1 of 2

DOE/CE/27504-T3

February 1993

**INTERIM REPORT - ENERGY OPTIMIZATION OF WATER DISTRIBUTION
SYSTEM**

A Technical Report

Energy Task Force
of the Urban Consortium
for Technology Initiatives

CITY OF DETROIT
Coleman A. Young, Mayor

Conducted by:
Creighton C. Lederer, P.E.
Bobbie G. Dickerson
Frederick R. Janeczko, P.E.
ACKNOWLEDGEMENTS

MASTER

DO NOT WRITE IN OR ON THIS DOCUMENT

PREFACE

1992 Urban Consortium Energy Task Force Publications

With staff, management, and business services provided by PTI, the Urban Consortium (UC) addresses the critical needs of large local governments through 3 task forces: Energy, Environment, and Telecommunications and Information. The Urban Consortium Energy Task (UCETF) was set up with the main objective to improve urban energy management and decision-making through applied research and technology transfer.

The UCETF focuses on developing and sharing new approaches and innovative solutions to energy management problems with local governments. Projects are organized in thematic units and co-managed by a member of the Task Force.

A description of the Units and projects included in the 1992 program are as follows:

ENERGY, ENVIRONMENT, ECONOMIC AND SOCIAL DEVELOPMENT

"Sustainability" is a planning goal to provide an integrative systems approach to meeting all our needs for today and tomorrow. Evaluating the needs of citizens and developing effective and efficient ways to meet those needs is a primary responsibility of local governments. Cities and counties are currently beset by a wide range of problems that in fact are symptoms of some common and pervasive ills. Our problems with energy, environment, economic and social development are related in a complex and interdependent way. These problems, therefore, cannot be effectively solved through a piecemeal approach without recognizing and addressing the interdependent relationships between these areas. The 1992 Energy, Environment, Economic and Social Development consist of:

Dade County, FL — A Long Term Urban Carbon Dioxide Emission Reduction Program

Pima County, AZ — Sustainable Community Implementation Partnership

Portland, OR — Sustainable Business Development Program

San Jose, CA — Negotiating a Demand Side Bid: The City of San Jose Case Study

San Jose, CA — "Green Aisle" Research Program

Santa Clara, CA — Fuel Cell Demonstration Partnership Program

Austin, TX — Sustainable Building Sourcebook

Chicago, IL — Downtown District Cooling: A 21st Century Approach

Chicago, IL — Role of Municipal Governments in the Design and Implementation of Energy Efficiency Codes and Standards Designed to Capture Lost Efficiency Opportunities

Seattle, WA — Coordination of Energy and Air Quality (CEAM)

St. Louis, MO — Earthways Home Project: An Educational Center for Sustainable Urban Development

Tucson, AZ — Minority Marketing for Resource Conservation

Washington, DC — Energy Auditor Training Course for High School Students

ENERGY EFFICIENT FACILITIES

Activities involving energy efficient facilities are part of a national effort to achieve maximum cost-effective energy productivity in the building sector. New technologies and management/administration practices to advance energy efficiency in facilities require major partnership efforts and transfer programs. Multifamily housing that has a large concentration of low-income families presents a unique challenge to lowering energy costs and maintaining energy efficient facilities. Both existing building stock and near-term new construction need to be made much more energy efficient if we are to meet local, state, and national objectives related to energy security, energy supply, and energy affordability. Space heating and cooling, lighting, water heating, refrigeration, cooking, ventilation, building envelope, energy efficient codes implementation, operation and maintenance (O&M), education, etc. are areas where opportunities exist to improve energy efficiency. The 1992 Energy Efficient Facilities Unit consists of:

Boston, MA — Energy Efficiency Outreach Partnership

Columbus, OH — Integrating Operations and Maintenance (O&M) for Energy Efficiency with O&M for Improving Indoor Air Quality

Hennepin County, MN — Integrated Rehab and Weatherization Program for Low Income Suburban Homeowners

Memphis, TN — Upgrade Energy Building Standards and Develop Rating System for Existing Low-Income Housing

New Orleans, LA — Utilization of Energy Efficiency to Support Homeownership Affordability

Detroit, MI — Energy Optimization of Water Distribution System

Montgomery County, MD — CFC Maintenance and Conversions in Chillers: The Commercial Building Response to the 1990 Clean Air Act

New York City, NY — Development of an Energy Services Corporation

Phoenix, AZ — Solar Cooling Demonstration Project

San Francisco — Energy Management Action Plan (EMAP)

TRANSPORTATION

It is frequently said that the goal of transportation strategies should be moving people, not vehicles. But in the day and age of satellite networks, cellular phones, and personal computers, we can redefine transportation as access to goods, services, and information to meet the needs of local governments and their citizens. Alternative transportation fuels are still a major piece in a very large and complex puzzle facing local governments that includes wide-reaching concerns about transportation. There are many factors related to transportation that affect local governments: increasing congestion, crumbling infrastructure of roads and bridges, unchecked urban/suburban sprawl, and the increased "paving over" of our communities that leads to urban heat islands. Federal, state, and urban governments each share in the responsibility and must play a role in providing a sustainable and multi-faceted transportation system that is based on comprehensive and integrated planning at all levels. The 1992 Transportation unit consists of:

Houston, TX — Public/Private Partnership to Identify Barriers & Provide Solutions to Implement Large Scale Fleet Natural Gas Vehicle Utilization

in Ozone Non-attainment Areas

New York City, NY — Energy and Economic Implications of Transportation Demand Management Strategies

Pittsburgh, PA — Natural Gas Infrastructure Development

Seattle, WA — Telecommuting for City Employees

Albuquerque, NM — A Fully Integrated Multi-Fuels Service Stations

Denver, CO — Technical Comparison Between Hythane (H₂/CNG) and CNG Fueled Vehicles

Las Vegas, NV — Reduction of Diesel Exhaust Emissions in Urban Mass Transit Vehicles with Alcohol Injection Systems

San Diego City, CA — California Clean Air Act - A Compliance Strategy for the City of San Diego's Non-Emergency Fleet

Reports from each of these research projects, including this report, are specifically designed to aid the transfer of proven experience to other local governments. Readers interested in obtaining additional reports or further information about the Urban Consortium Energy Task Force should contact:

**Energy R,D&C Program
Public Technology, Inc.
1301 Pennsylvania Avenue, NW
Suite 800
Washington, DC 20004**

**Tel: 1-800/852-4934 or
202/626-2400**

Fax: 202/626-2498

ACKNOWLEDGEMENTS

Sincere appreciation is extended to the members of the City of Detroit's Energy Task Force team for their assistance and cooperation during the preparation of the Energy Optimization of Water Distribution System Report: Creighton C. Lederer, P.E., Director of the Buildings and Safety Engineering Department, and Energy Task Force member; Bobbie G. Dickerson, Project Director and Chief/Building Inspection Division; Frederick R. Janeczko, P.E., Project Manager and General Superintendent of Engineering of the Detroit Water and Sewerage Department; Bennie L. Benjamin, P.E., Director of the Detroit Water and Sewerage Department; Remedios del Rosario, Assistant Director of the Detroit Water and Sewerage Department; Marilyn Gazadag, Administrative Assistant of the Buildings and Safety Engineering Department; and Linda Miller, Contracts Section of the Detroit Water and Sewerage Department.

Special mention of our consultant for their assistance in the investigation and for report delineation. The firm responsible for the project was Tucker, Young, Jackson, Tull, Inc.; Consulting Engineers; Detroit, Michigan. Those staff members directly involved included David K. Yang, P.E. and Edward Young, P.E.

Special thanks are given to the U.S. Department of Energy for providing the grant to the Urban Consortium Energy Task Force Members and staff and to Public Technology, Inc. for their assistance and critiques.

TABLE OF CONTENTS	Page
Preface	
Acknowledgements	
Chapter 1 - Overview	
1.1 Abstract	1
1.2 Project Purpose	3
1.3 Report Organization	3
Chapter 2 - General Background and Description	
2.1 Introduction	5
2.2 General Background and Description	6
Chapter 3 - Project Description	
3.1 Introduction	9
3.2 Data Collection	11
3.3 System Inventory	12
3.3.1 General	12
3.3.2 Pressure Districts	15
3.4 Computer Model	17
3.5 Guidebook	19
3.6 Work to be Completed	19
Chapter 4 - Summary	21
Appendices	
A -- Pumping Equipment Database	
B -- Energy Optimization of Water Distribution System Guidebook	
Figures	
3-1 DWSD Water Transmission System	10
3-2 DWSD Water Distribution Pressure Districts	14
3-3 System Computer Model of DWSD Water Transmission	18

CHAPTER 1

OVERVIEW

1.1 Abstract

Energy costs associated with pumping treated water into the distribution system and boosting water pressures where necessary is one of the largest expenditures in the operating budget of a municipality. Due to the size and complexity of Detroit's water transmission system, an energy optimization project has been developed to better manage the flow of water in the distribution system in an attempt to reduce these costs.

The Detroit Water and Sewerage Department (DWSD) water distribution system provides drinking water to over four million people in 116 communities throughout southeastern Michigan. The city's annual energy cost to operate the pumps at the water treatment plants and the booster stations in this system is between 15 and 17 million dollars.¹

¹ Energy Task Force of the Urban Consortium for Technology Initiatives, "Hydraulic Waste Energy Recovery, Phase II, A Technical Report," February 1992, p. 23.

To reduce energy consumption associated with pumping, a computer program will be developed to analyze different pumping combinations for particular system demands and identify the ones that yield the least energy cost. The computer program will then be utilized to develop an energy strategy and planning guidelines for cost effective pumping operations for the water distribution system.

A guidebook will be developed to assist other municipalities in developing their own energy optimization programs. The guidebook will identify the methodology used to develop the computer program, the energy strategy, and planning guidelines. Technical advice on gathering and utilizing the data will also be provided in the guidebook.

The Energy Optimization of Water Distribution System project for the city of Detroit is being conducted in two parts, each having a duration of approximately one year. The efforts of the first year of the project as well as a summary of the work to be completed in the second year are documented in this report.

The first year of the project was spent collecting data and information on the water distribution system that will be utilized in developing the computer model. The information collected was also used to develop a database of the pumping equipment at each facility.

1.2 Project Purpose

The purpose of this project is to develop a computer program which will simulate various pumping and distribution scenarios with the objective of minimizing power consumption at DWSD's pumping facilities. The computer program will be used to develop energy strategies and planning guidelines. The results of the analysis will be used to identify operational improvements that would minimize power cost and improve pumping efficiency. Information obtained from the project would eventually be incorporated into the computer software and hardware design for the Supervisory Control and Data Acquisition (SCADA) system now under development by DWSD. A guidebook will be produced to assist other municipalities in developing their own energy optimization programs.

1.3 Report Organization

The following provides a brief description of the remaining chapters in this report:

Chapter 2 - General Background and Description

Provides an explanation of what the project is about and how the work will be accomplished.

Chapter 3 - Project Description

This chapter describes the work that was completed in the first year and discusses what will be accomplished in order to complete the project.

Chapter 4 - Summary

Describes how the information obtained to date will be utilized to meet the objectives of the project.

CHAPTER 2

GENERAL BACKGROUND AND DESCRIPTION

2.1 Introduction

Energy costs associated with operating its water distribution pumps is one of the largest expenditures for the Detroit Water and Sewerage Department (DWSD). In an effort to reduce this energy cost, the energy optimization project will develop a computer program to simulate and evaluate various pumping and distribution scenarios for the DWSD water distribution system. For a particular water demand, the computer program will evaluate several pump combinations and select the optimal combination based on the lowest electrical power cost. The program will be utilized in developing an energy strategy and planning guidelines.

Additionally, a guidebook will be produced to provide the methodology used in developing the program. This book will provide guidance for other municipalities in the development of their own energy optimization programs.

2.2 General Background and Description

In order to optimize the pump usage and thereby reduce the energy costs, a computer program will be developed utilizing available water distribution software and modified to provide a customized program that will simulate DWSD's water distribution system and pumping operations. The program will allow several scenarios to be analyzed for a particular system demand and then, based on a power cost determined from the local utility company's (Detroit Edison) rate structure, identify the least cost scenario. Energy costs for each scenario selected will also be provided.

A database has been developed which includes existing information on individual pumps and their motors. The program will utilize information from the database developed, the pump curves, and pumping records for the facilities, to assist in developing an energy strategy. The energy strategy will identify the optimal pumping combination that provides the least cost for the selected scenario.

In the future, flows through the water distribution system will be coordinated with a SCADA computer system, which will monitor all pump operations. Once the SCADA system and the computer program developed in this project are linked together, DWSD will be able to utilize the energy strategies to realize additional energy savings.

The computer program will also be utilized to produce planning guidelines for an energy efficient, system wide

pumping operation. The guidelines will identify operating practices and operational improvements that would further reduce energy cost and improve pumping efficiency for the system.

Because this type of project is applicable to other communities, a guidebook will be developed. This guidebook will address how to develop the distribution system database and computer model, and provide technical advice on analyzing the data and utilizing the results.

