020	4,000	2202.35
F-495-003	4,000	2103.57
F-347-016	4,000	2207.7
F-151-001	4,000	2127.76
F-274-014	4,000	2232.93

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INDUSTRIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-037-004	4,000	2,241.19
F-527-001	4,000	2107.41
F-386-004	4,000	2158.6
F-550-020	4,000	1837.07
F-382-012	4,000	2090.77
F-385-011	4,000	2145.96
F-329-009	4,000	2096.19
F-194-005	4,000	2225.18
F-527-005	4,000	2085.23
F-217-025	4,000	2220.56
F-527-002	4,000	2084.94
F-535A-004	4,000	2082.67
F-527-003	4,000	2071.96
F-165-011	4,000	2162.65
F-527-004	4,000	2067.81
F-159-011	4,000	2065.19
F-550-019	4,000	1786.61
F-151-014	4,000	2019.29
F-530-001	4,000	2019.35
F-418-006	4,000	2016.62
F-134-006	4,000	2139.34
F-437-011	4,000	2062.57
F-147-010	4,000	1980.77
F-164-011	4,000	2106.62
F-550-018	4,000	1742.48
F-157-010	4,000	1988.54
F-169-002	4,000	2107.14
F-382-019	4,000	1987.61
F-151-009	4,000	1970.01
F-436-009	4,000	2026
F-151-002	4,000	1975.65
F-383-012	4,000	1990.53
F-550-017	4,000	1703.05
F-396-004	4,000	2012.95
F-437-013	4,000	1973.55
F-401-010	4,000	1933.52
F-169-003	4,000	2059.71
F-036-026	4,000	2,110.43
F-165-005	4,000	2030.25
F-144-001	4,000	2039.52
F-550-015	4,000	1660.92
F-381-012	4,000	1911.58
F-175-005	4,000	2017.22
F-432-002	4,000	1937.33
F-386-003	4,000	1975.95

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INDUSTRIAL (CONT'D)		
FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)
F-418-002	4,000	1949.24
F-183-005	4,000	2010.69
F-147-003	4,000	1890.87
F-550-014	4,000	1624.29
F-550-016	4,000	1634.3
F-436-020	4,000	1918.37
F-185-010	4,000	2026
F-159-031	4,000	1903.37
F-166-002	4,000	1963.04
F-418-007	4,000	1848.42
F-168-004	4,000	2004.85
F-550-013	4,000	1588.4
F-152-007	4,000	1859.4
F-168-002	4,000	1987.46
F-168-005	4,000	1988.13
F-157-015	4,000	1818.1
F-151-010	4,000	1833.29
F-273-007	4,000	1927.35
F-550-012	4,000	1556.3
F-416-004	4,000	1862.9
F-208-003	4,000	1916.82
F-217-011	4,000	1942.36
F-134-007	4,000	1950.46
F-048-032	4,000	1,956.37
F-159-022	4,000	1829.67
F-146-013	4,000	1788.63
F-183-006	4,000	1906.95
F-194-006	4,000	1950.6
F-217-022	4,000	1928.39
F-550-011	4,000	1524.32
F-532-001	4,000	1820.16
F-175-009	4,000	1884.39
F-527-009	4,000	1782.38
F-150-001	4,000	1743.15
F-550-010	4,000	1498.25
F-367-013	4,000	1826.46
F-168-006	4,000	1884.22
F-383-011	4,000	1761.96
F-329-014	4,000	1756.58
F-194-013	4,000	1891.93
F-550-009	4,000	1473.08
F-183-009	4,000	1820.66
F-169-001	4,000	1856.2
F-217-023	4,000	1861.06
F-175-010	4,000	1824.38

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INDUSTRIAL (CONT'D)		
FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)
F-143-025	4,000	1843.21
F-550-008	4,000	1449.34
F-482-034	4,000	1704.9
F-183-007	4,000	1793.98
F-183-008	4,000	1786.91
F-159-023	4,000	1712.55
F-535A-006	4,000	1721.34
F-437-008	4,000	1750.86
F-183-039	4,000	1762.25
F-550-007	4,000	1425.1
F-101-005	4,000	1,641.68
F-150-007	4,000	1654.22
F-147-002	4,000	1662.7
F-151-013	4,000	1655.44
F-438-004	4,000	1714.72
F-165-010	4,000	1745.38
F-550-006	4,000	1403.05
F-436-008	4,000	1706.64
F-329-008	4,000	1679.78
F-217-017	4,000	1788.52
F-329-010	4,000	1656.22
F-418-012	4,000	1721.08
F-150-003	4,000	1652.46
F-550-005	4,000	1381.4
F-416-003	4,000	1660.53
F-382-021	4,000	1644.64
F-136-002	4,000	1605.44
F-419-001	4,000	1626.25
F-217-013	4,000	1743.64
F-382-014	4,000	1629.04
F-146-012	4,000	1607.34
F-419-002	4,000	1666.08
F-550-004	4,000	1360.95
F-527-010	4,000	1625.17
F-420-011	4,000	1579.72
F-165-012	4,000	1704.67
F-146-008	4,000	1591.66
F-159-004	4,000	1631.12
F-385-014	4,000	1644.7
F-384-018	4,000	1633.6
F-550-003	4,000	1341.77
F-218-012	4,000	1704.66
F-036-025	4,000	1,748.76
F-550-002	4,000	1322.51
F-124-009	4,000	1563.54

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INDUSTRIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-146-015	4,000	1547.37
F-482-035	4,000	1585.97
F-550-001	4,000	1304.79
F-147-006	4,000	1552.34
F-150-005	4,000	1542.3
F-146-009	4,000	1540.77
F-183-022	4,000	1643.48
F-218-016	4,000	1643.4
F-151-012	4,000	1547.77
F-551-022	4,000	1290.52
F-383-018	4,000	1556.88
F-175-007	4,000	1623.12
F-216-020	4,000	1647.35
F-169-024	4,000	1654.13
F-437-005	4,000	1573.28
F-551-021	4,000	1273.61
F-183-010	4,000	1582.94
F-169-004	4,000	1631.18
F-036-016	4,000	1,650.31
F-438-003	4,000	1549.39
F-551-020	4,000	1255.53
F-208-013	4,000	1605.77
F-175-006	4,000	1574.83
F-169-005	4,000	1618.5
F-527-011	4,000	1488.5
F-551-019	4,000	1238.16
F-208-002	4,000	1561.65
F-151-011	4,000	1472.92
F-151-018	4,000	1457.88
F-551-018	4,000	1223.74
F-208-017	4,000	1549.4
F-085-001	4,000	1,421.18
F-049-005	4,000	1,597.56
F-217-020	4,000	1585.55
F-216-018	4,000	1581.08
F-551-017	4,000	1207.88
F-367-011	4,000	1494.5
F-159-026	4,000	1468.57
F-147-012	4,000	1431.59
F-037-038	4,000	1,560.28
F-551-014	4,000	1189.84
F-165-004	4,000	1507.37
F-85A-001	4,000	1396.5
F-551-013	4,000	1196.42
F-437-009	4,000	1466.36

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INDUSTRIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-169-019	4,000	1535.6
F-217-021	4,000	1528.47
F-396-005	4,000	1457.51
F-551-015	4,000	1169.2
F-551-012	4,000	1146.59
F-417-022	4,000	1435.31
F-183-021	4,000	1477.91
F-164-014	4,000	1483.18
F-183-014	4,000	1472.68
F-182-018	4,000	1464.9
F-85A-003	4,000	1351.79
F-168-003	4,000	1505.37
F-273-020	4,000	1480.21
F-436-024	4,000	1408.64
F-183-011	4,000	1447.47
F-150-006	4,000	1348.4
F-183-020	4,000	1442.58
F-159-025	4,000	1379.15
F-417-020	4,000	1408.53
F-347-023	4,000	1426.22
F-383-020	4,000	1361.41
F-447-004	4,000	1330.19
F-101-006	4,000	1,318.18
F-367-012	4,000	1388.24
F-194-007	4,000	1472.84
F-218-013	4,000	1432.47
F-551-016	4,000	1119.37
F-439-009	4,000	1372.23
F-385-015	4,000	1369.1
F-218-015	4,000	1431.02
F-169-014	4,000	1438.12
F-182-020	4,000	1384.11
F-216-019	4,000	1432.96
F-137-001	4,000	1302.2
F-383-021	4,000	1328.36
F-216-013	4,000	1405.62
F-101-003	4,000	1,281.47
F-091-010	4,000	1,248.60
F-194-004	4,000	1425.48
F-452-010	4,000	1263.74
F-169-017	4,000	1398.42
F-452-007	4,000	1256.43
F-441-021	4,000	1259.08
F-217-015	4,000	1369.2
F-400-009	4,000	1247.61

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INDUSTRIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-439-004	4,000	1266.03
F-026-005	4,000	1,400.53
F-164-012	4,000	1312.3
F-182-017	4,000	1313.97
F-414-024	4,000	1252.25
F-164-013	4,000	1315.54
F-187-008	4,000	1345.68
F-396-006	4,000	1270.3
F-048-026	4,000	1,326.82
F-091-004	4,000	1,172.84
F-184-004	4,000	1312.44
F-85A-002	4,000	1187.42
F-417-021	4,000	1243.21
F-381-004	4,000	1184.12
F-169-018	4,000	1303.77
F-532-002	4,000	1215.28
F-182-009	4,000	1254.76
F-394-016	4,000	1168.21
F-137-002	4,000	1138.09
F-078-004	4,000	1,103.66
F-381-006	4,000	1114.98
F-381-005	4,000	1112.07
F-447-003	4,000	1090.18
F-452-019	4,000	1056.34
F-049-008	4,000	1,209.39
F-501-003	4,000	1108.04
F-439-008	4,000	1093.99
F-396-007	4,000	1107.44
F-186-010	4,000	1140.44
F-447-002	4,000	1002.25
F-447-001	4,000	970.31
F-133-005	4,000	1108.05
F-164-005	4,000	1082.61
F-091-005	4,000	981.90
F-438-011	4,000	1048.22
F-438-009	4,000	1033.43
F-164-001	4,000	1057.22
F-439-006	4,000	1029.08
F-149-005	4,000	954.22
F-185-003	4,000	993.3
F-416-028	4,000	989.75
F-182-019	4,000	1030.26
F-452-006	4,000	933.87
F-186-009	4,000	1042.33
F-439-005	4,000	966.6

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INDUSTRIAL (CONT'D)		
FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)
F-452-020	4,000	885.67
F-184-020	4,000	921.16
F-383-032	4,000	919.35
F-182-010	4,000	965.33
F-163-007	4,000	901.29
F-216-008	4,000	956.1
F-366-018	4,000	913.31
F-452-001	4,000	810.59
F-417-017	4,000	866.9
F-134-015	4,000	921.55
F-036-018	4,000	931.13
F-182-021	4,000	889.01
F-416-005	4,000	856.38
F-436-023	4,000	843.95
F-183-012	4,000	873.62
F-165-013	4,000	874.63
F-163-001	4,000	845.84
F-085-005	4,000	768.73
F-163-006	4,000	838.01
F-183-035	4,000	844.06
F-384-030	4,000	764.68
F-184-021	4,000	756.03
F-417-007	4,000	748.75
F-184-022	4,000	733.25
F-182-011	4,000	774.38
F-383-031	4,000	733.59
F-384-021	4,000	730.11
F-185-004	4,000	664.03
F-184-009	4,000	751
F-383-036	4,000	687.26
F-183-018	4,000	677.54
F-183-013	4,000	688.46
F-216-009	4,000	704.9
F-183-016	4,000	637.71
F-194-017	4,000	688.12
F-417-001	4,000	625.09
F-036-022	4,000	679.07
F-384-026	4,000	617.2
F-383-033	4,000	604.66
F-417-008	4,000	593.58
F-183-015	4,000	610.13
F-183-019	4,000	574.24
F-168-013	4,000	608.4
F-183-027	4,000	592.57
F-151-007	4,000	556.52

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INDUSTRIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-422-011	4,000	565.98
F-183-017	4,000	545.28
F-163-010	4,000	555.19
F-184-023	4,000	512.57
F-440-001	4,000	465.2
F-163-011	4,000	482.35
F-101-001	4,000	447.07
F-440-014	4,000	409.64
F-310-004	4,000	388.8
F-078-006	4,000	323.95
F-216-014	4,000	226.06
F-385-017	4,000	215.78
F-216-017	4,000	213.72

EAST BANK

HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INSTITUTIONAL

Public (621 Hydrants)

Criteria: 5,000 gpm @ 20 psi
4 hr flow

Statistics:

Flow (gpm)	# Hydrants
4500-5000	29
4000-4500	23
3500-4000	50
3000-3500	47
2500-3000	59
2000-2500	84
1500-2000	144
1000-1500	132
500-1000	43
0-500	10
Total (<5,000)	621

FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)	Upstream Pipes Failing to Supply AVG MDD +FF Demand	
			Pipe Recno	Pipe Diameter (in)
F-248-036	5,000	4949.78	155273	6
F-049-009	5,000	4,938.47	123587	12
F-292-017	5,000	4909.7	151486	12
F-292-034	5,000	4898.39	151488	12
F-170-011	5,000	4837.04	164341	12
F-292-022	5,000	4833.3	151490	12
F-157-008	5,000	4828.54	110206	12
F-356-012	5,000	4843.92	145122	6
F-245-012	5,000	4832.31	155559	6
F-269-023	5,000	4795.39	153568	12
F-113-013	5,000	4783.75	114659	6
F-342-017	5,000	4740.8	108477	6
F-097-013	5,000	4725.67	128122	6
F-295-013	5,000	4660.7	151341	8
F-269-029	5,000	4693.9	153552	6
F-122-014	5,000	4699.6	113631	6
F-299-023	5,000	4666.94	150773	8
F-296-008	5,000	4631.6	151219	12
F-105-013	5,000	4649.3	115416	6
F-300A-001	5,000	4564.23	146821	12
F-246-002	5,000	4595.98	155501	6
F-216-003	5,000	4606.24	159631	6
F-299-021	5,000	4542.41	150773	8
F-197-044	5,000	4560	161141	6
F-197-048	5,000	4527.85	160939	8

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INSTITUTIONAL (CONT'D)				
FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)	Upstream Pipes Failing to Supply AVG MDD +FF Demand	
			Pipe Recno	Pipe Diameter (in)
F-028-004	5,000	4,584.09	125968	6
F-064-004	5,000	4,524.87	131136	6
F-064-001	5,000	4,504.84	131151	6
F-356-021	5,000	4506.3	145085	6
F-170-010	5,000	4419.17	164341	12
F-529-003	5,000	4401.68	116729	12
F-275-005	5,000	4426.12	152980	12
F-170-009	5,000	4332.18	164341	12
F-250-042	5,000	4386.39	200647	6
F-299-022	5,000	4321.78	150773	8
F-296-005	5,000	4294.7	151237	6
F-121-013	5,000	4357.08	113803	6
F-113-018	5,000	4313.18	114672	6
F-197-046	5,000	4326.25	161162	6
F-225-021	5,000	4301.42	158609	6
F-036-036	5,000	4,269.68	124903	6
F-243-007	5,000	4179.34	155677	6
F-459-049	5,000	4151.19	135673	6
F-299-015	5,000	4117.84	150776	6
F-182-002	5,000	4197.01	162852	6
F-276-012	5,000	4066.24	152950	6
F-296-007	5,000	3998.66	151224	6
F-106-001	5,000	4121.15	115326	6
F-473-001	5,000	4074.26	132953	8
F-296-003	5,000	3995.51	151247	6
F-504-008	5,000	4014.28	116520	12
F-286-036	5,000	4065.82	152239	6
F-295-014	5,000	3955.79	151318	8
F-127-003	5,000	4023.76	113211	6
F-473-003	5,000	3998	132953	8
F-489-043	5,000	3951.82	201463	8
F-298-012	5,000	3925.37	150909	6
F-197-045	5,000	3966.18	161146	6
F-073-004	5,000	4043.02	130489	6
F-441-015	5,000	3840.4	137844	6
F-170-008	5,000	3812.19	164341	12
F-457-012	5,000	3882.14	136048	6
F-161-008	5,000	3881.25	109706	6
F-086-014	5,000	3811.96	200600	6
F-181-016	5,000	3941.45	162956	6
F-037-006	5,000	3,974.69	124802	6
F-070-019	5,000	3885.37	130713	6
F-181-018	5,000	3918.66	162873	6
F-198-029	5,000	3873.67	161109	6
F-473-029	5,000	3831.98	132907	6
F-473-002	5,000	3847.25	132953	8
F-048-024	5,000	3,919.22	123681	6
F-267-010	5,000	3783.88	154048	6
F-149-002	5,000	3691.2	110960	8
F-181-008	5,000	3820.56	162936	6
F-184-011	5,000	3825.42	162583	6
F-370-030	5,000	3690.3	143680	6
F-036-003	5,000	3,848.56	124953	6
F-535-002	5,000	3687.46	116532	12
F-243-005	5,000	3726.92	155696	6
F-047-017	5,000	3,802.39	123831	6
F-356-011	5,000	3730.14	145122	6

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INSTITUTIONAL (CONT'D)				
FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)	Upstream Pipes Failing to Supply AVG MDD +FF Demand	
			Pipe Recno	Pipe Diameter (in)
F-535-001	5,000	3666.23	116520	12
F-247-012	5,000	3733.91	155351	6
F-017-003	5,000	3,769.57	126923	12
F-184-018	5,000	3711.52	162546	6
F-296-012	5,000	3575.31	151232	6
F-047-022	5,000	3,740.69	123836	6
F-109-015	5,000	3748.64	127938	6
F-342-018	5,000	3537.26	108477	6
F-066-002	5,000	3,473.46	131064	12
F-125-005	5,000	3549.53	113439	6
F-147-004	5,000	3508.02	111118	6
F-298-009	5,000	3552.84	150909	6
F-180-010	5,000	3609.97	163043	6
F-402-030	5,000	3525.14	141419	6
F-220-010	5,000	3609.21	159094	6
F-086-012	5,000	3420.95	129116	6
F-416-029	5,000	3479.83	140210	6
F-049-010	5,000	3,604.17	123579	6
F-038-001	5,000	3,607.20	124650	6
F-287-031	5,000	3519.75	152097	6
F-070-017	5,000	3491.55	130728	6
F-356-020	5,000	3448.77	145085	6
F-038-003	5,000	3,526.03	124648	6
F-247-016	5,000	3458.08	155347	6
F-028-005	5,000	3,556.18	124533	6
F-186-005	5,000	3510.96	162406	6
F-124-017	5,000	3346.03	113471	6
F-529-001	5,000	3202.21	116700	12
F-249-040	5,000	3405.98	154897	6
F-296-004	5,000	3326.32	151245	6
F-288-002	5,000	3416.55	151910	6
F-246-010	5,000	3388.48	155497	6
F-445-018	5,000	3359.9	137305	6
F-248-064	5,000	3361.54	155249	6
F-132-021	5,000	3435.3	112645	6
F-047-023	5,000	3,432.95	123813	6
F-070-022	5,000	3355.52	130673	6
F-295-015	5,000	3203.48	151318	8
F-233-027	5,000	3368.45	157601	6
F-250-043	5,000	3326.58	154635	6
F-472-024	5,000	3256.08	133165	6
F-242-002	5,000	3244.82	151018	6
F-181-023	5,000	3293.71	162887	6
F-113-012	5,000	3229.42	114634	6
F-053-012	5,000	3,198.85	123270	6
F-114-009	5,000	3186.25	114566	8
F-454-023	5,000	3173.32	136490	6
F-320-028	5,000	3176.47	148549	6
F-248-026	5,000	3192.34	155256	6
F-198-030	5,000	3170.85	161109	6
F-018-002	5,000	3,247.51	126923	12
F-248-035	5,000	3184.15	155273	6
F-481-009	5,000	3118.68	131420	6
F-502-003	5,000	2920.71	119962	1
F-197-051	5,000	3128.37	161146	6
F-453-002	5,000	3034.53	136608	12
F-150-004	5,000	3001.61	110912	6

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INSTITUTIONAL (CONT'D)				
FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)	Upstream Pipes Failing to Supply AVG MDD +FF Demand	
			Pipe Recno	Pipe Diameter (in)
F-457-010	5,000	3081.99	136033	6
F-193-006	5,000	3235.5	201975	6
F-144-010	5,000	3156.64	111456	6
F-245-003	5,000	3108.43	155421	6
F-198-031	5,000	2970.2	160918	6
F-476-020	5,000	3064.04	132327	6
F-195-004	5,000	3170.75	160137	6
F-366-016	5,000	3070.84	144127	6
F-295-016	5,000	2922.37	151341	8
F-097-001	5,000	3137.52	128176	6
F-097-009	5,000	3148.31	128158	6
F-066-001	5,000	2,840.48	131064	12
F-489-046	5,000	2933.31	201463	8
F-441-016	5,000	2868.54	137838	6
F-370-027	5,000	2900.26	143690	6
F-186-006	5,000	3041.62	162401	6
F-182-004	5,000	2993.28	162836	6
F-054-001	5,000	2,998.39	123250	6
F-247-013	5,000	2967.68	155351	6
F-242-001	5,000	2884.61	151018	6
F-207-009	5,000	3010.82	160066	6
F-081-030	5,000	2861.93	129614	6
F-457-011	5,000	2850.95	136035	6
F-476-019	5,000	2853.93	132327	6
F-248-037	5,000	2847.09	155273	6
F-096-010	5,000	2900.21	128229	6
F-182-012	5,000	2879.27	162822	6
F-333-030	5,000	2758.58	147176	6
F-206-010	5,000	2938.04	159310	6
F-360-008	5,000	2849	144729	6
F-243-019	5,000	2816.12	155669	6
F-093-027	5,000	2773.86	128573	6
F-295-017	5,000	2672.98	151342	8
F-181-019	5,000	2837.49	162874	6
F-149-001	5,000	2595.31	110210	8
F-245-001	5,000	2795.71	155421	6
F-198-032	5,000	2676.12	160916	6
F-216-004	5,000	2858.14	159626	6
F-066-011	5,000	2575.38	131080	12
F-298-011	5,000	2699.54	150909	6
F-070-012	5,000	2760.28	130718	6
F-297-025	5,000	2662.76	151150	6
F-233-007	5,000	2798.66	157468	6
F-133-015	5,000	2791.64	112511	6
F-179-029	5,000	2742.03	201797	6
F-267-016	5,000	2652.65	154031	6
F-298-010	5,000	2665.02	150909	6
F-304-011	5,000	2693.33	150037	6
F-248-027	5,000	2702.22	155260	6
F-318A-006	5,000	2661.04	148796	6
F-233-025	5,000	2759.93	157436	6
F-458-002	5,000	2687.61	135951	6
F-333-017	5,000	2597.73	147126	6
F-111-001	5,000	2556.58	114221	12
F-489-044	5,000	2614.17	201462	6
F-036-001	5,000	2,728.79	124961	6
F-053-005	5,000	2,651.26	123292	6

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INSTITUTIONAL (CONT'D)				
FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)	Upstream Pipes Failing to Supply AVG MDD +FF Demand	
			Pipe Recno	Pipe Diameter (in)
F-243-020	5,000	2605.86	155669	6
F-445-017	5,000	2601.52	137305	6
F-245-002	5,000	2626.47	155421	6
F-247-017	5,000	2615.6	155347	6
F-458-003	5,000	2549.73	135953	6
F-269-014	5,000	2574.36	153583	6
F-198-033	5,000	2551.73	161048	6
F-248-067	5,000	2503.62	155249	6
F-366-026	5,000	2537.15	144142	6
F-208-006	5,000	2576.86	160068	6
F-149-003	5,000	2340.41	110960	8
F-053-009	5,000	2,541.82	123286	6
F-436-018	5,000	2454.76	138206	6
F-489-045	5,000	2444.54	121441	8
F-180-002	5,000	2447.46	160918	6
F-248-068	5,000	2436.15	155294	6
F-113-019	5,000	2433.07	114617	6
F-297-026	5,000	2391.99	151104	6
F-111-002	5,000	2350.37	114273	6
F-066-012	5,000	2246.44	131080	12
F-089-015	5,000	2443.71	128873	6
F-296-009	5,000	2331.65	151221	6
F-206-019	5,000	2526.95	160229	6
F-402-025	5,000	2358.84	141434	6
F-375C-001	5,000	2317.49	143174	12
F-157-007	5,000	2229.62	110210	8
F-182-003	5,000	2463.6	162844	6
F-049-011	5,000	2,478.46	123574	6
F-049-016	5,000	2,443.13	123564	6
F-320-026	5,000	2323.87	148547	6
F-037-008	5,000	2,435.66	124754	6
F-276-011	5,000	2277.11	152943	6
F-038-004	5,000	2,448.24	124633	6
F-181-017	5,000	2401.47	162873	6
F-472-090	5,000	2321.38	133165	6
F-181-015	5,000	2394.56	162956	6
F-145-018	5,000	2404.55	111297	6
F-306-011	5,000	2327.85	149826	6
F-415-032	5,000	2267.82	140250	6
F-404-012	5,000	2304.01	141073	6
F-406-015	5,000	2271.9	140811	6
F-113-023	5,000	2252.71	114676	6
F-248-069	5,000	2249.5	155294	6
F-286-037	5,000	2295.46	152240	6
F-248-071	5,000	2236.64	131420	6
F-402-009	5,000	2236.97	141464	6
F-179-007	5,000	2299.02	163222	6
F-304-013	5,000	2265.65	150019	6
F-248-028	5,000	2281.54	155260	6
F-331-006	5,000	2148.56	147451	6
F-145-005	5,000	2332.62	111318	6
F-079-014	5,000	2171.87	129871	6
F-402-035	5,000	2197.39	141402	6
F-228-002	5,000	2260.89	158026	6
F-103-018	5,000	2195.23	115580	6
F-216-001	5,000	2323.52	159644	6
F-363-009	5,000	2201.02	144409	6

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INSTITUTIONAL (CONT'D)				
FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)	Upstream Pipes Failing to Supply AVG MDD +FF Demand	
			Pipe Recno	Pipe Diameter (in)
F-207-014	5,000	2312.57	160138	6
F-197-047	5,000	2212.59	161134	6
F-180-015	5,000	2219.53	163033	6
F-103-013	5,000	2130.06	115579	6
F-181-007	5,000	2218.86	162936	6
F-049-017	5,000	2,241.13	123560	6
F-018-004	5,000	2,226.29	126910	6
F-350-034	5,000	2112.88	143851	6
F-054-009	5,000	2,229.09	123224	6
F-248-033	5,000	2169.65	155297	6
F-248-029	5,000	2169.59	200623	6
F-049-018	5,000	2,224.74	123559	8
F-286-033	5,000	2155.46	152248	6
F-083-015	5,000	2215.61	200588	6
F-217-026	5,000	2234.58	159488	6
F-038-015	5,000	2,217.31	123559	8
F-122-026	5,000	2200.48	113672	6
F-181-004	5,000	2135.24	162259	6
F-304-003	5,000	2110.01	150065	6
F-246-013	5,000	2129.62	155483	8
F-118-010	5,000	2043	114077	6
F-457-015	5,000	2096.63	135951	6
F-181-006	5,000	2140.55	162936	6
F-180-009	5,000	2113.21	163043	6
F-188-017	5,000	2070	162259	6
F-225-023	5,000	2126.44	158609	6
F-004-009	5,000	2,201.32	124462	6
F-248-032	5,000	2073.07	155299	6
F-180-008	5,000	2065.59	163043	6
F-434-005	5,000	1970.52	137857	6
F-070-021	5,000	2061.29	130698	6
F-180-007	5,000	2037.53	163039	6
F-049-012	5,000	2,104.69	123577	6
F-049-015	5,000	2,095.35	123561	6
F-184-010	5,000	2064.5	162207	6
F-319-030	5,000	1960.44	148701	6
F-352-019	5,000	1950.32	145529	6
F-181-002	5,000	2060.53	162251	6
F-248-031	5,000	2001.97	155301	6
F-454-015	5,000	1951.08	136535	6
F-312-004	5,000	1918.68	149293	6
F-454-032	5,000	1929.96	136459	6
F-404-013	5,000	1965.5	141124	6
F-130-017	5,000	2071.03	112919	6
F-375E-001	5,000	1880.35	200988	6
F-375G-001	5,000	1894.02	143111	6
F-067-015	5,000	1846.95	130968	6
F-248-073	5,000	1940.54	155276	6
F-208-004	5,000	1982.69	160073	6
F-184-012	5,000	1973.57	162583	6
F-059-021	5,000	2,038.40	131229	6
F-002-008	5,000	2,108.02	126854	4
F-285-001	5,000	1935.8	148136	6
F-113-017	5,000	1892.83	114672	6
F-114-011	5,000	1896.2	114583	4
F-248-030	5,000	1929.7	200622	6
F-329-029	5,000	1923.68	147709	6

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INSTITUTIONAL (CONT'D)				
FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)	Upstream Pipes Failing to Supply AVG MDD +FF Demand	
			Pipe Recno	Pipe Diameter (in)
F-286-032	5,000	1908.02	152248	6
F-417-009	5,000	1883.79	140019	6
F-145-003	5,000	1984.67	111297	6
F-089-017	5,000	1900.96	128871	6
F-245-013	5,000	1929.71	155559	6
F-122-023	5,000	1961.54	113651	6
F-314-017	5,000	1799.62	149088	6
F-208-011	5,000	1962.78	160066	6
F-189-012	5,000	1890.51	162207	6
F-044-003	5,000	1,961.02	124111	6
F-097-002	5,000	1956.29	128166	6
F-189-011	5,000	1872.04	162204	6
F-070-018	5,000	1859.39	130714	6
F-416-025	5,000	1824.2	140096	6
F-045-008	5,000	1,947.49	124047	6
F-370-029	5,000	1782.12	143680	6
F-457-017	5,000	1839.11	135953	6
F-228-003	5,000	1854.2	158026	6
F-312-005	5,000	1759.45	149297	6
F-144-003	5,000	1891.75	111462	6
F-370-019	5,000	1755.72	143705	6
F-089-016	5,000	1819.51	128873	6
F-065-011	5,000	1,876.69	131101	6
F-097-008	5,000	1932.21	128154	6
F-225-022	5,000	1864.23	158609	6
F-132-006	5,000	1892.46	111318	6
F-184-019	5,000	1893.85	162220	6
F-198-034	5,000	1821.31	161048	6
F-150-002	5,000	1722.37	110050	6
F-155-001	5,000	1800.62	110442	6
F-319-027	5,000	1730.27	148708	6
F-457-013	5,000	1770.33	136053	6
F-065-001	5,000	1,821.40	130604	6
F-208-008	5,000	1828.65	160065	6
F-402-031	5,000	1730.61	141417	6
F-113-029	5,000	1663.25	114638	6
F-186-004	5,000	1832.32	162406	6
F-074-001	5,000	1864.01	130398	6
F-207-013	5,000	1844.38	160138	6
F-332B-002	5,000	1677.91	147352	6
F-004-008	5,000	1,864.58	124462	6
F-443-002	5,000	1722.45	137663	6
F-333-012	5,000	1678.09	147129	6
F-088-021	5,000	1729.09	128909	6
F-208-005	5,000	1768.57	158056	6
F-181-003	5,000	1782.98	160857	6
F-018-006	5,000	1,773.50	126910	6
F-366-020	5,000	1702.15	144169	6
F-216-002	5,000	1803.13	159637	6
F-148-003	5,000	1663.07	111027	6
F-287-032	5,000	1729.64	152097	6
F-436-016	5,000	1673.59	138201	6
F-089-018	5,000	1722.92	128848	4
F-220-011	5,000	1740.36	159094	6
F-084-016	5,000	1801.92	129254	6
F-066-006	5,000	1,587.16	131071	6
F-454-019	5,000	1651.88	136485	6

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INSTITUTIONAL (CONT'D)				
FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)	Upstream Pipes Failing to Supply AVG MDD +FF Demand	
			Pipe Recno	Pipe Diameter (in)
F-184-013	5,000	1664.24	162579	6
F-068-006	5,000	1645.19	130893	6
F-071-005	5,000	1718.22	130628	6
F-079-007	5,000	1597.02	129831	6
F-167-013	5,000	1756	109145	6
F-114-004	5,000	1651.27	114534	6
F-248-065	5,000	1668.01	155249	6
F-097-007	5,000	1783.78	128154	6
F-073-007	5,000	1789.54	130468	6
F-296-011	5,000	1614.98	151199	6
F-047-018	5,000	1,722.89	123888	6
F-016-014	5,000	1,532.54	164406	8
F-333-019	5,000	1581.06	147122	6
F-129-009	5,000	1698.16	108824	6
F-080-004	5,000	1618.32	129040	6
F-038-036	5,000	1,769.45	124533	6
F-088-022	5,000	1616.49	128907	4
F-286-022	5,000	1658.79	152231	6
F-028-016	5,000	1,756.97	125823	6
F-052-018	5,000	1,611.23	123366	4
F-182-005	5,000	1672.81	162836	6
F-065-003	5,000	1,673.10	131120	6
F-035-006	5,000	1,722.44	124953	6
F-028-006	5,000	1,744.73	124533	6
F-151-015	5,000	1551.53	110814	6
F-206-011	5,000	1700.04	159310	6
F-305-008	5,000	1619.18	149965	6
F-345-008	5,000	1598.9	146301	6
F-089-003	5,000	1644.4	128806	4
F-071-007	5,000	1634.68	130622	6
F-142-005	5,000	1628.55	111629	6
F-142-008	5,000	1632.09	111626	6
F-095-010	5,000	1612.39	128318	6
F-094-004	5,000	1584.9	128358	4
F-142-004	5,000	1620.01	111631	6
F-161-019	5,000	1597.41	202017	6
F-134-014	5,000	1665.74	112385	6
F-088-013	5,000	1563.61	128929	6
F-067-017	5,000	1524.22	130958	6
F-066-004	5,000	1,490.32	131065	6
F-248-066	5,000	1567.92	155249	6
F-055-007	5,000	1,580.74	123146	6
F-435-010	5,000	1538.89	138317	6
F-288-011	5,000	1574.33	151955	6
F-184-017	5,000	1494.71	162546	6
F-269-030	5,000	1581.48	153552	6
F-305-018	5,000	1570.03	150019	6
F-152-004	5,000	1542.99	110699	4
F-312-002	5,000	1500.24	149284	6
F-153-018	5,000	1541.72	110699	4
F-130-007	5,000	1634.8	112930	6
F-366-007	5,000	1535.49	144113	6
F-071-017	5,000	1572.33	130672	6
F-045-001	5,000	1,633.15	124071	6
F-066-005	5,000	1,429.14	131069	6
F-464-035	5,000	1352.88	134354	6
F-132-020	5,000	1589.07	112645	6

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INSTITUTIONAL (CONT'D)				
FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)	Upstream Pipes Failing to Supply AVG MDD +FF Demand	
			Pipe Recno	Pipe Diameter (in)
F-207-008	5,000	1573.96	160161	6
F-434-004	5,000	1444.14	137857	6
F-045-002	5,000	1,617.33	124050	6
F-064-005	5,000	1,540.86	131111	6
F-103-040	5,000	1481.54	115580	6
F-052-013	5,000	1,502.29	123381	6
F-454-013	5,000	1470.63	136499	6
F-129-019	5,000	1551.91	108858	6
F-065-002	5,000	1,555.94	130604	6
F-068-012	5,000	1465.27	130898	4
F-016A-002	5,000	1,386.59	164406	8
F-366-005	5,000	1485.38	144125	6
F-035-010	5,000	1,594.39	125081	4
F-094-019	5,000	1504.18	128433	6
F-018-005	5,000	1,544.74	126910	6
F-103-012	5,000	1451.18	115579	6
F-084-017	5,000	1589.29	129254	6
F-327-018	5,000	1491.22	147838	6
F-363-019	5,000	1483.63	144415	6
F-065-005	5,000	1,518.67	131112	6
F-142-009	5,000	1524.54	111626	6
F-327-022	5,000	1489.59	147823	6
F-319-031	5,000	1459.45	148547	6
F-319-029	5,000	1434.69	148701	6
F-033-005	5,000	1,559.79	125211	6
F-366-021	5,000	1445.54	144007	6
F-167-017	5,000	1532.99	109145	6
F-114-006	5,000	1433.69	114546	4
F-319-028	5,000	1417.98	148701	6
F-416-027	5,000	1430.18	140095	6
F-137-018	5,000	1401.2	112053	6
F-271-009	5,000	1475.43	152107	6
F-089-013	5,000	1463.56	128376	6
F-090-012	5,000	1488.59	128230	6
F-055-002	5,000	1,519.44	131101	6
F-197-043	5,000	1454.29	160940	4
F-049-013	5,000	1,474.52	123568	6
F-073-006	5,000	1529.13	130466	6
F-114-21	5,000	1441.2	114542	6
F-053-008	5,000	1,438.13	123286	6
F-047-024	5,000	1,482.41	123813	6
F-188-016	5,000	1458.06	160857	6
F-008-001	5,000	1,422.91	122925	8
F-184-025	5,000	1442.83	162470	6
F-139-021	5,000	1393.43	111900	6
F-104-007	5,000	1399.11	115426	4
F-129-004	5,000	1452.88	108765	6
F-090-009	5,000	1450.18	128233	6
F-071-015	5,000	1451.86	130596	6
F-128-005	5,000	1438.16	113104	6
F-067-018	5,000	1349.22	130958	6
F-006-019	5,000	1,323.68	123008	6
F-037-040	5,000	1,481.05	124797	6
F-189-016	5,000	1470.75	162220	6
F-065-006	5,000	1,432.20	131112	6
F-045-003	5,000	1,494.47	124050	6
F-048-029	5,000	1,475.46	123658	4

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INSTITUTIONAL (CONT'D)				
FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)	Upstream Pipes Failing to Supply AVG MDD +FF Demand	
			Pipe Recno	Pipe Diameter (in)
F-417-010	5,000	1379.62	140036	6
F-310-018	5,000	1400.04	147834	6
F-016A-003	5,000	1,282.97	164406	8
F-126-019	5,000	1375.57	113319	6
F-220-013	5,000	1412.31	159161	6
F-188-019	5,000	1424.56	160846	6
F-245-014	5,000	1390.41	155559	6
F-182-023	5,000	1396.83	162836	6
F-198-015	5,000	1377.68	153552	6
F-064-006	5,000	1,380.72	131111	6
F-248-038	5,000	1345.27	155276	6
F-403-005	5,000	1347.91	141202	6
F-319-026	5,000	1310.35	147352	6
F-276-007	5,000	1292.92	152936	6
F-065-007	5,000	1,364.26	131111	6
F-084-021	5,000	1414.96	200595	6
F-448A-002	5,000	1291.94	136620	6
F-295-002	5,000	1285.51	151329	6
F-037-039	5,000	1,393.07	124797	6
F-248-070	5,000	1299.97	200628	6
F-016A-004	5,000	1,213.45	164413	8
F-089-012	5,000	1330.21	128376	6
F-065-012	5,000	1,362.48	131101	6
F-006-012	5,000	1,222.17	123015	6
F-332B-003	5,000	1244.07	147353	6
F-246-030	5,000	1282.61	150593	6
F-139-013	5,000	1288.33	111853	6
F-065-008	5,000	1,318.70	131111	6
F-435-011	5,000	1273.95	138317	6
F-065-009	5,000	1,309.82	131111	6
F-089-011	5,000	1290.53	128376	6
F-139-012	5,000	1256.99	111813	6
F-139-016	5,000	1257.8	111864	6
F-182-013	5,000	1301.09	162822	6
F-070-011	5,000	1286.54	130699	6
F-149-004	5,000	1160.25	200866	4
F-036-002	5,000	1,317.46	124961	6
F-016A-005	5,000	1,153.74	164406	8
F-055-001	5,000	1,315.40	131101	6
F-181-020	5,000	1277.08	162874	6
F-245-015	5,000	1267.19	155559	6
F-017-006	5,000	1,302.01	126968	6
F-406-013	5,000	1225.98	140858	6
F-088-014	5,000	1215.56	128930	4
F-088-004	5,000	1219.38	128418	6
F-404-004	5,000	1217.12	141202	6
F-366-024	5,000	1191.32	144171	6
F-366-025	5,000	1187.13	144016	6
F-402-040	5,000	1174.56	141290	4
F-098-002	5,000	1278.58	128042	4
F-184-016	5,000	1068.35	162546	6
F-293-017	5,000	1140.83	200669	6
F-033-009	5,000	1,263.26	124029	4
F-193-007	5,000	1259.81	161772	4
F-221-009	5,000	1205.3	159007	6
F-016A-006	5,000	1,070.87	164406	8
F-068-007	5,000	1139.2	130919	6

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INSTITUTIONAL (CONT'D)				
FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)	Upstream Pipes Failing to Supply AVG MDD +FF Demand	
			Pipe Recno	Pipe Diameter (in)
F-366-022	5,000	1120.25	144016	6
F-436-019	5,000	1133.26	138196	6
F-184-014	5,000	1023.39	162569	4
F-114-012	5,000	1129.26	114561	6
F-045-007	5,000	1,209.76	124020	4
F-413-005	5,000	1053.25	140577	6
F-347-008	5,000	1138.69	144223	6
F-066-009	5,000	1,048.69	131075	6
F-016A-007	5,000	1,032.90	164406	8
F-009-002	5,000	1,117.99	122856	6
F-333-029	5,000	1064.55	147095	6
F-184-015	5,000	939.51	162546	6
F-367-001	5,000	1084.3	144044	6
F-333-028	5,000	1054.59	147095	6
F-046-013	5,000	1,166.37	123954	4
F-245-016	5,000	1109.1	155559	6
F-162-012	5,000	1091.34	109640	6
F-101-007	5,000	1013.63	128736	6
F-275-009	5,000	1066.16	152936	6
F-293-018	5,000	1038.88	200670	6
F-366-006	5,000	1062.03	144124	6
F-179-010	5,000	1061.6	163235	6
F-184-026	5,000	868.25	162546	6
F-207-006	5,000	1035.22	160128	6
F-293-014	5,000	1020.57	149345	6
F-436-017	5,000	1009.1	138202	6
F-246-014	5,000	1018.1	155484	6
F-156-007	5,000	1043.22	109528	6
F-171-052	5,000	983.23	164256	4
F-179-030	5,000	1020.58	163113	4
F-434-012	5,000	953.18	138403	6
F-228-006	5,000	1030.25	158023	6
F-195-007	5,000	973.14	160178	6
F-312-003	5,000	961.56	149306	6
F-246-015	5,000	981.09	155483	8
F-037-015	5,000	1,050.49	124776	4
F-295-001	5,000	943.28	200685	6
F-294-003	5,000	940.6	200685	6
F-065-004	5,000	1,002.01	131120	6
F-160-012	5,000	956.8	109815	6
F-228-007	5,000	974.76	201812	4
F-088-011	5,000	938.35	128911	6
F-088-012	5,000	927.19	128911	6
F-293-015	5,000	901.05	151379	6
F-294-004	5,000	903.2	151380	6
F-294-006	5,000	891.15	151379	6
F-294-007	5,000	891.38	151379	6
F-182-014	5,000	938.51	162822	6
F-186-007	5,000	943.75	162401	6
F-350-036	5,000	860.71	143852	6
F-332-028	5,000	837.91	147320	4
F-207-004	5,000	845.44	160178	6
F-228-004	5,000	884.08	158034	4
F-246-003	5,000	867.58	150593	6
F-229-006	5,000	871.14	157983	6
F-434-001	5,000	820.38	138401	6
F-207-003	5,000	787.34	160178	6

EAST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INSTITUTIONAL (CONT'D)				
FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)	Upstream Pipes Failing to Supply AVG MDD +FF Demand	
			Pipe Recno	Pipe Diameter (in)
F-207-002	5,000	779.37	160130	6
F-294-002	5,000	793.64	151360	6
F-294-005	5,000	793.65	151358	6
F-049-014	5,000	853.16	123568	6
F-023-024	5,000	870.16	126691	6
F-082-005	5,000	809.39	129471	6
F-241-010	5,000	817.46	155923	6
F-066-010	5,000	748.56	131075	6
F-088-020	5,000	768.07	128907	4
F-316-018	5,000	708.67	148934	4
F-433-001	5,000	654.86	138456	6
F-246-004	5,000	681.43	150593	6
F-294-001	5,000	652.38	151357	6
F-208-009	5,000	566.09	160059	4
F-023-020	5,000	567.55	126671	6
F-331-001	5,000	502.66	147320	4
F-182-022	5,000	446.82	162835	6
F-070-010	5,000	436.22	130694	4
F-071-016	5,000	432.83	130598	4
F-071-018	5,000	430.36	130592	4
F-208-010	5,000	403.49	201281	4
F-054-008	5,000	408.53	123229	4
F-435-007	5,000	296.68	138314	6
F-207-012	5,000	190.65	160142	4
F-029-010	5,000	172.40	125777	4
F-017-007	5,000	155.94	125777	4

EAST BANK PIPES FAILING TO SUPPLY REQUIRED PEAK HOURLY DEMAND		
Node ID	Upstream Pipe	
	Pipe Recno	Pipe Diameter (in)
561-002	115743	8
560-002	115867	8
540-001	116361	2
R-508-001	118868	12
480-028	131470	2
471-007	133430	6
471-016	133431	6
471-017	133432	6
471-020	133433	6
471-021	133434	6
460-051	135368	8
460-052	135370	8
460-053	135374	6
460-054	135379	8
460-055	135380	6
460-056	135380	6
460-050	135472	8
460-040	135529	8
V-460-021	135530	8
460-041	135532	8
460-045	135537	8
460-044	135536	8
460-043	135539	8
460-046	135563	8
460-047	135545	8
460-048	135547	8
460-049	135547	8
460-038	135560	8
460-042	135566	6
460-039	135560	8
431-048	138627	6
431-051	138465	6
431-050	138475	6
431-049	138627	6
431-046	138485	6
431-045	138511	6
431-047	138630	6
431-044	138502	6
431-043	138604	6
431-040	138532	6
431-056	138517	6
431-042	138602	6
431-038	138533	6
431-052	138543	6
431-035	138547	6
431-032	138551	6
431-034	138550	6

EAST BANK PIPES FAILING TO SUPPLY REQUIRED PEAK HOURLY DEMAND		
Node ID	Upstream Pipe	
	Pipe Recno	Pipe Diameter (in)
431-031	138600	6
431-033	138619	4
431-036	138623	6
431-037	138625	6
431-039	138633	6
431-054	138629	6
300A-011	150721	6
227-001	158256	6
375B-003	143208	12
078-003	129931	8
078-002	129933	6
078-001	129934	6
452-014	136713	6
413-200	140562	12
400-205	141746	12
400-201	141741	12
400-207	141687	12
400-209	141729	12
400-211	141723	12
400-213	141723	12
400-215	141722	12
400-217	141713	12
400-219	141713	12
381-216	108731	4
381-219	108731	4
282-022	201422	12
176-204	163700	12
176-208	163720	8
123-007	113567	8
117-029	200689	6
117-028	200691	6
117-008	200691	6
123-008	113567	8
X-320-001	150579	12
X-317-001	148920	12
X-320-002	202266	12
X-435-002	138385	20
X-313-001	149187	12
X-331-001	202272	12

WEST BANK

HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - RESIDENTIAL

Single-Family Residential (52 hydrants)

Criteria: 1,000 gpm @ 20 psi
2 hr flow

Statistics:

Flow (gpm)	# Hydrants
750-1000	~~38~~
500-750	7
250-500	7
Total (< 1,000)	52

FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)
F-A8-042	1,000	999.7
F-A32-005	1,000	994.97
F-A7-041	1,000	993.75
F-A8A-018	1,000	991.13
F-A6-006	1,000	983.20
F-A7-044	1,000	978.02
F-A48-006	1,000	962.31
F-A13-042	1,000	958.60
F-A7-066	1,000	957.80
F-A48-004	1,000	953.12
F-A7-047	1,000	941.79
F-A6-003	1,000	937.34
F-A48-003	1,000	930.06
FR-A48-005	1,010	938.41
F-A7-036	1,000	928.73
F-A6-004	1,000	927.92
F-A3-075	1,000	926.52
F-A48-009	1,000	909.28
F-A7-070	1,000	917.72
F-A2-045	1,000	914.02
FR-A48-002	1,005	905.81
F-A7-045	1,000	902.44
F-A7-040	1,000	902.63
F-A7-067	1,000	898.74
F-A7-046	1,000	900.79
F-A10-011	1,000	891.32
F-A48-010	1,000	880.89
F-A10-015	1,000	891.41
F-A7-069	1,000	892.09
F-A7-068	1,000	887.03
F-A5-034	1,000	881.56
F-A48-011	1,000	855.91
F-A7-051	1,000	867.32

