Water System Master Plan

prepared for

The North Central Missouri Regional Water Commission

2003
32598

Mission Statement

"The Mission of the Commission is
to provide an abundant source of
low-cost, pure, quality water for the
residents of North Central Missouri."

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November 19, 2003

North Central Missouri Regional Water Commission
1415 East Main
Unionville, MO 63565
ATTN: Mr. Don Summers

WATER SYSTEM MASTER PLAN
BURNS & MCDONNELL PROJECT NO. 32508, 32521, AND 32598

Dear Mr. Summers:

Enclosed is the final draft of the *Water System Master Plan* which has been prepared for the North Central Missouri Regional Water Commission. We were assisted in the study by Rhodes Engineering Company of Brookfield, Missouri.

This report presents a Master Plan for the proposed regional water supply that was recommended in the Feasibility Study to serve the future needs of the Green Hills area. The Master Plan examines the proposed reservoir in detail and evaluates the dam and spillway, water supply infrastructure, environmental conditions and economic parameters.

We appreciate this opportunity to be of service to the North Central Missouri Regional Water Commission. We wish to express our appreciation for the assistance provided by you and the City of Milan, the City of Green City and Sullivan Public Water Supply District No. 1.

Five copies of the Master Plan have been included for the Water Commission and twelve copies have been forwarded to the National Resources Conservation Service in Columbia, Missouri. Please feel free to contact any of the undersigned at 816-333-9400 with any questions.

Sincerely,

Donald J Novak
Donald J. Novak, P.E.
Project Engineer

Fred Pinkney
Fred Pinkney, P.E.
Project Engineer

David Silverstein, P.E.
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cc: NRCS
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Enclosure

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WATER SYSTEM MASTER PLAN

Prepared For
NORTH CENTRAL MISSOURI REGIONAL WATER COMMISSION

INDEX AND CERTIFICATION

PART	PART TITLE	NUMBER OF PAGES
ES	Executive Summary	5
I	Introduction	2
II	Dam and Reservoir	58
III	Water System Improvements and EPA Compliance	33
IV	Environmental Analysis	19
V	Economical Analysis	12

ENGINEERING CERTIFICATION

STATE OF MISSOURI
DONALD J. NOVAK
NUMBER E-12953
REGISTERED PROFESSIONAL ENGINEER

Donald Novak

11/19/2003

Don Novak, P.E.

TABLE OF CONTENTS

EXECUTIVE SUMMARY
- A. Introduction ES-1
- B. Water Requirements ES-1
- C. Master Plan ES-2
  - 1. Dam and Reservoir ES-2
  - 2. Water Supply Infrastructure ES-3
  - 3. Environmental Conditions ES-4
  - 4. Economical Parameters ES-5

PART I – INTRODUCTION
- A. Introduction I-1
- B. Purpose I-1
- C. Scope I-1

PART II – DAM AND RESERVOIR EVALUATION
- A. Reservoir Yields Analysis II-1
  - 1. General II-1
  - 2. Reservoir Inflow II-1
    - a. Historic Streamflow Data II-1
    - b. Statistical Analyses II-2
    - c. Reservoir Inflow Estimates II-4
  - 3. Reservoir Evaporation II-5
    - a. Pan Evaporation Data II-5
    - b. Climatic Data II-7
    - c. Evaporation Model II-7
    - d. Model Calibration II-8
    - e. Net Evaporation Rate Estimates II-8
  - 4. Reservoir Data and Operation Assumptions II-9
  - 5. Firm Yield Analyses II-11
  - 6. Probable Yield Analyses II-11
  - 7. Sensitivity Analyses II-13
- B. Reservoir Hydrologic Analyses and Spillway Sizing II-14
  - 1. Watershed Characteristics II-14
    - a. Description of Watershed II-14
    - b. Basin Soils II-15
    - c. Stream Characteristics II-16
    - d. Subbasin Delineation II-16
  - 2. Hydrologic Modeling Parameters II-17
    - a. Basic Methods II-17
    - b. Synthetic Unit Hydrographs II-17
      - 1) HEC-1 Unit Hydrograph Approach II-17
      - 2) SCS Unit Hydrograph II-18
    - c. Runoff and Infiltration Loss Rates II-19
    - d. Rainfall II-19
      - 1) Probable Maximum Precipitation (PMP) II-20
        - a) Coordinates for Basin and Subbasins II-20
        - b) Probable Maximum Precipitation for Storm Area II-20
        - c) Preferred Storm Orientation II-21

        d) Temporal Distribution Data II-21
        e) Results II-21
      2) 100 Year Event II-22
      3) Spillway Design Flood (SDF) II-23
  3. Hydrologic Modeling – Existing Conditions II-23
  4. Principal Spillway Design II-24
    a. Principal Spillway Design Flood II-24
    b. General Configuration II-25
    c. Spillway Crest II-25
    d. Throat and Conduit Transition II-26
    e. Conduit II-26
    f. Spillway Rating II-27
  5. Principal Spillway Hydrologic Modeling II-28
    a. Principal Spillway and Reservoir Storage/Discharge II-28
    b. 100 Year 24 Hour and 10 Day Storm Events II-29
  6. Auxiliary Spillway Design II-30
    a. General Configuration II-30
    b. Approach Channel II-31
    c. Sill II-32
    d. Discharge Channel II-32
    e. Spillway Rating II-33
  7. Auxiliary Spillway Hydrologic Modeling II-33
  8. Bypass During Construction and Emergency Drawdown II-34
C. Freeboard Analysis II-34
  1. Fetch Length II-34
  2. Wind Speed II-35
  3. Wave Characteristics II-36
  4. Deepwater Wave Growth Assumption II-37
  5. Wind Setup II-37
  6. Wave Runup II-37
    a. Uncorrected Wave Runup II-38
    b. Corrected Wave Runup #1 .... II-38
    c. Corrected Wave Runup #2 .... II-38
    d. Varied Wave Heights II-38
  7. Top of Dam II-39
D. Subsurface Investigation and Geotechnical Analyses II-39
  1. Geotechnical Design Parameters II-40
  2. Dam Geometry II-40
  3. Underseepage Analysis II-40
  4. Geotechnical Analysis of Potential Spillway Alignments II-40
E. Impacts to Existing Infrastructure II-41
  1. Introduction II-41
  2. Transportation II-41
  3. Rural Drinking Water System II-42
  4. Electrical Power Distribution Lines II-42
  5. Telephone and Fiber Optic Cable II-43
F. Recommended Land Acquisition II-43
  1. Permanent Fee Acquisition II-44
  2. Flood Storage Easements II-45

PART III – WATER SYSTEM IMPROVEMENTS

A. Introduction III-1
B. Phase One Construction III-2
  1. Intake Structure III-2
  2. Raw Water Transmission Main III-2
  3. Pump Station and Raw Water Line Spur to Elmwood Lake III-3
  4. Water Treatment Plant Improvements III-4
  5. Relocation of Other Pipeline III-5
C. Phase Two Construction III-5
  1. Finished Water Transmission Mains III-5
  2. Pump Station Construction III-6
  3. Expansion of Milan Water Treatment Plant III-7
D. Phase Three Construction III-7
  1. Finished Water Transmission Mains III-7
  2. Pump Station Construction III-9
  3. Expansion of the Milan Water Treatment Plant III-10
E. EPA Compliance III-10
  1. Introduction III-10
  2. Surface Water Treatment Rule (SWTR) III-11
  3. Microbial/Disinfection By-Product Rule (MDBP) III-12
    a) D-DBP Rule III-12
    b) Enhanced Surface Water Treatment Rule (ESWTR) III-14
      1) Turbidity III-14
      2) Revised Giardia and Virus Removal/Inactivation III-14
  4. Phase I, II, and V Rules III-16
    a) Phase I Rule III-16
    b) Phase II Rule III-16
    c) Phase V Rule III-16
  5. Total Coliform Rule (TCR) III-17
  6. Arsenic III-17
  7. Lead and Copper Rule III-18
  8. Radionuclides/Radon III-18
  9. Secondary Standards III-19
  10. Drinking Water Candidate Contaminant List III-20
    a) Aldicarbs III-21

PART IV – ENVIRONMENTAL ANALYSIS

A. Introduction IV-1
B. Data Collection IV-1
  1. Desktop Survey IV-1
  2. Field Reconnaissance IV-2
C. Reservoir Site Description IV-2
  1. Land Use and Existing Infrastructure IV-2
  2. Wetlands IV-3
  3. Threatened and Endangered Species IV-4
  4. Cultural Resources IV-5
D. Supporting Infrastructure Description IV-5
  1. Phase One IV-6
    a) Land Use and Existing Infrastructure IV-6
    b) Wetlands IV-7

c) Threatened and Endangered Species IV-7
d) Cultural Resources IV-7
2. Phase Two IV-8
a) Land Use and Existing Infrastructure IV-8
b) Wetlands IV-9
c) Threatened and Endangered Species IV-10
d) Cultural Resources IV-11
3. Phase Three IV-12
a) Land Use and Existing Infrastructure IV-12
b) Wetlands IV-12
c) Threatened and Endangered Species IV-13
d) Cultural Resources IV-14
E. Environmental Evaluation IV-14
1. Social Impacts IV-14
2. Environmental Impacts IV-15
3. Required State/Federal Permits/Clearances/Approvals IV-17
F. Environmental Conclusion IV-18

PART V – ECONOMIC EVALUATION
A. Introduction V-1
B. Water Unit Cost Background V-2
C. Water Unit Cost Calculation V-3
1. Initial Projected Water Unit Cost V-5
2. Projected Phase One Water Unit Cost V-5
3. Projected Phase Two Water Unit Cost V-6
4. Phase Three V-6
D. Projected Raw Water Unit Cost V-7

APPENDIX A – SUBSURFACE INFORMATION AND PRELIMINARY GEOTECHNICAL REPORT
APPENDIX B – PRELIMINARY GEOTECHNICAL ANALYSES
APPENDIX C – ECONOMICAL ANALYSIS DATA
APPENDIX D – REFERENCES

LIST OF FIGURES

FIGURE NO.	TITLE	FOLLOWS PAGE NO.
I-1	Proposed Reservoir Location	I-1
II-1	Stream Gages and Climate Stations	II-1
II-2	Annual Reservoir Flow	II-5
II-3	Annual Reservoir Evaporation	II-9
II-4	Proposed Reservoir Elevation-Area-Storage	II-9
II-5	Simulated Pool Elevations	II-11
II-6	East Fork Locust Creek Watershed Upstream Of Proposed Dam	II-14
II-6A	HEC-1 Routing Schematic / Existing Conditions	II-23
II-7	Principal Spillway Schematic	II-25
II-8	Dam and Auxiliary Spillway	II-25
II-9	Critical Fetch and Wind Orientation	II-35
II-10	Existing Roadway and Water Supply Infrastructure Affected by the Proposed Reservoir	II-41
II-11	Existing Telephone and Power Lines Affected by the Proposed Reservoir	II-43
II-12	Proposed Land Acquisition	II-44
III-1	Intake Structure and Screen	III-2
III-2	Proposed Raw Water Transmission Main Alignment	III-2
III-3	Phase One Hydraulic Grade Lines for Proposed 36-inch Raw Water Transmission Main to Milan WTP	III-3
III-4	Hydraulic Grade Line for Proposed 24-inch Raw Water Line to Elmwood Reservoir	III-4
III-5	Typical Layout for Pump Station on Line to Elmwood Lake	III-4
III-6	Modifications to Raw Water Piping at Milan WTP	III-4
III-7	Existing Water Mains Located Within Proposed Lake Area	III-5
III-8	Distribution System Improvements	III-5
III-9	Phase 2 and 3 Proposed Finished Water Distribution Line	III-5
III-10	Phase 2 Proposed Finished Water Distribution Line	III-5

FIGURE NO.	TITLE	FOLLOWS PAGE NO.
III-11	Phase 2 and 3 Proposed Finished Water Distribution Line	III-5
III-12	Expansion of Existing Milan Water Treatment Plant	III-7
IV-1	Proposed Reservoir Wetland Impacts	IV-3

LIST OF TABLES

TABLE NO.	TITLE	PAGE NO.
II-1	USGS Stream Gaging Stations	II-2
II-2	Pearson Correlation Coefficients (R) for Stream Gages	II-3
II-3	Regression Analysis Summary for Stream Gages	II-4
II-4	Climatic Data Stations	II-6
II-5	Average Monthly Climatic Data	II-7
II-6	Elevation-Area-Storage Data	II-9
II-7	Subbasin Areas for Existing Conditions	II-16
II-8	Subbasin Areas for Proposed Conditions	II-17
II-9	Synthetic Unit Hydrograph Data for Existing Conditions	II-18
II-10	Synthetic Unit Hydrograph Data for Proposed Conditions	II-19
II-11	PMP for East Fork Locust Creek Watershed	II-20
II-12	Cumulative PMP from HMR52	II-21
II-13	Incremental Precipitation data	II-22
II-14	Summary of HEC-1 Results – Existing Conditions	II-24
II-15	Principal Spillway Crest	II-26
II-16	Principal Spillway Throat	II-26
II-17	Principal Spillway Conduit	II-27
II-18	Principal Spillway Rating	II-28
II-19	Surface Area and Elevation Data	II-28
II-20	Summary of HEC-1 Results	II-29
II-21	Auxiliary Spillway Rating	II-33
II-22	Summary of HEC-1 Results	II-34
II-23	Fetch-Limited Wave Characteristics	II-36
II-24	Duration-Limited Wave Characteristics	II-36
II-25	Freeboard	II-39
III-1	Finished Water Transmission Line Size for Phase Two	III-6
III-2	Finished Water Transmission Line Size for Phase Three	III-8
III-3	DBP and Maximum Residual Disinfectant Levels	III-12
III-4	MCLS for Radionuclides and Radon	III-19

TABLE NO.	TITLE	PAGE NO.
III-5	Secondary Drinking Water Contaminant Standards	III-20
IV-1	Potential Wetland Impact Acreage for the Proposed Reservoir at Conservation Pool and Flood Pool Elevations	IV-4
IV-2	Projected Species Know to Occur in the Phase 2 Project Vicinity	IV-10
V-1	Opinion of Construction and Other Costs	V-1
V-2	Water Unit Cost Inputs and Assumptions	V-2
V-3	Projected Unit Water Cost with Treatment Plant Purchase Only	V-4
V-4	Projected Unit Water Cost with Treatment Plant Purchase and Dam Construction	V-5

EXECUTIVE SUMMARY

A. INTRODUCTION

A Regional Water Commission was formed in North Central Missouri to develop a reliable supply of water for the area. The water utilities of the cities of Milan and Green City and Public Water Supply District No. 1 of Sullivan County organized in 2002 as the "North Central Missouri Regional Water Commission", hereafter called the "Commission". They adopted the following Mission Statement:

> *The Mission of the Commission*
> *is to provide an abundant source*
> *of low-cost, pure, quality water for the*
> *residents of North Central Missouri.*

The area proposed for service by the Commission is often referred to as the "Green Hills" Region of North Missouri. The Green Hills area has been plagued by regular droughts in recent years. The area is currently under a "Category 3" drought as established by the Missouri Department of Natural Resources (MDNR). This level drought requires water conservation practices and is just one step below the emergency "Category 4". A Feasibility Study was completed by Burns & McDonnell Engineering on August 1, 2003, which estimated water needs and evaluated potential water sources.

The purpose of this report is to present a Master Plan for the regional water supply source recommended in the Feasibility Study to serve the future needs of the Green Hills area. The recommended water supply is a surface water reservoir located in the East Fork Locust Creek watershed, north and east of Milan, Missouri.

B. WATER REQUIREMENTS

There are currently 35 municipal water utilities and all or portions of ten public water supply districts in the Green Hills area. Many of these water suppliers have a need for additional or supplemental water sources to reliably serve their customers. As an example, Green City has recently been ordered by MDNR to abandon their existing water plant; thus, they became a charter member of the Commission.

Existing water usage in the Green Hills area is reported in the *Department of Natural Resources Census of Public Water Supply Systems 2001*. Prior census information was used as background information to aid in projecting future water use. The MDNR Regional office also provided information and several communities were contacted, responding by letter. Public meetings were held monthly, and water use was discussed with the charter members of the Commission and the public.

Existing average usage in the Green Hills area is approximately 12,440,000 gallons daily. Individual private farm supplies exist that are not included in the MDNR statistics. With a service population of approximately 98,000 persons, the average water use is around 127 gallons per capita per day (not including private farm supplies).

Forty years into the future, by 2042, it is estimated that a regional water supply will be needed to serve the following:

- Population served of 21,193
- 5.75 MGD average daily demand
- 7.53 MGD maximum daily demand

C. MASTER PLAN

The master plan examines in detail the recommended reservoir as proposed in the Feasibility Study that was previously completed by Burns & McDonnell. The Master Plan evaluates the dam and reservoir, water supply infrastructure, environmental conditions and economic parameters.

1. Dam and Reservoir

The proposed dam and spillway is generally located in Sections 12 and 13, Township 63 N, Range 20 W and Sections 7 and 18, Township 63 N, Range 19 W. Relevant features of the proposed reservoir to supply 5.75 MGD average daily demand are as follows:

- Drainage Area: 32.9 square miles
- Normal Pool Elevation: 910' NGVD
- Normal Surface Area: Approximately 1600 acres
- Normal Pool Volume: Approximately 30,400 acre feet
- Maximum Dam Height: 73 feet
- Approximate Dam Length: 2100 feet

- Required Area for Permanent Acquisition: 3875 acres
- Required Area for Flood Storage Easements : 1500 acres

Water supply yield analyses were performed to verify that the reservoir could provide the required yield of 5.75 MGD and it was determined that the yield could be provided at the normal pool or conservation pool elevation of 910' NGVD. Extensive analyses were then performed to determine the required flood pool elevations and capacity of the reservoir's spillway system. The results indicate that the flood pool elevations for the 100-year and Probable Maximum Flood events will be 915' and 928' feet, respectively. Preliminary analyses were completed for the principal and auxiliary spillway structures to verify that the spillway system was adequately sized to pass the required flood event discharges safely and without increasing impacts when compared to pre-existing conditions. The analyses indicate that the proposed dam will provide substantial flood protection benefits; however, this was a purely incidental result of the spillway sizing analyses.

Goetechnical analyses were also performed to determine basic criteria for the proposed dam and to evaluate the characteristics of the existing site as they relate to suitability for dam construction. The proposed dam will be an earthen structure with an impervious clay core and a downstream drainage system. The stability of the dam was evaluated under various loading conditions and construction parameters were developed based on the results of the analyses. Analyses were also conducted to determine the potential for seepage under the dam and through the abutments. The analyses indicated that the potential for seepage is of concern and measures such as a slurry wall and grout curtains are proposed to mitigate seepage impacts.

2. Water Supply Infrastructure

New construction and upgrades to the existing water supply systems have been classified into three phases corresponding to the years when it is projected new customers will be served by the North Central Missouri Regional Water Commission.

Phase One includes new construction of raw and finished water systems to provide water to the charter members of the North Central Missouri Regional Water Commission. It has also bee proposed in Phase One that the Commission purchase the Milan Water Treatment Plant and supplemental facilities to provide finished water to the current members until the reservoir is completed. This would also require the Commission to lease the existing Elmwood Lake as a source of raw water from the City of Milan until the new water supply reservoir is completed.

Phase Two corresponds to the year 2020 when it is projected supplemental water will be provided to the following in addition to the charter members of the North Central Missouri Regional Water Commission

- Livingston PWSD No. 2
- Linn-Livingston PWSD No. 3
- Chariton PWSD No. 2
- Linn-Chariton PWSD No. 3
- Linn PWSD No. 1
- City of Laclede

Phase Three corresponds to the year 2030 when it is projected supplemental water will be provided to the following in addition to what is being served in Phase One and Two of the project.

- City of Brookfield
- City of Meadville
- City of Bucklin
- City of Unionville

3. Environmental Conditions

Impacts resulting from the construction of the proposed reservoir would be limited to the inundation of the community of Boynton and existing infrastructure, loss of approximately 200 acres of wetlands, loss of potential roosting and foraging habitats for the Indiana bat, and potential loss of cultural resource sites. Impacts from the construction of the supporting linear facilities would be minimal and temporary. The impacts from the proposed pipeline could be minimized by directional drilling wetlands and stream crossings, and by avoiding possible tree clearing during the Indiana bat maternity roosting season.

4. Economic Parameters

The preliminary opinion of the cost to produce water includes debt retirement for the capital expenditures required plus annual costs to operate and maintain the system. These annual costs are compared to the estimated annual water use to arrive at a preliminary opinion of water charge per 1000 gallons of water purchased. The estimated costs for construction of the dam and related facilities, not including cost of purchasing the Milan treatment plant, and acquisition of the required property is as follows:

- Construction of Dam, Spillways, and Intake : $11.26 Million
- Land Acquisition including permanent acquisition, flood storage easements, purchase of houses, surveys and 10 percent contingency on the total amount: $5.5 Million
- Phase One Water Supply Improvements and Infrastructure Costs : $4.96 Million
- Phase One Engineering (Design and Construction), Surveys, Subsurface Investigations, Legal, etc: $3.24 Million.
- Phase One Wetland and Archeological Mitigation: $1.3 Million
- Total : $20.26 Million

Part I

Introduction

PART I

INTRODUCTION

A. INTRODUCTION

A Water System Feasibility Study, dated August 1, 2003 was prepared for the North Central Missouri Regional Water Commission (NCMORWC). A total of 22 different alternatives were considered for the development of additional water supply for the proposed service area. It was the recommendation of the Feasibility Study that a reservoir be developed by constructing a dam across the East Fork Locust Creek Northeast of the City of Milan. It was also recommended that the NCMORWC purchase the Milan Water Treatment Plant. The Master Plan further expands on this recommendation by developing design criteria for the construction of the new reservoir near Milan and related water infrastructure system.

B. PURPOSE

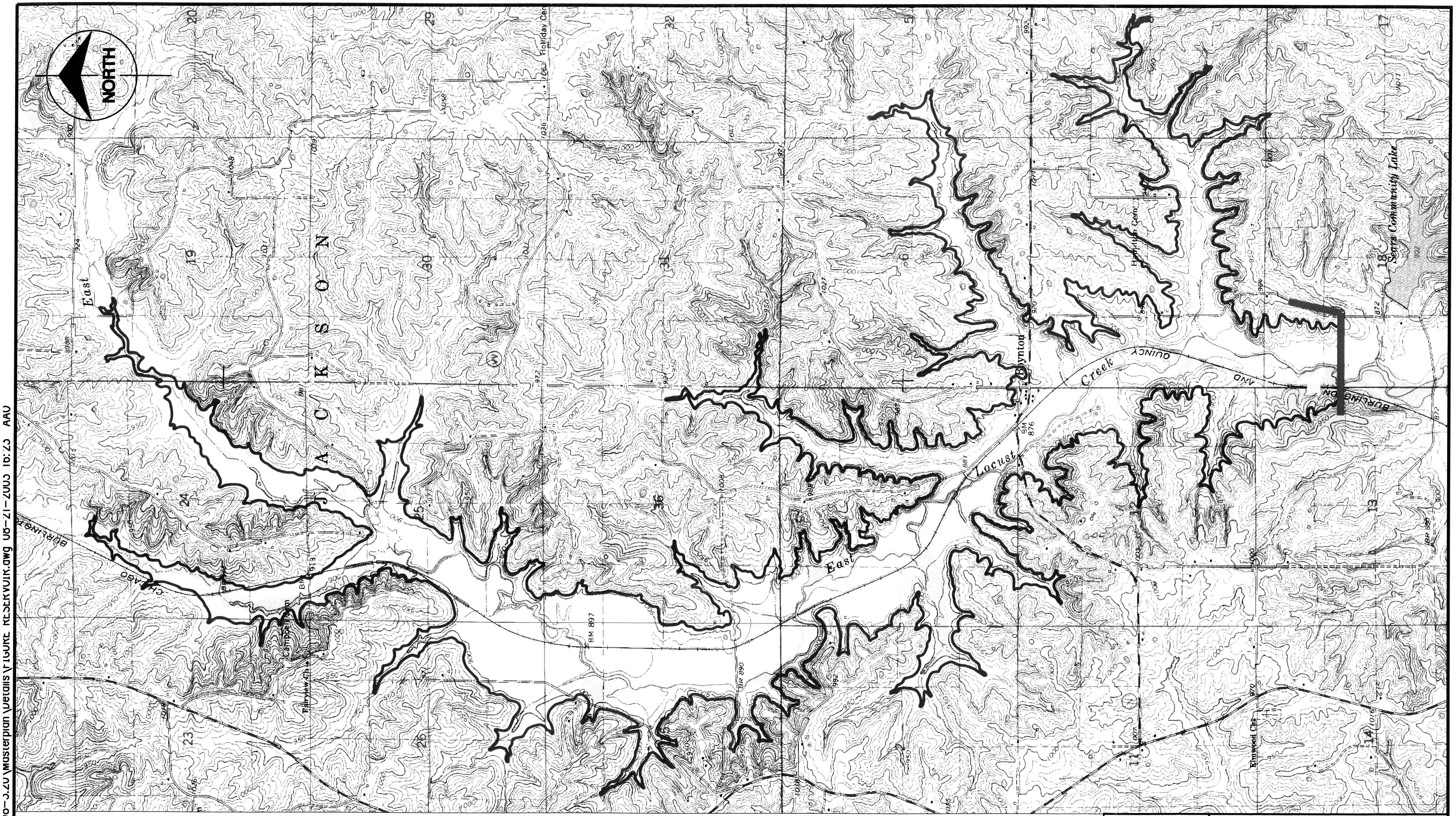
The Master Plan examines in detail the recommended location for the new water supply reservoir in North Central Missouri. Additional alternative analyses were also preformed to determine the recommended reservoir capacity and yield and dam configuration. A phased plan for the development of infrastructure required to deliver both potable and non-potable water to prospective future customers was also developed.

C. SCOPE

Burns & McDonnell was authorized by the North Central Missouri Regional Water Commission, under Authorization No. 1 dated November 26th 2002, to provide this Master Plan. Upon completion of the Feasibility Study, this Water Supply Master Plan for the selected new water supply and associated infrastructure for the North Central Missouri Regional Water Commission was developed. Figure I-1 shows the location of the proposed reservoir in North Central Missouri.

As a part of this Master Plan, the following tasks are performed:

- Develop project design criteria
- Conduct discussions with the Natural Resource Conservation Service (NRCS) regarding coordination with the local Watershed District and anticipated federal funding
- Develop recommendations for land purchase/ flowage easements
- Develop preliminary opinion of cost for the complete project
- Evaluate of purchase of the Milan Water Plant
- Develop cost of service and estimated Commission water rates



2000 0 2000 4000

SCALE IN FEET

LEGEND

ELEVATION 910

DAM

Burns & McDonnell SINCE 1898

Figure I–1

PROPOSED RESERVOIR LOCATION
NORTH CENTRAL MISSOURI
REGIONAL RESERVOIR
MASTER PLAN

J:\NCMRWP\32590-3.20\Masterplan\Details\FIGURE RESERVOIR.dwg 06-21-2005 16:25 AAU

PART II

Dam and Reservoir

PART II

DAM AND RESERVOIR EVALUATION

A. RESERVOIR YIELD ANALYSES

1. General

This section of the report contains a description of the yield analyses conducted for the proposed reservoir. The primary purpose of these yield analyses was to determine the required size of the reservoir, or the amount of conservation storage required to provide the target water supply yield under drought conditions. These analyses required completion of the following tasks:

- Estimate historic streamflow at the site of the proposed reservoir
- Estimate historic lake evaporation rates at the reservoir site
- Collect physical data for the proposed reservoir
- Perform computer simulations of reservoir operation to test adequacy of various project configurations
- Complete analyses to test the sensitivity of the selected project configuration to changing assumptions

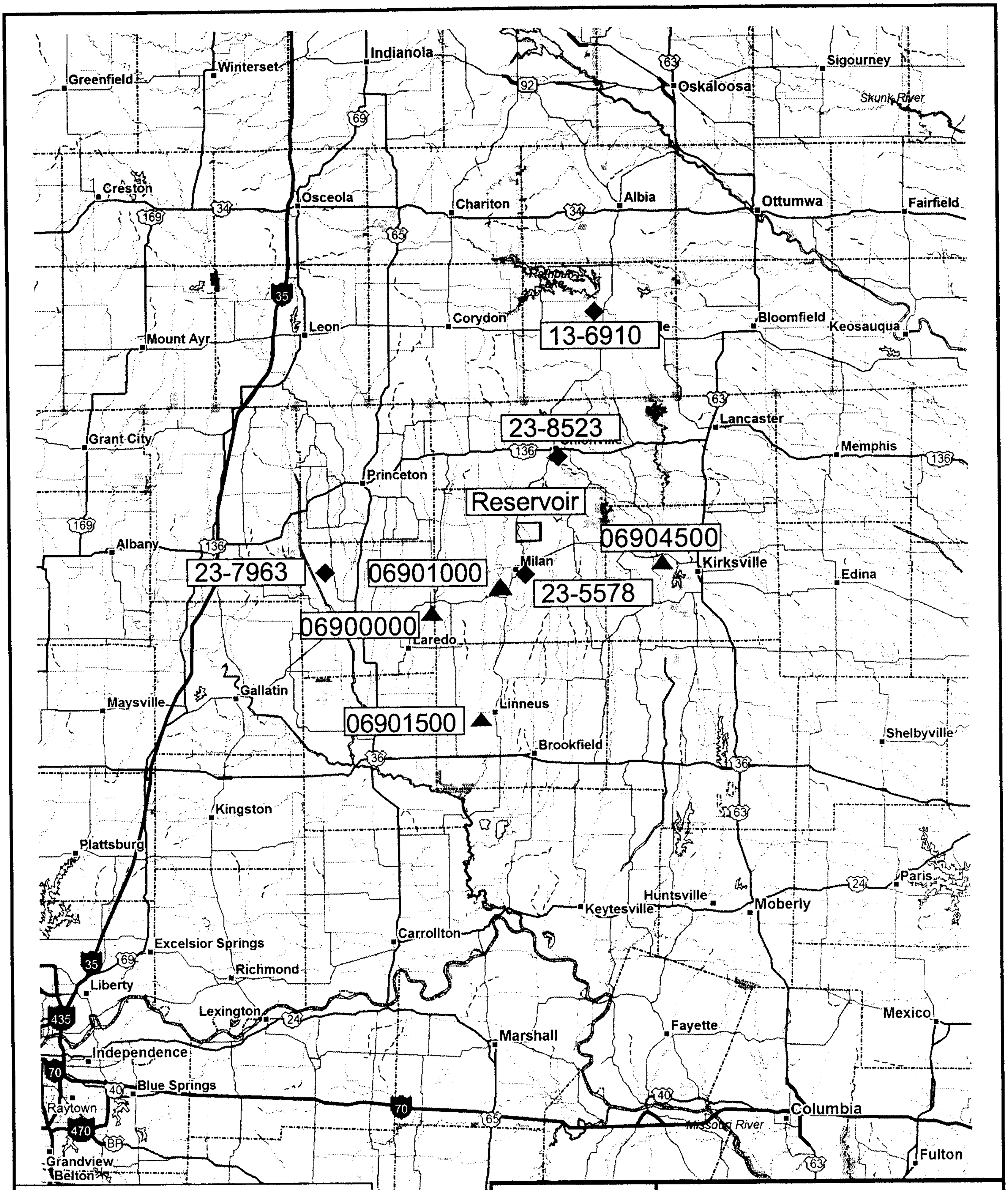
Each of these topics is discussed in the following paragraphs.

2. Reservoir Inflow

Various methods are available to estimate the yield of a reservoir, but all require estimates of natural stream discharge at the specified dam axis. The data sources and methodology used to estimate the historic inflow to the proposed reservoir are described below.

a. Historic Streamflow Data

Stream discharge data are collected primarily by the U.S. Geological Survey (USGS). Although the USGS maintains a network of stream gaging stations located throughout the country, there are no records of natural discharge for the East Fork of Locust Creek at the proposed dam axis. For this reason, the historic discharge at this location was estimated using streamflow data recorded by the USGS at nearby gaging stations as shown on Figure II-1. Gaging stations used in this analysis are listed in Table II-1, along with other pertinent data. Historic streamflow data available for these gages were obtained from the National



▭ ProposedReservoir

▲ USGSStreamGage

◆ Climate Station

Scale:1:1,600,000(1inch=25.3miles)

NORTH

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Figure II-1

STREAM GAGES
AND
CLIMATE STATIONS

Water Information System (NWIS-W) via the Internet (USGS, no date-a, no date-b, no date-c, no date-d).

TABLE II-1

USGS STREAM GAGING STATIONS

Station No	Station Name	Location (Lat./Long)	Drainage Area (Square Miles)	Available Period of Record
06900000	Medicine Creek near Galt, MO	40° 07' 45" 93° 21' 45"	225	10/01/1921 - 10/31/1928 12/01/1928 - 09/30/1975 10/01/1977 - 12/31/1990
06901000	Locust Creek near Milan, MO	40° 11' 00" 93° 10' 13"	225	10/01/1921 - 09/30/1933
06901500	Locust Creek near Linneus, MO	39° 53' 45" 93° 14' 10"	550	04/01/1929 - 09/30/1972 10/01/2000 - 09/30/2002
06904500	Chariton River at Novinger, MO	40° 14' 05" 92° 41' 14"	1370	10/01/1930 - 09/30/1952 10/01/1954 - 09/30/2002

Yield analyses require estimates of natural discharge at the proposed dam axis over a relatively long period. Natural discharge is the discharge that would have occurred in a stream without any man-made influences, such as construction of a reservoir or withdrawals for water supply or irrigation. Estimating natural discharge from recorded discharge at a particular gaging station requires detailed records on the historic operation of any upstream reservoirs and withdrawals. Except for large reservoirs developed by the Corps of Engineers, Bureau of Reclamation and other government agencies, such records are usually difficult or impossible to obtain. However, given that there are no major reservoirs in the upper reaches of Locust and Medicine creeks, the discharge recorded at three of the four gaging stations listed in Table II-1 is considered to be reasonably close to natural discharge. The fourth gage for the Chariton River at Novinger, MO (No. 06904500) is downstream of Rathbun Lake so the more recent flow records at this location may be significantly altered from natural conditions. Construction of Rathbun Lake was begun in 1964 and the reservoir began storing water in the late 1960's.

b. Statistical Analyses

The normal procedure used to translate flow data to a different location is to assume that the runoff at any location in a watershed is proportional to the contributing drainage area at that point. That is, the unit discharge (cfs/mile^2) is assumed uniform across the entire watershed. With this assumption, the flow at any point in a stream's watershed can be estimated from the unit discharge calculated at a stream gage by multiplying this unit discharge by the drainage area of the desired point. To test the validity of this uniform unit discharge assumption, the available flow data were subjected to statistical analyses.

The first statistical test applied to the available flow data was to calculate Pearson correlation coefficients (*r*) using the overlapping periods of record for each stream gage listed in Table II-1. For these and subsequent statistics, the data set consisted of the total flow by month at each gage. Pearson correlation coefficients give an indication of how closely the relative changes in one variable — the monthly flow at a particular stream gage — correspond to the relative changes in another. A high correlation coefficient, close to one, indicates close agreement between the relative changes in the flow at the two stream gages.

The Pearson correlation coefficients calculated for the four stream gages are listed in Table II-2. As expected, one of the highest correlation coefficients ($r = .967$) is between the two Locust Creek gages. The correlation coefficient between the Milan and Novinger gages is even slightly higher ($r = .974$) but these two gages have only 36 months of overlapping record in the early 1930's (water years 1931–1933) so this result is probably not indicative of current conditions. Correlation coefficients between the Novinger gage and Galt and Linneus gages are also relatively high ($r = .883$ and $r = .888$, respectively) even with the flow regulation provided by Rathbun Lake upstream of Novinger.

TABLE II-2

PEARSON CORRELATION COEFFICIENTS (R) FOR STREAM GAGES[a]

Gage Location	Galt	Milan	Linneus	Novinger
Medicine Creek near Galt, MO	--	.950 (143)	.947 (522)	.833 (657)
Locust Creek near Milan, MO		--	.967 (54)	.974 (36)
Locust Creek near Linneus, MO				.888 (504)
Chariton River at Novinger, MO				--

(a) Numbers in parentheses are the number of months of overlapping record

The next series of statistical analyses performed on these flow data was to fit linear regression models to each pair of gages with overlapping data. These regression models are an estimate of the best-fit straight line that describes the relationship between the two sets of monthly flow data. For each regression model, a coefficient of determination (r^2) was also calculated. The r^2 statistic is a measure of how well the regression model explains the variations in the dependent variable. A r^2 of 1.0 would indicate that the regression model is a perfect fit (that is, there is an exact linear relationship between the two sets of flow data).

The slopes of these regression lines are an indication of the best estimate of the discharge ratio between the dependent and independent gages. These regression line slopes were then compared to the actual drainage area ratios to validate or disprove the uniform unit discharge assumption.

The results of the regression analyses are summarized in Table II-3. As shown in this table, the best-fit regression line slopes range from slightly more than 5 percent less to over 21 percent more than the actual drainage area ratios. Ignoring the one outliner (Milan vs. Novinger) that has only three years of overlapping data, all regression line slopes are within 10 percent of the actual drainage area ratio. Therefore, these regression results lend further credence to the uniform unit discharge assumption discussed above.

TABLE II-3

REGRESSION ANALYSIS SUMMARY FOR STREAM GAGES

Dependent Gage	Independent Gage	Data Points	Coefficient of Determination	Regression Line Slope	Drainage Area Ratio	Percent Difference
Milan	Linneus	54	0.954	0.387	0.409	-5.4
Milan	Galt	143	0.935	0.948	1.000	-5.2
Milan	Novinger	36	0.962	0.199	0.164	+21.3
Linneus	Galt	522	0.923	2.232	2.444	-8.7
Linneus	Novinger	504	0.846	0.439	0.402	+9.5

c. Reservoir Inflow Estimates

Of these four gages listed above, the Milan gage is considered the most representative of flow at the proposed dam axis on the East Fork of Locust Creek because it is downstream of the dam site in the same watershed. Therefore, flow estimates for the proposed reservoir were derived from the records at this gage when available. The next best estimator of reservoir inflow is considered to be the Linneus gage, which is farther downstream of the dam site than the Milan gage but also has a much longer period of record. For gaps in the flow record when neither the Milan nor Linneus gages have data available, records at first the Galt gage and then the Novinger gage were used. The Galt gage has the exact same drainage area as the Milan gage and is located in an adjacent and largely parallel watershed. The Novinger gage has the least similar watershed to that of the proposed reservoir. It has a much larger drainage area and Rathbun Lake has affected the flow at this gage since the late 1960's. However, the time periods when this gage was used to complete the reservoir inflow record were outside of the critical 1930's and 1950's drought periods, so any inaccuracies in these flow estimates is not expected to materially affect reservoir yield.

The mean daily flow at the dam axis, or historic reservoir inflow, was estimated using the daily unit discharge recorded at the four stream gages and multiplying by the drainage area of the reservoir. The watershed above the proposed dam is estimated to be approximately 21,053 acres, or 32.9 square miles. Overall, reservoir inflow estimates were developed for calendar years 1922 – 2001, a period of 80 years. The list below indicates the gages and specific time periods used to estimate these reservoir inflows.

- Milan: 1 January 1922 – 30 September 1933
- Linneus: 1 October 1933 – 30 September 1972
- Galt: 1 October 1972 – 30 September 1975
- Novinger: 1 October 1975 – 30 September 1977
- Galt: 1 October 1977 – 31 December 1990
- Novinger: 1 January 1991 – 30 September 2000
- Linneus: 1 October 2000 – 31 December 2001

The resulting annual reservoir inflow volume is shown in Figure II-2 and illustrates the variability of these reservoir inflow estimates with time. Review of this graph clearly shows some of the more significant drought periods during the last 80 years, specifically the 1930's and mid-1950's.