CHAPTER 3

PROJECT DESCRIPTION

3.1 Introduction

The DWSD water distribution system supplies water to over four million people in 116 communities. The present water demand for the total system averages approximately 640 mgd. The distribution system consists of approximately 3,500 miles of water mains, 20 booster stations, and five water treatment plants. The maximum day demand for fiscal year 1991/1992 for each plant was as follows:

Water Works Park	190 mgd
Springwells	388 mgd
Northeast	281 mgd
Southwest	125 mgd
Lake Huron	214 mgd

There is a total of approximately 363 million gallons (mg) of system storage. The communities served and the transmission mains, booster stations, and water treatment plants are shown in Figure 3-1.

MICHIGAN — OHIO STATE LINE

TUCKER YOUNG JACKSON TULL, INC.
CONSULTING ENGINEERS
565 E. LARNED SUITE 300 DETROIT, MI 48226 (313) 963-0812

SCALE: NONE FIGURE 3-1

The chapter describes the work that has been completed in the first year of the project. This work includes data collected on the existing system and status of development of the computer model and guidebook. A summary of the work to be performed in year 14 is also included.

3.2 Data Collection

In order to analyze pump operating scenarios for the system with the computer model, information on existing pumping equipment and the distribution system was collected. The information includes the following:

- Component description and design criteria for line booster stations, booster stations with reservoirs, and high lift pumps at the water treatment plants.
- Daily operations data for 1988.
- Annual reports from fiscal year 1987/1988 to fiscal year 1991/1992.
- A 1985 calibrated KYPIPE computer model of DWSD's water distribution system which included input data for the maximum hour and average day demands on the system for that year.

This information has been utilized to produce the inventory database of the system and will be used to develop the computer program to analyze the system.

3.3 System Inventory

3.3.1 General. The water distribution system of the city of Detroit is served by five water plants each supplying treated water into the distribution system. These plants include the following:

- Water Works Park Plant
- Springwells Plant
- Northeast Plant
- Southwest Plant
- Lake Huron Plant

Four of these plants, Water Works Park, Springwells, Northeast, and Southwest are located strategically within the metropolitan area of Detroit. The Lake Huron Plant is located near Lake Huron, 50 miles north of Detroit, some five miles north of the city of Port Huron.

Due to the size of the system and the typography, the distribution system is divided into three pressure districts. Each plant is equipped with high lift pumps which supply water to these pressure districts, at the following average pressures:

- Low pressure: 45 to 60 psig
- Intermediate pressure: 65 to 85 psig
- High pressure: 40 to 180 psig

The different pressure districts are interconnected to facilitate the continuity of service and to meet the flow and pressure demands occurring during peak load periods or emergencies. The flow from the water plants is split into different pressure districts and regulated by a series of ten remote regulating valves. Figure 3-2 presents an approximate delineation of the three pressure districts.

In addition, 20 booster stations are strategically located throughout the system to maintain adequate water pressures for remote area customers or those at higher elevation areas. These booster stations provide required pressure for areas where pressure is not sufficient. Five of the boosters are line-booster stations and the rest are booster stations with reservoirs, as follows:

1. Line booster stations:
 - Adams Road
 - Newburgh
 - Orion
 - Roseville
 - Ypsilanti
2. Booster stations with reservoirs:
 - East side (Canyon)
 - Electric Avenue
 - Farmington
 - Ford Road
 - Franklin
 - Imlay
 - Joy Road
 - Michigan Avenue
 - North Service Center
 - Northwest
 - St. Clair Shores

CITY OF DETROIT WATER AND SEWERAGE DEPARTMENT		ENERGY OPTIMIZATION OF WATER DISTRIBUTION SYSTEM
TUCKER YOUNG JACKSON TULL, INC. CONSULTING ENGINEERS 565 E LARNED SUITE 300 DETROIT, MI 48226 (313) 963-0612		DWSD WATER DISTRIBUTION PRESSURE DISTRICTS	
		SCALE NONE	FIGURE 3-2

Schoolcraft
West Chicago
West Service Center
Wick Road

Booster stations with reservoirs are equipped with line pumps and reservoir pumps. The line pumps are used to maintain pressures at remote areas and higher elevations in the system, while the reservoir pumps are used to supply additional water from the reservoirs when required.

The database developed for the existing pumping equipment at the booster stations and for the high lift pumps at the treatment plants is provided in Appendix A.

3.3.2 Pressure Districts. The low pressure district includes the downtown central business area and the lower east area of the city of Detroit. This service area is completely separated from other pressure districts by closed valves.

The low pressure district is supplied by the high lift pumps at Water Works Park, which are designed to serve the intermediate pressure district. Water Works Park is equipped with two pressure reducers capable of reducing the normal high lift output of 70-80 psi down to 50-60 psi which is then available for the low pressure district. If necessary, the low pressure district can be supplied from Springwells which normally serves the intermediate and high pressure districts.

Back-up from Springwells for the low pressure district is provided through three pressure reducing stations located in the distribution system connecting the intermediate and low pressure districts. The three stations are located at Chene and Maple, Porter and Sixth, and Park and Elizabeth. The

valves at these stations are automatically opened at approximately 40 psi in the event that pressure supplied from Water Works Park is below the normal conditions (50 psi to 60 psi).

The intermediate pressure district generally includes southwest Detroit (excluding the downtown area) and the downriver suburban areas. This pressure district is served by three plants at the following pressures:

- Water Works Park: 70 psi to 80 psi
- Springwells Plant: 65 psi to 75 psi
- Southwest Plant: 70 psi to 85 psi

The intermediate district is interconnected with Water Works Park and Springwells at five major points. The Springwells Plant also supplies water to the area served by the Southwest Plant.

The high pressure district includes the northern portion of the city of Detroit, the north and northwest suburbs, reaching north to Pontiac and Flint. This pressure district is supplied by the three plants at the following pressures:

- Springwells Plant: 75 psi to 85 psi
- Northeast Plant: 70 psi to 85 psi
- Lake Huron Plant: 160 psi to 180 psi

The Lake Huron plant supplies treated water through a 120 inch transmission main, approximately 25 miles west to the Imlay booster station.² The Imlay station is currently out

² Energy Task Force of the Urban Consortium for Technology Initiatives, "Hydraulic Waste Energy Recovery, A Technical Report," December 1990, p. 8 - 13.

of service because, since the water demand for higher flow rates have not developed in this area, the pressure does not need to be boosted.

3.4 Computer Model

As stated, a hydraulic computer model completed in 1985 was obtained. The model provides a skeleton of the distribution system, representing transmission mains 16 inches and greater in diameter and consists of 1009 pipe elements and 735 nodes. In order to analyze different pump combinations to determine energy costs and to utilize graphical displays, the existing model was revised as follows:

- Multiple data points describing each in-line booster and reservoir pump was inputted to describe its head-flow characteristics.
- An x-y coordinate system for the model was inputted based on data established.

Figure 3-3 depicts the revised model. Only the sizes of the selected transmission mains are shown for clarity.

The revised model will be utilized to develop the computer program for this project. Specified demands will be analyzed to determine optimum pumping combinations and their associated energy costs.

CITY OF DETROIT WATER AND SEWERAGE DEPARTMENT	ENERGY OPTIMIZATION OF WATER DISTRIBUTION SYSTEM
TUCKER YOUNG JACKSON TULL, INC. CONSULTING ENGINEERS 565 E. LARNED SUITE 300 DETROIT, MI 48226 (313) 963-0612	COMPUTER MODEL OF DWSD WATER DISTRIBUTION SYSTEM	
	SCALE: NONE	FIGURE 3-3

LEGEND

- WATER TREATMENT PLANT
- BOOSTER STATION W/RESERVOIR
- BOOSTER STATION

3.5 Guidebook

The guidebook will be produced in two parts. The first part describes the development of the pump and system database and the software used. A draft of this is provided in Appendix B. The second part will be provided in the final report and will include commentary and advice on analyzing the data and utilizing the data to develop and implement an energy optimization program.

3.6 Work to be Completed

In the final year of the project, the information obtained will be used to produce a computer program. To accomplish this, several pipe distribution network computer software packages will be evaluated. A software package will be selected and it will be modified as required to produce a computer model of the DWSD system. The computer model will then be utilized as the tool to develop the energy strategy and planning guidelines.

Both parts of the guidebook will also be completed in the final year. The first part will be finalized and the second part will be developed to include commentary on analyzing the data and utilizing the results. Technical advice on

implementing an energy optimization program will also be provided.

CHAPTER 4

SUMMARY

The information presented in this report has provided the necessary data for a computer program to be developed and used to analyze the DWSD water distribution system. The results obtained from the computer analysis will be utilized to produce an energy strategy and planning guidelines. In the future, the city plans to incorporate the information obtained from this study into the computer software and hardware design for the SCADA system now under development by DWSD.

Since the results of this project could be applied by other communities with similar interests, the guidebook developed will provide these communities with guidance on collecting and analyzing data as well as technical advice for implementing an energy optimization program.

Appendix A
Pumping Equipment
Database

APPENDIX A

TABLE OF CONTENTS	Page
<u>Booster Stations</u>	
Adams Road Station	A-1
Eastside (Canyon) Station	A-2
Electric Avenue Station	A-3
Farmington Station	A-4
Ford Road Station	A-5
Franklin Station	A-6
Imlay Station	A-7
Joy Road Station	A-8
Michigan Avenue Station	A-9
Newburgh Station	A-10
North Service Center	A-11
Northwest Station	A-12
Orion Station	A-13
Roseville Station	A-14
St. Clair Station	A-15
Schoolcraft Station	A-16
West Chicago Station	A-17
West Service Center	A-18
Wick Road Station	A-19
Ypsilanti Station	A-20
<u>Water Treatment Plants</u>	
Lake Huron Water Plant	A-21
Northeast Water Plant	A-22
Southwest Water Plant	A-23
Springwells Water Plant	A-24
Water Works Plant	A-25

Energy Optimization of Water Distribution System
City of Detroit, Michigan
Pumping Equipment Database

Adams Road Station

1. Booster Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
L1	Horizontal, centrifugal	18.20	191.0	1200	Allis Chalmers	Horizontal, synchronous, AC	750	4800	1200	Ideal Electric
L2	Horizontal, centrifugal	18.20	191.0	1200	Allis Chalmers	Horizontal, synchronous, AC	750	4800	1200	Ideal Electric
L3	Horizontal, centrifugal	18.20	191.0	1200	Allis Chalmers	Horizontal, synchronous, AC	750	4800	1200	Ideal Electric
L4	Horizontal, centrifugal	18.20	191.0	1200	Allis Chalmers	Horizontal, synchronous, AC	750	4800	1200	Ideal Electric

2. Reservoir Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture

3. Reservoir Capacity

No.	Capacity (mg)

Energy Optimization of Water Distribution System
City of Detroit, Michigan
Pumping Equipment Database

Eastside (Canyon) Station

1. Booster Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture

2. Reservoir Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
1	centrifugal	10.00	150.0	1185	Morris	Polyphase, induction	350	2300	1185	Ideal Electric
2	centrifugal	10.00	150.0	1185	Morris	Polyphase, induction	350	2300	1185	Ideal Electric
3	centrifugal	10.00	150.0	1185	Morris	Polyphase, induction	350	2300	1185	Ideal Electric

3. Reservoir Capacity

No.	Capacity (mg)
1	10.00

Energy Optimization of Water Distribution System
City of Detroit, Michigan
Pumping Equipment Database

Electric Avenue Station

1. Booster Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
1	centrifugal	5.04	75.0	1175	Economy	Squirrel cage, induction	100	440	1175	Ideal Electric
2	centrifugal	5.04	75.0	1175	Economy	Squirrel cage, induction	100	440	1175	Ideal Electric

2. Reservoir Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
3	centrifugal	5.76	150.0	1175	Wheeler	Squirrel cage, induction	200	440	1750	Ideal Electric
4	centrifugal	8.64	150.0	1160	Morris	Polyphase, induction	300	440	1175	Ideal Electric

3. Reservoir Capacity

No.	Capacity (mg)
1	3.30
2	3.30

Energy Optimization of Water Distribution System
 City of Detroit, Michigan
 Pumping Equipment Database

Farmington Station

1. Booster Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (V)	Motor Speed (rpm)	Motor Manufacture
1	Centrifugal	1.00	90.0	1750	Peerless	AC, induction	25	220/440	1750	General Electric
2	Centrifugal	1.00	90.0	1750	Peerless	AC, induction	25	220/440	1750	General Electric
3	Centrifugal	2.16	150.0	1766	Union Steam	AC, induction	75	220/440	1766	Fairbanks Morse
4	Centrifugal	2.16	150.0	1766	Union Steam	AC, induction	75	220/440	1766	Fairbanks Morse

2. Reservoir Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture

3. Reservoir Capacity

No.	Capacity (mg)
1	1.00
2	0.25

Energy Optimization of Water Distribution System
City of Detroit, Michigan
Pumping Equipment Database

Ford Road Station

1. Booster Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
L1	Vertical	18.00	60.0	900	Johnston	Induction	250	4600	900	General Electric
L2	Vertical	10.00	120.0	1200	Johnston	Induction	250	4600	1200	General Electric
L3	Vertical	10.00	120.0	1200	Johnston	Induction	250	4600	1200	General Electric
L4	Vertical	10.00	120.0	1200	Johnston	Induction	250	4600	1200	General Electric
L5	Vertical	10.00	120.0	1200	Johnston	Induction	250	4600	1200	General Electric