WEST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - RESIDENTIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-A7-037	1,000	862.11
F-A7-039	1,000	861.82
F-A7-038	1,000	844.36
F-A4-032	1,000	810.89
F-A10-017	1,000	800.14
F-A7-052	1,000	631.55
F-A7-026	1,000	621.39
F-A10-010	1,000	593.43
F-A10-016	1,000	597.56
F-A5-033	1,000	571.77
F-A9-001	1,000	544.18
F-A7-053	1,000	533.17
F-A7-054	1,000	487.24
F-A7-055	1,000	437.79
F-A7-056	1,000	391.37
F-A7-057	1,000	364.26
F-A8-034	1,000	343.14
F-A47-010	1,000	306.90
F-A56-001	1,000	462.53

Multi-Family Residential (70 hydrants)

Criteria:	2,500 gpm 2 hr flow	@ 20 psi
Statistics:	Flow (gpm)	# Hydrants
	2000-2500	31
	1500-2000	16
	1500-1000	14
	750-1000	9
	Total (< 2,500)	70

FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)
F-A36-023	2,500	2,490.65
F-A39-004	2,500	2,487.66
F-A37-060	2,500	2,480.76
F-A39-007	2,500	2,445.00
F-A39-005	2,500	2,444.60
F-A37-045	2,500	2,440.45
F-A37-048	2,500	2,438.49
F-A14-092	2,500	2,438.76
F-A37-056	2,500	2,432.47
F-A37-041	2,500	2,429.72
F-A37-051	2,500	2,418.03

WEST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - RESIDENTIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-A37-047	2,500	2,404.90
F-A37-052	2,500	2,389.71
F-A14-088	2,500	2,394.19
F-A37-036	2,500	2,386.53
F-A37-046	2,500	2,379.65
F-A37-053	2,500	2,375.45
F-A37-049	2,500	2,371.92
F-A37-062	2,500	2,362.57
F-A37-050	2,500	2,356.36
F-A37-059	2,500	2,347.26
F-A37-044	2,500	2,343.70
F-A37-042	2,500	2,343.20
F-A36-026	2,500	2,345.94
F-A37-055	2,500	2,331.24
F-A37-043	2,500	2,323.19
F-A37-054	2,500	2,313.12
F-A37-057	2,500	2,303.98
F-A37-058	2,500	2,286.63
F-A14-062	2,500	2,178.34
F-A4-079	2,500	2,071.92
F-A5-017	2,500	1,998.54
F-A39-006	2,500	1,977.80
F-A5-003	2,500	1,807.50
F-A5-002	2,500	1,749.74
F-A15-023	2,500	1,848.14
F-A8-066	2,500	1,721.67
F-A8-011	2,500	1,697.02
F-A36-048	2,500	1,769.18
F-A8-004	2,500	1,682.76
F-A5-018	2,500	1,624.10
F-A8-006	2,500	1,644.08
F-A4-010	2,500	1,634.38
F-A4-009	2,500	1,635.42
F-A8-007	2,500	1,617.61
F-A8-005	2,500	1,591.70
F-A8-010	2,500	1,532.14
F-A4-008	2,500	1,490.86
F-A4-007	2,500	1,479.63
F-A8-009	2,500	1,443.64
F-A5-024	2,500	1,402.12
F-A5-023	2,500	1,346.08
F-A8-008	2,500	1,334.32
F-A5-019	2,500	1,318.98
F-A37-061	2,500	1,390.45
F-A5-015	2,500	1,215.11

WEST BANK

HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - RESIDENTIAL (CONT'D)

FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)
F-A5-014	2,500	1,197.47
F-A5-016	2,500	1,163.43
F-A5-001	2,500	1,191.52
F-A5-020	2,500	1,211.34
F-A5-004	2,500	1,086.33
F-A5-010	2,500	990.10
F-A5-013	2,500	996.31
F-A5-009	2,500	986.86
F-A5-005	2,500	953.30
F-A5-011	2,500	937.18
F-A5-012	2,500	932.02
F-A5-008	2,500	922.18
F-A5-006	2,500	907.23
F-A5-007	2,500	895.57

Wetland (0 hydrants)

Recreation (5 hydrants)

Criteria: 1,000 gpm @ 20 psi
2 hr flow

Statistics:

Flow (gpm)	# Hydrants
750-1000	4
500-750	1
Total (< 1,000)	5

FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)
F-A8-022	1,000	941.77
F-A48-012	1,000	834.48
F-A8-021	1,000	829.23
F-A10-053	1,000	800.85

WEST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - RESIDENTIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-A8-020	1,000	719.78

WEST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND COMMERCIAL		
Commercial (54 hydrants)		
Criteria:	3,000 gpm 3 hr flow	@ 20 psi
Statistics:	Flow (gpm)	# Hydrants
	2500-3000	13
	2000-2500	17
	1500-2000	12
	1500-1000	11
	500-1000	1
	Total (< 3,000)	54

FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)
F-A23-051	3,000	2,984.18
F-A36-012	3,000	2,931.81
F-A13-067	3,000	2,921.83
F-A36-011	3,000	2,880.66
F-A4-023	3,000	2,824.95
F-A4-045	3,000	2,775.15
F-A21-048	3,000	2,692.30
F-A23-036	3,000	2,687.10
F-A11-065	3,000	2,651.98
F-A23-035	3,000	2,623.63
F-A13-055	3,000	2,573.93
F-A15-025	3,000	2,577.63
F-A10-012	3,000	2,514.95
F-A13-051	3,000	2,487.52
F-A19-051	3,000	2,498.04
F-A12A-032	3,000	2,490.49
F-A7-030	3,000	2,448.13
F-A22-032	3,000	2,387.77
F-A1-046	3,000	2,366.17
F-A21-053	3,000	2,372.34
F-A11-001	3,000	2,317.87
F-A36-049	3,000	2,259.86
F-A19-049	3,000	2,264.13
F-A8-026	3,000	2,250.19
F-A15-024	3,000	2,255.70
F-A19-050	3,000	2,210.63
F-A15-038	3,000	2,131.20
F-A18-048	3,000	2,082.01
F-A21-054	3,000	2,026.17
F-A15-033	3,000	2,034.22
F-A10-013	3,000	1,969.78
F-A8-017	3,000	1,958.53
F-A1-006	3,000	1,918.21

WEST BANK

HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND COMMERCIAL (CONT'D)

FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)
F-A8A-013	3,000	1,948.70
F-A18-049	3,000	1,896.88
F-A1-007	3,000	1,825.47
F-A2-005	3,000	1,828.38
F-A1-041	3,000	1,718.20
F-A1-048	3,000	1,735.22
F-A19-047	3,000	1,736.21
F-A8-014	3,000	1,604.31
F-A11-002	3,000	1,550.64
F-A2-004	3,000	1,471.48
F-A8-013	3,000	1,414.80
F-A8-019	3,000	1,389.37
F-A8-015	3,000	1,353.60
F-A15-022	3,000	1,347.98
F-A5-027	3,000	1,155.86
F-A8A-019	3,000	1,163.67
F-A5-021	3,000	1,095.42
F-A5-025	3,000	1,092.94
F-A8A-020	3,000	1,124.22
F-A5-026	3,000	1,053.08
F-A5-022	3,000	913.08

Residential/ Commercial (75 hydrants)

Criteria: 3,000 gpm @ 20 psi
3 hr flow

Statistics:

Flow (gpm)	# Hydrants
2500-3000	15
2000-2500	18
1500-2000	25
1500-1000	11
500-1000	6
Total (< 3,000)	75

FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)
F-A1-077	3,000	2,949.36
F-A2-002	3,000	2,920.81
F-A2-020	3,000	2,851.14
F-A1-021	3,000	2,794.28
F-A3-080	3,000	2,774.93
F-A1-060	3,000	2,779.57
F-A2-055	3,000	2,736.46
F-A2-052	3,000	2,712.74
F-A1-078	3,000	2,654.98
F-A2-028	3,000	2,589.15
F-A3-047	3,000	2,567.57
F-A3-076	3,000	2,517.46
F-A4-046	3,000	2,532.91
F-A2-018	3,000	2,515.14
F-A4-069	3,000	2,504.17
F-A3-068	3,000	2,433.44
F-A2-053	3,000	2,420.18
F-A1-001	3,000	2,416.29
F-A3-057	3,000	2,382.55
F-A1-086	3,000	2,370.80

WEST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND COMMERCIAL (CONT'D)		
FF Hydrant ID	**FF Demand (gpm)**	**Available Flow to Hydrant @ 20 psi (gpm)**
F-A2-025	3,000	2,395.29
F-A3-052	3,000	2,274.23
F-A2-026	3,000	2,308.46
F-A1-036	3,000	2,229.92
F-A1-045	3,000	2,237.11
F-A3-053	3,000	2,180.14
F-A2-054	3,000	2,193.13
F-A2-027	3,000	2,202.68
F-A1-080	3,000	2,087.08
F-A1-059	3,000	2,051.57
F-A4-068	3,000	2,013.05
F-A1-003	3,000	1,988.07
F-A4-075	3,000	2,002.21
F-A4-037	3,000	2,001.46
F-A1-040	3,000	1,951.43
F-A1-022	3,000	1,892.34
F-A4-066	3,000	1,953.92
F-A2-019	3,000	1,932.34
F-A3-037	3,000	1,891.39
F-A2-031	3,000	1,895.38
F-A3-051	3,000	1,829.92
F-A2-016	3,000	1,825.57
F-A1-037	3,000	1,794.79
F-A1-043	3,000	1,789.31
F-A1-039	3,000	1,731.46
F-A2-032	3,000	1,766.92
F-A1-055	3,000	1,723.00
F-A1-038	3,000	1,693.86
F-A1-023	3,000	1,641.28
F-A3-058	3,000	1,620.02
F-A1-061	3,000	1,607.03
F-A1-084	3,000	1,598.21
F-A1-062	3,000	1,576.79
F-A4-058	3,000	1,596.98
F-A1-082	3,000	1,540.25
F-A1-056	3,000	1,558.93
F-A3-046	3,000	1,573.90
F-A1-020	3,000	1,457.64
F-A2-001	3,000	1,504.89
F-A1-005	3,000	1,453.00
F-A4-067	3,000	1,460.70
F-A2-049	3,000	1,448.35
F-A3-072	3,000	1,298.37
F-A1-004	3,000	1,158.35
F-A1-017	3,000	1,133.02
F-A2-048	3,001	1,161.78
F-A1-083	3,000	1,055.85
F-A4-038	3,000	1,072.99
F-A3-087	3,000	1,039.24
F-A3-073	3,000	838.43
F-A2-029	3,000	827.49
F-A4-053	3,000	854.93
F-A4-039	3,000	760.91
F-A3-074	3,000	655.61
F-A1-044	3,000	567.50

HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INDUSTRIAL

Industrial (36 Hydrants)

Criteria: 4,000 gpm @ 20 psi
4 hr flow

Statistics:

Flow (gpm)	# Hydrants
3500-4000	0
3000-3500	8
2500-3000	8
2000-2500	4
1500-2000	4
1000-1500	4
500-1000	8
Total (<5,000)	36

FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)	Upstream Pipes Failing to Supply AVG MDD +FF Demand	
			Pipe Recno	Pipe Diameter (in)
F-A1-047	4,000	3,494.49	108466	8
F-A2-013	4,000	3,420.81	105845	8
F-A36B-003	4,000	3,362.54	102452	8
F-A1-008	4,000	3,378.76	108237	8
F-A36A-001	4,000	3,210.30	102449	12
F-A36A-002	4,000	3,196.37	102456	12
F-A3-064	4,000	3,042.95	103643	8
F-A36A-003	4,000	2,996.27	102460	12
F-A3-063	4,000	3,009.45	103647	6
F-A3-015	4,000	2,803.72	103740	8
F-A3-040	4,000	2,708.73	103727	8
F-A4-049	4,000	2,788.52	101797	6
F-A36B-002	4,000	2,662.16	102452	8
F-A3-036	4,000	2,582.52	103734	8
F-A3-027	4,000	2,585.94	103736	8
F-A3-041	4,000	2,457.13	103730	8
F-A3-007	4,000	2,494.99	103741	8
F-A3-038	4,000	2,533.16	103525	4
F-A36B-001	4,000	2,287.55	200078	8
F-A3-042	4,000	2,160.71	103546	8
F-A4-050	4,000	1,759.31	101795	6
F-A4-054	4,000	1,640.19	101849	6
F-A1-050	4,000	1,577.31	108351	6
F-A40-001	4,000	1,513.42	101602	8
F-A1-010	4,000	1,485.05	108208	6
F-A1-009	4,000	1,312.14	108418	6
F-A2-023	4,000	1,129.21	200134	6
F-A2-006	4,000	1,039.01	105874	6

WEST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INDUSTRIAL (CONT'D)				
FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)	Upstream Pipes Failing to Supply AVG MDD +FF Demand	
			Pipe Recno	Pipe Diameter (in)
F-A9-003	4,000	900.99	100003	6
F-A2-017	4,000	890.38	200133	6
F-A2-034	4,000	849.97	105885	6
F-A2-007	4,000	836.27	200137	6
F-A2-024	4,000	816.87	200134	6
F-A3-039	4,000	754.65	103707	6
F-A9-002	4,000	703.01	100013	4
F-A2-030	4,000	586.88	105712	6

WEST BANK
HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INSTITUTIONAL

Public (96 Hydrants)

Criteria: 5,000 gpm @ 20 psi
4 hr flow

Statistics:

Flow (gpm)	# Hydrants
4500-5000	7
4000-4500	5
3500-4000	8
3000-3500	12
2500-3000	20
2000-2500	11
1500-2000	14
1000-1500	16
500-1000	3
Total (<5,000)	96

FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)	Upstream Pipes Failing to Supply AVG MDD +FF Demand	
			Pipe Recno	Pipe Diameter (in)
F-A26-034	5,000	4,978.56	104615	6
F-A4-055	5,000	4,853.75	101752	6
F-A33-005	5,000	4,821.77	102977	8
F-A29-011	5,000	4,672.11	103953	6
F-A35-053	5,000	4,572.09	102868	8
F-A4-051	5,000	4,518.58	101730	6
F-A33-006	5,000	4,503.42	102977	8
F-A33-007	5,000	4,307.88	102977	8
F-A21-047	5,000	4,263.44	105560	6
F-A12-008	5,000	4,278.91	107606	6
F-A4-047	5,000	4,180.42	101735	6
F-A30-047	5,000	4,004.75	103348	6
F-A33-012	5,000	3,947.54	102977	8
F-A30-010	5,000	3,841.52	103254	6
F-A17-001	5,000	3,761.89	106753	8
F-A33-011	5,000	3,735.65	102977	8
F-A8A-007	5,000	3,747.54	100063	8
F-A33-013	5,000	3,618.70	102984	12
F-A8A-004	5,000	3,604.65	100055	8
F-A11-010	5,000	3,582.68	107880	6
F-A35-052	5,000	3,459.04	102868	8
F-A33-014	5,000	3,498.53	102992	12
F-A34-004	5,000	3,489.29	102945	12
F-A34-011	5,000	3,409.42	102901	8
F-A11-066	5,000	3,421.25	107889	6
F-A23-026	5,000	3,293.33	105173	6
F-A26-052	5,000	3,234.77	104599	6
F-A8A-008	5,000	3,214.40	200101	8

WEST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INSTITUTIONAL (CONT'D)				
FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)	Upstream Pipes Failing to Supply AVG MDD +FF Demand	
			Pipe Recno	Pipe Diameter (in)
F-A34-003	5,000	3,142.84	102913	8
F-A7-013	5,000	3,027.52	100601	6
F-A4-048	5,000	3,036.98	101714	6
F-A1-052	5,000	2,954.80	108266	6
F-A33-017	5,000	3,020.05	102973	8
F-A17-002	5,000	2,936.88	106753	8
F-A34-002	5,000	2,965.85	102914	8
F-A30-027	5,000	2,892.91	200066	6
F-A33-018	5,000	2,899.02	102976	8
F-A7-012	5,000	2,848.91	100692	6
F-A34-001	5,000	2,875.71	102946	8
F-A33-021	5,000	2,858.90	102947	8
F-A33-019	5,000	2,830.50	102953	8
F-A4-070	5,000	2,828.25	101681	6
F-A33-020	5,000	2,821.38	102949	8
F-A1-085	5,000	2,746.50	108469	6
F-A13-001	5,000	2,695.02	107477	6
F-A30-011	5,000	2,645.81	103448	6
F-A17-027	5,000	2,649.49	106695	6
F-A34-012	5,000	2,706.43	102901	8
F-A17-029	5,000	2,572.01	106700	6
F-A10-044	5,000	2,636.90	108156	6
F-A2-021	5,000	2,628.99	105862	6
F-A33-022	5,000	2,537.90	102962	2
F-A17-003	5,000	2,477.09	200035	8
F-A24-033	5,000	2,473.57	105007	6
F-A17-028	5,000	2,421.14	106699	6
F-A7-014	5,000	2,261.65	100600	6
F-A34-013	5,000	2,316.52	102900	8
F-A4-078	5,000	1,981.90	101987	12
F-A33-023	5,000	2,250.30	102962	2
F-A6-014	5,000	2,067.35	100678	8
F-A7-011	5,000	2,090.09	100465	6
F-A5-028	5,000	1,821.27	100867	6
FR-A33-024	5,000	2,039.45	102962	2
F-A7-015	5,000	1,960.83	100449	6
F-A34-014	5,000	2,045.40	102898	8
F-A14-077	5,000	2,027.79	106930	6
F-A5-031	5,000	1,677.85	102044	6
F-A4-004	5,000	1,658.90	101998	6
F-A34-015	5,000	1,843.04	102898	8
F-A18-051	5,000	1,826.50	106397	6
F-A18-050	5,000	1,821.74	106396	6
F-A5-029	5,000	1,614.58	100873	6
F-A1-058	5,000	1,694.81	108415	6
F-A4-006	5,000	1,537.35	101982	6
F-A34-016	5,000	1,724.55	200073	8
F-A1-057	5,000	1,604.76	108277	6
F-A30-029	5,000	1,591.15	103441	6
F-A1-042	5,000	1,484.93	108269	6
F-A9-009	5,000	1,441.06	100016	6
F-A6-015	5,000	1,383.16	100678	8
F-A5-030	5,000	1,315.90	102043	6
F-A4-001	5,000	1,290.02	102009	6
F-A19-054	5,000	1,353.44	105685	2
F-A2-033	5,000	1,258.09	105883	6

WEST BANK HYDRANTS FAILING TO SUPPLY REQUIRED FIRE-FLOW DEMAND - INSTITUTIONAL (CONT'D)				
FF Hydrant ID	FF Demand (gpm)	Available Flow to Hydrant @ 20 psi (gpm)	Upstream Pipes Failing to Supply AVG MDD +FF Demand	
			Pipe Recno	Pipe Diameter (in)
F-A6-001	5,000	1,234.62	100671	6
F-A6-016	5,000	1,186.53	100678	8
F-A4-052	5,000	1,243.62	101790	6
F-A21-040	5,000	1,115.71	106769	6
F-A1-019	5,000	1,077.88	108371	6
F-A19-055	5,000	1,142.59	105685	2
F-A1-018	5,000	954.12	108435	6
F-A24-011	5,000	1,028.14	105061	6
F-A6-002	5,000	1,021.14	100669	6
F-A4-021	5,000	1,015.37	101903	6
F-A24-010	5,000	952.75	105062	6
F-A6-005	5,000	852.06	100668	6

Pipe Velocity Criteria

Velocity Criteria

East Bank

Velocity	Count	Percent %
≤2.5 fps	17124	99.0%
> 5 fps	33	0.2%
Total	***17303***	***99.2%***

Minimum Velocity	Count	Maximum Velocity	Count
0-2	16990	0	10895
2.1	31	1	5361
2.2	36	2	703
2.3	26	3	228
2.4	25	4	68
2.5	16	5	15
2.6	24	6	14
2.7	22	7	2
2.8	17	8	5
2.9	4	9	4
3.0	12	10	2
3.1	11	11	2
3.2	7	12	1
3.3	13	13	2
3.4	15	17	1
3.6	7	**Total**	**17303**
3.8	2		
3.9	2		
4.0	3		
4.1	1		
4.2	1		
4.3	4		
4.5	1		
4.8	1		
4.9	1		
5.1	11		
5.4	2		
5.5	1		
6.1	1		
6.6	3		
7.0	1		
7.1	2		
7.2	1		
7.8	1		
8.4	1		
9.0	1		
9.1	1		
9.4	1		
10.7	1		
11.2	1		
11.5	1		
15.3	1		
Total	**17303**		

West Bank

Velocity	Count	Percent %
≤2.5 fps	2624	99.9%
> 5 fps	3	0.1%
Total	***2627***	***100.0%***

Minimum Velocity	Count	Maximum Velocity	Count
0.0	862	0.0	537
0.1	615	0.1	440
0.2	369	0.2	309
0.3	254	0.3	319
0.4	151	0.4	192
0.5	122	0.5	173
0.6	67	0.6	103
0.7	40	0.7	108
0.8	49	0.8	89
0.9	34	0.9	58
1.0	12	1.0	54
1.1	13	1.1	35
1.2	8	1.2	30
1.3	4	1.3	33
1.4	10	1.4	29
1.5	4	1.5	13
1.6	2	1.6	27
1.8	2	1.7	15
2.0	2	1.8	12
2.1	2	1.9	10
2.3	2	2.0	7
3.8	1	2.1	2
4.5	1	2.2	3
6.1	1	2.3	2
Total	**2627**	2.4	3
		2.5	3
		2.6	1
		2.7	1
		2.8	6
		2.9	1
		3.0	2
		3.2	1
		3.5	2
		4.1	2
		4.2	2
		5.8	1
		7.5	1
		7.6	1
		Total	**2627**

Pipe Headloss Criteria

Headloss Criteria

East Bank

Head Loss Diameter <16"	Count	Percent %
≤10 ft/1000 ft	15666	99.4%
> 10 ft/1000 ft	97	0.6%
Total	***15763***	***100.0%***
Diameter ≥16"		
≤3 ft/1000 ft	1494	97.0%
> 3 ft/1000 ft	46	3.0%
Total	***1540***	***100.0%***
Total Pipes	**17303**	

West Bank

Head Loss Diameter <16"	Count	Percent %
≤10 ft/1000 ft	2366	99.7%
> 10 ft/1000 ft	8	0.3%
Total	***2374***	***100.0%***
Diameter ≥16"		
≤3 ft/1000 ft	252	99.6%
> 3 ft/1000 ft	1	0.4%
Total	***253***	***100.0%***
Total Pipes	**2627**	

East Bank

Diameter < 16"		Diameter ≥16"	
Maximum Headloss	**Count**	**Maximum Headloss**	**Count**
0-10	15666	0	948
11	13	1	386
12	6	2	137
13	6	3	23
14	8	4	21
15	7	5	10
16	5	7	3
17	2	9	2
18	2	13	1
20	1	14	1
21	4	15	1
22	2	16	2
23	6	18	1
24	3	23	1
25	4	33	1
28	1	40	1
29	1	52	1
30	1	**Total**	**1540**
31	2		
33	1		
34	3		
36	2		
37	2		
41	1		
46	1		
48	1		
53	1		

West Bank

Diameter < 16"		Diameter ≥16"	
Maximum Headloss	**Count**	**Maximum Headloss**	**Count**
0	2022	0	215
1	251	1	27
2	56	2	10
3	11	28	1
4	7	**Total**	**253**
5	10		
6	5		
7	1		
9	1		
10	2		
11	2		
12	2		
18	1		
21	1		
37	1		
49	1		
Total	**2374**		

Headloss Criteria

East Bank

Diameter < 16"		Diameter ≥16"	
Maximum Headloss	**Count**	**Maximum Headloss**	**Count**
56	2		
57	1		
58	1		
59	2		
69	1		
73	1		
222	1		
412	1		
592	1		
Total	**15763**		

West Bank

Diameter < 16"		Diameter ≥16"	
Maximum Headloss	**Count**	**Maximum Headloss**	**Count**

System Reliability Criteria

Hydrant Spacing
Maximum Spacing Criteria = 350 feet

East Bank			
Hydrant Spacing (ft)	**Number of Hydrants**	**Percent of Total (%)**	**Estimated # of Hydrants Required**
≤350	16,408	60%	8,524
≤500	13,819	51%	1,351
≤700	5,960	22%	375
Total	**27,331**	**100%**	-

West Bank			
Hydrant Spacing (ft)	**Number of Hydrants**	**Percent of Total (%)**	**Estimated # of Hydrants Required**
≤350	2,522	62%	1,346
≤500	2,056	51%	334
≤700	892	22%	107
Total	**4,049**	**100%**	-

Valve Spacing
Maximum Spacing Critiera = 1,000 feet

East Bank	
Valve Spacing (ft)	**Number of Valves**
0 - 1000	34,809
1001 - 2000	9,345
2001 - 3000	1,099
3001 - 4000	225
4001 - 5000	77
5001 - 6000	60
6001 - 7000	30
7001 - 8000	21
8001 - 9000	28
9001 - 10000	27
10001 - 11000	9
11001 - 12000	43
12001 - 13000	55
13001 - 14000	77
14001 - 15000	22
15001 - 16000	-
16001 - 17000	5
17001 - 18000	1
18001 - 19000	8
23001 - 24000	2
24001 - 25000	4
Total	**45,947**
Valves Exceeding Criteria	**11,138**
% Exceeding Critieria	**24%**
Estimated # of Valves Required	**16,535**

West Bank	
Valve Spacing (ft)	**Number of Valves**
0 - 1000	3,685
1001 - 2000	1,146
2001 - 3000	213
3001 - 4000	40
4001 - 5000	23
5001 - 6000	8
6001 - 7000	4
7001 - 8000	1
Total	**5,120**
Valves Exceeding Criteria	**1,435**
% Exceeding Critieria	**28%**
Estimated # of Valves Required	**1,855**

Appendix G

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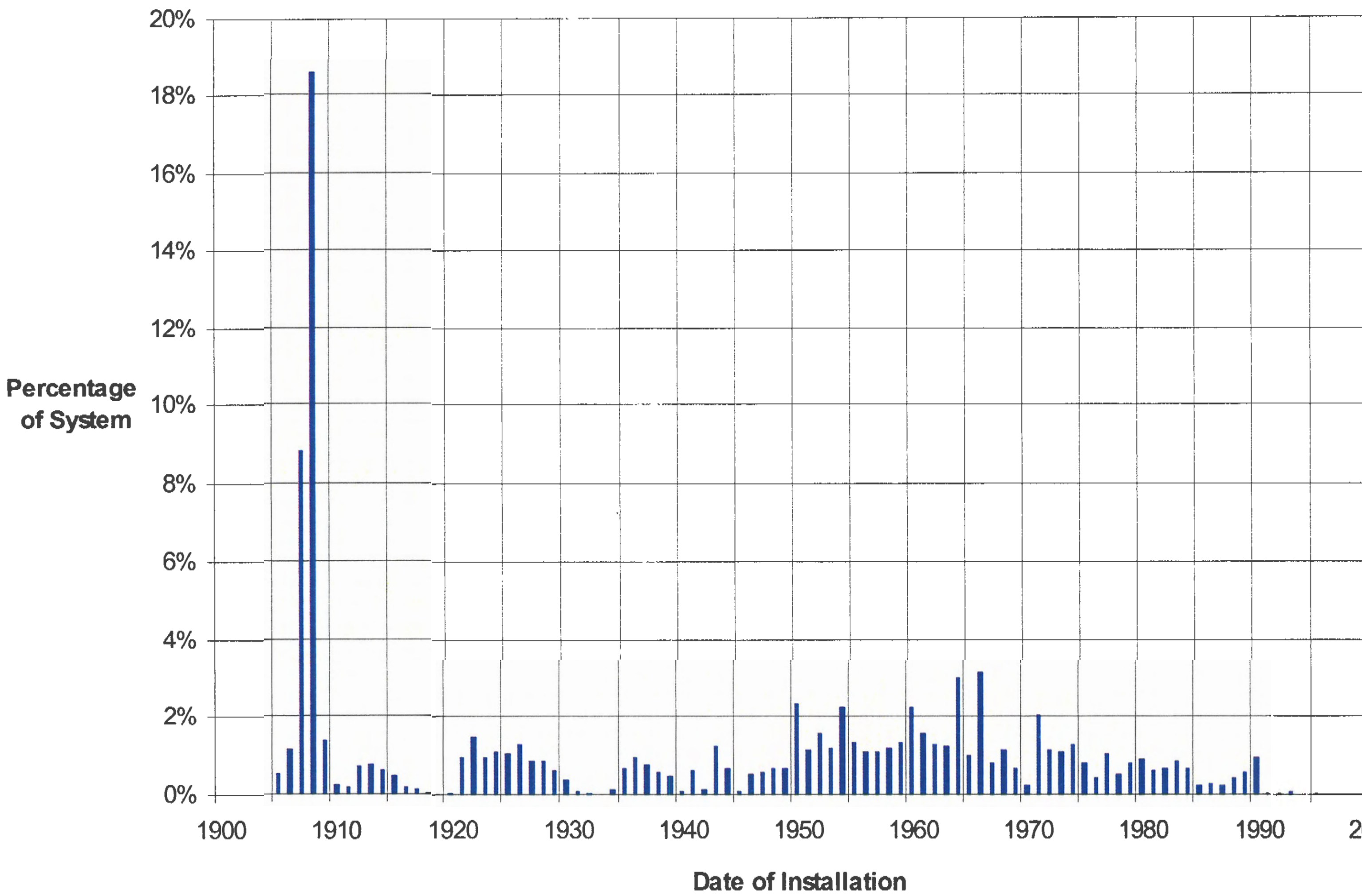
Appendix G – Results of KANEW Analysis

APPENDIX G

Summary of Distribution System by Installation Date



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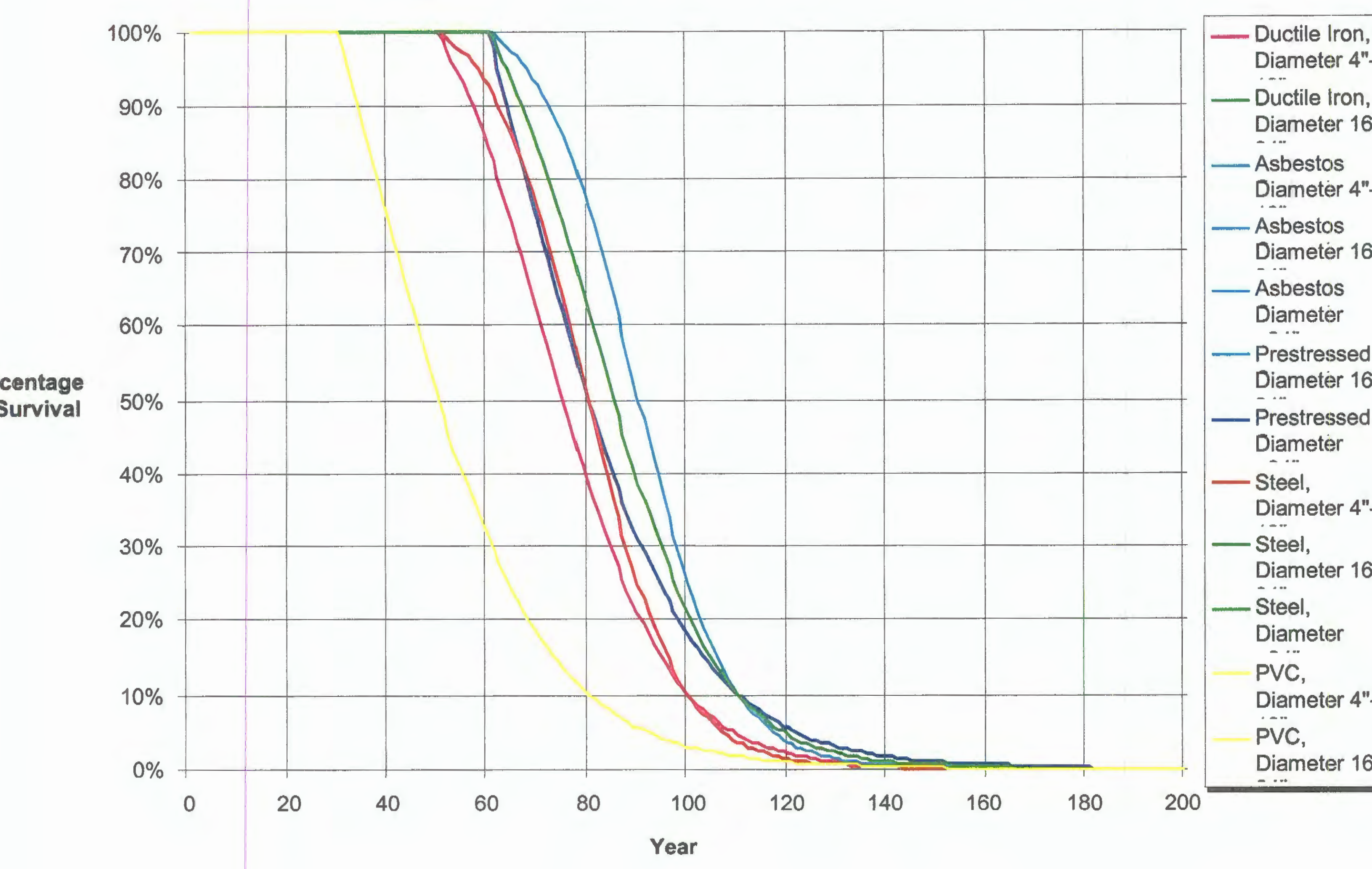
APPENDIX G

Water Main Survival Curve Long Life Expectancies
Mixed Material Categories



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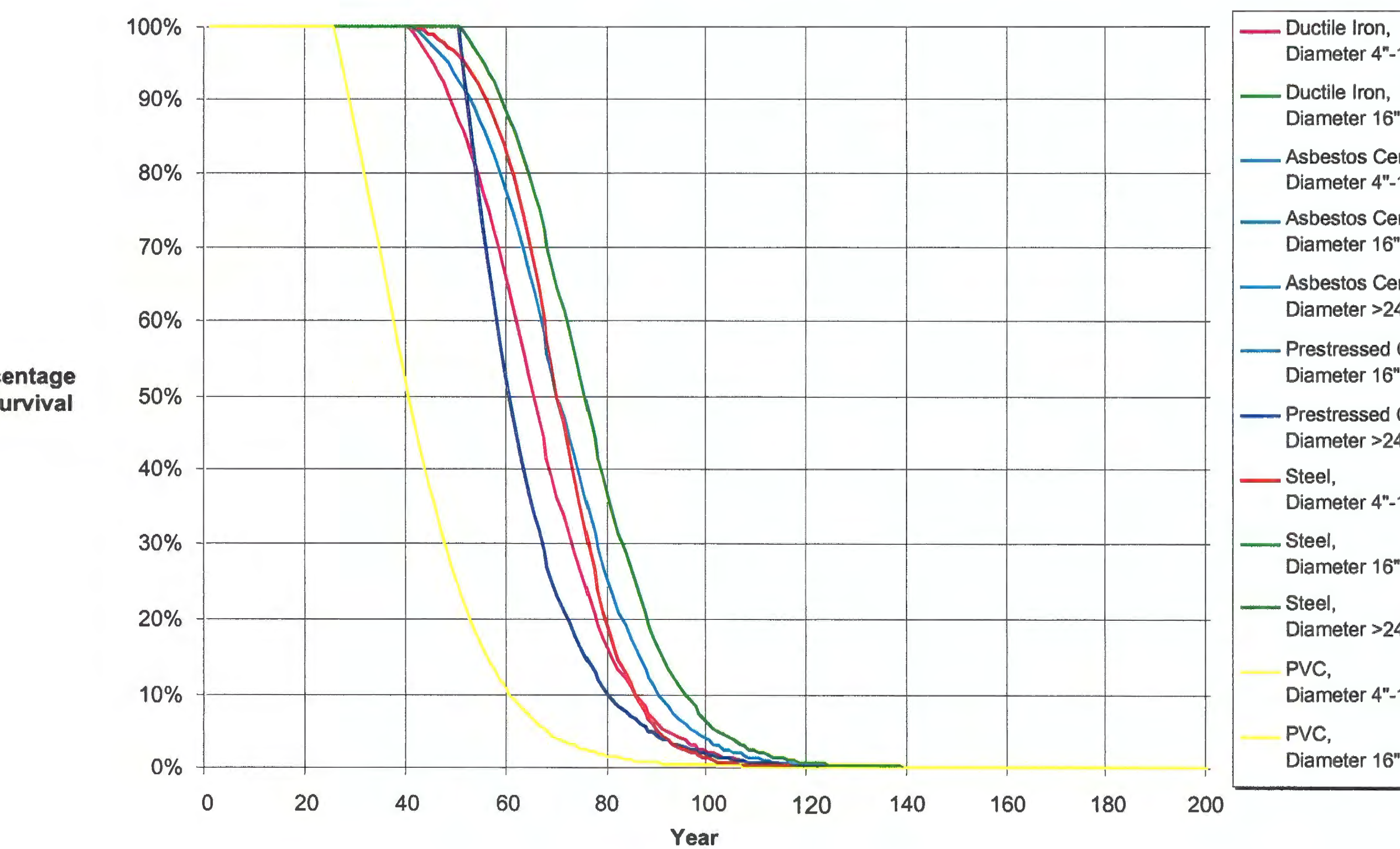
APPENDIX G

Water Main Survival Curve Short Life Expectancies
Mixed Material Categories



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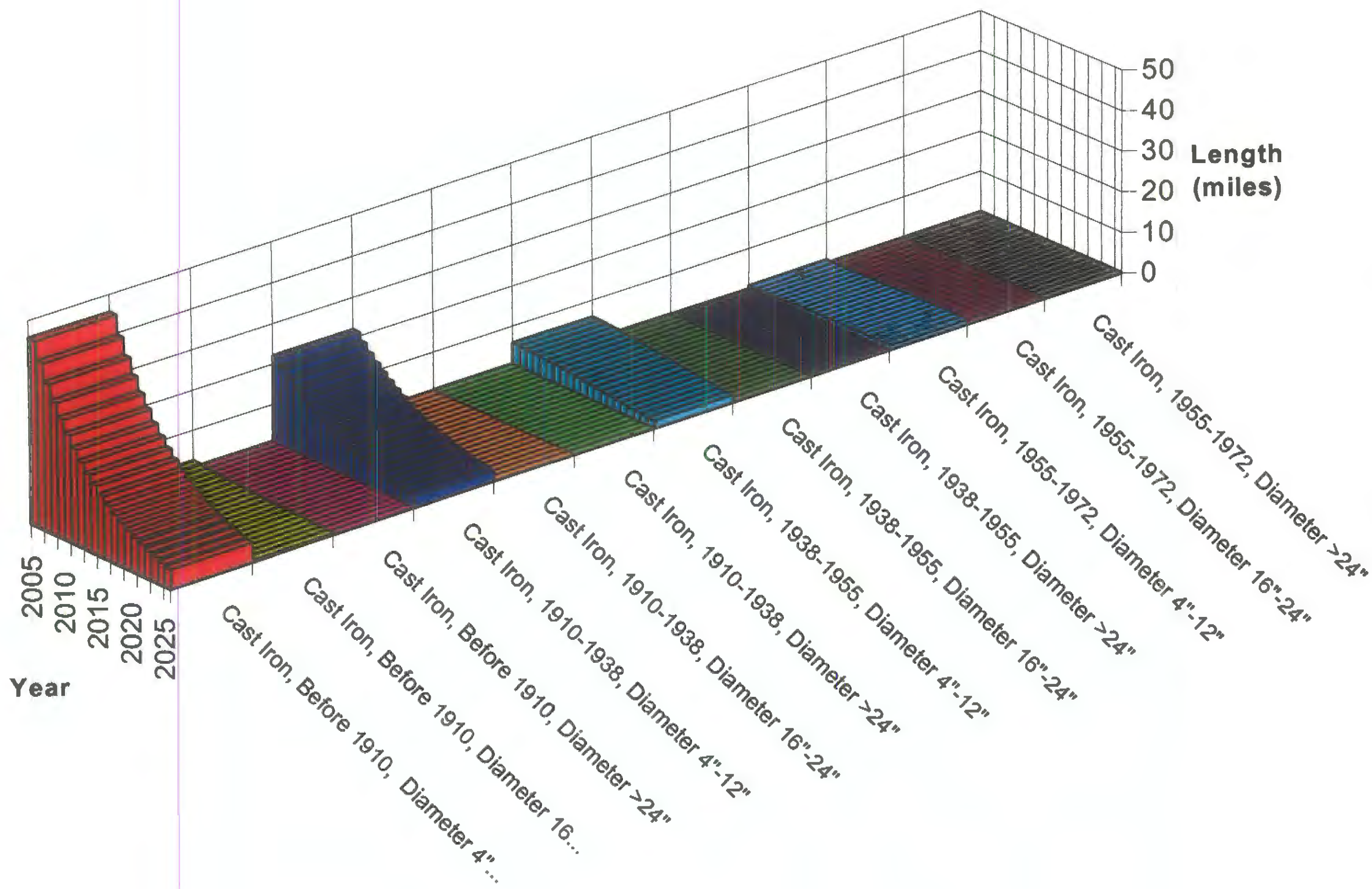
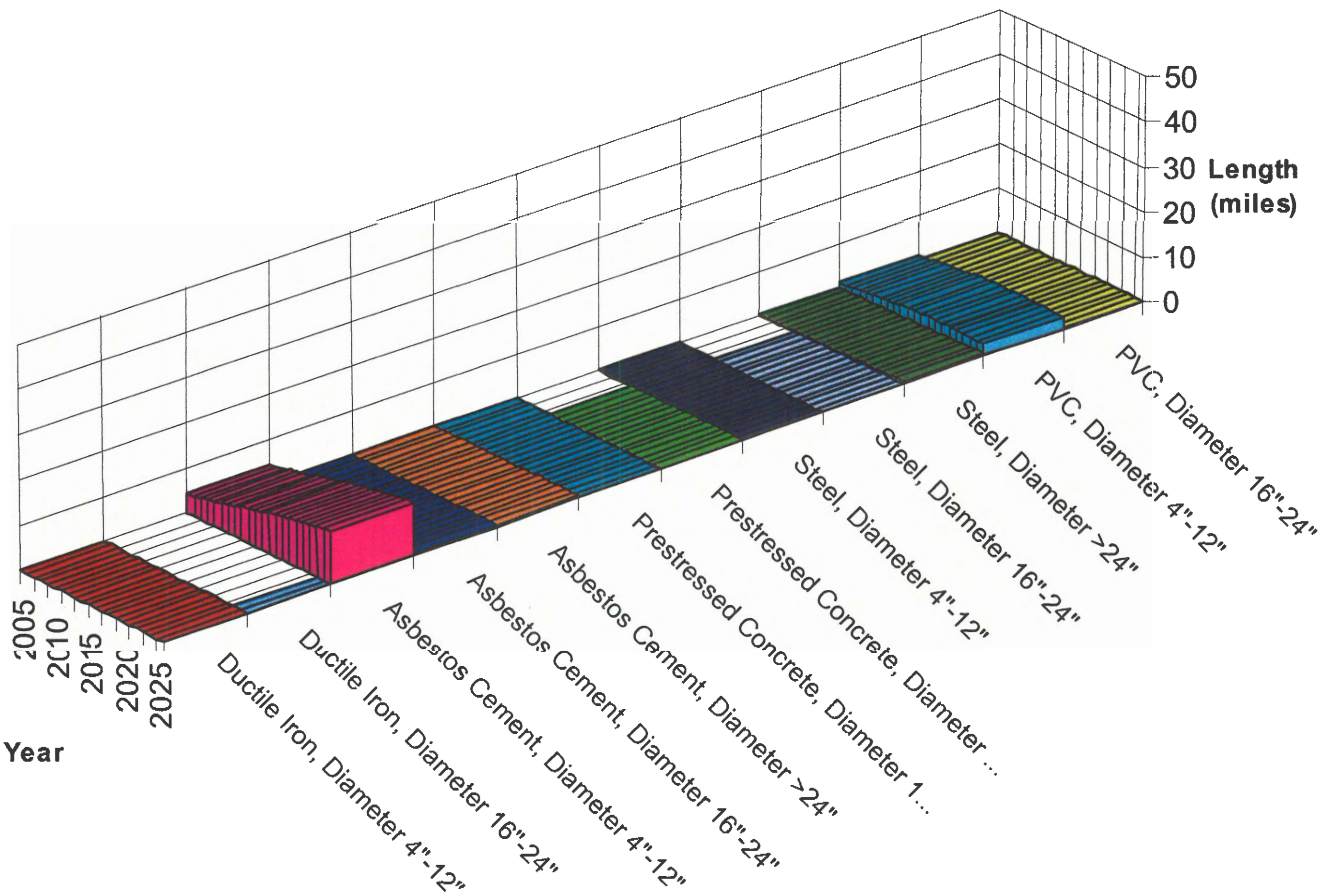
APPENDIX G

Water Main Replacement Length Based on Short Life Expectancy Cast Iron Categories



APPENDIX G

Water Main Replacement Length Based on Short Life Expectancy
Mixed Material Categories



Appendix H

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Appendix H – Capital Improvement Projects

Leakage Management Projects

Pilot DMAs Cost Estimate Breakdown

Location	Equipment and Materials	Unit Cost	Quantity	Total Cost
Pilot DMA 1: East Bank District 16	Insertion Meter with portable data logger	$4,000	3	$12,000
	Precast Concrete Manhole - 30" Diameter Pipe	$10,000	3	$30,000
	2-Inch Hot Tap - 30" Diameter Pipe	$1,500	3	$5,000
	Site Preparation and Restoration	$5,000	3	$15,000
	Boundary Valve Replacement/Repair[1]	$10,000	28	$280,000
			Subtotal	**$342,000**
Pilot DMA 2: East Bank District 18	Insertion Meter with portable data logger	$4,000	5	$20,000
	Precast Concrete Manhole - 30" Diameter Pipe	$10,000	3	$30,000
	Precast Concrete Manhole - 20" or less Diameter Pipe	$8,000	2	$16,000
	2-Inch Hot Tap - 30" Diameter Pipe	$1,500	3	$5,000
	2-Inch Hot Tap - 20" Diameter Pipe	$1,000	2	$2,000
	Site Preparation and Restoration	$5,000	5	$25,000
	Boundary Valve Replacement/Repair[1]	$10,000	34	$340,000
			Subtotal	**$438,000**
Pilot DMA 3: East Bank District 32	Insertion Meter with portable data logger	$4,000	1	$4,000
	Precast Concrete Manhole - 30" Diameter Pipe	$10,000	1	$10,000
	2-Inch Hot Tap - 30" Diameter Pipe	$1,500	1	$2,000
	Site Preparation and Restoration	$5,000	1	$5,000
			Subtotal	**$21,000**
Pilot DMA 4: West Bank District 4	Insertion Meter with portable data logger	$4,000	6	$24,000
	Precast Concrete Manhole - 30" Diameter Pipe	$10,000	1	$10,000
	Precast Concrete Manhole - 20" or less Diameter Pipe	$8,000	5	$40,000
	2-Inch Hot Tap - 30" Diameter Pipe	$1,500	1	$2,000
	2-Inch Hot Tap - 20" Diameter Pipe	$1,000	1	$1,000
	2-Inch Hot Tap - 12" Diameter Pipe	$600	4	$3,000
	Site Preparation and Restoration	$5,000	6	$30,000
	Boundary Valve Replacement/Repair[1]	$10,000	3	$30,000
			Subtotal	**$140,000**
Four Pilot DMAs	Construction Cost for Four Pilot DMAs			$941,000
	Construction Contingency (30%)			$285,000
	Design & Engineering Services During Construction (10%)			$95,000
	Construction Management (10%)			$95,000
	Legal and Administrative (1%)			$10,000
	Support from S&WB for Operation of System (1%)			$10,000
			Total	**$1,440,000**

Note:
1 - Assumes 50% of valves will need to be replaced or repaired to stop leakage.