3. Reservoir Evaporation

Evaporation from the surface of a reservoir can represent a major loss to the local hydrologic system and contribute to streamflow depletions. To quantify these losses for the proposed reservoir on East Fork Locust Creek, estimates of historic net evaporation rates were developed for the reservoir vicinity. The data sources and methods used to develop these evaporation estimates are discussed in subsequent paragraphs.

a. Pan Evaporation Data

Pan evaporation data are recorded at several stations in Missouri and Iowa but the stations that are the closest to the proposed reservoir are Spickard 7W (station no. 23-7963) in northwest Grundy County and Rathbun Dam (station no. 13-6910), which is located near Rathbun Lake. As shown in Figure II-1, these stations are located respectively about 33

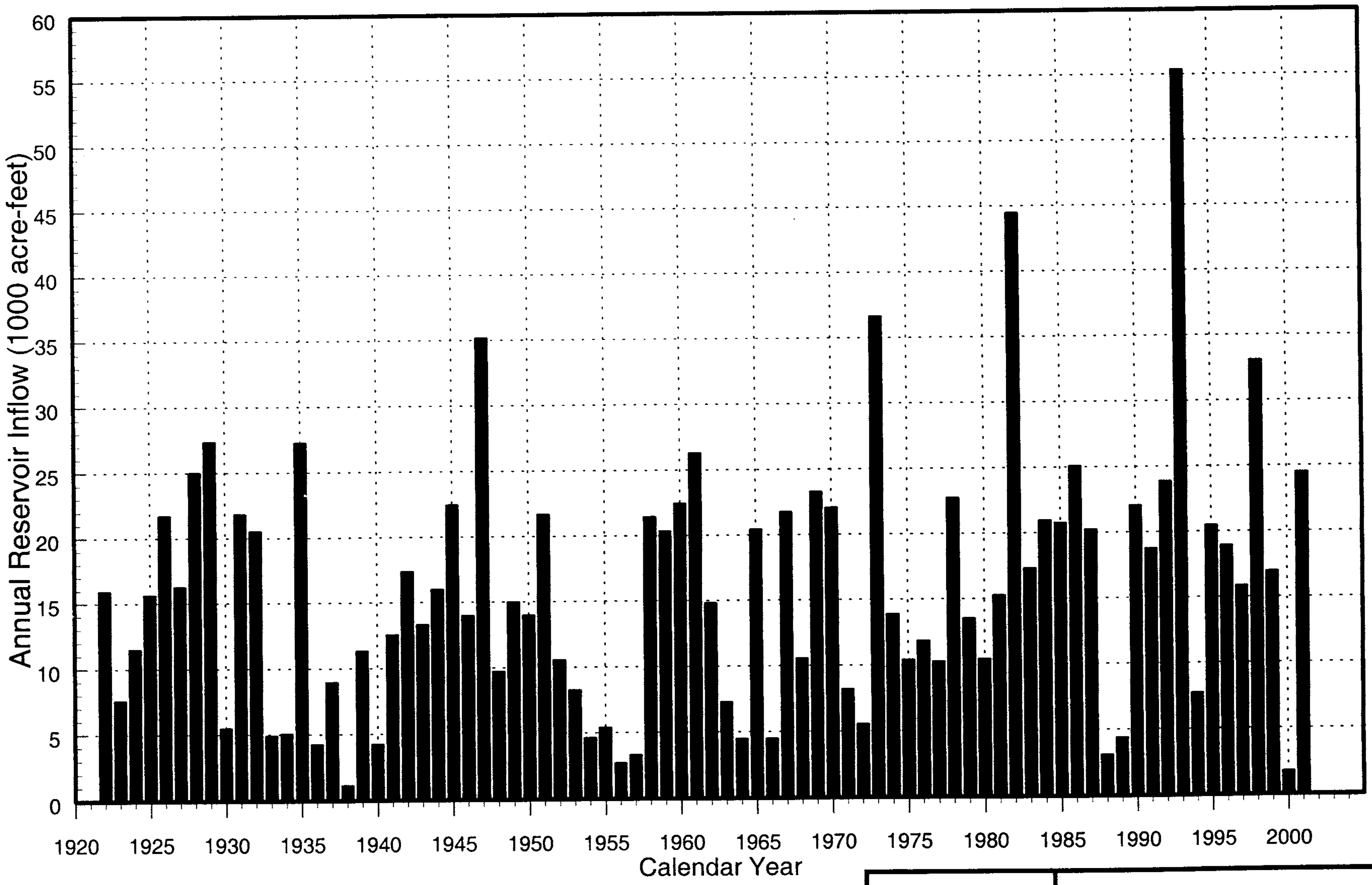

Figure II-2

ANNUAL RESERVOIR INFLOW

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Note

Reservoir inflow estimated from streamflow recorded by USGS at nearby stream gages.

miles west and 45 miles north of the proposed reservoir site (NCDC, 2002). These and the other climatic data stations used in estimating reservoir evaporation are listed in Table II-4.

TABLE II-4

CLIMATIC DATA STATIONS

Station No	Station Name	Location (Lat./Long)	Available Period of Record
13-6910	Rathbun Dam, IA	40° 49' 00" 92° 54' 00"	Pan Evaporation: 9/1993 - 11/2000 Wind Speed: 9/1993 - 11/2000
23-4544	Kirksville, MO	40° 12' 00" 92° 34' 00"	Temperature: 7/1993 - 12/2001
23-5578	Milan, MO	40° 12' 00" 93° 07' 00"	Precipitation: 7/1948 - 12/2001
23-7963	Spickard 7W, MO	40° 15' 00" 93° 43' 00"	Pan Evaporation: 8/1957 - 8/1993 Wind Speed: 8/1957 - 8/1993
23-8523	Unionville, MO	40° 28' 00" 93° 00' 00"	Precipitation: 7/1948 - 6/1948 Temperature: 1/1922 - 6/1993

Water will evaporate from an evaporation pan at a faster rate than from an actual lake. This phenomenon occurs because an evaporation pan is a much smaller body of water and will heat up and cool off much faster during a day or season than a lake. The ratio of lake to pan evaporation is referred to as the pan coefficient. These pan coefficients vary geographically and range from 64 to 88 percent with a default value of 70 percent typically used when a better estimate is not available. Based on a map published by the National Oceanic and Atmospheric Administration (NOAA, 1982), the pan coefficient at the proposed reservoir site is estimated to be 75.6 percent.

Pan evaporation records available at the Spickard station cover a period of record from August 1957 to August 1993, with missing data common during the winter months. At Rathbun Dam, the available pan evaporation data runs from April 1970 to November 2000. These periods of record are substantially shorter than that of the available reservoir inflow estimates and do not cover the critical drought periods of the 1930's and mid-1950's. Therefore, a reservoir evaporation computer model was used to estimate lake evaporation for the entire 80-year period of record (calendar years 1922–2001).

b. Climatic Data

The lake evaporation model requires estimates of historic climatic data for the entire period of interest. Both average monthly and actual monthly climatic data were obtained from published sources and the National Climatic Data Center (NCDC, 2002). The long-term average monthly data used are listed in Table II-5 and represent an average of the data for Columbia, Missouri and Des Moines, Iowa. In addition to these long-term average climatic data, daily temperature, precipitation, and wind speed data were obtained for the stations listed in Table II-4.

TABLE II-5

AVERAGE MONTHLY CLIMATIC DATA

Month	Solar Radiation (Langleys)	Possible Sunshine (percent)	Relative Humidity (percent)	Wind Speed (mph)	Barometric Pressure (millibars)
Jan	174	50.5	76.0	12.20	986.4
Feb	252	52.0	78.5	11.35	985.1
Mar	333	53.0	78.0	12.40	980.8
Apr	418	55.0	77.0	12.20	981.1
May	505	59.5	80.5	10.15	980.0
Jun	558	68.0	81.5	9.45	980.9
Jul	555	71.0	83.0	8.55	982.5
Aug	491	68.0	85.0	4.30	983.2
Sep	410	64.0	85.0	4.90	983.9
Oct	298	61.5	8.5	9.95	984.4
Nov	206	48.5	79.5	10.95	983.9
Dec	151	44.5	79.0	11.05	984.7

c. Evaporation Model

Reservoir evaporation rate estimates were calculated for the proposed reservoir using Burns & McDonnell's ETCALC computer model. This model uses a form for the Penman Equation to estimate evaporation depths. In general, the ETCALC model uses the following procedure to estimate evaporation rates (Linsley, Kohler & Paulhus, 1982).

- Advective Losses: The ETCALC model contains a number of relationships to estimate advective losses from the reservoir surface. Advective losses occur as water evaporates from the reservoir into the air immediately above the water surface, when this air is not saturated with water vapor (that is, has a relative humidity less than 100 percent). This moister air is then carried away by the wind and replaced with drier air so the process can continue. The principal factors affecting the rate of advective losses are wind speed, air temperature and relative humidity.

- Energy Budget: A substantial amount of heat energy is required to transform water into water vapor. The ETCALC model also contains relationships to estimate the amount of evaporation that would occur using an energy budget, or heat balance, methodology. The principal source of heat energy that controls evaporation is the Sun. Incident solar radiation at the reservoir varies seasonally, based on the inclination of the Earth's axis and its distance from the Sun, and with the amount of cloud cover (percent possible sunshine).

- Weighting Function: The Penman Equation uses a weighting function to estimate lake evaporation from the separate advective loss and energy balance estimates. This weighting function is based on the slope of the saturation-vapor-pressure versus temperature curve at the given air temperature.

d. Model Calibration

The ETCALC model must be calibrated to yield accurate evaporation estimates. The model was calibrated using the available pan evaporation data and a pan coefficient of 75.6 percent. The available calibration coefficients were adjusted by trial and error to find the values that yielded the least squares difference between the measured and calculated evaporation estimates.

e. Net Evaporation Rate Estimates

Once the ETCALC model was successfully calibrated, it was used to estimate monthly evaporation rates for the entire simulation period, calendar years 1922–2001. The evaporation rates estimated by the ETCALC model are gross rates. Precipitation that falls directly on the surface of the proposed reservoir will tend to offset some of the gross evaporation from the reservoir. The resulting evaporation — gross evaporation less direct precipitation — is referred to as net evaporation. Not all of the precipitation that strikes the surface of a reservoir is considered to reduce evaporation. In the absence of the reservoir, some of this precipitation would run off from the reservoir area and would be contributed to the discharge in the East Fork Locust Creek. This direct runoff is assumed to be included in the lake inflow estimates discussed above. Therefore, to avoid double counting this water, monthly net evaporation estimates are calculated by ETCALC assuming that runoff equals 30 percent of total precipitation, and only 70 percent of the direct precipitation will offset evaporation.

Estimated annual gross and net evaporation depths are shown in Figure II-3. Review of Figure II-3 shows that gross evaporation is fairly predictable, ranging from 33.6 to 36.8 inches per year, and averages about 33.6 inches. Net evaporation is much more variable since it depends on precipitation totals, which can vary significantly from year to year. Estimated annual net evaporation ranges from –10.6 to 19.2 inches per year, and averages 7.4 inches.

4. Reservoir Data and Operating Assumptions

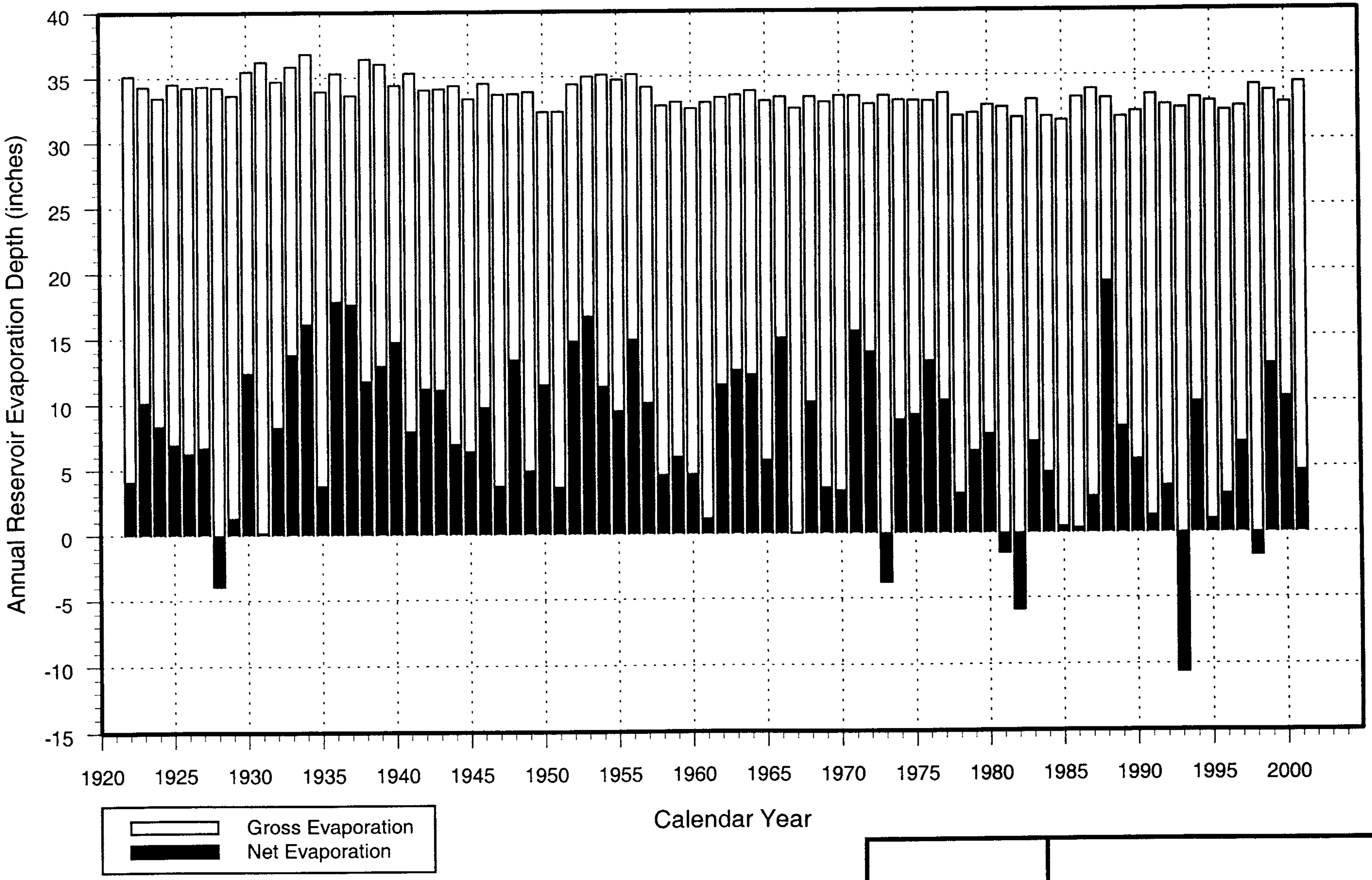
Certain physical data for the proposed reservoir and other operating assumptions are necessary in any type of yield analysis. These data are described in this section.

The size of the proposed reservoir is represented by the elevation-area-storage data listed in Table II-6. A graph of these same data is included as Figure II-4. These data, specifically the relationship between reservoir pool elevation and surface area, were estimated from the topographic data provided to Burns & McDonnell by the Commission.

TABLE II-6

ELEVATION-AREA-STORAGE DATA

Pool Elevation (feet NGVD)	Pool Area (acres)	Storage (acre-feet)
860	26	0
865	63	222
870	100	630
875	194	1,364
880	300	2,569
885	489	4,509
890	618	7,452
895	906	11,439
900	1,142	16,511
905	1,388	22,787
910	1,594	30,386
915	1,918	39,309
920	2,181	49,560



Note

From monthly evaporation estimates developed using Burns & McDonnel's ETCALC evaporation model.

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Figure II-3

ANNUAL RESERVOIR EVAPORATION

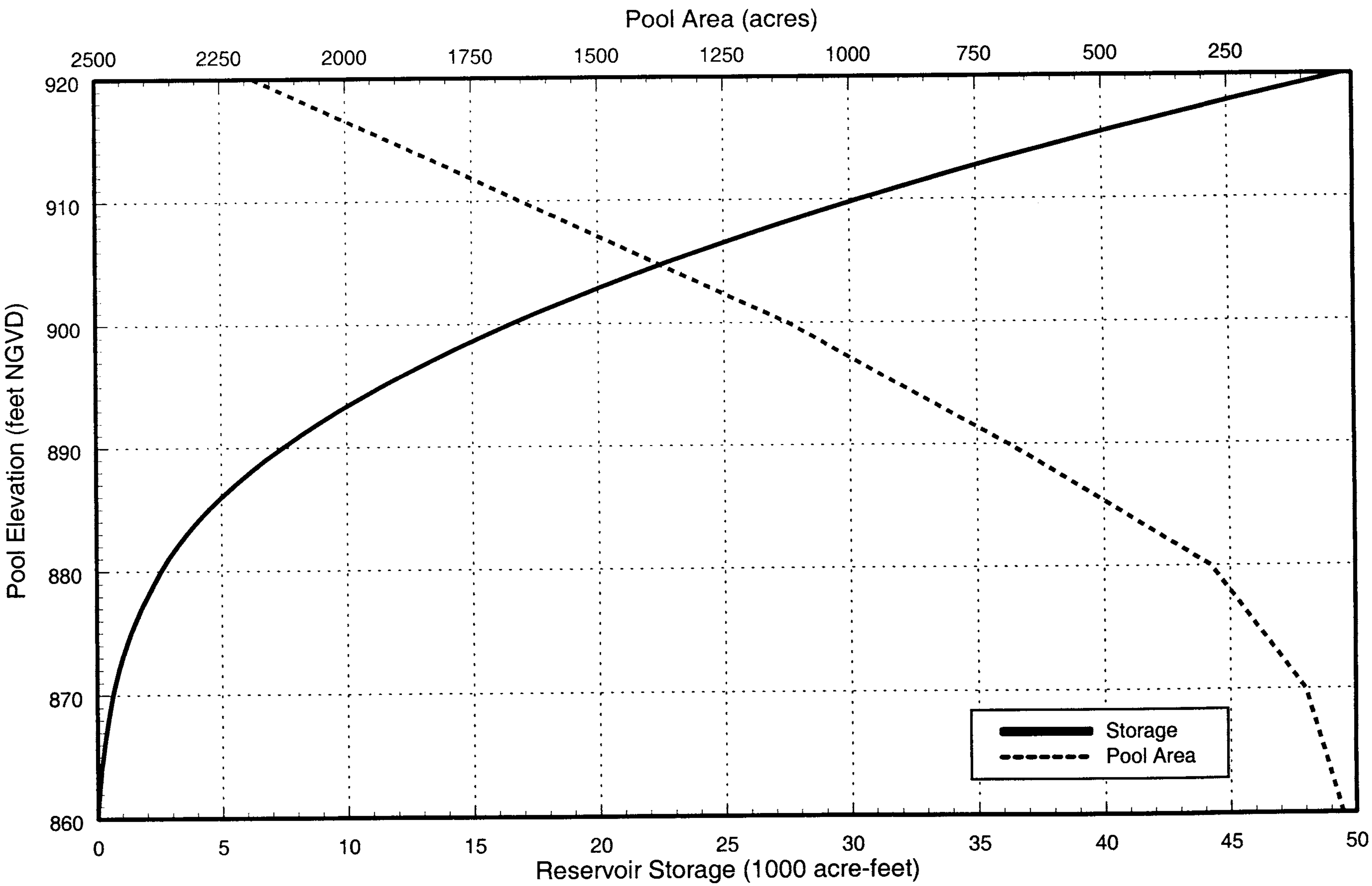

Figure II-4

PROPOSED RESERVOIR ELEVATION-AREA-STORAGE

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Note:

Developed from topographic data provided by District.

A portion of the reservoir's potential storage should be allocated for storage of sediment that will accumulate over the life of the reservoir. In this area of Missouri, the NRCS indicated that the erosion potential of the soils is fairly high and recommended using a worst case sediment production rate of two acre-inches (over an 80 year period) for the entire watershed. With a watershed of approximately 21,053 acres, this rate yields a sediment volume of 3,509 acre-feet. This sediment storage volume is considered generous as much of the watershed is no longer in row crop production and consists of pasture or fallow land enrolled in the Federal Government's CRP program. Additionally, the NRCS has constructed numerous small flood control and sediment storage reservoirs within the reservoir's watershed that aid in sediment reduction.

The Commission desires that the lake provide recreation and conservation benefits in addition to water supply. In order to help sustain fish and wildlife during a major drought, some additional storage was added to the sediment storage volume to define the bottom of the reservoir's conservation pool. This level was set at an elevation of 885 feet, which provides an additional 1000 acre-feet of storage above the long-term sediment storage level for the benefit of fish and wildlife. For the purpose of the yield analyses, the bottom of the conservation pool is the assumed level of the lowest water supply intake. Once the reservoir is drawn down to elevation 885 feet, no further water supply withdrawals are possible.

Any reservoir seepage, or other non-water supply releases from the reservoir, would also reduce the available water supply yield. A constant seepage allowance of 1.0 cubic feet per second (cfs) was assumed. Additional geotechnical studies would be necessary to determine the validity of this assumption. Also, any mandated minimum releases that may be imposed by regulatory authorities would also reduce the net water supply yield of this reservoir. An additional 0.5-cfs minimum release allowance was also incorporated into the yield analyses.

The other major operating assumption used in the firm yield analyses was to assume that the reservoir starts at the full level — that is, the current pool elevation was at the specified top-of-conservation (TOC) pool elevation — at the beginning of the simulation period. This of course will not actually be the case; however, during filling of the reservoir, the actual withdrawals will be much less than the projected 50-year usage of 5.75 MGD. Therefore, considering the reservoir full that start of the simulation period was considered appropriate.

5. Firm Yield Analyses

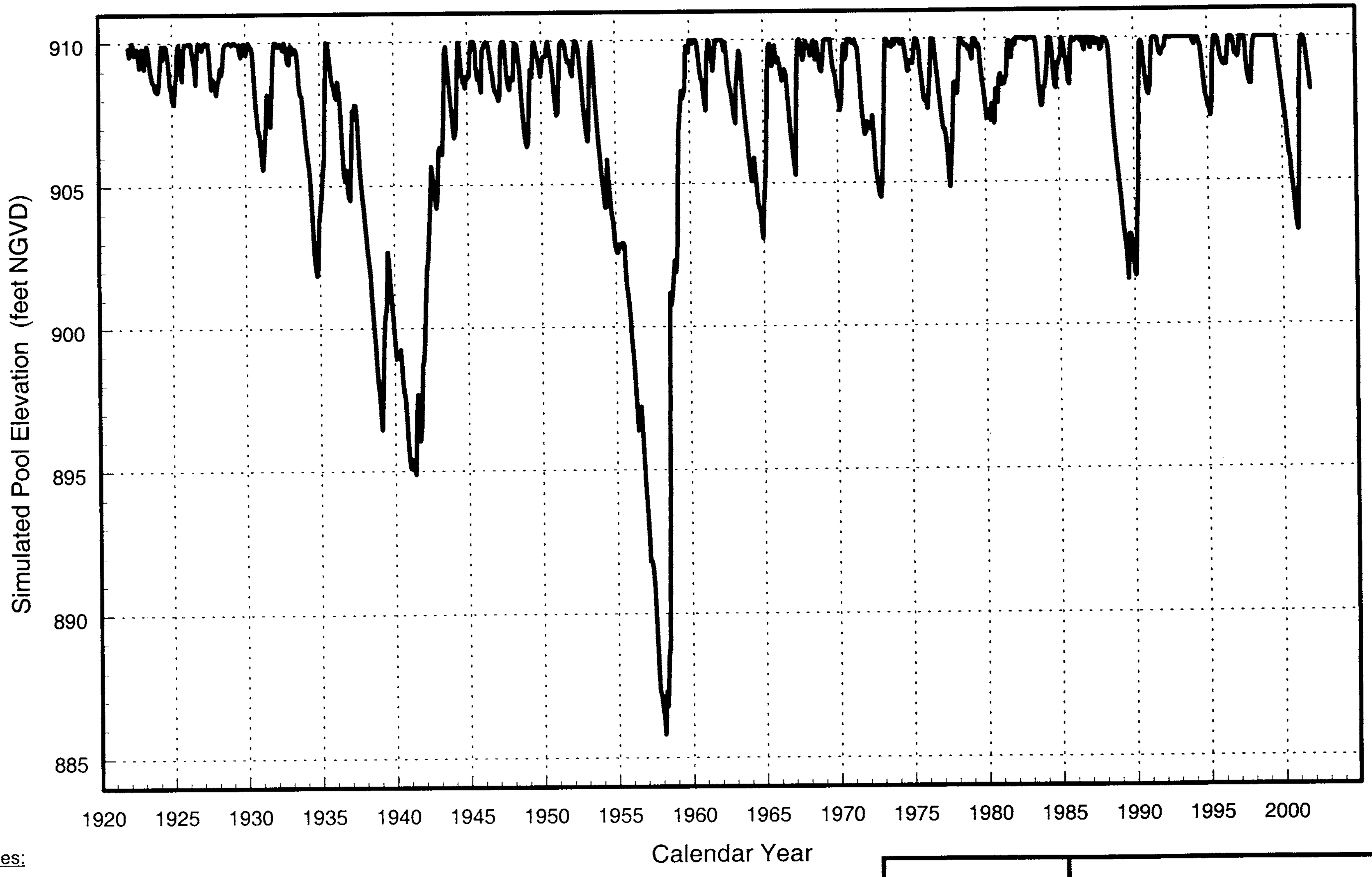
The firm yield of a reservoir is defined as the maximum constant draft it can sustain through the worst drought of record. The desired yield, or average water supply demand, is fixed at 5.75 MGD, or approximately 6,445 acre-feet per year. For this project, the goal of the firm yield analyses is to determine the amount of conservation storage required to sustain this desired yield. This storage quantity is determined by selecting a trial value and then performing computer simulations of the reservoir using the inflow, evaporation and other data previously discussed to determine if any demand shortages occur. In this manner, the minimum amount of conservation storage, and the corresponding minimum TOC pool elevation, is found by trial and error.

The firm yield analyses for the proposed reservoir were completed using Burns & McDonnell's Reservoir Network (RESNET) simulation model (Foster, 1989). This model calculates a water balance for the reservoir for each day during the simulation period. The simulation period used for these analyses was calendar years 1922–2001. For each daily time step, the RESNET model considers the following:

- Reservoir inflow
- Reservoir evaporation losses — a function of average pool area and the current day's evaporation depth
- Water supply withdrawals — assumed to be constant 5.75 MGD
- Seepage allowance — assumed to be constant 1.0 cfs
- Minimum releases — assumed to be constant 0.5 cfs
- Spills — inflow in excess of what can be stored in reservoir at or below TOC pool level
- Changes in reservoir storage

The RESNET model was used to estimate the required amount of conservation storage by adjusting the TOC pool elevation in increments of 0.5 foot. Through trial and error, the necessary TOC pool elevation was determined to be 910 feet NGVD.

Simulated reservoir pool elevations for the selected TOC pool elevation of 910 feet are shown in Figure II-5. This graph clearly shows that the critical period for this reservoir is the drought of the mid-1950's. In February 1958, the simulated pool elevation falls to within 0.45 foot of the bottom of the conservation pool (elevation 885 feet). A drought similar to that of the 1930's and early 1940's (the "dust bowl days") would also place significant stress on the reservoir. This



Notes:

1. Pool elevations derived from operations simulation for period 1922-2001.
2. Simulations assume water supply demands of 5.75 MGD with TOC pool elevation of 910 feet, plus seepage and minimum flow allowances of 1 cfs and 0.5 cfs, respectively.
3. Combined sediment storage and fish & wildlife pool assumed to contain approximately 4,500 acre-feet at elevation 885 feet.

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Figure II-5

SIMULATED
POOL ELEVATIONS

drought was actually longer but less intense than the one in the mid-1950's. The minimum pool elevation during this earlier drought was 894.98 feet, reached in January 1941.

6. Probable Yield Analyses

The probable yield of a reservoir is defined as the yield that can be sustained with a given annual probability of shortages. However, for this analysis the goal is to determine what the annual probability of failure is for the selected reservoir configuration. A two-percent failure probability (once every 50 years on average) is a common criterion used in water supply planning so the calculated failure probability was compared to this target value.

In a probable yield analysis, a failure or shortage is defined as any day during a year when the Commission could not withdraw at least 5.75 MGD. Shortages can be partial or total. Also, since this analysis does not take into account the impact of any conservation measures that would likely be implemented during a serious drought, the annual probability of not meeting essential water demands will be less than the calculated value.

The shortage probabilities for the proposed reservoir were calculated using an option available in the same RESNET computer model discussed previously. The probable yield analysis uses a method known as the Gould Probability Matrix to estimate the probability of shortages for a given reservoir configuration and demand (McMahon & Mein, 1986). This procedure is summarized briefly below.

- In a typical reservoir simulation, the entire modeling period is considered to be a continuous time series. The state of the system at the end of first day is used as the starting state for the system in the second day and so on until the end of the modeling period. However, for the probable yield analysis, each calendar year is treated as a distinct time series.

- In probable yield mode, the RESNET model divides the usable conservation storage of the reservoir into a specified number of zones. For this analysis, 20 zones were used. Zone 0 is an empty reservoir (that is, empty with respect to conservation storage) and zone 19 is a full reservoir. The intervening zones are evenly distributed on a volumetric basis. The model performs a simulation for each of the 80 years during the model simulation period with the initial reservoir contents each year reset to the current storage zone. This simulation is repeated for each of the 20 zones yielding 1,600 annual simulations.

- At the end of every annual simulation, the RESNET model keeps track of the ending storage zone for the reservoir in a matrix indexed by the starting zone for that year. This matrix is referred to as the transition matrix. The model also counts the number of days with shortages relative to the starting storage zone and stores this information in a shortage matrix.
- After the annual simulations are completed, a series of matrix manipulations are performed on the transition matrix to yield the steady-state probability of the reservoir starting in each storage zone. The shortage counts in the shortage matrix are divided by the total number of days to yield the probability of shortages for each starting reservoir zone. These two matrices are then multiplied together — the probability of the reservoir starting in each storage zone times the probability of a shortage if the reservoir starts in that zone — to yield the total probability of shortages.

For the selected reservoir configuration, with a TOC pool elevation of 910 feet, the annual probability of failure is estimated to be 2.11 percent. This value is close enough to the typical target value of 2 percent that the selected configuration is considered to be reasonable.

7. Sensitivity Analyses

To test the sensitivity of the selected reservoir configuration to changing assumptions, a number of sensitivity analyses were also completed. These adjustments and their impact on the TOC pool elevation required to meet the firm yield criterion or on the shortage probability are discussed below.

- Reduced Seepage: If the assumed seepage allowance is cut in half from 1.0 cfs to 0.5 cfs, and minimum releases are left at 0.5 cfs, the total reservoir loss rate would be 1.0 cfs. With this loss rate, the required TOC pool elevation needed to meet the firm yield criterion is reduced by one foot, from 910 to 909 feet. Also, with the TOC pool elevation left at 910 feet, the probability of failure decreases to 1.98 percent.

- Increased Minimum Releases: If regulatory agencies require a minimum release that is double the assumed value of 0.5 cfs, the total reservoir loss rate (minimum release plus seepage) would increase to 2.0 cfs. With this higher loss rate, the TOC pool elevation required to meet the firm yield criterion would increase by 1.5 feet to 911.5 feet. Leaving the TOC pool elevation at 910 feet but increasing the reservoir loss rate by 0.5 cfs raises the probability of failure to 2.28 percent.

- Reduced Inflow: If the estimated reservoir inflow were found to be optimistic (that is, high) because of problems with the estimation technique or intensified conservation practices within the reservoir's watershed, the probability of failure would increase. If the estimated daily reservoir inflow were reduced by 10 percent each day, the probability of failure would increase from 2.11 to 2.38 percent.

- Increased evaporation: If the gross evaporation estimates were increased by 10 percent, the probability of failure would increase from 2.11 to 2.20 percent.

The adjustments in TOC pool elevation needed to respond to changing reservoir loss assumptions are relatively modest. The impact of increasing reservoir losses, or errors in inflow or evaporation estimates, also do not dramatically alter the calculated failure probabilities. Therefore, it is concluded that the selected reservoir configuration is not overly sensitive to changing input assumptions.

B. RESERVOIR HYDROLOGIC ANALYSES AND SPILLWAY SIZING

1. Watershed Characteristics

a. Description of Watershed

The proposed dam and reservoir are located on the East Fork Locust Creek in Sullivan County in North Central Missouri as shown in Figure II-6. The proposed dam site is located approximately one-mile south of Boynton, Missouri. East Fork Locust Creek joins Locust Creek several miles south of the proposed dam location near Milan, Missouri.

The project drainage basin is characterized by typical ridge and valley topography, with moderate to gentle slopes on hills. Areas of steep slopes are present along portions of the East Fork Locust Creek. The area is sparsely populated with limited development. Land use is a mixture of row crops, pasture, and undeveloped wooded areas. Pasture and fallow farmland enrolled in the Federal Government's Conservation Reserve Program (CRP) are the dominant land uses.

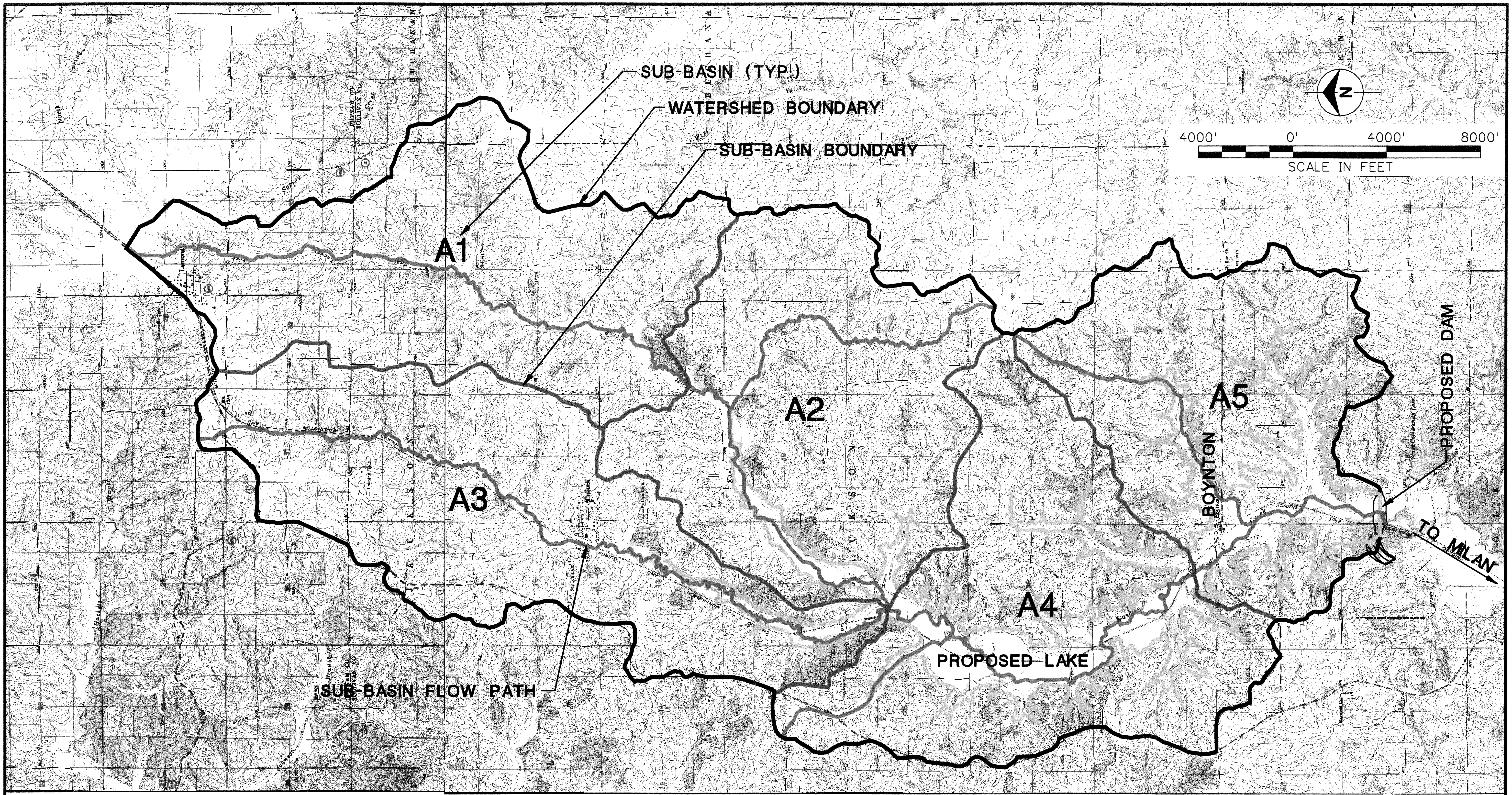

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Figure II-6

EAST FORK LOCUST CREEK
WATERSHED UPSTREAM
OF PROPOSED DAM

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The topography of the 33 square mile drainage basin consists of moderate 5 to 10 percent slopes, with considerable relief between the divide ridges and the valley floors (100 to 160 feet). The site valley proper is approximately 1000 feet to 1500 feet wide with areas as wide as 2500 feet. The stream gradient is approximately 10 feet per mile for much of the reach length upstream of the project site. Steeper incised channels typify the tributary streams with inverts in bedrock detritus and alluvial soils.

b. Basin Soils

The NRCS Soil Surveys for Sullivan County, Missouri were referenced to determine the soil characteristics and hydrologic soil groups for the project drainage basin. Sullivan County lies in the glaciated region of northern Missouri. Glacial till is 70 to 110 feet thick over most of the upland part of the county. The till is completely gone in a few upland areas and it is more than 200 feet thick in buried major stream valleys.

The soil associations present at the project site include the Winnegan-Keswick association and the Gara-Armstrong association. Although of varying lateral character, all soil associations are gently sloping to very steep. Moderately well drained and somewhat poorly drained soils that formed in glacial till or in pedisediments and a paleosol weathered from glacial till are located on the uplands.

For hydrologic analysis, the soils were grouped in accordance with the NRCS methodology. Group A soils typically have a high infiltration rate when thoroughly wet resulting in little runoff. There are no soils present within the drainage basin which exhibit hydrologic characteristics of Group A. Group B soils have a moderate infiltration rate when thoroughly wet. Soils in the hydrologic Group C typically have a slow infiltration rate when thoroughly wet, and Group D soils have an extremely slow infiltration rate.

The Sullivan County Soil Surveys list the appropriate hydrologic soil group for each soil type. The percentage of each hydrologic soil group within each subbasin was estimated from a delineation of the major soil associations. Soils information indicates that approximately 10%, 70%, and 20% of the watershed soils are assigned to hydrologic soil groups B, C, and D, respectively. Based on this information, an average value of C was assigned to all areas of the watershed for subsequent use.

c. Stream Characteristics

The channel of East Fork Locust Creek has a generally mild slope, incised in clay/silt soils overlying alluvial sands, and is considered to be a perennial stream. Tributaries are typically streams and draws that are ephemeral and typically extend no more than two miles. The stream bottom consists of interlayered alluvial sands, silts and clays overlying a thick layer of alluvial sand. The representative Manning's roughness coefficient for East Fork Locust Creek was estimated to be 0.045.

d. Subbasin Delineation

The watershed boundary and the subbasin boundaries were delineated from the following USGS 7.5 minute Topographic Quadrangle maps: Pollock and Unionville West, both in Missouri. The subbasins were delineated differently for the existing conditions versus the altered conditions for the proposed improvements. For the existing conditions, the watershed was divided into five subbasins as shown on Figure II-6 and listed in Table II-7.