2. Reservoir Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
R6	Vertical	10.00	210.0	1180	Peerless	Polyphase, induction	450	4600	1182	Ideal Electric
R7	Vertical	10.00	210.0	1180	Peerless	Polyphase, induction	450	4600	1182	Ideal Electric
R8	Vertical	10.00	210.0	1180	Peerless	Polyphase, induction	450	4600	1182	Ideal Electric
R9	Vertical	10.00	210.0	1180	Peerless	Polyphase, induction	450	4600	1182	Ideal Electric
R10	Vertical	10.00	210.0	1180	Peerless	Polyphase, induction	450	4600	1182	Ideal Electric

3. Reservoir Capacity

No.	Capacity (mg)
1	10.00

Energy Optimization of Water Distribution System
City of Detroit, Michigan
Pumping Equipment Database

Franklin Station

1. Booster Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
L1	Centrifugal	22.00	250.0	900	DeLaval	Synchronous, AC	1250	4600	900	Ideal Electric
L2	Centrifugal	22.00	250.0	900	DeLaval	Synchronous, AC	1250	4600	900	Ideal Electric
L3	Centrifugal	22.00	250.0	900	DeLaval	Synchronous, AC	1250	4600	900	Ideal Electric

2. Reservoir Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
R1	Centrifugal	22.00	320.0	900	DeLaval	Synchronous, AC	1570	4600	900	Ideal Electric
R2	Centrifugal	22.00	320.0	900	DeLaval	Synchronous, AC	1570	4600	900	Ideal Electric

3. Reservoir Capacity

No.	Capacity (mg)
1	10.00

Energy Optimization of Water Distribution System
City of Detroit, Michigan
Pumping Equipment Database

Imlay Station

1. Booster Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture

2. Reservoir Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
R1	Horizontal, centrifugal	75.00	335.0	1200	DeLaval	Horizontal, synchronous	5700	13200	1200	Pontec
R2	Horizontal, centrifugal	75.00	335.0	720	DeLaval	Horizontal, synchronous	5250	13200	720	Pontec
R3	Horizontal, centrifugal	75.00	335.0	1200	DeLaval	Horizontal, synchronous	5700	13200	1200	Pontec

3. Reservoir Capacity

No.	Capacity (mg)
1	20.00

Energy Optimization of Water Distribution System
City of Detroit, Michigan
Pumping Equipment Database

Joy Road Station

1. Booster Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
L1	Centrifugal	15.80	288.0	1200	DeLaval	Synchronous, AC	1050	4600	1200	Ideal Electric
L2	Centrifugal	15.80	288.0	1200	DeLaval	Synchronous, AC	1050	4600	1200	Ideal Electric
L3	Centrifugal	15.00	286.0	1200	Worthington	Brushless, synchronous, AC	1000	4600	1200	Ideal Electric

2. Reservoir Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage	Motor Speed (rpm)	Motor Manufacture
R1	Centrifugal	16.10	332.0	1200	DeLaval	Synchronous, AC	1200	4600	1200	Ideal Electric
R2	Centrifugal	16.10	332.0	1200	DeLaval	Synchronous, AC	1200	4600	1200	Ideal Electric
R3	Centrifugal	15.00	332.0	1200	Worthington	Brushless, synchronous, AC	1250	4600	1200	Ideal Electric

3. Reservoir Capacity

No.	Capacity (mg)
1	5
2	5

Energy Optimization of Water Distribution System
 City of Detroit, Michigan
 Pumping Equipment Database

Michigan Avenue Station

1. Booster Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
1	Centrifual	3.60	90.0	1765	American Well Works	AC, induction	75	440	1765	General Electric
2	Centrifual	3.60	90.0	1765	American Well Works	AC, induction	75	440	1765	General Electric
3	Centrifual	4.30	110.0	1175	Morris	AC, induction	125	440	1175	Ideal Electric

2. Reservoir Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
4	Centrifual, vertical	8.64	150.0	1180	Peerless	AC, induction, vertical	300	440	1180	Ideal Electric
5	Centrifual, vertical	8.64	150.0	1170	DeLaval	AC, induction, vertical	300	440	1180	General Electric

3. Reservoir Capacity

Name	Capacity (mg)
East	3.50
West	3.30

Energy Optimization of Water Distribution System
City of Detroit, Michigan
Pumping Equipment Database

Newburgh Station

1. Booster Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
1	Vertical, centrifugal	8.00	200.0	1200	Fairbanks Morse	Vertical, synchronous, AC	450	4160	1200	Fairbanks Morse
2	Vertical, centrifugal	8.00	200.0	1200	Fairbanks Morse	Vertical, synchronous, AC	450	4160	1200	Fairbanks Morse
3	Vertical, centrifugal	12.00	200.0	1182	Fairbanks Morse	Vertical, synchronous, AC	515	4160	1182	Fairbanks Morse
4	Vertical, centrifugal	12.00	200.0	1182	Fairbanks Morse	Vertical, synchronous, AC	515	4160	1182	Fairbanks Morse
5	Vertical, centrifugal	12.00	200.0	1182	Fairbanks Morse	Vertical, synchronous, AC	515	4160	1182	Fairbanks Morse

2. Reservoir Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture

3. Reservoir Capacity

No.	Capacity (mg)

Energy Optimization of Water Distribution System
City of Detroit, Michigan
Pumping Equipment Database

North Service Center

1. Booster Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
1*	Centrifugal	17.00	180.0	900	Byron-Jackson		700			
2	Centrifugal	30.0/23.0	370/240	900/720	DeLaval	Synchronous, 1 high speed & 1 low speed**	H2500/L1250	4600	H900/L720	Westinghouse
3	Centrifugal	25.5/19.3	400/260	900/720	DeLaval	Synchronous, 1 high speed & 1 low speed**	H2500/L1250	4600	H900/L720	Ideal Electric
4	Centrifugal	30.0/23.0	370/240	900/720	DeLaval	Synchronous, 1 high speed & 1 low speed**	H2500/L1250	4600	H900/L720	Westinghouse
5	Centrifugal	25.5/19.3	400/260	900/720	DeLaval	Synchronous, 1 high speed & 1 low speed**	H2500/L1250	4600	H900/L720	Ideal Electric
6	Centrifugal	25.5/19.3	400/260	900/720	DeLaval	Synchronous, 1 high speed & 1 low speed**	H2500/L1250	4600	H900/L720	Ideal Electric

* Pump is in building but is not connected.

** Only one motor runs at a time, while the other free wheels.

2. Reservoir Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
R1	Vertical	15.00	75.0	1200	Fairbanks Morse	AC, induction	250	4600	1185	General Electric
R2	Vertical	15.00	75.0	1200	Fairbanks Morse	AC, induction	250	4600	1185	General Electric
R3	Vertical	20.00	76.0	1185	Johnson	Vertical, AC, induction	350	4600	700	General Electric
R4	Vertical	20.00	76.0	1185	Johnson	Vertical, AC, induction	350	4600	700	General Electric

3. Reservoir Capacity

No.	Capacity (mg)
1	10.00
2	10.00

Energy Optimization of Water Distribution System
City of Detroit, Michigan
Pumping Equipment Database

Northwest Station

1. Booster Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture

2. Reservoir Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
1	Vertical, centrifugal	10.00	150.0	1175	Morris	Polyphase, induction	350	2300	1185	Ideal Electric
2	Vertical, centrifugal	10.00	150.0	1175	Morris	Polyphase, induction	350	2300	1185	Ideal Electric
3	Vertical, centrifugal	10.00	150.0	1175	Morris	Polyphase, induction	350	2300	1185	Ideal Electric
4	Vertical, centrifugal	10.00	150.0	1175	Morris	Polyphase, induction	350	2300	1185	Ideal Electric
5	Vertical, centrifugal	10.00	150.0	1175	Morris	Polyphase, induction	350	2300	1185	Ideal Electric

3. Reservoir Capacity

No.	Capacity (mg)
1	10.00

Energy Optimization of Water Distribution System
City of Detroit, Michigan
Pumping Equipment Database

Orion Station

1. Booster Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
L1	Horizontal, centrifugal	2.00	85.0	1170	Allis Chalmers	Horizontal, AC, induction	40	230/460	1185	US Electrical Motors
L2	Horizontal, centrifugal	4.00	85.0	1170	Allis Chalmers	Horizontal, AC, induction	75	230/460	1185	US Electrical Motors
L3	Horizontal, centrifugal	4.00	85.0	1170	Allis Chalmers	Horizontal, AC, induction	75	230/460	1185	US Electrical Motors

2. Reservoir Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture

3. Reservoir Capacity

No.	Capacity (mg)

Energy Optimization of Water Distribution System
City of Detroit, Michigan
Pumping Equipment Database

Roseville Station

1. Booster Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
1	Vertical, double stage, turbine	3.00	185.0	1760	Peerless	Vertical, AC, induction	100	440	1760	Electric Products
2	Vertical, double stage, turbine	3.00	185.0	1760	Peerless	Vertical, AC, induction	100	440	1760	Electric Products
3	Vertical, single stage, turbine	5.00	185.0	1760	Peerless	Vertical, AC, induction	200	440	1760	Electric Products
4	Vertical, single stage, turbine	10.00	183.0	1180	Peerless	Vertical, AC, induction	350	440	1180	Electric Products

2. Reservoir Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture

3. Reservoir Capacity

No.	Capacity (mg)

Energy Optimization of Water Distribution System
City of Detroit, Michigan
Pumping Equipment Database

Schoolcraft Station

1. Booster Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
L1	Centrifugal	20.00	170.0	1180	Worthington	Polyphase, AC, induction, variable speed	800	4000	770-1190	Ideal Electric
L2	Centrifugal	20.00	170.0	1180	Worthington	Polyphase, AC, induction, variable speed	800	4000	770-1190	Ideal Electric

2. Reservoir Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
R1	Centrifugal	20.00	238.0	800	DeLaval	AC, induction	1150	13200	892	Protec
R2	Centrifugal	20.00	238.0	800	DeLaval	AC, induction	1150	13200	892	Protec

3. Reservoir Capacity

No.	Capacity (mg)
1	10.00

Energy Optimization of Water Distribution System
 City of Detroit, Michigan
 Pumping Equipment Database

St. Clair Shores Station

1. Booster Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
1	Vertical, centrifugal	6.00	140.0	1770	Peerless	Polyphase, induction	200	440	1770	Ideal Electric
2	Vertical, centrifugal	6.00	140.0	1770	Peerless	Polyphase, induction	200	440	1770	Ideal Electric
3	Vertical, centrifugal	6.00	140.0	1770	Peerless	Polyphase, induction	200	440	1770	Ideal Electric

2. Reservoir Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture

3. Reservoir Capacity

No.	Capacity (mg)
1	4.00

Energy Optimization of Water Distribution System
City of Detroit, Michigan
Pumping Equipment Database

West Chicago Station

1. Booster Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
1	Centrifugal	7.42	180.0	1175	Worthington	AC, induction	300	440	1175	General Electric
2	Centrifugal	7.42	180.0	1175	Worthington	AC, induction	300	440	1175	General Electric
3	Centrifugal	4.32	110.0	1170	Morris	AC, induction	125	440	1175	Ideal Electric

2. Reservoir Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
4	Vertical, turbine	7.20	185.0	1160/1760	Peerless	Vertical, AC	300	440	1000/1200	US Electric Motors
5	Vertical, turbine	7.20	185.0	1160/1760	Peerless	Vertical, AC	300	440	1000/1200	US Electric Motors
6	Vertical, turbine	7.20	185.0	1160/1760	Peerless	Vertical, AC	300	440	1000/1200	US Electric Motors

3. Reservoir Capacity

No.	Capacity (mg)
1	9.50

Energy Optimization of Water Distribution System
City of Detroit, Michigan
Pumping Equipment Database

West Service Center

1. Booster Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
1	Centrifugal	29.90	101.0	890	Fairbanks Morse	AC, induction	700	4600	890	Fairbanks Morse
2	Centrifugal	29.90	101.0	890	Fairbanks Morse	AC, induction	700	4600	890	Fairbanks Morse
3	Centrifugal	29.90	101.0	890	Fairbanks Morse	AC, induction	700	4600	890	Fairbanks Morse
4	Centrifugal	28.80	188.0	900	Fairbanks Morse	AC, synchronous	1250	4600	900	Fairbanks Morse
5	Centrifugal	29.50	188.0	900	Fairbanks Morse	AC, synchronous	1250	4600	900	Fairbanks Morse
6	Centrifugal	29.50	188.0	900	Fairbanks Morse	AC, synchronous	1250	4600	900	Fairbanks Morse

2. Reservoir Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
R1	Centrifugal	23.90	96.0	720	Fairbanks Morse	AC, induction	400	4600	720	Fairbanks Morse
R2	Centrifugal	23.90	96.0	720	Fairbanks Morse	AC, induction	400	4600	720	Fairbanks Morse
R3	Single stage, vertical, turbine	20.00	85.0	700	Johnson	Vertical, AC, induction	400	4600	700	Ideal Electric
R4	Single stage, vertical, turbine	20.00	85.0	700	Johnson	Vertical, AC, induction	400	4600	700	Ideal Electric

3. Reservoir Capacity

No.	Capacity (mg)
1	10.00
2	10.00

Energy Optimization of Water Distribution System
City of Detroit, Michigan
Pumping Equipment Database