Washout Valve Locations East Bank

Count	Valve ID	Street Name	Pipe Diameter (inches)
1	V-506-014	VINCENT	2
2	V-479-016	REYNES	4
3	V-331-037	FLORIDA	4
4	V-331-036	TREASURE	4
5	V-015-022	PONTCHARTRAIN	4
6	V-083-014	ROBERTSON	4
7	V-445-016	LAW	4
8	V-436-021	JOURDAN	4
9	V-217-019	ALEXANDER	4
10	V-144-031	PRIEUR	4
11	V-143-020	CLAIBORNE	4
12	V-460-036	MARTIN	6
13	V-460-042	MORRISON	6
14	V-459-067	HAYNE	6
15	V-431-026	RANSOM	6
16	V-359-013	UNKNOWN	6
17	V-298-001	UNKNOWN	6
18	V-227-017	CANAL	6
19	V-211-016	CANAL	6
20	V-211-029	FLORIDA	6
21	V-082-029	NASHVILLE	6
22	V-080-022	COLISEUM	6
23	V-076-003	MC KENNA	6
24	V-076-011	MC KENNA	6
25	V-074-015	JOHNSON	6
26	V-073-012	NASHVILLE	6
27	V-046-009	LOWERLINE	6
28	V-456-023	PRIEUR	6
29	V-045-004	LOWERLINE	6
30	V-443-040	ANDRY	6
31	V-439-010	FLORIDA	6
32	V-419-023	ALVAR	6
33	V-363-018	FRANKLIN	6
34	V-311-023	HAVANA	6
35	V-303-002	CLAIBORNE	6
36	V-003-012	OLEANDER	6
37	V-288-010	ESPLANADE	6
38	V-285-007	ESPLANADE	6
39	V-023-007	LEONIDAS	6

Washout Valve Locations East Bank

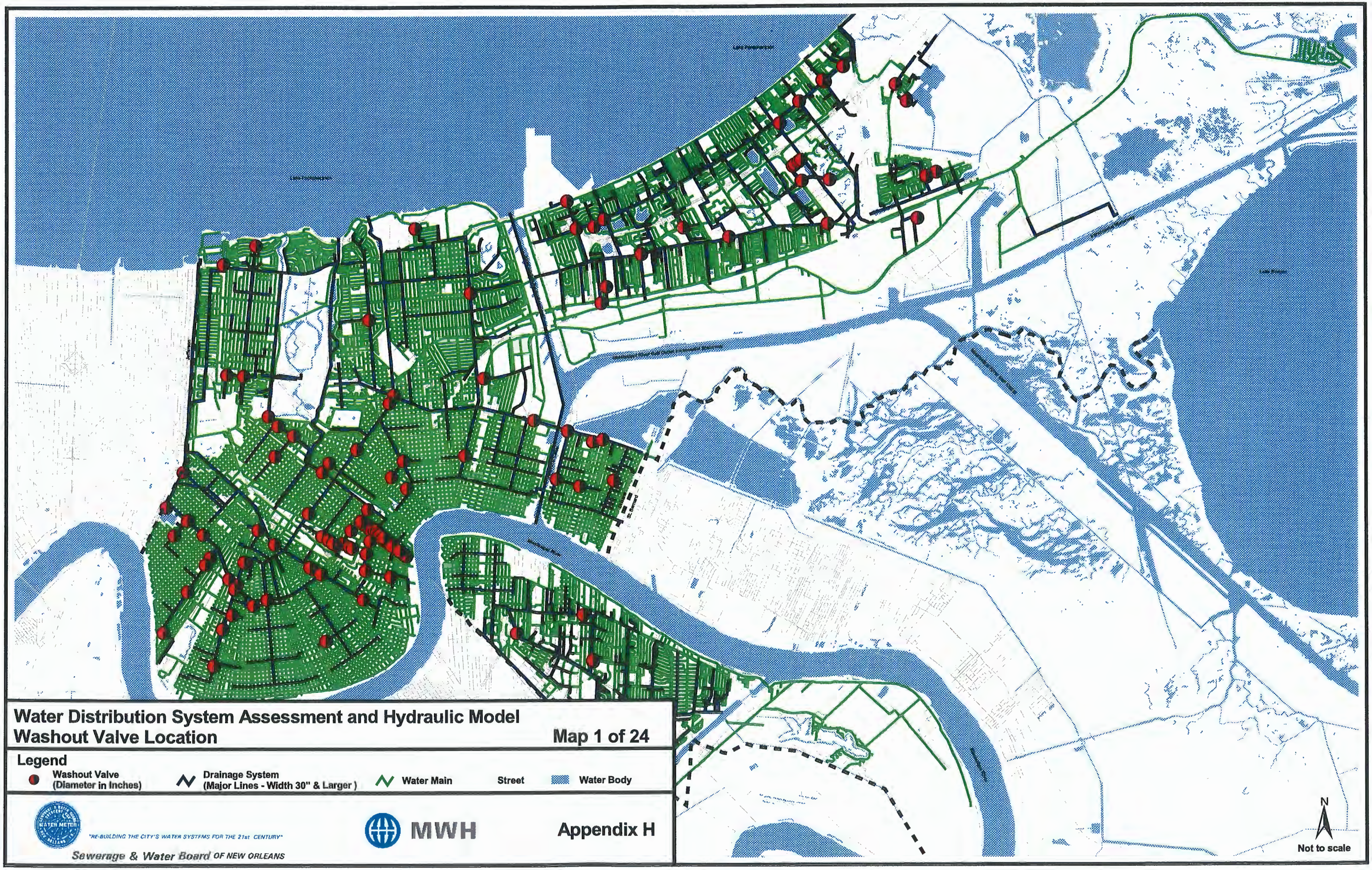
Count	Valve ID	Street Name	Pipe Diameter (inches)
40	V-217-010	ORLEANS	6
41	V-205-008	CARROLLTON	6
42	V-197-025	BASIN	6
43	V-183-007	UNKNOWN	6
44	V-183-028	UNKNOWN	6
45	V-181-011	POYDRAS	6
46	V-181-001	I- 10	6
47	V-180-020	MAGNOLIA	6
48	V-180-017	ROBERTSON	6
49	V-179-038	POYDRAS	6
50	V-179-007	LOYOLA	6
51	V-175-010	UNKNOWN	6
52	V-173-016	JULIA	6
53	V-171-036	MAGAZINE	6
54	V-154-019	MELPOMENE	6
55	V-135-005	JEFFERSON DAVIS	6
56	V-120-006	ST CHARLES	6
57	V-001-009	MONTICELLO	6
58	V-446-013	FLORIDA	6
59	V-284-013	ESPLANADE	6
60	V-184-007	GRAVIER	6
61	V-182-021	UNKNOWN	6
62	V-182-014	BERTRAND	6
63	V-543-019	MICHOUD	8
64	V-511-015	UNKNOWN	8
65	V-510-003	BULLARD	8
66	V-510-017	BULLARD	8
67	V-510-016	UNKNOWN	8
68	V-510-015	UNKNOWN	8
69	V-505-039	UNKNOWN	8
70	V-486-007	UNKNOWN	8
71	V-485-002	DWYER	8
72	V-485-003	UNKNOWN	8
73	V-470-025	UNKNOWN	8
74	V-144-035	MARTIN LUTHER KING J	8
75	V-542-004	UNKNOWN	12
76	V-519-012	EASTOVER	12
77	V-512-002	DWYER	12
78	V-511-014	BULLARD	12

Washout Valve Locations East Bank

Count	Valve ID	Street Name	Pipe Diameter (inches)
79	V-507-039	MORRISON	12
80	V-501-005	POCHE	12
81	V-490-067	GANNON	12
82	V-463-059	DWYER	12
83	V-459-072	MORRISON	12
84	V-388-034	ALMONASTER	12
85	V-372-032	PEOPLES	12
86	V-218-009	ORLEANS	12
87	V-097-012	WILLOW	12
88	V-082-019	LOYOLA	12
89	V-073-020	CLAIBORNE	12
90	V-073-011	NASHVILLE	12
91	V-043-017	LOWERLINE	12
92	V-034-012	CLAIBORNE	12
93	V-269-032	CLAIBORNE	12
94	V-024-026	LEONIDAS	12
95	V-134-015	DUPRE	12
96	V-107-017	CLAIBORNE	12
97	V-508-062	MORRISON	12
98	V-052-012	PRYTANIA	16
99	V-273-026	GAYOSO	20
100	V-273-011	ST LOUIS	20
101	V-173-017	JULIA	20
102	V-517-001	DWYER	30
103	V-025-018	LEONIDAS	43

Washout Valve Locations West Bank

Count	Valve ID	Street Name	Pipe Diameter (inches)
1	V-A8-023	Victory Park	12
2	V-A39-001	HWY 406	6
3	V-A18-029	MACARTHUR	6
4	V-A18-043	MACARTHUR	6
5	V-A14-058	RICHLAND	6



Water Distribution System Assessment and Hydraulic Model
Washout Valve Location

Map 1 of 24

Legend

- Washout Valve (Diameter in Inches)
- Drainage System (Major Lines - Width 30" & Larger)
- Water Main
- Street
- Water Body

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Sewerage & Water Board OF NEW ORLEANS

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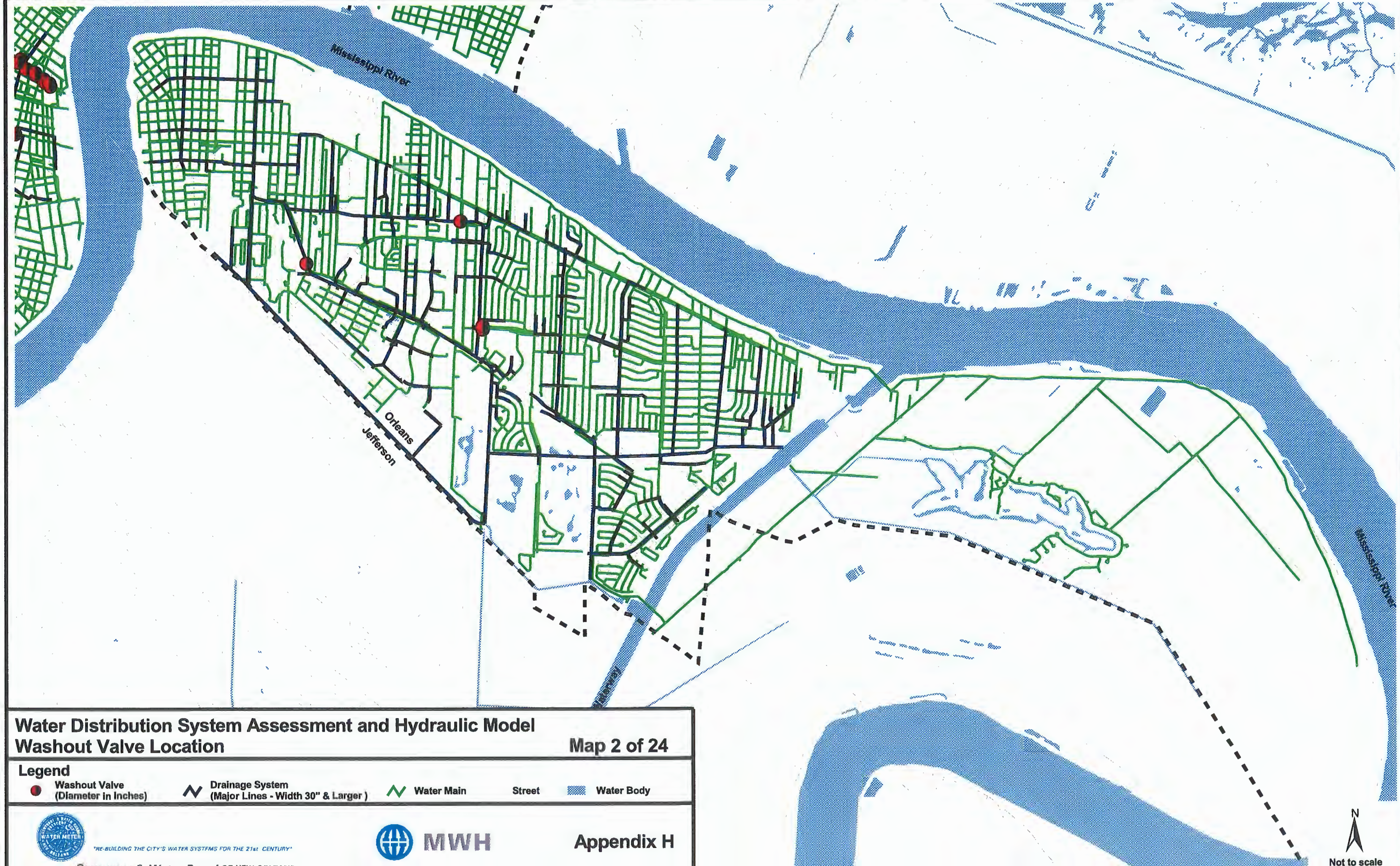
Appendix H



Water Distribution System Assessment and Hydraulic Model
Washout Valve Location

Map 2 of 24

Legend

- Washout Valve (Diameter in Inches)
- Drainage System (Major Lines - Width 30" & Larger)
- Water Main
- Street
- Water Body

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Sewerage & Water Board OF NEW ORLEANS

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Water Distribution System Assessment and Hydraulic Model
Washout Valve Location

Map 3 of 24

Legend

Washout Valve (Diameter in Inches)	Drainage System (Major Lines - Width 30" & Larger)	Water Main	Street	Water Body

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Sewerage & Water Board OF NEW ORLEANS

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Appendix H

Water Distribution System Assessment and Hydraulic Model
Washout Valve Location

Map 4 of 24

Legend

Washout Valve (Diameter in Inches)	Drainage System (Major Lines - Width 30" & Larger)	Water Main	Street	Water Body

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Appendix H

Water Distribution System Assessment and Hydraulic Model
Washout Valve Location

Map 5 of 24

Legend

Washout Valve (Diameter in Inches) | Drainage System (Major Lines - Width 30" & Larger) | Water Main | Street | Water Body

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Sewerage & Water Board OF NEW ORLEANS

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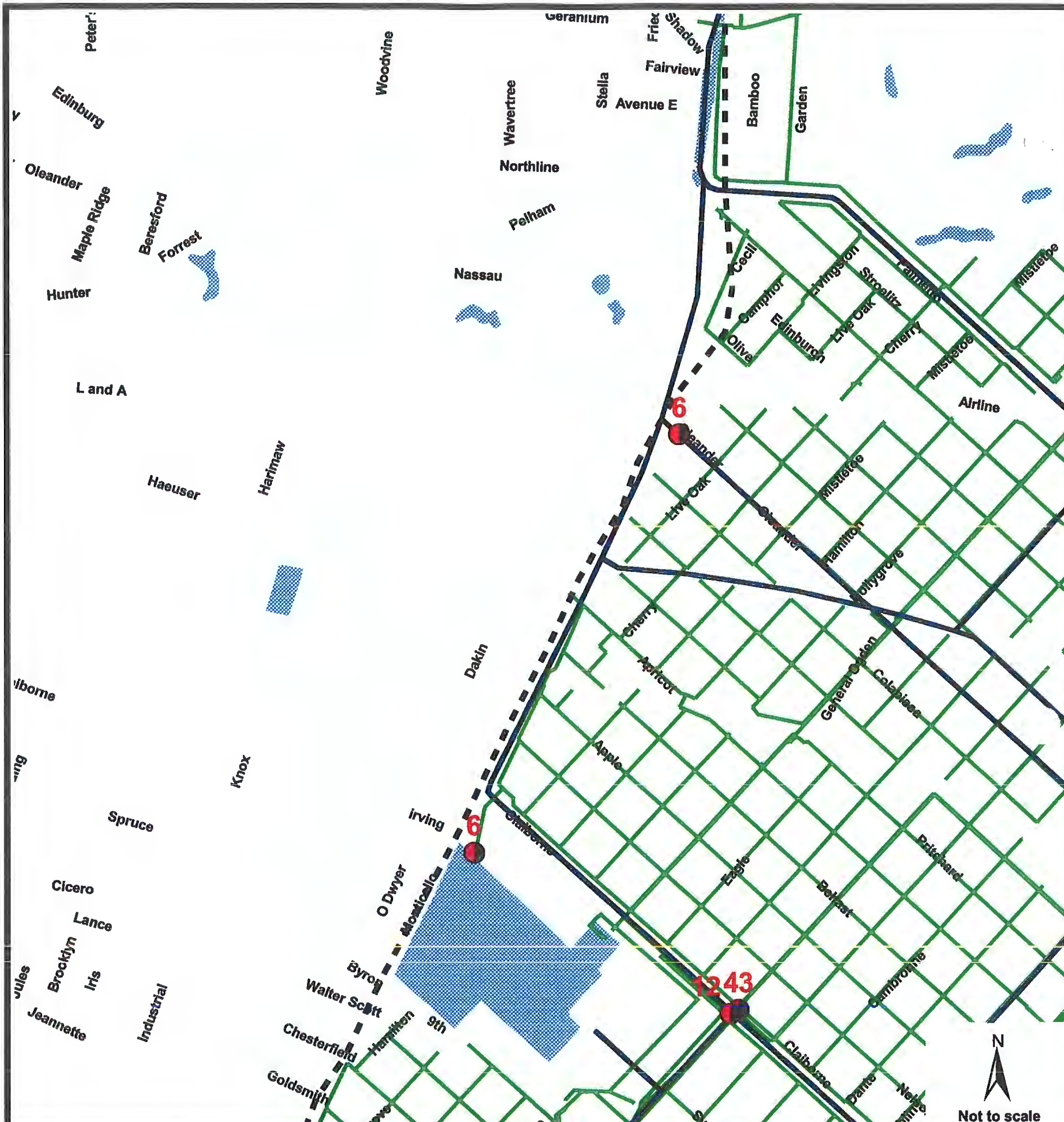

Water Distribution System Assessment and Hydraulic Model
Washout Valve Location

Map 6 of 24

Legend

- Washout Valve (Diameter in Inches)
- Drainage System (Major Lines - Width 30" & Larger)
- Water Main
- Street
- Water Body

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Water Distribution System Assessment and Hydraulic Model
Washout Valve Location

Map 7 of 24

Legend

- Washout Valve (Diameter in Inches)
- Drainage System (Major Lines - Width 30" & Larger)
- Water Main
- Street
- Water Body

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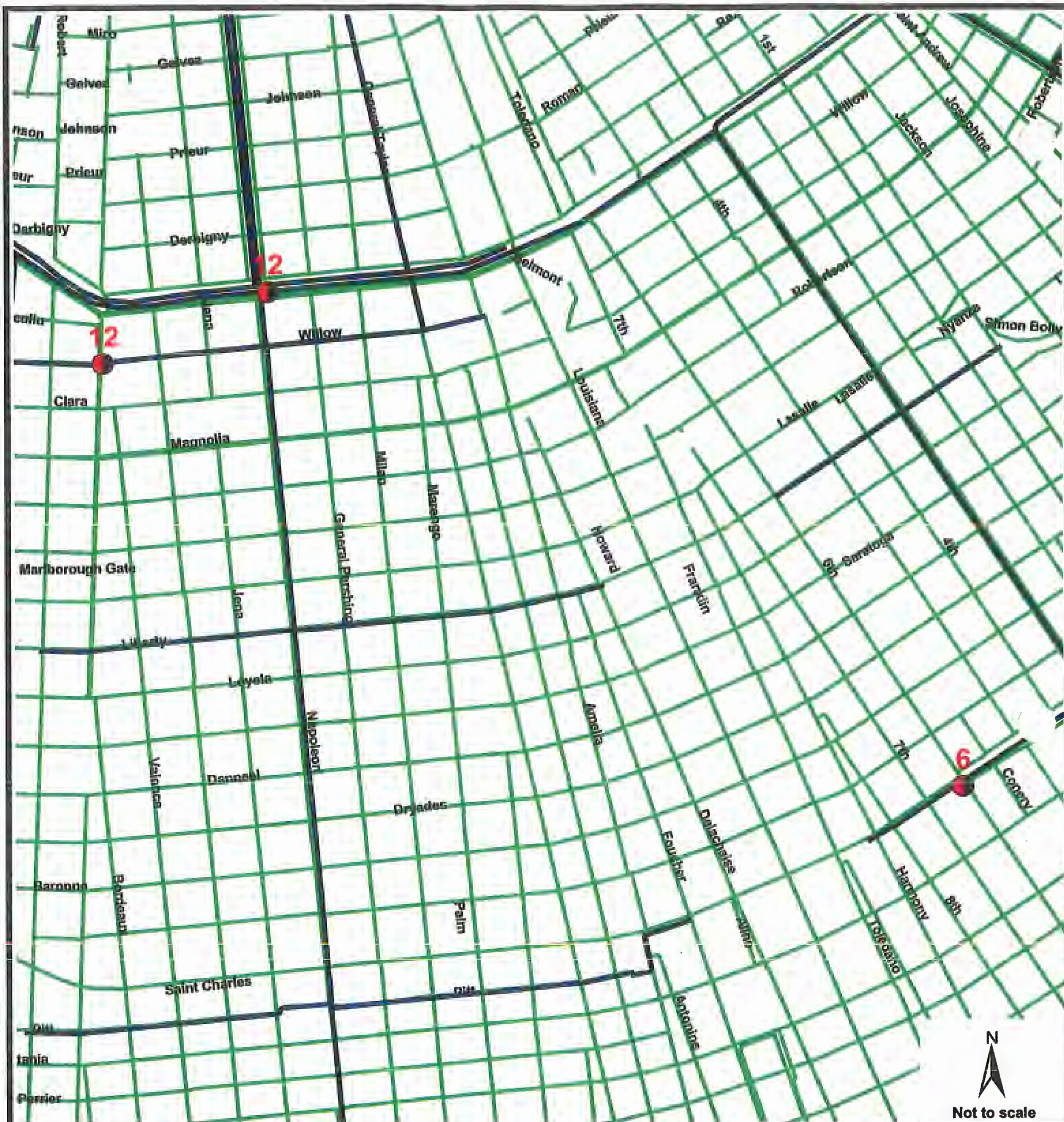

Water Distribution System Assessment and Hydraulic Model

Washout Valve Location

Map 8 of 24

Legend

- Washout Valve (Diameter in Inches)
- Drainage System (Major Lines - Width 30" & Larger)
- Water Main
- Street
- Water Body

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Sewerage & Water Board OF NEW ORLEANS

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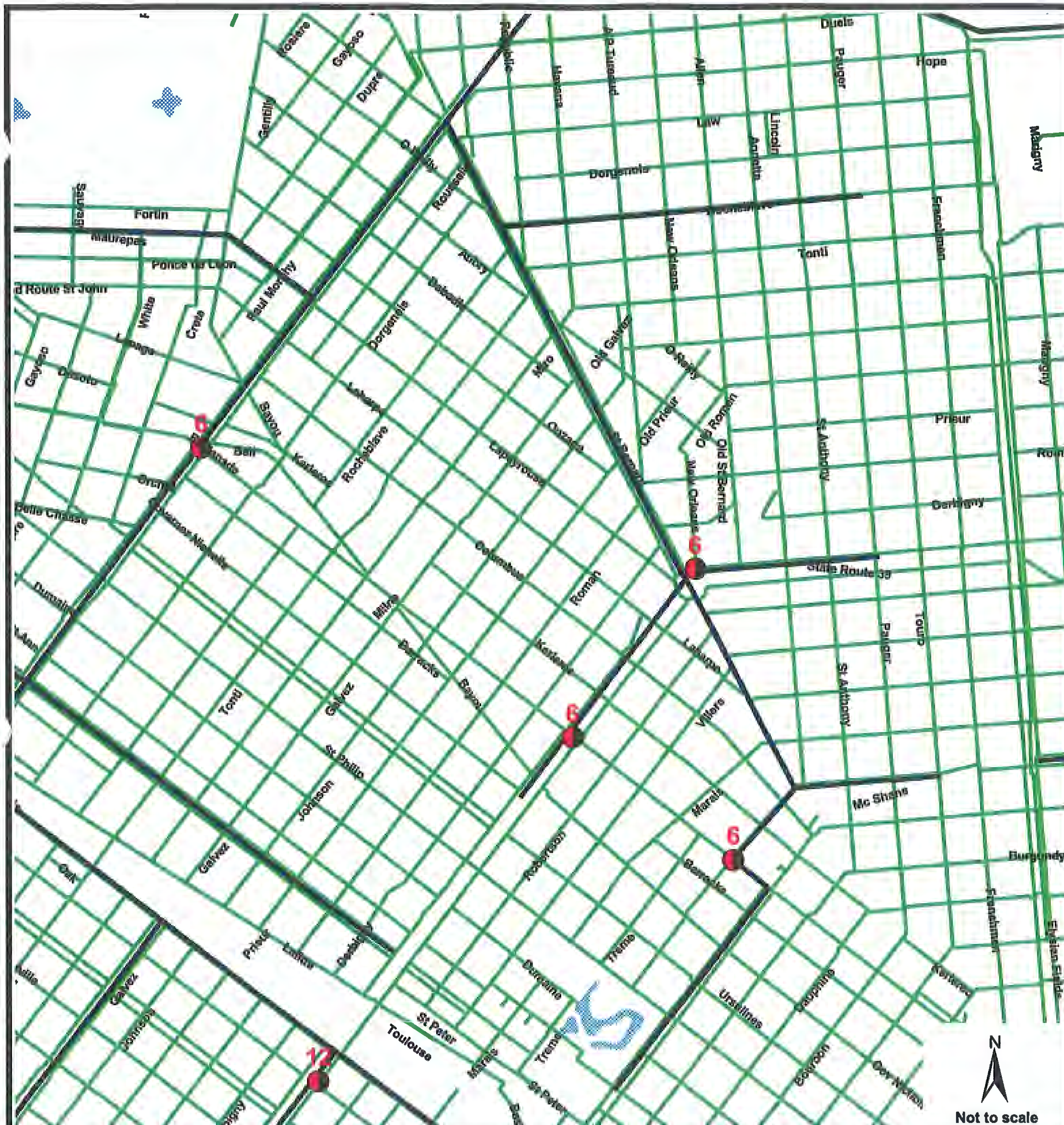

Water Distribution System Assessment and Hydraulic Model
Washout Valve Location

Map 9 of 24

Legend

- Washout Valve (Diameter in Inches)
- Drainage System (Major Lines - Width 30" & Larger)
- Water Main
- Street
- Water Body

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Sewerage & Water Board OF NEW ORLEANS

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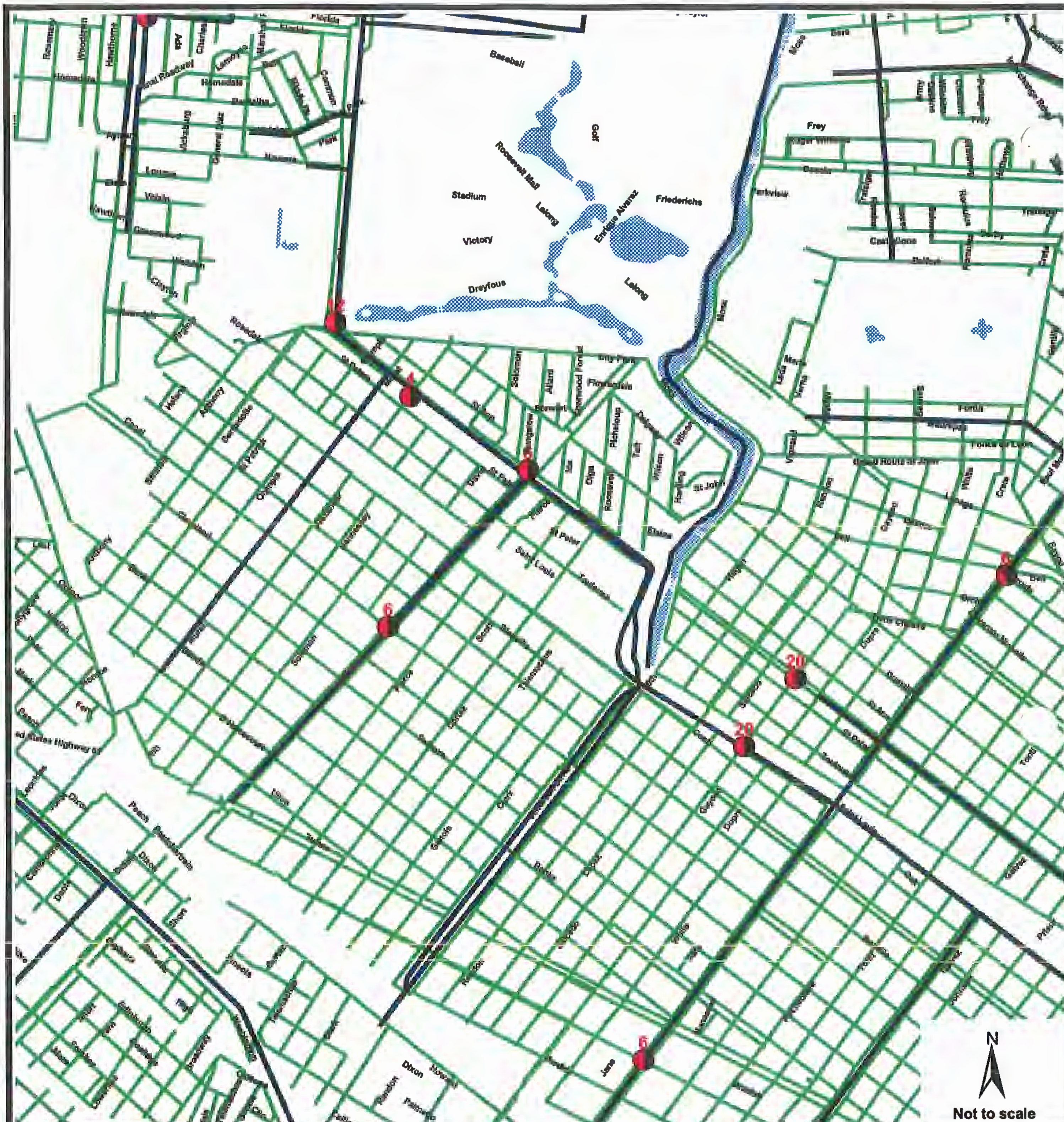
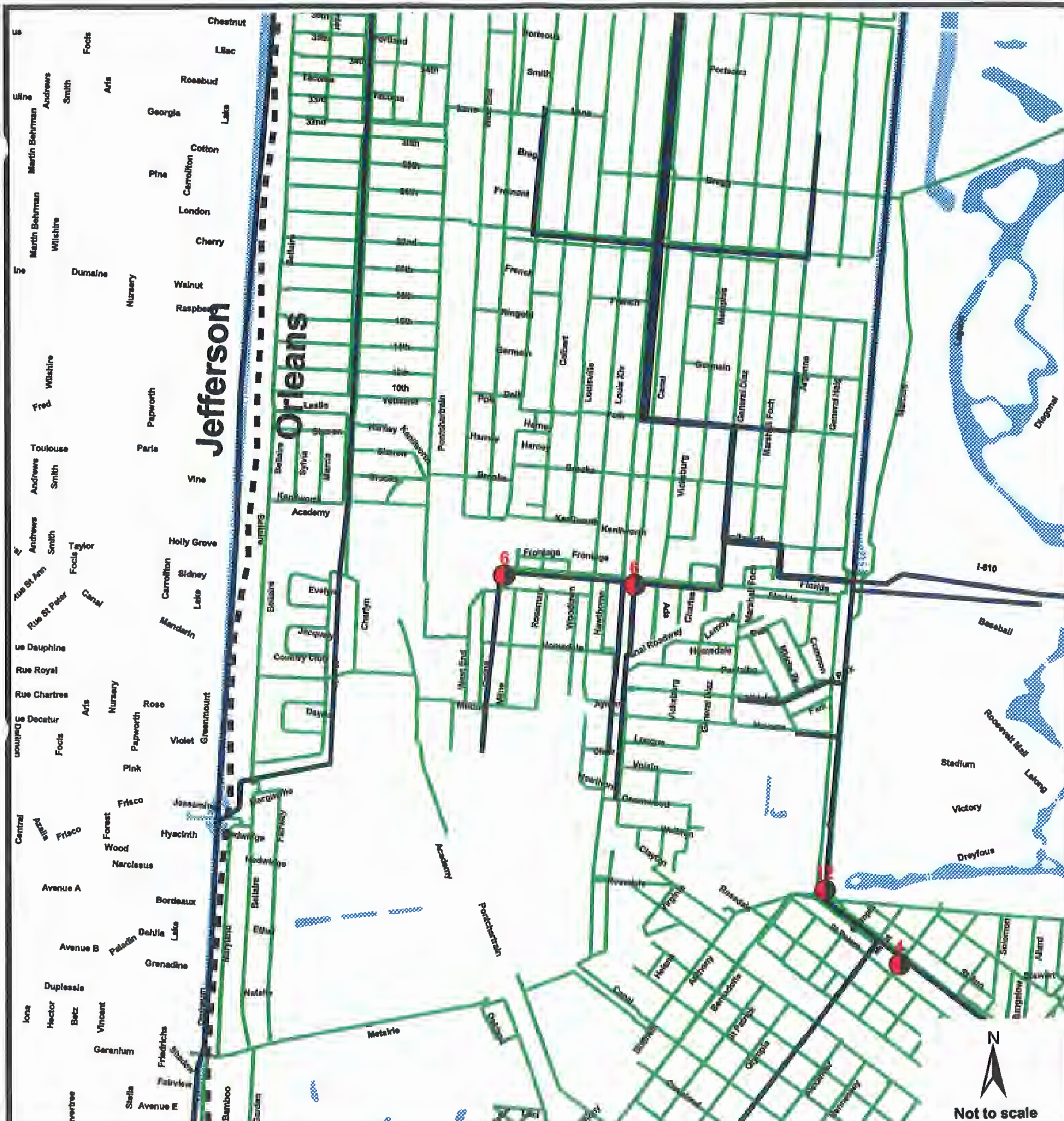


Water Distribution System Assessment and Hydraulic Model
Washout Valve Location

Map 10 of 24

Legend

- Washout Valve (Diameter in Inches)
- Drainage System (Major Lines - Width 30" & Larger)
- Water Main
- Street
- Water Body



Water Distribution System Assessment and Hydraulic Model

Washout Valve Location

Map 11 of 24

Legend

- Washout Valve (Diameter in Inches)
- Drainage System (Major Lines - Width 30" & Larger)
- Water Main
- Street
- Water Body

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Sewerage & Water Board OF NEW ORLEANS

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Water Distribution System Assessment and Hydraulic Model
Washout Valve Location

Map 12 of 24

Legend

- Washout Valve (Diameter in Inches)
- Drainage System (Major Lines - Width 30" & Larger)
- Water Main
- Street
- Water Body

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Sewerage & Water Board OF NEW ORLEANS

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Appendix H

Water Distribution System Assessment and Hydraulic Model
Washout Valve Location

Map 13 of 24

Legend

- Washout Valve (Diameter in Inches)
- Drainage System (Major Lines - Width 30" & Larger)
- Water Main
- Street
- Water Body

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

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Appendix H

Water Distribution System Assessment and Hydraulic Model
Washout Valve Location

Map 14 of 24

Legend

- Washout Valve (Diameter in Inches)
- Drainage System (Major Lines - Width 30" & Larger)
- Water Main
- Street
- Water Body

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

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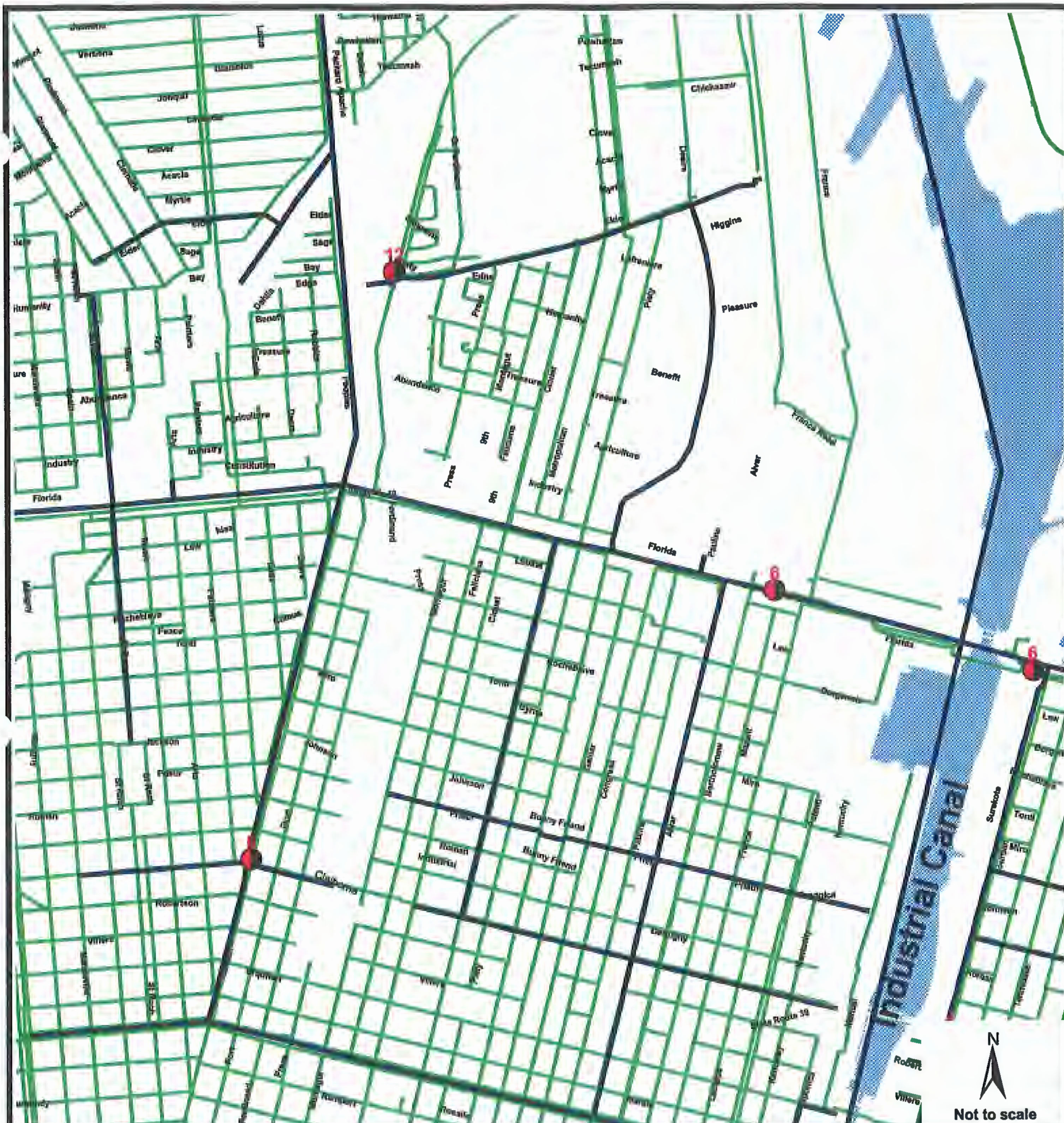
Appendix H



Water Distribution System Assessment and Hydraulic Model
Washout Valve Location

Map 15 of 24

Legend

- Washout Valve (Diameter in Inches)
- Drainage System (Major Lines - Width 30" & Larger)
- Water Main
- Street
- Water Body

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

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Appendix H

Water Distribution System Assessment and Hydraulic Model
Washout Valve Location

Map 16 of 24

Legend

- Washout Valve (Diameter in Inches)
- Drainage System (Major Lines - Width 30" & Larger)
- Water Main
- Street
- Water Body

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

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Appendix H

Water Distribution System Assessment and Hydraulic Model
Washout Valve Location

Map 17 of 24

Legend

- Washout Valve (Diameter in Inches)
- Drainage System (Major Lines - Width 30" & Larger)
- Water Main
- Street
- Water Body

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

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Water Distribution System Assessment and Hydraulic Model
Washout Valve Location

Map 18 of 24

Legend

- Washout Valve (Diameter in Inches)
- Drainage System (Major Lines - Width 30" & Larger)
- Water Main
- Street
- Water Body

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

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Water Distribution System Assessment and Hydraulic Model
Washout Valve Location

Map 19 of 24

Legend

Washout Valve (Diameter in Inches)	Drainage System (Major Lines - Width 30" & Larger)	Water Main	Street	Water Body

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

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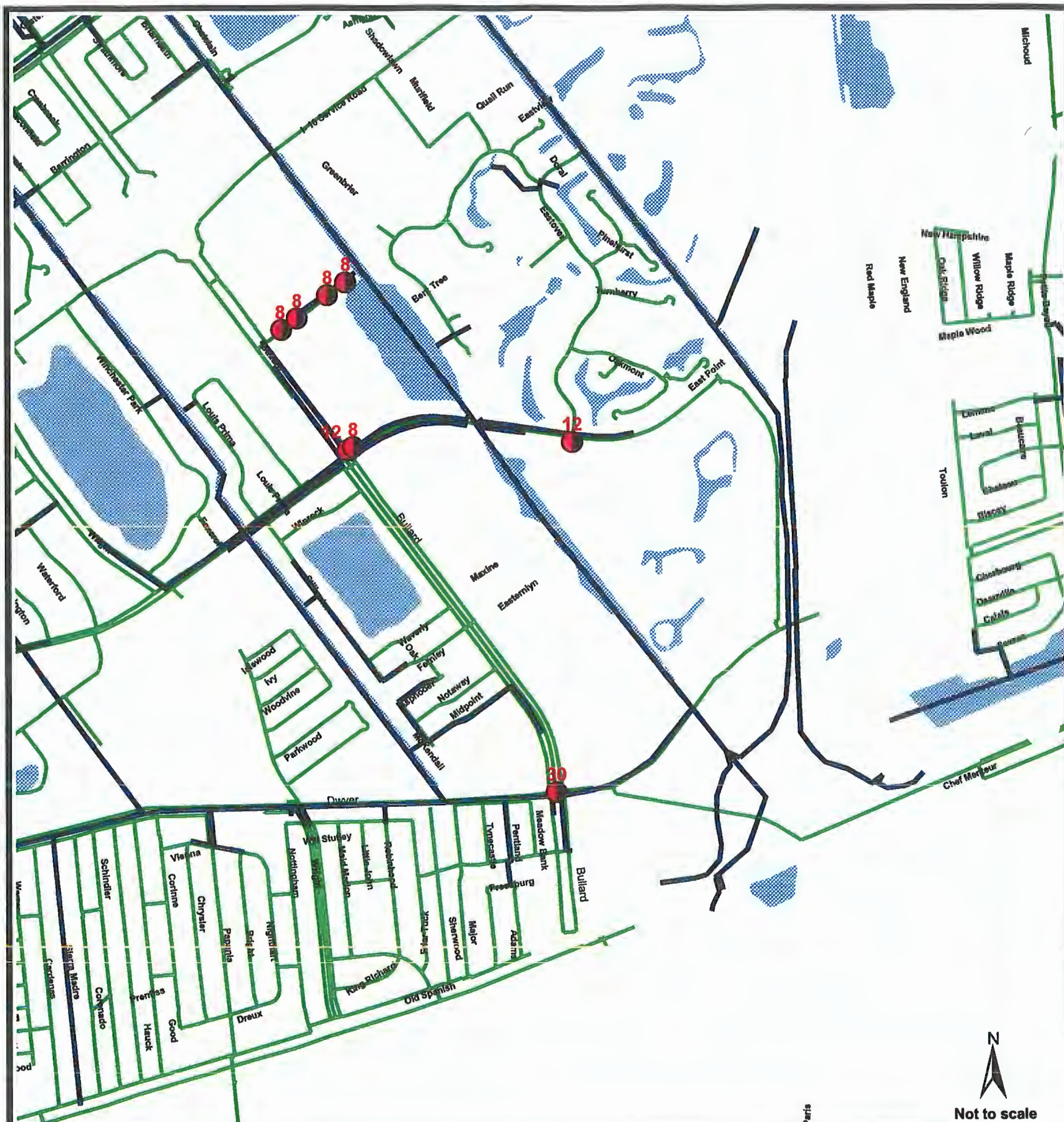
Appendix H



Water Distribution System Assessment and Hydraulic Model
Washout Valve Location

Map 20 of 24

Legend

- Washout Valve (Diameter in Inches)
- Drainage System (Major Lines - Width 30" & Larger)
- Water Main
- Street
- Water Body

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

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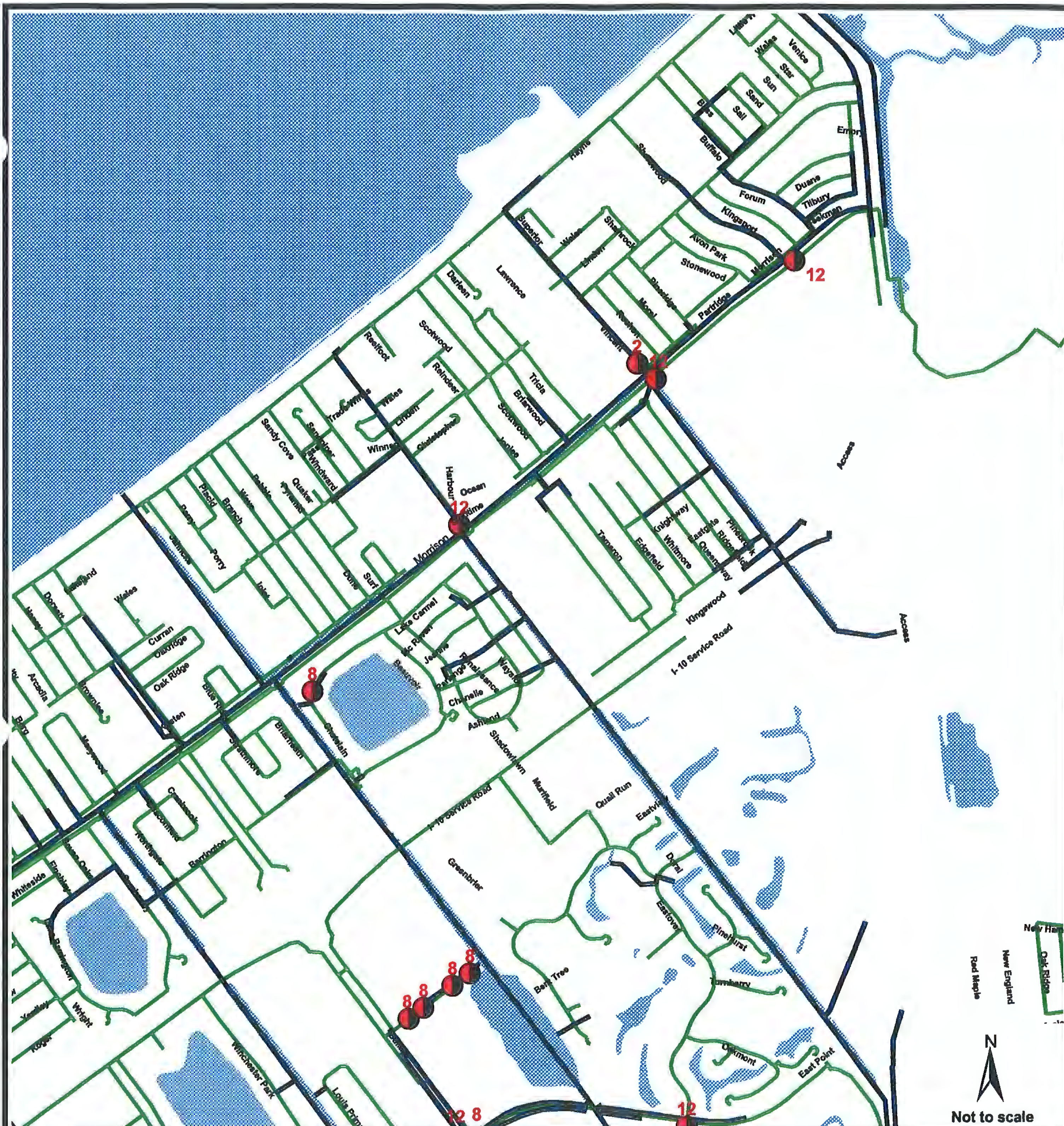
Appendix H



Water Distribution System Assessment and Hydraulic Model
Washout Valve Location

Map 21 of 24

Legend

Washout Valve (Diameter in Inches)	Drainage System (Major Lines - Width 30" & Larger)	Water Main	Street	Water Body