TABLE II-7

SUBBASIN AREAS FOR EXISTING CONDITIONS

Subbasin	Drainage Area (mi^2)
A1	6.84
A2	6.59
A3	7.08
A4	6.73
A5	5.66
Total	**32.90**

For the proposed conditions, the new reservoir (@ an estimated 100-year pool elevation of 915') was treated as a separate subbasin, therefore reducing the areas of the adjacent watersheds as summarized in Table II-8.

TABLE II-8
SUBBASIN AREAS FOR PROPOSED CONDITIONS

Subbasin	Drainage Area (mi^2)
A1	6.84
A2	6.37
A3	6.92
A4	5.30
A5	4.46
Lake	3.00
Total	**32.90**

2. HYDROLOGIC MODELING PARAMETERS

a. Basic Methods

The hydrologic and hydraulic design development is consistent with the criteria outlined in USDA-NRCS Technical Release No. 60 (TR-60) *Earth Dams and Reservoirs* and Section 4 of the USDA-NRCS National Engineering Handbook (NEH-4). The USBR's *Design of Small Dams* was also extensively referenced. Chapter 3, of USDA-NRCS Technical Release No. 55, was also referenced for the determination of travel times.

For the development of the Probable Maximum Precipitation (PMP), the USACE's HMR52 software was utilized. This software is based on guidance contained in Hydrometeorological Report No. 52 (HMR52) (National Weather Service, 1982) and Hydrometeorological Report No. 51 (HMR51) (National Weather Service, 1978).

U.S. Weather Bureau, NOAA, Rainfall Frequency Atlas of the United States Technical Papers 40, 49 as well as Hydrometeorological Paper 35 methods and data were utilized to develop the recurrent flood analysis, based on storm depths and durations.

b. Synthetic Unit Hydrographs

1) HEC-1 Unit Hydrograph Approach

In accordance with the USACE precipitation-runoff analyses in the HEC-1 model, the rainfall is represented by a hyetograph. The losses within a system are estimated and then subtracted from the basin average precipitation. The remaining rainfall is referred to as rainfall excess. This rainfall excess is then transformed into direct runoff by means of a unit hydrograph (USACE, February 13-16, 1996).

2) SCS Unit Hydrograph

The Soil Conservation Service (USDA-NRCS) method, known as the SCS dimensionless unit hydrograph, was selected for the purpose of modeling flood events. A key component of the method is the time lag (T_L). Time lag is calculated at 0.6 times the travel time or time of concentration. For each subbasin, travel time was calculated using a combination of overland flow, shallow channelized flow, and channel flow. The first two segments of the overall travel time were calculated using the methods presented in TR55. The channel flow time was found by estimating a channel section and slope in each subbasin and calculating flow velocity using Manning's equation. The resultant flow velocities ranged from 2.2 feet per second to almost 7 feet per second with an average of about 4 feet per second. The calculated travel and lag times for existing conditions in the East Fork Locust Creek watershed are shown in Table II-9.

TABLE II-9

SYNTHETIC UNIT HYDROGRAPH DATA FOR EXISTING CONDITIONS

	Overland Flow			Shallow Concentrated Flow			Channel Flow				
Subbasin	Length (feet)	Slope (ft/ft)	Travel Time (hour)	Length (feet)	Slope (ft/ft)	Travel Time (hour)	Length (feet)	Slope (ft/ft)	Travel Time (hour)	Total (hour)	Lag Time (hour)
A1	300	0.024	0.36	1000	0.022	0.12	28,887	0.00497	2.19	2.67	1.60
A2	300	0.033	0.32	1000	0.030	0.10	29,252	0.00451	1.94	2.36	1.41
A3	300	0.033	0.32	1000	0.015	0.14	39,796	0.00358	3.24	3.70	2.22
A4	0	--	0.00	0	--	0.00	25,380	0.00095	3.20	3.20	1.92
A5	300	0.040	0.29	1000	0.051	0.08	15,611	0.00749	0.62	0.99	0.60

Lag times for the proposed conditions (with lake) were calculated in a similar manner. However, the channel flow time in each subbasin, except A1, was reduced due to the fact that the lake occupies a portion of the main channel. For each subbasin, the travel time was calculated using the flow velocity times the remaining length of channel not inundated by the lake. Travel time through the lake itself was not considered. The calculated travel and lag times for proposed conditions in the East Fork Locust Creek watershed are shown in Table II-10.

TABLE II-10

SYNTHETIC UNIT HYDROGRAPH DATA FOR PROPOSED CONDITIONS

	Overland Flow			**Shallow Concentrated Flow**			**Channel Flow**				
Subbasin	**Length (feet)**	**Slope (ft/ft)**	**Travel Time (hour)**	**Length (feet)**	**Slope (ft/ft)**	**Travel Time (hour)**	**Length (feet)**	**Slope (ft/ft)**	**Travel Time (hour)**	**Total (hour)**	**Lag Time (hour)**
A1	300	0.024	0.36	1000	0.022	0.12	28,887	0.00497	2.19	2.67	1.60
A2	300	0.033	0.32	1000	0.030	0.10	19,238	0.00451	1.28	1.69	1.02
A3	300	0.033	0.32	1000	0.015	0.14	29,844	0.00358	2.43	2.89	1.73
A4	300	0.043	0.28	1000	0.050	0.08	9,463	0.00095	1.19	1.55	0.93
A5	300	0.040	0.29	1000	0.051	0.08	3,212	0.00749	0.13	0.50	0.30

Under PMF conditions, each lag time was reduced by 20% in anticipation of higher average velocities in the watercourses under such an extreme event.

The nature and response over time of the runoff under a PMF event differs significantly from the smaller flood events due to the greatly increased flow volumes and discharge rates. Flow paths are altered and the energy losses in the system are lessened.

c. Runoff and Infiltration Loss Rates

The SCS Curve Number methodology was utilized to develop and define infiltration capacity of the soils and runoff volumes based on the physical characteristics of the basin. The predominant soils found within the watershed are defined as Hydrologic Soil Group C by the NRCS. The majority of the watershed was considered to be pasture or range in fair condition, which results in a Curve Number of 79 (AMC II). The Curve Number was reduced to 64 when modeling storms with a duration of 10 days as recommended in TR-60.

d. Rainfall

Synthetic rainfall depths and distributions were used in the HEC-1 model for the development of this project.

1) Probable Maximum Precipitation (PMP)

The Probable Maximum Flood (PMF), developed from the PMP, is the design flood controlling the combined spillway capacity and dam crest. The PMP is defined as "the theoretically greatest depth of precipitation for a given duration that is physically possible over a particular drainage area at a certain time of year," (American Meteorological Society, 1959). Since the PMP is the theoretical maximum precipitation amount, the PMF is considered to be the maximum flood event.

The U.S. Army Corps of Engineers' HMR52 model was utilized to generate the PMP distribution. Once the PMP distribution was developed, it was imported into HEC-1 along with the other watershed characteristics to model the PMF.

The following input data was required to characterize the watershed within the HMR52 software: the x- and y- coordinates of the basin and subbasins, the PMP rainfall distribution for the storm area, the preferred storm orientation, and data for the temporal distribution.

a) Coordinates for Basin and Subbasins

Coordinate boundaries for the entire watershed and the subbasins were defined within the model. The basin and subbasins were digitized in CADD Microstation from the drainage area as defined on the USGS 7.5 minute Topographic Quadrangle mapping.

b) Probable Maximum Precipitation for Storm Area

The PMP for standard areas and durations for the Sullivan County, Missouri area were interpolated from Figures 18-47 in the HMR No. 51. The PMP utilized in this analysis is summarized in Table II-11

TABLE II-11

PMP FOR EAST FORK LOCUST CREEK WATERSHED

Drainage Area (mi^2)	PMP for 6 hr duration (in)	PMP for 12 hr duration (in)	PMP for 24 hr duration (in)	PMP for 48 hr duration (in)	PMP for 72 hr duration (in)
10	27.2	32.0	33.7	37.5	39.1
200	19.7	23.8	25.5	28.7	30.6
1000	14.5	18.0	19.9	22.9	24.9
5000	8.8	11.8	13.8	16.9	18.4
10,000	6.9	9.4	11.3	14.5	15.9
20,000	5.0	7.4	9.2	12.0	13.6

c) **Preferred Storm Orientation**

For different geographical locations, the preferred orientation of storms will differ. A preferred storm orientation of 246 degrees (azimuth basis from the north), running southwest to northeast, was interpolated from Figure 3 of the HMR52 User's Manual for the North Central Missouri area.

d) **Temporal Distribution Data**

The computational time interval and a ratio of one hour to six hours of precipitation for isohyet A of a 20,000 square mile storm had to be defined, in order to aid the model in determining the temporal distribution of the Probable Maximum Storm (PMS) for intervals less than six hours. A time interval of 30 minutes was specified. The ratio of one hour to six hours of precipitation for isohyet A of a 20,000 square mile storm was set at 0.296. This value was obtained from Figure 39 in HMR No. 51.

e) **Results**

The HMR52 results are summarized in Table II-12. It shows the cumulative PMP over a 72-hour duration for the different subbasins within the study area.

The variation in the cumulative PMP within the subbasins is a caused by the specific geometry and location of the subbasin as imposed on the overall storm patterns.

TABLE II-12

CUMULATIVE PMP FROM HMR52

Subbasin	Cumulative PMP for 72-hr Duration (in)
A1	35.40
A2	36.68
A3	35.63
A4	35.59
A5	34.88
Average	35.64

HMR 52 also provided the incremental rainfall depth (as a percentage of the total depth) versus time for the 72 hour PMF event and these values were directly imported into the HEC-1 model.

2) 100 Year Event

Along with the PMF, the 100-yr 24 hour and 10 day events were also evaluated. The incremental precipitation data was taken from NOAA Technical Memorandum HYDRO-35 (NOAA, 1977) for durations below 2-hours.

For durations between 2-hours and 24-hours, the U.S. Weather Bureau Technical Paper No. 40 (Hershfield, 1961) was referenced, and the U.S. Weather Bureau Technical Paper No. 49 (Miller, 1961) was used to determine precipitation data with durations greater than 24-hours. Table II-13 summarizes the incremental precipitation data obtained from these references.

Rainfall hyetographs were defined employing the SCS Type II distribution for the 24 hour event and the synthetic storm option in HEC-1 for the 10 day event. The synthetic storm option places the most intense rainfall in the central part of the overall storm duration.

TABLE II-13
INCREMENTAL PRECIPITATION DATA

Duration	100 Year Rainfall Depth (inches)
5 minutes	0.85
15 minutes	1.80
60 minutes	3.38
2 hours	4.10
3 hours	4.45
6 hours	5.33
12 hours	6.25
24 hours	7.05
2 days	8.25
4 days	10.10
7 days	11.60
10 days	12.70

3) **Spillway Design Flood (SDF)**

In accordance with NRCS Technical Release 60, the precipitation for the SDF is as follows:

$$SDP = P_{100} + 0.26(PMP - P_{100})$$

The rainfall amount was calculated using the PMP rainfall depths (72 hour duration) and an interpolated value of 9.3 inches for the 100 year 72 hour rainfall. The incremental rainfall percentages versus time determined for the PMF were also use for the SDF.

3. HYDROLOGIC MODELING - EXISTING CONDITIONS

Existing conditions were modeled for flood events as follows and as shown in Figure II-6a. First, the calculated runoff hydrograph from Area 1 was routed through Area 2. The runoff hydrographs from Area 2 and Area 3 were then combined with the routed hydrogragh from Area 1. Next, the combined flows from these three areas were routed through Area 4. Then, the runoff hydrograph from Area 4 was combined with the routed flows. Next, these combined flows were routed through Area 5. Finally, the runoff from Area 5 was added to all of the combined, routed flows.

Hydrologic routing between nodes was performed using the Normal-Depth Channel Routing method in HEC-1. This method uses the estimated channel and overbank characteristics such as cross section, Manning's "N" and slope to compute storage and outflow values for a channel reach under subcritical flow conditions.

The HEC-1 model results for the existing conditions are summarized below in Table II-14. PMF and SDF results are for 72-hr duration events and the results for the 100-yr return event are for the 24 hour and 10-day duration storms.

The difference in peak discharges for the 100 year 24 hour and 10 day duration events is caused by differences in the rainfall distribution used in HEC-1 for each event. For the 24 hour event, the SCS Type II distribution was used, while HEC-1's rainfall blocking method was used for the 10 day event. Although the 10 day event peak flow rate should be similar to that obtained for the 24 hour event, no attempt was made to adjust the model for the 10 day event because subsequent analyses using the principal spillway configuration determined that the reservoir stage continues to rise due to inflows occurring well beyond the time of the peak inflow rate.

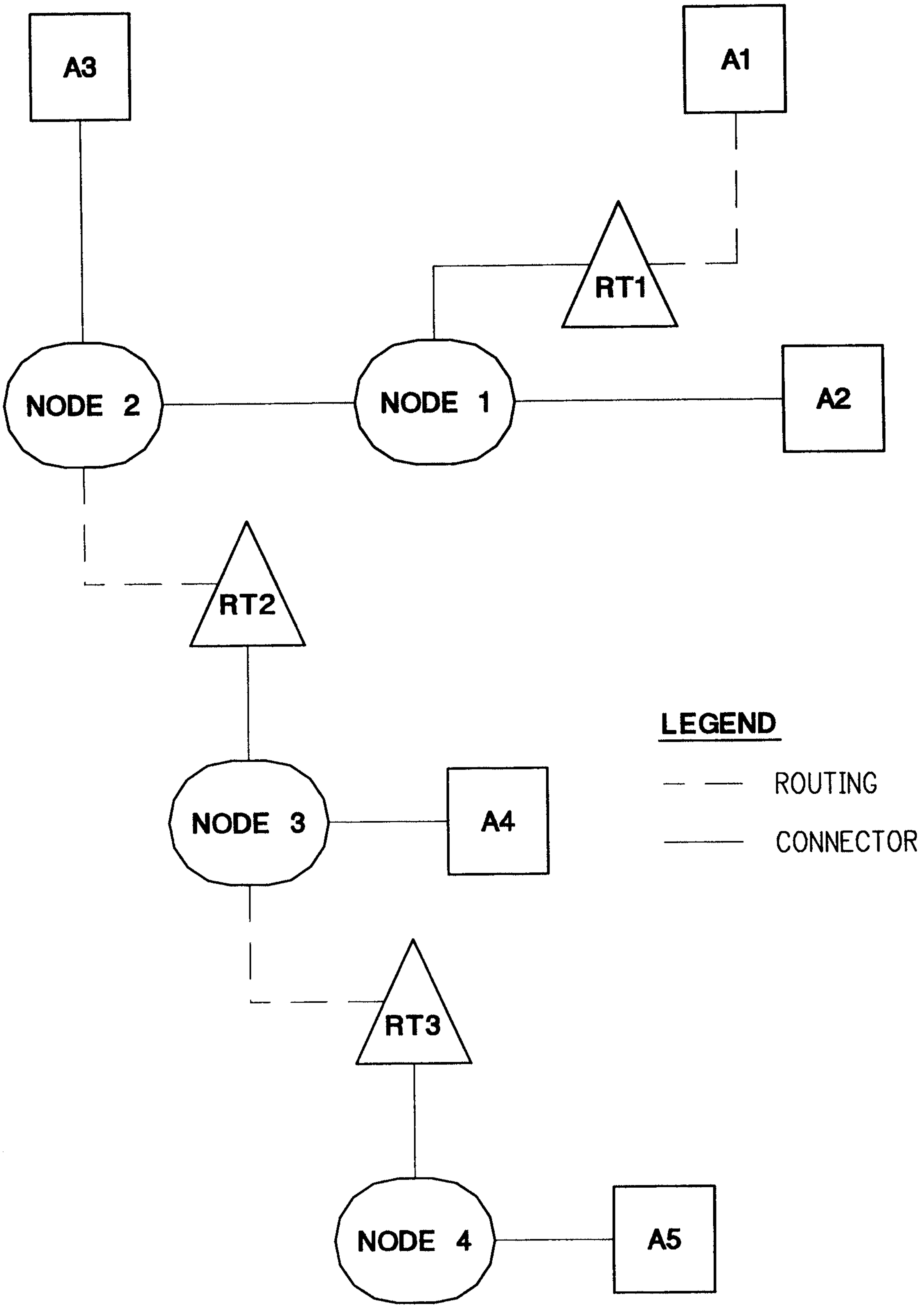

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Figure II-6A

HEC-1 ROUTING SCHEMATIC
EXISTING CONDITIONS

TABLE II-14
SUMMARY OF HEC-1 RESULTS – EXISTING CONDITIONS

	EXISTING CONDITIONS
Return Event	**Peak Outflow (cfs)**
PMF	166,201
SDF	52,588
100Yr 24 hr	21,729
100Yr 10 day	16,066

4. PRINCIPAL SPILLWAY DESIGN

a. Principal Spillway Design Flood

All reservoir flood release discharges under events up to and including the 100-year event will be made through the principal spillway. The hydraulic capacity of the principal spillway was established to result in the evacuation of not less than 85% of the stored volume of the 100-year, 10-day event above the spillway crest within ten days of the time of the peak reservoir stage, so as to restore reservoir flood storage volume in the event of a recurring event. This approach results in the smallest (hence least expensive) principal spillway considered reasonably applicable to the site. The results of the flood routings (subsequently presented in this Part II) indicate that the maximum surcharge depth under the 100-year event is slightly less than five feet.

Although that depth of flood surcharge storage is rather nominal, additional analyses were conducted in which the capacity of the principal spillway was increased in an attempt to reduce the depth of flood surcharge storage. It was concluded that major (order of magnitude) increases in spillway capacity (and, as a result, cost) would be required to reduce that surcharge storage depth by even two feet. It was therefore concluded that providing a principal spillway having the minimum capacity corresponding to the desired evacuation time for flood surcharge storage was most appropriate for this reservoir system.

b. General Configuration

This section documents the results of the conceptual design analysis for the proposed facilities. This includes preliminary, recommended design criteria and constraints for the outlet works and the spillway systems. The principal spillway is composed of the following primary components, listed in order of downstream progression:

- An uncontrolled circular spillway crest or "morning glory"
- A vertical flow constricting conduit
- A transition from the vertical conduit to the outlet conduit
- A circular outlet conduit

The spillway was sized through trial and error methods and resulted in a structure that allows the 100 year flood to be stored to approximately 915' (discharge of approximately 1700 cfs), meets the criteria of TR60 for evacuation of storage, and limits discharge during the PMF to approximately twice the 100 year discharge (3400 cfs +/-). This limitation on discharge during the PMF is the maximum obtainable for the basic spillway configuration selected, and was incorporated in the design to minimize the required capacity and cost of the conduit. A graphical representation of the spillway is presented in Figure II-7.

The anticipated location of the principal spillway is shown on Figure II-8. This location was established based on review of available subsurface information (see Appendix A), with the intent to found the principal spillway on or in bedrock in the foundation. The final location of the spillway may be adjusted during subsequent design as additional subsurface information becomes available.

c. Spillway Crest

Discharge through the principal spillway will enter the structure by flowing over a circular weir. The crest shape and nappe were developed on the basis of guidance contained in *Design of Small Dams.* The resultant crest length was reduced to account the effects of piers associated with an anti-vortex structure and trash rack. Table II-15 shows detailed information on the spillway crest.

1 NORMAL POOL EL. 910.0

2 100 YEAR 10 DAY EL. 914.7

3 SDF EL. 919.5

4 PMF EL. 927.5

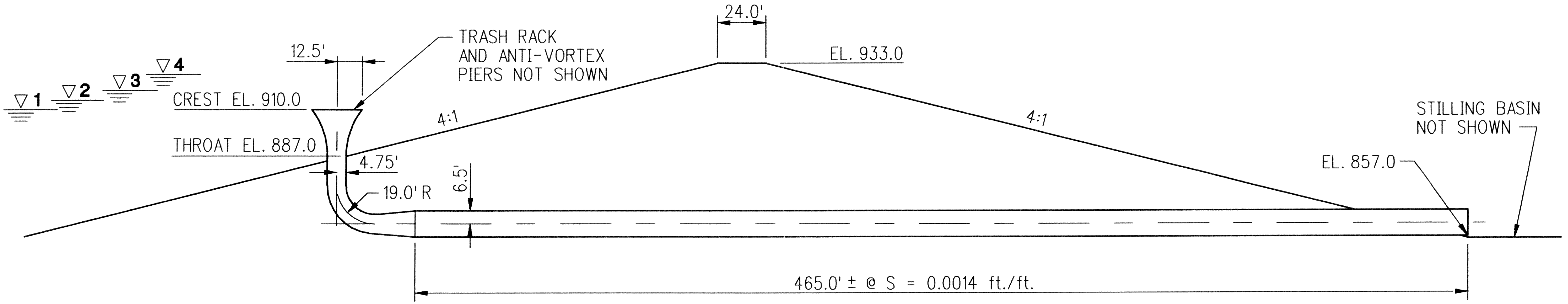

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Figure II-7

PRINCIPAL SPILLWAY SCHEMATIC

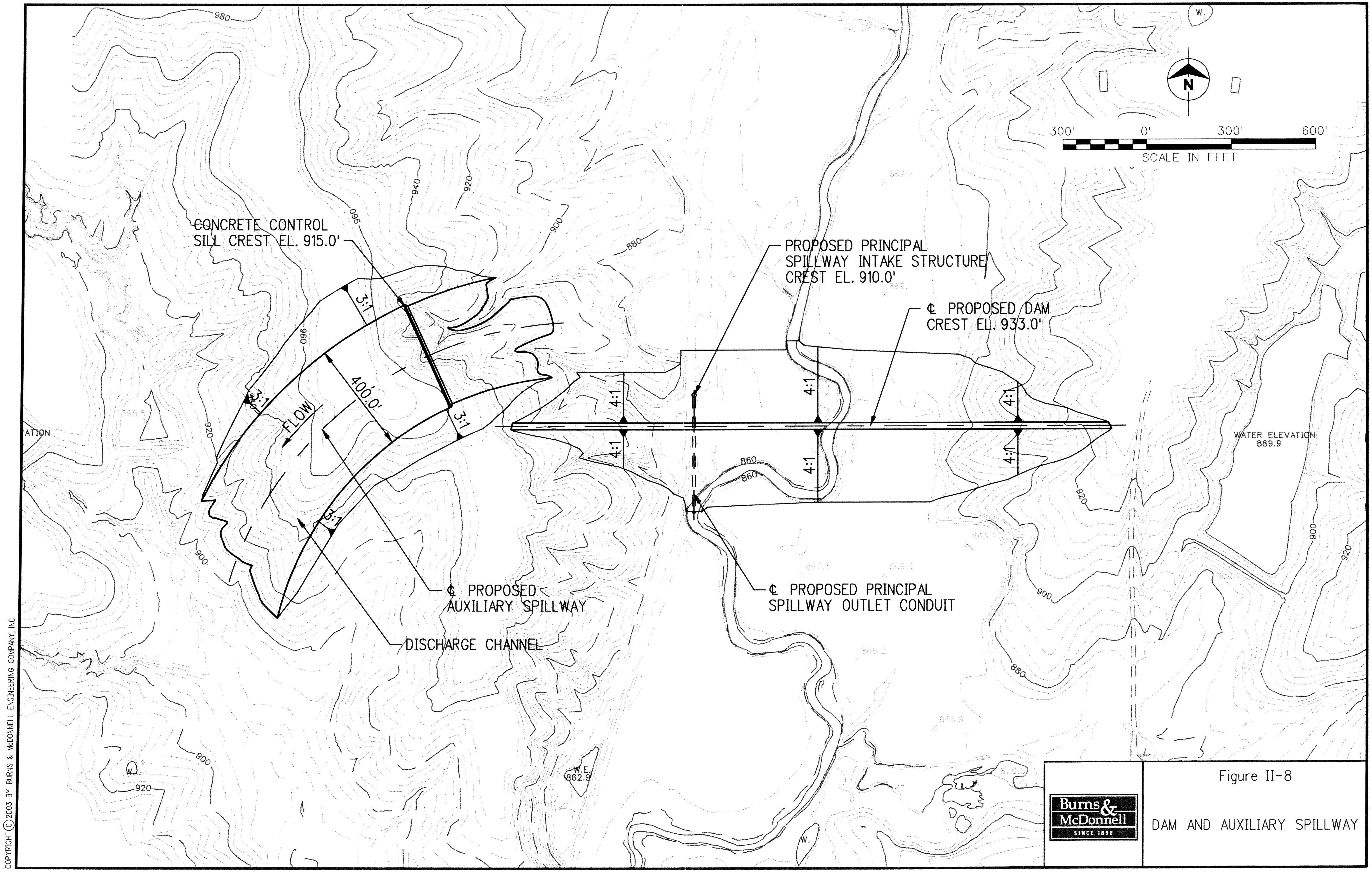

Figure II-8

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DAM AND AUXILIARY SPILLWAY

TABLE II-15

PRINCIPAL SPILLWAY CREST

Design Element	Unit	Value
Crest Elevation	Ft.	910.0
Crest Radius	Ft.	12.5
Crest Length	Ft.	78.5
Design Head	Ft.	5.0

d. Throat and Conduit Transition

As described previously, it is desirable to restrict flows through the spillway during the PMF in order to limit the required size of the spillway conduit. The projected maximum level for the PMF was estimated to be elevation 930 and it was desired to restrict the discharge to two times the 100 year spillway discharge of 1700 cfs. In order to achieve this goal, a throat restriction and transition section were designed using the methods described in *Design of Small Dams*. Significant further reductions in the throat diameter would not be practicable within the geometric constraints of the design. The resulting configuration of the throat is described in Table II-16.

TABLE II-16

PRINCIPAL SPILLWAY THROAT

Design Element	Value
Throat Radius	4.75'
Throat Elevation	887'
Transition Radius	19'

e. Conduit

The spillway crest and throat will discharge to a conduit passing through the dam embankment. The location and alignment of the conduit was selected to assure that it is founded on native soils. The conduit serves not only to carry principal spillway discharges across the alignment of the dam, but also to limit the maximum discharge, which must be considered in the design of the downstream components of the spillway.

The conduit will consist of a 13' diameter reinforced concrete culvert or similarly sized horseshoe shaped conduit. The culvert is designed to flow no more than 70% full under maximum flow conditions per criteria outlined in *Design of Small Dams*. The conduit will discharge to a stilling basin downstream of the dam. The size and configuration of the basin were not estimated as part of these analyses.

The following is a summary of key data for the principal spillway conduit.

TABLE II-17
PRINCIPAL SPILLWAY CONDUIT

Design Element	Value
Diameter	13'
Conduit Length	465'
Conduit Slope	.0014 ft/ft
Outlet Invert Elevation	857'

f. Spillway Rating

A composite rating curve for the principal spillway system is presented in Table II-18. The overall rating is comprised of two zones. Zone 1 extends from the principal spillway crest elevation (910.0 ft. NGVD) to elevation 917'. In this zone, discharges are controlled by the weir crest. Zone 2 extends from elevation 917 to elevation 930. In this zone, discharges are controlled by the throat of the structure (orifice flow).

TABLE II-18

PRINCIPAL SPILLWAY RATING

Stage (ft)	Discharge (cfs)	Control
910	0.0	Crest
911	154.5	Crest
912	435.6	Crest
913	797.4	Crest
914	1223.5	Crest
915	1703.9	Crest
916	2231.9	Crest
917	2802.6	Crest
918	3018.6	Throat
919	3066.9	Throat
920	3114.5	Throat
921	3161.3	Throat
922	3207.5	Throat
923	3253.0	Throat
924	3297.8	Throat
925	3342.1	Throat
926	3385.8	Throat
927	3428.9	Throat
928	3471.5	Throat
929	3513.6	Throat
930	3555.2	Throat

5. PRINCIPAL SPILLWAY HYDROLOGIC MODELING

a. Principal Spillway and Reservoir Storage/Discharge

For the proposed conditions, the reservoir surface area and elevation data was input into the model to determine the storage-discharge relationship. The stage-discharge data was directly input into HEC-1. Table II-19 displays the surface area and elevation input data for the proposed lake.

TABLE II-19

Surface Area and Elevation Data

Surface Area (acres)	Elevation (ft.)
0.1	859
300.2	880
618.4	890
1142.8	900
1593.9	910
2180.6	920
2868.3	930

The stage-discharge rating curve for the proposed reservoir is shown in Table II-18 and was input directly into the HEC-1 model to define the proposed design conditions.

b. 100 Year 24-Hour and 10-Day Storm Events

The structure of the hydrologic model for the proposed conditions is as follows. The hydrograph from Area 1 was routed through Area 2 just as was done under the existing conditions. However, the distance traveled through Area 2 was shortened due to the presence of the new reservoir. The hydrograph from Area 2 was then combined to the routed flow. Next, the hydrographs from the remaining areas (Areas 3-5) were combined with the routed flow. The travel times through Areas 3-5 were all reduced (due to shorter channel reaches) from the existing conditions model because of the presence of the new reservoir. The combined inflow hydrograph was then routed through the proposed reservoir. Finally, direct rainfall on the reservoir surface was added. The rating curve for the spillway was utilized to develop the outflow hydrograph for the 100 year events.

The HEC-1 model results for both existing conditions and "with project" or proposed conditions are summarized below in Table II-20. The PMF and SDF results are shown for storm events with durations of 72 hours and the results for the 100-yr flood are based on the 10-day duration storm event.

TABLE II-20
SUMMARY OF HEC-1 RESULTS

	EXISTING CONDITIONS	**PROPOSED CONDITIONS**		
Return Event	**Peak Outflow (cfs)**	**Peak Inflow (cfs)**	**Peak Stage (NGVD)**	**Peak Outflow (cfs)**
100-yr 24-hr	21,729	22,289	914.3	1,347
100-yr 10-day	16,066	21,574	914.7	1,546

The model results for the 10 day event indicate that the peak stage occurs at hour 10:30 on the 6th day of the storm (max. storage = 36,986 ac-ft.), and that the reservoir level falls to elevation 910.7 at hour 10:30 of the 16th day from the beginning of the event (storage = 30,097 ac-ft.). Consequently, the design of the spillway meets TR60 criteria calling for discharge of 85% of the peak storage volume above the spillway crest (storage is 28,933 ac-ft. at 910') in no more than 10 days.

The projected peak rates of discharge from the principal spillway under the 100-year event are expected to be contained within the existing incised channel of the East Fork of Locust Creek downstream of the dam.. As a result, it can be anticipated that some, perhaps significant, flood damage reduction benefits may occur as a result of the proposed dam and reservoir, although not a presently intended function of the project.

6. AUXILIARY SPILLWAY DESIGN

The auxiliary spillway will act in combination with the principal spillway to pass reservoir discharges under events having an annual probability of occurrence of less than 1%, up to the PMF. The spillway is designed to operate passively (i.e., without operator intervention) for all reservoir stages above 915 ft. NGVD.

The auxiliary spillway is designed to operate with limited damage (generally limited to erosion of the channel invert in the immediate vicinity of the downstream end of the spillway discharge channel) under the Spillway Design Flood (SDF), and to pass the peak discharge resulting from the PMF without endangering the dam embankment. Substantial damage to the auxiliary spillway discharge channel can be expected under events markedly exceeding the SDF. Rainfall amounts for both the SDF and the PMF have been previously defined and will not be repeated here.

a. General Configuration

The auxiliary spillway will be situated on the right abutment, above the principal spillway crest. The proposed alignment and configuration of the spillway are shown in Figure II-8. It is composed of the following primary components, listed in order of downstream progression:

- Approach channel.
- Control sill.
- Discharge channel.

The proposed auxiliary spillway provides a crest length of approximately 400 ft. at elevation 915.0. The location and alignment of the auxiliary spillway allows the dam crest (elevation 933.0 ft. NGVD) to extend to the existing ground surface elevation on the right abutment. Additionally, the alignment was selected to assure that the discharge channel is constructed entirely in excavation.

Presently available subsurface information along the alignment of the auxiliary spillway is limited. It is anticipated that the approach channel, control sill, and discharge channel will be founded primarily in shales, with interbedded zones or layers of sandstone. For this analysis, permissive (e.g., non-erosive) velocities have been established at presumptive values suggested in Table 2-5 of EM 1110-1-1601, *Hydraulic Design of Flood Control Channels,* USACE, as follows:

- Poor rock (usually sedimentary), allowable velocity of 10 fps.
- Weathered shale, presumed analogous to clay, allowable velocity of 6 fps.

It has been assumed that shales and sandstones exposed in the auxiliary spillway will eventually weather, given an infrequent operation of the spillway erosion would be limited to surficial soils for all velocities up to 10 fps. Velocities exceeding 10 fps are presumed to result in undesirable removal of intact shales.

As developed herein, the auxiliary spillway will be constructed on a mild slope (e.g., subcritical flow) in order to limit the potential for damage to the spillway under its infrequent operation. The configuration presented herein is preliminary in nature, and is subject to confirmation and/or adjustment during subsequent design.

For the analyses subsequently presented herein, the auxiliary spillway was modeled as an uncontrolled overflow weir. The weir coefficient was reduced from normal values to reflect the intended submergence effect of the mild slope of the spillway discharge channel downstream of the control sill. That weir coefficient (2.45) was selected based on recent similar experience.

During detailed design, the Auxiliary Spillway rating will be developed from a series of step-backwater water surface profile analyses initiated at the downstream end of the discharge channel and extending upstream to the reservoir. The final width of the spillway may be adjusted slightly.

b. Approach Channel

The approach channel (e.g., area upstream of the control sill) is anticipated to be excavated to elevation 910.0 ft. NGVD. This elevation was selected to minimize approach channel losses, and to assure:

- Under the SDF, velocities are limited to 6 fps or less (e.g., no erosion or damage to the approach channel under the SDF).
- Under the PMF, velocities are limited to 10 fps or less (e.g., erosion in the approach channel under the PMF limited to weathered surficial soils).

That projected maximum velocity is below the 10 fps presumptive allowable velocity for intact shales, which should provide adequate assurance of acceptable erosive losses under the PMF event.

c. Sill

The crest of the auxiliary spillway will be established through construction of a reinforced concrete control sill having a crest elevation of 915 ft. NGVD (just above the maximum 100 year flood stage). The control sill will be paved from the approach channel (elevation 910.0 ft. NGVD) to a short distance downstream of the crest. The control sill will be further protected with a deepened toe both upstream and downstream to assure its stability under all anticipated discharges. The configuration of the sill will be developed during subsequent design efforts.

d. Discharge Channel

The discharge channel shall consist of a trapezoidal cross section having a bottom width of approximately 400 ft. (equal to the control sill crest length). Excavation slopes on both banks of the discharge channel (e.g., nearest the dam embankment) are tentatively established at 1 vertical on 3 horizontal. The stability of those slopes will be confirmed during detailed design, once adequate subsurface information is available. It is recommended that the bed slope of the discharge channel be established in order to:

- Limit channel velocities to 10 fps or less under all events up to and including the SDF when analyzed for minimum losses. The intent in this criterion is to limit erosive losses to weathered surficial soils.
- Provide adequate discharge capacity under all events up to and including the PMF when analyzed for maximum losses.

Under events exceeding the SDF, erosion of and damage to the discharge channel can be anticipated.

A preliminary alignment of the spillway discharge channel has been established to result in the (uncontrolled) release of auxiliary spillway flows on the right abutment to an adjacent valley that outlets well downstream of the dam embankment and principal spillway. The alignment of the channel is considered preliminary in nature and further subsurface information and topographic data will be required to finalize the design.

e. Spillway Rating

A rating curve for the auxiliary spillway is presented in Table II-21. The stage-discharge rating curve for the spillway was combined with the stage-discharge rating curve for the principal spillway (see Table II-18) and input directly into the HEC-1 model to define the proposed design conditions for modeling of the SDF and PMF events.

TABLE II-21
AUXILIARY SPILLWAY RATING

Discharge (cfs)	Elevation (feet)
0	915
868	916
2698	917
5030	918
7433	919
10,886	920
14,139	921
17,892	922
21,747	923
26,202	924
30,658	925
35,614	926
40,221	927
45,528	928

7. AUXILIARY SPILLWAY HYDROLOGIC MODELING

The HEC-1 model results for both the existing conditions and the conditions with the project implemented are summarized below in Table II-22. PMF and SDF results are for 72-hr duration events.

The maximum stage considered in establishing required freeboard and the top of dam elevation is 927.5 ft. NGVD.

TABLE II-22
SUMMARY OF HEC-1 RESULTS

	EXISTING CONDITIONS	PROPOSED CONDITIONS		
Return Event	**Peak Outflow (cfs)**	**Peak Inflow (cfs)**	**Peak Stage (NGVD)**	**Peak Outflow (cfs)**
PMF	166,201	166,865	927.5	46,227
SDF	52,588	64,427	919.5	12,304

8. BYPASS DURING CONSTRUCTION AND EMERGENCY DRAWDOWN

During construction of the dam, bypass of East Locust Creek flows will be required. It is likely that the proposed principal spillway, in conjunction with a cofferdam, will be used to bypass stream flows. The design of the bypass system and the required level of protection were not evaluated as part of this Master Plan and will be developed during subsequent design efforts.

It is recommended that facilities be provided for emergency drawdown of the reservoir. Such facilities are normally incorporated into the water supply intake tower or principal spillway. Due to preliminary nature of the designs completed in this Master Plan, the required drawdown facilities have not been determined and will be fully developed during subsequent design efforts.

C. FREEBOARD ANALYSIS

The required freeboard between the maximum reservoir stage and the top of dam was determined in accordance with the methodology outlined in the USACE, EM 1110-2-1414, entitled *Water Levels and Wave Heights for Coastal Engineering Design* and the methodology in USACE, *Shore Protection Manual.*

1. Fetch Length

The maximum fetch length was calculated in order to define the characteristics of the design wave, and was based on water surface elevation at 928 ft (NGVD) to account for uncertainty in water surface profiles thus giving a conservative fetch length estimate. The length for any given wind direction was determined by centering the fetch on the wind direction and then placing radials at 3 degrees on each side to create a total arc of 24 degrees. The maximum fetch length was then calculated by taking the average of these lengths.

A variety of wind directions and points of wave impingement on the dam embankment were considered. It was concluded that the design fetch length was 1.42 miles. The wind direction and point of impingement resulting in that fetch is shown in Figure II-9.

2. Wind Speed

After the fetch was calculated, the wind speed was determined using Figure 5-18 in EM 1110-2-1414. The approximate wind speed for the study area was 75 miles per hour, 30 ft. above ground for the 25-year recurrence interval.

Several adjustments were made to the wind speed. The first adjustment was to apply a factor to the wind speed to correct it to a wind speed at 33 ft. above ground, utilizing the following equation.

$$U_{33} = \left(\frac{33}{Z}\right)^{1/7} U_z = R_{33} U_z$$

where:

U_{33} = the wind speed at the 33 ft. level
Z = the distance above ground that the wind speed was observed
U_z = the wind speed observed at a distance Z above ground
R_{33} = adjustment to the 33 ft. level

A correction factor of 1.01 was applied to the wind speed to adjust the speed to the 33 ft. level.

The wind speed was also adjusted from overland to overwater. A correction factor of 1.2 was applied to the wind speed since the fetch length was less than 10 miles. Also, an adjustment was made to correct for the air-water temperature difference. Since this was not known, a factor of 1.1 was used as suggested in EM 1110-2-1414.

To determine the wave characteristics, wind speeds with durations of 1-hour, 1.5-hours, and 2-hours were analyzed. The duration for the 75 miles per hour wind speed was found by referencing Figure 5-25 in EM 1110-2-1414.