Wick Road Station

1. Booster Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
L1	Centrifugal, double suction, volute	18.00	252.0	540-1185	Torishima	Polyphase, wound rotor, variable speed	1000	4000	1185	Ideal Electric
L2	Centrifugal, double suction, volute	18.00	252.0	540-1185	Torishima	Polyphase, wound rotor, variable speed	1000	4000	1185	Ideal Electric

2. Reservoir Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
R1	Centrifugal, double suction, volute	12.00	328.0	1173	Torishima	Polyphase, squirrel cage, induction	1000	4000	1173	Ideal Electric
R2	Centrifugal, double suction, volute	12.00	328.0	1173	Torishima	Polyphase, squirrel cage, induction	1000	4000	1173	Ideal Electric
R3	Centrifugal, double suction, volute	12.00	328.0	1185	Torishima	Polyphase, wound rotor, induction	1000	4000	1185	Ideal Electric

3. Reservoir Capacity

No.	Capacity (mg)
1	10.00

Energy Optimization of Water Distribution System
City of Detroit, Michigan
Pumping Equipment Database

Ypsilanti Station

1. Booster Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage	Motor Speed (rpm)	Motor Manufacture
L1	Horizontal, centrifugal	18.00	250.0	1190	Ebara	AC, horizontal, induction	1000	4000	1189	Ideal Electric
L2	Horizontal, centrifugal	18.00	250.0	1190	Ebara	AC, horizontal, induction	1000	4000	1189	Ideal Electric
L3	Horizontal, centrifugal	18.00	250.0	1190	Ebara	AC, horizontal, induction	1000	4000	1189	Ideal Electric

2. Reservoir Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage	Motor Speed (rpm)	Motor Manufacture

3. Reservoir Capacity

No.	Capacity (mg)

Energy Optimization of Water Distribution System
City of Detroit, Michigan
Pumping Equipment Database

Lake Huron Water Plant

1. High Lift Pumps

[illegible]

2. Reservoir Capacity

Name	Capacity (mg)
North	15
South	15

Energy Optimization of Water Distribution System
City of Detroit, Michigan
Pumping Equipment Database

Northeast Water Plant

1. High Lift Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
9	Vertical, centrifugal	52.00	240.0	514	Fairbanks Morse	synchronous	3000	4160	514	Fairbanks Morse
10	Vertical, centrifugal	52.00	240.0	514	Fairbanks Morse	synchronous	3000	4160	514	Fairbanks Morse
11	Vertical, centrifugal	50.00	200.0	514	Fairbanks Morse	synchronous	1750	4160	514	Fairbanks Morse
12	Vertical, centrifugal	50.00	200.0	514	Fairbanks Morse	synchronous	1750	4160	514	Fairbanks Morse
13	Vertical, centrifugal	50.00	200.0	514	Fairbanks Morse	synchronous	1750	4160	514	Fairbanks Morse
14	Vertical, centrifugal	40.00	200.0	510*	Fairbanks Morse	Induction, variable speed	1750	2300	510*	Fairbanks Morse
15	Vertical, centrifugal	52.00	240.0	514	Fairbanks Morse	synchronous	3000	4160	514	Fairbanks Morse
16	Vertical, centrifugal	52.00	240.0	514	Fairbanks Morse	synchronous	3000	4160	514	Fairbanks Morse
17	Vertical, centrifugal	52.00	240.0	514	Fairbanks Morse	synchronous	3000	4160	514	Fairbanks Morse
18	Vertical, centrifugal	40.00	200.0	510*	Fairbanks Morse	Induction, variable speed	1750	2300	510*	Fairbanks Morse
19	Vertical, centrifugal	50.00	200.0	514	Fairbanks Morse	synchronous	1750	4160	514	Fairbanks Morse
20	Vertical, centrifugal	50.00	200.0	514	Fairbanks Morse	synchronous	1750	4160	514	Fairbanks Morse

* Maximum speed

2. Reservoir Capacity

No.	Capacity (mg)
1	15
2	15

Energy Optimization of Water Distribution System
City of Detroit, Michigan
Pumping Equipment Database

Springwells Water Plant

1. High Lift Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
11	Horizontal, centrifugal	40.00	200.0	600	Worthington	Synchronous	1725	4600	600	General Electric
12	Horizontal, centrifugal	50.00	150.0	514	Worthington	Synchronous, self-excited	1675	4600	514	General Electric
13	Horizontal, centrifugal	60.00	200.0	514	DeLaval	Synchronous	2500	4600	514	Ideal Electric
14	Horizontal, centrifugal	60.00	150.0	514	DeLaval	Synchronous	2750	4600	514	Ideal Electric
15	Horizontal, centrifugal	40.00	200.0	600	Worthington	Synchronous	1725	4600	600	General Electric
16	Horizontal, centrifugal	50.00	150.0	514	Worthington	Synchronous, self-excited	1440	4600	514	General Electric
17	Horizontal, centrifugal	40.00	200.0	600	Worthington	Synchronous	1725	4600	600	General Electric
18	Horizontal, centrifugal	50.00	150.0	514	Worthington	Synchronous, self-excited	1440	4600	514	General Electric
19	Horizontal, centrifugal	60.00	200.0	514	DeLaval	Synchronous	2500	4600	514	Ideal Electric
20	Horizontal, centrifugal	60.00	150.0	514	DeLaval	Synchronous	2750	4600	514	Ideal Electric
21	Horizontal, centrifugal	40.00	200.0	600	Worthington	Synchronous	1725	4600	600	General Electric
22	Horizontal, centrifugal	50.00	150.0	514	Worthington	Synchronous, self-excited	1675	4600	514	General Electric
23	Horizontal, centrifugal	60.00	200.0	514	DeLaval	Synchronous	2500	4600	514	Ideal Electric
24	Horizontal, centrifugal	60.00	200.0	514	DeLaval	Synchronous	2500	4600	514	Ideal Electric
25	Horizontal, centrifugal	50.00	200.0	600	Worthington	Synchronous	2250	4600	600	Electric Machinery
26	Horizontal, centrifugal	60.00	200.0	514	DeLaval	Synchronous	2500	4600	514	Ideal Electric

2. Reservoir Capacity

No.	Capacity (mg)
1	20
2	20
3	20

Southwest Water Plant

[illegible]

No.	Capacity (mg)
1	10
2	10
3	10

Energy Optimization of Water Distribution System
City of Detroit, Michigan
Pumping Equipment Database

Water Works Park

1. High Lift Pumps

Pump No.	Type	Rated Capacity (mgd)	Rated Head (ft)	Pump Speed (rpm)	Pump Manufacture	Motor Type	Motor Power (hp)	Motor Voltage (v)	Motor Speed (rpm)	Motor Manufacture
2	Horizontal, centrifugal	90.00	180.0	600	Fairbanks Morse	Synchronous	3500	4160	600	Fairbanks Morse
3	Horizontal, centrifugal	80.00	180.0	514	Worthington	Synchronous	3000	4160	514	Ideal Electric
4	Horizontal, centrifugal	90.00	180.0	600	Fairbanks Morse	Synchronous	3500	4160	600	Fairbanks Morse
5	Horizontal, centrifugal	60.00	180.0	600	DeLaval	Synchronous	2250	4160	600	Ideal Electric
6	Horizontal, centrifugal	60.00	180.0	600	DeLaval	Synchronous	2250	4160	600	Ideal Electric
7	Horizontal, centrifugal	60.00	180.0	600	DeLaval	Synchronous	2250	4160	600	Ideal Electric
8	Horizontal, centrifugal	60.00	180.0	600	DeLaval	Synchronous	2250	4160	600	Ideal Electric
9	Horizontal, centrifugal	40.00	180.0	720	DeLaval	Synchronous	1500	4160	720	Westinghouse
10	Horizontal, centrifugal	40.00	180.0	720	DeLaval	Synchronous	1500	4160	720	Westinghouse
11	Horizontal, centrifugal	40.00	180.0	720	DeLaval	Synchronous	1500	4160	720	Westinghouse
12	Horizontal, centrifugal	40.00	180.0	720	DeLaval	Synchronous	1500	4160	720	Westinghouse

2. Reservoir Capacity

No.	Capacity (mg)
1	35
2	20

Appendix B
Energy Optimization
of Water Distribution
System Guidebook

**ENERGY OPTIMIZATION
OF
WATER DISTRIBUTION SYSTEM
GUIDEBOOK**

TABLE OF CONTENTS	Page
Chapter 1 - Introduction	1
Chapter 2 - Data Collection	
2.1 Introduction	2
2.2 Water Distribution Pipe Network	2
2.3 Water Storage and Pumping Facilities	3
2.4 Pressure and Flow Specifications	7
2.5 Energy Charges	7
Chapter 3 - Hydraulic Computer Model Software	
3.1 Introduction	8
3.2 Water Distribution Computer Programs	8
3.3 Energy Optimization Programs	8
Chapter 4 - Summary	10
Appendix	
A -- Network Model Survey	
Figures	
2-1 Water Storage Facility Data Summary Form	5
2-2 Pump Data Summary Sheet	6

CHAPTER ONE

INTRODUCTION

Energy costs associated with municipalities providing treated water to its customers continues to be one of its largest expenditures. Typically, the largest consumers of energy in water distribution systems are the high lift and booster pumps.

The Energy Optimization of Water Distribution System Guidebook has been developed to assist municipalities in developing their own energy optimization system. The guidebook is based on the experience gained from the Energy Optimization of Water Distribution System project for the Detroit Water and Sewerage Department (DWSD) and will address the methodology used, together with criteria for evaluating results and technical advice on gathering and using data.

The guidebook describes work completed in the first year of the DWSD project. This work included the development of the pump and system database which will be utilized in producing the computer program for analyzing different pump combinations.

A final version of the guidebook will be produced at the completion of the project. The final version will be expanded to include commentary on analyzing data and utilizing the results from the computer model. The guidebook will be revised based on the experience gained in completing the project and will contain technical advice on implementing an energy optimization program.

CHAPTER TWO

DATA COLLECTION

2.1 INTRODUCTION

An energy optimization project to reduce energy cost at pumping facilities is typically based on or linked with a hydraulic computer model of the system. Therefore, the data collection phase should consist of collecting the data that will be utilized as input for the computer model. Sources of information for this phase of the project are typically the municipality and the local utility company.

2.2 WATER DISTRIBUTION PIPE NETWORK

The initial step in preparing the input data for the computer model is to develop a plan for summarizing specific information on the pipe network and pumping and storage facilities. The methods suggested are described below and should be used as a preliminary attempt to collect and tabulate necessary information. These methods should be modified as required to include other information that may be specific to the system being modeled.

In order to compile the pipe data a water map depicting the system should be used. This map can usually be acquired from the municipality and typically indicates the size, location, and length of the pipes, as well as size and location of valves and meters. Information on the pipe age and material and valve settings can be obtained from operation and maintenance logs and as-built drawings. Pipe age and material information will be used to estimate the pipe friction coefficients. This information can be written directly on a copy of the water map.

Once the information described above is compiled a coordinate system can be established. Nodal points would then be identified and coordinates assigned to each node.

There are a number of components in a system, such as valves, bends, junctions, etc., that would be classified as minor losses, but may produce significant head losses and should be accounted for. Although it is necessary to account for this information in the data collection phase, the need for actually including these minor losses in the model should depend on the judgement of person developing the model.

Consideration should be made to simplify the model to the extent that the solution will not significantly be affected. Reducing the size of the computer file, especially for large systems, will reduce computer time and reduce the manhours required to obtain and input the information. Typically this is accomplished by reducing the number of pipes in the model and is referred to as "skeletonizing" the system. Commonly this is accomplished by only considering pipes above a certain minimum size. Network skeletonizing may be difficult in certain cases and the user is referred to AWWA Manual M32, "Distribution Network Analysis for Water Utilities," for additional information.

2.3 WATER STORAGE AND PUMPING FACILITIES

Usually there are two types of scenarios that energy optimization programs are based on. For a specified time interval, the user wants to determine the most cost effective pump combinations that would be required to either produce desired water elevations in the storage tanks, or to meet a required system demand. In order to

collect information required to analyze these scenarios, two data summary forms were developed and are shown in Figures 2-1 and 2-2.

Figure 2-1 provides a space for the dimensions of the tanks or reservoirs and their operating ranges. This information should be collected if the energy optimization project is trying to determine cost effective pumping combinations to produce desired water elevations in the system.

Pump curve data for each pump is essential for developing an energy optimization model. Selected points from the pump curves are inputted into the computer program to describe the head-flow characteristics of each pump. The pump curves also provide pump efficiency and brake horsepower data which is required to calculate the overall or "wire-to-water" efficiency. The wire-to-water efficiency will be used in calculating the energy cost for the pumping. This information would be recorded on the form shown in Figure 2-2.