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

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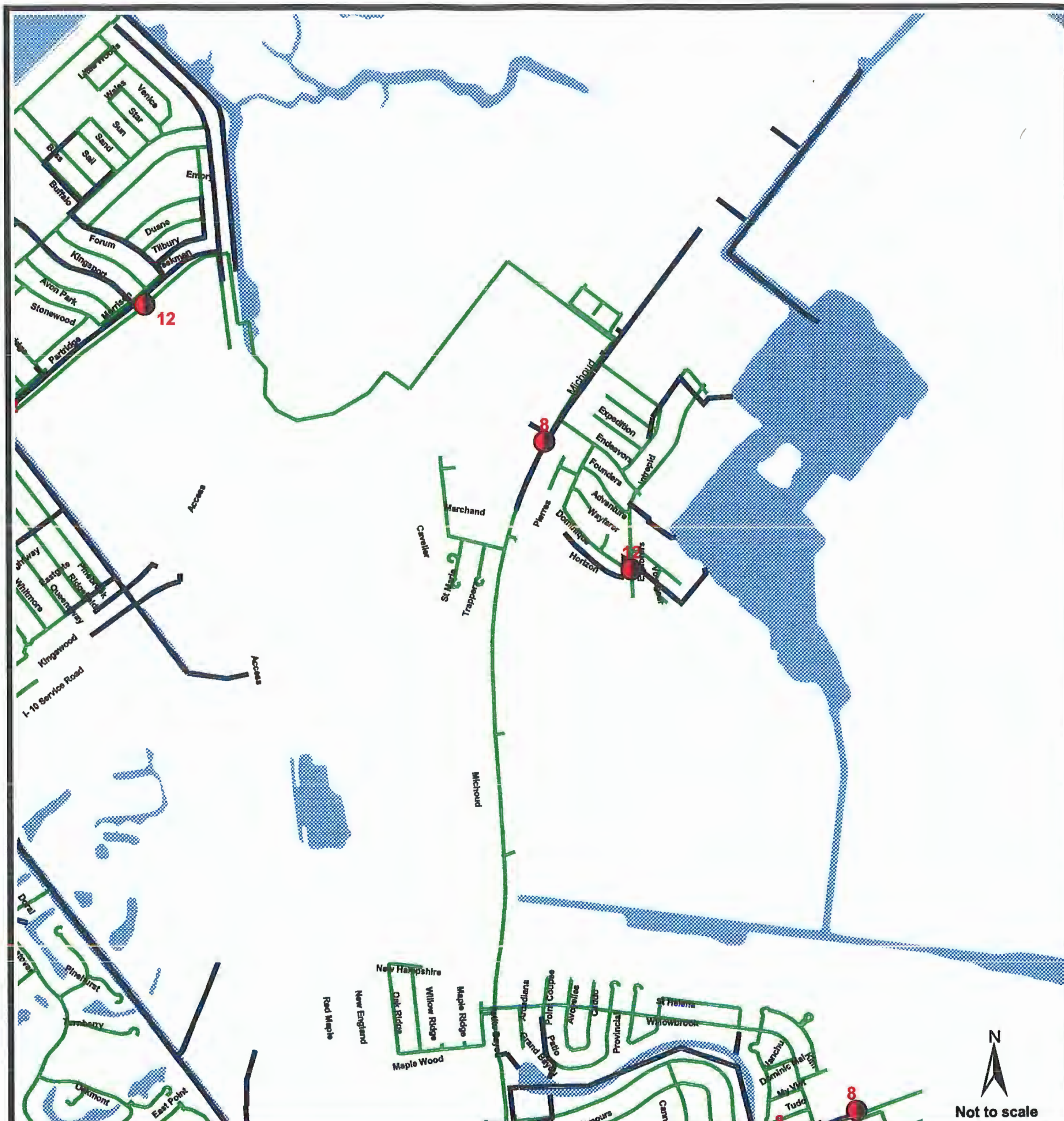
Appendix H



Water Distribution System Assessment and Hydraulic Model
Washout Valve Location

Map 22 of 24

Legend

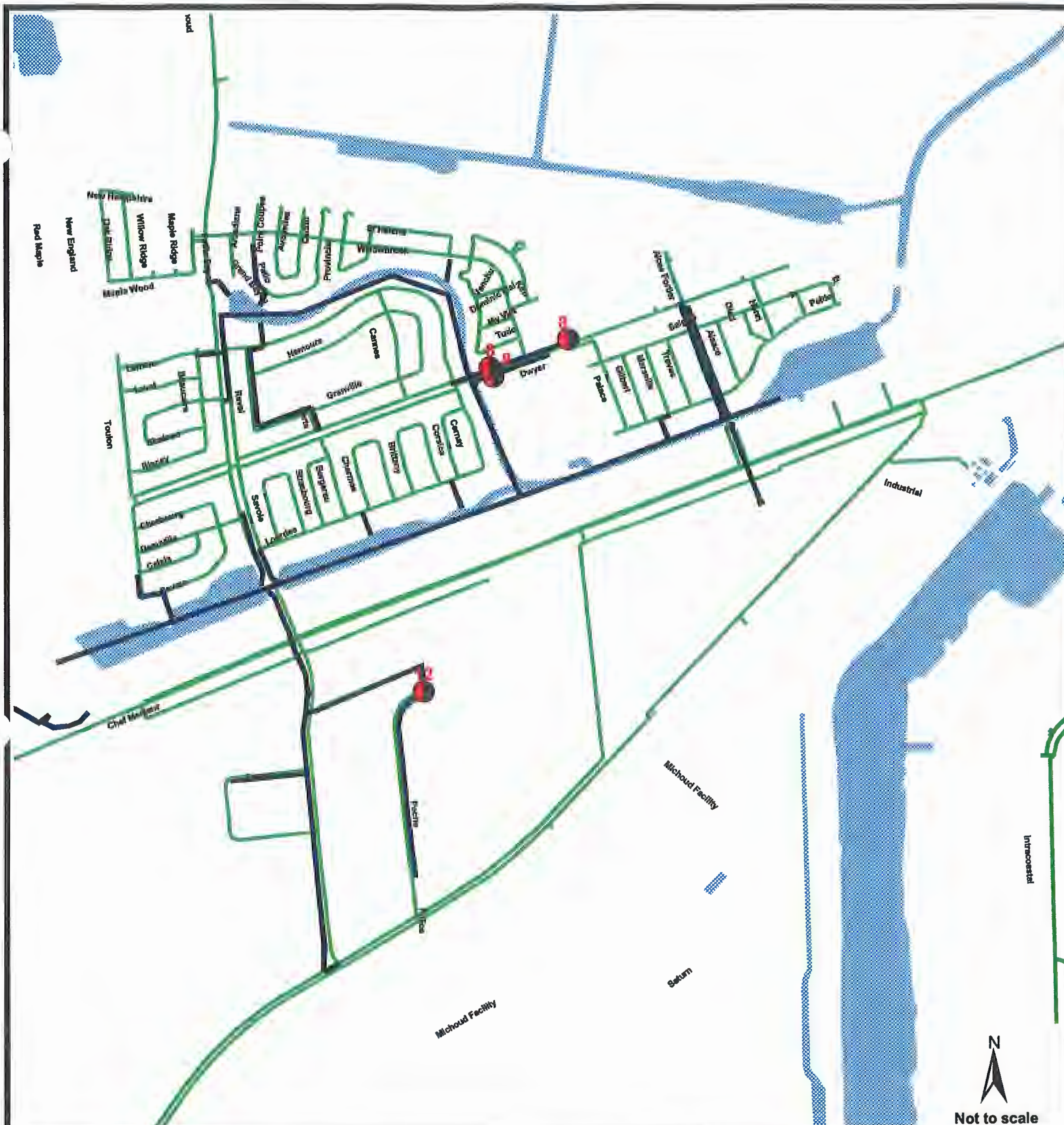
- Washout Valve (Diameter in Inches)
- Drainage System (Major Lines - Width 30" & Larger)
- Water Main
- Street
- Water Body

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

MWH

Appendix H



Water Distribution System Assessment and Hydraulic Model
Washout Valve Location

Map 23 of 24

Legend

- Washout Valve (Diameter in Inches)
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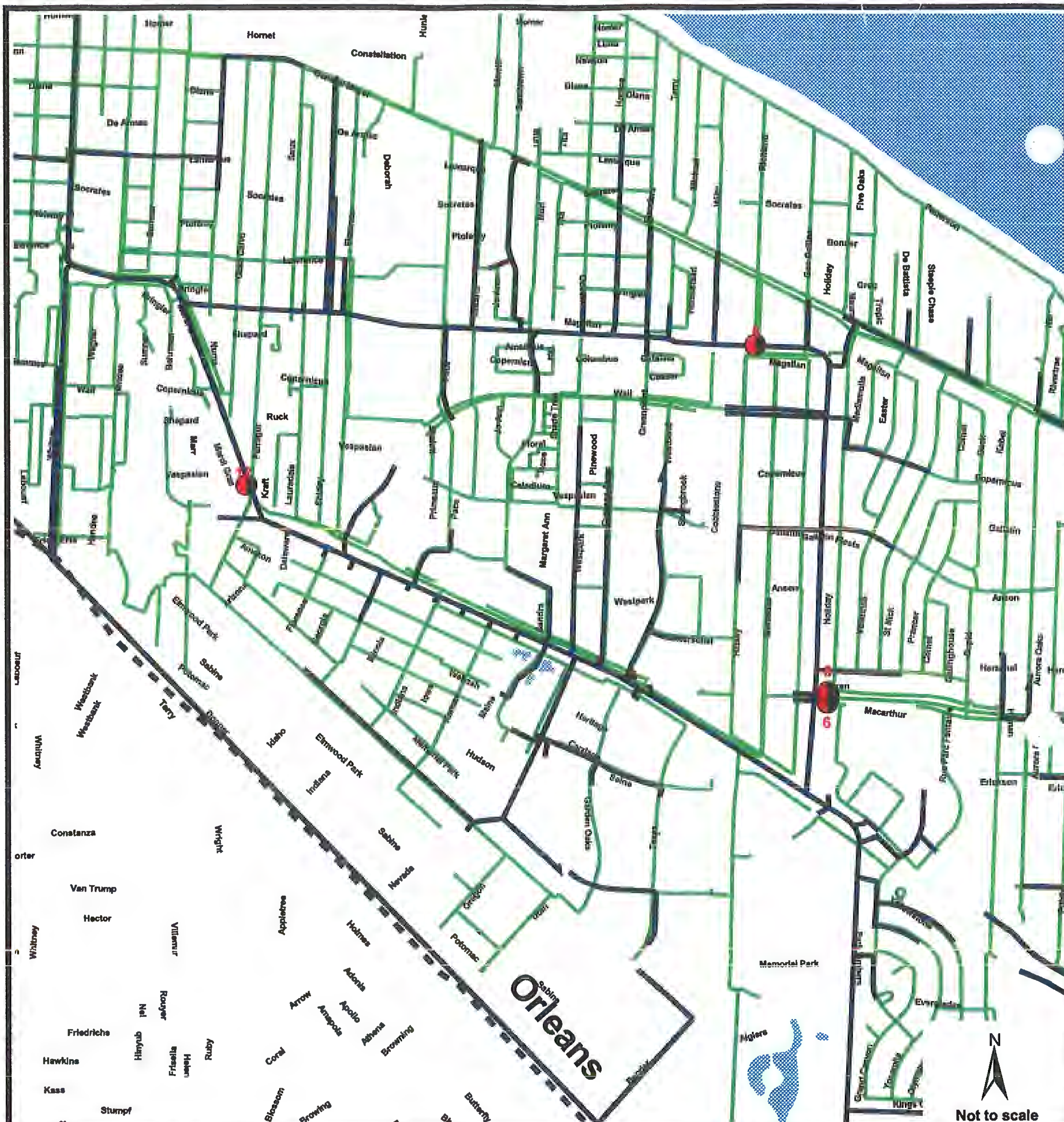
"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

MWH

Appendix H



Water Distribution System Assessment and Hydraulic Model
Washout Valve Location

Map 24 of 24

Legend

- Washout Valve (Diameter in Inches)
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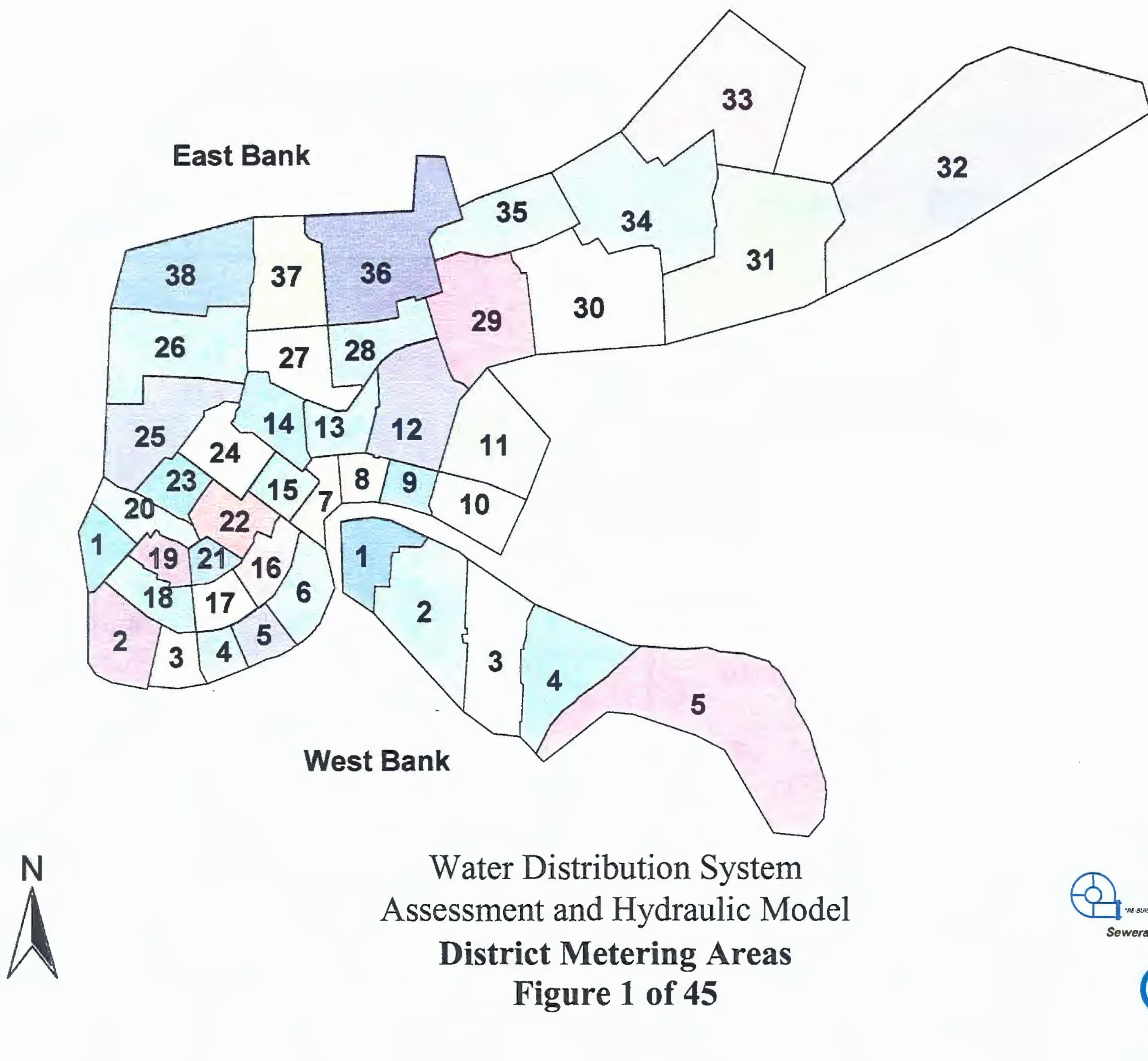
"RE-BUILDING THE CITY'S WATER SYSTEMS FOR THE 21st CENTURY"

Sewerage & Water Board OF NEW ORLEANS

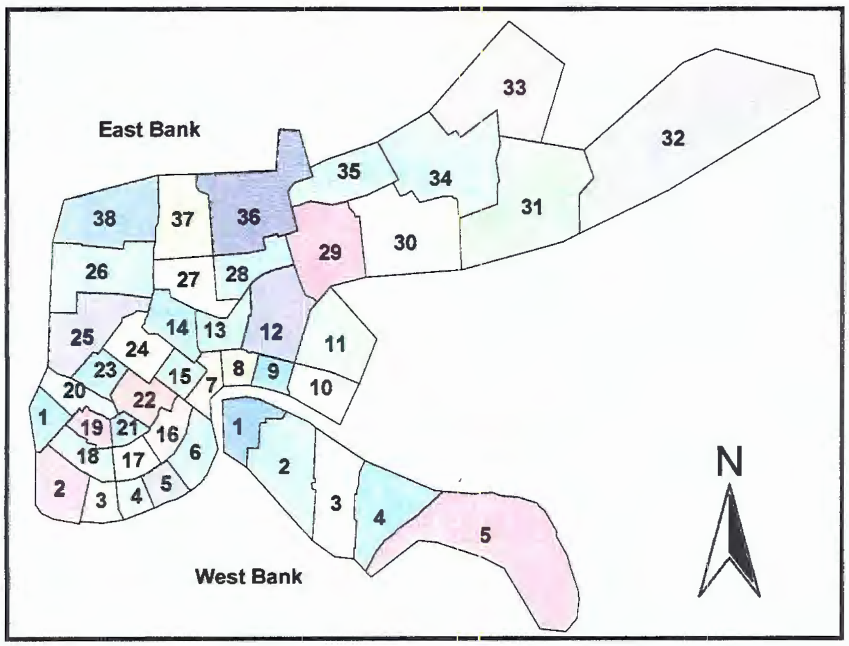
MWH

Appendix H



Water Distribution System
Assessment and Hydraulic Model
District Metering Areas
Figure 1 of 45

"RE-BUILDING THE CITY'S WATER SYSTEM"
Sewerage & Water Board



LEGEND

District Metering Location

DIAMETER

1-6 in	29 in
8 in	30 in
10 -12 in	36 in
14 -15 in	41 in
16 -18 in	42 in
20 in	43 in
21 in	48 in
24 in	50 in
	54 in

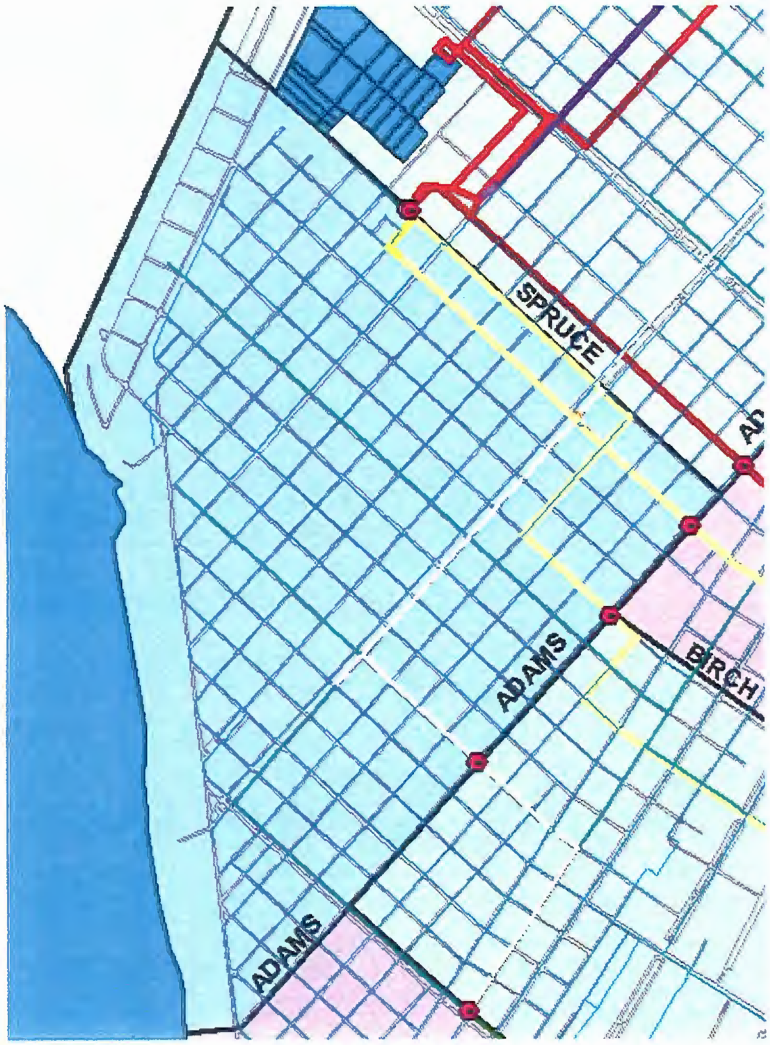
Street

Water Body

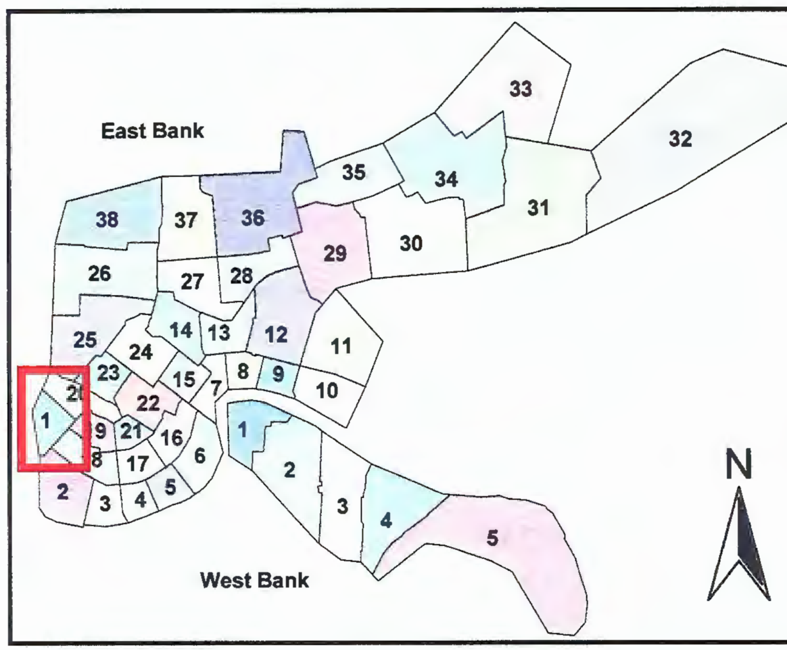
Water Distribution System
Assessment and Hydraulic Model
District Metering Areas Legend
Figure 2 of 45

Sewerage & Water Board OF

MW



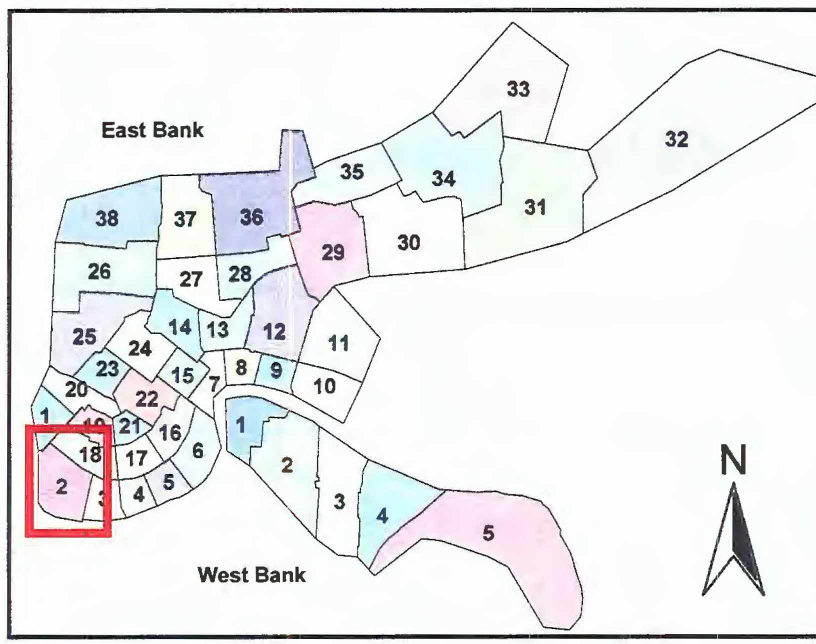
East Bank District 1	
Length of Water Main	26 miles
Number of Service Connections	3,727
Density of Service Connections	143 service connections/mile
Number of Closed Valves	29
Number of District Meters	5
Average Daily Demand (1997-2001)	1.1 MGD



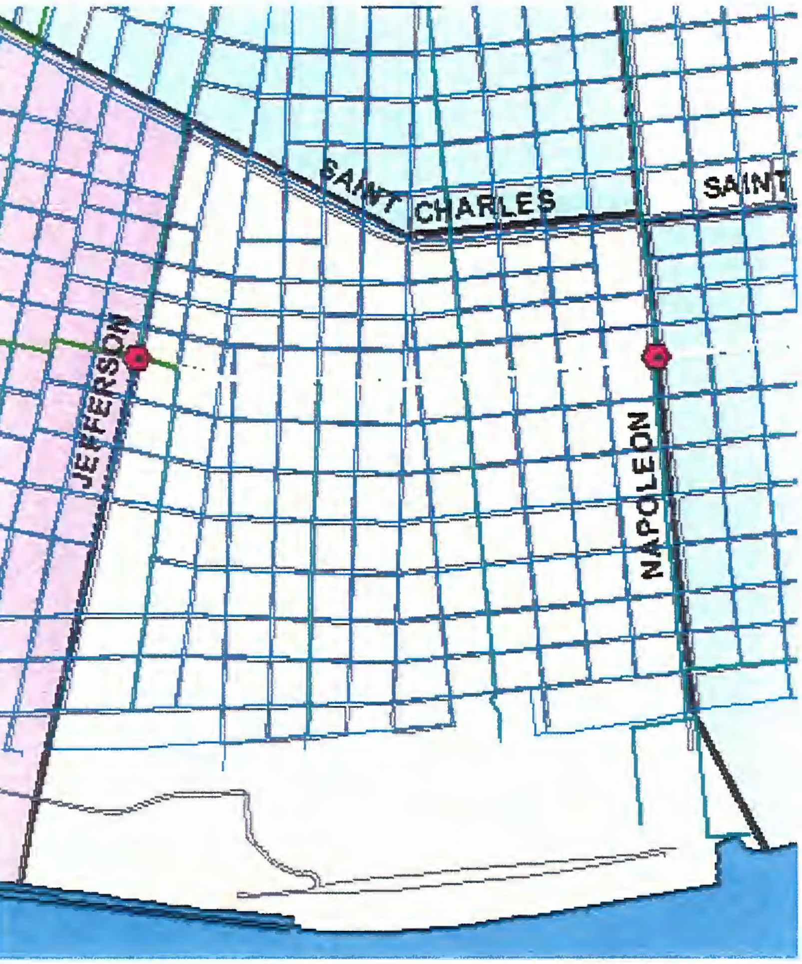
Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 1
Figure 3 of 45

Sewerage & Water Board

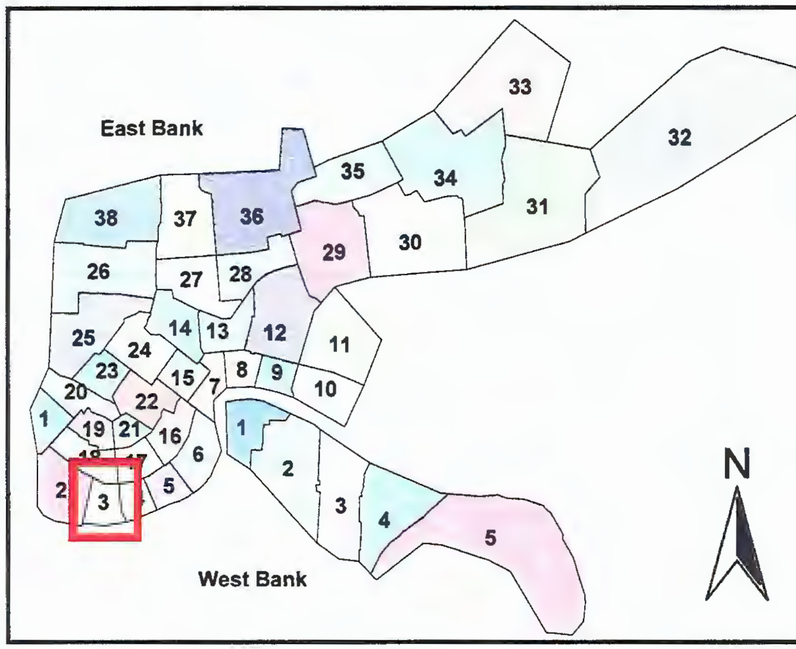
East Bank District 2	
Length of Water Main	34 miles
Number of Service Connections	4,028
Density of Service Connections	117 service connections/mile
Number of Closed Valves	37
Number of District Meters	2
Average Daily Demand (1997-2001)	1.7 MGD



Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 2
Figure 4 of 45

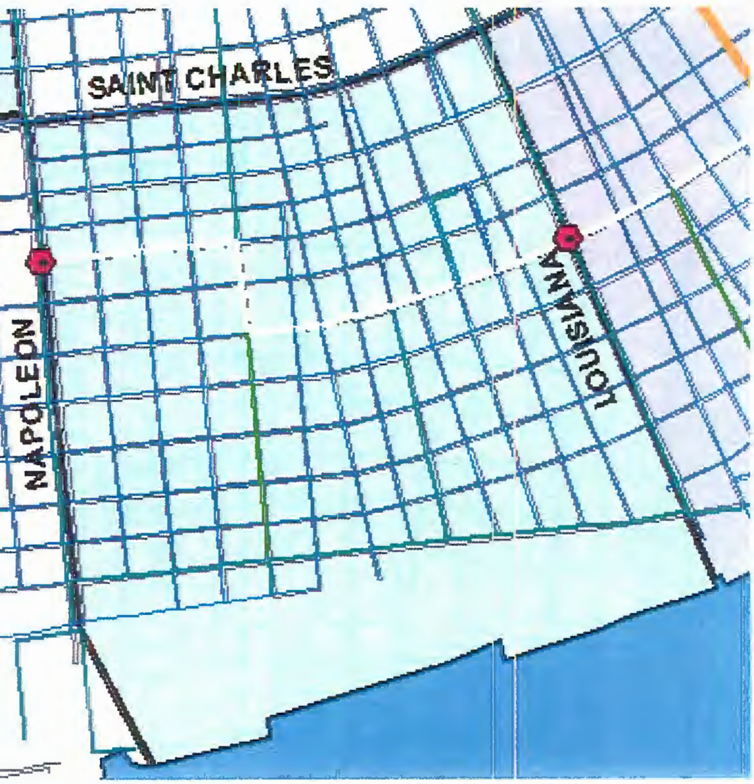


East Bank District 3	
Length of Water Main	20 miles
Number of Service Connections	3,106
Density of Service Connections	156 service connections/mile
Number of Closed Valves	38
Number of District Meters	2
Average Daily Demand (1997-2001)	0.9 MGD

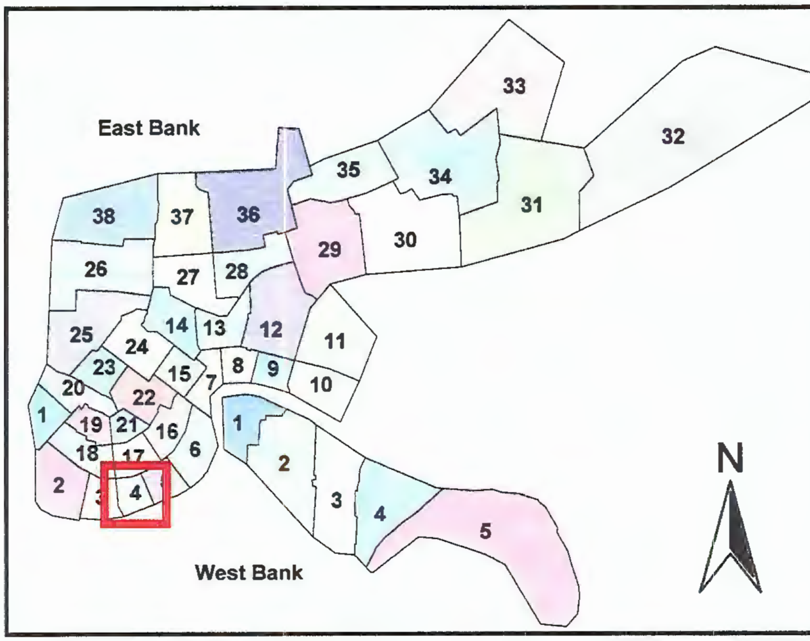


Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 3
Figure 5 of 45

Sewerage & Water Board

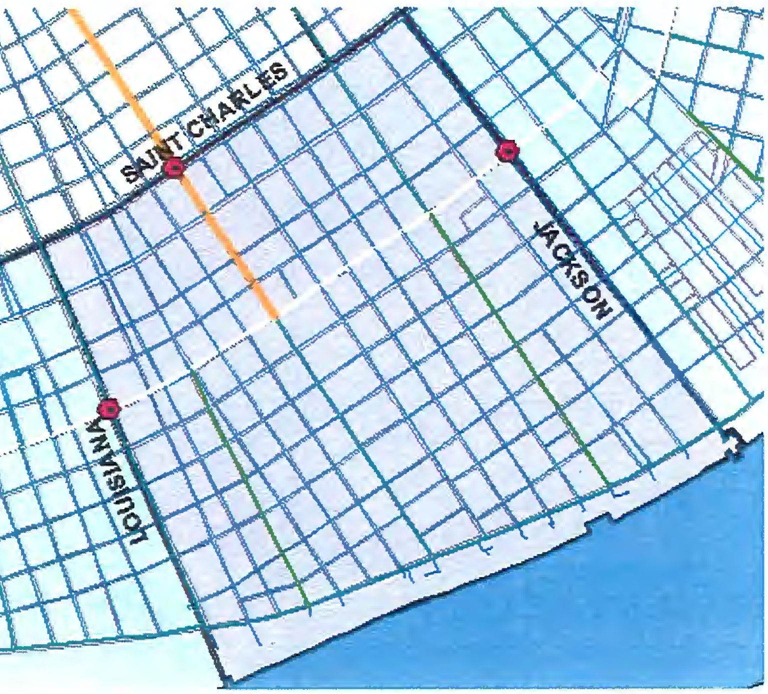


East Bank District 4	
Length of Water Main	17 miles
Number of Service Connections	2,387
Density of Service Connections	141 service connections/mile
Number of Closed Valves	33
Number of District Meters	2
Average Daily Demand (1997-2001)	1.1 MGD

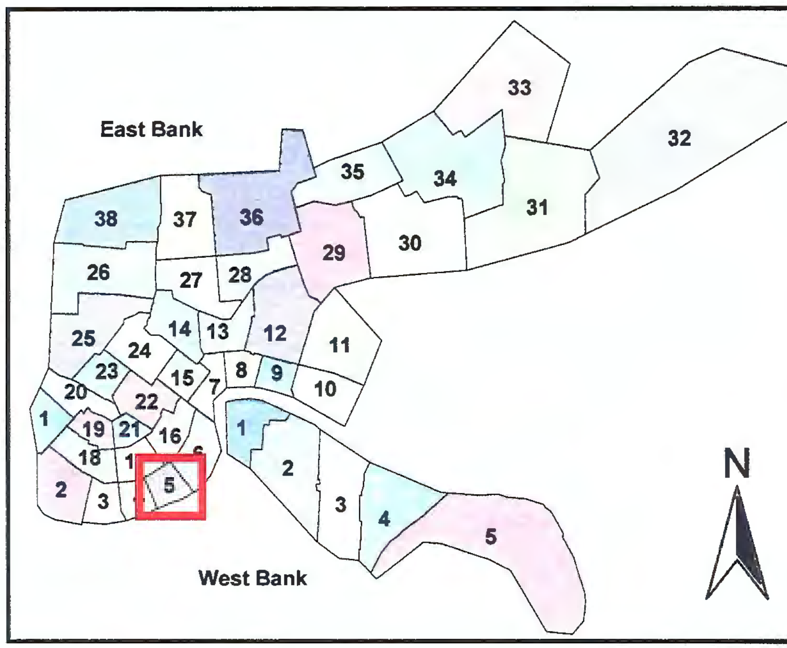


Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 4
Figure 6 of 45

Sewerage & Water Board

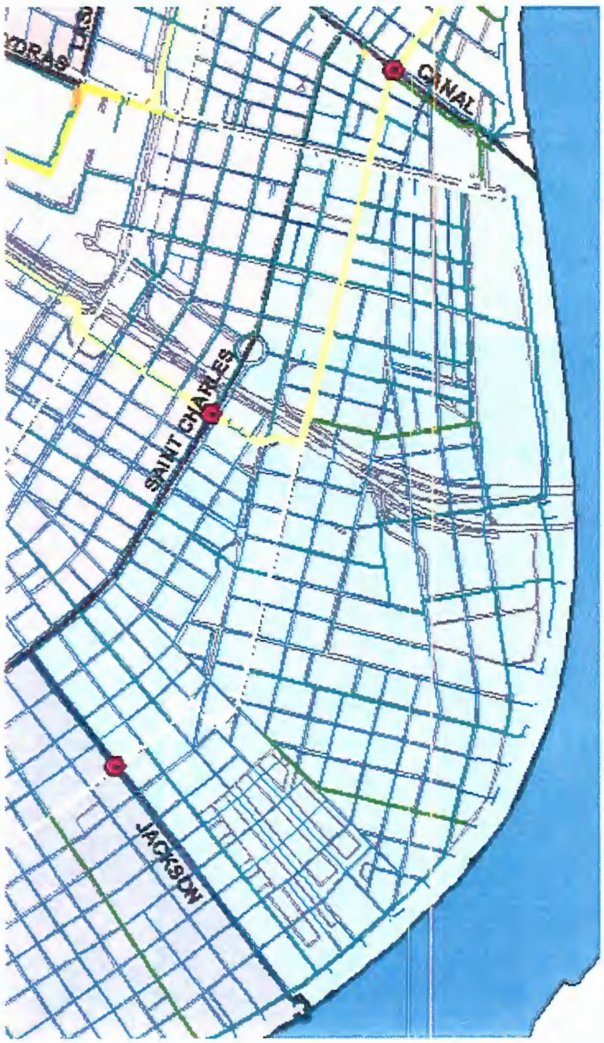


East Bank District 5	
Length of Water Main	24 miles
Number of Service Connections	3,089
Density of Service Connections	127 service connections/mile
Number of Closed Valves	28
Number of District Meters	3
Average Daily Demand (1997-2001)	1.1 MGD

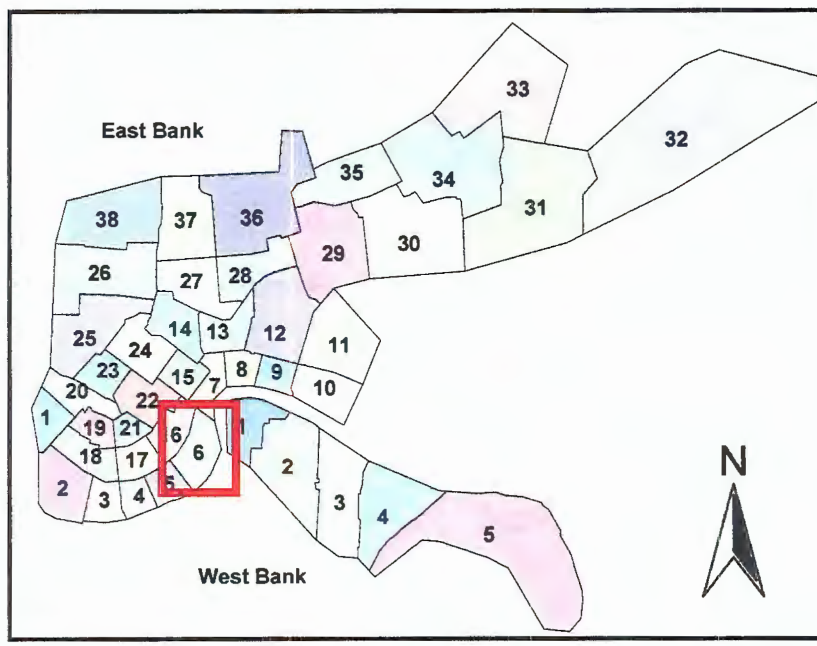


Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 5
Figure 7 of 45

Sewerage & Water Board



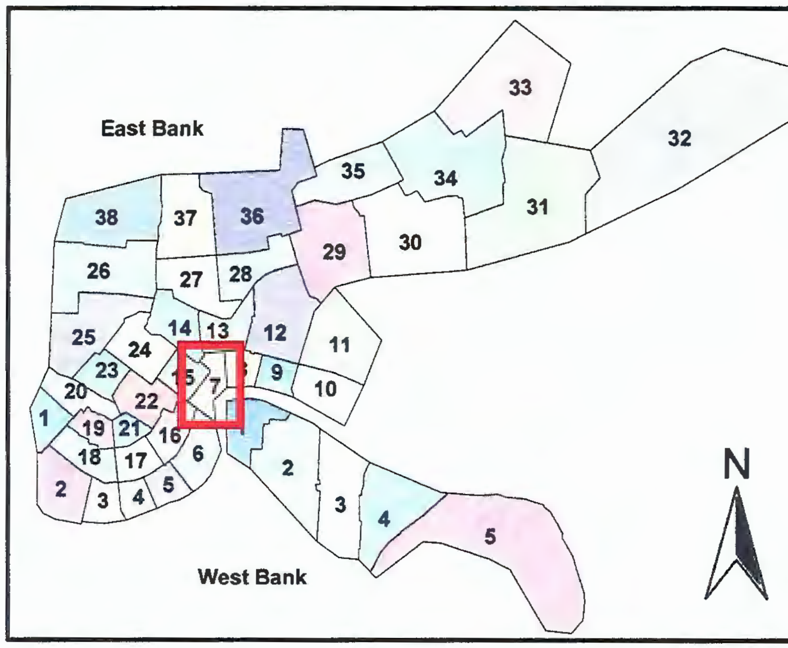
East Bank District 6	
Length of Water Main	24 miles
Number of Service Connections	2,337
Density of Service Connections	96 service connections/mile
Number of Closed Valves	32
Number of District Meters	3
Average Daily Demand (1997-2001)	4.0 MGD



Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 6
Figure 8 of 45

Sewerage & Water Board OF

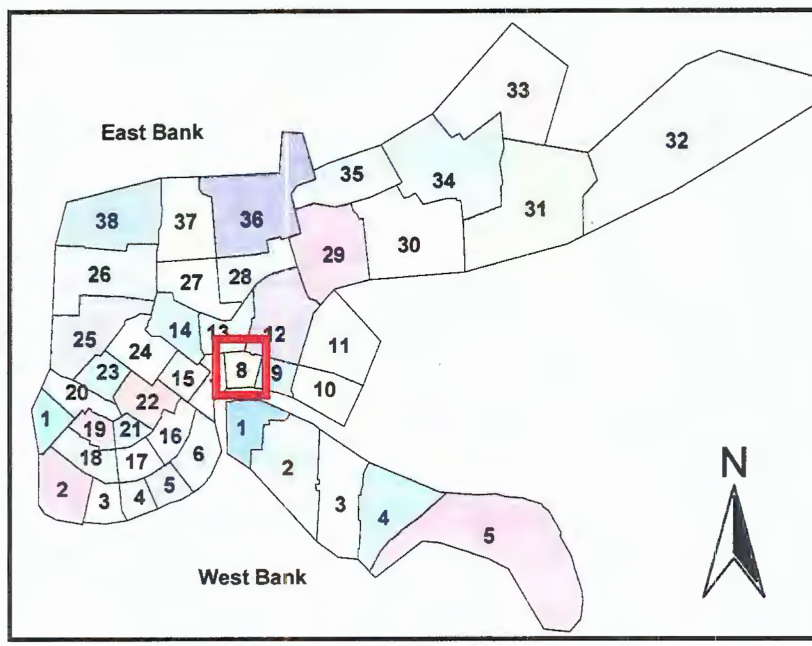
East Bank District 7	
Length of Water Main	27 miles
Number of Service Connections	3,959
Density of Service Connections	148 service connections/mile
Number of Closed Valves	48
Number of District Meters	3
Average Daily Demand (1997-2001)	3.6 MGD



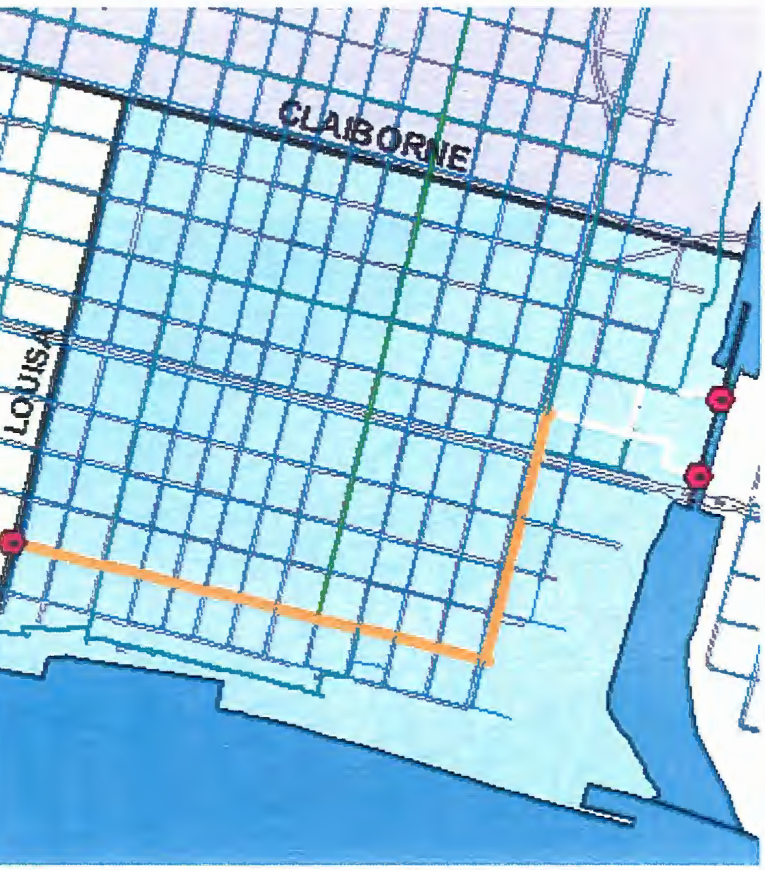
Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 7
Figure 9 of 45

Sewerage & Water Board

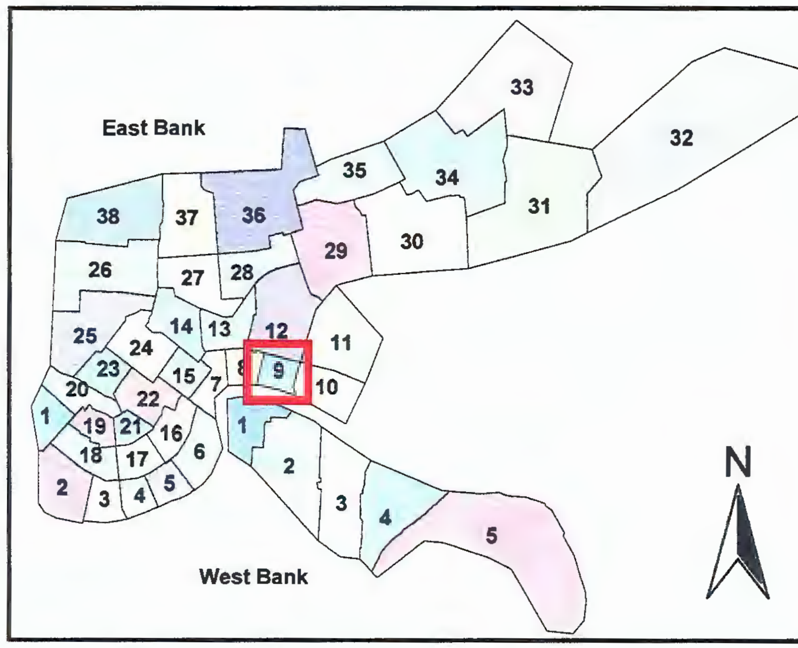
East Bank District 8	
Length of Water Main	21 miles
Number of Service Connections	2,615
Density of Service Connections	126 service connections/mile
Number of Closed Valves	36
Number of District Meters	3
Average Daily Demand (1997-2001)	0.9 MGD