The duration for 75 miles per hour was determined to be 48 seconds. Figure 5-26 in EM-1110-2-1414 was utilized to convert the 48-second duration to 1-hour, 1.5-hours, and 2-hour durations.

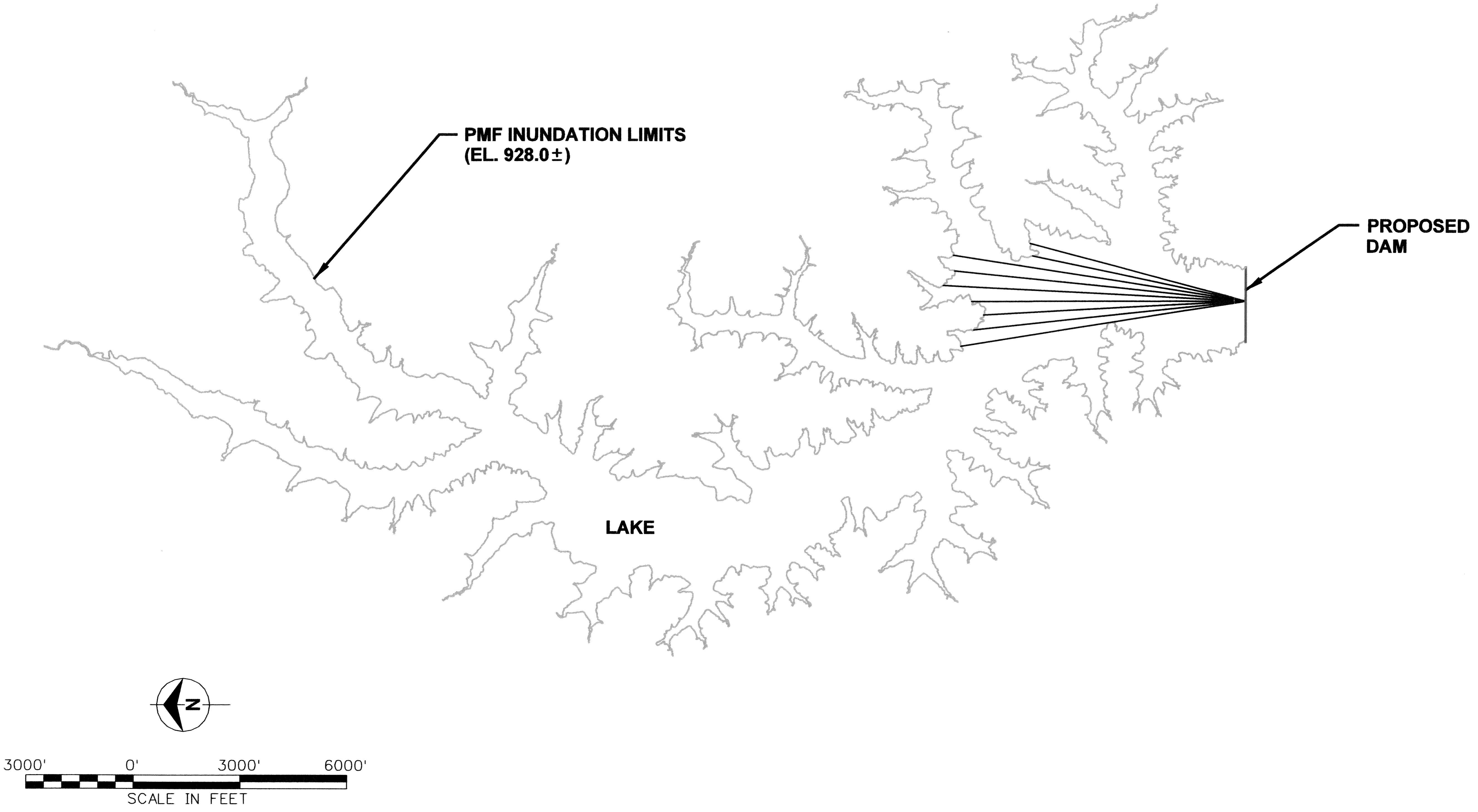

Figure II-9

CRITICAL FETCH
AND WIND ORIENTATION

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From this figure, it was found that the wind speed would be 59 miles per hour for a 1-hour duration, 58 miles per hour for a 1.5-hour duration, and 57 miles per hour for a 2-hour duration.

After the wind speeds were determined for each duration, the correction factors were applied to each wind speed. The composite correction factor was 1.34.

3. Wave Characteristics

Wave characteristics were determined with reference to Figure 5-34 in EM 1110-2-1414. The values from Figure 5-34 were obtained in two different manners.

The first set of values, which are summarized in Table II-23, were determined by using the fetch length (1.42 miles).

TABLE II-23

FETCH-LIMITED WAVE CHARACTERISTICS

Adj. Wind Speed (mph)	Wind Duration (hr)	Wave Height (ft)	Wave Period (sec)
79.0	1.0	4.7	3.20
77.0	1.5	4.5	3.16
75.5	2.0	4.3	3.12

The values summarized in Table II-24 were obtained by using the duration as the controlling factor.

TABLE II-24

DURATION-LIMITED WAVE CHARACTERISTICS

Adj. Wind Speed (mph)	Wind Duration (hr)	Wave Height (ft)	Wave Period (sec)
79.0	1.0	8.9	4.90
77.0	1.5	10.8	5.90
75.5	2.0	13.8	6.75

On the basis of the above, it was determined the waves at the North Central Missouri Dam will be fetch-limited. It was concluded that the design wave would have a wave height of about 4.7 ft. and a period of 3.20 seconds.

4. **Deepwater Wave Growth Assumption**

The methodology for the above calculations is only valid for deepwater waves. To ensure the deepwater wave growth was a reasonable assumption, the wave length was also calculated with the following equation.

$$L_o = 5.12(T)^2$$

where:

L_o = the wave length, ft.

T = the wave period, seconds

The wave length was calculated to be 52.4 ft. The water depth was determined to be 53 ft. In order for the deepwater assumption to be reasonable, the wave length divided by two must be less than the water depth. For this analysis, it was concluded that the deepwater wave assumption was correct since half of the wave length is less than the water depth.

5. **Wind Setup**

The methodology in EM 1110-2-1414 was also followed to determine the wind setup. The following equation (the "Zuider Zee" formula) was utilized to determine the wind setup.

$$S = \frac{U^2 F}{1400d}$$

where:

S = the wind setup, ft.

U^2 = the adjusted wind speed for the design wave, mph

F = the fetch length, mi

d = the water depth, ft.

It was determined that the wind setup was 0.12 ft.

6. **Wave Runup**

The methodology outlined in the USACE, *Shore Protection Manual* was utilized to calculate the wave runup.

a. Uncorrected Wave Runup

The uncorrected wave runup was determined from Figure 7-20 of the *Shore Protection Manual*. This particular figure was used because the data summarized was for deepwater conditions. With a deepwater wave height of 4.70 ft., a wave period of 3.20 seconds, and an embankment slope of 1 on 4.0, the runup was determined to be 3.85 ft.

b. Corrected Wave Runup #1

After the uncorrected runup value was found, runup correction factor #1 was applied to account for scale effects. A correction factor of 1.104 for a 1 on 4.0 embankment slope was selected from Figure 7-13 of the *Shore Protection Manual*. With correction factor #1 applied, the corrected runup was calculated to be 4.25 ft.

c. Corrected Wave Runup #2

After the corrected runup value #1 was applied, runup correction factor #2 was applied to account for slope protection type. The proposed embankment of the new North Central Missouri Dam will have grass from the top of dam to 5' above normal pool level (910') which will be 915' NGVD. Below that level, crushed limestone riprap will be used. It is estimated that wave runup will be affected by each material used, thus an average correction factor was computed using a grass correction factor of 0.875 from Table 7-2 and rubble slope factor of 0.41 from Figure 7-20, both from the *Shore Protection Manual*. With the computed average correction factor of 0.64 applied, the corrected runup was calculated to be 2.73 ft.

d. Varied Wave Heights

The above calculations were completed with a wave runup height, H_s, of 2.73 ft. H_s (the significant wave height) is defined as the average of the highest 33 percent of all waves. Therefore, some waves will have a wave runup height larger than 2.73 ft. To ensure that an adequate amount of freeboard would be supplied, wave heights H_5 and H_1 were also analyzed. H_5 is the average of the highest five percent of all waves and H_1 is the average of the highest one percent of all waves as defined in the *Shore Protection Manual.*

The following equation was used to calculate the wave runup for wave heights, H_5 and H_1.

$$\frac{\hat{H}}{H_s}=\frac{R_P}{R_s}=\left(-\frac{LnP}{2}\right)^{1/2}$$

where:

H = an arbitrary wave height for probability distribution, ft.

H_s = average of the highest one-third of all waves, ft.

R_p = wave runup associated with a particular probability of exceedance, ft.

R_s = wave runup of the significant wave height, H_s, ft.

P = probability of exceedance

The wave runup height for the probability of exceedance of five percent (H_5) was calculated to be 3.35 ft. and the height for the one percent probability (H_1) was determined to be 4.15 ft.

7. Top of Dam

The freeboard required was determined by adding the wind setup of 0.12 ft. and the wave runup as detailed in Table II-25.

TABLE II-25

FREEBOARD

Wave Runup	Freeboard (ft)
Hs	2.85
H_5	3.47
H_1	4.27

It was concluded that a freeboard of 5.00 ft. should be used to adequately prevent overtopping of the new dam. That value is a presumptive minimum freeboard for a dam of this general size. Given a PMF surcharge pool elevation at 928 ft., it was calculated that the top of dam elevation would be 933 ft. (NGVD).

D. SUBSURFACE INVESTIGATION AND GETOTECHNICAL ANALYSES

A preliminary subsurface investigation completed in June 2002 provides a general description of the soils and subsurface strata underlying the proposed dam and in the abutments. The scope of the investigation was limited and any information presented should be considered preliminary in nature and subject to change. The report concluded that the proposed dam site appears to be suitable for the intended use. The report is presented in Appendix A.

Preliminary analyses were conducted using the data obtained from the subsurface investigation to further define geotechnical design parameters, dam geometry, suitability of the abutments for construction of an auxiliary spillway, and potential seepage losses. The following is a summary of the analyses that were performed. Complete documentation of the results are presented in Appendix B.

1. Geotechnical Design Parameters

Geotechnical parameters for each fill material and each natural soil and bedrock were developed using data from the preliminary subsurface investigation that has been completed at the site. Where sufficient data as not currently available, parameters were estimated and recommendations were developed to confirm the estimated parameters during the final subsurface investigation at the site.

2. Dam Geometry

The estimated geometry of the dam embankment was determined, including determination of upstream and downstream slopes, elevations of breaks in the slope angles, internal zoning of the dam (core, upstream shell, downstream shell, internal drains), slope protection, and extent of below grade seepage reduction measures. Sketches with representative dimensions and elevations were developed. Preliminary slope stability analyses were preformed to determine if the proposed slopes will be adequate under a variety of loading conditions.

3. Underseepage Analysis

An analysis was completed to determine the potential for excessive seepage of reservoir water under the dam or through the abutments. Recommendations for remedial measures to limit the seepage were developed and include construction of a slurry wall below the dam and grout curtains in the abutments. The analyses indicate that the measures are required to minimize seepage losses to acceptable levels, but further data is required to develop final recommended measures.

4. Geotechnical Analysis of Potential Spillway Alignments

A analysis of the ridge along the west abutment was completed to determine the suitability of the soils for construction of an auxiliary spillway. The analysis concluded that the shales and limestone in the abutment are likely to be suitable for the intended purpose provided flow velocities are kept to acceptable levels. The auxiliary spillway design presented earlier in utilized the recommendations of this analysis to determine the spillway size.

E. IMPACTS TO EXISTING INFRASTRUCTURE

1. Introduction

The proposed regional water supply reservoir is located in a mostly rural area with little development and infrastructure. The transportation system includes a network of minor state highways, county roads and private gravel roads. Utilities located within the area include overhead power lines, buried telephone cables and rural water district-owned drinking water pipelines. The existing infrastructure will be impacted by construction of the proposed dam and reservoir and mitigation of the impacts will be required. The following sections discuss the impacts to existing infrastructure as well as any required mitigation including relocation of utilities.

2. Transportation

The proposed reservoir area does not affect a significant portion of the existing road network. (See Figure II-10). The major road network in this area contains some state highways, county roads (gravel) and private dirt roads. State Highway N is the only major highway that is affected by the proposed regional lake, as all other roads affected by the lake are either county roads or gravel roads.

The section of State Highway N that bisects the proposed reservoir near the town of Boynton will be closed and abandoned, as it will be inundated by the new reservoir. Future access will not be required in this area or is provided by other existing state lettered routes; thus the section of highway will not be relocated. The Missouri Department of Transportation (MoDOT) has advised, "the proposed closing of Route N would be satisfactory with the MoDOT on the condition that there would be no resulting cost to the MoDOT." As part of the construction of the new water supply reservoir, removal of the roadway and related right-of-way features within the reservoir will be required, and the remaining sections of the road east and west of the reservoir must be accepted by Sullivan County for continued maintenance as a county road.

Five sections of county maintained roads will be closed due to inundation by the new reservoir. Two impacted road sections are located near Boynton and the remaining three are located at the north end of the reservoir. No road relocations are proposed to mitigate for impacts to county roads as access to property outside of land to be acquired by the Commission is provided by connections to other existing roads. One section of a county road located in the northeast finger

COUNTY ROAD AFFECTED ONLY DURING PMF NO RELOCATION PROPOSED

STATE HIGHWAY N PROPOSED TO CONVERT TO COUNTY MAINTAINED

PROPOSED AUXILIARY SPILLWAY

PROPOSED DAM

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Figure II-10

EXISTING ROADWAY AND WATER SUPPLY INFRASTRUCTURE AFFECTED BY THE PROPOSED RESERVOIR

NCMRWPMAP&PHOTO.DGN / 9-17-2003 10:27 / MDH of the reservoir is currently within the flood pool, but it is appears that it would be inundated only during an extreme flood event approaching the level of the PMF. Consequently, relocation of this road section is not proposed. Further investigations are needed to verify the adequacy of the road.

On August 19, 2003 the Sullivan County Commission officially made a resolution to support the lake project and stated they will cooperate in the necessary closure of roads for the reservoir with no objections as long as access is provided to properties not purchased by the North Central Missouri Regional Water Commission.

3. Rural Drinking Water System

The majority of drinking water transmission mains located in the region of the proposed water supply reservoir are part of the Sullivan County Public Water Supply District No. 1 system. Drinking water transmission mains are only affected in the southern region of the proposed reservoir with minor relocations necessary (see Figure II-10).

The drinking water transmission mains located along State Highway N and a county road running south from Boynton will be abandoned and removed due to their location in the permanent pool of the proposed reservoir. One drinking water service main, which is located on the eastern side of the reservoir, will also be abandoned due to service no longer having to be provided to this area.

A new 6-inch water main is proposed to be located south of the dam extending east from the 6-inch main located along State Highway 5, across the East Locust Creek Valley to a 4-inch main located southeast of the reservoir along State Highway N. This proposed water main will replace the current water main "loop" through Boynton, which will be abandoned with the construction of the new reservoir. A 4-inch water main extension has also been proposed to provide water to locations that will be isolated from current water mains due to the reservoir pool. All current proposals have been discussed with and meet the approval of the Sullivan County No. 1 Public Water Supply District.

4. Electrical Power Distribution Lines

The majority of electrical power distribution lines located in the area of the proposed reservoir will be removed due to no longer having to provide service to a particular area as shown on

Figure II-11. Several existing power distribution lines will have to be interconnected to provide a power loop and a reliable source of power. An existing three-phase power distribution line currently follows State Highway N through the town of Boynton. The owner of the line, North Central Missouri Electric Cooperative, has expressed interest in converting the overhead line to an underground line that would be buried beneath the reservoir floor along its current alignment. Direct burial of 4000' of line is considered a viable option because routing of the line around the lake would require construction of over 5 miles of new overhead line and approximately 3 miles of new access roads. New overhead service lines will be required to provide power to the dam intake tower and to provide a connection to an existing line isolated by the reservoir.

5. Telephone and Fiber Optic Cable

The majority of telephone lines located in the area of the proposed reservoir will be removed from service due to no longer having to provide service to a particular area as shown on Figure II-11. An existing fiber optic cable located in the area of the permanent pool approximately two miles south of the town of Pollock currently provides service to land on both sides of the proposed lake. It does not appear to be viable to route the cable around the lake as this would require approximately 3 miles of new cable. Therefore, the owner of the cable, the North East Rural Telephone Company, recommends relocation of the fiber optic cable on the bottom of the reservoir. Approximately 2000' of cable will require relocation. A new service line will also be required to replace service to an area isolated by the reservoir.

F. RECOMMENDED LAND ACQUISITION

The proposed reservoir will inundate approximately 1600 acres, 1900 acres, and 2900 acres at the conservation pool elevation of 910', the 100 year flood elevation of 915', and at the PMF elevation of 928', respectively. In order to offset impacts due to reservoir inundation, the North Central Missouri Regional Water Commission will be required to obtain rights on all affected land. Furthermore, the NRCS requires that the Commission control the rights to all land below the top of dam elevation of 933'. For purposes of this Master Plan, the land acquisition has been divided into two categories: permanent fee title acquisition, and flood storage easements. The rationale for selecting these methods of land acquisition as well as the rational for defining the limits of each category are described in the following sections.

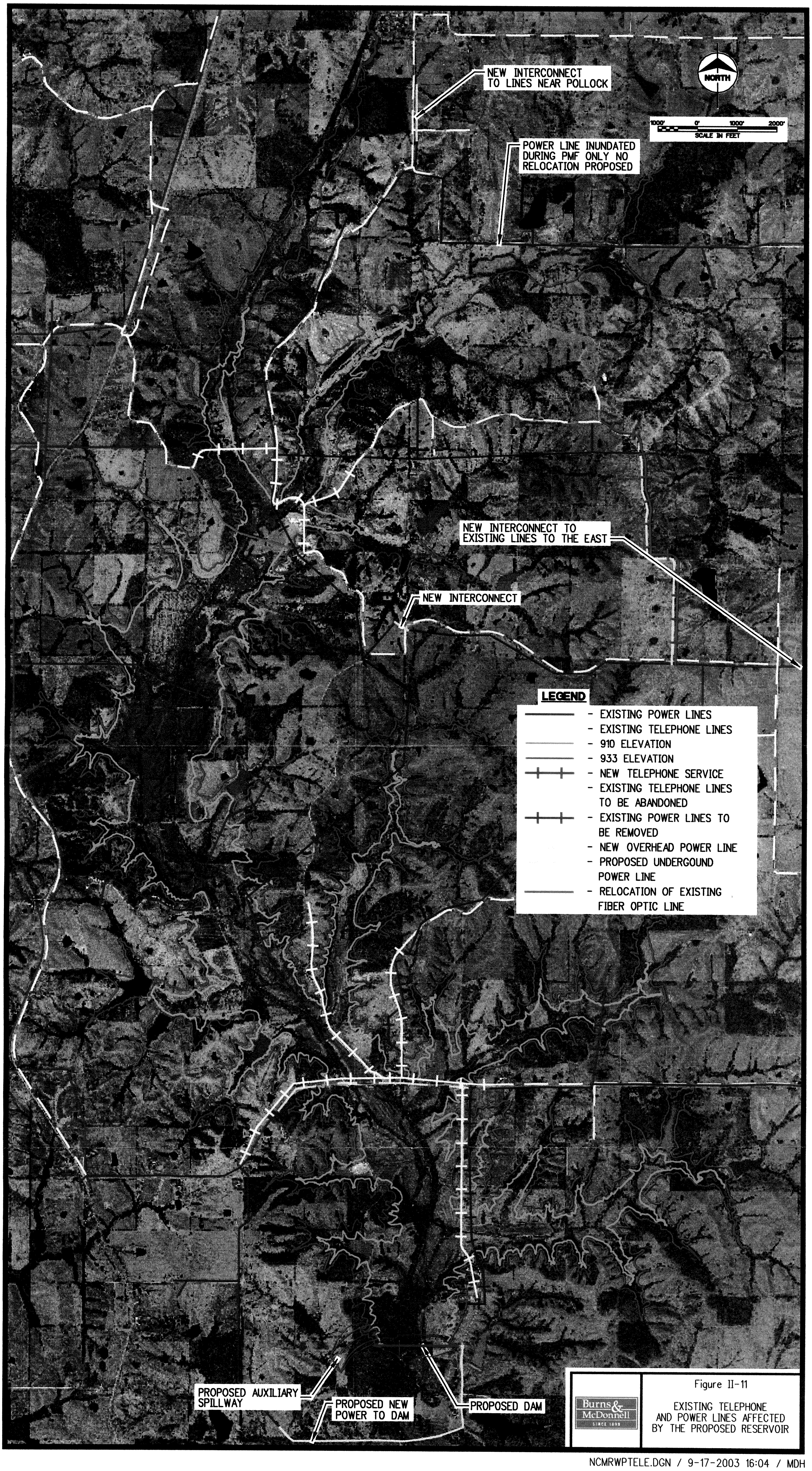

Figure II-11

EXISTING TELEPHONE AND POWER LINES AFFECTED BY THE PROPOSED RESERVOIR

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1. Permanent Fee Title Acquisition

Fee Title Acquisition will be required for all lands permanently inundated by the conservation pool, as any use of the land will be lost. Permanent acquisition should also include a green belt buffer around the entire perimeter of the reservoir to protect water quality from source pollution impacts caused by residential and commercial development, agricultural activities, and livestock grazing. The Missouri Department of Natural Resources currently does not require a greenbelt buffer around water supply reservoirs, but criteria in their *Draft Design Guide for Community Water System* calls for a 300' wide buffer. Therefore, it is recommended that the minimum permanent acquisition be extended to 300' beyond the 910' conservation pool elevation as the buffer zone requirement may be required by the time the project is permitted.

Impacts to overall landowner's property must also be considered when establishing the limits of land acquisition. In many instances, the conservation pool and buffer areas will require the acquisition of the majority of an individual landowner's total parcel area. It was assumed that the remaining portion of the parcel was not large enough to support continued farming or livestock grazing and that complete acquisition would be required. It may be possible to avoid purchasing this additional land, but this cannot be determined without holding detailed negotiations with the individual landowners.

Land acquisition was also required when the proposed reservoir pool bisects a landowner's property and a portion of the property is left without access to a dedicated access route. It may be possible to provide access to an isolated parcel by purchasing an easement through another landowners property, but willingness of landowners to grant this access is not known at this time. Therefore, acquisition of isolated parcels is recommended pending detailed negotiations with landowners.

Permanent acquisition is also recommended for the lands affected by construction of the dam and auxiliary spillway. The proposed acquisition of lands for this purpose extends a significant distance beyond the dam and spillway features in order to allow sufficient room for construction access and staging areas and to provide adequate setbacks for dam safety and security.

The proposed limit of land acquisition is shown on Figure II-12. The area proposed for permanent acquisition considering the above rationale is estimated to be approximately 3875 acres.

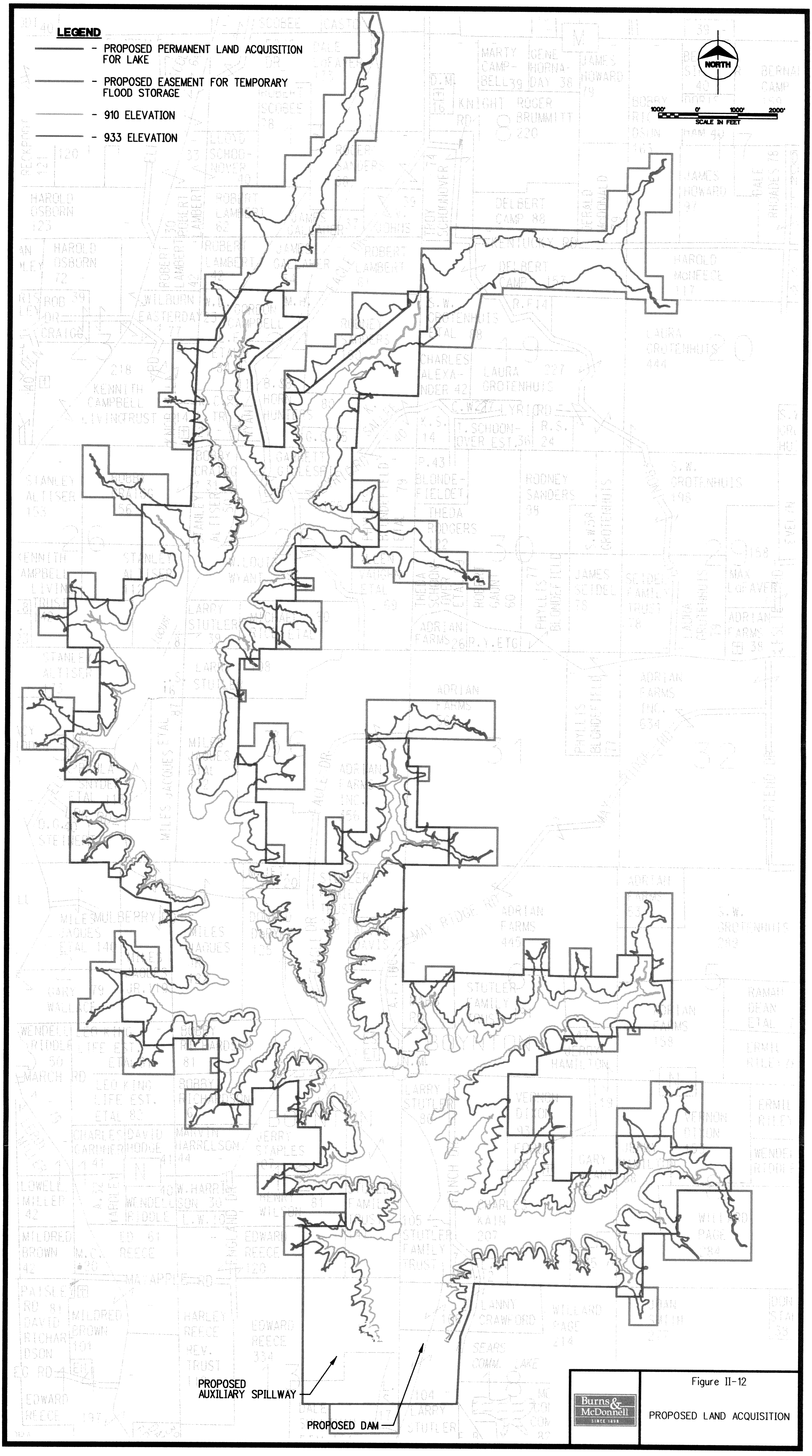

Figure II-12

PROPOSED LAND ACQUISITION

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2. Flood Storage Easements

The purchase of flood storage easements is recommended for those lands that are below top of dam elevation (933'), but outside the boundary of the 300-foot buffer zone. Lands within this area would be subject to temporary flooding, but the flooding would typically be limited to extreme events with a probability of occurrence less than 1% such as the Spillway Design Flood and the Probable Maximum Flood. The easements would prohibit the construction of residences and structures, but typical farming and ranching operations could continue subject to restrictions. The level of allowable activities and corresponding restrictions will be dependent on how much control the Commission wishes to have in order protect the quality of the water supply. The amount of control desired by the Commission will dictate the compensation required for obtainment of the easements.

The areas where flood storage easements are recommend are shown on Figure II-12. The aggregate area considering the above rationale is estimated to be approximately 1500 acres of additional land.

PART III

Water System Improvements and EPA Compliance

PART III

WATER SYSTEM IMPROVEMENTS

A. INTRODUCTION

This section of the report discussed water system improvements necessary to treat and distribute water in the system. The Cities of Milan and Green City and Sullivan County Public Water Supply District No. 1 each have their own water distribution system. Both Milan and Green City can supply water to Sullivan PWSD No. 1, which does not have a supply of their own. Sullivan PWSD No. 1 can also purchase finished water from the City of Trenton via a transmission line into the west side of their system.

New construction and upgrades to the existing systems have been classified into three phases corresponding to the years when it is projected new customers will be served by the North Central Missouri Regional Water Commission. Phase One includes new construction of the raw and finished water systems to provide water to the charter members of the North Central Missouri Regional Water Commission. It is assumed that in Phase One the existing distribution system will be adequate to supply finished water to the current members of the Commission. Phase Two corresponds to the year 2020 when it is projected supplemental water will be provided to the following:

- Livingston PWSD No. 2
- Linn-Livingston PWSD No. 3
- Chariton PWSD No. 2
- Linn-Chariton PWSD No. 3
- Linn PWSD No. 1
- The City of Laclede.

Since the publication of the Feasibility Study a Public Water Supply District in the Northwest region of the study area has expressed interest in water. It is assumed this will be possible in Phase One and will be accomplished through an existing system interconnect with Sullivan Public Water Supply District No. 1.

Phase Three corresponds to the year 2030 when it is projected supplemental water will be provided to the Cities of Brookfield, Meadville, Bucklin and Unionville.

B. PHASE ONE CONSTRUCTION

Phase One construction includes the construction of a new intake structure and associated elements located in the proposed reservoir on the East Fork Locust Creek. This phase also includes the addition of a raw water transmission main to the Milan Water Treatment plant and to Elmwood Lake, relocation of existing finished water mains located within the reservoir area and piping modifications to the existing Milan Water Treatment Plant.

1. Intake Structure

A new intake structure is to be located near the dam in the proposed East Fork Locust Creek Reservoir. The intake directs raw water from the reservoir to the raw water transmission main, which is connected to the Milan Water Treatment Plant. Several intake structures were evaluated and a tower type intake was selected as the best alternative for the reservoir. The design of the tower type intake structure should be based on the following criteria:

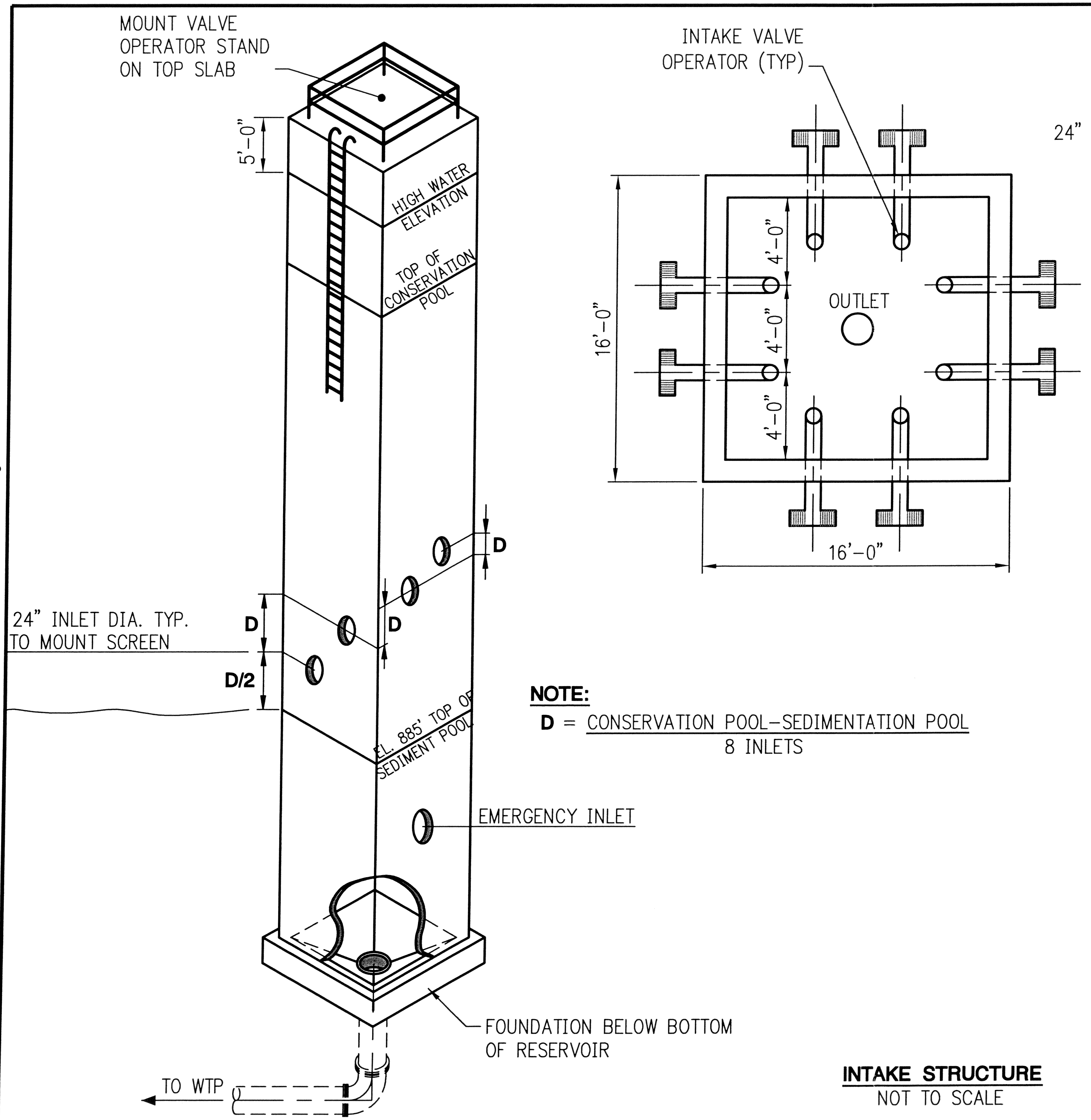
- Top of the structure a minimum of 5'-0" above the high water elevation of the reservoir.
- Capable of receiving 7.53 Million Gallons per Day (MGD) from eight different levels in the storage pool of the reservoir and from one intake located within the sediment pool
- Each intake screen and opening designed for 7.53 MGD.
- Tower accessible from a watercraft.
- Intake valve operators located on top of the structure.

A concept design of this intake structure and the intake screens are shown on Figure III-1.

2. Raw Water Transmission Main

A raw water transmission main from the intake structure to the Milan Water Treatment Plant is required to provide the Plant's raw water needs. The proposed alignment for this raw water transmission main is shown in Figure III-2. The main raw water line also includes a spur to the existing Elmwood Lake as a means to transmit raw water to keep the lake level high. Premium Standard Farms, a food processor, also uses Elmwood Lake for their raw water supply, and have their own intake and water treatment facility. The main raw water transmission main should be designed based on the following criteria:

J:\NCMRWP\32598\Masterplan\Details\FIGURE INTAKE STRUCTURE.dwg 11-18-2003 13:51 AAO

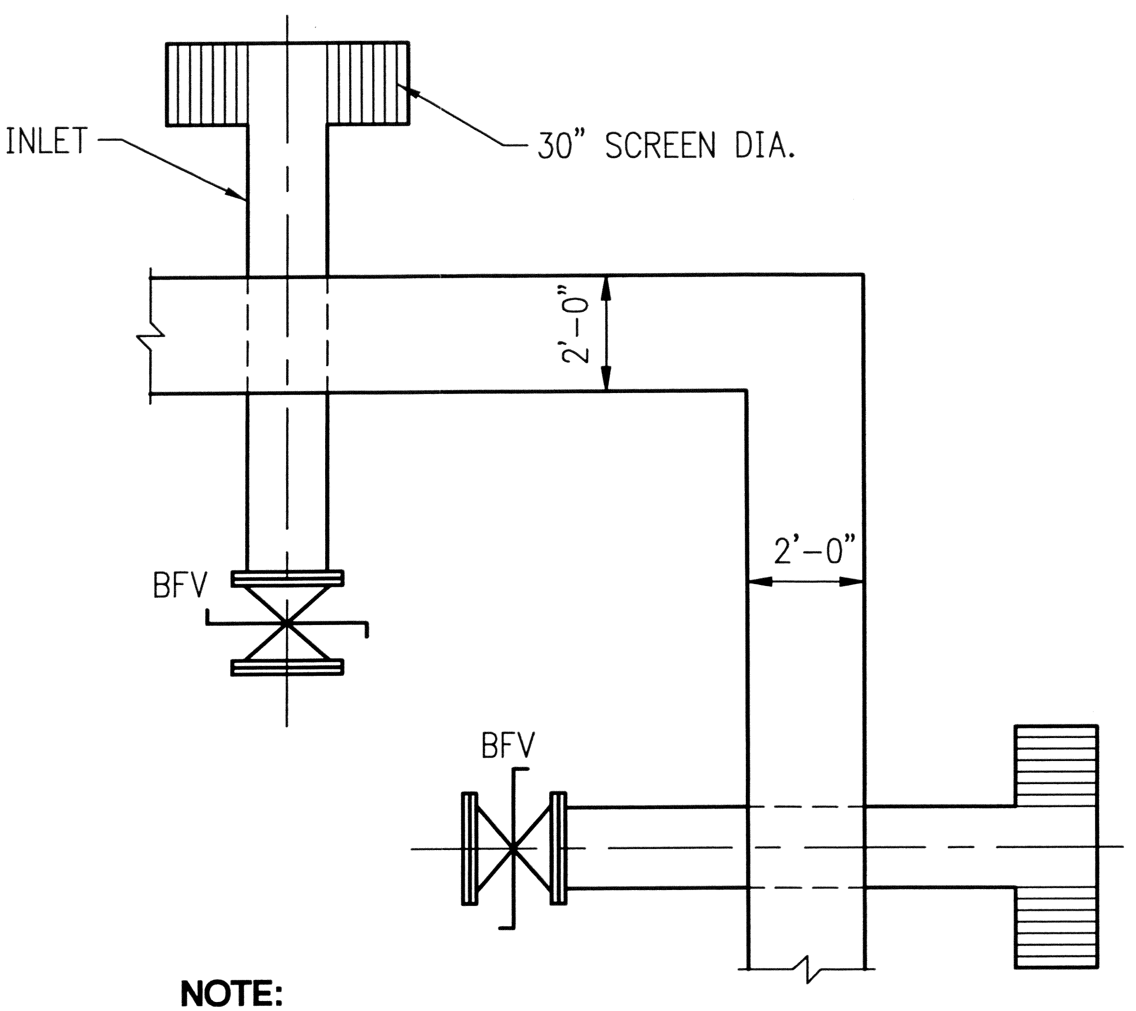


NOTE:

D = $\frac{\text{CONSERVATION POOL-SEDIMENTATION POOL}}{\text{8 INLETS}}$

INTAKE STRUCTURE

NOT TO SCALE



NOTE:

LOCATE VALVE OPERATOR AND FLOOR STAND DIRECTLY ABOVE SHAFT.