WATER STORAGE FACILITY
DATA SUMMARY FORM

I. GENERAL

STATION: _____

LOCATION: _____

GROUND ELEV: _____

II. TANKS/RESERVOIR

NO.	CAPACITY	CROSS SECTIONAL		OVERFLOW OPERATING		RANGE
		AREA	(sf)	HEIGHT	ELEVATION	
_____	(mg) _____	_____	_____	(ft) _____	(ft) _____	(ft) _____
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____

RECORDED BY: _____

DATE: _____

FIGURE 2-1

PUMP DATA SUMMARY SHEET

I. GENERAL

STATION: _____

LOCATION: _____

GROUND ELEV: _____

TYPE: _____ RESERVOIR

_____ IN-LINE BOOSTER

_____ HIGH LIFT

If reservoir pump, indicate reservoir number. _____

II. PUMP

Pump No. _____

Mfg. _____

Rated Head _____

Rated Flow _____

Imp. Size _____

Speed _____

Is pump curved attached? _____

III. MOTOR

Mfg. _____

Type _____

Horsepower _____

Voltage _____

Speed _____

RECORDED BY: _____

DATE: _____

FIGURE 2-2

2.4 PRESSURE AND FLOW SPECIFICATIONS

Information is required to describe the flows entering and leaving the system. There are typically several monitoring points within the system that can be utilized to collect pressure data. Examples of these locations would be places like pumping stations and fire houses. Meter records from the municipalities can be obtained to determine water demands as well as data from various flow meters located in the system. Fire hydrants are also good locations for measuring both pressures and flow demands.

Currently, this information is still being collected for the project. Additional information will be provided in the final version of the guidebook.

2.5 ENERGY CHARGES

The last piece of information needed in developing an energy optimization project is the energy costs associated with pump operations. The electrical rates charged by the utility company can usually be separated into two categories, electrical usage charges and demand charges. Electrical usage charges are direct charges for the volume of electricity consumed. Demand charges are based on the maximum amount of power consumed in a short time during the billing period; typically 30 minutes.

The electrical power rate structure can be obtained from the local utility company as well as billing statements for individual pumping stations. This information will be utilized to determine the most cost effective pump combinations and identify which stations are consuming a major fraction of the electricity.

CHAPTER THREE

HYDRAULIC COMPUTER MODEL SOFTWARE

3.1 INTRODUCTION

Chapter two described the data necessary for developing an energy optimization computer model. In most cases the municipality will have a computer model of their distribution system. If this is the case, it must be determined if the model is still an accurate representation of the existing system and whether or not it can interface with an energy optimization package.

This chapter will provide information on the current hydraulic computer software available on the market and telephone numbers to call for additional information. Currently, the guidebook does not provide selection criteria of computer software for an energy optimization program. However, this information will be provided in the final version of the guidebook.

3.2 WATER DISTRIBUTION COMPUTER PROGRAMS

A summary of a network model survey was compiled by Lindell Ormsbee and Don Chase from the University of Kentucky and Walter Grayman, a consulting engineer. The information is shown in Appendix A. The survey provides the model name, contact person, and telephone number for each program. A summary of the program features, computer requirements and maximum number of pipe links allowed is also included.

3.3 DEVELOPMENT OF AN ENERGY OPTIMIZATION PROGRAM

The final version of the guidebook will provide information on energy optimization programs that can be

utilized to evaluate the response of a water distribution system for a variety of pump combinations and calculate the associated energy costs of operating each combination. The guidebook will include commentary on how to use the results of the analysis to improve operating practices and develop an energy strategy and planning guidelines.

CHAPTER FOUR

SUMMARY

The guidebook discusses what data is required for a computer model that would be used to develop an energy optimization program and what software is currently available. The final version of the guidebook will be expanded to include commentary on analyzing data and utilizing the results. The guidebook will be revised based upon the experience gained during the final half of the project and will contain additional technical advice on implementing an energy optimization program.

Appendix A
Network Model Survey

**ENERGY OPTIMIZATION OF WATER
DISTRIBUTION SYSTEM GUIDEBOOK
APPENDIX A**

TABLE OF CONTENTS	Page
AQUA	A-1
CalcFlow	A-2
CYBERNET Version 1.2	A-3
FAAST-3 (Fluid Analysis and Simulation Technique)	A-5
KYPIPE2	A-7
PIPES FOR WINDOWS	A-8
RINCAD 3.0	A-9
SDP	A-10
Stoner Workstation Service (SWS)	A-11
TDHNET 2.6/3.0 TDHUTILS 1.0	A-13
USU-NETWK	A-15
WADISO (Water Distribution System Optimization)	A-17
WATER / WGRAPH	A-18
Waterworks all-in-one PC Software (Lotus 1-2-3 Version)	A-19
WATSYS	A-21
WATNET	A-23
Waterworks for AutoCAD	A-24

NETWORK MODEL SURVEY

MODEL NAME: AQUA

Company/Institution: Computer Modeling, Inc.

Address: 2121 Front Street, Cuyahoga Falls, OH 44221

Contact person: Yutang Chuang Phone: (216) 929-7886 FAX: (216) 929-2756
or John Carpenter

Check all features that apply:

☒ Steady State ☒ Internal editor ☒ Time of travel model

☒ Extended period simulation ☒ Graphical display ☒ Water quality model

Model formulation/solution techniques for hydraulic model:

Problem formulation: ☐ Node ☒ Loop Other: _____

Solution method: ☐ Linearized ☒ Newton Raphson Other: _____

Sparse matrix techniques: Qausi-Newton Raphson with high efficiency BFGS method

Maximum number of pipe links:

Only limited by available computer memory (For a PC with 640 KB RAM - up to 5,000 pipes).

Computer requirements:

PC with 512 KB RAM (640 KB preferred).
For system larger than 5,000 pipes, Minicomputers,
Workstations and PC with Windows.

Cost of model (include options):

Cost of model varies, depending on capacity, computer, and custom design needs.

Required external packages (e.g., Lotus, AutoCAD, etc.): None

Documentation/support: Yes. Manuals, seminars and 90 days free phone support.

Describe features that facilitate its use by inexperienced modelers:

User-friendly, on-screen help. Powerful internal editor with input field guide template for entering data (pipes, nodes, tanks, etc.) with search capability. Extensive example tutorials.

Describe any special features of the model: Handles large systems. Model can be coupled with the following:

- Cost Model
- Field Inventory Model
- Automatic Fire Flow Model
- Demand Allocation Model.

NETWORK MODEL SURVEY

MODEL NAME: CalcFlow

Company/Institution: Click & Go Ltd.

Address: 2023 20th Avenue S.W., Calgary, Alberta, Canada, T2T0M1

Contact person: John M. Living Phone: (403) 244-5476 FAX: (403) 245-0381
or Gordon A. Cuming

Check all features that apply:

- ☒ Steady State ☒ Internal editor ☐ Time of travel model
☒ Extended period simulation ☒ Graphical display ☐ Water quality model

Model formulation/solution techniques for hydraulic model:

Problem formulation: ☒ Node ☐ Loop Other: Shamir/Howard Algorithm

Solution method: ☐ Linearized ☒ Newton Raphson Other: _____

Sparse matrix techniques: Pointer Optimization

Maximum number of pipe links: 8,000 (Professional Version)

Computer requirements: Intel 80 x 86 (IBM PC/AT) with Hercules (VGA preferred Graphics card, Mouse

Cost of model (include options):

25 Node / 24 Hour Model.....	\$ 169.00 US
100 Node / 24 Hour Model.....	\$ 669.00 US
8,000 Node / 24 Hour Model.....	\$1,669.00 US

Required external packages (e.g., Lotus, AutoCAD, etc.): None required - standalone DOS program

Documentation/support:

- On Line Help
- Reference Manual on Disk
- Technical Support Line
- Quick Reference Guide

Describe features that facilitate its use by inexperienced modelers:

- CalcFlow requires no special computer programming skills
- modeler executes commands by "clicking" on menu buttons
- data entry screens provided with east entry format
- tutorial leads user through modelling process

Describe any special features of the model:

- Operate model from 2D/3D graphics display - "click" to add nodes/links or change data, and then continue
- "Management by exception" alarms
- Turn pumps on or off at any time during calculations - eight different pumps at each pump station - efficiencies calculated for each pump, and for pump station
- Reservoirs - supports pressure tanks and varying geometry
- Presentation output includes graphics, also writes spreadsheet files
- Additionally, designed as a training tool for system operators

NETWORK MODEL SURVEY

MODEL NAME: CYBERNET Version 1.2

Company/Institution: Haestad Methods, Inc.

Address: 37 Brookside Road, Waterbury, CT 06708

Contact person: John Powell Phone: 1-800-727-6555 FAX: (203) 597-1488
or (203) 755-1666

Check all features that apply:

☒ Steady State ☒ Internal editor ☒ Time of travel model
(for Version 2.0)

☒ Extended period simulation ☒ Graphical display ☒ Water quality model
(for Version 2.0)

Model formulation/solution techniques for hydraulic model:

Problem formulation: ☐ Node ☒ Loop Other: _____

Solution method: ☒ Linearized ☐ Newton Raphson Other: _____

Sparse matrix techniques: Yes (same algorithms as Kypipe)

Maximum number of pipe links: Virtually unlimited - depends on RAM

Computer requirements: 386 PC - Compatible with math coprocessor and 4 megs RAM

Cost of model (include options):

<u>Capacity</u>		<u>Price</u>
250 Pipes	=	\$ 995
500	=	1,495
1,000	=	1,995
2,000	=	2,995
5,000	=	4,995
10,000	=	6,995
>10,000 Pipes	=	negotiated

Required external packages (e.g., Lotus, AutoCAD, etc.):

Requires AutoCAD release 11

Documentation/support:

Cybernet includes complete documentation with example problems and lifetime, **unlimited** toll-free (in U.S. and Canada) technical support. FAX and Bulletin Board (BBS) available 24 hours/day for transmitting data.

Describe features that facilitate its use by inexperienced modelers:

Cybernet is intuitive to the new user. The program is organized around a system of easy-to-use menus which allow the modeler to build and maintain a complete network model. Engineers with no prior AutoCAD experience find this model quick and easy to learn. There is a comprehensive tutorial and

NETWORK MODEL SURVEY

MODEL NAME: CYBERNET Version 1.2 (continued)

learning guide in the documentation and software Cybernet can import existing data created with other network models including Kypipe, Water, and Waterworks.

Describe any special features of the model:

Water distribution design and analysis with Cybernet is radically different from conventional modeling methods. Cybernet is a comprehensive modeling tool embedded in AutoCAD with advanced mapping and graphics extensions to create a powerful pressure network modeling package.

Cybernet can model pipe networks to scale. The program includes routines to allow you to convert existing AutoCAD drawings or digitize your data from base maps. Pipes are not restricted to straight runs and can follow street or right-of-way alignments. Since pipes are defined by polylines and the default pipe length is automatically set to the scaled drawing length, a Cybernet network can conform to the actual system layout under design or analysis.

Multiple modeling scenarios can be defined to aid in the system analysis using the Modeling Control Center (MCC). The MCC is fully menu driven and gives the engineer complete control over the modeling environment. Features include: Scrollable data entry forms with context sensitive (F1 key) help. Special forms for the setup of Steady State and Extended Period Simulations (EPS). Run queuing which lets an engineer evaluate a series of scenarios, and Results display and output facilities.

Output options available include: Color Mapping of pipe flowrates, velocities, headloss, diameters, junction pressures, and hydraulic grades; Flow Direction Arrows; Contour Maps of HGL, elevation, pressure, and enhanced pressure; 3-D Graphics with pressure bars on junction nodes and suspended pressure meshes; Report Ready Tabular Output for all network elements; Time Series Plots for extended period simulation; Profiles of connected pipes or a user defined transect for elevation, HGL, pressure, and enhanced pressure; "Click on" Element Presentation of input and output data of pipes, nodes, pumps, tanks, pressure regulating valves, supply wells, and other elements; and the ability to fully Annotate and Label pipes and other network elements with input and output data including diameter, length, flowrate, roughness, age, and more.

NETWORK MODEL SURVEY

MODEL NAME: FAAST-3 (Fluid Analysis and Simulation Technique)

Company/Institution: Faast Software

Address: 3062 East Avenue, Livermore, California 94550 USA

Contact person: Russ Greenlaw Phone: (510) 455-8086 FAX: on request

Check all features that apply:

☒ Steady State ☒ Internal editor ☐ Time of travel model

☒ Extended period simulation ☒ Graphical display ☒ Water quality model

Model formulation/solution techniques for hydraulic model:

Problem formulation: ☒ Node ☐ Loop Other: _____

Solution method: ☒ Linearized ☐ Newton Raphson Other: _____

Sparse matrix techniques: Originated by Faast in 1976

Maximum number of pipe links:

Depends on type of computer: up to 9,999 presently.

Computer requirements:

MS-Dos 2 or better on PC/XT or better; DEC: VAX/VMS

CDC: Cyber NOS 1 or 2; HP 3000; IBM 370 TSO

Under development: Sun Spare, Intergraph, IBM RISC 6000

Cost of model (include options):

Depends on type of computer, version, and options. PC versions start at \$795.00.

Required external packages (e.g., Lotus, AutoCAD, etc.):

External packages not required. User may optionally use external data editor.

Documentation/support:

More than 300 pages of explanations and examples.

Describe features that facilitate its use by inexperienced modelers:

- Faast-3 provides free-form data input with plain-language commands and option names.
- Faast-3 provide interactive error recovery with built-in help to explain the command and option in progress.
- Faast-3 provides full log of all input data and commands to allow easy rerun of debugged models.