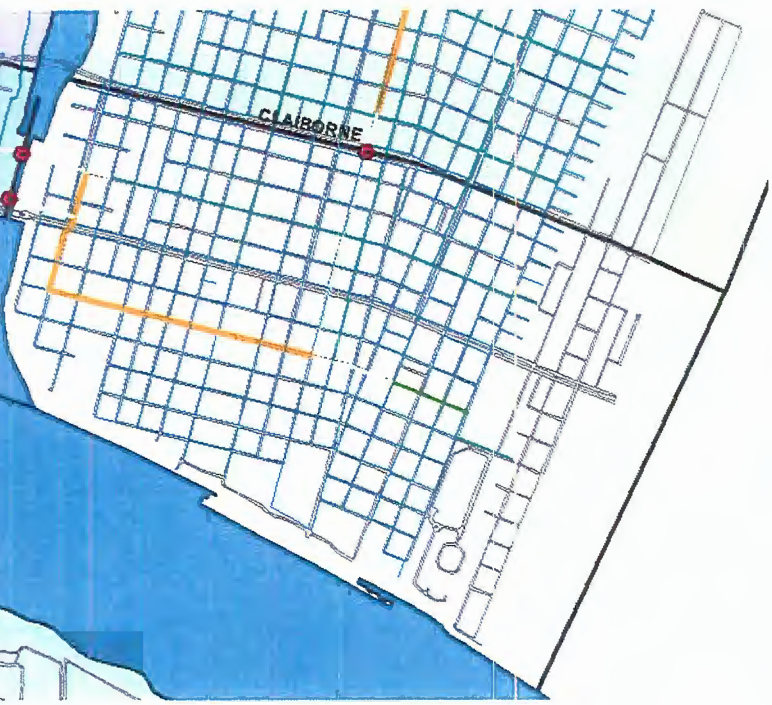
Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 8
Figure 10 of 45



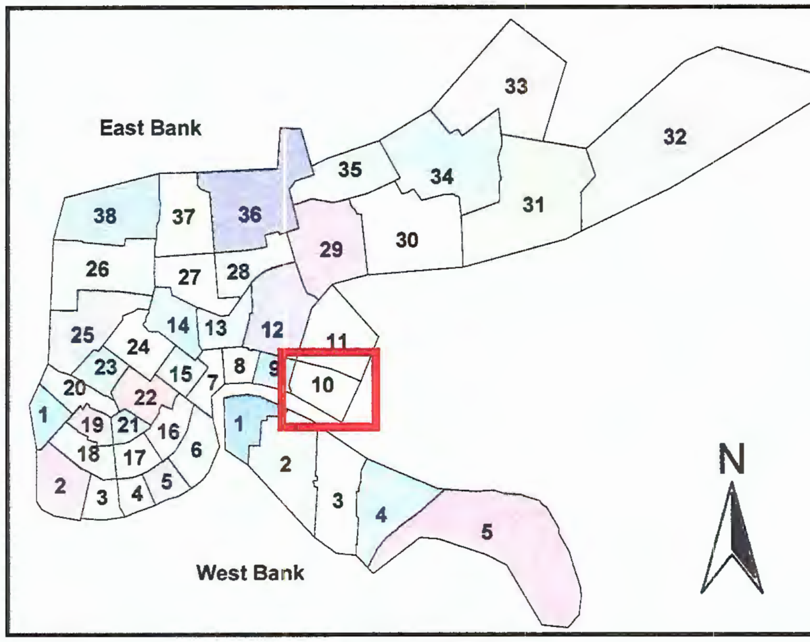
East Bank District 9	
Length of Water Main	22 miles
Number of Service Connections	2,492
Density of Service Connections	115 service connections/mile
Number of Closed Valves	29
Number of District Meters	3
Average Daily Demand (1997-2001)	0.8 MGD



Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 9
Figure 11 of 45



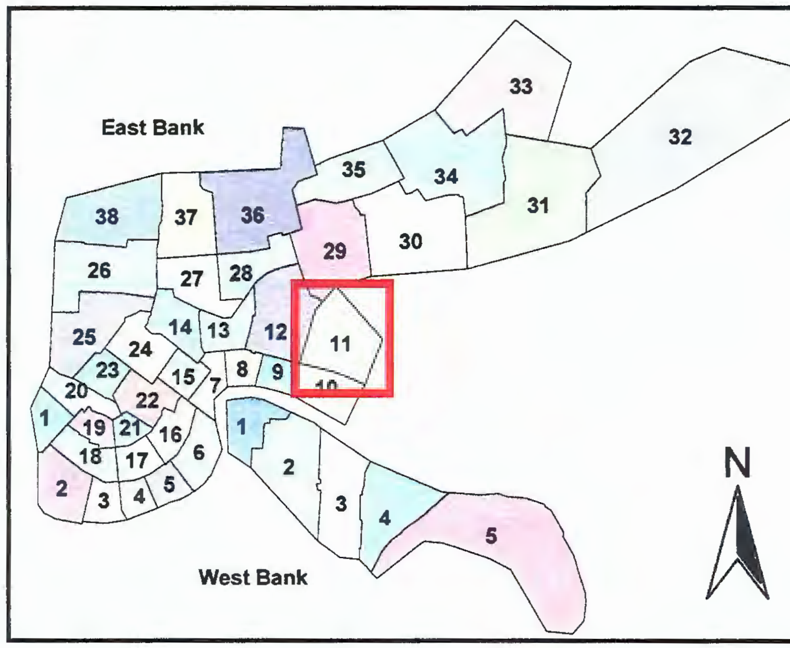
East Bank District 10	
Length of Water Main	29 miles
Number of Service Connections	3,193
Density of Service Connections	108 service connections/mile
Number of Closed Valves	19
Number of District Meters	3
Average Daily Demand (1997-2001)	0.9 MGD



Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 10
Figure 12 of 45

Sewerage & Water Board

East Bank District 11	
Length of Water Main	33 miles
Number of Service Connections	3,575
Density of Service Connections	108 service connections/mile
Number of Closed Valves	19
Number of District Meters	2
Average Daily Demand (1997-2001)	0.9 MGD

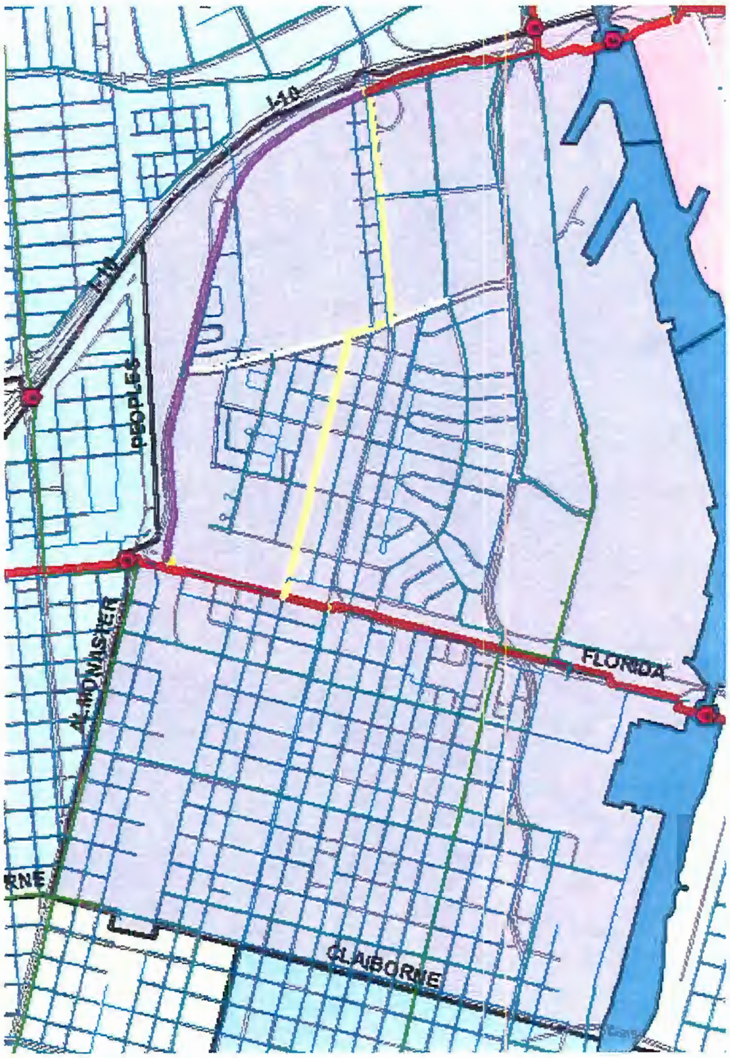


Water Distribution System
Assessment and Hydraulic Model

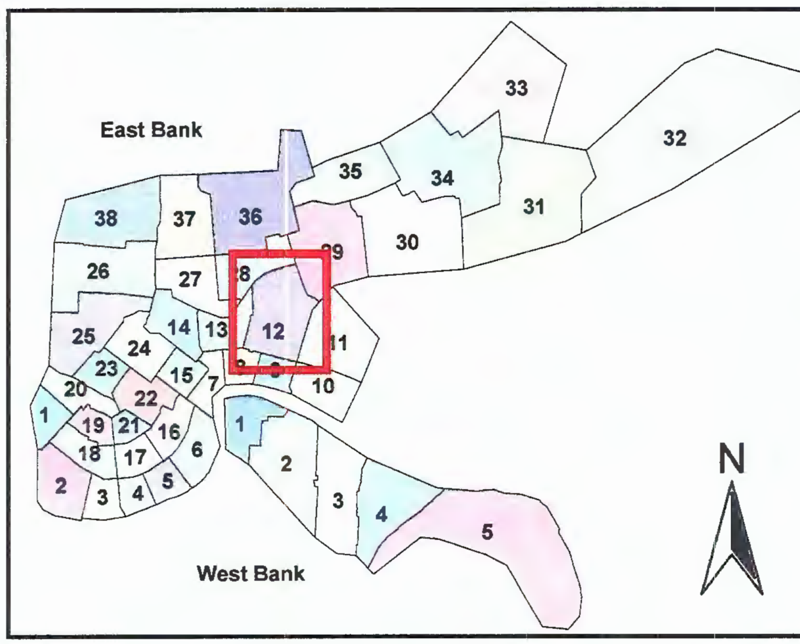
East Bank District Metering Area 11

Figure 13 of 45

Sewerage & Water Board

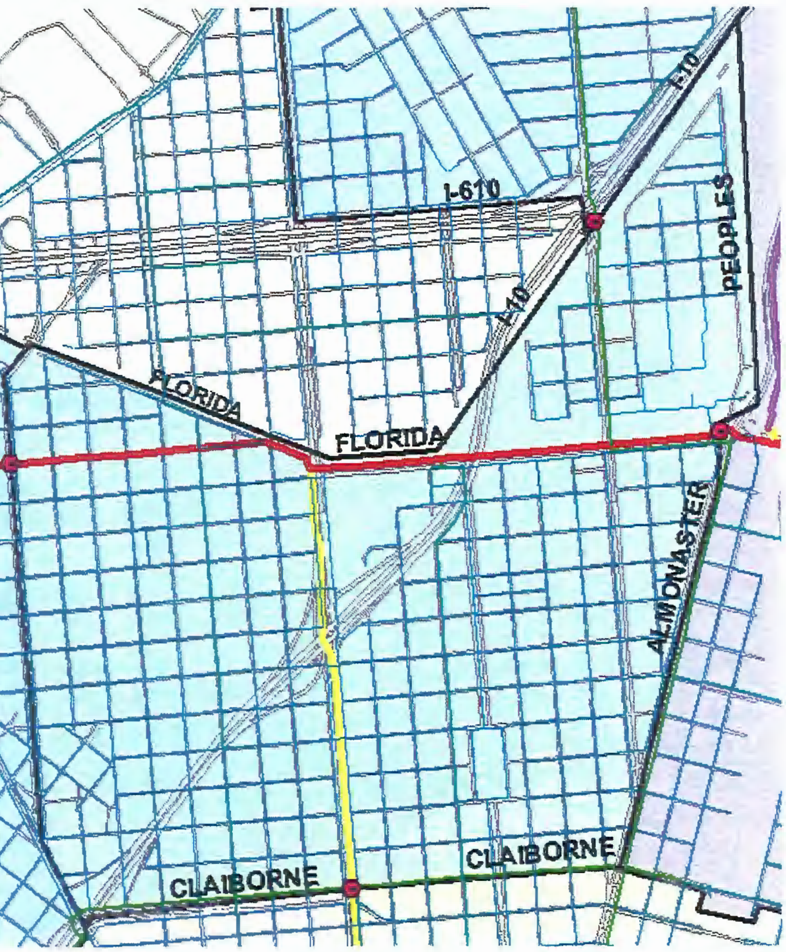


East Bank District 12	
Length of Water Main	54 miles
Number of Service Connections	4,015
Density of Service Connections	75 service connections/mile
Number of Closed Valves	28
Number of District Meters	4
Average Daily Demand (1997-2001)	1.7 MGD

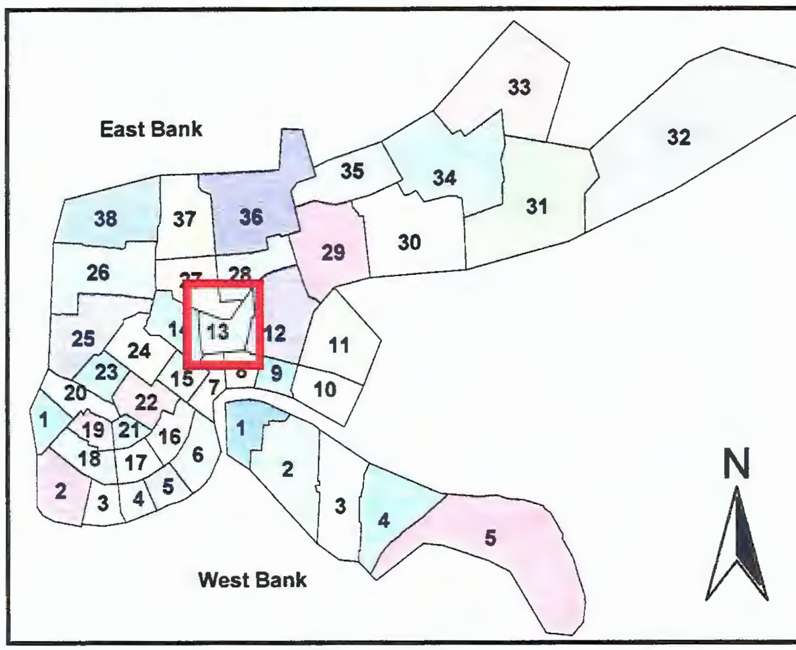


Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 12
Figure 14 of 45

Sewerage & Water Board

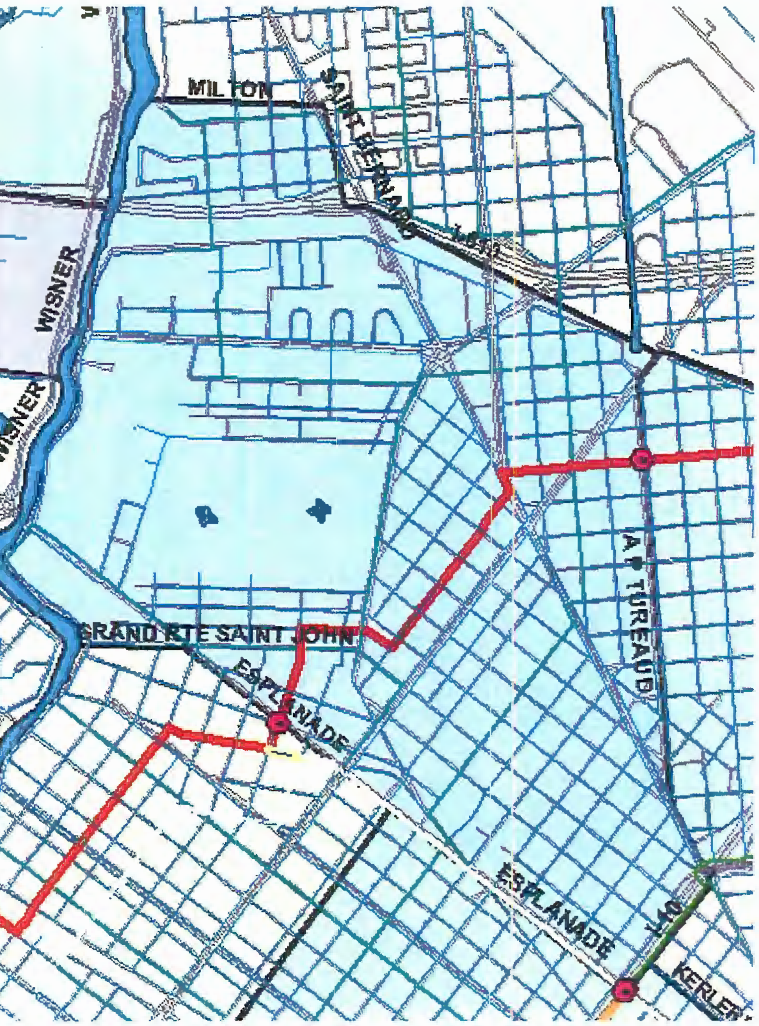


East Bank District 13	
Length of Water Main	40 miles
Number of Service Connections	4,907
Density of Service Connections	124 service connections/mile
Number of Closed Valves	34
Number of District Meters	4
Average Daily Demand (1997-2001)	1.5 MGD

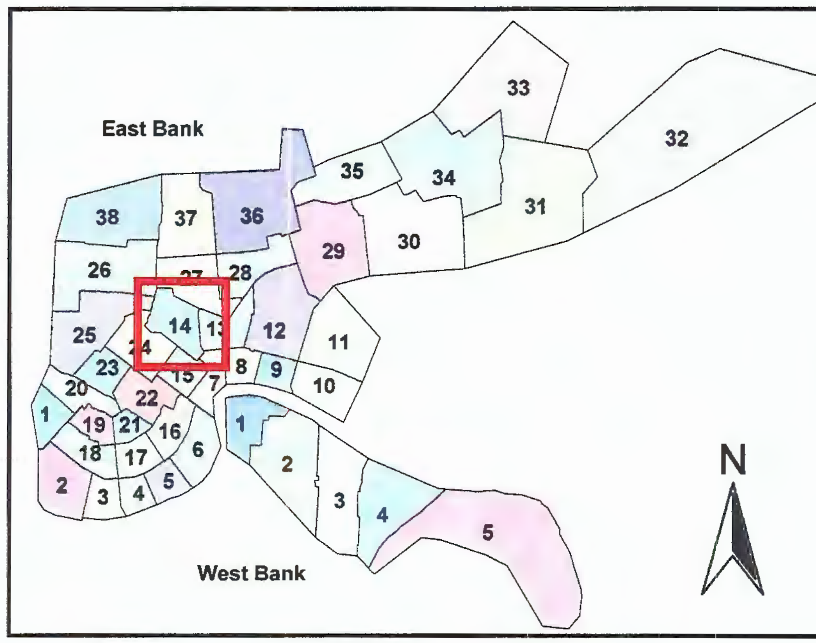


Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 13
Figure 15 of 45

Sewerage & Water Board



East Bank District 14	
Length of Water Main	39 miles
Number of Service Connections	4,718
Density of Service Connections	122 service connections/mile
Number of Closed Valves	47
Number of District Meters	2
Average Daily Demand (1997-2001)	1.7 MGD

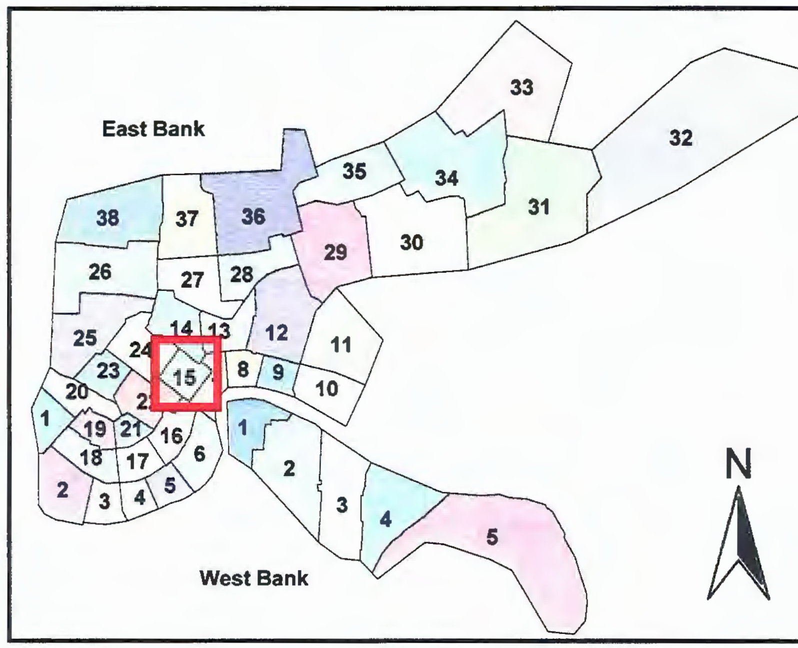


Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 14
Figure 16 of 45

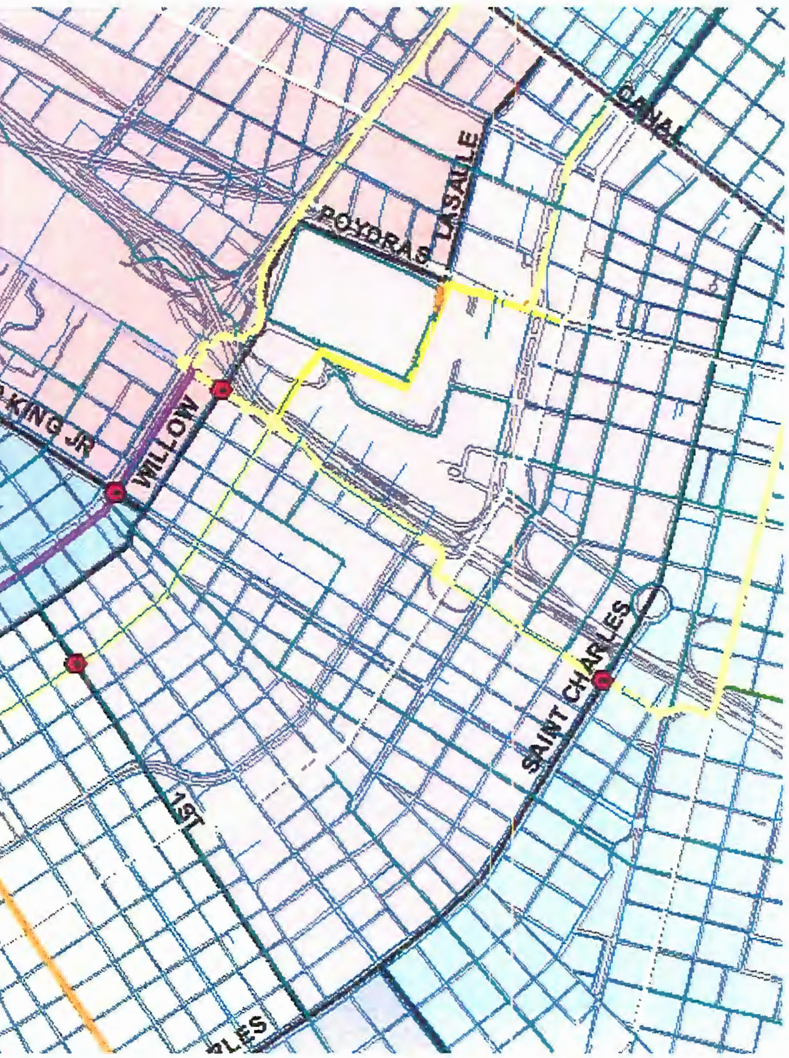
Sewerage & Water Board OF

MW

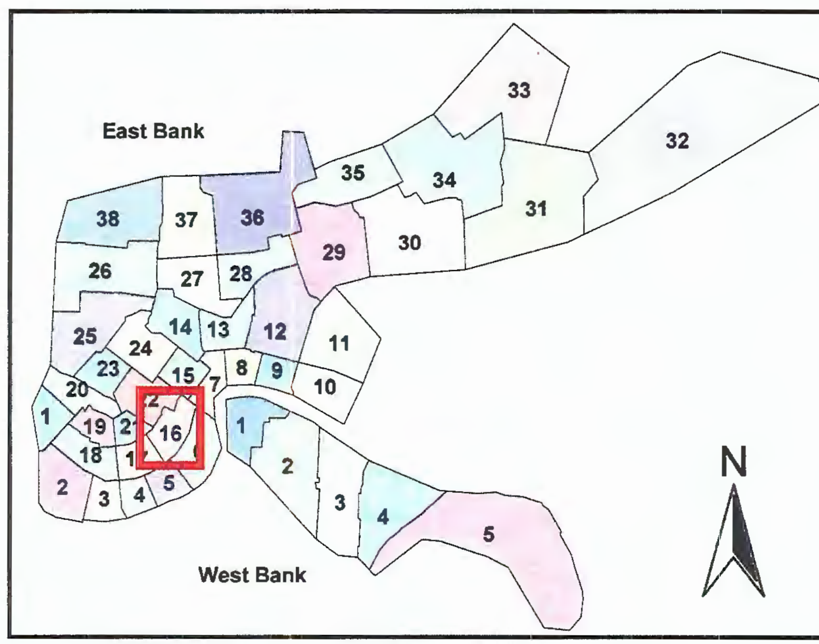
East Bank District 15	
Length of Water Main	30 miles
Number of Service Connections	2,765
Density of Service Connections	93 service connections/mile
Number of Closed Valves	59
Number of District Meters	3
Average Daily Demand (1997-2001)	1.5 MGD



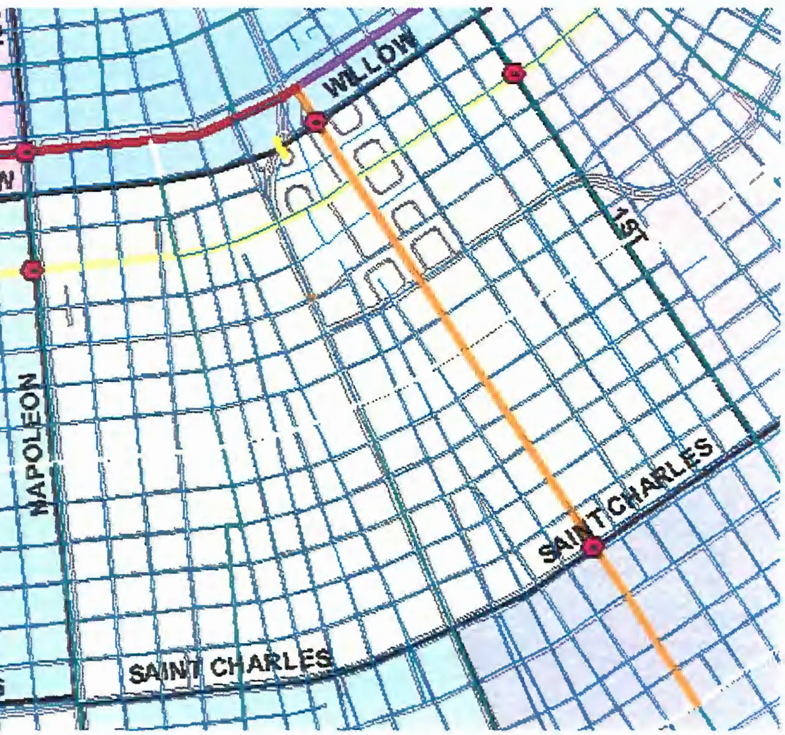
Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 15
Figure 17 of 45



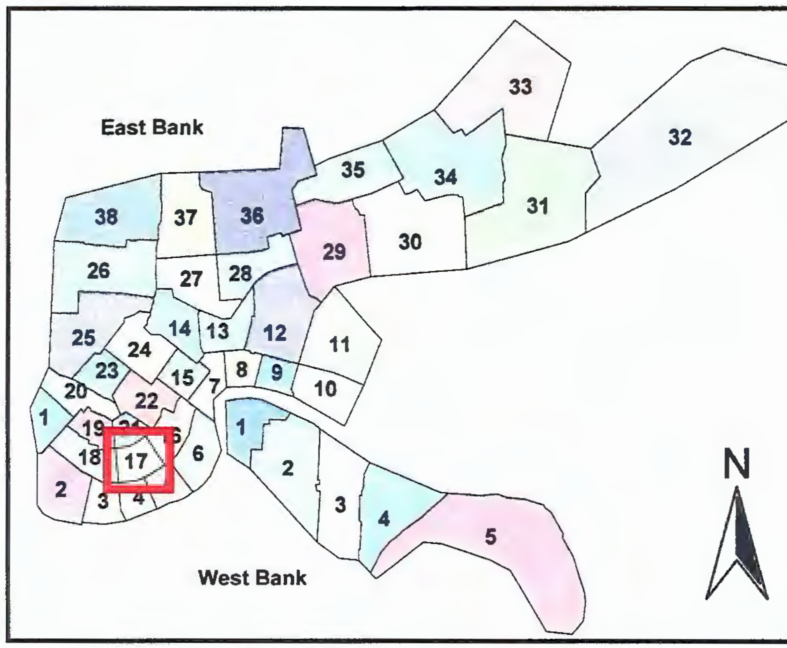
East Bank District 16	
Length of Water Main	37 miles
Number of Service Connections	2,555
Density of Service Connections	70 service connections/mile
Number of Closed Valves	56
Number of District Meters	3
Average Daily Demand (1997-2001)	5.0 MGD



Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 16
Figure 18 of 45

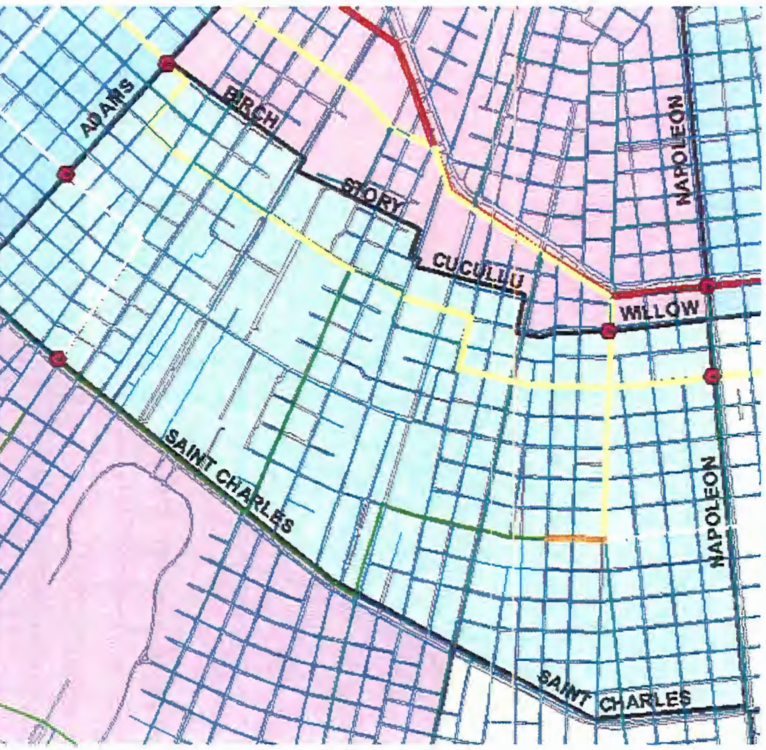


East Bank District 17	
Length of Water Main	32 miles
Number of Service Connections	3,752
Density of Service Connections	118 service connections/mile
Number of Closed Valves	53
Number of District Meters	5
Average Daily Demand (1997-2001)	1.2 MGD

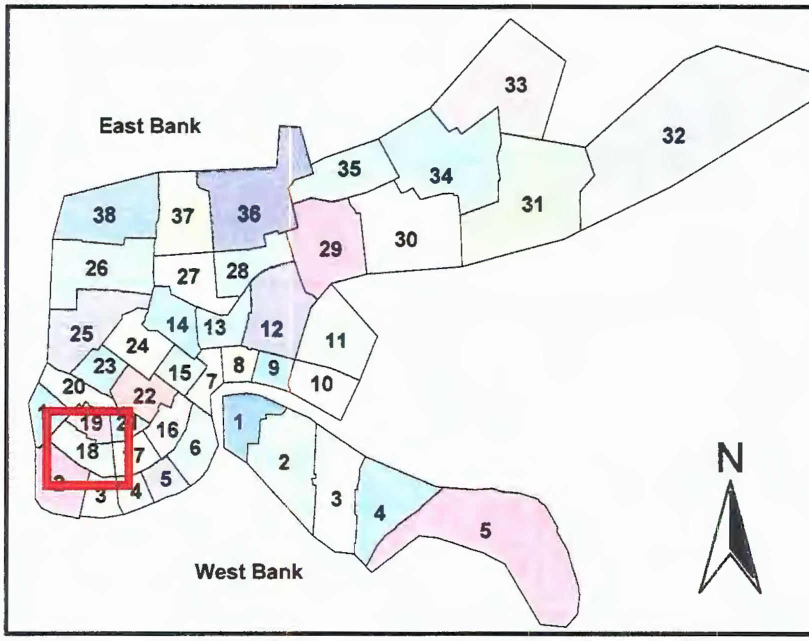


Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 17
Figure 19 of 45

Sewerage & Water Board



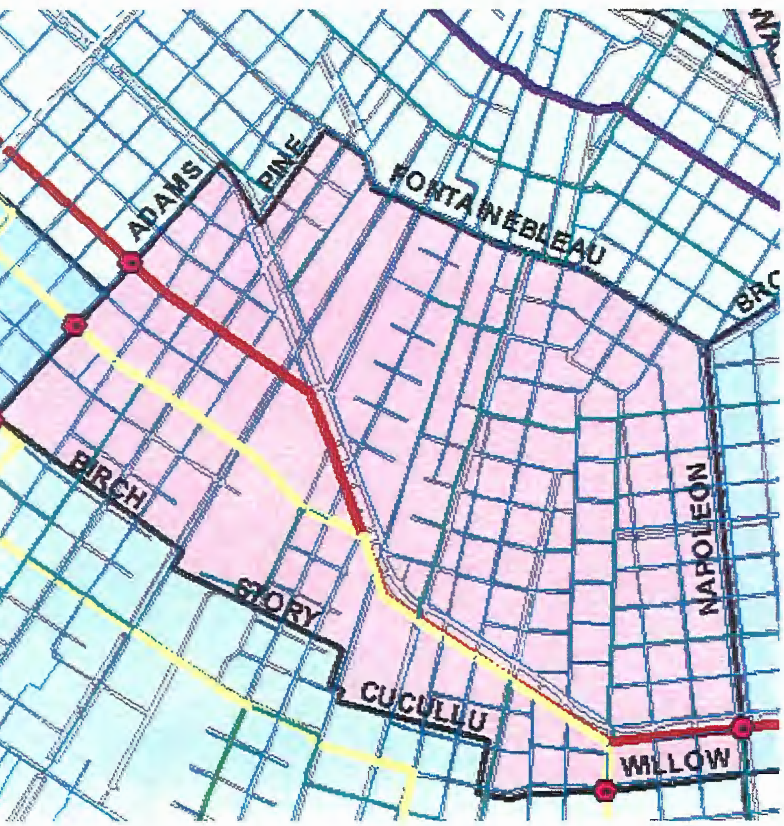
East Bank District 18	
Length of Water Main	32 miles
Number of Service Connections	4,718
Density of Service Connections	145 service connections/mile
Number of Closed Valves	67
Number of District Meters	5
Average Daily Demand (1997-2001)	1.9 MGD



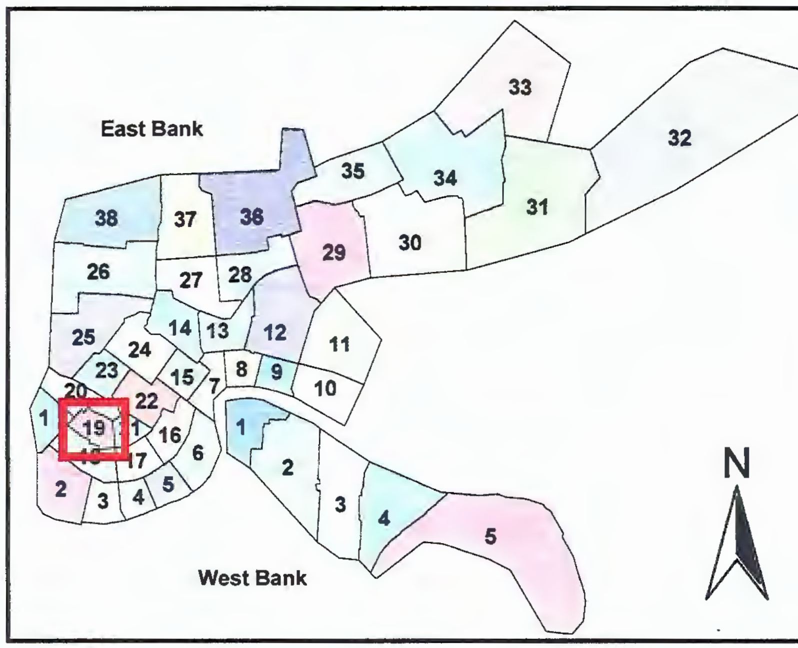
Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 18
Figure 20 of 45

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR
Sewerage & Water Board OF

MW

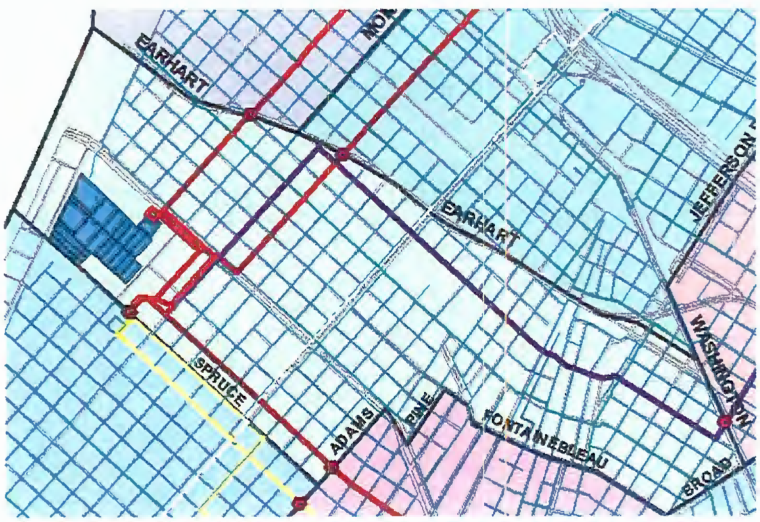


East Bank District 19	
Length of Water Main	22 miles
Number of Service Connections	2,797
Density of Service Connections	126 service connections/mile
Number of Closed Valves	54
Number of District Meters	5
Average Daily Demand (1997-2001)	0.8 MGD

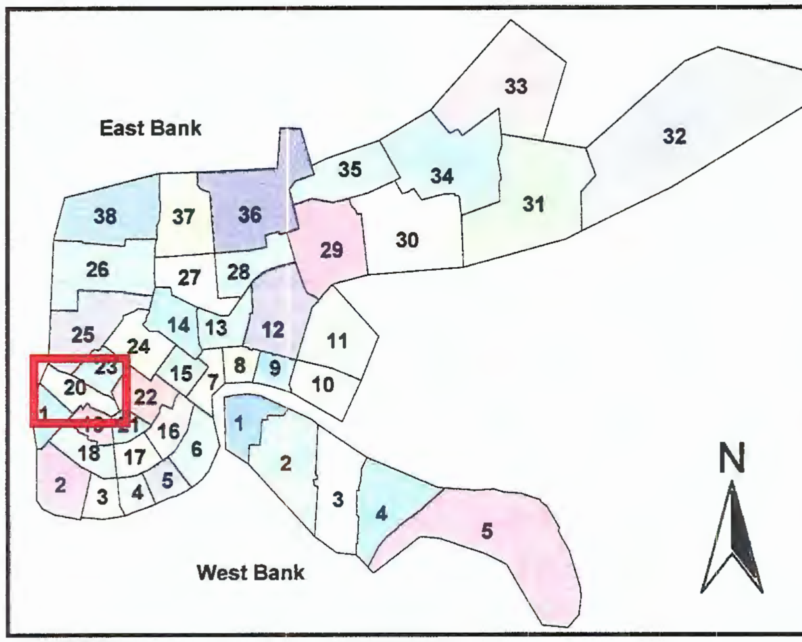


Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 19
Figure 21 of 45

Sewerage & Water Board

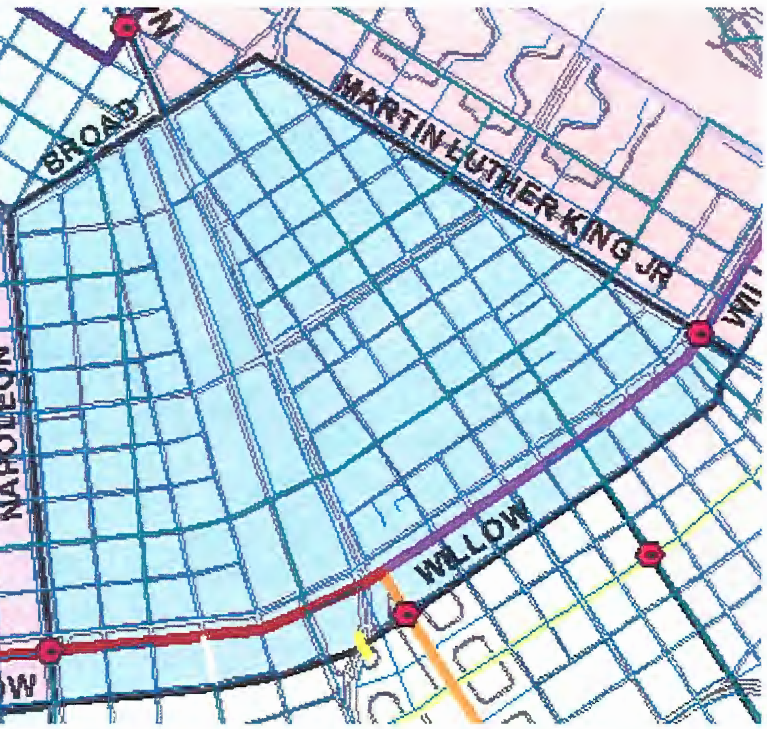


East Bank District 20	
Length of Water Main	
Number of Service Connections	3,798
Density of Service Connections	#DIV/0!
Number of Closed Valves	43
Number of District Meters	6
Average Daily Demand (1997-2001)	1.7 MGD

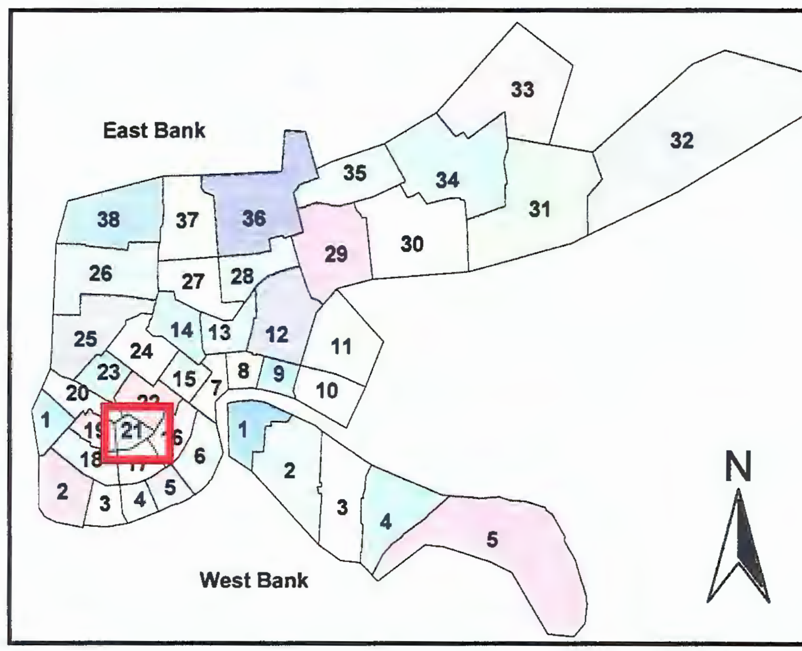


Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 20
Figure 22 of 45

Sewerage & Water Board of

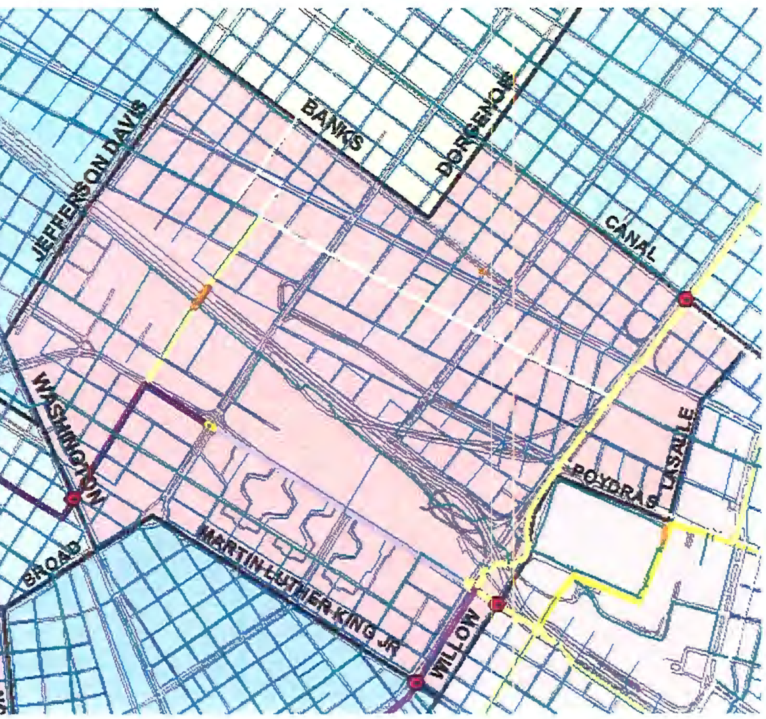


East Bank District 21	
Length of Water Main	19 miles
Number of Service Connections	1,933
Density of Service Connections	103 service connections/mile
Number of Closed Valves	38
Number of District Meters	3
Average Daily Demand (1997-2001)	0.9 MGD

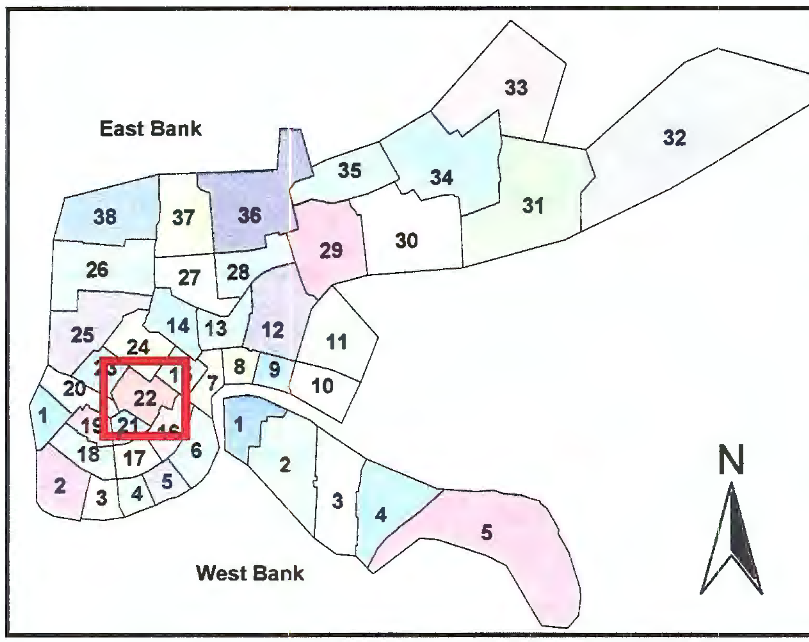


Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 21
Figure 23 of 45

Sewerage & Water Board



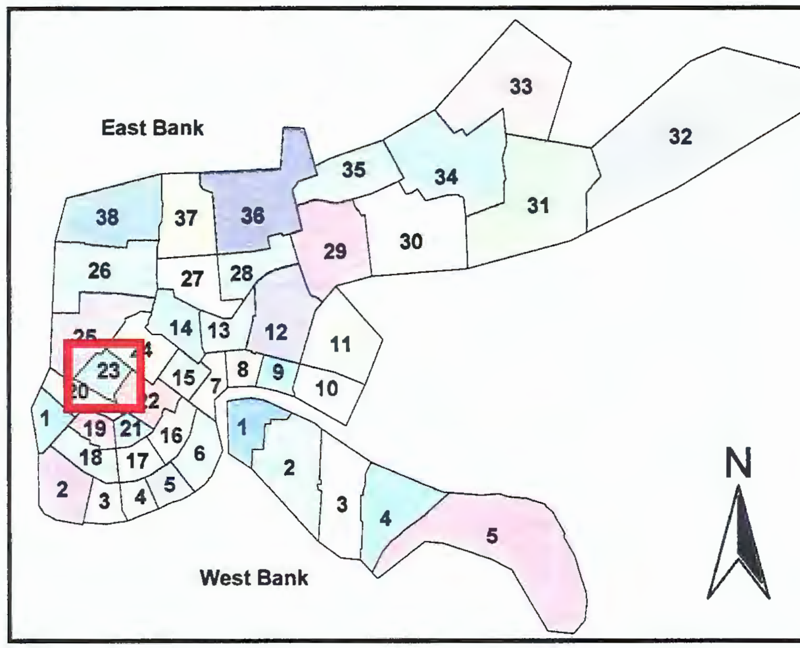
East Bank District 22	
Length of Water Main	39 miles
Number of Service Connections	1,597
Density of Service Connections	41 service connections/mile
Number of Closed Valves	51
Number of District Meters	4
Average Daily Demand (1997-2001)	3.5 MGD



Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 22
Figure 24 of 45

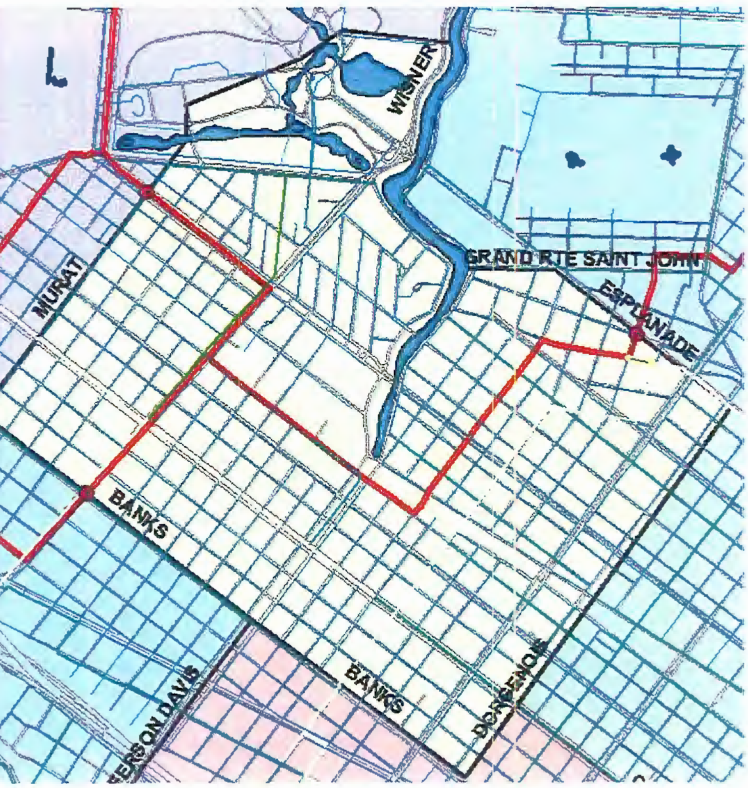
RE-BUILDING THE CITY'S WATER SYSTEMS FOR
Sewerage & Water Board OF
MW

East Bank District 23	
Length of Water Main	28 miles
Number of Service Connections	2,686
Density of Service Connections	94 service connections/mile
Number of Closed Valves	44
Number of District Meters	2
Average Daily Demand (1997-2001)	1.3 MGD

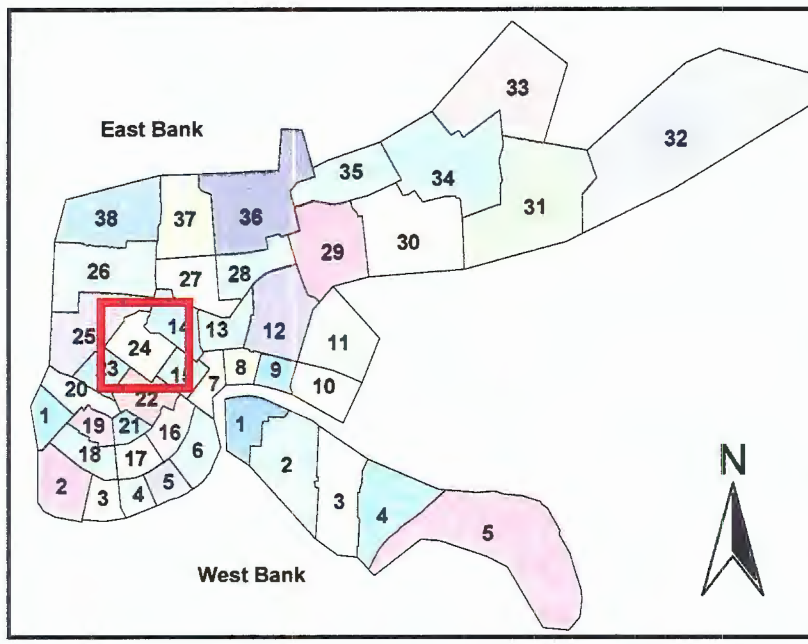


Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 23
Figure 25 of 45

Sewerage & Water Board

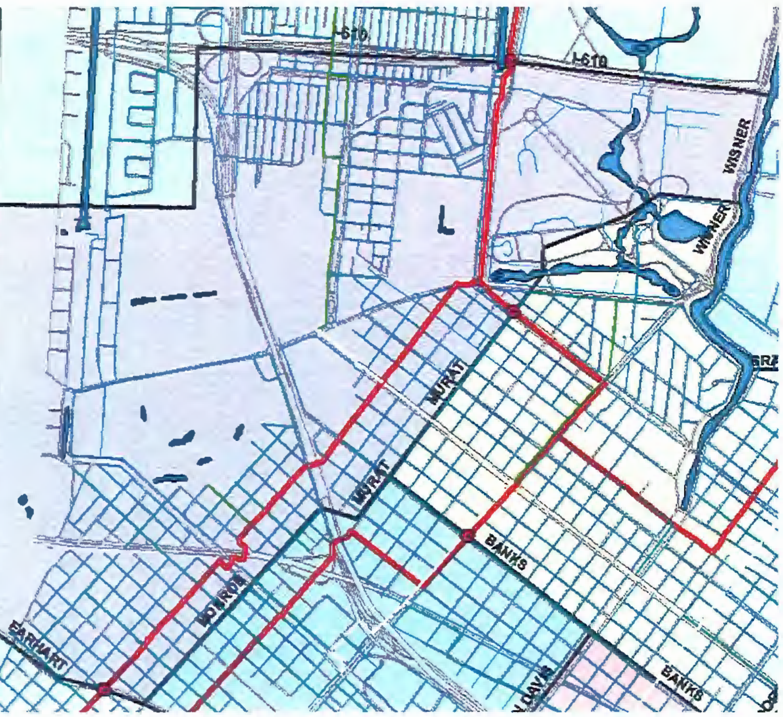


East Bank District 24	
Length of Water Main	49 miles
Number of Service Connections	6,187
Density of Service Connections	126 service connections/mile
Number of Closed Valves	73
Number of District Meters	3
Average Daily Demand (1997-2001)	2.3 MGD

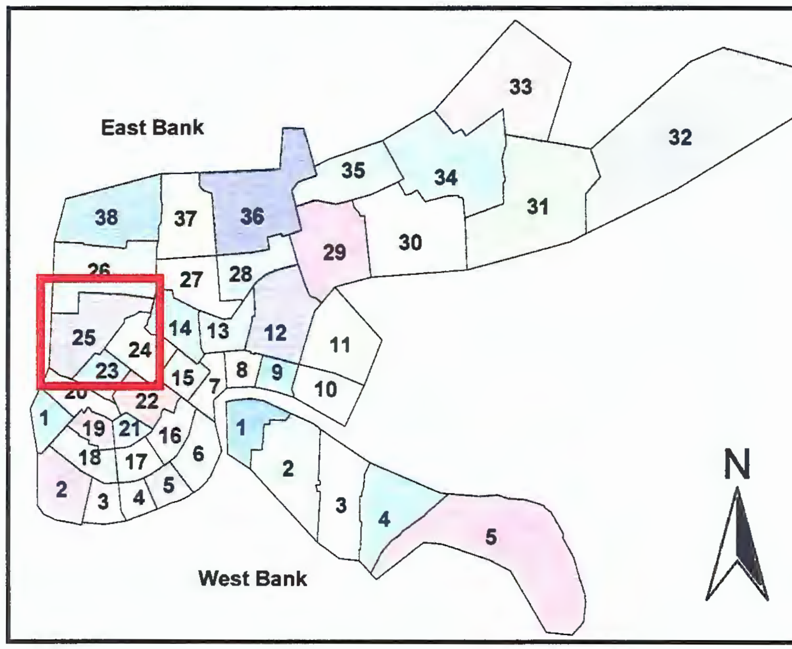


Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 24
Figure 26 of 45

Sewerage & Water Board OF

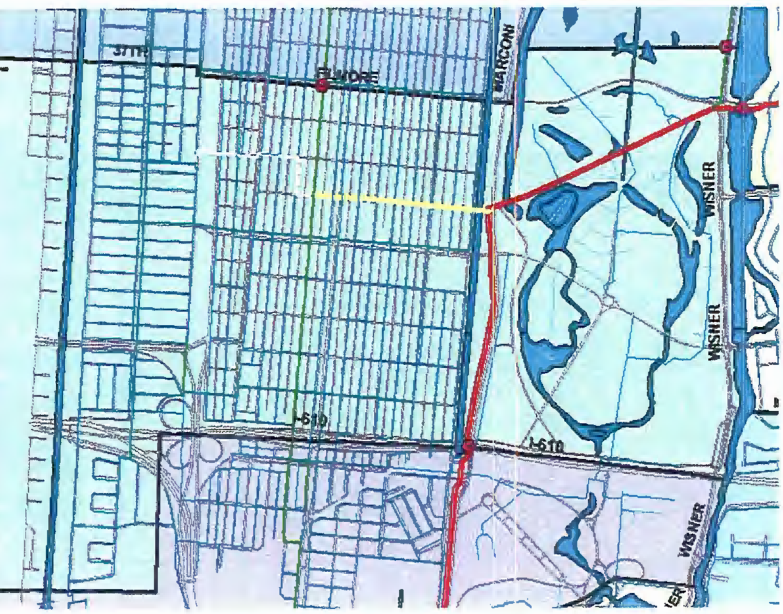


East Bank District 25	
Length of Water Main	44 miles
Number of Service Connections	4,076
Density of Service Connections	93 service connections/mile
Number of Closed Valves	47
Number of District Meters	3
Average Daily Demand (1997-2001)	1.7 MGD

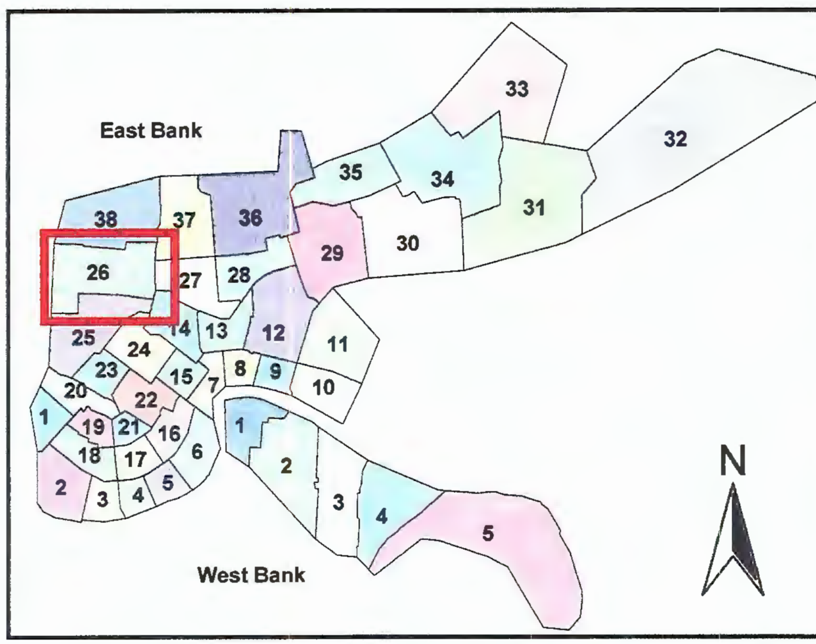


Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 25
Figure 27 of 45

RE-BUILDING THE CITY'S WATER SYSTEMS
Sewerage & Water Board

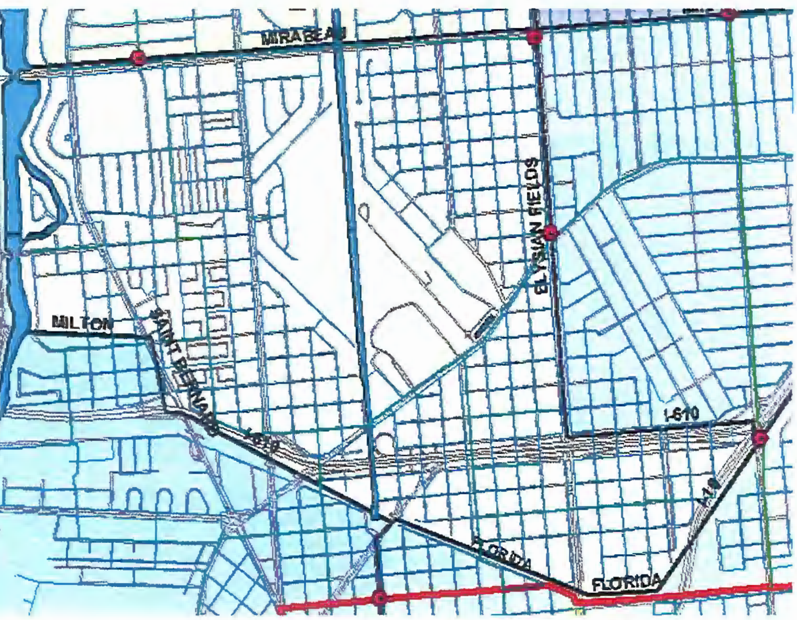


East Bank District 26	
Length of Water Main	51 miles
Number of Service Connections	4,695
Density of Service Connections	93 service connections/mile
Number of Closed Valves	32
Number of District Meters	4
Average Daily Demand (1997-2001)	1.3 MGD

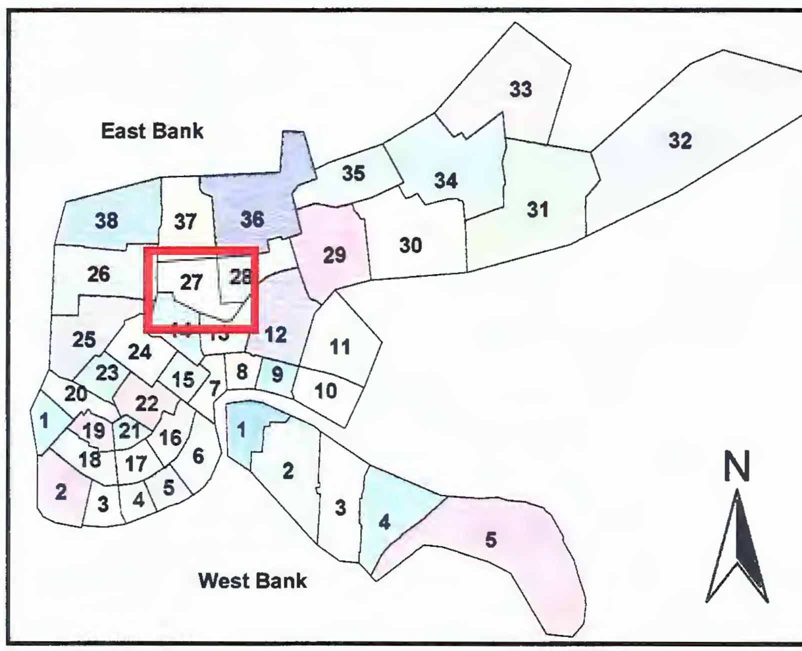


Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 26
Figure 28 of 45

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR
Sewerage & Water Board OF
MW



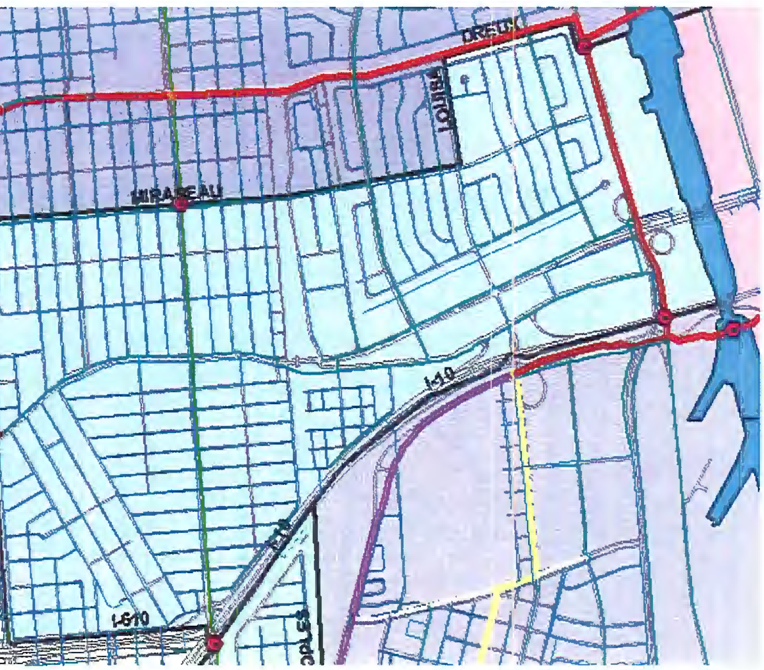
East Bank District 27	
Length of Water Main	45 miles
Number of Service Connections	4,477
Density of Service Connections	99 service connections/mile
Number of Closed Valves	28
Number of District Meters	3
Average Daily Demand (1997-2001)	1.5 MGD



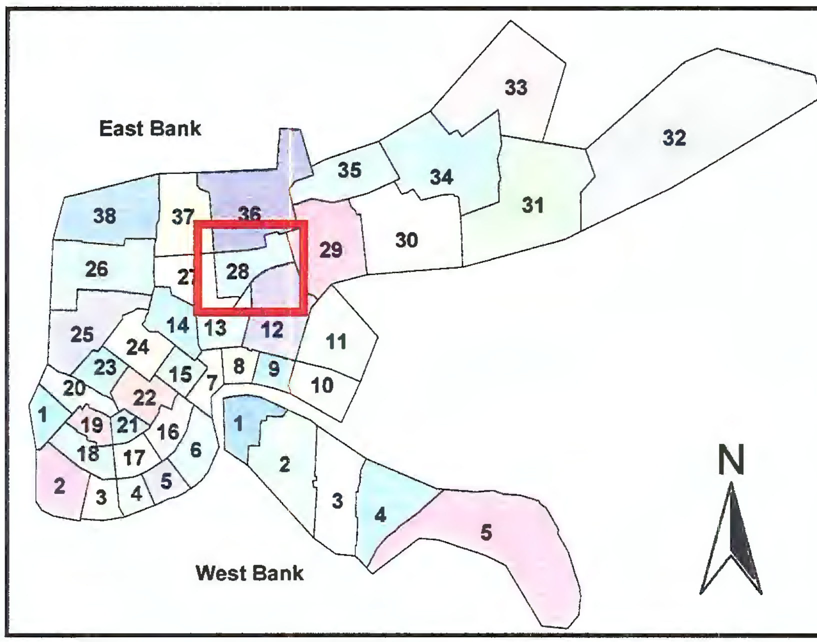
Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 27
Figure 29 of 45

Sewerage & Water Board

MV

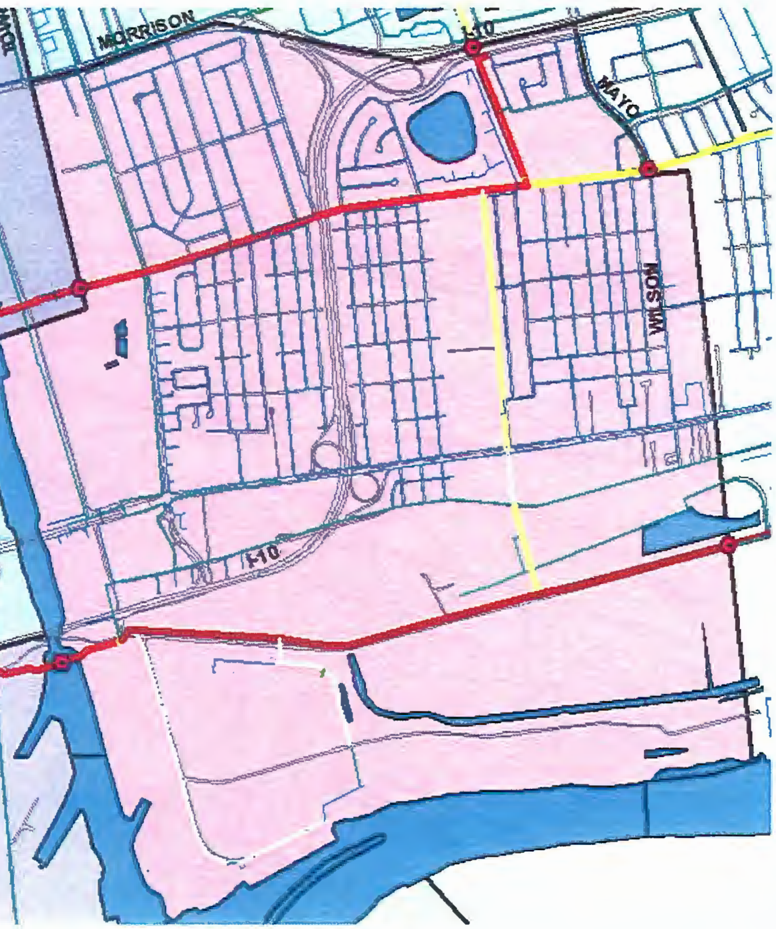


East Bank District 28	
Length of Water Main	38 miles
Number of Service Connections	4,590
Density of Service Connections	121 service connections/mile
Number of Closed Valves	37
Number of District Meters	6
Average Daily Demand (1997-2001)	1.5 MGD

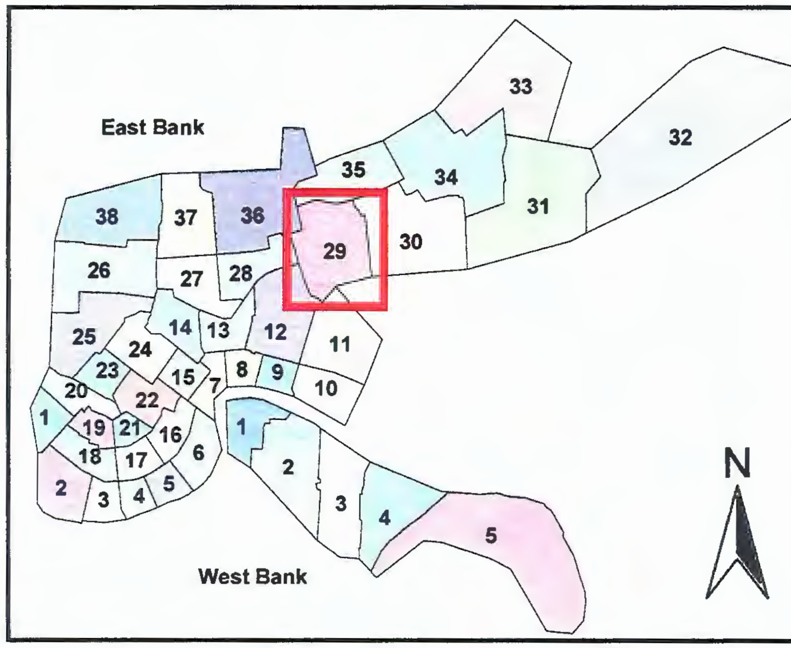


Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 28
Figure 30 of 45

Sewerage & Water Board OF

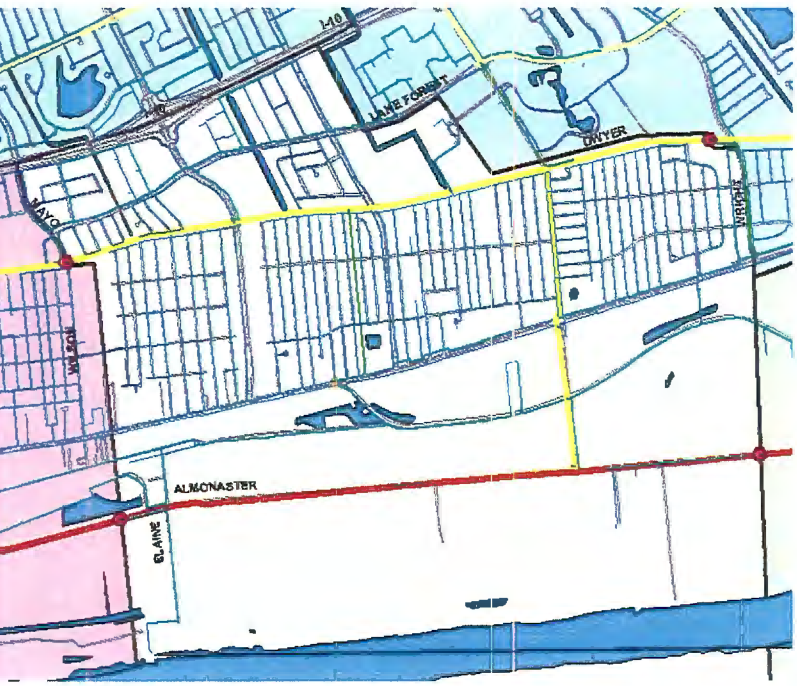


East Bank District 29	
Length of Water Main	42 miles
Number of Service Connections	3,547
Density of Service Connections	85 service connections/mile
Number of Closed Valves	11
Number of District Meters	5
Average Daily Demand (1997-2001)	1.6 MGD

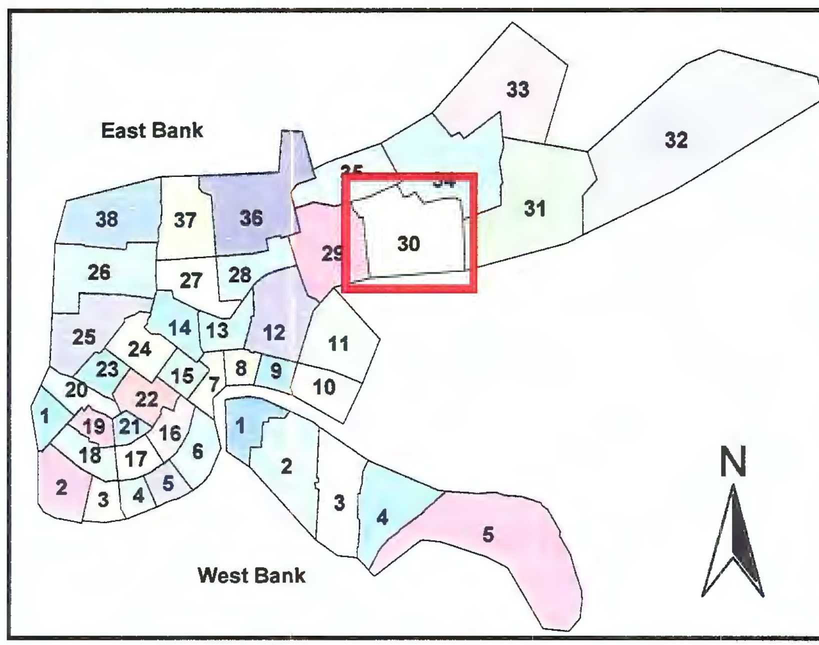


Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 29
Figure 31 of 45

Sewerage & Water Board
MW



East Bank District 30	
Length of Water Main	63 miles
Number of Service Connections	4,779
Density of Service Connections	76 service connections/mile
Number of Closed Valves	14
Number of District Meters	4
Average Daily Demand (1997-2001)	1.9 MGD

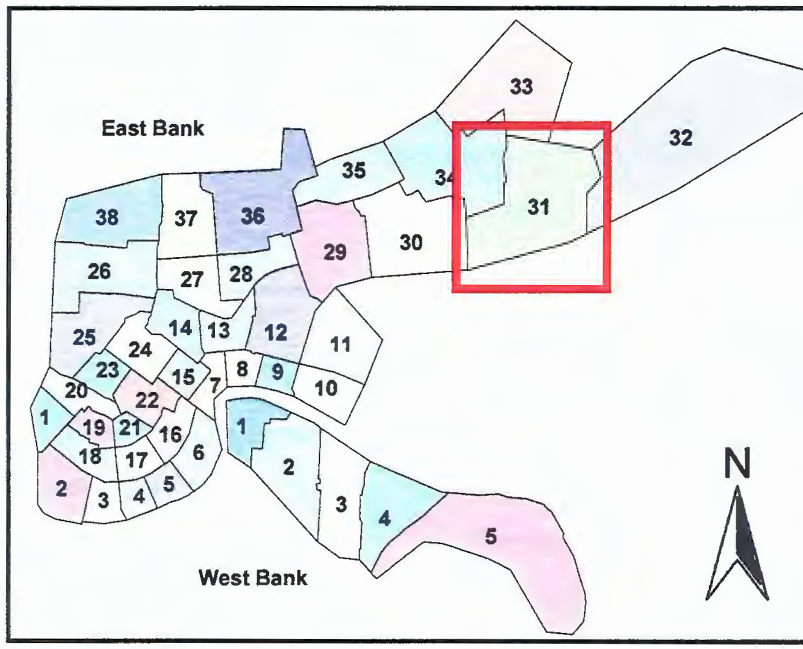


Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 30
Figure 32 of 45

Sewerage & Water Board OF

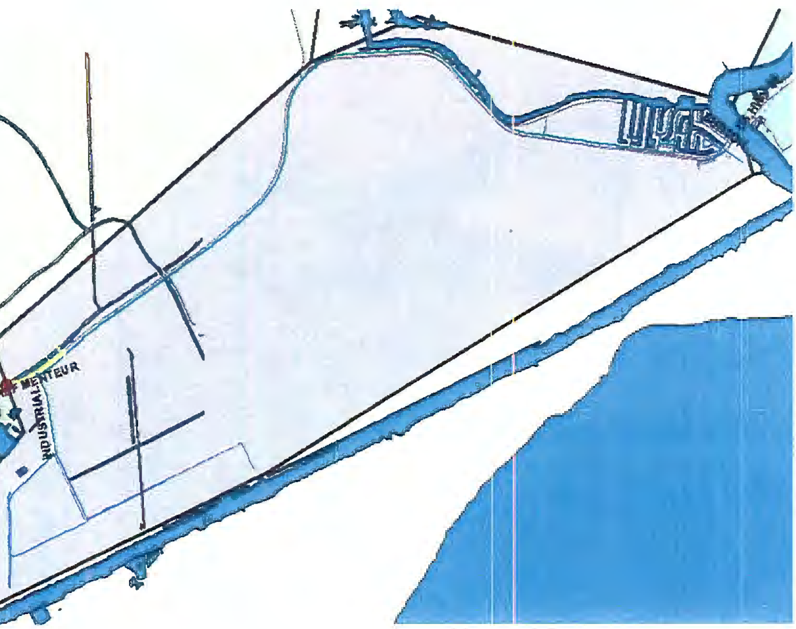
MW

East Bank District 31	
Length of Water Main	35 miles
Number of Service Connections	2,053
Density of Service Connections	58 service connections/mile
Number of Closed Valves	1
Number of District Meters	4
Average Daily Demand (1997-2001)	2.1 MGD

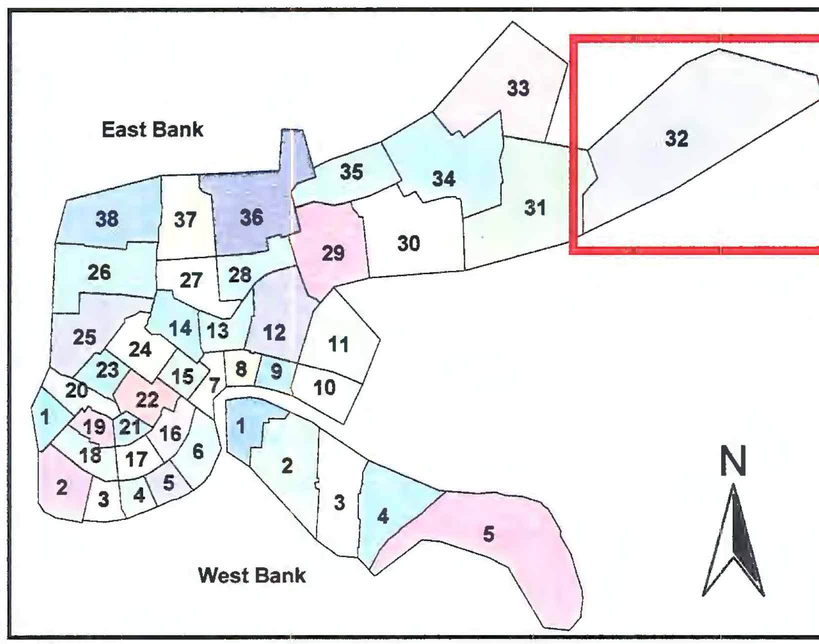


Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 31
Figure 33 of 45

Sewerage & Water Board
MV

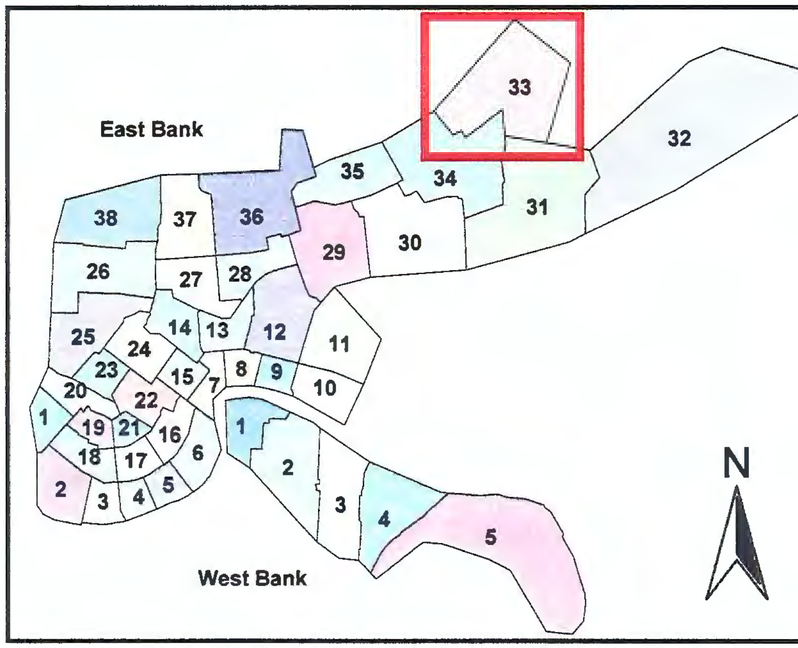


East Bank District 32	
Length of Water Main	17 miles
Number of Service Connections	435
Density of Service Connections	26 service connections/mile
Number of Closed Valves	0
Number of District Meters	1
Average Daily Demand (1997-2001)	0.3 MGD



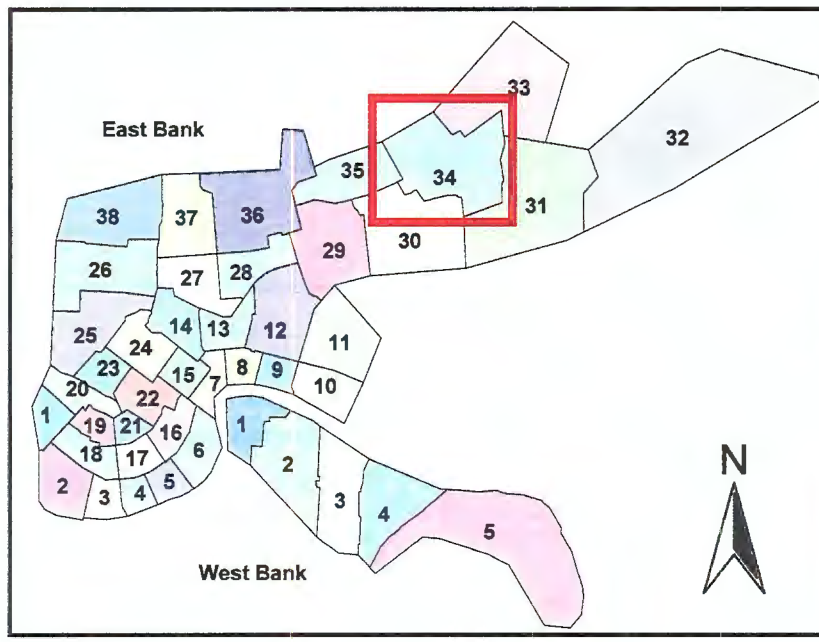
Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 32
Figure 34 of 45

East Bank District 33	
Length of Water Main	33 miles
Number of Service Connections	3,391
Density of Service Connections	104 service connections/mile
Number of Closed Valves	3
Number of District Meters	2
Average Daily Demand (1997-2001)	1.1 MGD



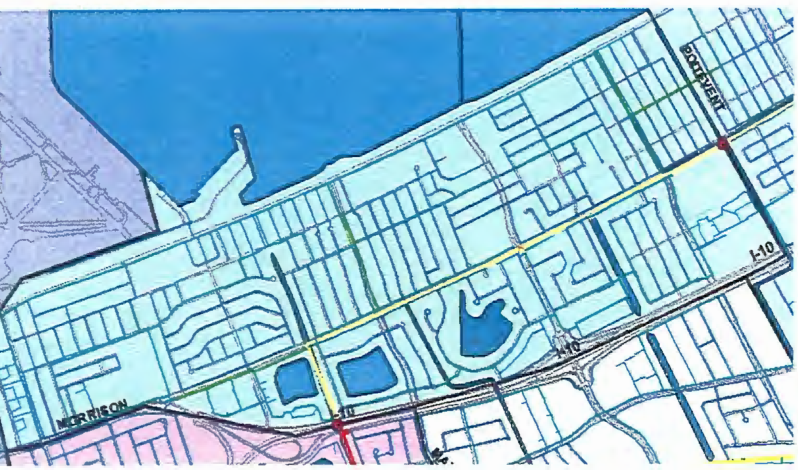
Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 33
Figure 35 of 45

East Bank District 34	
Length of Water Main	69 miles
Number of Service Connections	5,245
Density of Service Connections	76 service connections/mile
Number of Closed Valves	10
Number of District Meters	4
Average Daily Demand (1997-2001)	2.6 MGD

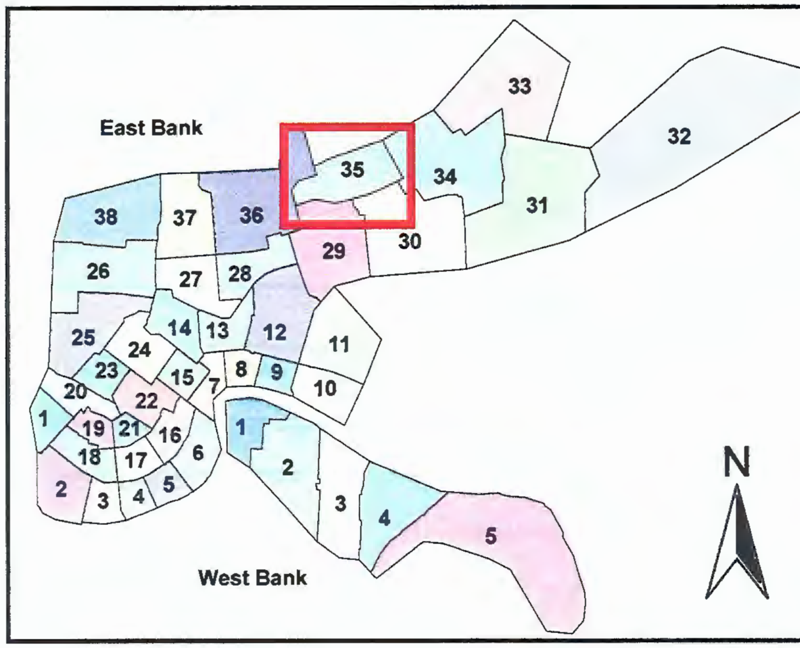


Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 34
Figure 36 of 45

"RE-BUILDING THE CITY'S WATER SYSTEMS FOR
Sewerage & Water Board OF
MW

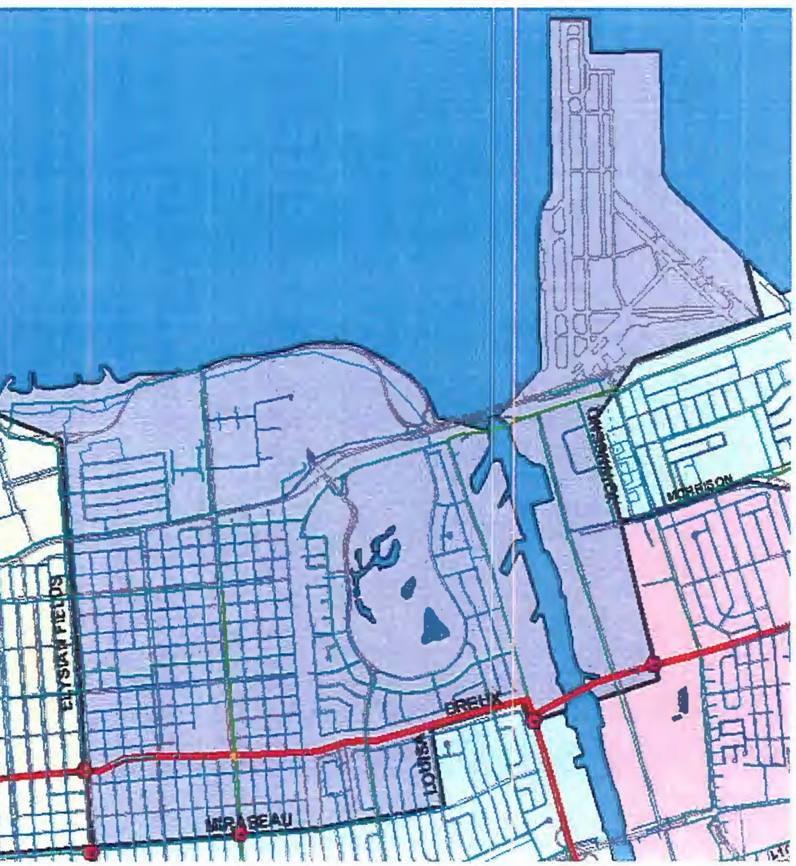


East Bank District 35	
Length of Water Main	48 miles
Number of Service Connections	4,806
Density of Service Connections	100 service connections/mile
Number of Closed Valves	5
Number of District Meters	2
Average Daily Demand (1997-2001)	2.0 MGD

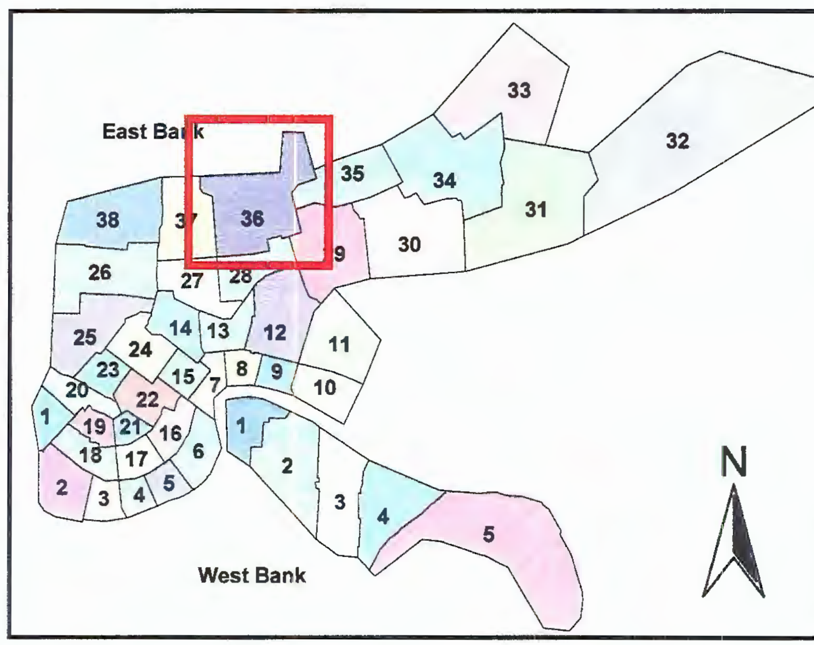


Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 35
Figure 37 of 45

Sewerage & Water Board



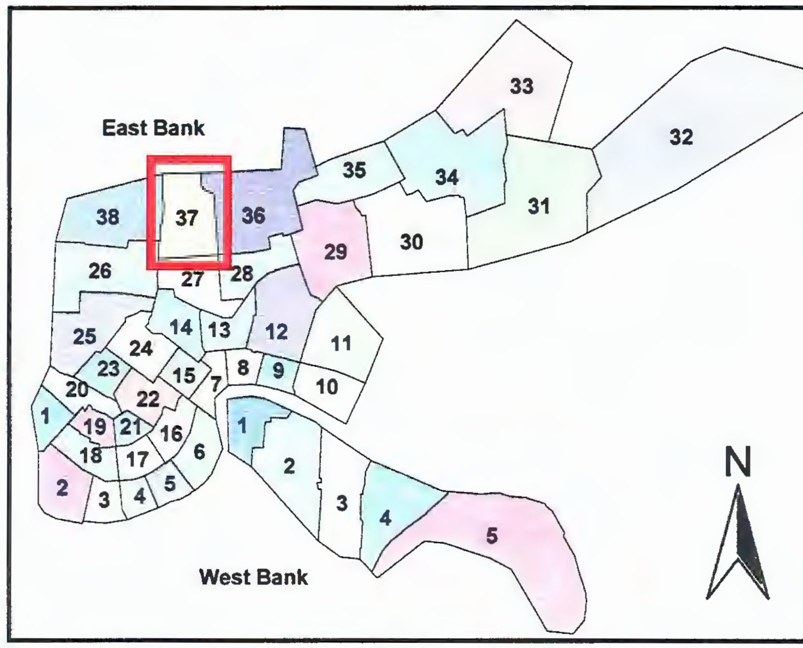
East Bank District 36	
Length of Water Main	56 miles
Number of Service Connections	4,330
Density of Service Connections	78 service connections/mile
Number of Closed Valves	38
Number of District Meters	4
Average Daily Demand (1997-2001)	1.4 MGD



Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 36
Figure 38 of 45

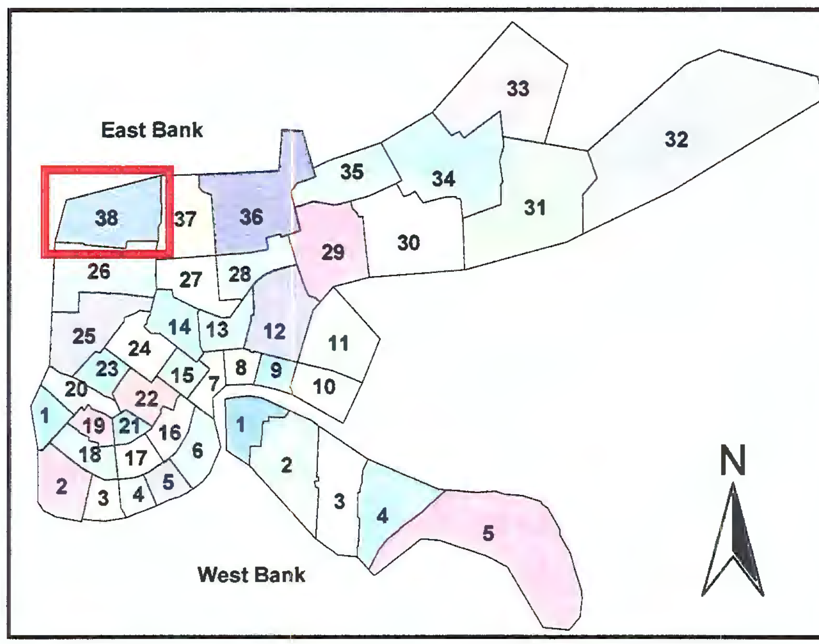
Sewerage & Water Board

East Bank District 37	
Length of Water Main	47 miles
Number of Service Connections	4,010
Density of Service Connections	86 service connections/mile
Number of Closed Valves	21
Number of District Meters	3
Average Daily Demand (1997-2001)	1.2 MGD