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Figure III-1

INTAKE STRUCTURE
AND SCREEN

J:\NCMRWP\32598\Masterplan\Details\FIGURE PIPELINE.dwg 11-18-2003 13:54 AAO

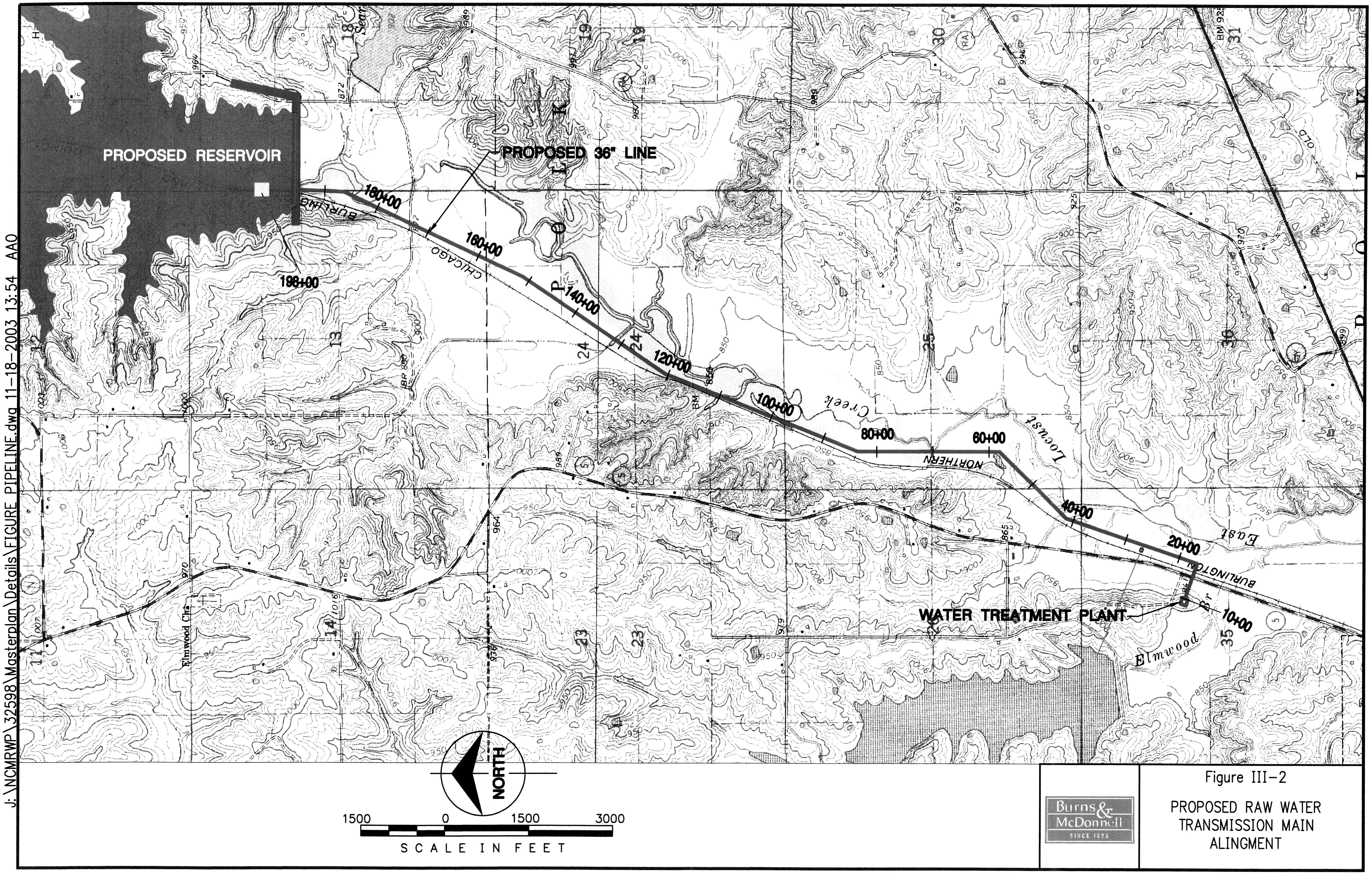

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Figure III-2

PROPOSED RAW WATER
TRANSMISSION MAIN
ALINGMENT

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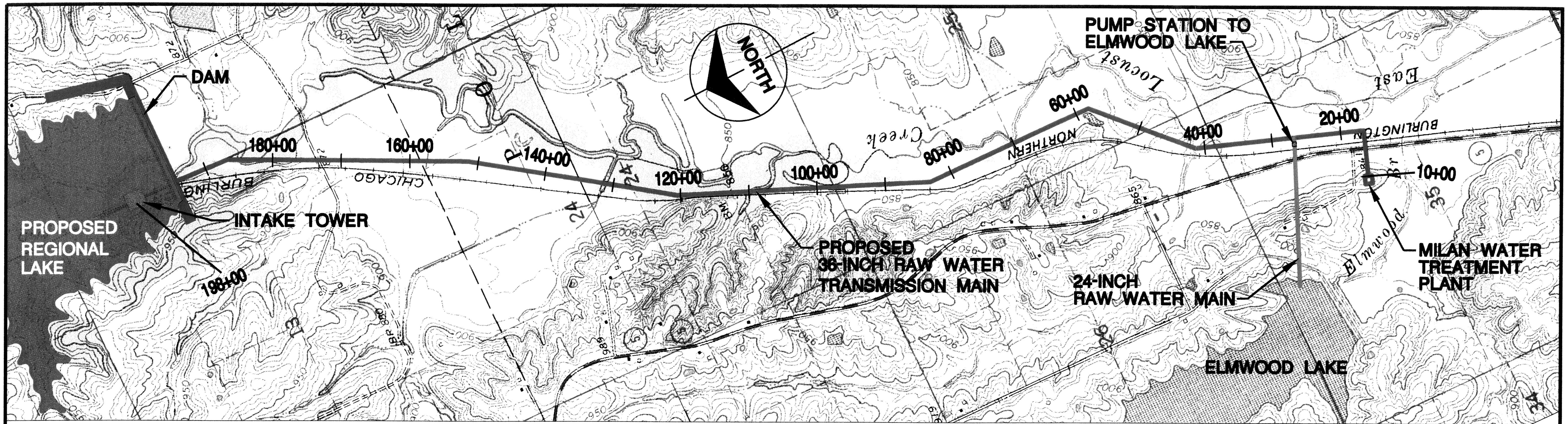

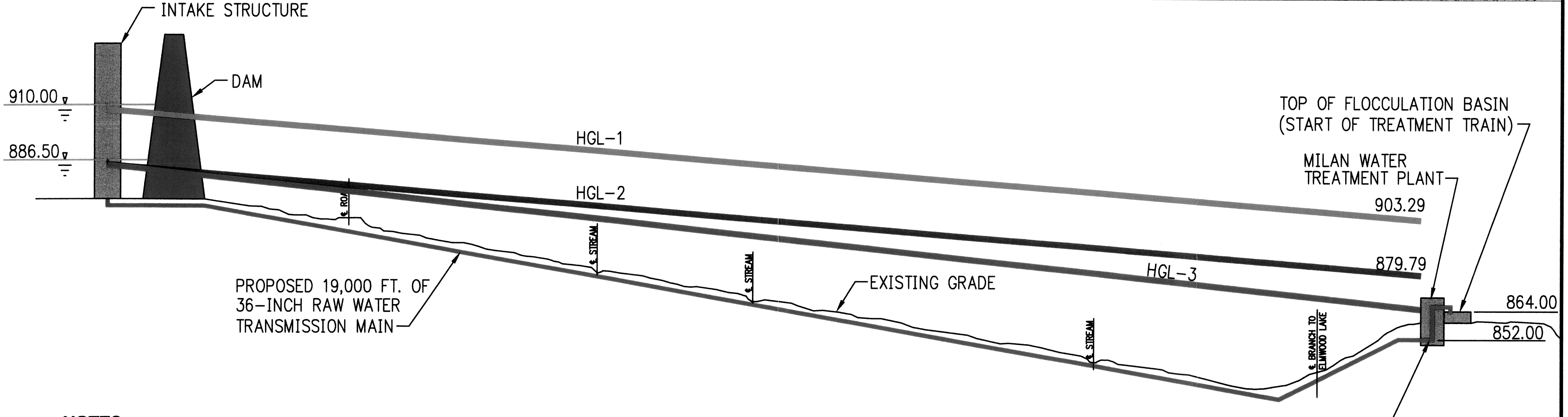

NOTES:

HGL 1 DESIGN	HGL 2 DESIGN	HGL 3 DESIGN
Q: 7.53 MGD	Q: 7.53 MGD	Q: 7.53 MGD
HEAD AVAILABLE: 58 FEET	HEAD AVAILABLE: 34.5 FEET	HEAD AVAILABLE: 34.5 FEET
LINE SIZE: 36-INCH	LINE SIZE: 36-INCH	LINE SIZE: 36-INCH
C: 140	C: 140	C: 63

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Figure III-3
PHASE ONE
HYDRAULIC GRADE LINES
FOR PROPOSED 36-INCH
RAW WATER TRANSMISSION
TO MAIN WTP

- Design flow of 7.53 MGD. (Initially sized at 36-inches)
- Lake operation level of 885 to 910 feet USGS.
- Total length of transmission main of 19,000 feet from intake to Milan Water Treatment Plant.
- C-value of 140 when pipeline is new and lower after several years of use.
- Centerline of raw water pump at Milan Water Treatment Plant is 852 feet USGS and the top of the flocculation basin is 864 feet USGS.
- Range of gravity head available from reservoir to the pump suction of 34 to 58 feet, depending on reservoir levels.
- Full-opening valves should be located in the raw water line to provide isolation in the line and to provide flexibility for future pigging operations to swab and clean the line periodically. These valves could be either gate or ball valves.

Hydraulic grade lines (HGL) were calculated using both 36-inch and 30-inch diameter pipelines. The goal of the pipeline design is to provide water to the Milan Water Treatment Plant by gravity flow and bypass the current raw water pumps. This can be accomplished by providing enough head to discharge directly into the flocculation basin, thus saving pumping costs at the plant.

C-values were varied to determine how a 36-inch and 30-inch pipeline would operate in the future, when the pipe interior is expected to degrade, thus having a greater loss to friction. A 36-inch diameter line was selected due to its ability to provide water to the flocculation basin with a C-value as low as 63. By contrast, the lowest C-value allowable for a 30-inch line to provide the design flow would be 101. The HGL for the 36-inch pipeline is shown in Figure III-3 for both the high and low water elevations within the reservoir and at the low elevation with the lower friction factor (C-value).

3. Pump Station and Raw Water Line Spur to Elmwood Lake

A raw water transmission main to Elmwood Lake would provide a means to add raw water during times of low runoff, thus allowing Elmwood Lake to have a more constant and higher water surface elevation. Due to a ridgeline between the proposed 36-inch raw water transmission main and Elmwood Lake, a booster pump station is required. The raw water transmission main to Elmwood Lake should be designed based on the following criteria:

- Design flow of 5.74 MGD (Initially sized at 24-inch) .
- Total length of transmission main of 2200 feet between the 36-inch raw water transmission line and Elmwood Lake.
- Provide energy dissipating discharge structure at Elmwood Lake.
- Maximum suction head available of 14 feet.
- Highest ground elevation along pipeline profile of 910 feet.
- Surface water elevation at Elmwood Lake of 870 feet.

Once the basic design criteria had been determined, hydraulic grade lines (HGLs) were calculated using both 20-inch and 24-inch diameter pipelines. It was the goal of the design to provide water to Elmwood Lake in the most cost-effective manner possible. A 24-inch diameter pipeline was selected as the best alternative. The HGL for this pipeline is shown in Figure III-4.

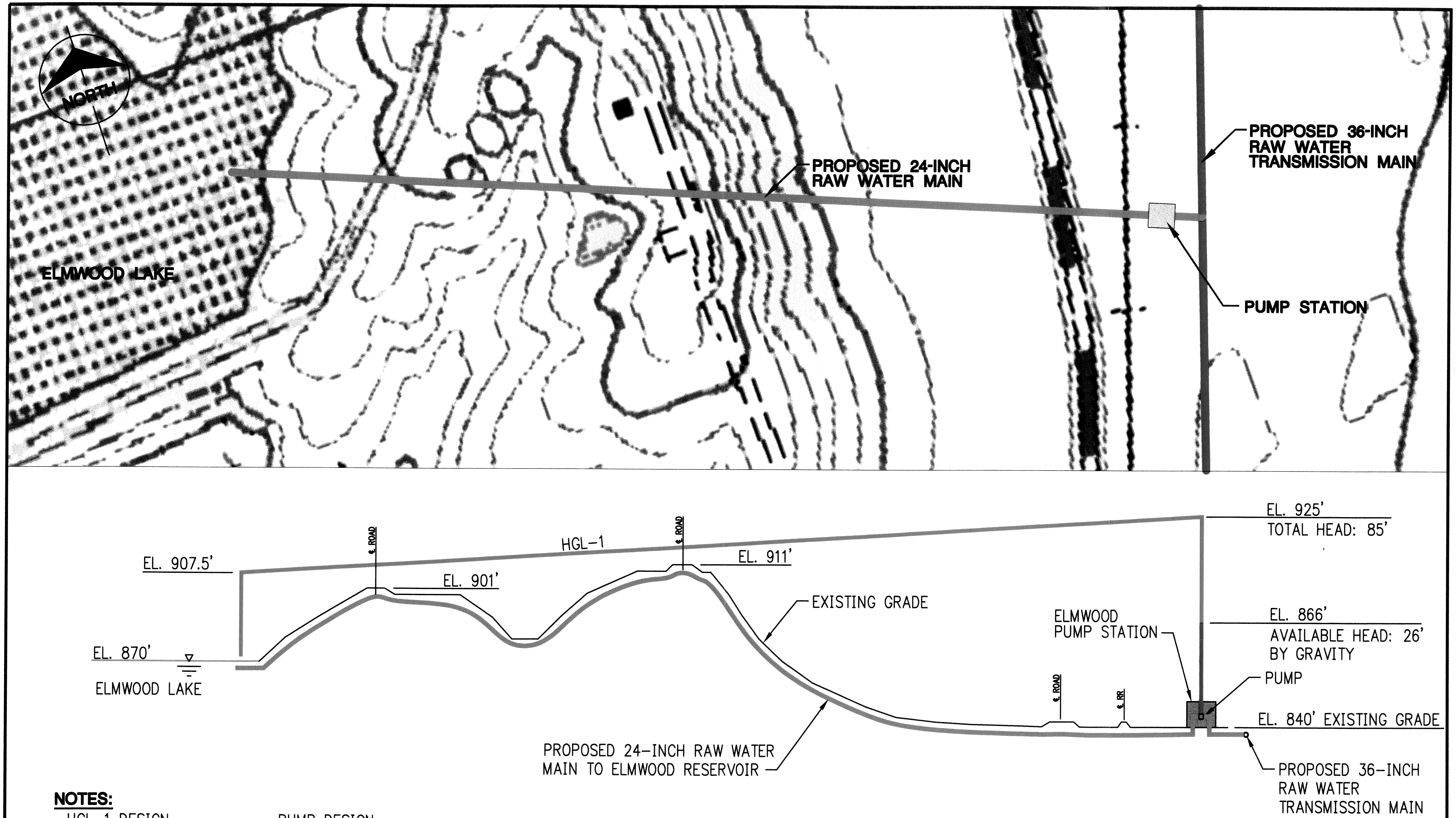
Due to the ground evaluation profile and the amount of head required to transport the raw water to the lake, a pump station is necessary to obtain the proper amount of head. A typical layout for this pump station is shown in Figure III-5. The following design criteria is recommended for the pump station:

- Total flow of 4000 gallons per minute.
- Two horizontal split-case pumps for the pump station (One Duty, One Standby).
- Total pump head of 60 feet.
- Total pump horsepower of 75 Hp for each pump.

4. Water Treatment Plant Improvements

Improvements at the existing Milan Water Treatment Plant in Phase One include connection of the new raw water pipeline from the proposed regional lake to the existing raw water influent system and the installation of new butterfly (BFV) and throttling valves.

It is proposed to connect the new raw water transmission main to the existing raw water pump discharge and suction piping in the basement of the Milan Water Treatment Plant as shown in Figure III-6. This will provide the raw water pumps as an alternative, if needed, and as a possible source to supply pressure and water from Elmwood Lake for



NOTES:

HGL-1 DESIGN
Q: 5.74 MGD
HGL REQUIRED: 925'±
LINE SIZE: 24-INCH
C: 63

PUMP DESIGN
Q: 5.74 MGD
PUMP HEAD: 60'±
LINE SIZE: 24-INCH
HP: 75

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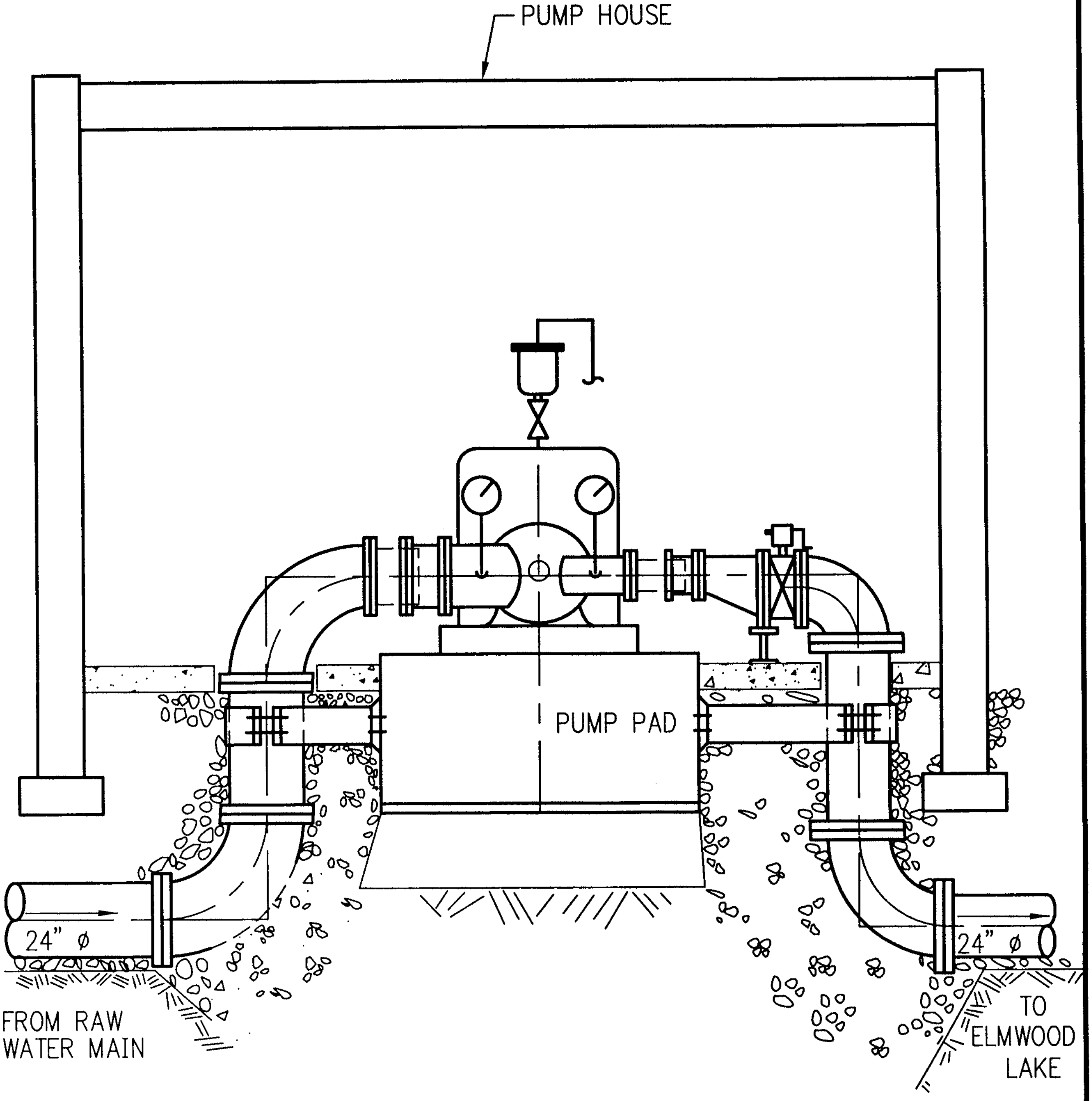
Figure III-4

HYDRAULIC GRADE LINE FOR PROPOSED 24-INCH RAW WATER LINE TO ELMWOOD RESERVOIR



NOT TO SCALE

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Figure III-5

TYPICAL LAYOUT FOR
PUMP STATION ON
LINE TO ELMWOOD LAKE

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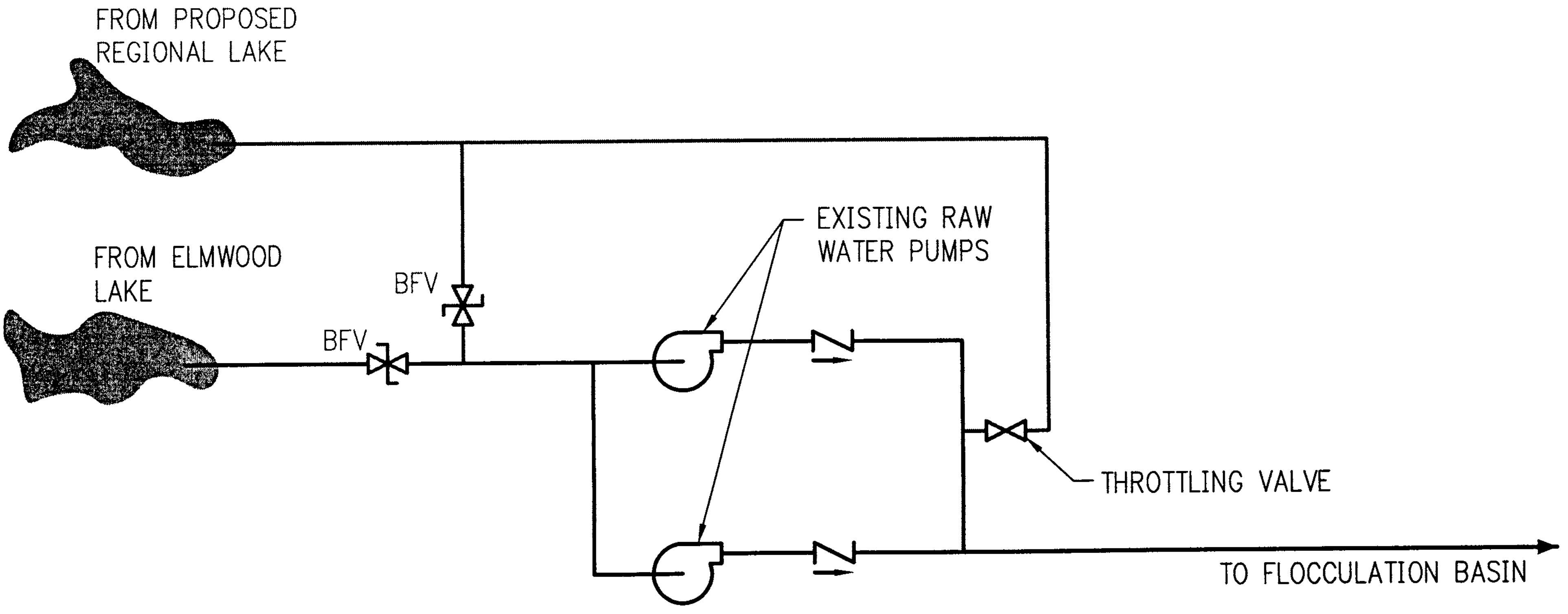

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Figure III-6

MODIFICATIONS TO
RAW WATER PIPING
AT MILAN WTP

future pigging (cleaning) operations in the raw water pipeline. New butterfly valves should be installed as indicated to allow the operator to select raw water from either Elmwood or the proposed lake and to provide proper flow for pigging operations. On the discharge piping of the existing raw water pumps a throttling valve should be installed to shear excess head remaining in the line from the proposed regional lake.

5. Relocation of Other Pipelines

Several finished water distribution lines for Sullivan County Public Water Supply District No. 1 are located in an area that is to be inundated by the proposed reservoir. The lines will either need to be relocated or abandoned, depending on who they currently serve and whether they complete a loop within the finished water distribution system. The pipelines that are currently within this area and a proposed scheme for relocation are shown in Figure III-7.

C. PHASE TWO CONSTRUCTION

Phase Two includes the construction of a new finished water distribution system to provide finished water to the future customers of the North Central Missouri Regional Water Commission. This Phase also includes the construction of three finished water pump stations to provide water to these future customers and the expansion of the Milan Water Treatment Plant to meet the projected increase in water demand.

1. Finished Water Transmission Mains

The construction of finished water transmission mains from the Milan Water Treatment Plant is required to provide water to the existing water systems located in North Central Missouri. Preliminary transmission pipeline routes have been determined and are shown in Figure III-8 through III-11. These transmission mains should be based on the following design criteria:

- Operating pressure will vary from 40 to 80 psi.
- C-value of 120 when pipeline is new and lower after several years of use.
- Line One running south from the City of Milan to the City of Laclede. Design flow for Line One of 3.0 MGD.

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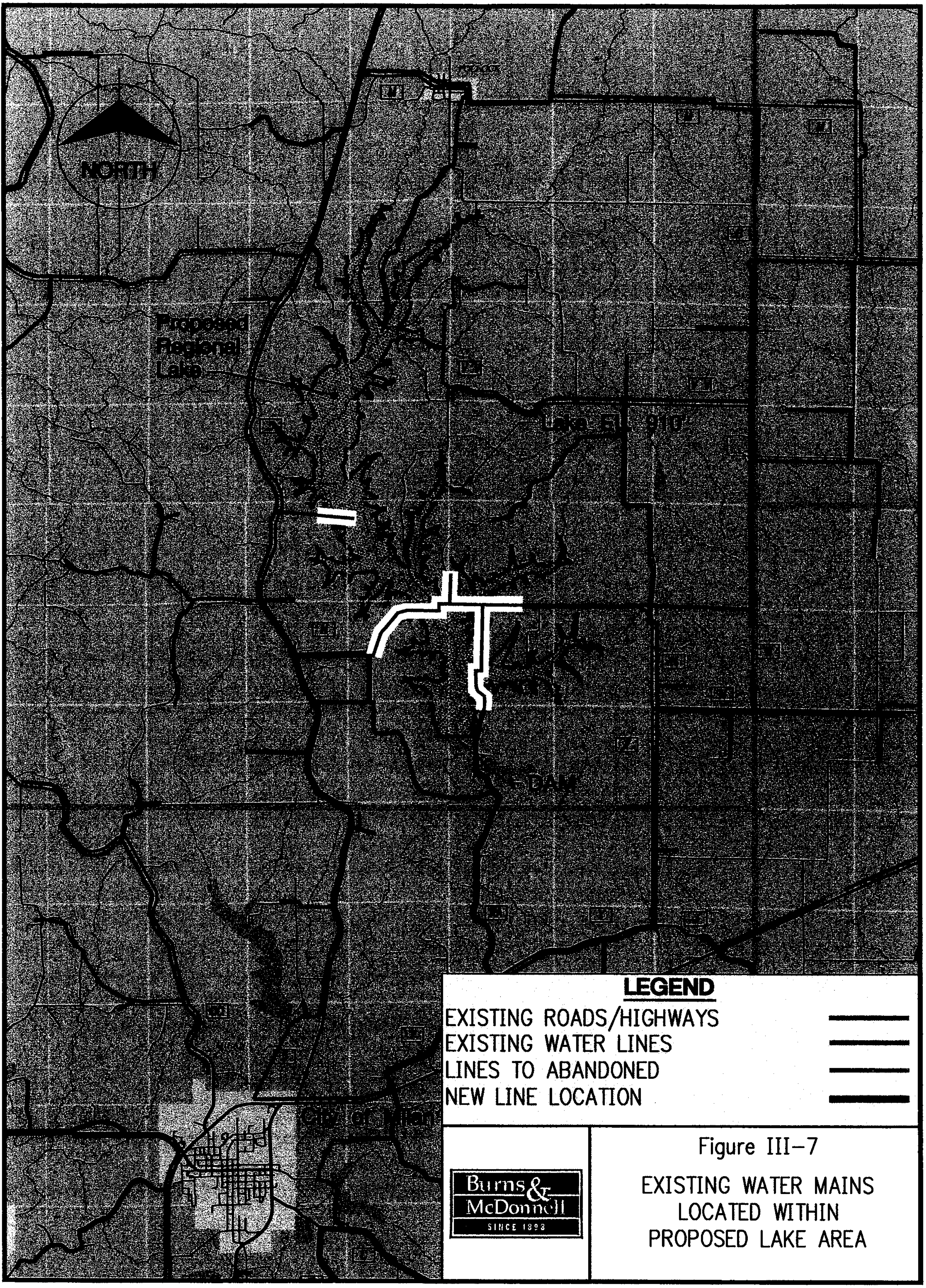

LEGEND

EXISTING ROADS/HIGHWAYS

EXISTING WATER LINES

LINES TO ABANDONED

NEW LINE LOCATION

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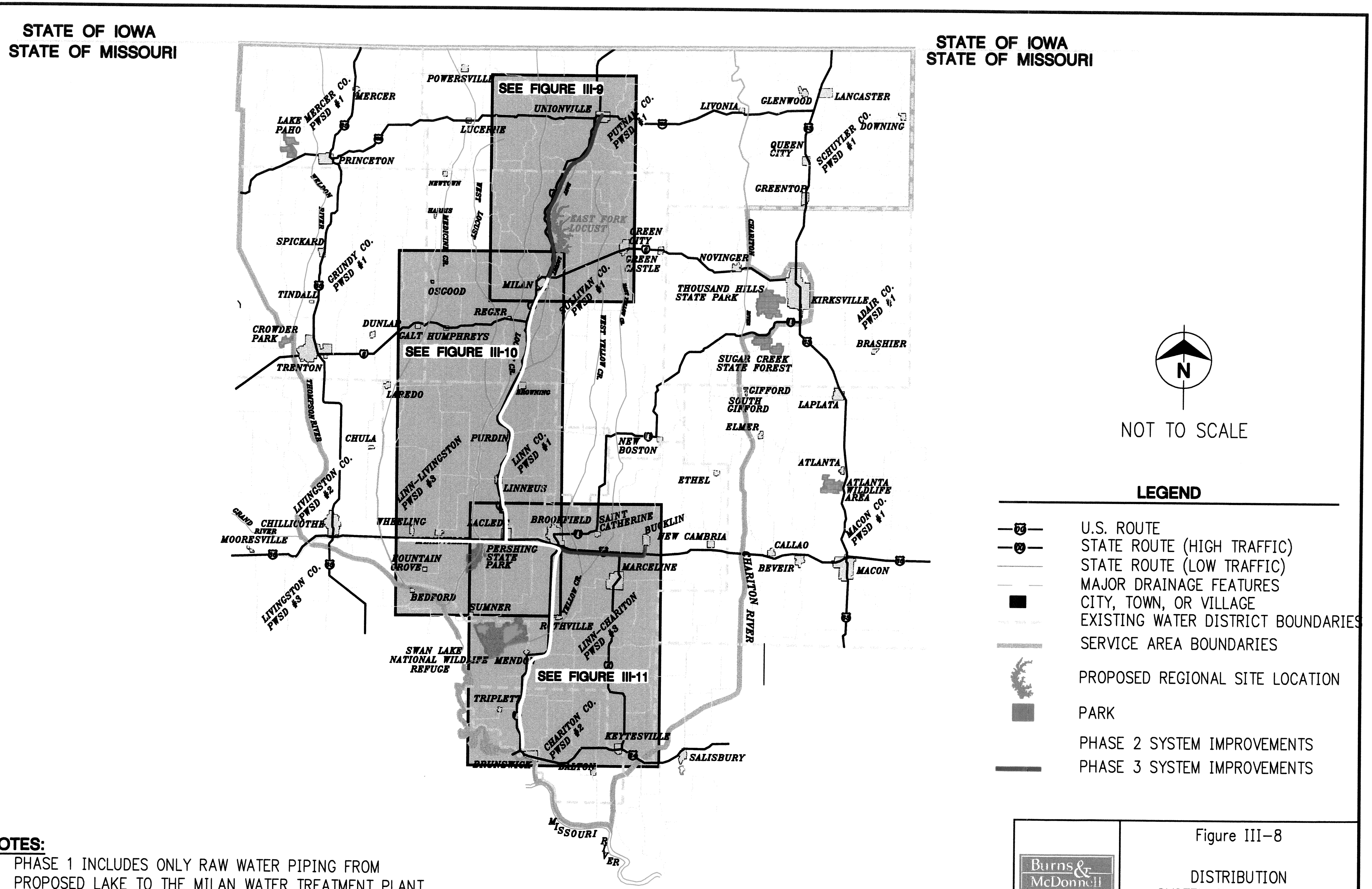
Figure III-7

EXISTING WATER MAINS
LOCATED WITHIN
PROPOSED LAKE AREA



NOTES:

PHASE 1 INCLUDES ONLY RAW WATER PIPING FROM PROPOSED LAKE TO THE MILAN WATER TREATMENT PLANT.

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Figure III-8

DISTRIBUTION SYSTEM IMPROVEMENTS

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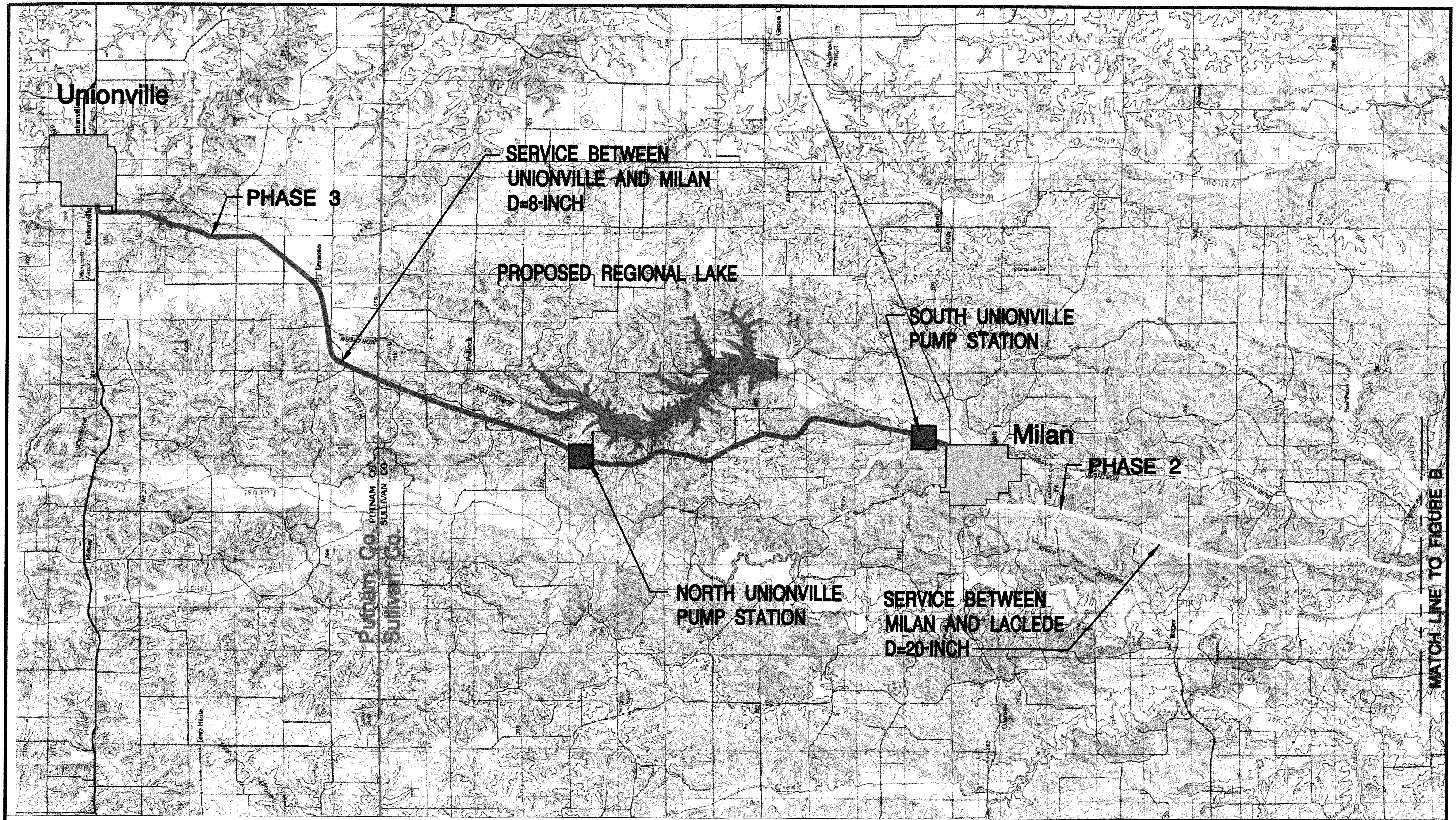

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Figure III-9

PHASE 2 AND 3 PROPOSED FINISHED WATER DISTRIBUTION LINE

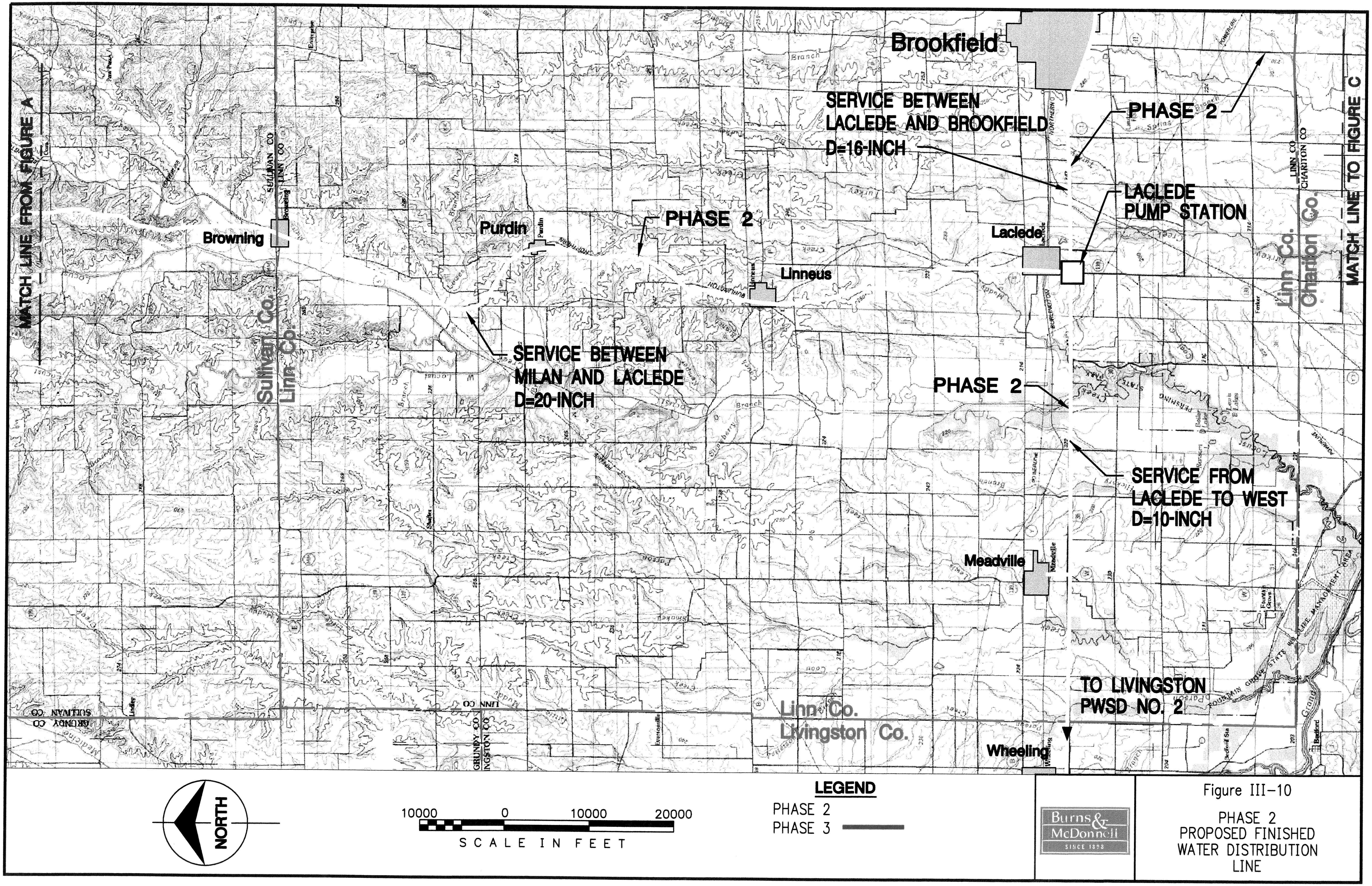

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Figure III-10

PHASE 2
PROPOSED FINISHED
WATER DISTRIBUTION
LINE

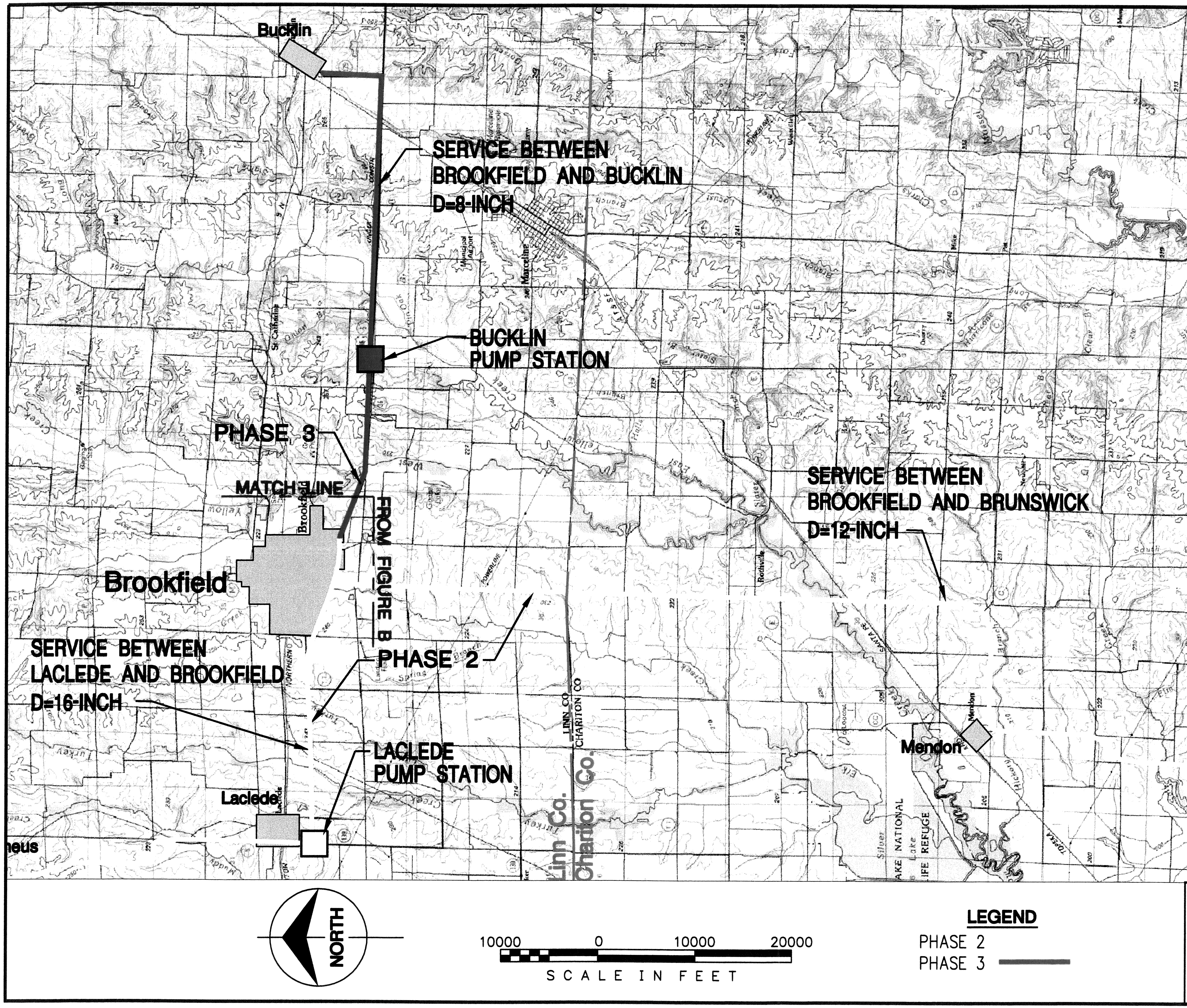

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Figure III-11

PHASE 2 AND 3
PROPOSED FINISHED
WATER DISTRIBUTION
LINE

- Line Two running west from the City of Laclede past the City of Meadville to connect to the distribution system of Livingston PWSD No. 2. Design flow for Line Two of 0.7 MGD.
- Line Three running east from the City of Laclede to the City of Brookfield. Design flow for Line Three of 2.1 MGD.
- Line Four running south from the City of Brookfield to the City of Brunswick. Design flow for Line Four of 0.9 MGD.