NETWORK MODEL SURVEY

MODEL NAME: FAAST-3 (Fluid Analysis and Simulation Technique) (continued)

Describe any special features of the model:

- Faast is the original finite-element technique for fluid system analysis and simulation, first released for users in 1972. No limits on elements in parallel.
- Faast originated the concept of time-simulation of fluid systems in 1972, and has been benchmarked against closed-form problems (solved by differential equations).
- Faast originated water-quality determination and path-tracing in 1974.
- Faast originated model plots (1980) with hydraulic and pressure contour plots in 1984.
- Faast allows any fluid of constant properties (not just fresh water). Choice of Darcy or Hazen-Williams pipe friction formulas. Pumps have 6-point user-input pump curve.
- Faast includes 6 element types, with sprinklers and 15 valve types, including both pressure and flow regulation valves. Properties of any element may be changed, and any element may be changed to another element type within a session.
- Faast provides 4 node types (fixed head, fixed pressure, fixed in/out-flow, and an variable head/pressure tank) and any node may have its properties changed, or be changed to another type within a session.
- Foreign language versions and SI units versions available on request.

NETWORK MODEL SURVEY

MODEL NAME: KYPIPE2

Company/Institution: University of Kentucky

Address: Civil Engineering Software Center, U of Kentucky, Lexington, KY 40506

Contact person: Dr. Don Wood

Phone: 606-257-3436

FAX: 606-257-4297

Check all features that apply:

☒ Steady State ☒ Internal editor ☒ Time of travel model

☒ Extended period simulation ☒ Graphical display ☐ Water quality model

Model formulation/solution techniques for hydraulic model:

Problem formulation:

☐

Node

☒

Loop

Other: _____

Solution method:

☐

Linearized

☒

Newton Raphson

Other: _____

Sparse matrix techniques: modified Harwell routines

Maximum number of pipe links: 1,000 (standard program), 6,000 (expanded version)

Computer requirements: 640K (standard), 4MB (expanded), VGA recommended

Cost of model (include options): \$450 (standard)
\$700 (expanded)

graphics (\$300)
graphics (CAD) (\$475)

Required external packages (e.g., Lotus, AutoCAD, etc.): None

Documentation/support:

Users Manual with tutorial and demonstrations

Phone and FAX support by developers and support engineer

Describe features that facilitate its use by inexperienced modelers:

Tutorial exercises in manual, simple menu operation full screen-cursor
controlled data entry-editing-error checking Periodic training courses

Describe any special features of the model:

A number of new features such as:

- 1) automatic regulating valve modeling
- 2) variable area storage, flow meters, pressure switches, demand pattern variations - for EPS modeling
- 3) direct parameter calculations for:
 - a) pump speed - power requirement
 - b) settings for storage levels, regulating valves
 - c) pipe diameter, roughness (calibration)
 - d) control valve settings
 - e) flow requirements

NETWORK MODEL SURVEY

MODEL NAME: PIPES FOR WINDOWS

Company/Institution: WATERCOM PTY LTD

Address: 105 Queen Victorian St., Bexley NSW 2217

Contact person: R.J. Stack

Phone: (02) 587-5384

FAX: (02) 587-538

Check all features that apply:

☒ Steady State ☒ Internal editor ☐ Time of travel model

☐ Extended period simulation ☒ Graphical display ☐ Water quality model

Model formulation/solution techniques for hydraulic model:

Problem formulation:

☐

Node

☒

Loop

Other: _____

Solution method:

☐

Linearized

☐

Newton Raphson

Other: Modified Newton Raphson

Sparse matrix techniques: _____

Maximum number of pipe links:

1,200

Computer requirements:

IBM or compatible 286, 386, or 486

Cost of model (include options):

Required external packages (e.g., Lotus, AutoCAD, etc.): MS WINDOWS Version 3. or later

Documentation/support:

USER MANUAL

Phone & FAX support anticipated

Describe features that facilitate its use by inexperienced modelers:

Visual cues indicate when all essential data has been provided for each element (e.g. pump, pipe, etc.) in the network. Data is checked as it is entered.

Describe any special features of the model:

MS WINDOWS provides intuitive graphical user interface. Built in CAD, with icons for pumps, valves, hydrants, sprinklers, nodes, etc. Data entry is done with WINDOWS dialogue boxes for each network element.

NETWORK MODEL SURVEY

MODEL NAME: RINCAD 3.0
Company/Institution: CEDEGER
Address: 1417, rue Michlin, Laval (Quebec), Canada H7L4S2
Contact person: Dr. Bahjat Ashkar Phone: (514) 629-888 FAX: (514) 382-3077

Check all features that apply:

☒ Steady State ☒ Internal editor ☒ Time of travel model
☐ Extended period simulation ☒ Graphical display ☐ Water quality model

Model formulation/solution techniques for hydraulic model:

Problem formulation: ☒ Node ☐ Loop Other: _____

Solution method: ☐ Linearized ☐ Newton Raphson Other: Newton Modified

Sparse matrix techniques: Automatic optimization of bandwidth & storage by skyline method

Maximum number of pipe links:

5500 links, 4500 nodes

Computer requirements:

286, 386, or 486; 640 kb; EGA or better

Cost of model (include options):

\$2,500

Required external packages (e.g., Lotus, AutoCAD, etc.):

AutoCAD (for digitizing and plotting)

Documentation/support:

244 page documentation

Describe features that facilitate its use by inexperienced modelers:

Choice of English or SI units

Describe any special features of the model:

Generation of DXF output file

A new version (RINCAD 4.0) will be released in 1993 which will include EPS mode, water quality modeling, and increased allowable number of nodes/links.

NETWORK MODEL SURVEY

MODEL NAME: SDP

Company/Institution: Charles Howard & Associates Ltd.

Address: 303 - 1111 Blanshard Street, Victoria, B.C. V8W 2H7, Canada

Contact person: Tung Van Do Phone: (604) 385-0206 FAX: (604) 385-7737

Check all features that apply:

☒ Steady State ☒ Internal editor ☐ Time of travel model

☒ Extended period simulation ☒ Graphical display ☐ Water quality model

Model formulation/solution techniques for hydraulic model:

Problem formulation: ☒ Node ☐ Loop Other: _____

Solution method: ☐ Linearized ☒ Newton Raphson Other: _____

Sparse matrix techniques: Currently being tested. Available 1992

Maximum number of pipe links: Limited only by computer memory. About 500 links, 300 nodes in 640K.

Computer requirements: Computation is portable to any Fortran compiler. Graphics only for IBM-PC compatibles.

Cost of model (include options): \$500.00 including technical support.

Required external packages (e.g., Lotus, AutoCAD, etc.):

None required. Input and output are handled via graphics. Report quality tables.

Documentation/support:

100 page user manual. Telephone support by professional engineers specialized in network analysis.

Describe features that facilitate its use by inexperienced modelers:

Input data errors are next to impossible because data is entered directly in the graphics screens. Output display shows variation in time and space.

Describe any special features of the model:

SDP for mainframes has been in use since 1966. SDP was designed to minimize engineering time by solving directly for pipe/pump characteristics reservoir capacities and operating rules, etc., by using specified performance requirements for the network. Pressure reducing valves, hydroelectric plants, etc., can be designed by directly solving for the required characteristic and operations. Data management is through dimensionless curves that typify hourly consumption patterns and specified hourly variations in heads.

NETWORK MODEL SURVEY

MODEL NAME: Stoner Workstation Service (SWS)

Company/Institution: Stoner Associates, Inc.

Address: P.O. Box 86, Carlisle, PA 17013

Contact person: Mr. Frank Rankin Phone: (717) 243-1900 FAX: (717) 243-5564

Check all features that apply:

☒ Steady State ☒ Internal editor ☒ Time of travel model

☒ Extended period simulation ☒ Graphical display ☒ Water quality model

Model formulation/solution techniques for hydraulic model:

Problem formulation:

☒ Node ☐ Loop Other: _____

Solution method:

☐ Linearized ☒ Newton Raphson Other: _____

Sparse matrix techniques: Proprietary, highly efficient, specialized techniques

Maximum number of pipe links: Unlimited (largest model to date over 40,000 pipe links)

Computer requirements:

386/486 (DOS), IBM RS/6000 (AIX), DEC VAX (VMS)
Additional UNIX versions planned.

Cost of model (include options): Varies. Contact SAI.

Required external packages (e.g., Lotus, AutoCAD, etc.): None

Documentation/support:

Well organized comprehensive User's Guide, Installation Instructions, 4-day training course, unlimited telephone support by a team of experienced engineers.

Describe features that facilitate its use by inexperienced modelers:

Interactive color graphical user interface presents a color coded annotated system plot, self documenting menu system, function key access to frequently used commands, on-screen "point and click" mouse operation, scaled digitizing of new pipes, complete model maintenance, updating, use and results presentation through a single user environment - no need to work with data files. Supports a variety of color plotters to generate scaled color system plots.

Describe any special features of the model:

Water Quality Modeling: steady-state equilibrium or quasi-dynamic propagation of conservative or reactive substance. Age of water. Source contributions at any location. Very fast execution speeds.

NETWORK MODEL SURVEY

MODEL NAME: Stoner Workstation Service (SWS) (continued)

Built-in "Demand Manger" gives tremendous demand scenario setup capabilities. Realistic simulation of equipment operation (pumps, tanks, regulators, valves) including automatic control or easy manual intervention.

Operational Status Setup Capability allows equipment operating status data (pump speeds, tank levels, master meter flowrates, etc.) to be imported and automatically establish a new scenario, including adjustment of demands. Data can be transferred by SCADA system for model - SCADA linkage.

Interfaces with several leading AM/FM/GIS systems are available.

NETWORK MODEL SURVEY

MODEL NAME: TDHNET 2.6/3.0 TDHUTILS 1.0

Company/Institution: TDH Engineering

Address: 607 Ninth St., Laurel, MD 20707

Contact person: Tim Hirrel

Phone: (301) 490-4515

FAX: _____

Check all features that apply:

☒ Steady State ☒ Internal editor ☒ Time of travel model

☒ Extended period simulation ☒ Graphical display ☐ Water quality model

Model formulation/solution techniques for hydraulic model:

Problem formulation:

☐

Node

☒

Loop

Other: _____

Solution method:

☐

Linearized

☐

Newton Raphson

Other: X

Sparse matrix techniques: 2.

Maximum number of pipe links:

2. TDHNET uses only dynamically allocated data structures; no dimensioned arrays. The maximum number of links or any other component is constrained only by the available RAM. TDHNET 3.0 uses extended memory while 2.6 uses only conventional memory.

Computer requirements:

TDHNET 3.0 requires a 80386 or higher processor and a math coprocessor. TDHNET 2.6 runs on any standard DOS microcomputer; a math coprocessor is not required but will be used if available.

Cost of model (include options):

The three program package of TDHNET 3.0, TDHNET 2.6 and TDHUTILS 1.0 is available for \$600.00.

Required external packages (e.g., Lotus, AutoCAD, etc.):

1. TDHNET provides the ability to write input and output data to comma delimited ASCII files. Using popular database, spreadsheet or graphics programs, these files can be used for database queries or graphical displays. No external packages are mandatory for model use.

Documentation/support:

A complete documentation file is provided. This file can be both printed and viewed onscreen during program execution. The best possible user support is provided by the author via telephone.

NETWORK MODEL SURVEY

MODEL NAME: TDHNET 2.6/3.0 TDHUTILS 1.0 (continued)

Describe features that facilitate its use by inexperienced modelers:

The entire program is menu driven and explicit prompts are provided. The user interface is intuitive and consistent throughout the program. The integrated Editor is designed so that introduction of data syntax errors is impossible. The user manual is available online throughout the program execution. The detection of logical errors in the input data, such as pipe connected to nonexistent pipes or nodes, can be performed on demand and is performed automatically before a model execution. The truly integrated Editor / Solve / View Results environment allows the user to move from data input to network solution to results inspection without having to switch programs.

Describe any special features of the model:

TDHNET solves networks with junction nodes and pipes isolated from the fixed grade nodes so that future pipes can be closed and ignored until needed. Any number of disconnected network segments can be included in a single file and solved.

TDHNET performs explicit simulation of both pressure reducing and pressure relief valves. Both types are automatically closed to prevent unwarranted backflow and automatically removed to prevent fictitious PRV pumping.

Nodal demand factors can be selectively applied based on data in the Node Information field. The most obvious application of this feature is the use of demand factors for individual zones; however the inherent flexibility presents other interesting possibilities and does not require any node renumbering.

EPS data can be suppressed so the user can switch between extended periodic simulations and regular simulations without deleting EPS data. Change data can be suppressed so the user can deactivate a change situation and later reactivate it without reentering the data.

Non-cylindrical tanks can be simulated to improve EPS accuracy. Change situations can be made effective at any time during an EPS, not just at scheduled simulation times.

NETWORK MODEL SURVEY

MODEL NAME: USU-NETWK

Company/Institution: Utah State University, Dept. of Civil & Environmental Engineering

Address: Logan, UT 84322-4100

Contact person: Prof. Roland W. Jeppson Phone: (801) 750-2943 FAX: (801) 750-1185

Check all features that apply:

- ☒ Steady State ☒ Internal editor ☐ Time of travel model
- ☒ Extended period simulation ☒ Graphical display ☐ Water quality model
- ☒ Design (solve Dia, or other components) ☒ Engineering Economic Analysis

Model formulation/solution techniques for hydraulic model:

Problem formulation: ☐ Node ☒ Loop Other: _____

Solution method: ☐ Linearized ☒ Newton Raphson Other: _____

Sparse matrix techniques:

PC version uses sparse matrix methods for solving one-dimensional Jacobian array. Version for larger computers has 3 solution methods built in and selects best method for problem, or allows user to specify method. These methods are: (a) banding Jacobian matrix by renumbering equations and unknowns for non symmetric Jacobians; (b) banding Jacobian matrix but maintaining symmetry and solving using the Koleski algorithm; and (c) utilizing sparse matrix methods.