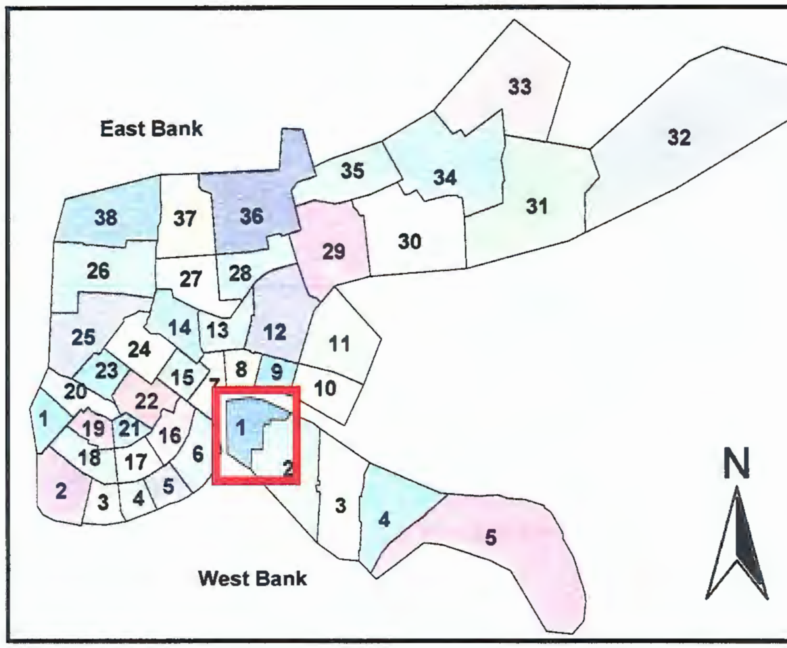
Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 37
Figure 39 of 45

East Bank District 38	
Length of Water Main	45 miles
Number of Service Connections	3,820
Density of Service Connections	85 service connections/mile
Number of Closed Valves	23
Number of District Meters	2
Average Daily Demand (1997-2001)	2.2 MGD



Water Distribution System
Assessment and Hydraulic Model
East Bank District Metering Area 38
Figure 40 of 45

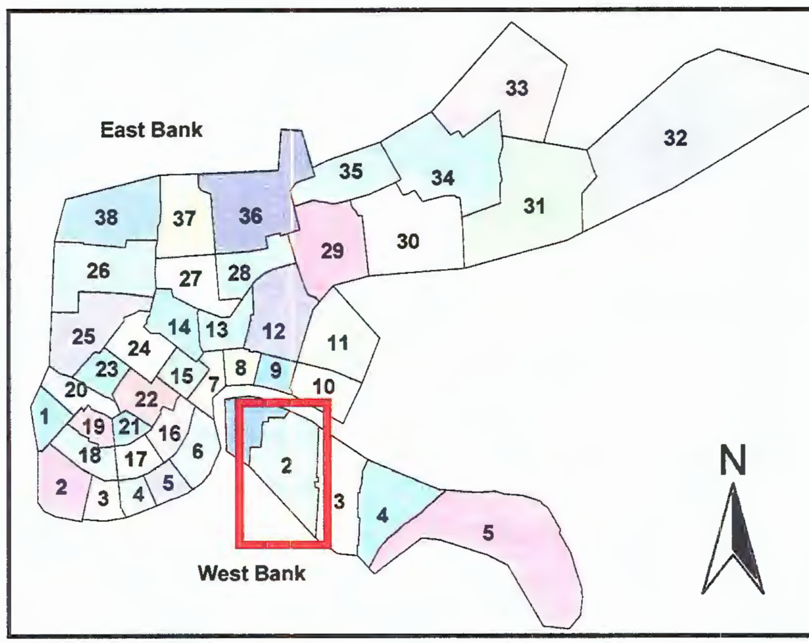
West Bank District 1	
Length of Water Main	30 miles
Number of Service Connections	2,825
Density of Service Connections	95 service connections/mile
Number of Closed Valves	10
Number of District Meters	3
Average Daily Demand (1997-2001)	2.0 MGD



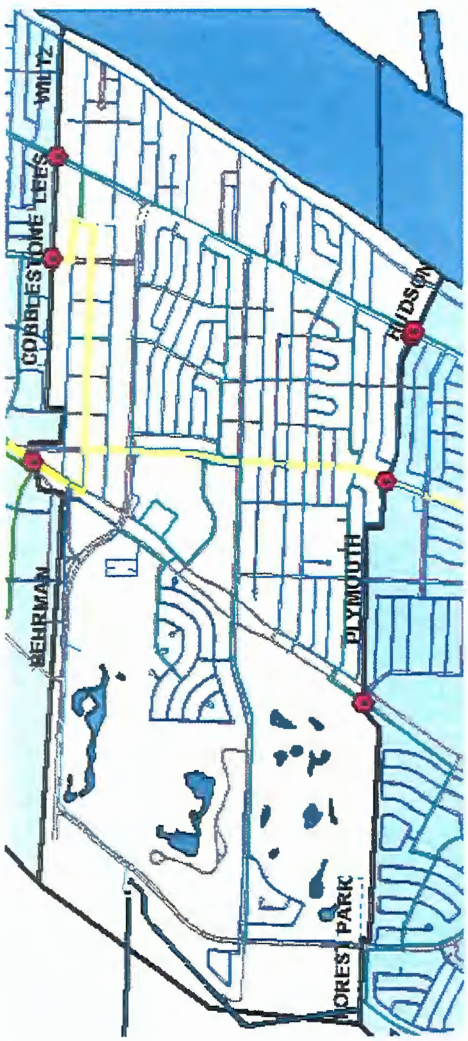
Water Distribution System
Assessment and Hydraulic Model
West Bank District Metering Area 1
Figure 41 of 45

Sewerage & Water Board

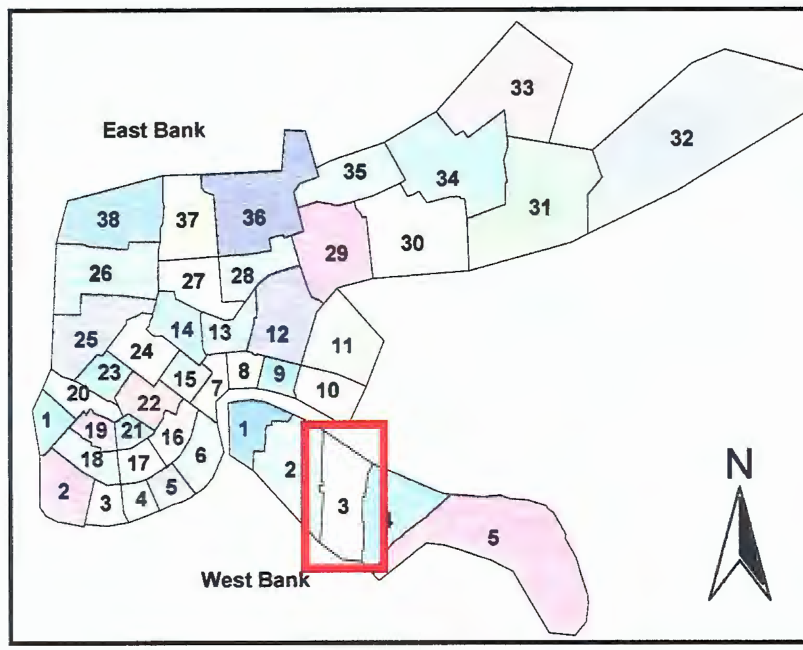
West Bank District 2	
Length of Water Main	51 miles
Number of Service Connections	3,442
Density of Service Connections	67 service connections/mile
Number of Closed Valves	14
Number of District Meters	6
Average Daily Demand (1997-2001)	2.1 MGD



Water Distribution System
Assessment and Hydraulic Model
West Bank District Metering Area 2
Figure 42 of 45

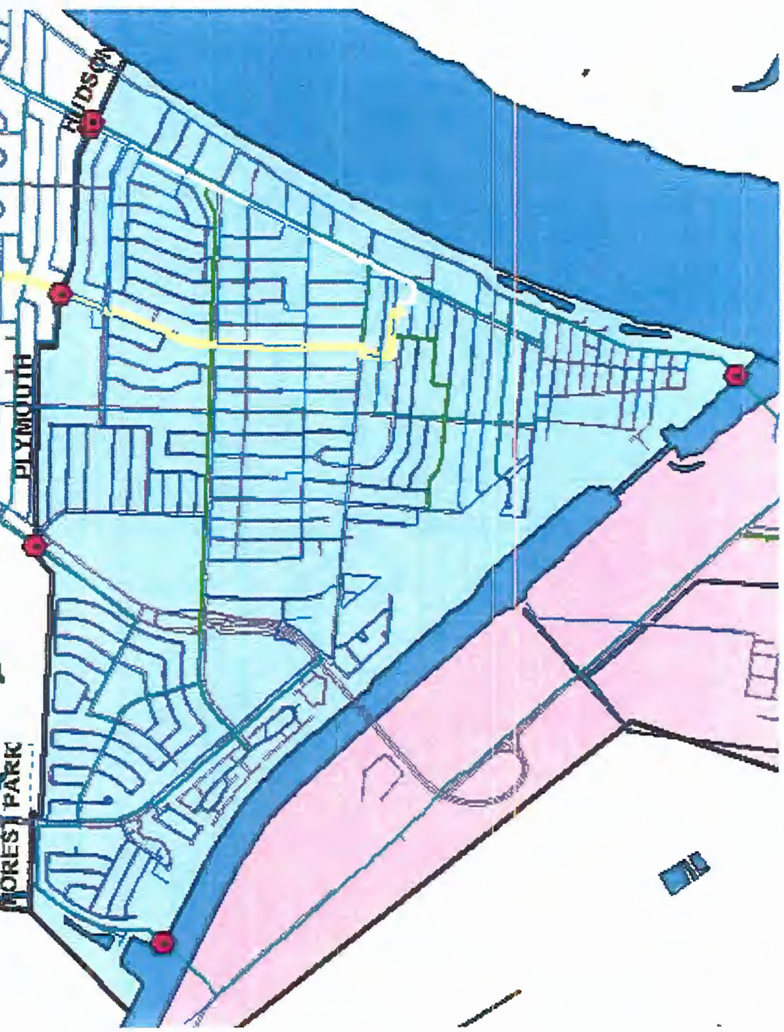


West Bank District 3	
Length of Water Main	44 miles
Number of Service Connections	3,986
Density of Service Connections	90 service connections/mile
Number of Closed Valves	9
Number of District Meters	7
Average Daily Demand (1997-2001)	1.4 MGD

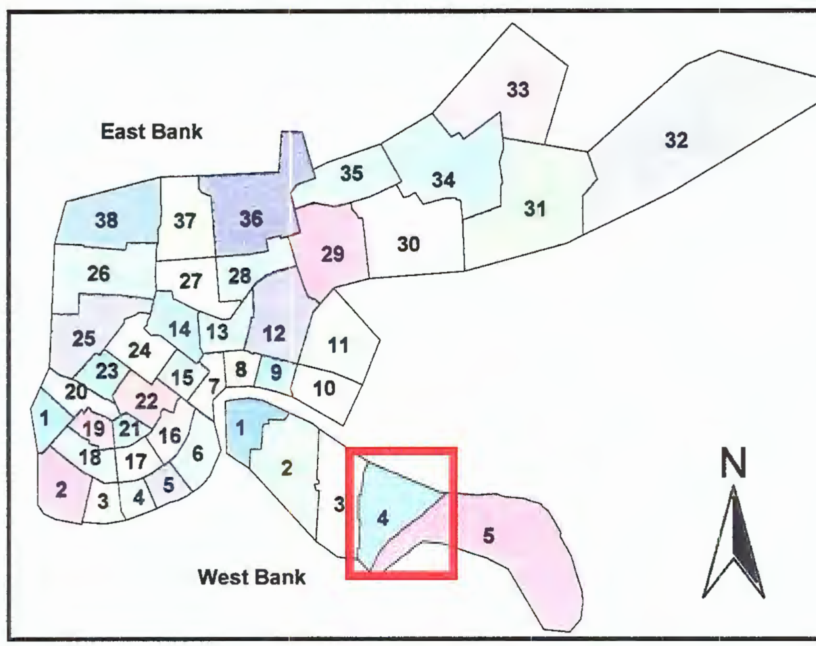


Water Distribution System
Assessment and Hydraulic Model
West Bank District Metering Area 3
Figure 43 of 45

Sewerage & Water Board



West Bank District 4	
Length of Water Main	52 miles
Number of Service Connections	4,156
Density of Service Connections	81 service connections/mile
Number of Closed Valves	5
Number of District Meters	6
Average Daily Demand (1997-2001)	1.8 MGD

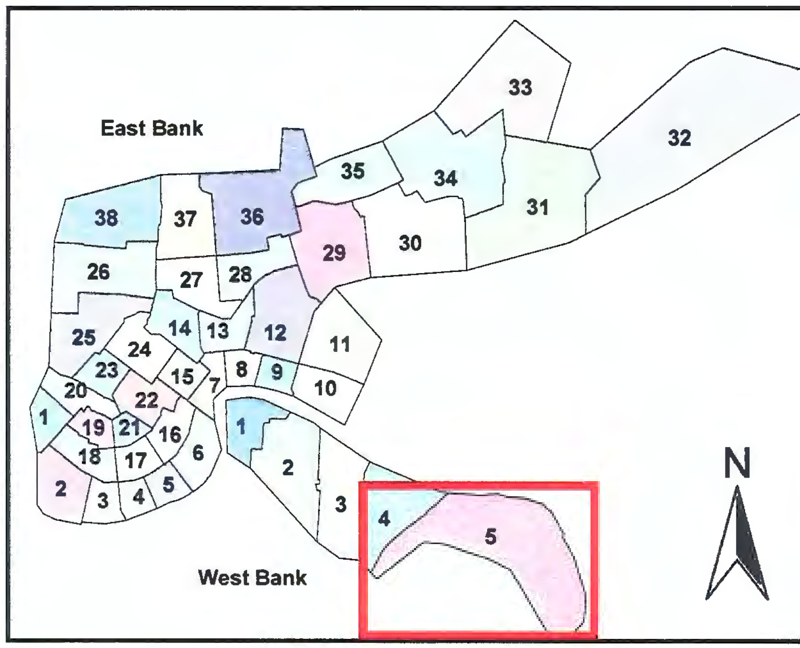


Water Distribution System
Assessment and Hydraulic Model
West Bank District Metering Area 4
Figure 44 of 45

Sewerage & Water Board OF

MW

West Bank District 5	
Length of Water Main	19 miles
Number of Service Connections	521
Density of Service Connections	27 service connections/mile
Number of Closed Valves	0
Number of District Meters	2
Average Daily Demand (1997-2001)	0.2 MGD



Water Distribution System
Assessment and Hydraulic Model
West Bank District Metering Area 5
Figure 45 of 45

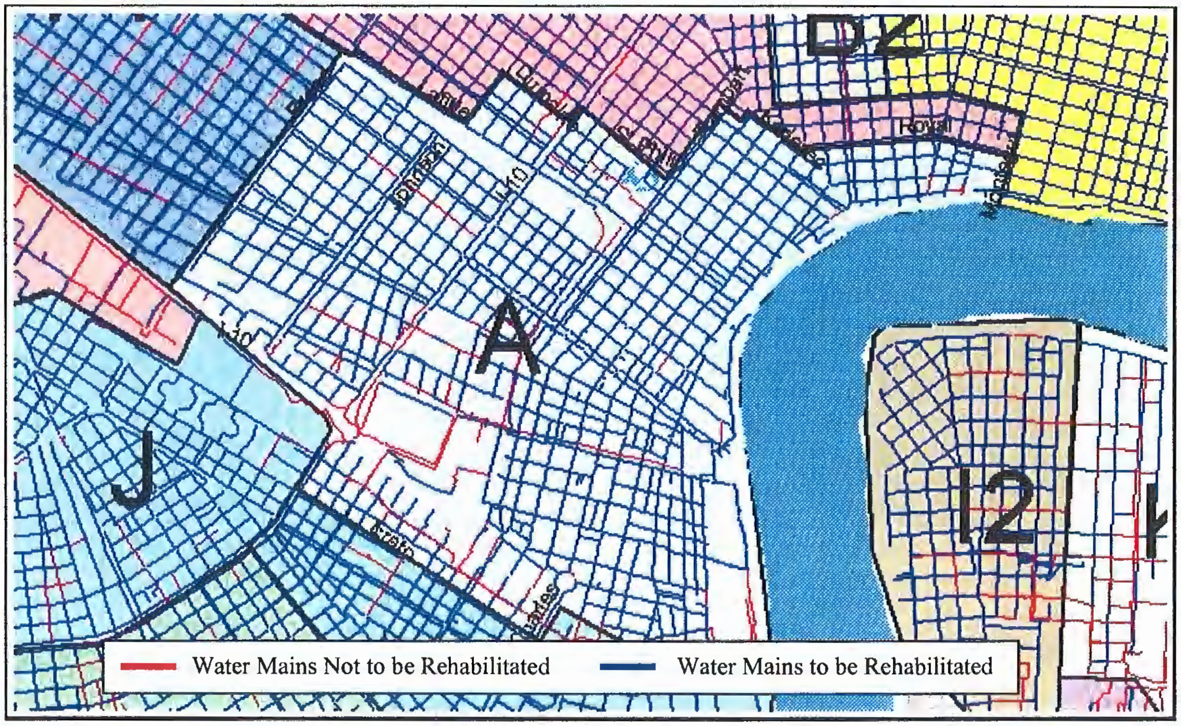
Structural Rehabilitation Projects

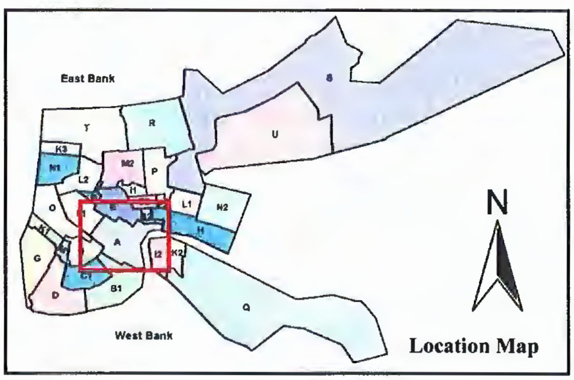
APPENDIX H

Water Main Prioritiazation PAN and Cost

newal Year verage Life xpectancy	Water Main ID (RECNO)	Location	Installation Year	Diameter (inches)	Material	Length (feet)	Leaks/ Breaks	Age	Water Material	Location	Critical Customer	Total	E (Es in
2005	161364	East Bank	1909	12	CI	130	40	73	16	20	30	178.9	
2005	110131	East Bank	1909	12	CI	172	40	73	16	20	30	178.9	
2005	123143	East Bank	1908	4	CI	39	40	74	16	14	30	174.3	
2005	144370	East Bank	1908	6	CI	127	40	74	16	10	30	170.3	
2005	128200	East Bank	1908	6	CI	388	40	74	16	10	30	170.3	
2005	128929	East Bank	1907	4	CI	603	40	76	16	8	30	169.7	
2005	160295	East Bank	1905	6	CI	401	40	78	16	4	30	168.5	
2005	109929	East Bank	1907	6	CI	603	20	76	16	20	30	161.7	
2005	161423	East Bank	1908	8	CI	369	20	74	16	20	30	160.3	
2005	160277	East Bank	1908	20	CI	421	40	65	16	4	30	154.7	
2005	153026	East Bank	1905	6	CI	384	20	78	16	10	30	154.5	
2005	111111	East Bank	1908	4	CI	1,126	20	74	16	14	30	154.3	
2005	110870	East Bank	1908	4	CI	679	20	74	16	14	30	154.3	
2005	163969	East Bank	1907	12	CI	275	40	76	16	20	0	151.7	
2005	153925	East Bank	1907	12	CI	332	40	76	16	20	0	151.7	
2005	163999	East Bank	1907	8	CI	170	40	76	16	20	0	151.7	
2005	130971	East Bank	1907	6	CI	397	20	76	16	10	30	151.7	
2005	125253	East Bank	1907	4	CI	1,387	20	76	16	10	30	151.7	
2005	162007	East Bank	1907	6	CI	1,617	20	76	16	10	30	151.7	
2005	113211	East Bank	1907	6	CI	1,745	20	76	16	10	30	151.7	
2005	129086	East Bank	1907	4	CI	1,378	20	76	16	10	30	151.7	
2005	162932	East Bank	1908	6	CI	89	40	74	16	20	0	150.3	
2005	109925	East Bank	1908	6	CI	263	40	74	16	20	0	150.3	
2005	153314	East Bank	1908	6	CI	308	20	74	16	10	30	150.3	
2005	109664	East Bank	1908	6	CI	369	20	74	16	10	30	150.3	
2005	162793	East Bank	1908	6	CI	515	20	74	16	10	30	150.3	
2005	162086	East Bank	1908	6	CI	1,388	20	74	16	10	30	150.3	
2005	128166	East Bank	1908	6	CI	869	20	74	16	10	30	150.3	
2005	153542	East Bank	1908	4	CI	939	20	74	16	10	30	150.3	
2005	108340	West Bank	1908	6	CI	769	20	74	16	10	30	150.3	
2005	201267	East Bank	1908	6	CI	1,181	20	74	16	10	30	150.3	

This project consists of approximately 85 miles of water main recommended for rehabilitation. The proposed project area boundaries extend from the Mississippi River to Broad Avenue encompassing the French Quarter and the Central Business District. The project location is shown below.



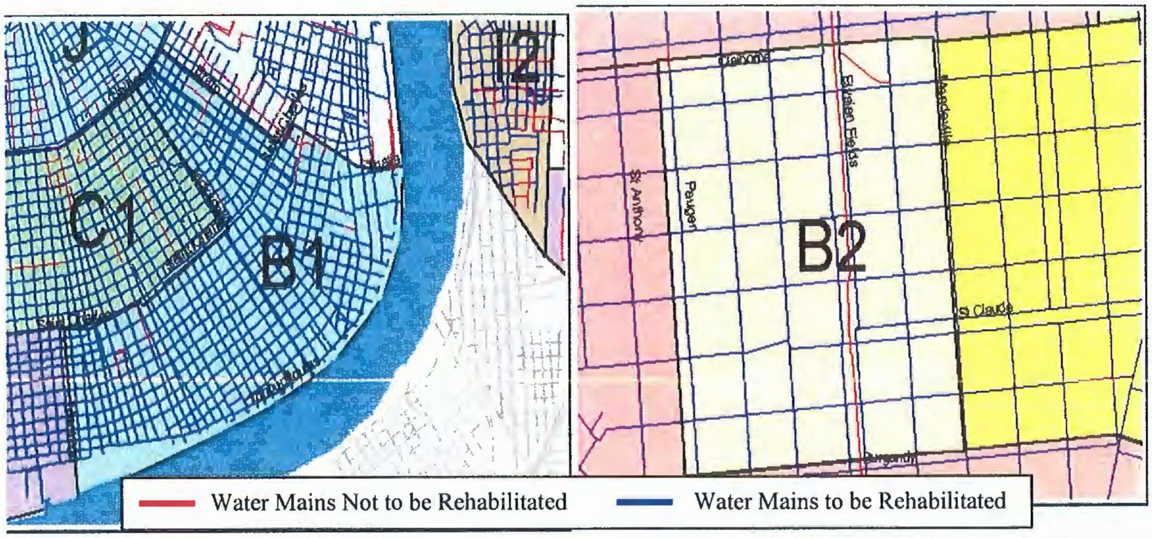


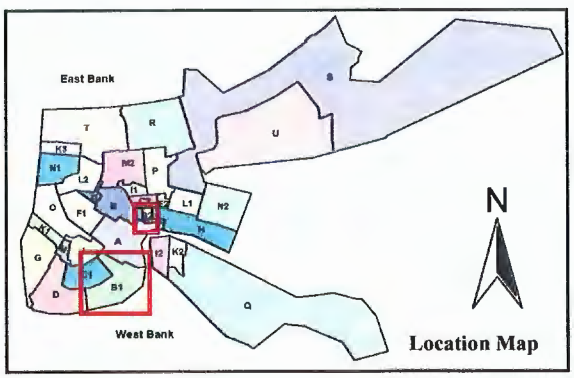
Project Area Statistics:

- Average weighted PAN 107.8
- Total length of water main 91.1 miles
- Length for rehabilitation 85.0 miles
- Percent replacement 93%

The planning level capital cost for this project is $181,000,000, not including inflation.

This project consists of approximately 77 miles of water main recommended for rehabilitation. The proposed project area boundaries for B1 extend from the Mississippi River to Claiborne Avenue and from Constantinople Street to Erato Street. The project area boundaries for B2 extend from Burgundy Street to Claiborne Avenue and from Pauger Street and Mandeville Street. The project locations are shown below.



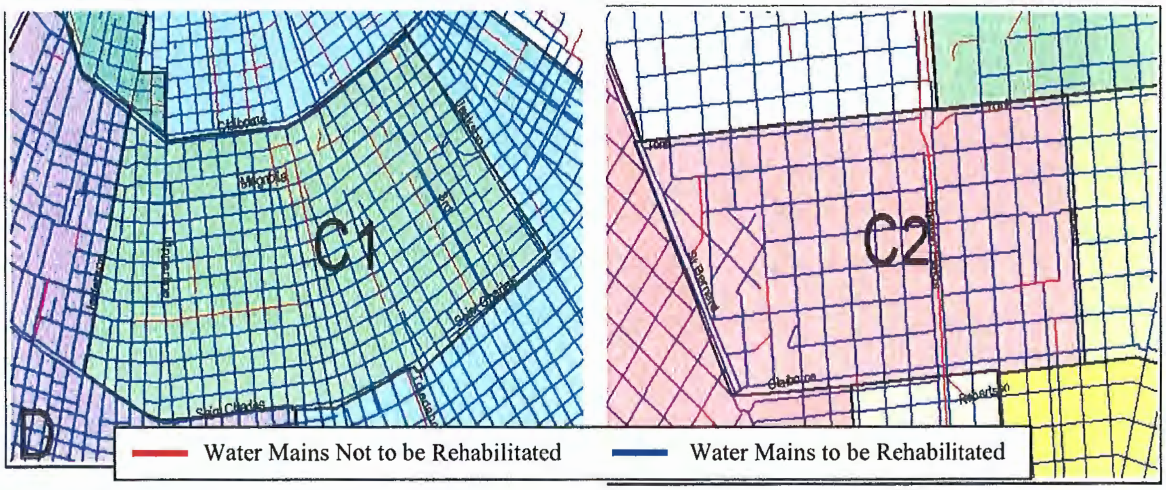


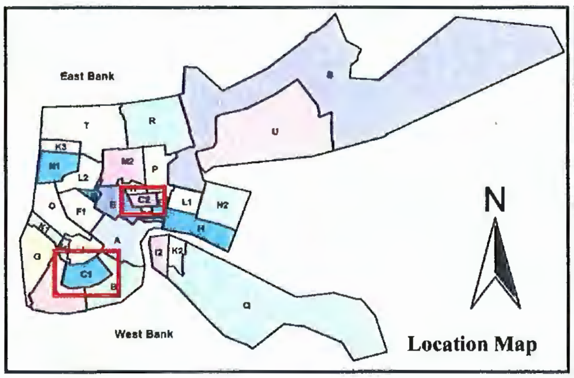
Project Area Statistics:

• Average weighted PAN (B1/B2)	104.5/102.8
• Total length of water main	78.7 miles
• Length for rehabilitation	77.4 miles
• Percent replacement	98%

The planning level capital cost for this project is $158,000,000, not including inflation.

This project consists of approximately 68 miles of water main recommended for rehabilitation. The proposed project area boundaries for C1 extend from St. Charles Avenue to Claiborne Avenue and from Jackson Avenue to Jefferson Avenue. The project area boundaries for C2 extend from Claiborne Avenue to Tonti Street and from Music Street to St. Bernard Avenue. The project locations are shown below.



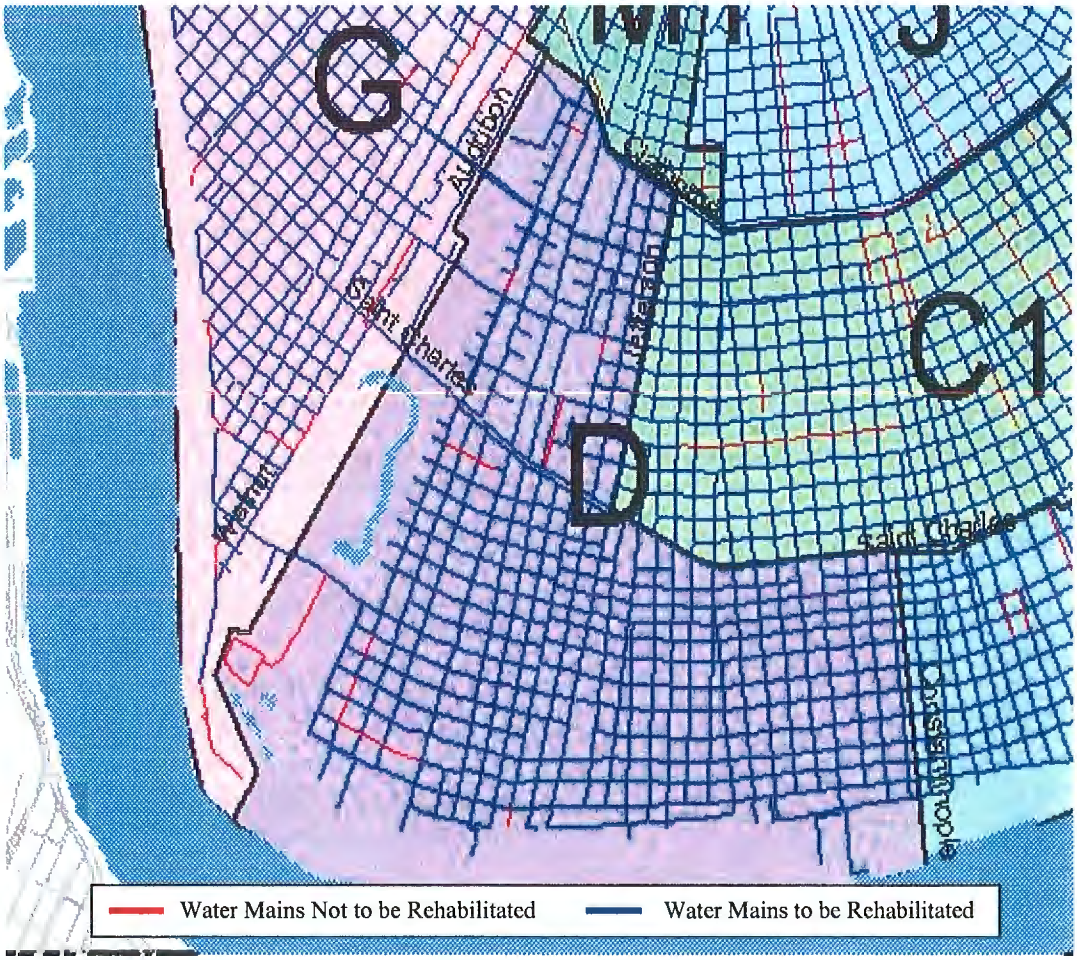


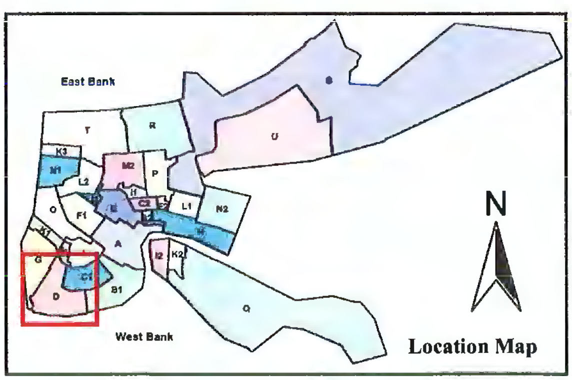
Project Area Statistics:

- Average weighted PAN (C1/C2) 103.8/102.3
- Total length of water main 72.6 miles
- Length for rehabilitation 68.1 miles
- Percent replacement 94%

The planning level capital cost for this project is $142,000,000, not including inflation.

This project consists of approximately 62 miles of water main recommended for rehabilitation. The proposed project area boundaries extend from the Mississippi River to Claiborne Avenue and from Constantinople Street to Audubon Street. The project location is shown below.



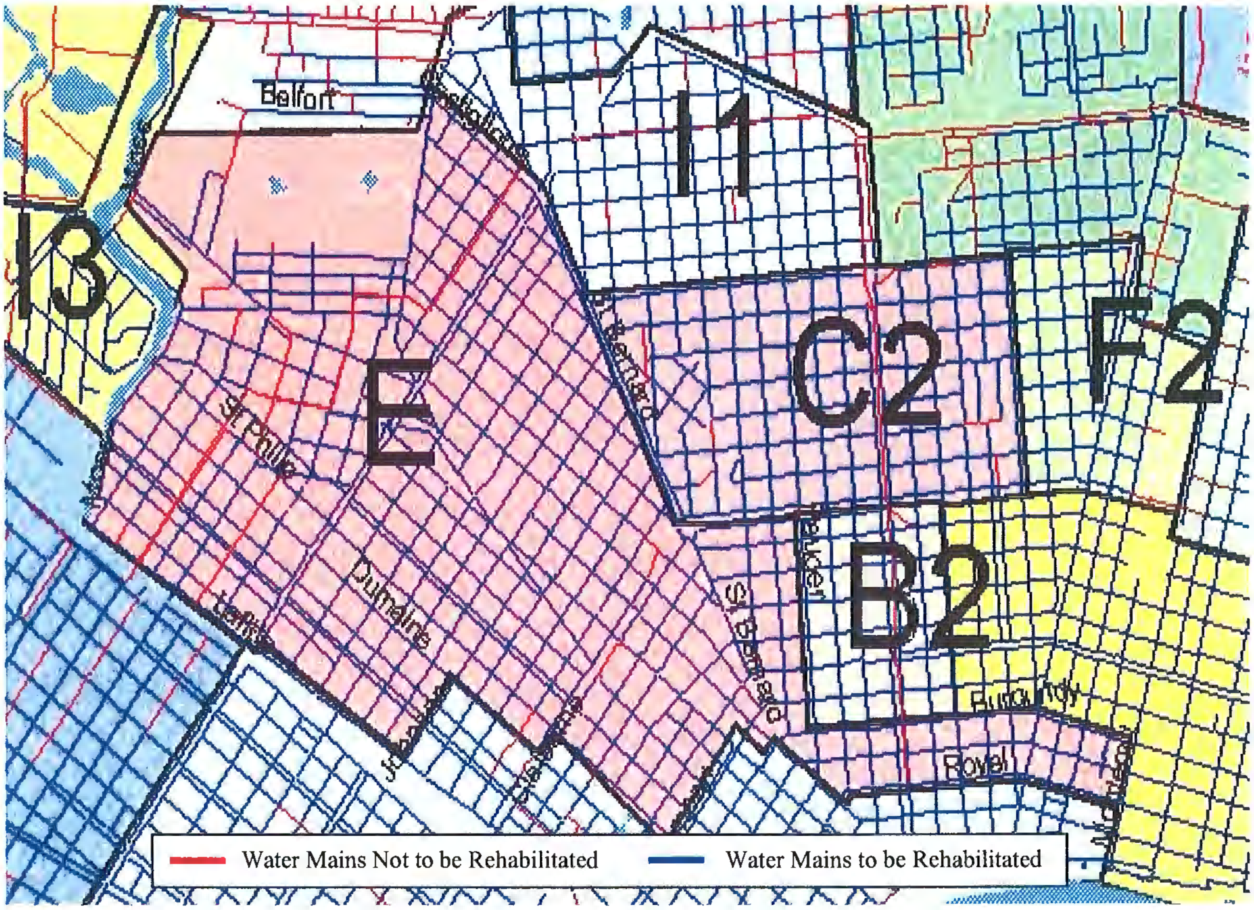


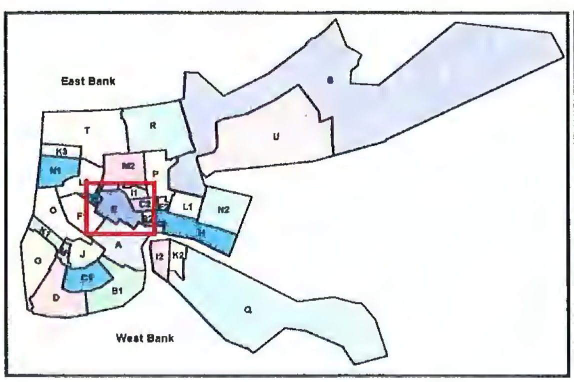
Project Area Statistics:

- Average weighted PAN 103.0
- Total length of water main 63.2 miles
- Length for rehabilitation 61.5 miles
- Percent replacement 97%

The planning level capital cost for this project is $127,000,000, not including inflation.

This project consists of approximately 54 miles of water main recommended for rehabilitation. The proposed project area boundaries extend from Royal Street to Belfort Street and from Lafitte Street to St. Bernard Street. The project location is shown below.



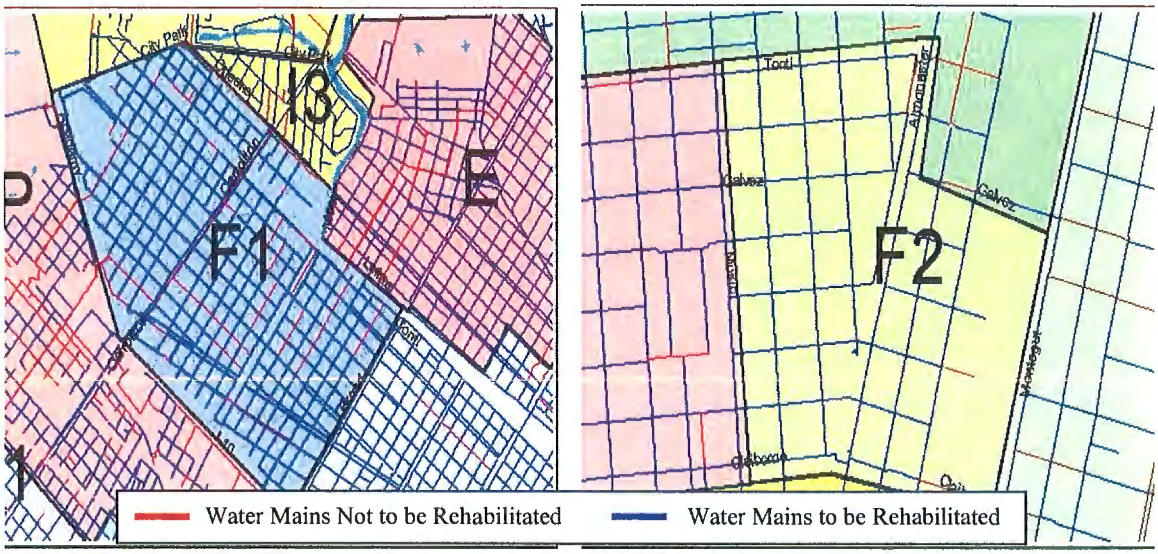


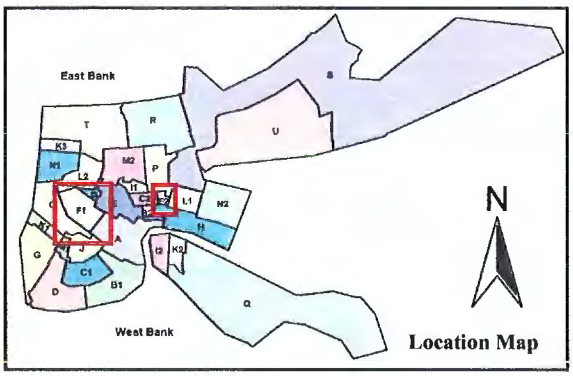
Project Area Statistics:

- Average weighted PAN 103.0
- Total length of water main 56.5 miles
- Length for rehabilitation 53.9 miles
- Percent replacement 95%

The planning level capital cost for this project is $110,000,000, not including inflation.

This project consists of approximately 50 miles of water main recommended for rehabilitation. The proposed project area boundaries for area F1 extend from Broad Avenue to City Park Avenue and from Orleans Avenue to Interstate 10. The proposed project area boundaries for area F2 extend from Tonti Street to Claiborne Avenue and from Montegut Street to Music Street. The project locations are shown below.



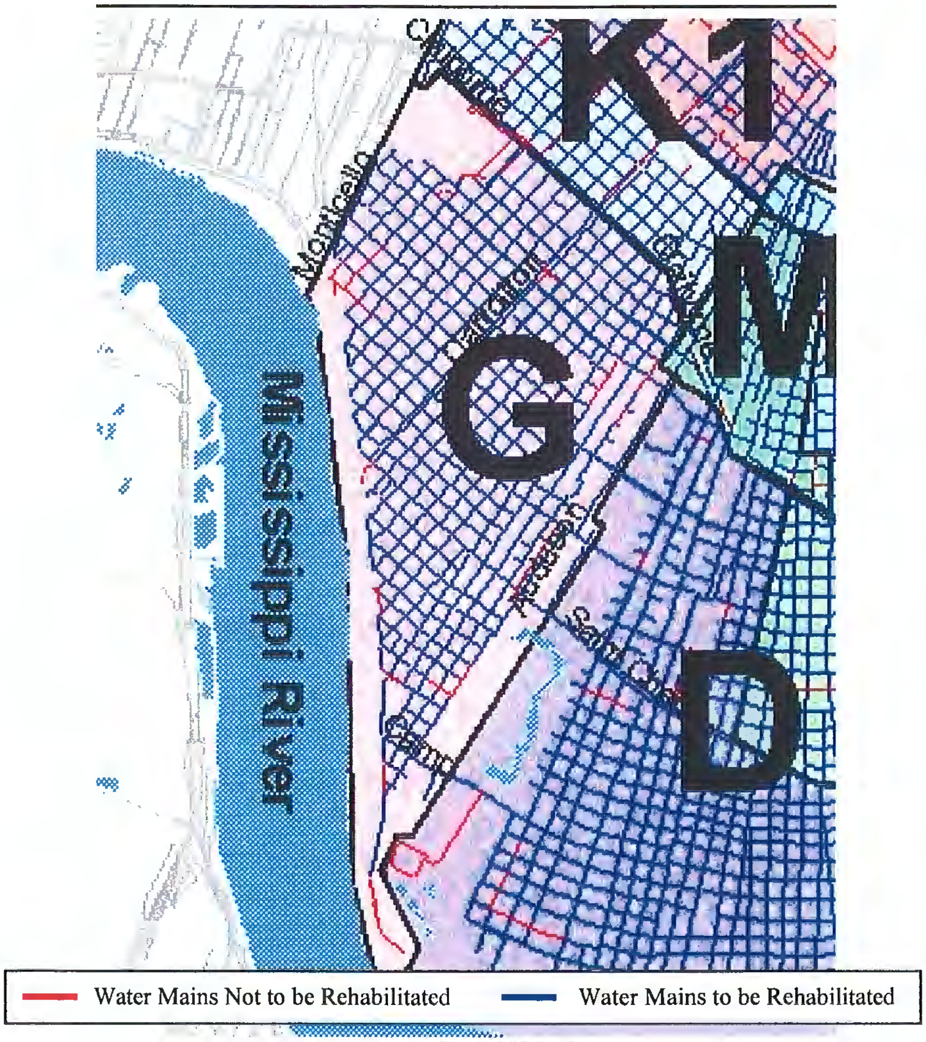


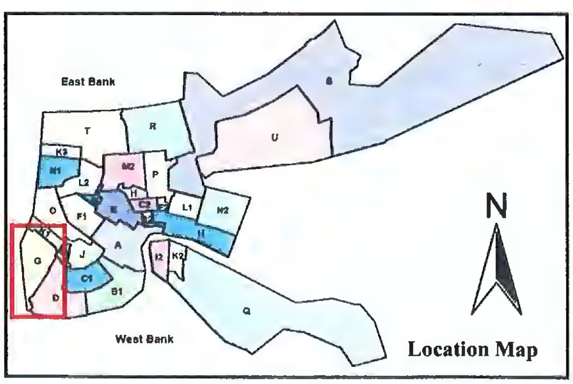
Project Area Statistics:

- Average weighted PAN (F1/F2) 101.6/100.0
- Total length of water main 55 miles
- Length for rehabilitation 50.4 miles
- Percent replacement 92%

The planning level capital cost for this project is $92,000,000, not including inflation.

This project consists of approximately 55 miles of water main recommended for rehabilitation. The proposed project area boundaries extend from the Mississippi River to Claiborne Avenue and from Audubon Street to the Orleans/Jefferson Parish border. The project location is shown below.



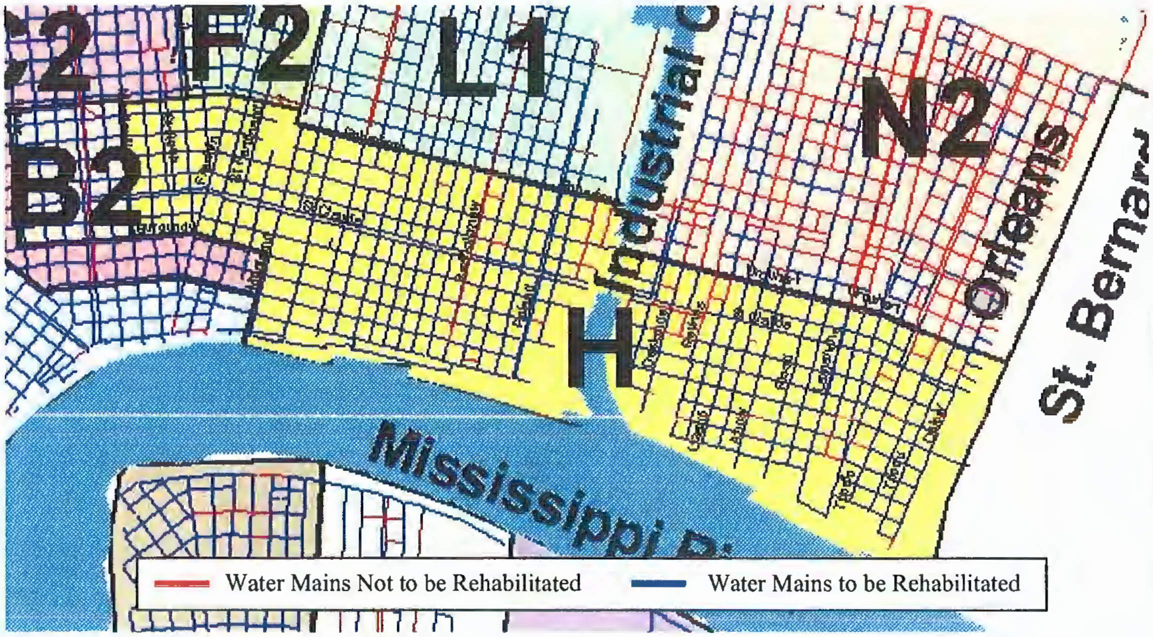


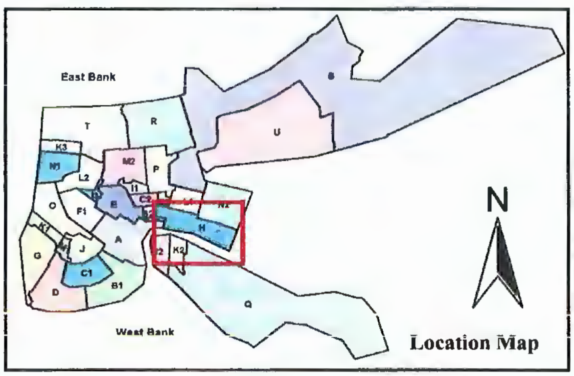
Project Area Statistics:

- Average weighted PAN 99.2
- Total length of water main 56.5 miles
- Length for rehabilitation 55.3 miles
- Percent replacement 94%

The planning level capital cost for this project is $131,000,000, not including inflation.

This project consists of approximately 53 miles of water main recommended for rehabilitation. The proposed project area boundaries extend from the Mississippi River to Robertson Street and from the Orleans/St. Bernard Parish border to Mandeville Street. The project location is shown below.