Hydraulic grade lines (HGL) were calculated using friction loss within the pipe, differential elevation between beginning and ending locations, and maintaining maximum and minimum head requirements within the water lines. The goal of the pipeline design is to provide the maximum amount of water using the least amount of pumping and the smallest feasible pipe diameter for each individual situation.

The following pipe diameters were selected based on their ability to meet all of the above stated design criteria. It should be noted that the following line sizes could change due to actual future demands or alignments, should they change in the future.

Table III-1

FINISHED WATER TRANSMISSION LINE SIZE

FOR PHASE TWO

Line One	20-inch
Line Two	10-inch
Line Three	16-inch
Line Four	12-inch

2. Pump Station Construction

Pumping is required at the Milan Water Treatment Plant and at Laclede to provide the required system pressure within the finished water distribution system. The pump station at Milan should be designed to provide in Line One from Milan to Laclede. The pump station at Laclede should be designed to provide water in Lines Two, Three and Four. The pump stations should be based on the following preliminary design criteria:

Milan Pump Station:

- Total flow of 2100 gallons per minute.
- Three horizontal split-case pumps for the pump station. (One Constant Speed, One Variable Speed Duty, One Variable Speed Standby)
- Total pump head of 130 feet.
- Total pump horsepower of 90 Hp for each pump

Laclede Pump Station:

- Total flow of 50 gallons per minute.
- Three pumps for the pump station. (One Constant Speed, One Variable Speed Duty, One Variable Speed Standby)
- Total pump head of 55 feet.
- Total pump horsepower of 1 Hp for each pump

It should be noted that the above pump station design criteria could vary due to actual future demands, pipeline sizes, alignment changes, or higher water demands.

3. Expansion of Milan Water Treatment Plant

The current Milan Water Treatment Plant is designed to treat 2000 gallons of water per minute, or 2.9 MGD. Phase Two expands this plant to process 4000 gallons of water per minute, or 5.8 MGD. This would allow the Milan Water Treatment Plant to provide all projected water needs to the North Central Missouri Regional Water Commission for Phase Two. The current Water Plant along with the proposed expansion is shown in Figure III-12

D. PHASE THREE CONSTRUCTION

Phase Three includes the construction of a new finished water transmission lines to provide finished water to the customers of the North Central Missouri Regional Water Commission. This Phase also includes the construction of two finished water pump stations to provide water to these customers and a second upgrade to the Milan Plant From 5.76 to 7.53 MGD.

1. Finished Water Transmission Mains

Phase Three transmission pipeline routes have been determined and are shown in Figure III-8. These transmission pipelines complete the distribution system south of Milan and

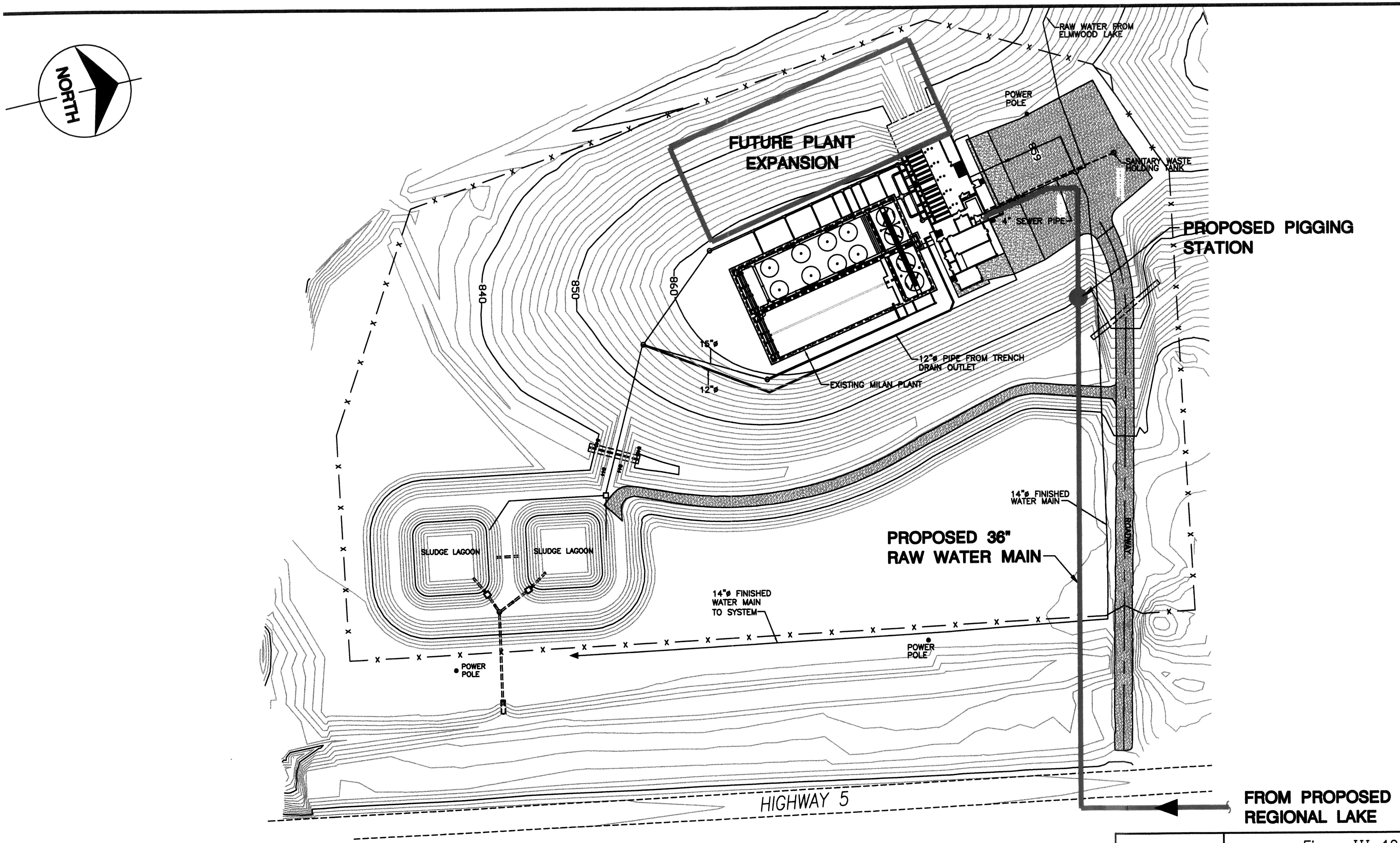

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Figure III-12

EXPANSION OF EXISTING
MILAN WATER PLANT

also transport water north of Milan to Unionville. Since the publication of the Feasibility Study, the City of Unionville has expressed the need for water much sooner than previously anticipated and a much greater volume. The transmission main design criteria listed below reflect this change. It should also be noted that this expansion of the distribution system is still included within Phase Three, but it is anticipated it will take place before this time. These transmission mains should be based on the following design criteria:

- Operating pressure will vary from 40 to 80 psi.
- C-value of 120 when pipeline is new and lower after several years of use.
- Line Five running east from the City of Brookfield to the City of Bucklin. Design flow for Line Five of 0.06 MGD.
- Line Six running north from the City of Milan to the City of Unionville. Design flow for Line Six of 0.6 MGD

Hydraulic grade lines (HGL) were calculated using friction loss within the pipe, differential elevation between beginning and ending locations, and maintaining maximum and minimum head requirements within the water lines. The goal of the pipeline design is to provide the maximum amount of water using the least amount of pumping and the smallest feasible pipe diameter for each individual situation.

The following pipe diameters were selected based on their ability to meet all of the above stated design criteria. It should be noted that the following line sizes could vary due to actual future demands or alignment changes.

Table III-2

FINISHED WATER TRANSMISSION LINE SIZE FOR PHASE THREE

Line Five	8-inch
Line Six	8-inch

2. Pump Station Construction

Pumping is required at the Milan Water Treatment Plant, south of Unionville and west of Bucklin to provide system pressure within the finished water distribution system. The pump station at Milan should be designed to provided water for Line Six from Milan to the intermediate pump station south of Unionville, and the intermediate pump station should be designed to provide the same water to Unionville. The pump station west of Bucklin should be designed to provide water in Line Five. The pump stations should be based on the following design criteria:

Milan Pump Station:

- Total flow of 60 gallons per minute.
- Three pumps for the pump station. (One Constant Speed, Once Variable Speed Duty, One Variable Speed Standby)
- Total pump head of 180 feet.
- Total pump horsepower of 5 Hp for each pump.

Pump Station South of Unionville:

- Total flow of 60 gallons per minute.
- Three pumps for the pump station. (One Constant Speed, Once Variable Speed Duty, One Variable Speed Standby)
- Total pump head of 70 feet.
- Total pump horsepower of 1 Hp for each pump.

Pump Station West of Bucklin:

- Total flow of 50 gallons per minute.
- Three horizontal split-case pumps for the pump station. (One Constant Speed, Once Variable Speed Duty, One Variable Speed Standby)
- Total pump head of 55 feet.
- Total pump horsepower of 1 Hp for each pump.

It should be noted that the above pump station design criteria could vary due to actual future demands, pipeline sizes or alignment changes.

3. Expansion of the Milan Water Treatment Plant

With the first expansion in Phase Two, the Milan Water Treatment Plant is capable of producing 5.8 MGD. The plant must be expanded again in Phase Three to 7.5 MGD. It is assumed this will be accomplished by adding two new filters to the plant and installing tube settlers in the sedimentation basin. In addition, some yard piping will have to be increased in size to accommodate the higher flows and increased sludge volumes.

E. EPA COMPLIANCE

1. Introduction

It is recommended that the Milan Water Treatment Plant be used as the principal water treatment facility for the North Central Missouri Regional Water Commission. The Milan Plant is proposed to treat water from the new reservoir on the East Fork Locust Creek. This portion of the Master Plan provides an assessment of Milan's compliance with current and proposed EPA Regulations for surface water treatment systems. The Milan Water Plant must be in compliance with current EPA Regulations and should be able to meet any proposed EPA Regulations that could have a major impact on the operation of the water treatment plant. Current and proposed EPA Regulations that could impact the plant include:

- Surface Water Treatment Rule (SWTR)
- Microbial/Disinfection By-Product Rule (MDBP)
- Enhanced Surface Water Treatment Rule (IESWTR) – Interim and Long Term Stage 1 and 2
- Filter Backwash Water Recycling Rule (FBRR)
- Inorganic Chemicals (IOC's)
- Volatile Organic Compounds (VOC's)
- Synthetic Organic Compounds (SOC's)
- Total Coliform Rule (TCR)
- Arsenic
- Lead and Copper Rule
- Radon/Radionuclides
- Secondary Standards
- Drinking Water Candidate Contaminate List (DWCCL)

The Milan Water Treatment Plant has been in operation for two years. The water plant receives raw water from Elmwood Lake, which is a surface water reservoir considerably smaller than the proposed East Fork Locust Creek site. In addition to being larger, the new reservoir will receive runoff from a much larger drainage area. The new reservoir will have a multi-level intake that can be controlled to receive the best raw water available within the water column of the reservoir. To be conservative, it is assumed that the new reservoir will provide water quality equal to that of Elmwood Lake. Thus if the Milan Water Treatment Plant can satisfactorily treat water from Elmwood Lake, it will be capable of doing the same with the new reservoir as a raw water source.

The water plant is required each month to send samples of water to a laboratory for testing and water quality reporting to the Missouri Department of Natural Resources. Milan water quality records from August 2002 through April 2003 were reviewed for this section of the report. This section reviews the compliance with current and future EPA Regulations.

2. Surface Water Treatment Rule (SWTR)

The Surface Water Treatment Rule (SWTR) applies to surface and ground water supplies under the influence of surface water. The SWTR has regulations for Giardia, viruses, Legionella, heterotrophic bacteria, and turbidity. All systems must filter and disinfect their water to provide the minimum level of reduction for these contaminants.

The EPA requires that conventional surface water treatment plants provide a 3-log (99.9%) reduction in Giardia and a 4-log (99.99%) reduction in viruses based on the SWTR. The regulations give a credit of 2.5-log Giardia and 2.0-log virus removal for plants operated within the turbidity requirements discussed later in this report. These credits are based on "Ct" values where "C" is the concentration of the disinfection in mg/L and "t" is the actual disinfection time (t_{10} time) in the basin. This value achieved by the plant must be greater than the published values for various water temperatures, pH values, and disinfectants.

The existing Milan Water Treatment Plant is in compliance for this rule at the time of this study.

3. Microbial/Disinfection By-Product Rule (MDBP)

The MDBP rule consists of three separate parts: the Disinfectants and Disinfection By-Products Rule (D-DBP), the Enhanced Surface Water Treatment Rule (ESWTR), and the Groundwater Disinfection Rule.

The D-DBP rule has been and currently is being formed differently then most other rules that have been promulgated in the past. The D-DBP rule is based on several points: a Congressional Mandate, the fact that all disinfection by-products have not been identified, controversial toxicological studies, and the tremendous cost of correction compared to uncertain risks. The D-DBP rule has been divided into two separate stages. This provides a step down in the regulations to allow for ongoing research and surveys of existing utilities. The impacts of regulated disinfection by-product levels on operating costs are being considered, in order to establish the final rule.

a. D-DBP Rule

Two elements of the D-DBP rule are the regulation of both disinfection by-products and maximum residual disinfectant levels. The promulgation of Stage I occurred before the end of the Information Collection Rule (ICR). Stage II development will examine the ICR data and utilize the results to determine the maximum DBP and maximum residual disinfectant levels. The levels of disinfection by-products and maximum residual disinfectant levels (MRDL) are shown in Table III-3

TABLE III-3

DBP AND MAXIMUM RESIDUAL DISINFECTANT LEVELS

Compound	Stage I	Current Proposed Stage II
Chlorine	4.0 mg/L	Same
Chloramine	4.0 mg/L	Same
Chlorine Dioxide	0.080 mg/L	Same
TTHM	0.080 mg/L composite	0.080 mg/L at all points
HAA5	0.060 mg/L composite	0.060 mg/L at all points
Bromate	0.010 mg/L	Same
Chlorite	1.0 mg/L	Same

The promulgation of Stage I occurred on December 16, 1998 and became effective three years following publications for large systems (serving more than 10,000 people). Stage I of the D-DBP rule requires that TTHM/HAA constituents be analyzed on a quarterly basis and compliance is based on a Running Annual Average

(RAA). Chlorine is to be measured at the same frequency as the total coliform rule and compliance is based on a quarterly running annual average.

Stage II of the D-DBP rule was signed July 14, 2003. Stage II of the D-DBP rule will impose a more restrictive sampling criteria as compared to Stage I by changing the calculation of compliance monitoring to reflect a Location Running Annual Average (LRAA) rather than the current RAA. According to the LRAA criterion, monitoring will still take place on a quarterly basis, but the MCLs for TTHMs and HAA5 will have to be met at each sampling location. The selection of new sampling sites will be based on an Initial Distribution System Evaluation (IDSE) study. It is important to note that new sampling sites will include locations of anticipated maximum levels of DBPs (i.e. two maximum THM sites, one maximum HAA5 site and one average residence time site).

In the interim, beginning three years after the rule is final, all systems must comply with MCLs of 0.120 mg/L for TTHM and 0.100 mg/L for HAA5 as LRAAs at Stage I sampling sites. This is in addition to continuing to comply with Stage I MCLs of 0.080 mg/L and 0.060 mg/L as running annual averages for TTHM and HAA5, respectively. In the second phase of the rule, systems will be required to comply with MCLs of 0.080 mg/L and 0.060 mg/L for TTHMs and HAA5 respectively, calculated at LRAA sites as identified in the Initial Distribution System Evaluation.

Review of the data provided by the Milan Water Treatment Plant indicates the LRAA for TTHM's as of 2002 was 0.10 mg/L, which is higher than second phase of the new D-DBP rule which sets the MCL at 0.080 mg/L. It should be noted the LRAA my increase or decrease due to new sampling locations as set forth in the IDSE.

Precursor control treatment techniques must be implemented if the raw water or finished water quality does not meet the above criteria. This element of the rule will require enhanced coagulation or softening to reduce the organics in the water source. The level of removal required will be dependent upon the raw water total organic carbon and the raw water alkalinity. It should be noted that in the future this could increase the amount of chemicals required by the water treatment plant and increase the cost of operations.

b. Enhanced Surface Water Treatment Rule (ESWTR)

The SWTR became effective on June 29, 1993. It defined turbidity and disinfection requirements for both surface waters and groundwaters under the influence of surface water. The ESWTR was proposed by the USEPA on July 29, 1994 to provide additional protection against disease-causing organisms (pathogens) in drinking water. The rule consists of three separate elements as follows:
The Interim Enhanced Surface Water Treatment Rule (IESWTR), promulgated on December 16, 1998 and to become effective in November 2003.

- Phase 1 of the Long Term Enhanced Surface Water Treatment Rule (LTESWTR), promulgated in November 2000 and to become effective in November 2003.

- Phase 2 of the LTESWTR, was promulgated in July 2003 and to become effective in three years.

All three elements set the maximum contaminant level goal (MCLG) for Cryptosporidium at zero. This MCLG cannot currently be measured, but is a goal for the treatment process. The IESWTR will required the Cryptosporidium removal or inactivation necessary for the proper treatment. There are currently no changes proposed for virus removal/inactivation in the IESWTR.

1) Turbidity

The Long Term 1 Enhanced Surface Water Treatment Rule changed current turbidity standards. These new turbidity standards will become enforceable on January 12, 2005. The new regulations will require combined filter effluent turbidity to be monitored and recorded at least every four hours. The combined filter effluent turbidity must be less than or equal to 0.3 Nephelometric Turbidity Units (NTU) in 95% of the readings taken each month, and must not exceed a maximum turbidity value of 1 NTU at any time.

2) Revised Giardia and Virus Removal/Inactivation

The disinfection portion of the SWTR requires 99.9% (3 log) reduction of Giardia lamblia and 99.99% (4 log) reduction of viruses. If the finished water turbidity is less than 0.5 NTU and a conventional process is used, then 2.5 log removal credit is granted for Giardia lamblia and 2.0 log removal credit is granted for viruses. The remaining credit for the removal is required to be completed using disinfection.

The IESWTR, which was written with the objective of preventing Cryptosporidium passage through physical barriers established for its removal in treatment plants, has set a Crypto removal goal of 2 logs. If the finished water turbidity is lass than the IESWTR standards (0.3 NTU during 95% of the readings), this removal credit is granted.

Phase 1 of the Long Term Enhanced Surface Water Treatment Rule (LT1ESWTR) extends the requirements of the IESWTR to systems serving less than 10,000 people. Phase 2 of the Long Term Enhanced Surface Water Treatment Rule (LT2ESWTR) was recently promulgated in July 2003. The LT2ESWTR is expected to include additional requirements in terms of Cryptosporidium log removal, which will depend on the average raw water Cryptosporidium concentration. If the system has an average raw water concentration of less than 0.075 Oocysts/L, no action would be required. However, if the average raw water Cryptosporidium concentration is equal to or greater than the above figure, systems with conventional treatment would be required to provide additional treatment for the enhanced removal of Cryptosporidium. Furthermore, the LT2ESWTR states that one or more source water detections of Cryptosporidium could move utilities into the higher risk category, requiring up to 2.5 log reduction credit for Cryptosporidium beyond sedimentation and filtration.

The existing Milan Water Treatment Plant is in compliance for this rule at the time of the study. As of March 24, 2003 the turbidity at the water plant was in compliance 100% of the time with the highest single measurement for the year of 0.2 NTU in December.

4. Phase I, II, and V Rules

EPA regulates most chemical contaminants through the rules know as Phase I, II, and V. In each rule the EPA has set limits on the contaminants, prescribed the schedule under which water systems must test for the presence of the contaminants, and described the treatments which systems may use to remove a detected contaminant. For each contaminant the EPA has a health goal, or Maximum Contaminant Level Goal (MCLG). This goal is not a legal limit with which water systems must comply; it is based solely on human health. These rules also set a legal limit or Maximum Contaminant Level (MCL) for each of the contaminants.

a. Phase I Rule

This rule limits exposure to eight chemicals that may be present in tap water. These eight are all Volatile Organic Chemicals (VOCs) that industries use in the manufacturing of products. The rule requires water systems to monitor and take corrective action if the levels exceed the legal limits.

b. Phase II Rule

This rule updated or created legal limits on 38 more contaminants that could be present in the water supply. Some of these contaminants are frequently applied agricultural chemicals, while other are more obscure industrial intermediates.

c. Phase V Rule

The Phase V Rule sat the standard for 23 more contaminants in the water. Several are inorganic chemicals that are present naturally in some water. However, industrial activity accounts for the more potentially harmful levels of these contaminants. Other Phase V contaminants include pesticides which can enter water supplies through run-off or by leaching through the soil.

The proposed East Fork Locust Creek drains a larger area than the water treatment plants current water supply Elmwood Lake. It is possible that more pesticides and agricultural products could enter the reservoir, but they will be diluted from the larger volume of water present. It is assumed this will offset any increase in agricultural chemical levels in the new reservoir.

The existing Milan Water Treatment Plant is in compliance for this rule at the time of the study. Water quality reports from the Missouri Department of Natural Resources indicate no violation for any chemical contaminates in Phase I, II, or V Rules.

5. Total Coliform Rule (TCR)

The Total Coliform Rule (TCR) was introduced in June 1989 and became effective as of January 1, 1992. The TCR set an MCL based on the presence-absence (P-A) of total coliform, which depends upon the total number of samples taken per month as follows:

- Systems analyzing at least 40 samples per month require that no more than 5.0 percent of the month's samples be positive for total coliform
- Systems analyzing less than 40 samples per month require that no more than 1 sample per month be positive for total coliform

The MCL can cause a utility to be in violation with just one positive sample, if that positive sample is followed by a positive repeat sample, or if that sample brings the total percent of positive samples to greater than 5.0 percent.

The existing Milan Water Treatment Plant is in compliance for this rule at the time of the study.

6. Arsenic

Originally under the authority of the Safe Drinking Water Act, the EPA issued a National Interim Primary Drinking Water Regulation for arsenic of 0.05 mg/L.

In October of 2000 a bill was passed directing the EPA to promulgate a final arsenic standard no later than June 22, 2001. The final rule, published on January 22, 2001, established the MCL at 0.01 mg/L and was supposed to become effective on March 23, 2001. The Rule also established that the 0.01 mg/L MCL becomes enforceable on January 23, 2006. The rule is currently being revised to rewrite the MCL at 0.010 mg/L

Due to concerns raised by States, PWSs, and other stakeholders the EPA took additional steps to reassess the scientific and cost issues associated with this rule. The EPA has extended the effective date of the rule to February 22, 2002, while maintaining the compliance date of January 23, 2006 for the arsenic MCL.

The existing Milan Water Treatment Plant is in compliance for this rule at the time of the study. Water quality reports from the Missouri Department of Natural Resources indicate no Arsenic in the water above the detectable level of 0.001 mg/L. Arsenic levels are principally found in groundwater and not in surface water reservoirs.

7. Lead and Copper Rule

The Lead and Copper Rule is a substantially different rule regarding to the regulations of contaminants in water. This rule regulates contaminants that nearly always enter the water after it leaves the water treatment plant.

The EPA requires water systems to evaluate not only the pipe in their distribution system, but also the age and type of house service piping that are installed in the water system. Water samples must be collected at points throughout the distribution system, which are vulnerable to lead or copper contamination. When the level of lead or copper reaches the action level in ten percent of the individual tap water samples, the water system must begin to take action against this elevated level. Currently the action level for lead is 0.015 mg/L and for copper is 1.3 mg/L.

The existing Milan Water System is in compliance for this rule at the time of the study. Water quality reports from the Missouri Department of Natural Resources indicate no Lead in the water above the detectable level of 0.004 mg/L and copper in the range of 0.0086 to 0.024 mg/L. Since the water from the Milan Water Treatment Plant will be entering other systems, it is important that finished water not be corrosive. Other systems may have lead or copper service lines that could be affected.

8. Radionuclides/Radon

USEPA proposed drinking water regulations for six different radioactive compounds in July 1991. A final rule for these radionuclides became effective in December of 2000 updating the MCL for some of the elements. The MCLs in the final rule are listed in Table III-4 below.

TABLE III-4

MCLS FOR RADIONUCLIDES AND RADON

Contaminant	MCL
Adjusted gross alpha emitters	15 pCi/L
Gross beta and photon emitters	4 mrems/yr
Radium 226 +288	5pCi/L
Radon 222	300 pCi/L
Uranium	30 µg/L

On November 2, 1999 the EPA published a proposed regulation for radon in drinking water. A final rule was required by the SDWA to be issued by August 2000 and is now expected in December 2004. The proposed MCL for radon is 300pCi/L with an alternative MCL proposed at 4,000 pCi/L, which would apply if a state or utility has a multimedia mitigation program to lower indoor air radon. The existing Milan Water Treatment Plant is in compliance for this rule at the time of the study.

9. Secondary Standards

Secondary standards deal with constituents in drinking water, which pose no threat to public health, but degrade aesthetic quality. Secondary standards were originally promulgated in 1979 and revised in 1986 and 1989, A list of contaminants for which Secondary Maximum Contaminant Levels (SMCLs) have been established by the EPA is provided in Table III-5

TABLE III-5

SECONDARY DRINKING WATER CONTAMINANT STANDARDS

Contaminant	Unit	SMCL
Aluminum	mg/L	0.05 - 0.2
Chloride	mg/L	250
Color	color units	15
Copper	mg/L	1.0
Corrosivity	--	Noncorrosive
Fluoride	mg/L	2
Foaming Agents	mg/L	0.5
Iron	mg/L	0.3
Manganese	mg/L	0.05
Odor	TON	3
pH	--	6.5 – 8.5
Silver	mg/L	0.10
Sulfate	mg/L	250
TDS	mg/L	500
Zinc	mg/L	5

The existing Milan Water Treatment Plant produces finished water that does not exceed any of the secondary standards shown in the above table.

10. Drinking Water Candidate Contaminant List

The purpose of the Drinking Water Candidate Contaminant List (DWCCL) is to identify contaminants for possible regulations under the SDWA. The DWCCL was developed with considerable input from the scientific community and stakeholders. A draft DWCCL was published in October of 1997 and a final list was published in March of 1998. The DWCCL contains 60 contaminants that are not subject to any current or Proposed NPDWRs.

In early spring of 2002, the EPA considered nine contaminants with sufficient data and information to determine of whether or not to regulate. The determination made June 2, 2002 was that at this time regulatory action is not appropriate for Acanthamoeba, aldrin, dieldrin, hexachlorobutadiene, manganese, metribuzin, naphthalene, sodium or sulfate. The EPA has also decided not to regulate nickel, aldicarb, and metabolites within the same timeframe as DWCCL contaminants. The National Drinking Water Advisory Council (NDWAC) is currently working on compiling a new list from the CCL that could be considered for regulation and should be published in February 2004.

a. Aldicarbs

The first regulation of aldicarbs was to be promulgated in July 1991, but was postponed by administrative order. It should be noted that Aldicarbs are considered regulated contaminants although, their MCLs are stayed. Reproposed standards for Aldicarb, Aldicarb Sulfoxide and Aldicarb Sulfoxide are expected in August 2004 and are to be finalized by August 2005. The proposed regulation included the following MCLs:

Aldicarb	0.003 mg/L
Aldicarb Sulfoxide	0.004 mg/L
Aldicarb Sulfone	0.002 mg/L

PART IV

Environmental Analysis

PART IV
ENVIRONMENTAL ANALYSIS

A. INTRODUCTION

This section of the report contains environmental and permitting information on the proposed reservoir site and supporting infrastructure being considered in the North Central Missouri Regional Water Commission Master Plan. Following is a description of the data collection process completed for the project, the general descriptions of the proposed reservoir site and supporting infrastructure, the methodology used in the evaluation of the site and infrastructure, and the analysis results.

B. DATA COLLECTION

Data was collected through a desktop analysis of available information and from a field reconnaissance of the project area. The project area included both the area of the proposed reservoir and the general area of the proposed alignment of the supporting infrastructure. Following is a description of both surveys.

1. Desktop Survey

The proposed reservoir and supporting infrastructure alignment were evaluated by using U.S. Geological Survey (USGS) 7.5-minute topographic maps; U.S. Fish and Wildlife Service National Wetland Inventory (NWI) maps; and the U.S. Department of Agriculture Natural Resource Conservation Service (NRCS) soil surveys of Sullivan, Putnam, Livingston, Linn, and Chariton counties. The topographic maps were used to locate potential engineering, social, and environmental/land use constraints including cities/communities, water bodies, residences and structures, observable cultural resources (i.e., cemeteries, historic structures), parks or recreational areas, roads and highways, general topography and land use. Wetlands that would potentially be impacted or lost with the project development were evaluated using the USGS and NWI maps, and NRCS soil surveys. Additionally, the NRCS soil surveys provided greater detailed general land use descriptions for the project area, as well as, supplemental wetland and habitat information.

2. Field Reconnaissance

A field reconnaissance for the proposed reservoir site and supporting infrastructure alignment was conducted during September 2003. The objective of the field reconnaissance was to obtain first-hand information about the proposed project site and the surrounding area. Additionally, the field reconnaissance was conducted to confirm engineering, social, and environmental/land use constraints (possible protected species habitat, wetlands, and observable cultural resources) identified from the desktop survey. The field reconnaissance consisted of an automobile survey along public roads in the project area. During frequent stops, descriptive field notes were recorded and photo documentation was obtained.

The reconnaissance team evaluated the project area for general site characteristics and existing land use, potential for sensitive or critical habitats (threatened, endangered, or candidate species habitat), general wetland identification, potential impact to existing cities/communities and roadway/highways, and general cultural resources high probability area identification.

C. RESERVOIR SITE DESCRIPTION

The reservoir site description was generated using information obtained from the desktop survey and the field reconnaissance. The descriptions provide information regarding the existing land use and existing infrastructure; wetland identification; threatened, endangered, or candidate species habitat; and probability of cultural resources occurring within the Area of Potential Effect (APE).

1. Land Use and Existing Infrastructure

The proposed reservoir site is located approximately five miles to the northeast of Milan, Missouri in Sullivan County. The topography in the area is best described as rolling hills separated by the East Fork of Locust Creek floodplain. The land use for the proposed site is predominately agricultural (pasture or cropped) with narrow wooded fencerows and woodlots. Additional woodlands are present on the slopes of hills and in deep ravines between the hills. Riparian woods are along the stream channels in the floodplain. The wooded areas in the vicinity of the proposed reservoir are dominated by oak and hickory trees. Additional species include eastern cottonwood, locust, redbud, silver maple, and shagbark hickory trees.

According to the topographic maps, at the conservation pool elevation at 910 feet, approximately 15 residences, 5 non-residential structures, and 1 church would need to be removed and relocated. The reservoir would impact the small community of Boynton. Fourteen of the 15 residences and the church are located within that community. One medium-duty paved road, County Road N, would be inundated by the reservoir development. Additionally, eight light-duty paved or gravel roads and one unimproved dirt road would also be removed. Based on the topographic maps and aerial photographs, no cemeteries are located within the proposed reservoir area. A Burlington Northern rail line, which is shown on the USGS topographic maps, formerly traversed the area. However, this rail line would not be impacted because it has been abandoned and the tracks removed.

Based on the topographic maps, at the flood pool elevation of 930 feet, four additional residences and six non-residential structures would need to be removed and relocated. Only one additional paved county road would be impacted. This county road is proposed to be relocated.

Additional infrastructure in the proposed reservoir site has the potential to be relocated or retired from service. This could include buried cable (phone/fiber optic), electrical transmission or distribution lines, water pipelines, and gas pipelines.

2. Wetlands

Based on the available NWI mapping and the field reconnaissance, emergent (PEM), scrub-shrub (PSS), and forested (PFO) wetlands are located within the proposed reservoir site. Combinations of the above wetland types (e.g., PEM/PSS and PSS/PFO) are also undoubtedly present. Locations of the NWI wetlands within the project area are shown on Figure IV-1. Acreage of NWI wetlands by type to the top-of-conservation pool elevation (910 feet) and to the top-of-flood pool elevation (930 feet) are shown in Table IV-I. A total of 198.7 acres of wetlands are located within the conservation and lower pools, while an additional 73.4 acres of wetlands are located within the flood pool, for a total of 272.1 acres of wetlands. Forested wetlands are the most common wetland type regardless of elevation, covering 93.9 acres of land within the conservation and lower pools in the lower elevation and 147.2 total. Emergent wetlands are slightly less prevalent than forested wetlands, and scrub-shrub wetlands are considerably less

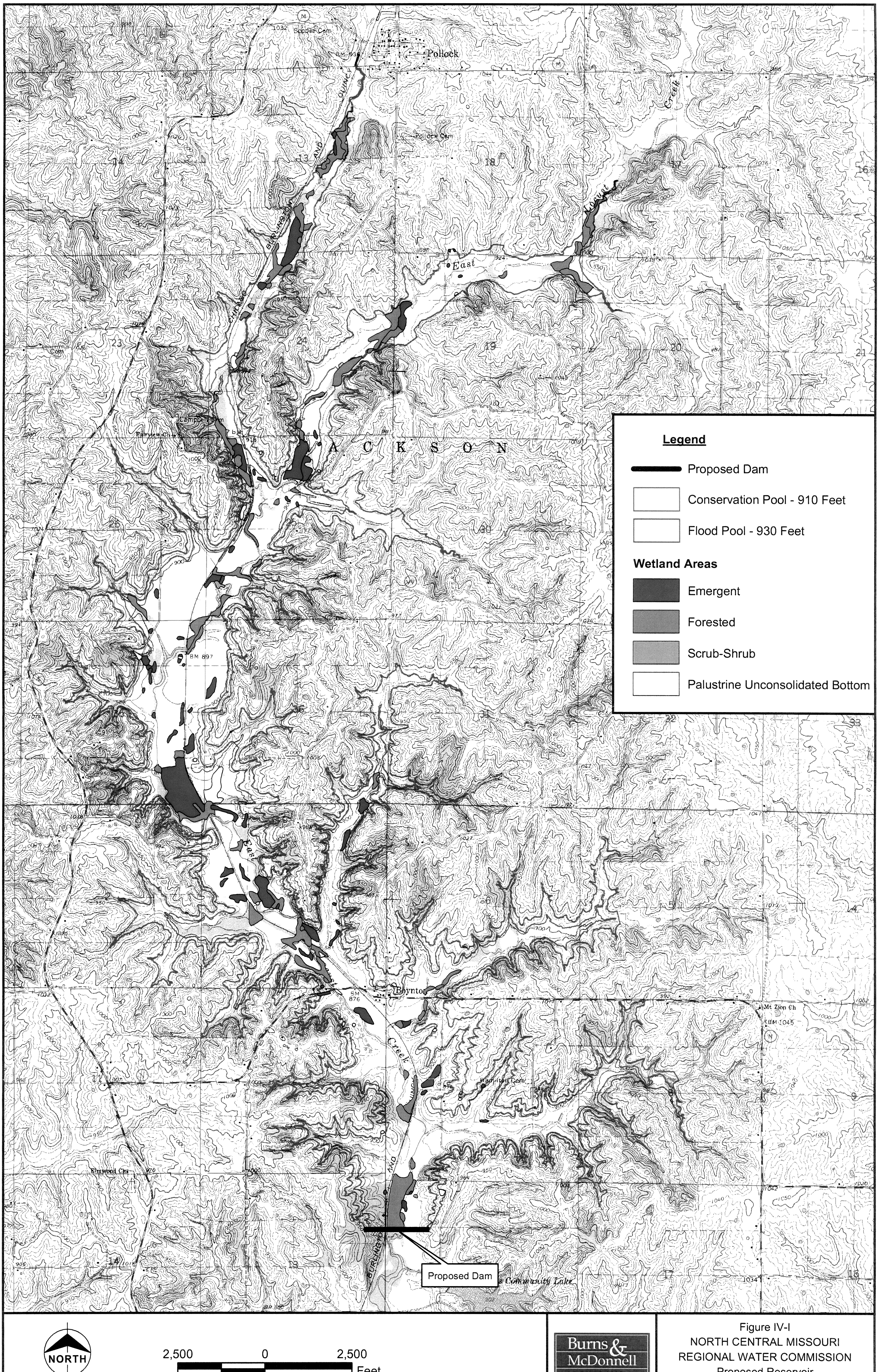

Figure IV-I
NORTH CENTRAL MISSOURI
REGIONAL WATER COMMISSION
Proposed Reservoir
Wetland Impacts

prevalent. Emergent wetlands occupy a total of 92.8 acres at or below the conservation pool elevation and 110.4 acres total. There is only 1.0 acre of scrub-shrub wetlands all within the conservation and lower pools.