Maximum number of pipe links:

1500 pipes for PC version under DOS and 640 Kbytes of RAM. Engineering RISC work stations. VAXes and other larger computers, version dimensioned to 6000 pipes keep for ready distribution, but maximum can be increased upon request.

Computer requirements:

Versions available for a variety of computers including PC's. Some graphics packages specifically designed for displaying on EGA and VGA PC monitors under DOS.

Cost of model (include options):

\$500 for the steady state package; \$750 for package that also can do extended time simulations. In addition to main processor USU-NETWK, package includes: (1) pre-processor & editor, PIPEINPT, (2) graphics utility that display network and solution items, PLTNET, (3) Graphics utility that: (a) shows network with pressure bars at nodes, (b) make contour type map of HGL elevations, or pressures, and (c) plot HGL or pressure profiles through

NETWORK MODEL SURVEY

MODEL NAME: USU-NETWK (continued)

selected sequences of pipes. PROFILM, (4) a graphics program that draws the network and prints solution parameters on drawing. OFPLOT, (this program consist of the CALCOMP plotting of network built into full program, and will display this plot on PC's monitor, (5) a menu driven hydraulic equation solver HYDEQS, (6) A utility that display pump curves based on same mathematical description allowed by NETWK and permits them to be altered to fit actual curves, (7) a printer utility, PRNT, (8) a list utility to display output files, etc., LIST. In addition, with the version that also allows time dependent solutions the package includes: (9) an auxiliary program that allows users to interactively request any information related to time dependent solution using a direct access file that NETWK can be requested to write, PRINT, and (10) a plot utility that displays solution variables as a function of time. In addition a TUTOR comes with the package to get new users started.

Required external packages (e.g., Lotus, AutoCAD, etc.):

No external packages are required. NETWK can be requested to write either of two "output graphics files" for use with other packages and the graphics utilities that are part of the USU-NETWK package. Spreadsheets such as LOTUS or QUATTRO can be used to prepare input files, as well as any ASCII editor (or word processor), if desired.

Documentation/support:

A user's manual comes with the package that documents the options, and input data needed to defining a large variety of network problems and utilize the package effectively.

Describe features that facilitate its use by inexperienced modelers:

Input data is free of any format (column) requirements. Data are entered by command names such as PIPES, NODES, PUMPS, VALVES, etc. Much checking of input data is done to help assure that a correct, and valid network problem is defined.

Describe any special features of the model:

In addition to analyzing networks whose components are given, component can be sized to satisfy specified conditions, e.g., networks can be designed. For example the heads and flow rates that pumps must supply to provide specified pressures anywhere in the network can be a direct part of the solution or by specifying nodal pressures, or slopes of HGLs, pipe diameters can be solved. Pipe roughness coefficient can be determined for the Darcy-Weisbach, the Hazen William, or the Mannings Equation. If pressures are known rather than demands at nodes, then the outflows at these nodes can be part of the solution. In addition the hydraulic solution capability, USU-NETWK contains an Engineering Economic package that allows costs to be computed on both an reoccurring and present worth basis. These cost analyses can be simple, (i.e., based on built in default costs) or comprehensive and applicable to the given network depending upon the amount of cost data supplied by the user.

NETWORK MODEL SURVEY

MODEL NAME: WADISO (Water Distribution System Optimization)

Company/Institution: U.S. Army Engineer Waterways Experiment Station

Address: 3909 Halls Ferry Road, Vicksburg, MS 39180-6199

Contact person: Ms. Gloria Naylor Phone: (601) 634-2265 FAX: _____

Check all features that apply:

☒ Steady State ☐ Internal editor ☐ Time of travel model

☒ Extended period simulation ☐ Graphical display ☐ Water quality model

Model formulation/solution techniques for hydraulic model:

Problem formulation: ☒ Node ☐ Loop Other: _____

Solution method: ☒ Linearized ☐ Newton Raphson Other: _____

Sparse matrix techniques: _____

Maximum number of pipe links:

800

Computer requirements:

640 k with math co-processor (800 links)
512 k with math co-processor (600 links)
512 k without math co-processor (500 links)

Cost of model (include options):

\$0

Required external packages (e.g., Lotus, AutoCAD, etc.):

None

Documentation/support:

User's Guide Included
Personal Contacts for Consultation

Describe features that facilitate its use by inexperienced modelers:

- User friendly data entry with keywords
- Input errors corrected by keywords - no data file to manipulate
- System appurtenances (PRV's, check valves, etc.) easily handled
- Output selected by users

Describe any special features of the model:

Optimization routine aids user in designing most economical pipe size while meeting system requirement for pressure and flow rate.

NETWORK MODEL SURVEY

MODEL NAME: WATER / WGRAPH
Company/Institution: MUNICIPAL HYDRAULICS LTD
Address: 2474 Pylades Drive RR#3, Ladysmith B.C., Canada VOR2EO
Contact person: A.G. Fowler Phone: (604) 722-3810 FAX: (604) 722-3081

Check all features that apply:

☒ Steady State ☒ Internal editor ☒ Time of travel model
☒ Extended period simulation ☒ Graphical display ☒ Water quality model

Model formulation/solution techniques for hydraulic model:

Problem formulation: ☐ Node ☒ Loop Other: _____

Solution method: ☐ Linearized ☒ Newton Raphson Other: _____

Sparse matrix techniques: _____

Maximum number of pipe links:

1,500

Computer requirements:

IBM PC or clone 500K

Cost of model (include options):

\$995.00 (including technical support)

Required external packages (e.g., Lotus, AutoCAD, etc.):

NONE

Documentation/support:

USER MANUAL

Describe features that facilitate its use by inexperienced modelers:

Two different editors - one full screen and one menu driven for beginners

Describe any special features of the model:

WATER was the original North American implementation using a matrix method (in this case based upon Newton-Raphson) to quickly solve a network system. It has been a gradual development over 25 years, so the program is a very "experienced" one.

NETWORK MODEL SURVEY

MODEL NAME: Waterworks all-in-one PC Software (Lotus 1-2-3 Version)
 Company/Institution: Synex Systems Corporation
 Address: 1188 West Georgia St., Vancouver, B.C. Canada V6E 4A2
 Contact person: Mark West Phone: 1 800 663-8663 FAX: (604) 681-1286

Check all features that apply:

- ☒ Steady State ☒ Internal editor ☐ Time of travel model
☒ Extended period simulation ☒ Graphical display ☐ Water quality model

Model formulation/solution techniques for hydraulic model: (Water algorithm by Fowler)

- Problem formulation: ☐ Node ☒ Loop Other: _____
 Solution method: ☐ Linearized ☒ Newton Raphson Other: _____

Sparse matrix techniques: Graph theoretical to reduce bandwidth of matrix

Maximum number of pipe links:
 1,500

Computer requirements:

PC with 640 k of RAM	(up to 500 pipes)	VGA or EGA graphics
1 M of RAM	(up to 1,000 pipes)	(to use graphics)
2 M of RAM	(up to 1,500 pipes)	

Cost of model (include options):

	<u>25 pipes</u>	<u>250 pipes</u>	<u>500 pipes</u>	<u>1,000 pipes</u>	<u>1,500 pipes</u>
Waterworks	\$ 99	\$595	\$995	\$1,545	\$1,995
ETM	295	295	295	295	295

Required external packages (e.g., Lotus, AutoCAD, etc.):

Requires Lotus 1-2-3 version 2.xx i.e.: 2, 2.01, 2.2, or 2.3

Documentation/support:

Easy to use, professionally manufactured user guide including simple tutorials and examples.
 Set-up support is provided free of charge (1 800 663-8663). Subsequent support is available at \$199 per year.

NETWORK MODEL SURVEY

MODEL NAME: Waterworks all-in-one PC Software (Lotus 1-2-3 Version) (continued)

Describe features that facilitate its use by inexperienced modelers:

Operating in Lotus provides the user unparalleled ease of entering model data in a tabular format. Because the model algorithm is called directly from within Lotus, the results of "what-if" scenarios can be determined in seconds.

On-line error handling and "expert help" make trouble shooting network errors quick and easy.

Describe any special features of the model:

The following is taken from THE WATERWORKS DISTRIBUTION SYSTEM ANALYSIS PROGRAM: A USER'S PERSPECTIVE by Carter H. Harrison, Jr., district engineer, Clackamas (Ore.) Water District which appeared in the May/June issue of the Waterworld News.

"The speed of color presentation is arguably the program's greatest virtue. After several "what-if" trial solutions done in sequence, the user quickly develops a feel for the weaknesses in a given system. In most cases this is the goal of such an analysis...The Waterworks program also lends itself to real-time, on-line solutions of "what-if" situations in which someone wants to know fire flows or the effects of a major system change. With this program they can be analyzed while the person requesting the information waits."

NETWORK MODEL SURVEY

MODEL NAME: WATSYS

Company/Institution: Hydraulic Computer Programming Pty Ltd

Address: 28 Colbran Avenue, Kenthurst, New South Wales 2156 Australia

Contact person: Max Olde Phone: (02) 654-1030 FAX: (02) 654-1274

Check all features that apply:

☒ Steady State ☒ Internal editor ☐ Time of travel model

☒ Extended period simulation ☒ Graphical display ☐ Water quality model

Model formulation/solution techniques for hydraulic model:

Problem formulation: ☐ Node ☐ Loop Other: _____

Solution method: ☐ Linearized ☒ Newton Raphson Other: Modified

Sparse matrix techniques: _____

Maximum number of pipe links: 4,000

Computer requirements:

PC 386/486 4MB - 4,000 links
PC 286 640K - 720 links

Cost of model (include options):

\$5,000.00 (Introductory Price) - Both versions supplied
\$7,500.00 (Normal Price)

Required external packages (e.g., Lotus, AutoCAD, etc.): None

Documentation/support: User Manual

Describe features that facilitate its use by inexperienced modelers:

The network can be drawn using the graphical display. Values (e.g., pipe diameters) are program prompted. Simulation results can be shown by the graphical display as well as in tabular text mode.

Describe any special features of the model:

The model will simulate the real time behavior of most water supply distribution networks that are likely to be met in practice. It handles most combinations of:

NETWORK MODEL SURVEY

MODEL NAME: WATSYS (continued)

Tanks (including variable cross sections)
Pipes
Restrictions
Check valves
Control valves
Pressure sustaining valves
Pressure reducing valves
Rate of flow valves
Pumping stations
Borehole drawdown characteristics
Sprinklers

The model can use either
SI units or USA units
and either the Hazen-
Williams or Colebrook-
White pipe flow formulae

NETWORK MODEL SURVEY

MODEL NAME: WATNET

Company/Institution: WRc plc

Address: P.O. Box 85, Swindon, N5 8YR, U.K.¹

Contact person: J. D. Creasey Phone: 011-44-793-511-711 FAX: 011-44-793-511-712

Check all features that apply:

☒ Steady State ☒ Internal editor ☒ Time of travel model²

☒ Extended period simulation ☒ Graphical display ☒ Water quality model²

Model formulation/solution techniques for hydraulic model:

Problem formulation: ☐ Node ☐ Loop Other: Hybird

Solution method: ☐ Linearized ☒ Newton Raphson Other: _____

Sparse matrix techniques: Yes

Maximum number of pipe links: 2,200

Computer requirements:

IBM PC Compatible, 4 Mbytes RAM, 20 Mbytes Hard Disk, Math Coprocessor

Cost of model (include options): \$15,000

Required external packages (e.g., Lotus, AutoCAD, etc.): None

Documentation/support:

User Guide. Support \$2,250 per Annum

Describe features that facilitate its use by inexperienced modelers:

On-Screen Schematic
Comprehensive User Guide
Demonstration Example Supplied

Describe any special features of the model:

- Accurate extended period simulation allowing automatic status change of components between defined time periods.
- Uses ASC II or Binary Data Files
- Operational Costing Capability

NOTE: ¹Support and Enquiries in USA to: WATNET

WRc
2655 Philmont Avenue
Huntingdon Valley, PA 19006
TEL: (215) 938-8444

²Associated Computer Program

NETWORK MODEL SURVEY

MODEL NAME: Waterworks for AutoCAD

Company/Institution: Synex Systems Corporation

Address: 1188 West Georgia St., Vancouver, B.C. Canada V6E 4A2

Contact person: Mark West Phone: 1 800 663-8663 FAX: (604) 688-1288

Check all features that apply:

☒ Steady State ☒ Internal editor ☒ Time of travel model

☒ Extended period simulation ☒ Graphical display ☒ Water quality model

Model formulation/solution techniques for hydraulic model: (Water algorithm b
Fowler)

Problem formulation: ☐ Node ☒ Loop Other: _____

Solution method: ☐ Linearized ☒ Newton Raphson Other: _____

Sparse matrix techniques: Graph theoretical to reduce matrix bandwidth

Maximum number of pipe links: n/a

Computer requirements: 386 or 496 4 M of RAM minimum VGA graphics

Cost of model (include options):

	<u>25 pipes</u>	<u>250 pipes</u>	<u>500 pipes</u>	<u>1,000 pipes</u>	<u>1,500 pipes</u>	<u>2,000 pipes</u>
Waterworks	\$ 99	\$1,095	\$1,445	\$2,045	\$2,495	\$2,995
ETM	299	299	299	299	299	299
Water Quality	595	595	595	595	595	595

Required external packages (e.g., Lotus, AutoCAD, etc.):

AutoCAD release 11 (DOS extender)

Documentation/support:

Easy to use, professionally manufactured user guide including simple tutorials and examples.