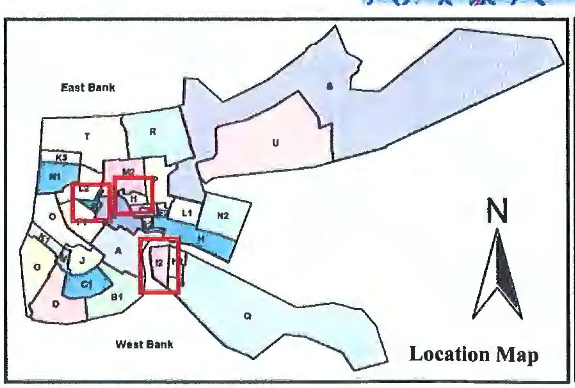
Location Map

Project Area Statistics:

- Average weighted PAN 97.2
- Total length of water main 53.7 miles
- Length for rehabilitation 53.0 miles
- Percent replacement 99%

The planning level capital cost for this project is $108,000,000, not including inflation.

This project consists of approximately 41 miles of water main recommended for rehabilitation. The proposed project area boundaries for area I1 extend from Florida Avenue to Tonti Street and from Elysian Fields Avenue to Gentilly Boulevard. The proposed project area boundaries for area I2 extend from the Mississippi River to Atlantic Avenue and to the Orleans/Jefferson Parish border. The proposed project area boundaries for area I3 extend from City Park Avenue to Moss Street (Bayou St. John) and from DeSaix Boulevard to Orleans Avenue. The project locations are shown below.

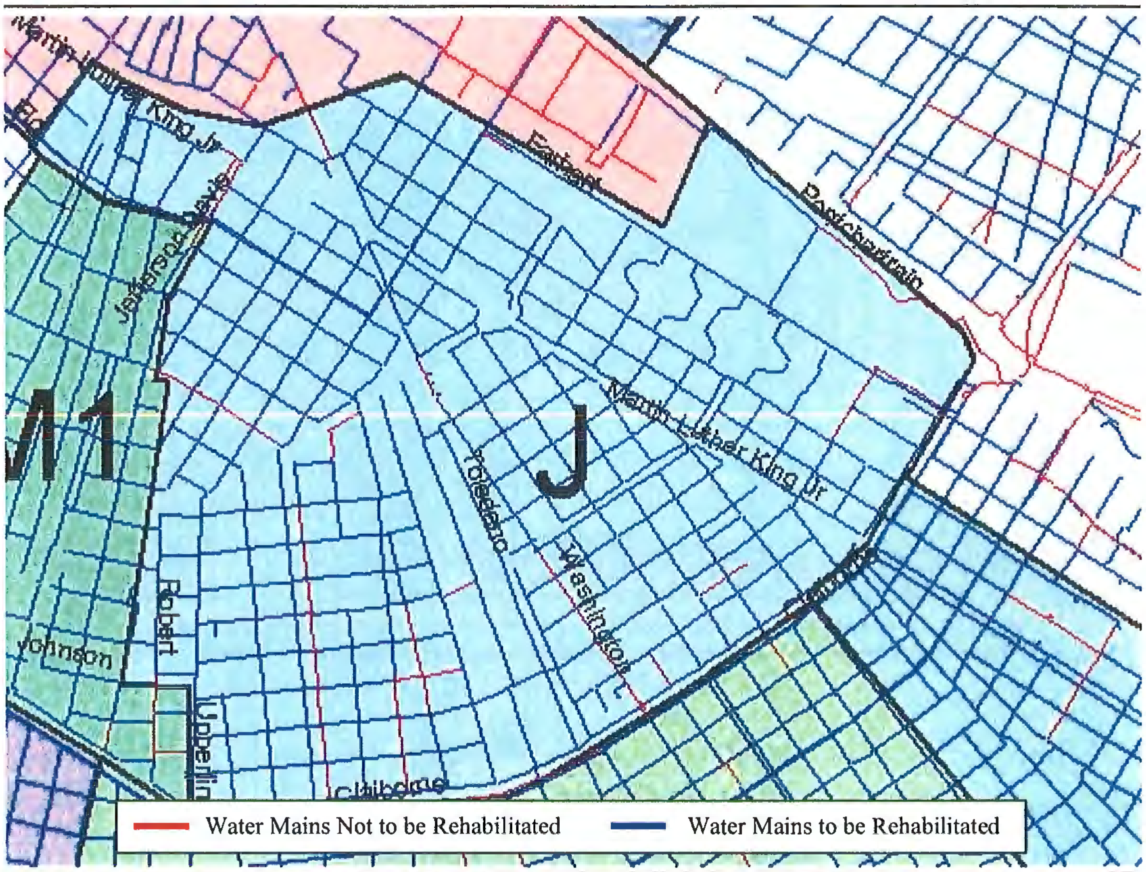


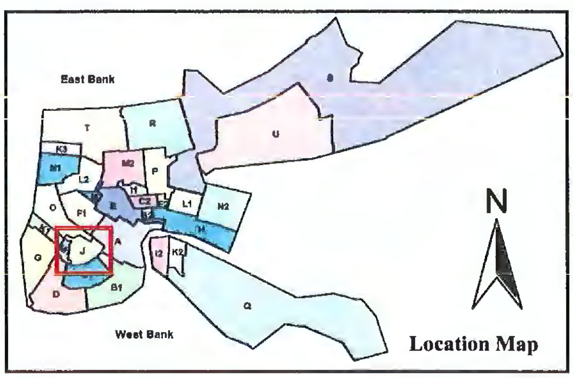
Project Area Statistics:

- Average weighted PAN (I1/I2/I3) 92.1/89.9/87.3
- Total length of water main 42.6 miles
- Length for rehabilitation 41 miles
- Percent replacement 96%

The planning level capital cost for this project is $83,000,000, not including inflation.

This project consists of approximately 36 miles of water main recommended for rehabilitation. The proposed project area boundaries for area J extend from Earhart Boulevard to Claiborne Avenue and from the Pontchartrain Expressway to Audubon Street. The project location is shown below.



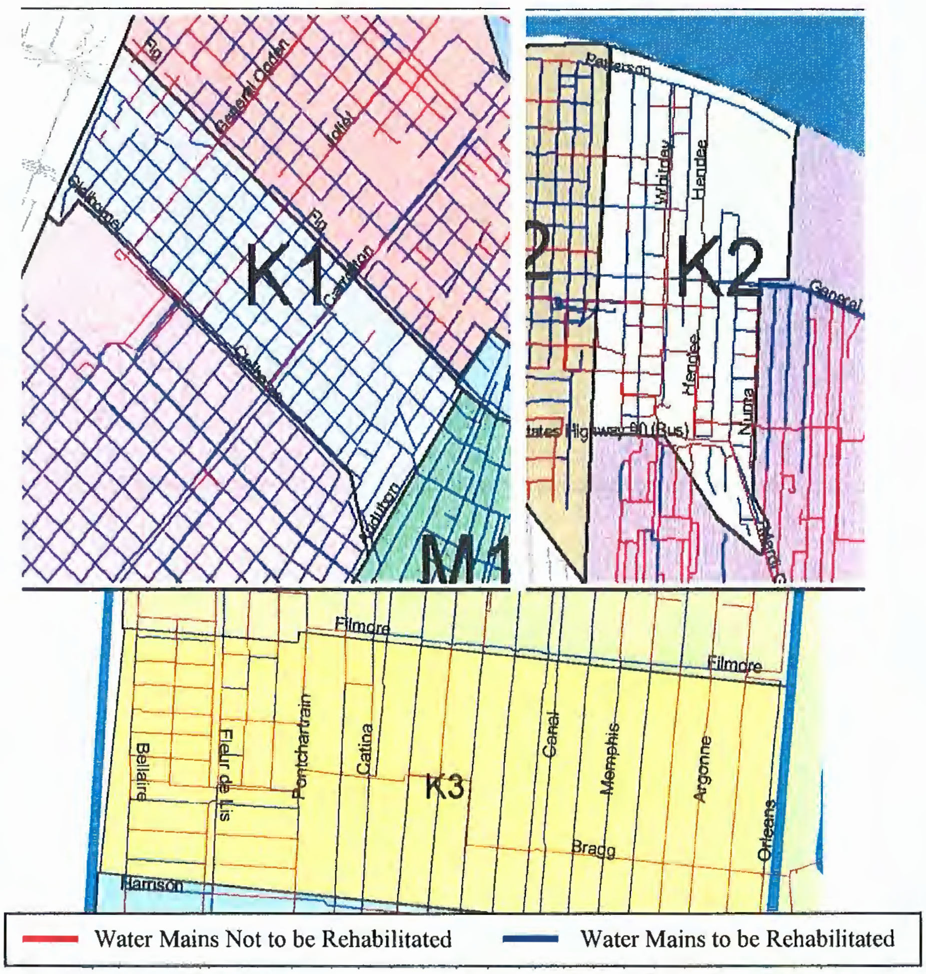


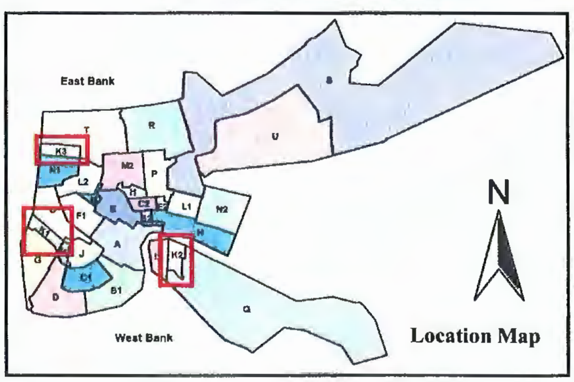
Project Area Statistics:

- Average weighted PAN 83.0
- Total length of water main 37.2 miles
- Length for rehabilitation 35.6 miles
- Percent replacement 96%

The planning level capital cost for this project is $74,000,000, not including inflation.

This project consists of approximately 32 miles of water main recommended for rehabilitation. The proposed project area boundaries for area K1 extend from Fig Street to Claiborne Avenue and from Audubon Street to the Orleans/Jefferson Parish border. The proposed project area boundaries for area K2 extend from the Mississippi River to Highway 90 and from Nuna Street to Atlantic Avenue. The proposed project area boundaries for area K3 extend from Filmore Avenue to Harrison Avenue and from Orleans Avenue (Orleans Outfall Canal) to Bellaire Drive (17th Street Drainage Canal). The project locations are shown below.



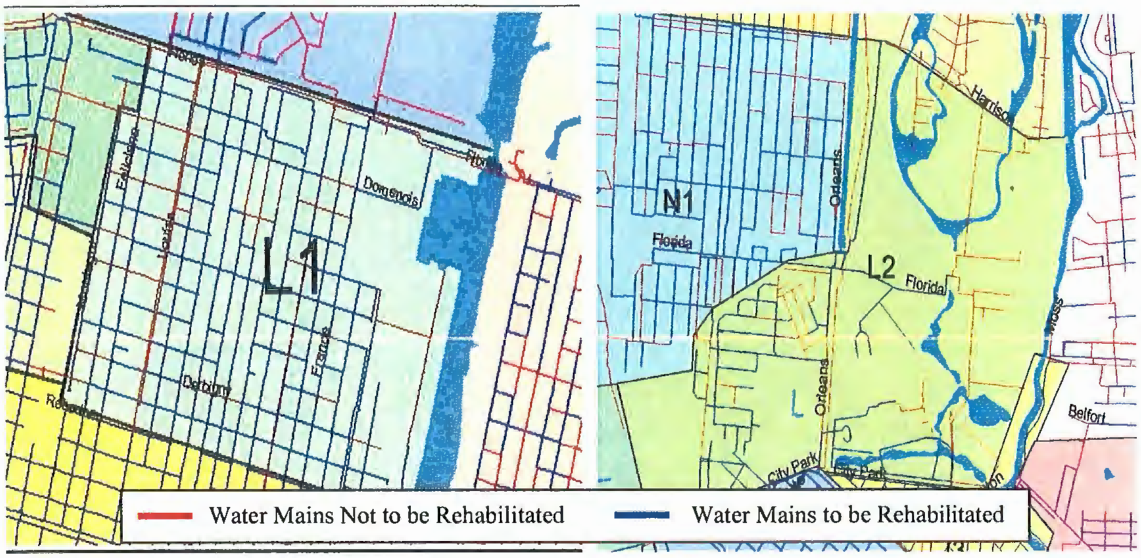


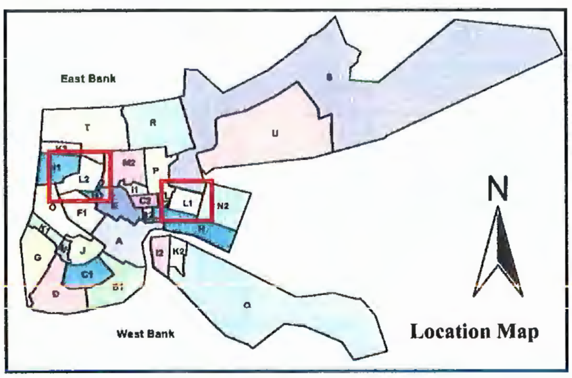
Project Area Statistics:

- Average weighted PAN (K1/K2/K3) 86.4/81.2/72.3
- Total length of water main 47.9 miles
- Length for rehabilitation 31.9 miles
- Percent replacement 67%

The planning level capital cost for this project is $34,000,000, not including inflation.

This project consists of approximately 31 miles of water main recommended for rehabilitation. The proposed project area boundaries for area L1 extend from Florida Avenue to Robertson Street and from Manuel Street (Inner Harbor Navigation Canal) to Montegut Street. The proposed project area boundaries for area L2 extend from Harrison Avenue to City Park Avenue and from Wisner Drive (Bayou St. John) to Interstate 10. The project locations are shown below.



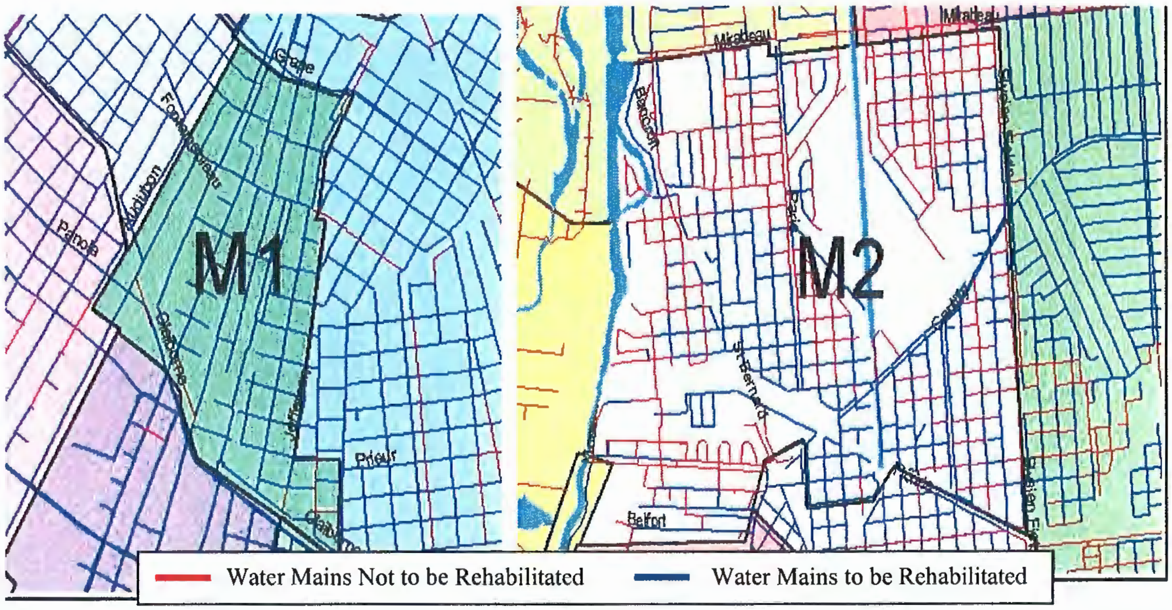


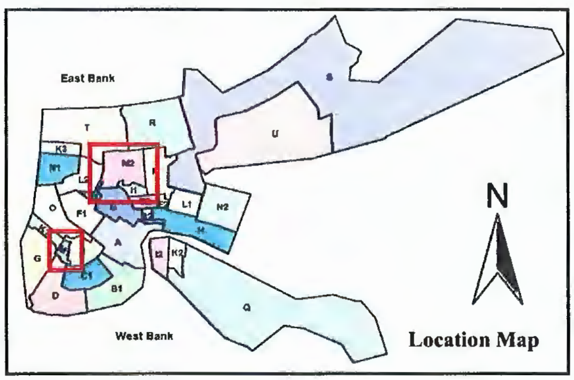
Project Area Statistics:

- Average weighted PAN (L1/L2) 77.8/70.7
- Total length of water main 44.5 miles
- Length for rehabilitation 30.9 miles
- Percent replacement 69%

The planning level capital cost for this project is $93,000,000, not including inflation.

This project consists of approximately 35 miles of water main recommended for rehabilitation. The proposed project area boundaries for area M1 extend from Claiborne Avenue to Fig Street and from Jefferson Avenue to Audubon Street. The proposed project area boundaries for area M2 extend from Belfort Street to Mirabeau Avenue and from Elysian Fields Avenue to Moss Street (Bayou St. John). The project locations are shown below.



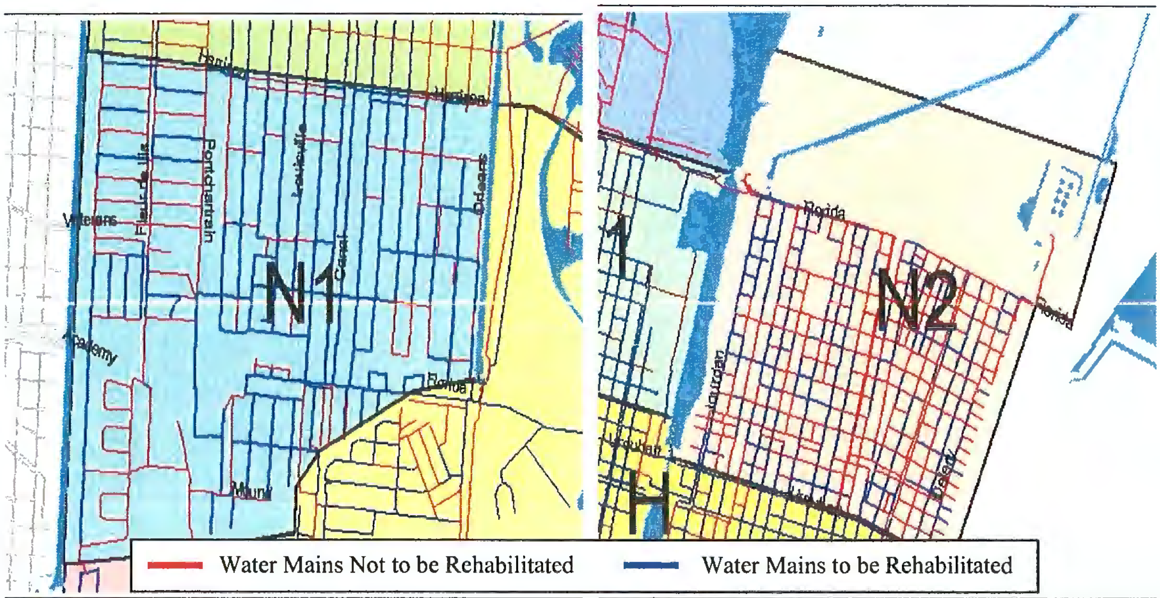


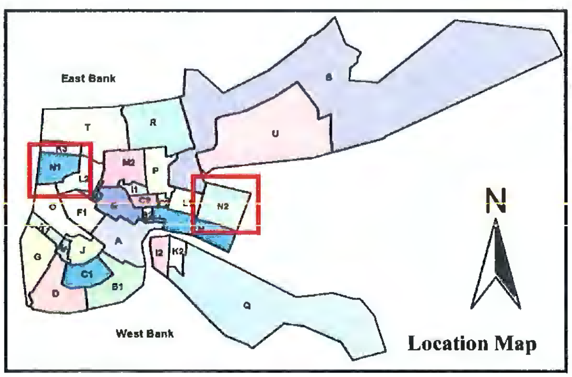
Project Area Statistics:

- Average weighted PAN (M1/M2) 74.6/73.3
- Total length of water main 59.7 miles
- Length for rehabilitation 35.2 miles
- Percent replacement 59%

The planning level capital cost for this project is $71,000,000, not including inflation.

This project consists of approximately 35 miles of water main recommended for rehabilitation. The proposed project area boundaries for area N1 extend from Harrison Avenue to Marcia Avenue and from Orleans Avenue (Orleans Outfall Canal) to Bellaire Drive (17th Street Drainage Canal). The proposed project area boundaries for area N2 extend from the Orleans/St. Bernard Parish border to Jordan Street (Inner Harbor Navigation Canal) and from Florida Avenue to Urquhart Street. The project locations are shown below.



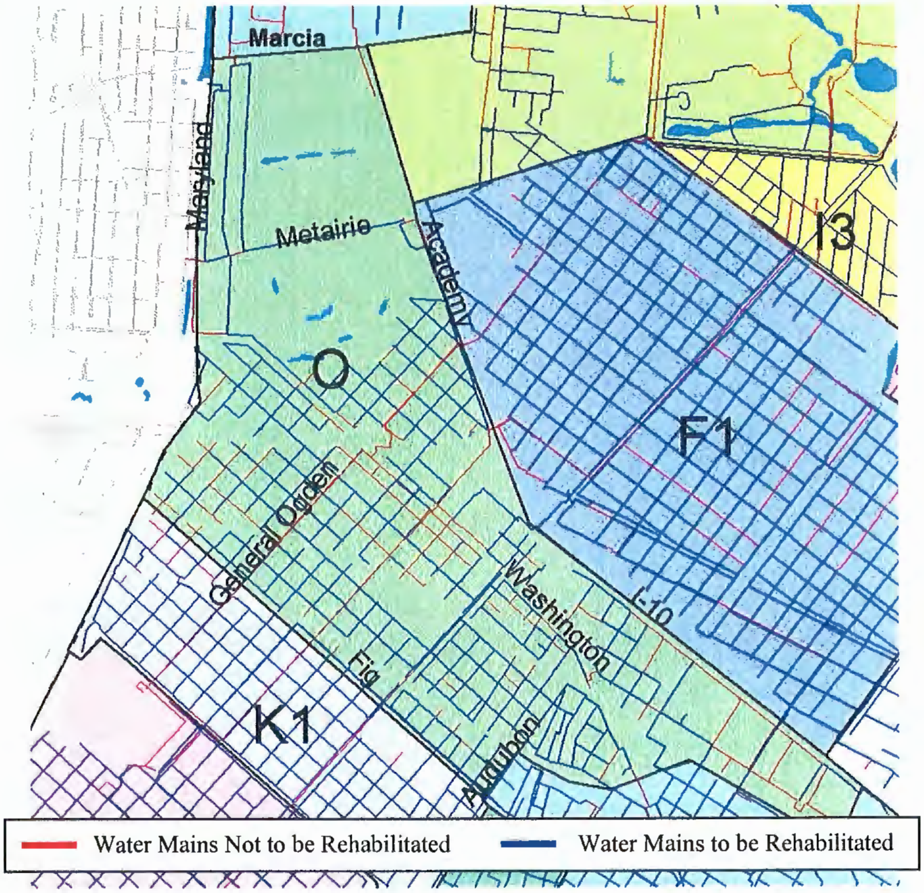


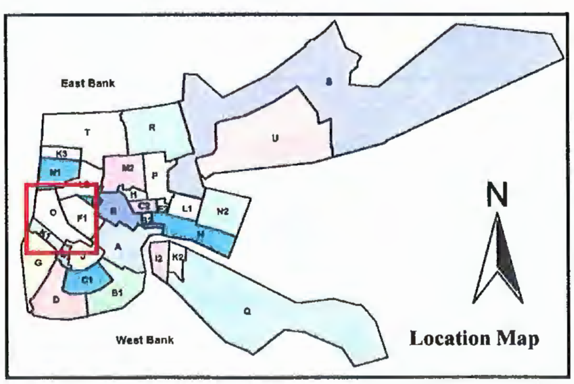
Project Area Statistics:

- Average weighted PAN (N1/N2) 71.7/71.1
- Total length of water main 70.1 miles
- Length for rehabilitation 35.1 miles
- Percent replacement 50%

The planning level capital cost for this project is $71,000,000, not including inflation.

This project consists of approximately 37 miles of water main recommended for rehabilitation. The proposed project area boundaries extend from Fig Street to Marcia Avenue and from Interstate 10 to Maryland Drive (17th Street Drainage Canal). The project location is shown below.



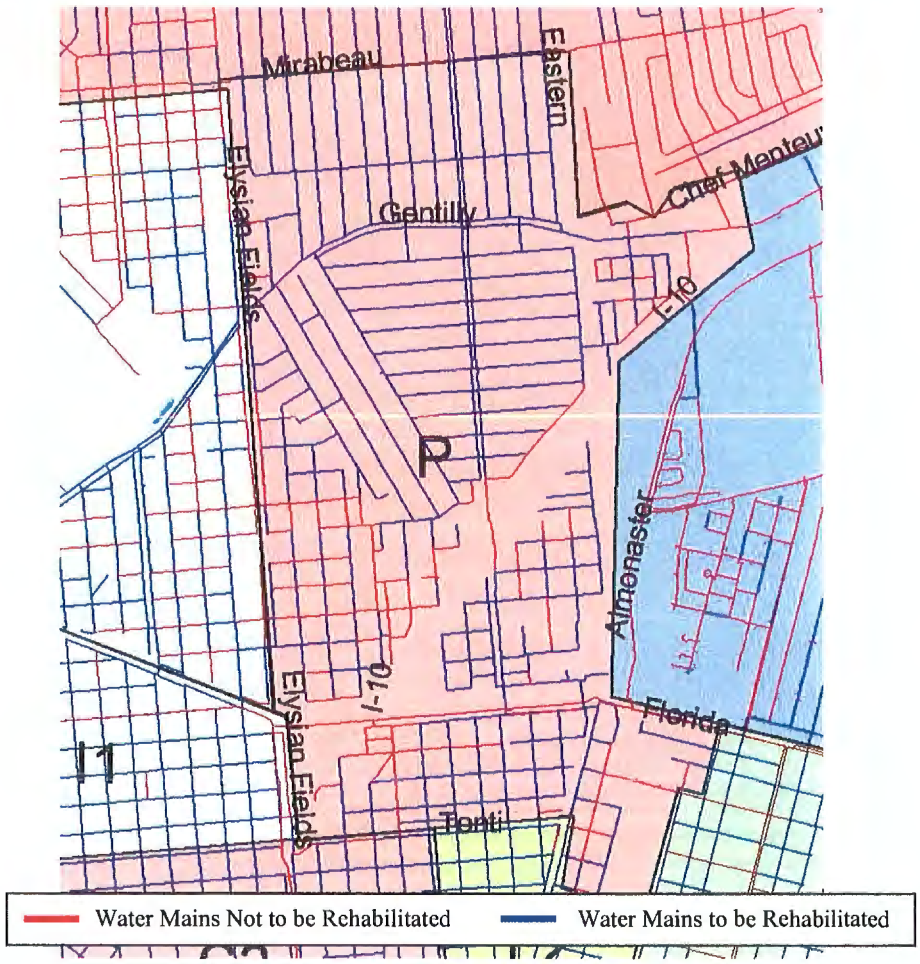


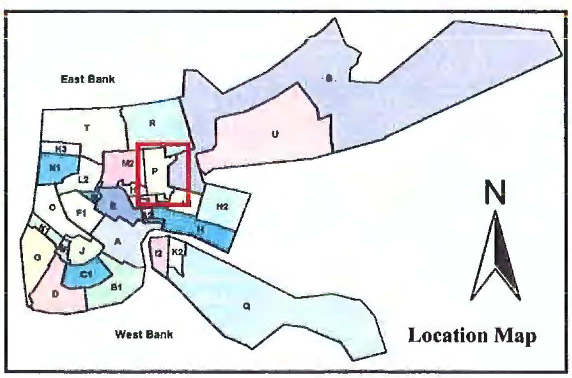
Project Area Statistics:

- Average weighted PAN 71.3
- Total length of water main 41.6 miles
- Length for rehabilitation 37.0 miles
- Percent replacement 89%

The planning level capital cost for this project is $78,000,000, not including inflation.

This project consists of approximately 38 miles of water main recommended for rehabilitation. The proposed project area boundaries extend from Tonti Street to Mirabeau Avenue and from Almonaster Avenue to Elysian Fields Avenue. The project location is shown below.



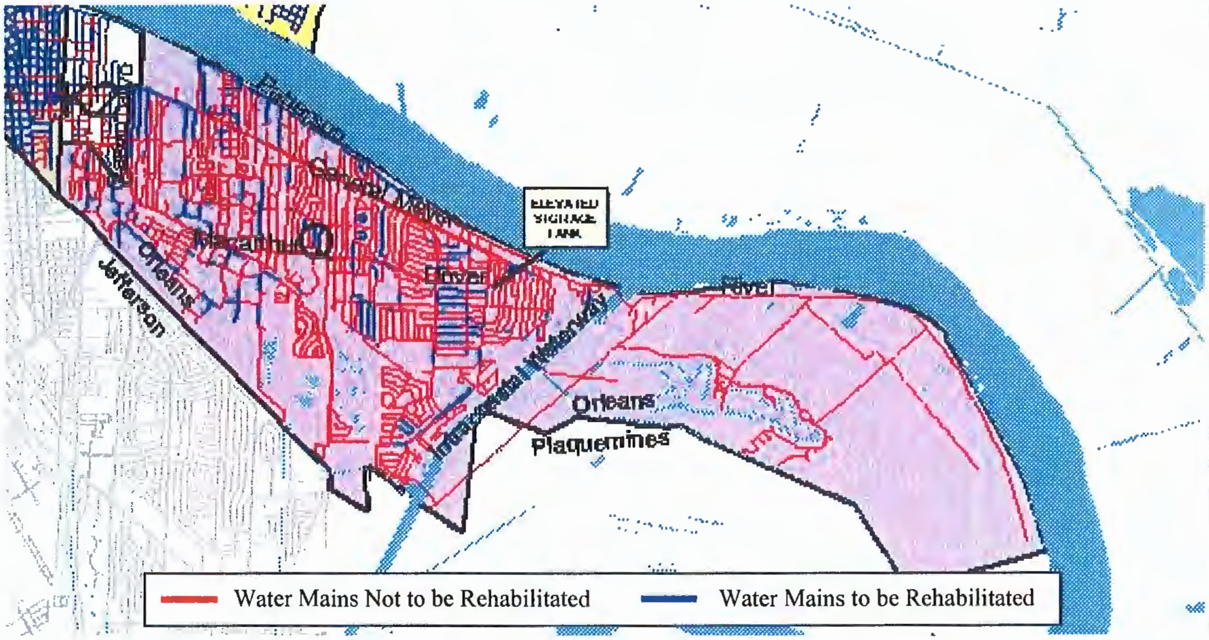


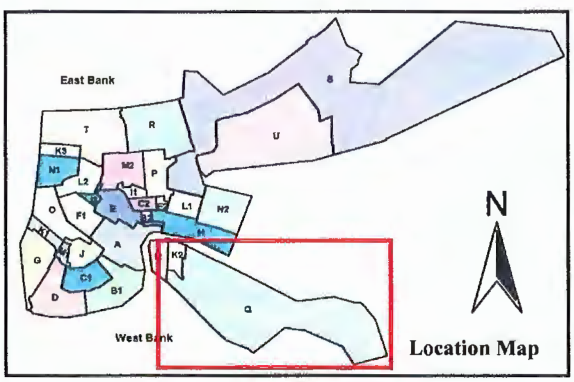
Project Area Statistics:

- Average weighted PAN 70.9
- Total length of water main 41.7 miles
- Length for rehabilitation 38.4 miles
- Percent replacement 92%

The planning level capital cost for this project is $78,000,000, not including inflation.

This project consists of approximately 27 miles of water main recommended for rehabilitation. The proposed project area boundaries extend from the Orleans/ Plaquemines Parish border to Atlantic Avenue and from the Mississippi River to the Orleans/ Jefferson Parish border. The project location is shown below.



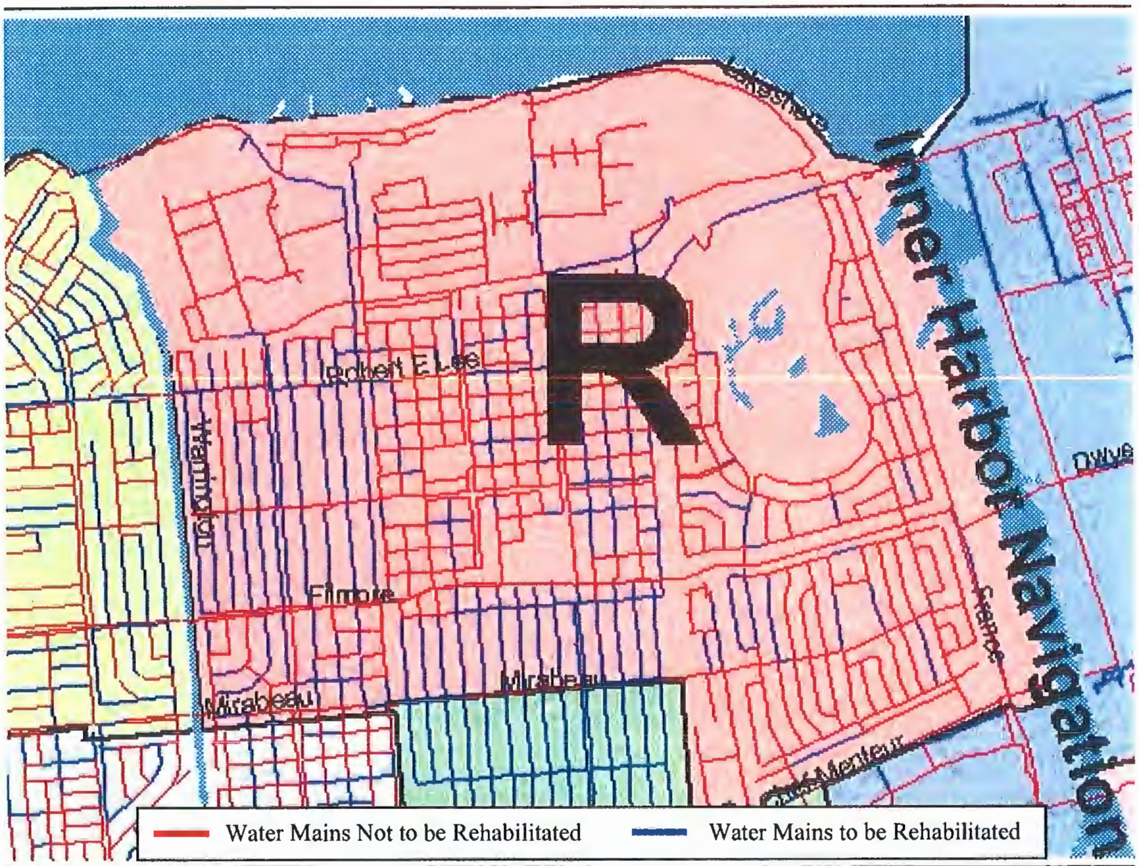


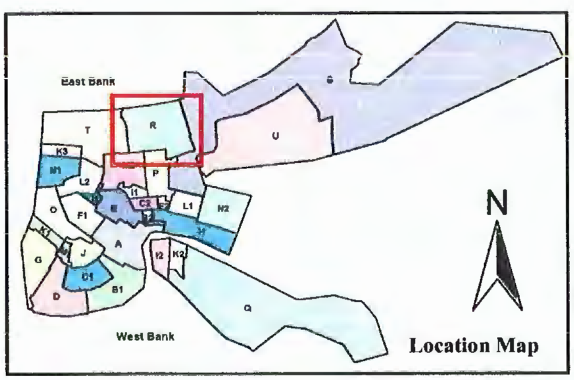
Project Area Statistics:

- Average weighted PAN 66.7
- Total length of water main 158.6 miles
- Length for rehabilitation 27.1 miles
- Percent replacement 17%

The planning level capital cost for this project is $54,000,000, not including inflation.

This project consists of approximately 30 miles of water main recommended for rehabilitation. The proposed project area boundaries extend from Chef Menteur Highway to Lake Pontchartrain and from France Road (Inner Harbor Navigation Canal) to Warrington Drive (London Outfall Drainage Canal). The project location is shown below.



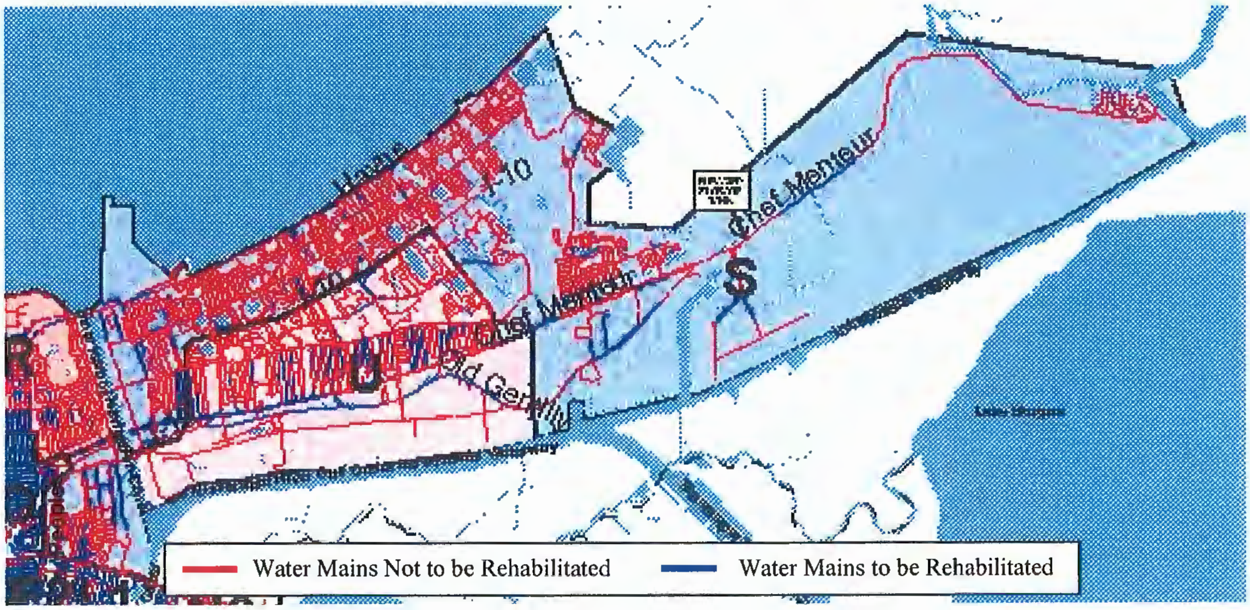


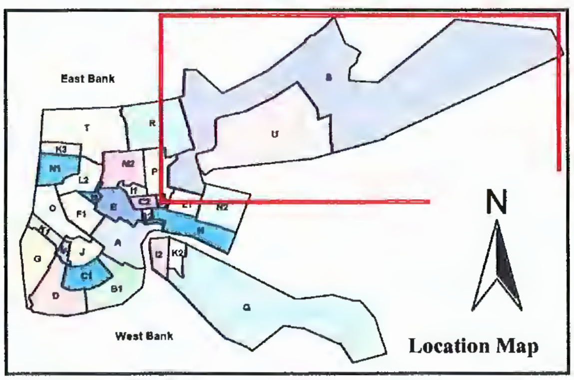
Project Area Statistics:

- Average weighted PAN 65.5
- Total length of water main 84.7 miles
- Length for rehabilitation 30.2 miles
- Percent replacement 36%

The planning level capital cost for this project is $61,000,000, not including inflation.

This project consists of approximately 29 miles of water main recommended for rehabilitation. The proposed project area boundaries extend from the Gulf Outlet Intracoastal Waterway to Lake Pontchartrain and from Venetian Isles to Peoples Avenue. The project location is shown below.



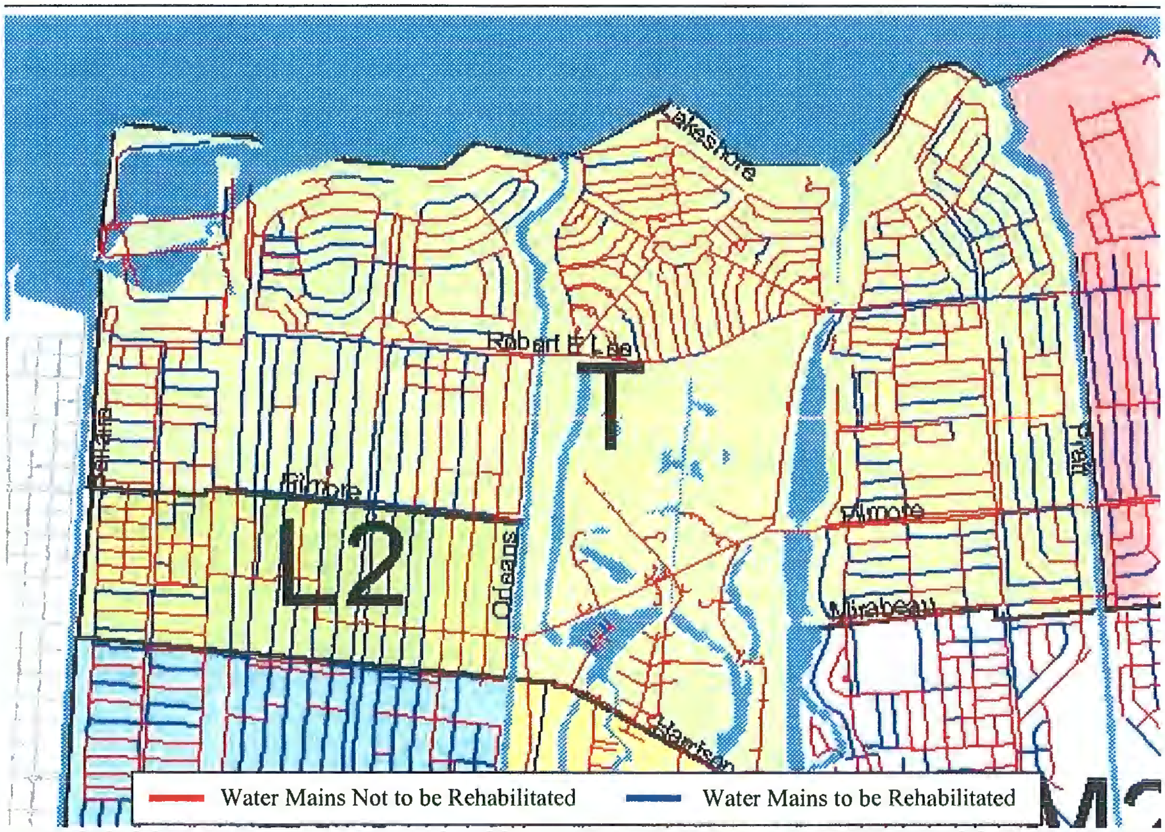


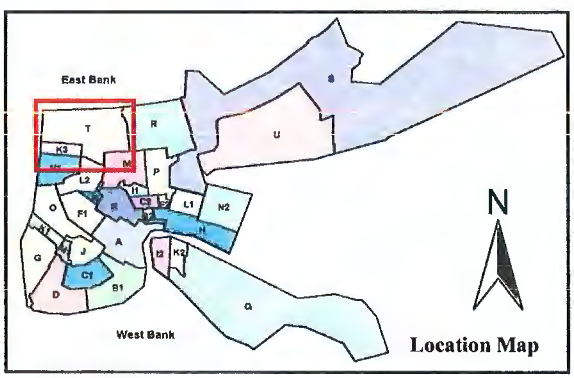
Project Area Statistics:

- Average weighted PAN 63.3
- Total length of water main 217.8 miles
- Length for rehabilitation 28.9 miles
- Percent replacement 13%

The planning level capital cost for this project is $66,000,000, not including inflation.

This project consists of approximately 28 miles of water main recommended for rehabilitation. The proposed project area boundaries extend from the Harrison Avenue to Lake Pontchartrain and from Pratt Drive (London Outfall Drainage Canal) to Bellaire Drive (17th Street Drainage Canal). The project location is shown below.



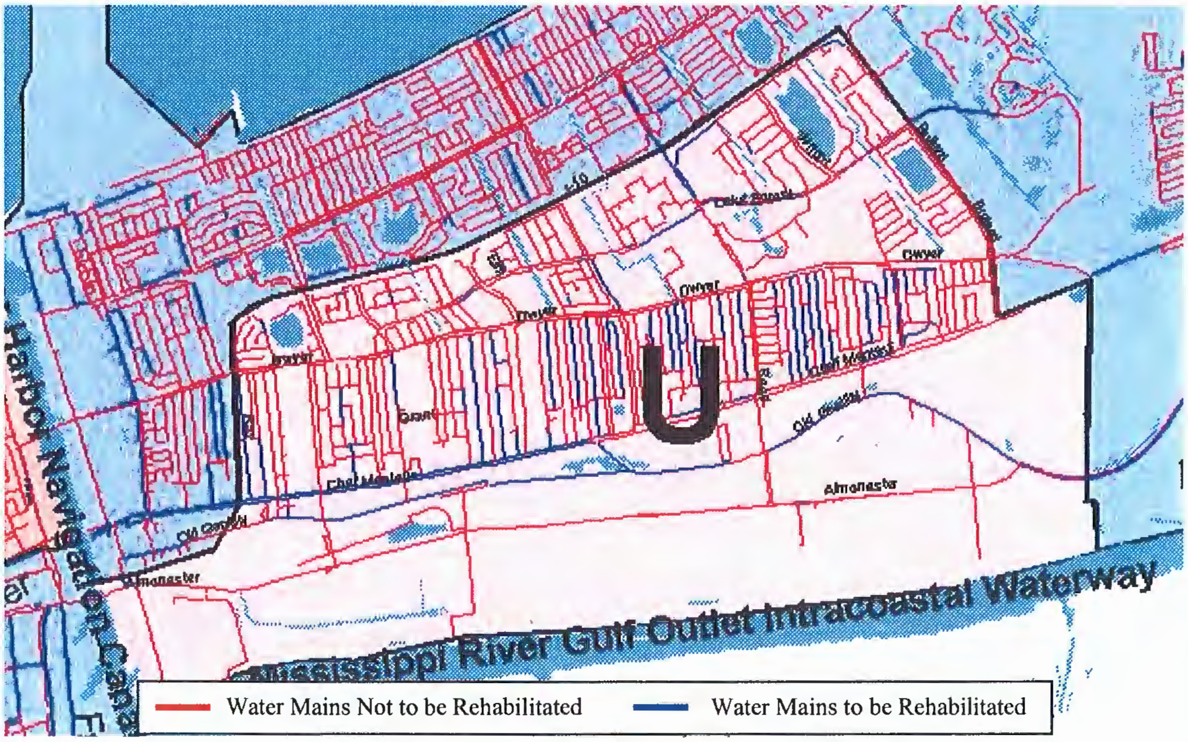


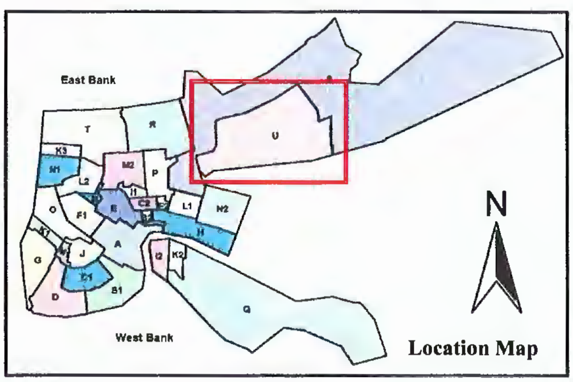
Project Area Statistics:

- Average weighted PAN 62.5
- Total length of water main 81.5 miles
- Length for rehabilitation 28.1 miles
- Percent replacement 34%

The planning level capital cost for this project is $57,000,000, not including inflation.

This project consists of approximately 26 miles of water main recommended for rehabilitation. The proposed project area boundaries extend from the Mississippi River Gulf Outlet Intracoastal Waterway to Interstate 10 and from Paris Road to Jordan Street (Inner Harbor Navigation Canal). The project location is shown below.





Project Area Statistics:

- Average weighted PAN 57.6
- Total length of water main 117.3 miles
- Length for rehabilitation 25.9 miles
- Percent replacement 22%

The planning level capital cost for this project is $55,000,000, not including inflation.

System Improvement Projects

SCADA Cost Estimate Breakdown

Facility	Revised cost
Carrollton Plant	$1,000,000
Carrollton Pump Stations	$900,000
Elevated Storage Tanks	$150,000
Algiers Pump Stations	$600,000
District Metering Sites	$600,000
Telemetry	$500,000
Total	**$3,750,000**