TABLE IV-1
POTENTIAL WETLAND IMPACT ACREAGE FOR THE PROPOSED RESERVOIR AT CONSERVATION POOL AND FLOOD POOL ELEVATIONS

Wetland Type	Conservation Pool Elevation at 910 feet (Acres)	Flood Pool Elevation at 930 feet (Acres)
Emergent (PEM)	92.8	110.4
Forested (PFO)	93.9	147.2
Scrub-Shrub (PSS)	1.0	1.0
Palustrine Unconsolidated Bottom (PUB)	11.0	13.5
Total	**198.7**	**272.1**

The 20-foot gain in elevation between the tops of the conservation and flood pools adds about 73.4 wetland acres, which are composed of mostly forested wetlands (53.3 acres). Emergent wetlands are also present, and occupy about 17.6 additional acres.

3. Threatened and Endangered Species

According to the Missouri Department of Natural Resources Heritage database, only two protected species are known to occur in Sullivan County. These are the state and federally endangered Indiana bat (*Myotis sodalis*) and the state endangered greater prairie chicken (*Tympanuchus cupido*). During the winter, Indiana bats hibernate in caves or abandoned mines. In the spring, the bats migrate to their summer habitats where they usually roost under loose tree bark on dead or dying trees. During summer, males roost alone or in small groups, while females roost in larger groups of up to 100 bats or more. Indiana bats also forage in or along the edges of forested areas. Greater prairie chickens prefer grassland tracts of at least 80 acres in area. Potential habitat should include herbaceous vegetation 8-16 inches tall for nesting, diverse structure and species composition for brood habitat, and dense stands of native grass or shrub thickets for winter cover. Greater prairie chickens inhabit tallgrass prairies and eat insects like grasshoppers, ants, and leafhoppers.

For the project areas, the riparian areas along the streams and the wooded areas that dot the landscape may provide potential roosting and foraging habitats for the Indiana bat. These wooded areas have numerous snags and tree species with exfoliating or loose bark (e.g. shagbark hickory and silver maple). During the field review, no areas containing tall grass prairie habitats suitable for greater prairie chickens were observed. Crop fields and pastures would be the only open areas that could provide suitable habitat in the vicinity of the proposed reservoir.

4. Cultural Resources

Background information for the proposed reservoir construction was obtained from the Archaeological Survey of Missouri (ASM). Very little archaeological or architectural evaluation or studies have been performed in the region. Based upon the ASM information, the floodplain of the East Fork of Locust Creek and its tributaries have a high probability of containing archaeological sites. It is also likely that there are buried sites within the floodplain of the creek based upon the topography and soils that were observed. As the hills slope toward the floodplain, there is a high probability that service sites will be found on the ridge toes along with buried sites at the base of the hills on the floodplain under alluvial fans.

The only available survey information from the ASM covered parts of Section 7, Township 63N, Range 19W. In this one section, there are seven known sites; one site was located in Section 18. The numbers of the sites are 23SU30 through 23SU37. Additional information about the sites is available, but was not gathered for this stage of the master plan investigation.

D. SUPPORTING INFRASTRUCTURE DESCRIPTION

As with the reservoir site description, the supporting or associated infrastructure description was generated using the findings of the desktop survey and the field reconnaissance. The supporting infrastructure descriptions also included information regarding the existing land use and existing infrastructure; wetland identification; threatened, endangered, or candidate species habitat; and probability of cultural resources observed for the proposed alignment. Construction of the supporting infrastructure and linear facilities will be completed in three phases over approximately 30 years. Each phase of development is discussed separately.

1. Phase One

Phase 1 will consist of construction of an intake tower, the Elmwood Lake Pump Station, raw water transmission pipelines, and improvements to the existing Milan Water Treatment Plant (See Figures included within Section III). The raw water transmission pipelines constructed during Phase 1 will include a proposed 36-inch raw water transmission main from the intake tower located in the proposed reservoir to the existing Milan Water Treatment Plant and a proposed 24-inch raw water transmission main to Elmwood Lake. The proposed 36-inch main travels from the intake tower located just north of the proposed dam south along the east side of the abandoned Burlington Northern railroad to the existing Milan Water Treatment Plant. The total length of the 36-inch pipeline would be approximately 4 miles. The proposed 24-inch pipeline would branch from the proposed 36-inch pipeline at the proposed location for the Elmwood Lake Pump Station, immediately east of Elmwood Lake. The 24-inch transmission pipeline would travel approximately one-half mile west to Elmwood Lake.

a. Land Use and Existing Infrastructure

Construction of Phase 1 will be located in Sullivan County, northeast of Milan. The topography in the area is fairly flat and contains numerous intermittent streams. The land use in the area is a mixture of wooded and agricultural (pasture or cropped).

Although the proposed 36-inch water pipeline would parallel the abandoned Burlington Northern railroad, the pipeline would be located outside of the railroad right-of-way. The 36-inch pipeline would cross one light-duty road. The 24-inch pipeline would not follow any existing right-of-way and would cross the abandoned Burlington Northern railroad, State Road 5, and two light-duty roads. Neither the 36-inch nor the 24-inch pipeline would cross near residences or communities.

There would be no impact to additional infrastructure along the proposed pipeline corridors. This additional infrastructure, including buried cable (phone/fiber optic), electrical transmission or distribution lines, water pipelines, and gas pipelines, would not be effected by construction and would remain in service.

b. Wetlands

The proposed 36-inch water pipeline would primarily pass through the floodplain of the East Fork of Locust Creek, crossing three intermittent creeks. The proposed route also crosses existing wetlands. Most of these wetlands, according to the NWI maps, are forested (PFO). The PEM and PSS wetlands are each crossed only once by this pipeline route. The proposed 24-inch pipeline from the 36-inch water pipeline to Elmwood Lake would cross one or two creeks and possibly impact emergent wetlands associated with Elmwood Lake.

c. Threatened and Endangered Species

According to the Missouri Department of Natural Resources Heritage database, the only protected species known to occur in Sullivan County are the state and federally endangered Indiana Bat (*Myotis sodalis*) and the state endangered greater prairie chicken (*Tympanuchus cupido*). Indiana bat and greater prairie chicken habitat is discussed previously in Part C.3.

The proposed 36-inch water supply pipeline route crosses woodlands, pastures, and cropland. The proposed 24-inch water supply pipeline alignment reveals that an upland wooded area may be impacted by construction. The wooded area is small, located along the hillside, and surrounded by pastures. It is unlikely that construction of either of the proposed pipelines would result in any permanent impacts to potential greater prairie chicken habitat; however, construction of the pipelines may result in the loss of potential roost trees for the Indiana bat.

d. Cultural Resources

Background information from the ASM for the initial phase of pipeline construction indicated that very little archaeological or architectural evaluation has been performed in the region. The 36-inch and 24-inch raw water pipelines have the potential to affect cultural resources. Based upon the ASM information, the proposed route is considered to be a high probability area for cultural resources because of its location within the floodplain of a major creek and its tributaries. Similar to the proposed reservoir site, it is also likely that there are buried sites based upon the topography and soils that were observed. Similarly, as the hills slope toward the floodplain, there is a high probability that there are sites located on the ridge toes, in addition to buried sites at the base of the hills on the floodplain under alluvial fans.

2. Phase Two

Construction of Phase 2 will include the placement of 10-inch, 12-inch, 16-inch, and 20-inch polyvinylchloride (PVC) water pipelines and the Milan and Laclede Pump Stations. In addition, there would be additional improvements made at the existing Milan Water Treatment Plant. The water pipelines will include service between Milan and Laclede (20-inch), service from Laclede west to Livingston Public Water Supply District (PWSD) No. 2 (10-inch), service between Laclede and Brookfield (16-inch), and service between Brookfield and Brunswick (12-inch). Proposed water pipeline alignments are shown on Figures III-VIII through III-XI.

The proposed water pipeline between Milan and Laclede will follow State Road 5 south passing through the community of Browning, into Linn County, and continuing south through the communities of Purdin, Linneus, and Laclede (Figure III-9 and III-10). The 20-inch pipeline would connect with the proposed Laclede pump station just south of Laclede. The proposed water pipeline from Laclede to the west to Livingston PWSD No. 2 would originate at the proposed Laclede pump station location, south of U.S. Highway 36 (Figure III-10). The 10-inch pipeline would travel west along U.S. Highway 36 crossing into Livingston County. Connection spurs from the 10-inch pipeline are proposed to provide service to the communities of Meadville and Wheeling. The service between Laclede and Brookfield would be provided by a 16-inch water pipeline from the Laclede pump station, following U.S. Highway 36 to the east to the town of Brookfield (Figure III-X). The proposed water pipeline between Brookfield and Brunswick would turn south from the town of Brookfield on State Road 11, and continue to the south following the road into Chariton County (Figure III-11). The 12-inch pipeline would pass southeast of the town of Mendon, and continue south along State Road 11 terminating at Brunswick.

a. Land Use and Existing Infrastructure

Construction activities in Phase 2 will be located in Sullivan County, Linn County, Livingston County, and Chariton County in north-central Missouri. The topography in the area is rolling hills, with numerous intermittent streams; the land use is a mosaic of woods and agriculture (pasture or cropped).

The proposed water pipelines would follow existing highways and roadways; however, the pipeline would be located outside existing rights-of-way. When crossing through or near communities or approaching delivery points, the pipelines will follow existing roadways or features to avoid possible impact to the adjacent residents. According to the topographic maps, the water pipelines would cross approximately 77 roads during Phase 2 construction activities. In addition, based on the topographic maps, the water pipelines would cross approximately 73 intermittent and perennial streams, including the larger streams of the East Fork of Locust Creek, Locust Creek, Parson Creek, Muddy Creek, and Yellow Creek.

Consistent with construction of Phase 1, there would be no impact to additional infrastructure that may be encountered along the proposed pipeline corridors since all facilities would remain in service.

b. Wetlands

Based on the review of the topographic and NWI maps, wetlands and other waters of the United States along each of the proposed water supply pipelines in Phase 2 were identified. Along the proposed pipeline between Milan to Laclede, about 30 creek crossings were observed. Most of the creeks were small and intermittent in nature; some were found to be associated with wetlands. Review of NWI maps revealed that only a few wetlands (PFO and PEM) along the route were found and were restricted to Muddy Creek and Locust Creek.

Additionally, along the proposed pipeline between Laclede and Wheeling, nine creeks and numerous wetlands primarily associated with Locust Creek were observed. Review of NWI maps showed that the wetlands found at creek crossings were mostly of the PFO wetland type.

Along the proposed pipeline from Laclede to Brookfield, four small creeks and a few possible wetlands associated with the creeks were observed. NWI wetland map review did not show any wetlands along this portion of the Phase 2 route.

Lastly, along the proposed water pipeline between Laclede and Brunswick, more than 30 creek crossings were located. Wetlands were mostly associated with the creeks. According to NWI maps, the larger creeks – Hickory Branch and Yellow Creek – had forested (PFO) wetlands located in the vicinity of at the pipeline crossings.

c. Threatened and Endangered Species

The protected species known to occur within the Phase 2 project counties, according to the Missouri Department of Natural Resources Heritage database, are shown in Table IV-2.

Table IV-2
PROTECTED SPECIES KNOWN TO OCCUR IN THE PHASE 2 PROJECT VICINITY

Common Name	Scientific Name	State Status	Federal Status	County
Bald eagle	*Haliaeetus leucocephalus*	E	T	Livingston
Barn owl	*Tyto alba*	E	-	Livingston
Eastern massasauga	*Sistrurus catenatus catenatus*	E	-	Linn Chariton
Greater prairie chicken	*Tympanuchus cupido*	E	-	Sullivan
Indiana bat	*Myotis sodalis*	E	E	Sullivan Linn Chariton
Northern harrier	*Circus cyaneus*	E	-	Linn
E= Endangered			T=Threatened	

The Phase 2 pipeline system is the most extensive of the proposed water supply pipeline development phases, and includes woodlands, pastures, cropland and occasionally rural residences adjacent to existing highway corridors. The woodlands were relatively small and sporadically placed within the landscape. Pastures, hay meadows, and crop fields were more prevalent along the route.

The Missouri Department of Conservation's Fish and Wildlife Information System was accessed for detailed descriptions of potential habitat for the protected species known to occur in Chariton, Linn, Livingston, and Sullivan counties.

- Bald eagles may have a statewide distribution during winter, but are rare summer residents. During the winter, bald eagles typically concentrate near rivers with open water and in areas with large numbers of wintering waterfowl. They roost in large trees near shore and prefer areas with limited human activity.

- Barn owls forage for mice and voles in open grassland or crop fields. Barn owls typically nest in cavity trees that are greater than 20 inches in diameter at breast height, and in barns, grain elevators, or abandoned buildings.
- Eastern massasaugas inhabit marshy areas, wet prairies, sloughs, and wetland vegetation, such as cattail (*Typha sp.*), bulrush (*Scirpus sp.*), sedge (*Carex sp.*), and willow (*Salix sp.*), around marshes, lakes, and floodplains of major rivers.
- In Missouri, northern harriers are rare summer residents and uncommon winter residents. They inhabit open fields, prairies, native grass plantings and shallow marshes. Herbaceous vegetation should be dense and reach a height of 10 inches by mid May.

Indiana bat and greater prairie chicken habitat was previously discussed in Part C.3.

Based on the desktop survey and field reconnaissance, there is a potential for habitats for all of the protected species along the existing road rights-of-way. The closer the pipeline construction is to the existing corridors or disturbed areas, the less likely the construction would impact potential habitats. However, the further the construction is away from the existing corridors or disturbed areas, the greater the potential to impact habitats of protected species. If the pipeline is constructed within the highway corridor and all streams and wetlands are directionally drilled, the proposed route will not impact any protected species habitat.

d. Cultural Resources

The proposed pipeline routing for Phase 2 construction is near existing highway right-of-way. As a result, the probability of encountering intact cultural deposits is low. If some flexibility concerning the route can be maintained, any sites that may be discovered should be easily avoided. The desktop survey and field reconnaissance indicate that few, if any, historic structures will be permanently impacted.

3. Phase Three

Construction activities in Phase 3 of the proposed water supply project will consist of 8-inch PVC water pipelines and the North Unionville, South Unionville, and Bucklin pump stations. The two proposed 8-inch water pipelines will provide service between Unionville and Milan and between Brookfield and Bucklin (Figures III-9 and III-11). The proposed water pipeline between Unionville and Milan would travel from the South Unionville pump station, located north of Milan, north along State Road 5, passing along the western edge of the proposed reservoir. The 8-inch water pipeline would continue north along State Road 5 into Putnam County, and then turn to the northeast passing along the edge of the community of Lemons, and continuing to north to Unionville. The water supply between Brookfield and Bucklin would be provided by an 8-inch water pipeline, originating from the 16-inch Laclede to Brookfield pipeline. The 8-inch pipeline would travel along U.S. Highway 36 to the east. The pipeline would then turn north to follow Highway 129, and continue north to Bucklin.

a. Land Use and Existing Infrastructure

Phase 3 construction activities will be located in Sullivan County, Putnam County, and Linn County in north-central Missouri. The topography in these counties is similar to other areas in the project vicinity – rolling hills, with numerous intermittent streams. The land use is a mixture of woods and agriculture (pasture or cropped).

Both proposed water pipelines would follow existing roadways; however, the pipelines would be located outside of the highway or road rights-of-way. When crossing through or near communities, the pipelines will follow existing roadways to avoid possible impact to residents. The water pipeline between Brookfield and Bucklin would cross approximately seven light-duty roads. Additionally, the water pipeline between Unionville and Milan would cross approximately 25 light-duty roads. No impact to additional infrastructure encountered along the proposed pipeline corridors would be expected since none would be removed from service.

b. Wetlands

For the proposed pipeline alignment between Unionville and Milan, only a few wetlands and eight watercourses were observed. South Blackbird Creek and Elmwood Creek are two of the larger creeks crossed by the proposed pipeline route.

PEM wetlands are infrequent and apparently restricted to the larger watercourses, such as Elmwood Creek.

Along the proposed pipeline between Brookfield and Bucklin, the alignment crosses about 13 watercourses. Most are small streams; however, both East and West Yellow Creeks are over ten feet wide. PEM and PFO wetlands along this pipeline alignment are rare, being restricted to the larger East and West Yellow Creeks.

c. Threatened and Endangered Species

As mentioned earlier, the only protected species known to occur in Sullivan County are the state and federally endangered Indiana Bat (*Myotis sodalis*) and the state endangered greater prairie chicken (*Tympanuchus cupido*). Protected species known to occur in Linn County are the state endangered eastern massasauga (*Sistrurus catenatus catenatus*), the Indiana bat, and the state and federally endangered northern harrier (*Circus cyaneus*). The state and federally endangered Topeka shiner (*Notropis topeka*) is the only protected species known from Putnam County. Woodlands, pastures, cropland and an occasional rural residence are located adjacent to the highway corridors along the proposed pipeline route. The woodlands were relatively small and sporadically placed within the landscape. Pastures, hay meadows, and crop fields were more prevalent along the route.

The Missouri Department of Conservation's Fish and Wildlife Information System was accessed for detailed descriptions of potential habitat for the protected species known to occur in Linn, Putnam, and Sullivan counties. The potential habitats for the Indiana bat, the greater prairie chicken, the eastern massasaugas, and the northern harriers were discussed previously in Part C.3. and Part D.2.c. Topeka shiners inhabit pools of small streams with clear water, and sand, gravel, or rubble bottoms. Shiners are typically found in clearer vegetated backwaters of streams that are generally less turbid.

Based on the desktop survey and field reconnaissance, there is a potential for habitats for all of the protected species along the existing road rights-of-way. Similar to the proposed Phase 2 construction, the closer the pipeline construction is to the existing corridors and disturbed areas, the less likely the construction would impact potential habitats. However, the farther the construction is away from the existing corridors or disturbed areas, the greater the potential to impact habitats of protected species. If the pipeline is constructed within the highway corridor and all streams and wetlands are directionally drilled, the proposed route will not impact any protected species habitat.

d. Cultural Resources

As with the proposed Phase 2 project construction, the probability of encountering intact cultural deposits in Phase 3 is low based on the proposed routing following existing highway right-of-way. Any sites that may be discovered should be easily avoided, if some route flexibility can be maintained. As before, few, if any, historic structures will be permanently impacted.

E. ENVIRONMENTAL EVALUATION

During the desktop survey and field reconnaissance, the phased development of the proposed reservoir site and supporting water transmission and distribution pipeline alignments were evaluated for social and environmental resources or constraints that could potentially impact the master plan for development. Such factors include cities/communities, existing roadways/highways, threatened and endangered species habitat, wetlands, and probability for cultural resources. Based upon previous experience on similar projects and available information, Burns & McDonnell also preliminarily identified the permits/clearances/approvals that would have to be obtained for the project.

1. Social Impacts

Development of the proposed reservoir would result in the relocation of the entire community of Boynton, including one church. In addition, other homes and non-residential structures located within the proposed reservoir boundaries, along with existing roads and utilities would be relocated, if necessary. Access would be maintained, if applicable, and the present service provided by the utilities would continue. Only one county road would significantly impact existing local access; this road would be relocated to mitigate for and continue the existing level of access. To minimize impact to the existing linear facilities, the transmission water pipelines would follow existing road rights-of-way throughout the proposed project. This action would minimize the possible impacts to most residents and communities.

The proposed reservoir development would have positive benefits to the surrounding communities. It would provide for continued and dependable growth in the region. If drought conditions continue, the proposed reservoir would provide high quality water to meet the regional public health and safety needs, including such services as municipal drinking water, commercial and industrial uses, and fire protection.

Additionally, although the recreational facilities have not been defined nor evaluated in any detail, it is likely that there would be recreation facilities development associated with a reservoir. With this type of development, an obligation to provide enough facilities to provide for public and health safety, including parking off the main roadways, trash facilities, and restroom facilities would normally be addressed.

2. Environmental Impacts

The proposed reservoir and supporting infrastructure would have minimal impact on the land use and existing infrastructure in the regional area. Impact to crops or pastures in the area would be minimal and temporary. Similar impacts to woodlands would occur if tree clearing within the reservoir or along the routes were required.

A total of 198.7 acres of wetlands will be inundated by the proposed reservoir. An additional 73.4 acres of wetlands located between the top of the conservation pool elevation and the top of the flood pool elevation could potentially be impacted. Wetlands and other waters of the United States would be crossed and temporarily impacted along all of the proposed pipeline routes. Impacts to wetlands and streams could be minimized if many of the crossings were directionally drilled.

In general, the proposed pipeline routes may minimally impact protected species or their habitat in both the proposed reservoir site and the proposed pipeline routes. These impacts along the proposed pipeline routes should not result in any long-term impacts to protected species or potential habitats if the pipelines are constructed immediately adjacent to the existing highway corridors and within existing disturbed areas; tree removal is kept to a minimum; and if all perennial streams, riparian habitats, and wetlands are directionally drilled. Impacts to perennial streams and associated riparian habitats along these routes should be avoided. In addition, the pastures and hay meadows along these routes are likely to experience short-term impacts during construction. The impacted pastures and hay meadows should revert back to pre-construction conditions. It is unlikely that construction of the proposed pipelines would result in any permanent impacts to potential habitats; however, construction of any of the pipeline routes may result in the loss of potential roost trees for the Indiana bat. Such impacts to potential habitat by the pipeline construction could be avoided by limiting necessary tree clearing to between October 1 and March 31 to prevent disturbing nesting birds and Indiana bats during the maternity roosting season.

Based on the background and field survey, the area included within the proposed reservoir and Phase 1 pipeline construction is considered a high probability for archaeological sites. With a high potential for buried cultural resources, it could be necessary to perform deep testing at specific locations and have the soils evaluated by a qualified geomorphologist. Burns & McDonnell's experience in these topographic settings indicates that the floodplain and alluvial fans are the only areas that have the potential for deeply buried sites while the hills and ridge toes will likely have little or no deposition (less than 50 centimeters). Based on the available survey information, at least seven archaeological sites for each square mile of the project area would be expected. Additionally, about ten percent of the total number of sites discovered could be determined significant.

With reservoir development, there is a potential for existing historic structures to be adversely affected by construction, wave action or inundation. The number of structures on the floodplain is minimal; however, a number of structures near the proposed conservation pool elevation level could be adversely affected by the project. It is also possible that the APE, which will be determined by the State Historic Preservation Office (SHPO), may be larger than the actual reservoir water area. Each of the sites within the APE would need to be individually evaluated by a qualified architectural historian. If the sites were significant and adversely effected, mitigation may be required. Under some circumstances, a portion of the area might be considered a historic landscape. This request for such an evaluation would be determined by SHPO or a federal agency.

The Phase 2 and 3 proposed pipeline construction will occur primarily along existing road rights-of-way, which are considered to be low probability areas for encountering intact cultural deposits. In addition, any sites that may be discovered can generally be avoided through routing and survey. Based on the desktop survey and recent field review, no historic structures are anticipated to be permanently impacted.

3. Required State/Federal Permits/Clearances/Approvals

Several state and federal permits/clearances/approvals will be required to construct and operate the proposed master plan. State and federal permits will be required for construction of the dam and reservoir, and associated linear support facilities. Based upon readily available information, a generic list of the permits was generated. The list includes the name of the permit and the regulating authority. They include:

- **Dam and Reservoir Safety Program** (Construction Permit and Registration and Safety Permit) – Missouri Department of Natural Resources, Geological Survey and Resources Assessment Division
- **Public Drinking Water Program** (Construction Permit MO780-0701 and Permit to Dispense Water MO780-1089) – Missouri Department of Natural Resources
- **New Service Area Certification** – Missouri Public Service Commission, Water and Sewer Department
- **National Pollution Discharge and Elimination System (NPDES) Stormwater Permit for Construction / Stormwater Pollution Prevention Plan (SWPPP)** – Missouri Department of Natural Resources
- **Agency Coordination** – Missouri Department of Transportation
- **Agency Consultation** – U.S. Department of Agriculture, Natural Resources Conservation Service, Missouri State Office
- **Section 404 of the Clean Water Act** – U.S. Corps of Engineers, Kansas City District
- **Section 401 of the Clean Water Act State Water Quality Certification** – Missouri Department of Natural Resources
- **Federal Threatened and Endangered Species Clearance** (Consultation required by Section 7 of the Endangered Species Act) – U.S. Fish and Wildlife Service
- **State Threatened and Endangered Species Clearance** (Consultation required by Section 7 of the Endangered Species Act) – Missouri Department of Conservation

- **Phase I Cultural Resources Investigation** [under Section 106 of the National Historic Preservation Act of 1966 (as amended)] – Missouri Department of Natural Resources and Archaeological Survey of Missouri

Additional local permits/clearances/approvals may be required from the county or local authorities. Other factors in the permitting process would include consideration that the Missouri Department of Conservation has identified the main stem of Locust Creek as one of the most diverse and high quality streams in north-central Missouri. Additionally, there are possible lands designated as Wetlands Reserve Program within the reservoir site, which may require further consultation with the U.S. Army Corps of Engineers, Kansas City District. The list may be expanded to be more specific or more inclusive as requirements become identified due to project changes or further evaluations.

F. ENVIRONMENTAL CONCLUSION

In conclusion, impacts resulting from the construction of the proposed reservoir would be limited to the inundation of the community of Boynton and existing infrastructure, loss of approximately 200 acres of wetlands, loss of potential roosting and foraging habitats for the Indiana bat, and potential loss of cultural resource sites. Impacts from the construction of the supporting linear facilities would be minimal and temporary. The impacts from the proposed pipeline could be minimized by directional drilling wetlands and stream crossings, and by avoiding possible tree clearing during the Indiana bat maternity roosting season.

Part V

Economical Analysis

PART V

ECONOMIC EVALUATION

A. INTRODUCTION

Included within Table V-1 is the opinion of construction and other costs for the new water supply reservoir and related infrastructure. The cost tables have been broken down into the three phases of the project beginning with the construction of the dam and reservoir and continuing with the expansion of the finished water distribution system in later phases.

Phase One of the construction cost has been broken down into the following categories:

- Dam and Reservoir
- Intake Tower
- Infrastructure Relocation / Construction
- Raw Water Transmission / /Pump Stations / Plant Improvements
- Land Acquisition
- Other Costs

It has been assumed in Phase One of the project that 75 percent of the construction cost for the reservoir and related structures and 100 percent of the engineering cost for these structures will be paid for by the project sponsor. The North Central Missouri Regional Water Supply Commission will be responsible for the remaining 25 percent of the construction costs for the reservoir and related structures and for the total amount of all other costs including construction, engineering and land acquisition.

In general these order-of-magnitude cost opinions presented in Table V-1 are based on experience and judgement as a professional consultant combined with information from past experience, vendors, and published sources, such as Means Construction Cost Guide. Since Burns & McDonnell has no control over weather, cost and availability of labor, material and equipment, labor productivity, construction contractor's procedures and methods, unavoidable delays, construction contractor's method of pricing, economic conditions, government regulations and laws, competitive bidding or market conditions and other factors affecting such opinions or projection, Burns & McDonnell does not guarantee the actual rates, costs, etc. will not vary from the opinions and projections developed herein.

TABLE V-1
NORTH CENTRAL MISSOURI REGIONAL WATER COMMISSION
OPINION OF CONSTRUCTION AND OTHER COSTS
NEW WATER SUPPLY RESERVOIR AND WORKS

Phase One					
Item	**Unit**	**Quantity**	**Unit Cost**	**Total Cost**	**Assumptions**
Dam and Reservoir					
Reservoir Clearing	AC	450	600	270,000	Assumed 30% of permanent pool area requires tree cutting
Clear and Grub for Dam and Spillway	AC	40	1,500	60,000	
Foundation Preparation	CY	60,000	2	120,000	Excavate and recompact 2 feet below entire dam.
Dam Construction					
Slurry Wall	LS	1	305,000	310,000	$5.40/ sf + 35,000 mob. Based on 1000' x 50 feet (50000 sf) - Mozingo costs of $3.85/sf (81,000 sf) escalated to 2004 cost (140%).
Abutment Grouting	LS	1	200,000	200,000	estimate only
Clay Core	CY	190,000	6	1,140,000	$3.00 yd for placement from Ft Smith and $3/yd for exca vation and haul. Minimal processing per Geotech
Chimney and Finger Drains	CY	25,000	13	330,000	Use $8/yd for purchased sand and $5yd/ for placement.
Embankment	CY	720,000	2	1,440,000	FT smith rate was $1/yd. Use $2 due to lower quantities. Majority of material from Auxiliary spillway.
Riprap Upstream Face to 915'	Tons	30,000	20	600,000	to 915' 24" thick. Use rock mined in reservoir.
Principal Spillway					
Drop-inlet and Pipe	LS	1	1,000,000	1,000,000	15' dia culvert with 2' walls x length of 533' = 2110 cy x $500/yd
Stilling Basin	LS	1	400,000	400,000	2/3 cost of Ft. Smith outlet works stilling basin
Auxiliary Spillway					
Excavation	CY	750,000	3	1,880,000	675K yds to dam, 75K yds to waste. Limited blasting required (rippable)
Control Sill	CY	300	375	110,000	2' x 10' x 400'
Seeding and Restoration	AC	300	800	240,000	Assume dam and a portion of cleared area requires seeding.
Subtotal Dam and Reservoir				**8,100,000**	
Construction Contingency @25%				**2,025,000**	
Total Dam and Reservoir				**10,125,000**	
NCMO Share @25%				**2,531,250**	
Sponsor Share @ 75%				**7,593,750**	
Intake Tower					
Concrete (reinforced)					
Tower	CY	310	750	230,000	
Base	CY	90	450	40,000	
30" Intake Screens/Piping	EA	9	9,000	81,000	
24" BFV & Operator	EA	9	11,000	99,000	
Accessories	LS	1	250,000	250,000	
Outlet Pipe	LF	300	700	210,000	
Subtotal Intake Tower				**910,000**	
Construction Contingency @25%				**227,500**	
Total Intake Tower				**1,137,500**	
NCMO Share @25%				**284,375**	
Sponsor Share @ 75%				**853,125**	
Infrastructure Relocation/Construction					
Water Utilities	LF	22,000	5	110,000	From Dick Rhodes
Telephone Utilities	LS	1	50,000	50,000	
Power Utilities	LS	1	100,000	100,000	
Fencing	LF	3	70,000	175,000	
Demolition of Existing Utilities and Roads	LS	1	150,000	150,000	
Subtotal Infrastructure				**585,000**	
Construction Contingency @25%				**146,250**	
Total Infrastructure (100% NCMO)				**731,250**	
Raw Water Transmission					
24-inch Water Line (DIP)	LF	2,190	85	190,000	
36-inch Water Line (DIP)	LF	19,000	125	2,380,000	
Pump Stations					
Elmwood Lake Pump Station	LS	1	700,000	700,000	
Plant Improvements					
30" BFV & Operator	EA	2	11,000	22,000	
Throttling Valve	EA	1	10,000	10,000	
Raw Water Piping	LS	1	80,000	80,000	
Subtotal Transmission, Pumping and Plant				**3,382,000**	
Construction Contingency @25%				**845,500**	
Total Infrastructure (100% NCMO)				**4,227,500**	
Land Acquisition (100% NCMO)				**5,500,000**	Includes Permanent Acquisitions, Flood Storage Easements, Purchase of Houses, Surveys plus 10% contingency on Total
Project Subtotal					
NCMO Subtotal				13,274,375	
Sponsor Subtotal				8,446,875	
NCMO Engineering, Legal @20%				991,750	
Sponsor Engineering and Geotech				2,252,500	Assumed 20% for additional Geotech, Engineering including construction period services
Environmental Permitting, Wetlands Mitigation and Archeological Mitigation (100% NCMO)				1,300,000	Estimate only. All costs to Commission
Project Total					
NCMO Total				**15,566,125**	
Sponsor Total				**10,699,375**	
Total Project (Excluding Treatment Plant)				**26,265,500**	

TABLE V-1 CONT.
NORTH CENTRAL MISSOURI REGIONAL WATER COMMISSION
OPINION OF CONSTRUCTION AND OTHER COSTS
NEW WATER SUPPLY RESERVOIR AND WORKS

Phase Two				
Item	**Unit**	**Quantity**	**Unit Cost**	**Total Cost**
Finished Water Piping				
10-inch PVC	LF	75,000	40	3,000,000
12-inch PVC	LF	94,100	45	4,230,000
16-inch PVC	LF	28,500	55	1,570,000
20-inch PVC	LF	166,500	65	10,820,000
Pump Stations				
Laclede	LS	1	100,000	100,000
Milan	LS	1	200,000	200,000
Plant Expansion				
Expansion to 5.75 MGD	LS	1	3,600,000	3,600,000
Subtotal				23,520,000
Contingency @ 20%				4,700,000
Subtotal				28,220,000
Engineering and Other Costs @ 15%				4,230,000
Total				**32,450,000**

*All costs are in current dollars

Phase Three				
Item	Unit Cost	Quantity	Unit Cost	Total Cost
Finished Water Piping				
8-inch	LF	94,000	35	3,290,000
16-inch	LF	167,000	55	9,185,000
Pump Stations				
Milan	LS	1	100,000	100,000
South of Unionville	LS	1	100,000	100,000
West of Bucklin	LS	1	100,000	100,000
Plant Expansion				
Expansion to 7.53 MGD	LS	1	1,182,141	1,182,000
Subtotal				13,957,000
Contingency @ 20%				2,790,000
Subtotal				16,747,000
Engineering and Other Costs @ 15%				2,510,000
Total				**19,257,000**

*All costs are in current dollars

B. WATER UNIT COST BACKGROUND

The preliminary opinion of the cost to produce finished water is discussed in the following paragraphs. Included in the total cost is debt service for the capital expenditures required for the purchase of the Milan treatment plant and the dam and reservoir development. Also included in the total cost are the annual costs to operate and maintain the plant and the infrastructure system. These annual costs are compared to the estimated annual water use to arrive at a preliminary opinion of water cost per 1,000 gallons of water purchased.

To develop the preliminary opinion unit cost of water associated with raw water from the reservoir and treated water from the Milan plant, Burns & McDonnell made certain assumptions. Table V-2 provides a summary of the key inputs and assumptions pertaining to the Milan treatment plant purchase and to the dam and related structures construction. First, it was assumed the Milan treatment plant will be acquired and operated by the North Central Missouri Regional Water Commission. Total costs for the plant, supplemental pipeline and intake structure are currently estimated at $5,182,700. A portion of the costs for the acquisition of the plant may be offset by grants.

Capital will be required to finance the construction of the dam and related structures. The estimated capital requirement for Phase 1 includes $26,265,000 for dam and spillway construction and for other related structures necessary to transport raw water from the reservoir to the Milan Water Treatment Plant. A portion of the costs for the dam and spillway may be provided through grants with the remaining requirements financed through long term debt. For this analysis, Burns & McDonnell has included grant money covering 75 percent of the cost of construction of the dam, spillway and intake structures. Total grant money is assumed to be in the amount of $10,699,000. Debt to cover the remaining portion of the costs for construction is assumed to be issued for a period of 25 years with an interest rate of 5.00 percent. The estimated capital requirement for Phase 2 is $32,450,000. This estimate will vary based upon whom the commission will serve in the future and what upgrades to the existing infrastructure will be required to meet this new demand for finished water. The additional capital for Phase 2 will be financed through the issuance of long term debt.

TABLE V-2
WATER UNIT COST INPUTS AND ASSUMPTIONS

Starting Year	2004

Water Plant Capital

Milan Plant Purchase Capital Requirement	$3,564,500
Milan Plant Purchase Additional Capital	$482,200
Milan Plant Purchase Grant Funding	$1,214,010
Milan Plant Purchase Capital less Grants	$2,832,690

Supplemental Pipeline & Intake Capital Requirement	$1,136,000
Pipeline & Intake Grant Funding	$0
Pipeline & Intake Capital less Grants	$1,136,000

Interest Rate for Debt Financing	4.75%
Term of Project Financing - years	25

Phase 1 Capital

Investment Year	2005
Dam and Reservoir Construction Capital	$26,265,000
Dam Construction Grant Funding	$10,699,000
Dam Construction Capital less Grants	$15,566,000
Interest Rate for Debt Financing	5.00%
Term of Project Financing - years	25

Phase 2 Capital

Investment Year	2020
Dam and Reservoir Construction Capital	$32,450,000
Dam Construction Grant Funding	$0
Dam Construction Capital less Grants	$32,450,000
Interest Rate for Debt Financing	6.00%
Term of Project Financing - years	25

Plant O&M

Inflation Rate for Labor/Materials	4.0%
Inflation Rate for Energy	2.5%
Energy Unit Cost ($/kWh)	$0.0690
Average Monthly Energy Use (kWh)	55,000
Demand Charge ($/kW)	$206
Average Demand (kW)	8.50
Other Utility Costs (Gas?)	20,000
Plant Labor	$109,100
City Labor Offset (10%)	-$10,900
Routine Maintenance (1% of Plant Capital)	$35,600
Chemical Costs per Thousand Gallons	$0.275
General and Administration Expenses	$125,000
Lake Lease per Thousand Gallons	$0.150
Renewal & Replacement Fund Requirement	$20,000

Dam & Reservoir O&M

Phase 1	$40,000
Phase 2	$150,000

Water Usage

Milan Treated Water	0.350	[1]
Sullivan County #1 Treated Water	0.328	[1]
Green City Treated Water	0.094	[1]
Milan Industrial User Treated Water	0.363	[1]
Other Treated Water Customers (Begin 2011)	0.490	
PSF Raw Water	0.725	[1]
Milan Water Usage Growth	0.70%	
Sullivan County #1 Water Usage Growth	1.30%	
Green City Water Usage Growth	0.25%	
Raw Water Usage Growth (first 10 years)	6.00%	
Raw Water Usage Growth (after 2010)	0.00%	
Milan Industrial User Water Usage Growth	8.00%	
Milan Industrial User Water Usage Growth (after 2010)	0.00%	
Other Treated Water Growth	5.00%	

Return

Return (% of O&M expense, Years 1-5)	5%
Return (% of O&M expense, Years10 and beyond)	10%

[1] 2002 Average MGD

C. WATER UNIT COST CALCULATION

Six different scenarios were developed to analyze the possible unit costs for raw and treated water. These scenarios were developed assuming two different forecast levels of water sales; one with no additional sales to Milan industrial users and one with additional sales to Milan industrial users. These levels of water sales were then used to develop unit cost data assuming the following:

- No grant funding is available to finance the Milan treatment plant
- Assuming grant funding to cover 30 percent of the plant acquisition costs
- Assuming grant funding to cover 50 percent of the plant acquisition costs.