Set-up support is free of charge (1 800 663-8663). Subsequent support is available at \$199 per year.

Describe features that facilitate its use by inexperienced modelers:

Operating in AutoCAD provides the user unparalleled power with complete graphical editing features as well as tabular editing. Model output is part of the drawing and can be viewed and plotted. Mouse driven, highly intuitive dialogue boxes make data entry and edits quick and easy.

NETWORK MODEL SURVEY

MODEL NAME: Waterworks for AutoCAD (continued)

Describe any special features of the model:

Special features include:

- Color coding of both nodes and pipes (by input and output)
- 3D node bars, meshes and contouring
- Auto-locate features for finding network elements by input or output criteria
- Tables which can be easily sorted by both input and output criteria
- Global edit features for pipe diameters and roughnesses as well as node demands

LEGEND

- WATER TREATMENT PLANT
- BOOSTER STATION W/RESERVOIR
- BOOSTER STATION

CITY OF DETROIT WATER AND SEWERAGE DEPARTMENT	ENERGY OPTIMIZATION OF WATER DISTRIBUTION SYSTEM
TUCKER YOUNG JACKSON TULL, INC. CONSULTING ENGINEERS 300 E. LARNED BLVD. DETROIT, MI 48226 (313) 963-9812	COMPUTER MODEL OF DWS WATER DISTRIBUTION SYSTEM SCALE: NONE FIGURE 3-3

REPORT AND INFORMATION SOURCES

Additional copies of the Final Report, "Energy Optimization of Water Distribution System" are available from:

Publications and Distribution
Public Technology, Incorporated
1301 Pennsylvania Avenue, NW
Washington, DC 20004-1793

Additional information on the structure, operation, and results of this study as well as information on the energy management activities in the City of Detroit are available from:

Crieghton C. Lederer, Director
Buildings and Safety Engineering Department
401 City-County Building
Detroit, Michigan 48226
(313)224-3252

DG/92-301
08/93-150

2 of 2

CITY OF DETROIT

MAYOR

Coleman A. Young

CITY COUNCIL

Maryann Mahaffey, President

Gill Hill, Pres., Pro Tem.

Keith A. Butler

Clyde Cleveland

David Eberhard

Kay Everett

Nicholas Hood

Jack Kelley

Mel Ravitz

Publications Price List--UCETF Reports

ITEM #	TITLE	PRICE
90-331	Hydraulic Waste Energy Recovery: A Technical Report	15.00
90-318	A Regulatory Framework for Alternative Fuels and Transportation Management Services	15.00
90-316	Alternative Vehicle Fuels: A Demonstration Project	15.00
90-314	Energy Efficiency in Public Housing	15.00
89-330	Analysis of Programmatic Fleet Conversion to Ethanol Blends	15.00
89-325	An Alternative Fuels Evaluation System for Fleet Vehicles	15.00
89-323	Dual Fuel Conversion Demonstration and Technology Transfer Project	10.00
89-321	Summary of Low and Moderate Income Residential Energy Conservation Programs	15.00
89-315	A Case Study in the Pursuit of Urban Energy Efficiency	15.00
89-314	Communicating with the Public About Environmental Health Risks: A Case Study	13.00
89-313	Evaluation and Comparison of Selected Household Hazardous Waste Collection Facilities	15.00
89-311	Yard Waste Recycling Study: A Pilot Study	15.00
89-310	Sludge Storage Lagoon Biogas Recovery and Use, Volume 1	15.00
89-307	Proceeding: 1989 Electric Utility Franchise Conference	20.00
89-306	Reducing Electricity Demand Through Energy-Related Efficient Construction	15.00
89-304	Modernization of Lighting in Municipal Auditoriums	15.00
89-303	Wastewater Treatment Process Energy Optimization	13.00
89-301	Implementation of Alternative Technologies through the Assessment of Energy Markets	14.00
88-322	Marketing Energy Efficiency Programs to Commercial and Industrial Firms: Lighting Incentives and	15.00
88-321	Urban Energy Management Today: Ten Year Compendium of UCETF Programs	10.00
88-319	Integrating Energy Efficiency Into Municipal Purchasing Decisions: Computerizing Procurement	15.00
88-318	Household Hazardous Waste: Implementation of a Permanent Collection Facility	20.00
88-317	Hazardous Waste as an Energy Manager's Issue	15.00
88-316	Household Hazardous Waste Management Planning	15.00
88-312	Summary of Small Business Energy Conservation Programs	15.00
88-310	The Earth-Coupled Heat Pump: Utilizing Innovative Technology in Single Family Rehabilitation	15.00
88-309	Energy Planning for Economic Development	18.00
88-308	Conversion of Resource Recovery Steam to Hot and Chilled Water Systems	10.00
88-306	HVAC Equipment Replacement for Best Size and Efficiency, Transfer Report	15.00
88-305	Cogeneration and Cooling in Small Scale Applications	15.00
88-304	Energy Master Planning: Innovative Design and Energy Analysis Services for New Commercial	22.00
88-303	Energy Efficient Building Design: Guidelines for Local Government	15.00
88-302	Direct Digital Control of Air Washer Cooling System	15.00
88-301	Feasibility Study of Transportation Management Strategies in the Poplar Corridor, Memphis, Tennessee	18.00
87-327	Energy Efficient Urban Cooling Technologies: 1st National Conf.	20.00
87-324	Memphis Area Rideshare	15.00
87-317	Joint City Government/Utility Partnerships to Reduce Business Costs	15.00
87-314	The Impact of Budgetary Incentives on Energy Management	15.00

Publications Price List--UCETF Reports

ITEM #	TITLE	PRICE
87-313	Computer Assisted Control for Municipal Water Systems, Phase II	20.00
87-312	Economic Development Through Energy Technology Transfer	15.00
87-311	Electric Utility Franchise Guide	20.00
87-310	Hidden Link: The Energy and Economic Development, Phase II	15.00
87-307	Municipal Underground Storage Tanks: An Energy Manager's Guide	18.00
87-306	Integrating Energy Efficiency into Mun. Purchasing Decisions	20.00
87-305	Energy Enhancement in New Residential Construction	40.00
87-302	Thermal Energy Storage: Application Guide for Local Governments	20.00
87-301	HVAC Equipment Replacement for Best Size & Efficiency	20.00
86-315	Balancing Single Pipe Steam Heating Systems	20.00
86-314	Inhibition of Respiration in Activated Sludge by High Carbon Dioxide Concentration	7.50
86-313	Water Supply System Energy Conservation Through Computer Control	18.00
86-312	Energy Cost Reduction Through Wastewater Flow Equalization	20.00
86-311	High Efficiency Gas Furnace Modification in Low Income Housing	15.00
86-310	Hidden Link: Energy and Economic Development, Phase I	15.00
86-307	Disposal Techniques with Energy Recovery for Scrapped Vehicle Tires	20.00
86-306	District Heating Marketing: Analysis of a Twelve City Survey	20.00
86-305	Technology Transfer for Residential Energy Programs in New Construction and Existing Housing	15.00
86-304	Technology Transfer for Residential Energy Efficiency	15.00
86-302	Neighborhood Energy Efficiency & Reinvestment	15.00
86-301	On-Site Municipal Fuel Cell Power Plan: Feasibility and Application Guide	15.00
85-326	Resource Recovery for Urban Yard Waste	18.00
85-323	Energy Monitoring and Controlling in Municipal Facilities	10.00
85-320	Transportation Management for Business Relocation	15.00
85-319	District Heating in Denmark	10.00
85-318	Computer-Assisted Control for Municipal Water Systems, Phase I	18.00
85-317	Financing Energy Efficient Housing as a Community Economic Development Tool	15.00
85-316	Modular District Heating Planning as a Development Tool	15.00
85-314	Alternative Techniques for Dev. of Energy Efficient Residences	15.00
85-312	Shared Savings and Low Income Homeowners	18.00
85-311	Measures and Investment Options for Community Energy Conservation	18.00
85-310	Planning for Energy Efficiency in New Commercial Buildings	15.00
85-308	Residential Space Heating with Wood	15.00
85-307	Thermal Storage Strategies for Energy Cost Reduction	18.00
84-325	Shared Savings in the Residential Market	
84-324	Methanol Use in Vehicle Fleet Operations: Barriers	20.00
84-322	Energy Management and Technology for Urban Governments	15.00
84-321	Hydrate Process for Waste Water Treatment Plant Sludge Dewatering	15.00

Publications Price List--UCETF Reports

ITEM #	TITLE	PRICE
84-320	Development of Computerized Inventory and Maintenance System for Municipal Street Lights	15.00
84-315	Facilities Energy Monitoring System	15.00
84-314	Application of Mini-Van Technology to Vanpool Services	18.00
84-312	Implementation Methods for an Integrated Energy System	10.00
84-311	Feasibility of Water-Based District Heating and Cooling	15.00
84-310	Budgetary Incentives for Municipal Energy Management	22.00
84-309	Central Energy Systems Applications to Economic Development	20.00
84-308	On-Site Cogeneration for Office Buildings	15.00
84-306	Analysis of Municipal Bus Operations for the Advancement of Fuel Cell Technology	15.00
84-305	Computer Based Maintenance	15.00
84-304	Innovative Finance Plans for Privately Owned Waste/Vol. 2	15.00
84-303	Innovative Finance Plans for Privately Owned Waste/ Vol. 1	15.00
84-301	Coordinating Preventive Maintenance with Energy Management	15.00
83-319	The Rehabilitation and Retrofit of Older Houses to Superinsulated Standards	15.00
83-318	Developing Sources and Techniques for Alternative Financing of Energy Conservation	20.00
83-316	Hydrate Process for Dewatering Sewage Sludge	10.00
83-315	Financial Planning for District Heating: Brooklyn Navy Yard	15.00
83-314	Memphis Area Rideshare On-Line Information System	18.00
83-313	Renovation Opportunities for Steam District Heating Systems	18.00
83-312	Initial Assessment of District Heating and Cooling	20.00
83-311	Energy Conservation Through Computerized Automation	18.00
83-309	Development of an Energy Park: Issues and Implementation Options	15.00
83-308	Alternative Uses for Digester Methane Gas	25.00
83-307	Innovative Financing and Incentive Package to Reduce Energy	15.00
83-305	Multi-Jurisdictional Planning for District Heating and Cooling	10.00
83-303	Improving Energy Management and Accountability in Municipal Operations	15.00
82-320	Utilization of Felled City Trees as Supplemental Boiler Fuel	7.50
82-319	Methanol Use in Vehicle Fleet Operations: Comparisons	15.00
82-317	Microcomputer Tools for Trans. and Residential Energy Conservation	20.00
82-316	Reduction of Impediments to Alternative Energy Use	20.00
82-315	Reducing Regulatory and Financial Impediments to Energy Conservation	20.00
82-314	Integrating Energy Management with Economic Development	20.00
82-313	Energy Conservation and Economic Development	10.00
82-310	Municipal Technologies	20.00
82-307	Strategies to Improve Community Energy Use Practices	10.00
82-306	Energy Conservation In Water Treatment	
82-305	Development of an Energy Action Plan: Participating Approach	15.00
82-303	Energy Economic Development	20.00

Publications Price List--UCETF Reports

ITEM #	TITLE	PRICE
82-302	Public Housing Energy Efficiency Through Private Financing	10.00
82-300	Developing an Energy Management Tracking System	
81-328	Matching End Use Energy Needs to Source Possibilities	20.00
81-327	Development of a Hydrogen-Fueled Mass Transit Vehicle s	15.00
81-326	Operational and Maintenance Guidelines for Reducing Energy Consumption	
81-324	Energy Management for Small Business	10.00
81-320	Energy Data Gathering, Analysis, and Review System	20.00
81-318	Fuel Management and Planning System for Local Government	25.00
81-316	Production of Ethanol from Cellulosic Fraction	
81-313	Metro-Dade County Comprehensive Energy Emergency Plan	
81-311	Developing Energy Emergency Preparedness	15.00
81-310	Simplified Methodology for Community Energy Management	20.00
81-309	Energy Management: The Public Sector	15.00
81-307	Municipal Technical Assistance-Energy Monitoring	6.00
81-306	New Technology Demonstration	10.00
81-305	Technology Transfer: Unit Report from the Energy Task Force	15.00
81-304	Development of Local Energy Management Preparedness	10.00
81-303	Municipal Energy Management	10.00
80-314	Methodology for Energy Impact Analysis of Urban Development Projects	15.00
80-313	Evaluation of Landfill Gas as an Energy Source	15.00
80-309	Decision Process for the Retrofit of Municipal Buildings	20.00
80-308	Primary Urban Energy Management Planning Methodology	7.50
80-306	Local Government Use of Thermography for Energy	15.00
79-300	Planning for and Purchasing Computer Technology	6.50

**DATE
FILMED**

12 / 8 / 93

END