The remaining portion of the plant acquisition costs not covered by grants will be financed through the issuance of debt. The debt is assumed to be for a period of 25 years with an interest rate of 4.75 percent.

The Milan Water Treatment Plant will be owned, operated, and maintained by the Commission. Burns & McDonnell has estimated operation and maintenance costs for the plant based on information pertaining to the current operation of the plant. Appendix C contains tables for each of the six scenarios previously detailed with specific details pertaining to the analysis prepared. The six tables prepared for each of the scenarios are:

- Table 1 – Projected Water Costs
- Table 2 – Inputs and Assumptions
- Table 3 – Forecast of Operation and Maintenance Expenses
- Table 4 – Forecast Energy Expenses
- Table 5 – Projected Debt Expense
- Table 6 – Projected Water Sales

Table 3 provides the forecast of plant operation and maintenance expenses excluding energy expenses under various scenarios. Expenses associated with labor, utilities, routine maintenance, chemicals, and renewal and replacement fund were estimated for this analysis. Included in the estimate is an amount associated with a lease for the City of Milan's lake to the Commission the next five years. This will provide the Commission with a source of water until the dam is constructed and the reservoir is filled to a level necessary for proper operation. Annual operation and maintenance expenses associated with operation of the plant are estimated to be slightly more than $500,000 in the initial year and escalate from that point based on inflation of four percent annually for labor and materials and three percent annually for energy costs. Energy expenses are forecast separately and are provided in Table 4 in Appendix C.

Operation and maintenance expenses associated with the dam and reservoir have also been included in the analysis. These expenses are expected to include mowing of grass on the dam, maintenance of access roads, maintenance for the intake, regular safety inspections, maintenance of fences, etc. and begin at a level of $40,000 in 2005. An additional $150,000 is added to operation and maintenance expenses when Phase 2 is completed within about 20 years.

Water sales to various customers were projected and are provided in Table 6 of each of the scenarios in Appendix C. These projections include treated water sales to the City of Milan, Sullivan County Public Water Supply District No. 1, and Green City and raw water sales to local industry. In three of the six scenarios, projected sales to a Milan industrial user are included. The average daily water usage in 2002 for each of these entities was used as the starting point for forecasting water sales. Treated water sales were forecast to grow annually based on the growth rates for each customer shown in Table V-2 and raw water sales were forecast to grow at a rate of six percent annually.

Table V-3 presents a summary of the projected unit costs associated with the Commission owning and operating the Milan Water Treatment Plant and the construction of the dam and spillway under the six different scenarios. Based on the analysis and assumptions utilized, a resulting average water cost for five year periods is shown. For years 1 to 5, the average treated water cost ranges from a high of approximately $4.10 per 1,000 gallons to a low of approximately $2.77 per 1,000 gallons. The average raw water cost is also shown on Table V-3 and ranges from a high of approximately $2.09 per 1,000 gallons to a low of $1.68 per 1,000 gallons. Over the succeeding ten years unit costs will decrease as the Commission is able to add customers and increase sales of treated and raw water.

TABLE V-3
PROJECTED UNIT WATER COST
WITH TREATMENT PLANT PURCHASE AND DAM CONSTRUCTION

		Years 1 - 5 $/1000 gal	Years 6 - 10 $/1000 gal	Years 11 - 15 $/1000 gal	Years 16 - 20 $/1000 gal	Years 21 -25 $/1000 gal
Scenario 1	**No Milan Industrial User, No Grants**					
	Including Phase 1 & 2 Capital					
	Treated Water	4.10	3.39	2.90	4.68	4.92
	Raw Water	2.09	1.67	1.43	3.21	3.46
Scenario 2	**No Milan Industrial User, With 30% Plant Grant**					
	Including Phase 1 & 2 Capital					
	Treated Water	3.80	3.17	2.75	4.54	4.80
	Raw Water	2.09	1.67	1.43	3.21	3.46
Scenario 3	**No Milan Industrial User, With 50% Plant Grant**					
	Including Phase 1 & 2 Capital					
	Treated Water	3.61	3.02	2.64	4.45	4.72
	Raw Water	2.09	1.67	1.43	3.21	3.46
Scenario 4	**With Milan Industrial User, No Grants**					
	Including Phase 1 & 2 Capital					
	Treated Water	3.09	2.04	1.88	3.14	3.40
	Raw Water	1.68	1.08	0.96	2.19	2.41
Scenario 5	**With Milan Industrial User, With 30% Plant Grant**					
	Including Phase 1 & 2 Capital					
	Treated Water	2.90	1.94	1.80	3.07	3.33
	Raw Water	1.68	1.08	0.96	2.19	2.41
Scenario 6	**With Milan Industrial User, With 50% Plant Grant**					
	Including Phase 1 & 2 Capital					
	Treated Water	2.77	1.88	1.75	3.02	3.29
	Raw Water	1.68	1.08	0.96	2.19	2.41

1. Initial Projected Water Unit Cost

It was recommended in the Feasibility Study previously completed by Burns & McDonnell Engineering, that the Commission purchase the Milan Water Treatment Plant. Along with this recommendation, other action items were recommended to the Commission to complete in the preliminary stages of the water supply project. The preliminary water unit cost is based on the Commission completing the items listed below

- Purchase of the Milan Water Treatment Plant.
- Leasing the rights to take raw water from Elmwood Lake from the City of Milan.
- Purchasing the new supplemental intake and pipeline from Locust Creek to Elmwood Lake.
- Providing finished water to the charter members of the Commission and local industries at the average rate 1.86 MGD in 2004.

Table V-4 presents a summary of the projected unit costs associated with the Commission owning, operating, and maintaining the Milan treatment plant. Based on the above stated criteria and projected sale of finished water to the charter members of the Commission, the opinion of charges required for finished water will range from a high of approximately $2.60 per 1,000 gallons to a low of approximately $1.60 per 1,000 gallons of water purchased for the first five years of operation. Over the succeeding ten years unit costs will decrease as the Commission is able to add customers and increase sales of treated water.

2. Projected Phase One Water Unit Cost

Phase One of the Master Plan includes the construction of the new water supply reservoir and appropriate facilities for the proposed reservoir located on the East Fork Locust Creek. This phase also includes:

- A Water supply intake in the reservoir.
- A raw water transmission main to the Milan Water Treatment plant and to Elmwood Lake from the new reservoir.
- Relocation of existing finished water mains within the reservoir area.
- Piping modifications to the existing Milan Water Treatment Plant.

TABLE V-4
PROJECTED UNIT WATER COST
WITH TREATMENT PLANT PURCHASE ONLY

		Years 1 - 5 $/1000 gal	Years 6 - 10 $/1000 gal
Scenario 1	**No Milan Industrial User, No Grants**		
	No Phase 1 & 2 Capital		
	Treated Water	2.61	2.08
	Raw Water	0.60	0.37
Scenario 2	**No Milan Industrial User, With 30% Plant Grant**		
	No Phase 1 & 2 Capital		
	Treated Water	2.31	1.87
	Raw Water	0.60	0.37
Scenario 3	**No Milan Industrial User, With 50% Plant Grant**		
	No Phase 1 & 2 Capital		
	Treated Water	2.12	1.72
	Raw Water	0.60	0.37
Scenario 4	**With Milan Industrial User, No Grants**		
	No Phase 1 & 2 Capital		
	Treated Water	1.91	1.21
	Raw Water	0.51	0.25
Scenario 5	**With Milan Industrial User, With 30% Plant Grant**		
	No Phase 1 & 2 Capital		
	Treated Water	1.72	1.11
	Raw Water	0.51	0.25
Scenario 6	**With Milan Industrial User, With 50% Plant Grant**		
	No Phase 1 & 2 Capital		
	Treated Water	1.60	1.05
	Raw Water	0.51	0.25

- Provide finished water to the charter members of the Commission and local industries at the average rate of 1.86 MGD beginning in 2004 increasing to 2.21 MGD in 2008.

Based on the above stated criteria and projected sale of finished water to the charter members of the Commission, the opinion of charges required for finished water will range from a high of approximately $4.10 per 1,000 gallons to a low of approximately $2.77 per 1,000 gallons of water purchased for the first five years of operation. Over the succeeding ten years unit costs will decrease as the Commission is able to add customers and increase sales of treated water. In years 11 through 15 the charges for finished water will range from a high of approximately $2.90 per 1,000 gallons to a low of approximately $1.75 per 1,000 gallons of water purchased.

3. Projected Phase Two Water Unit Cost

Phase Two construction includes:

- The construction of a new finished water distribution system to provide finished water to the future customers of the Commission.
- The construction of three finished water pump stations to provide water to these future customers.
- Expansion of the Milan Water Treatment Plant to meet the projected increase in water demand.
- Provide finished water to the charter members of the Commission and local industries at the average rate of 3.61 MGD in 2010.

In Phase Two of the water supply project, it is projected additional customers will be served by the Commission. With this additional sale of water included, the opinion of charges required for treated water increase to cover the additional capital expenditures but would be spread out to an increased volume. Unit costs would range from a high of $4.68 per 1,000 gallons to a low of $3.02 per 1,000 gallons of water purchased when Phase Two is completed.

4. Phase Three

Since Phase Three is projected 40 years into the future, an opinion of water cost at this time would not be practical and thus is not included within the Master Plan

D. PROJECTED RAW WATER UNIT COST

It is projected in Phase One of the water supply project the Commission will provide wholesale raw water to local industries. The unit cost of water is based primarily on debt retirement and annual operating costs compared against the estimated annual water use. The preliminary opinion charges required for raw water will range from a high of $2.09 per 1,000 gallons to a low of $1.68 per 1,000 gallons of water pumped to their industrial water plant. With the completion of Phase One and Phase Two, unit costs for raw water will increase.

APPENDIX

Appendix A

Subsurface Exploration and Preliminary Geotechnical Report

SUBSURFACE EXPLORATION AND

PRELIMINARY GEOTECHNICAL REPORT

SULLIVAN COUNTY DAM

SULLIVAN COUNTY, MISSOURI

Job No. 1025193

June 14, 2002

7802 Barton, Lenexa, Kansas 66214 (913) 962-0909/0924 fax (800) 930-4960 www.geosystemseng.com

GeoSystems
A KLEINFELDER COMPANY
employee owned

June 14, 2002

Mr. David Silverstein
Burns & McDonnell
P.O. Box 419173
Kansas City, Missouri 64141

RE: Subsurface Exploration and
Preliminary Geotechnical Report
Sullivan County Dam
Sullivan County, Missouri
Job No. 1025193

Dear David:

GeoSystems Engineering, Inc. has completed the authorized subsurface exploration and preliminary geotechnical engineering evaluation for the above project. The purpose of the exploration was to obtain information on subsurface conditions within the proposed dam and reservoir areas and, based on this information, to provide preliminary geotechnical recommendations for the design and construction of the proposed dam.

In summary, the primary geotechnical engineering concerns for this project are the presence of high permeability sands at the proposed dam location that could allow significant underseepage below the dam and the presence of a relatively shallow water table in the valley floor, making it more complex to maintain stable excavations. With the recommended site preparation procedures, the site should be suitable for the proposed dam, from a geotechnical standpoint.

The enclosed report describes our exploratory procedures and presents the results of the testing and evaluation, along with design and construction recommendations for this project. We appreciate the opportunity to work with you on this project and are prepared to provide the recommended construction services.

Respectfully submitted,
GeoSystems Engineering, Inc.

Steve Wendland

Steve Wendland, P.E.
Engineering Manager

Glen Ferguson

Glen Ferguson, Ph.D., P.E.
Chief Regional Geotechnical Engineer

SW/GF:sw

SUBSURFACE EXPLORATION AND PRELIMINARY GEOTECHNICAL REPORT

SULLIVAN COUNTY DAM

SULLIVAN COUNTY, MISSOURI

Job No. 1025193

June 14, 2002

INTRODUCTION

GeoSystems Engineering, Inc. (GeoSystems) has completed the authorized subsurface exploration and preliminary geotechnical engineering evaluation of the proposed dam site. The services provided were in accordance with our proposal dated March 6, 2002. The subsurface exploration consisted of ten borings conducted along or near the proposed centerline of the dam, within the reservoir area, and in potential borrow areas upstream and downstream of the dam. The primary objectives of this study were to evaluate the subsurface conditions at the site, and based on that information, to provide preliminary geotechnical recommendations for the design and construction of the proposed dam. A final geotechnical report will be prepared after more specific information is developed for the proposed project.

PROJECT INFORMATION

We understand that the project will consist of constructing an earth dam with a maximum height of approximately 70 feet and a total crest length of 1,500 to 2,000 feet. The normal pool would have 50 to 60 feet maximum water depth. The proposed dam location (Dam Site 3B) is approximately 5 miles north-northeast of Milan, Missouri. The dam would be constructed across the Locust Creek valley. Geometry of the dam embankment has not yet been developed. The borrow source for the embankment would likely be from within the reservoir area or just downstream of the dam. No detailed site plan drawings are available yet, but a general layout of the project is presented on Figure 1 in the Appendix.

DRILLING AND SAMPLING PROCEDURES

GeoSystems carried out the fieldwork for this study on May 21 and 28 to 30, 2002. The subsurface exploration consisted of ten borings conducted along or near the proposed centerline of the dam, within the reservoir area, and in potential borrow areas upstream and downstream of the dam. The borings extended to depths of 18.4 to 48.0 feet below existing grades. Boring locations are shown on Figure 1 in the Appendix.

Representatives of GeoSystems established the boring locations after the centerline of the dam had been staked by others. Once the field work was completed, representatives of Rhodes Engineering surveyed the boring locations and determined the ground surface elevations at each of the boring locations. The elevations indicated on the boring logs are based on data from the survey work.

The borings were performed with truck-mounted and track-mounted, rotary drill rigs using solid-stem augers to advance the boreholes. Representative samples were obtained by Shelby tube and split-barrel sampling procedures in accordance with ASTM D 1587 and D 1586, respectively. The Shelby tube sampling procedure utilizes a thin walled, steel tube with a sharp cutting edge that is pushed into the bottom of the boring to obtain relatively undisturbed samples of cohesive or moderately cohesive soils. The split-barrel sampling procedure utilizes a standard 2-inch O.D. split-barrel sampler that is driven into the bottom of the boring with a 140-pound hammer falling a distance of 30 inches. The number of blows required to advance the sampler the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Resistance Value (N). These "N" values are indicated on the boring logs at their depths of occurrence and provide an indication of the relative hardness of bedrock units. In addition, bulk soil samples were collected from the potential borrow area borings.

The samples were sealed and returned to our laboratory for further examination, classification and testing. Boring logs presented in the Appendix of this report present such data as soil and bedrock descriptions, consistency and relative hardness evaluations, boring depths, sampling intervals and observed groundwater conditions. Conditions encountered in each of the test borings were monitored and recorded by the drill crew. The field logs included visual classification of the materials encountered during drilling as well as drilling characteristics. Our final logs represent an interpretation of the field logs combined with laboratory observation and testing of the samples.

TESTING PROGRAM

Unconfined compression, water content and density tests were performed on representative portions of the undisturbed samples obtained by the Shelby tube sampler. A calibrated hand penetrometer was used to determine the approximate unconfined compressive strength when samples were deformed or of insufficient size for performing an unconfined compression test. Moisture contents of the disturbed samples obtained from the spilt-barrel sampler were also determined. Results of the laboratory tests are presented on the respective boring logs.

Atterberg limits tests were conducted on representative samples. These tests provide information on the plasticity of the soil, which is a basis for soil classification and for estimating the potential of subgrade soils to change volume with variations in moisture content. Results of these tests are also indicated on the respective boring logs.

Laboratory tests were also conducted on bulk samples, representative of the soils encountered within the reservoir and potential borrow areas. Testing of the bulk samples included standard Proctor compaction, Atterberg limits, and unconfined compression on remolded, recompacted samples. Moisture density relationships of the materials were determined in accordance with ASTM D 698 (Standard Proctor compaction). For the unconfined compression tests, samples were remolded at various moisture contents at approximately 95 percent compaction (per the standard Proctor tests), then tested for unconfined compressive strengths. Results of these tests are provided in the Appendix of this report.

All samples were classified by the geotechnical engineer using visual and manual procedures. The samples were classified in accordance with the General Notes included in the Appendix of this report. The bedrock units encountered in the borings were described in accordance with the enclosed General Notes for Bedrock on the basis of visual classification of disturbed auger cuttings, split-barrel samples, and drilling characteristics. Core samples may reveal other rock types.

SITE CONDITIONS

The proposed dam site is approximately 5 miles north-northeast of Milan, Missouri, and will be in the Locust Creek valley. Locust Creek flows from the north to the south. Relief of approximately 70 feet is present from the bottom of the creek channel to the top of the ridges to the west and east.

The ground surface along the ridge east of the dam site is rolling hills with moderate to gentle slopes that are covered with tall grass or pasture land. Groves of trees are present in some areas. County Road RA runs along the ridge east of the proposed dam centerline. A house and farmstead are present on the east ridge, north of the proposed dam centerline. The ground surface along the ridge west of the dam site is more steeply sloped and is thickly wooded.

The valley floor is relatively level and is approximately 400 feet wide (from the toe of the west valley wall to the toe of the east valley wall) along the proposed dam centerline. Locust Creek has a meandering channel that is located in the western portion of the valley floor. Along the creek banks and to the west of the creek, the site is thickly wooded. To the east of the creek, the ground is covered with tall grass or is pasture land. At the time of our site visits in May 2002, the ground surface over much of the valley floor east of the creek and south of the proposed dam centerline was soft and swampy. Surface drainage was very poor in this area, with water ponded in many areas. An abandoned railroad grade, running north-south, is present along the western edge of the valley floor.

The creek channel has relatively steep banks, approximately 5 to 12 feet tall. The banks have little or no vegetation.

No rock outcrops were observed on the valley walls or within the creek channel. No rock fragments were observed within the creek bed.

SUBSURFACE CONDITIONS

Specific subsurface conditions encountered at the boring locations are presented on the respective boring logs. Sections 1 and 2 in the Appendix depict the generalized subsurface profile along the centerline of the dam alignment and across the valley floor (Section 1), and along the ridge east of the proposed dam location (Section 2) based on information obtained from the borings. The stratification lines shown on the logs and sections represent the approximate boundaries between soil and rock types; in-situ, the transitions may be gradual. The following discussion presents a descriptive summary of the major strata encountered during the exploration program.

Valley Floor

Borings B-6 and B-10 were located within the valley floor. Borings B-4 and B-5 were located at the edges of the valley floor, but appear to have not encountered any alluvial soils, and therefore are discussed elsewhere. Section 1 in the Appendix presents a generalized subsurface profile across the valley floor.

Borings B-6 and B-10 encountered 0.4 to 0.5 feet of topsoil at the ground surface. The topsoil was underlain by dark gray brown silty lean clay, with a trace to some sand, that continued to a depth of approximately 6 feet in the borings. The lean clay exhibited a medium to stiff consistency, based on tactile evaluation and results of laboratory tests completed on samples recovered from the borings. This soil appeared to be alluvium that had been deposited by the creek. Below the lean clay stratum, the borings encountered variable subsurface conditions consisting of interlayered alluvial sands, silts, and clays. The clay and silt soils had variable sand contents and were primarily very stiff above the water table, becoming soft to medium below the water table. The sands were primarily fine grained and had variable clay content. The variable interlayered alluvial soils continued to a depth of approximately 19.5 to 19.7 feet in the borings.

The interlayered alluvial soils were underlain by gray alluvial sands. The sand was fine grained with a variable clay content. Boring B-10 was terminated within the alluvial sand at a depth of 20.0 feet. Below a depth of 28.5 feet in Boring B-6, the sand was noted to have a trace gravel. The alluvial sands continued to a depth of approximately 38.5 feet in Boring B-6.

In Boring B-6, the alluvial sands were underlain by highly weathered shale bedrock. The shale was approximately 0.5 feet thick and was underlain by 2 feet of weathered limestone bedrock. At a depth of 41.0 feet, the weathered limestone was underlain by maroon shale bedrock. The shale was moderately hard to hard and had calcareous seams. Standard penetration tests completed in the shale resulted in N values of 50 blows for 0 penetration. The shale continued to the bottom of Boring B-6 at a depth of 48.0 feet.

Ridge East of Valley

Borings B-1, B-2, B-3, B-7, B-8, and B-9 were located along the centerline of the dam on the ridge east of the valley, within the reservoir area of this ridge, and downstream of the dam centerline on this ridge. Boring B-4 was located at the toe of the ridge, along the eastern limit of the valley floor. Section 2 in the Appendix presents a generalized subsurface profile along this east ridge.

The borings encountered 0.2 to 0.5 feet of topsoil at the ground surface. In most of the borings, the topsoil was underlain by a 0.5 to 0.9 feet thick layer of dark brown lean clay. This lean clay is likely a well developed "B horizon" soil just below the topsoil.

In Borings B-4 and B-9, the topsoil and "B horizon" soil were underlain by yellow brown, gray brown, and brown lean clay that exhibited a medium to very stiff consistency. This soil continued to depths of approximately 2.5 to 7.0 feet and appears to be loess, a wind deposited soil.

The lean clay in Borings B-4 and B-9, and the topsoil and "B horizon" soil in the remaining borings were underlain very stiff, yellow brown, gray, and brown fat clay and lean to fat clay. The fat clay contained a trace sand and trace gravel, with seams of fine sand and sandy clay. This fat clay soil appears to be weathered glacial till. Glacial clay deposits frequently contain isolated pockets of water-bearing sands and gravel, as well as cobbles and large boulder-sized materials. The sand seams and lenses are generally of limited lateral extent. Boring B-9 was terminated in the fat clay till soil at a depth of 20.0 feet. In the remaining borings, the fat clay till soils continued to depths of approximately 8.5 to 26.0 feet below current grades.

In Boring B-8, the glacial till was underlain by residual fat clay soils at a depth of approximately 9.5 feet. The fat clay was brown, very stiff, with some sand. This residual soil appeared to have weathered from a sandy shale and continued to a depth of approximately 14.0 feet.

In Boring B-4, the glacial till was also underlain by residual fat clay soils at a depth of approximately 18.5 feet. The fat clay was olive gray and hard, and continued to a depth of approximately 21.5 feet.

In Borings B-1 and B-2, the fat clay till discussed above was underlain by what appeared to be unoxidized glacial till. This deeper till consisted of dark gray fat clay soils with variable sand and gravel contents, occasional sand seams, and a hard consistency. Standard penetration tests completed in this deeper till resulted in N values of 59 to 90 for 11 inches of penetration. This deeper till continued to the bottom of Boring B-1 at a depth of 34.4 feet.

Below the glacial till and residual clay soils, the borings encountered interlayered gray shale and yellow brown sandstone bedrock at depths of approximately 8.5 to 32.0 feet below current grades. In general, the upper 2 to 6 feet of bedrock was weathered. Degree of weathering decreased with depth and relative strengths increased. The sandstone units were typically poorly cemented. The shale units encountered were typically moderately hard, becoming hard with depth. Standard penetration tests completed in the sandstone and shale resulted in N values ranging from 45 to 50 blows for 0 penetration. The interlayered sandstone and shale continued to the planned depths of Borings B-2, B-3, B-4, B-7, and B-8 at depths of 18.4 to 33.4 feet.

Ridge West of Valley

Boring B-5 was located at the toe of the ridge west of the valley, along the abandoned railroad grade near the centerline of the dam. No other borings were drilled in this area, as the area is heavily tree covered and inaccessible to our drilling equipment.

Boring B-5 encountered gravel fill at the ground surface. The gravel fill continued to a depth of 3.0 feet and appeared to be ballast from the abandoned railroad grade where the boring was located. The gravel fill was underlain by highly weathered shale bedrock. The shale was maroon, soft, and had a blocky texture. The shale became less weathered and moderately hard with depth. Below a depth of 6.0 feet, the shale became maroon and gray to light gray. Standard penetration tests completed in the sandstone and shale resulted in N values ranging from 33 to 50 blows for 5 inches of penetration. The shale continued to the bottom of the boring at a depth of 24.0 feet.

GROUNDWATER OBSERVATIONS

Groundwater observations were made both during and after completion of drilling operations. All of the borings that were located in higher elevation areas (Borings B-1, B-2, B-3, B-7, B-8, and B-9) remained dry and no visible groundwater seepage was observed. The materials encountered in these test borings have relatively low permeabilities and observations over an extended period of time through use of piezometers or cased borings would be required to better define current groundwater conditions.

The borings located in the valley floor area (Borings B-4, B-5, B-6, and B-10) encountered groundwater at depths of approximately 2.0 to 12.0 feet while drilling. After drilling was completed in these borings, the groundwater level stabilized at depths of 4.0 to 16.5 feet below grade (elevation 856 to 865 feet). These groundwater levels are likely indicative of the groundwater table that is present within the valley and are likely controlled by the water level in the creek. The borings located in the valley encountered sands that were relatively permeable and the observed water levels should closely reflect groundwater conditions that existed at the time the borings were drilled.

The composition of the glacial soils is often erratic due to the random nature of its deposition. Glacial deposits frequently contain isolated pockets of water-bearing sands and gravels. Water-bearing lenses within natural glacial deposits are generally limited in extent. Even though the borings encountered no groundwater in higher elevation areas, excavations in those areas may encounter such lenses. The excavations would typically experience a sudden influx of groundwater due to the high permeability of the materials within the lens. If not fed by an outside source (i.e., the creek), the rate of flow should diminish rapidly as the lens is drained.

Fluctuations of groundwater levels can occur due to seasonal variations in the amount of rainfall, runoff, creek level and other factors not evident at the time the borings were performed. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

ANALYSIS AND RECOMMENDATIONS

In summary, the primary geotechnical engineering concerns for this project are the presence of high permeability sands at the proposed dam location that could allow significant underseepage below the dam and the presence of a relatively shallow water table in the valley floor, making it more complex to maintain stable excavations. With the recommended site preparation procedures, the site should be suitable for the proposed dam, from a geotechnical standpoint.

Underseepage Below Dam

Underseepage of dams is not an uncommon occurrence. The potential for underseepage at the proposed project site is increased by the presence of sandy alluvial soils and glacial till with sand and gravel seams that extend beneath the proposed centerline of the dam. Water seeping from the reservoir would flow downstream through these high permeability soils, under the dam (or under the ridges to the east and west of the reservoir), discharging at some low elevation area or seeping back up to the ground surface downstream of the dam. There is also a potential that such seepage could cause springs to develop in the valleys to the east and west of the proposed reservoir, but that is much less likely as the flow distance would be much greater (over 1,000 feet). The primary seepage loss would be through the alluvial deposits within the stream valley.

To limit the potential for underseepage, remedial measures should be completed under the dam centerline. Preliminarily, two measures are recommended. It is recommended that a seepage cut-off trench be excavated below the dam and backfilled with low permeability fill. The fat clay soils present at the site would be suitable for use as the low permeability fill.

The water table within the valley floor is relatively shallow, and the alluvial sands were encountered well below the water table. Therefore, excavation to the bottom of these sands would be quite deep and very difficult to dewater. Therefore, any seepage cut-off trench utilized for this project could only be constructed to a relatively shallow depth without wellpoints to control groundwater levels. For preliminary design purposes, it is recommended that a seepage cut-off trench be planned along the centerline of the dam. The trench should be excavated to a depth of 7 to 10 feet below current grades, for a width of approximately 12 feet at the bottom of the trench, and be backfilled with fat clay soils as recommended below in the Embankment Fill section of this report. The cut-off trench should be continued into both abutments to the top of the embankment.

To limit seepage below the cut-off trench, it is recommended that a grout curtain be installed below the centerline of the dam. The grout curtain would consist of a single curtain made up of three parallel lines of grout holes, each line approximately 10 feet apart. The grout holes would be placed at a spacing of 5 to 8 feet along the lines. Each line would have of primary, secondary and perhaps tertiary grout holes. The grouting should be continued down to top of bedrock (as deep as approximately 40 feet). The bedrock units are primarily lower permeability shale, and little seepage is expected through the bedrock. Therefore, no grouting within the bedrock is anticipated to be necessary. The curtain should extend at least 30 feet past each end of the dam. The grout curtain would greatly reduce the seepage under the dam by sealing sand and gravel deposits that would otherwise provide rapid flow paths for groundwater. As an alternate to the grouting, consideration could be given to the use of a slurry trench cut-off. The slurry trench should extend to the top of bedrock and should be continued into both abutments. More complete details of the grouting or slurry trench could be worked out during final analysis for the dam.

A detailed seepage analysis should be completed as part of the final analysis and design of the dam. The analysis would determine if the internal drains would be sufficient to control internal seepage and if the planned seepage cut-off trench and grout curtain would also be sufficient to limit underseepage.

Seepage within Embankment

The water impounded in the reservoir will eventually seep into the embankment. Such seepage can destabilize the downstream face of the dam or cause internal erosion (piping). To control the internal seepage, it is recommended that a chimney drain be constructed just downstream of the core of the dam, and that a blanket drain be constructed within the downstream shell. The chimney drain would consist of an approximately 6 feet thick layer of sand placed on the downstream side of the low permeability core of the dam. The chimney drain would extend vertically from the bottom of the seepage cutoff trench to within approximately 5 to 8 feet of the top of the dam. The blanket drain would be an approximately 4 feet thick layer of sand starting just above the downstream toe of the dam and continuing at a slight grade up from horizontal until it intercepts the chimney drain. These two drains would collect water from within the dam, limiting seepage forces on the downstream shell and piping of the embankment fill. For preliminary purposes, common river sand or masonry sand can be assumed to be a proper filter gradation for use in the internal drains. Water discharging from the blanket drain at the downstream toe of the dam would be collected by a ditch along the downstream toe of the dam and directed toward the creek channel.

Stabilitv of Embankment Slopes

Slope stability analysis will be completed as part the final analysis and design of the dam. The analysis should consider end-of-construction, long term, and seismic cases for both the upstream and downstream slopes of the dam for normal pool levels. A sudden drawdown analysis should also be completed for the upstream face. If maximum pool levels will be held for extended periods of time after heavy rains (more than several days), then additional analysis using the higher reservoir levels should be considered. Acceptable minimum factors of safety should be in accordance with State and US Army Corps of Engineers standards.

For preliminary plans, upstream and downstream slopes for the dam to be constructed from the local clay soils should be constructed at 2.5 Horizontal to 1.0 Vertical (2.5H:1V) or flatter in the upper 20 feet of the embankment, and at 3.0H:1.0V or flatter in the lower portion of the dam. Use of the steeper slopes in the upper portion could greatly reduce the volume of fill required to construct the dam, but would be harder to maintain. Slopes steeper than 3H:1V do not hold vegetation as well and can not be easily mowed. The preliminary recommendation for use of slopes steeper than 3H:1V is based on the results of laboratory tests completed on samples of the on-site clay soils. Standard Proctor tests (results in the Appendix) indicate that the on-site glacial till and alluvial soils can compact to relatively high dry densities. Also, tests on remolded, recompacted samples of the on-site glacial till resulted in relatively high unconfined compressive strengths, as summarized in Table 1 and again in the Appendix. As expected, the strength is higher at lower moisture contents. The Embankment Fill section of this report provides recommendations for placement and compaction of the embankment fill.

Percent Compaction (relative to max. dry density)	Moisture (relative to optimum)	Unconfined Compressive Strength
95.1 %	-3.2 %	8,990 psf
96.0 %	-0.8 %	7,280 psf
95.6 %	-0.1 %	5,890 psf
95.7 %	+2.4 %	3,630 psf

Table 1. Unconfined Compressive Strength Tests on Remolded, Recompacted On-Site Glacial Till Clay. Sample tested was composited auger cuttings from Borings B-8 and B-9 from depths of 1 to 18 feet.

Further testing and the stability analysis that will be conducted during the final phase of the design will be used to develop the final recommendations for dam geometry. The testing should include testing of the long-term (drained) strength of the clay fill material.

The upstream slope face will require armoring with riprap at, above, and below the anticipated pool levels to prevent erosion by waves splashing on the dam. Gradation and thickness of the riprap material should be addressed in the final design using Corps of Engineers methods that consider the anticipated wind speeds, surface area, and fetch of the reservoir. The downstream slope face should be revegetated as soon as possible, and the vegetation should be well maintained, to prevent erosion on the downstream dam face.

Site Preparation

Site preparation should commence with stripping of all topsoil and vegetation within the dam area. Stripping depths of approximately 2 to 6 inches are anticipated. However, depths should be adjusted to remove all vegetation and root systems. A representative of GeoSystems should monitor the stripping operations to observe that all unsuitable materials have been removed. Soils removed during site stripping operations could be used for final grading on the downstream face of the dam. Care should be exercised to separate these materials to avoid incorporation of the organic matter in embankment fill sections.

Any required tree removal should also be accomplished at this time. Care should be taken to thoroughly remove all root systems. Materials disturbed during removal of stumps should be undercut and replaced with structural fill.

Special attention should be paid to the presence of high permeability zones, such as sand or gravel seams observed in fill subgrades. Additional undercutting may be required in areas where sand or gravel soils are exposed.

In those areas where soil is exposed, outside of the cut-off trench area, the soil should be scarified to a depth of at least 9 inches and compacted with a pad foot roller prior to placement of the embankment fill. Soft or unstable areas should be undercut and replaced with controlled structural fill. The exposed subgrade should be evaluated to determine whether moisture contents are within the recommended range and to identify areas disturbed during site stripping. Unsuitable or disturbed areas should be undercut and replaced with structural fill. Partial or complete removal of materials may be required depending upon the extent and consistency of the materials encountered.

Boring B-5 encountered shale bedrock at a relatively shallow depth. No permeable bedrock units (limestone or sandstone) were encountered at shallow depths. If, during construction, permeable bedrock units are found to be outcropping in the reservoir area, then the rock should be covered with a compacted fat clay blanket having a minimum of thickness 24 inches.

Where fill is being placed on slopes steeper than 5H:1V, the existing slopes should be benched as fill placement progresses. These benches should be vertically stepped no more than 2 feet. This procedure would better key the fill into the original slopes and will facilitate compaction of the fill.

Excavations

It is anticipated that excavations at the site will be in clay and sand soils above and below the water table. In some areas, such as near Boring B-5, some excavations may encounter weathered shale bedrock. If water seepage is encountered within excavations at higher elevations, the use of temporary dewatering techniques such as sump pumps should be sufficient to dewater the short-term excavations. Below the water table, excavations will likely encounter significant inflow of water and will require more complex dewatering systems such as well point systems to limit the groundwater seepage.

Temporary construction slopes should be designed in strict compliance with the most recent governing regulations. Excavations should be cut to a stable slope or be temporarily braced, depending on the excavation depths and the subsurface conditions encountered. Stockpiles should be placed well away from both the edge of the excavations and crest of the slopes, and their height should be controlled so they do not surcharge the sides of the excavation and/or overall slope. Surface drainage should be carefully controlled to prevent flow of water into the excavations. Construction slopes should be closely observed for signs of mass movement: tension cracks near the crest, bulging at the toe, etc. If potential stability problems are observed, the geotechnical engineer should be immediately contacted. The responsibility for excavation safety and stability of temporary construction slopes should lie solely with the contractor.

Excavation of the soil will be possible with conventional excavation equipment. Soft, highly weathered shale bedrock with a Standard Penetration Resistance (N) value of less than 25 blows per foot can also generally be excavated with conventional heavy equipment such as backhoes, loaders, etc.

Excavation of harder, less weathered shales will most likely be difficult and will require the use of pneumatic breakers, or other rock excavating techniques to complete the excavations. Excavation of the harder shale in confined excavations will most likely be difficult.

The sand, silty clay, and sandy clay soils encountered at this site are highly susceptible to erosion. Excavations in these materials that are left open for even short durations may experience some form of failure such as sloughing of the sides or the excavation. Measures should be taken to stabilize the sides of the excavations. Such measures may include interception and diversion of surface water, placing a fabric over the material and/or bracing the sides of the excavations. If side slopes are not stabilized, reworking of the excavation should be anticipated.

Borrow Sources and Embankment Fill

It is anticipated that the primary borrow source will be the ridge east of the valley, within the reservoir area (near the areas of Borings B-7 and B-8 as shown on Figure 1 in the Appendix). Excavating the glacial till soils present in this area as a borrow source would increase reservoir volume and would be very close to the embankment. The east ridge downstream of the dam, near the location of Boring B-9, also has glacial till soils that would be a suitable borrow source, but this area is slightly further away and would not increase the reservoir volume. Bedrock is relatively deep in this area; so a sufficient volume of borrow should be available.

The glacial till soils are naturally in a very dense state. Based on the results of the standard Proctor compaction test and the measurement of in-situ density, a shrinkage value of 1.1 is recommended when evaluating borrow volumes, indicating that the natural soils will be at close to the same density as the compacted fill.

Although compaction tests on the alluvial soils indicate that it would also be suitable for use as borrow material, with the relatively shallow water table these soils would be excavated in a wet condition which would require additional processing before being placed as fill. Also, the borrow excavation would require continual dewatering. Therefore, it is not recommended that any borrow pits be planned within the valley floor.

As the subsurface investigation was limited on the western portion of the site, it can not be determined at the present time if suitable borrow soils are present in significant volume in the areas west of the creek.

Embankment fill should consist of a mixture of inorganic lean clays (CL) and/or fat clay (CH) soils having a clay content of at least 25% and a Liquid Limit of 35% or greater. All fill should consist of approved materials, free of organic matter and debris. Based on analysis of the samples obtained from the borings, it appears that either the alluvial soils or the glacial till soils would meet this criteria. Further testing would be necessary to develop design parameters (shear strength, permeability) of these soils.

Embankment fill should be placed in controlled lifts having maximum loose lift thickness of 9 inches. All embankment fill should be compacted to a minimum of 95 percent of the material's maximum dry density as determined by ASTM D-698 (Standard Proctor compaction). For preliminary purposes, the fill should be divided into two categories, the internal core that will provide a low permeability zone, and the upstream and downstream shells that provide a higher strength material to support the fill slopes. The moisture content of the fill placed within the central core of the embankment at the time of compaction should be within a range of 0 to 4 percent above optimum moisture content as defined by the Standard Proctor compaction procedure. For the upstream and downstream shells, the moisture content should range from 2 percent below to 2 percent above optimum. Sand used for the chimney and blanket drains should be placed in 12-inch thick, uncompacted lifts.

Compaction of each layer should be conducted in a systematic and continuous manner. Rolling should be done, parallel to the centerline of the dam wherever possible. The embankment should be brought up in layers such that the surface is essentially level except for a slight slope for surface drainage. The moisture condition of the exposed grade should be maintained within the recommended limits at all times to minimize the potential for shrinkage and cracking. The surface of the fill section should be scarified between lifts.

Where compaction of the fill by a large roller is impractical, the fill should be compacted by small vibratory rollers, mechanical tampers, jumping jacks, or other approved methods and equipment. These areas will likely include fill placed adjacent to internal drainage systems, seepage collars, structures, piping, and foundations, or fill placed at steep and irregular abutments. Lift thickness of fill placed by these methods should be reduced in accordance with the type of equipment being used.

Fill should not be placed in adverse weather conditions. Frozen materials or soils containing organic material should not be incorporated into the dam's section. Weather conditions will influence the site preparation and fill placement required. In spring and late fall, soil moisture contents may be abnormally high and drying of the soils exposed after undercutting may be required to develop a stable base for fill placement. Discing and aeration of the exposed grade may be sufficient to develop a stable base. If fill placement commences during the summer months, moisture contents may be low and moisture conditioning of the exposed grade may be required.

Embankment Settlement

During and after construction of the embankment, the natural soils present below the dam will consolidate. Also, consolidation of the materials within the embankment section will contribute to settlement of the embankment after construction. Consolidation testing of the clay soils was not within the scope of this preliminary investigation. Based on experience with similar dams and similar soils, we estimate that long-term structural settlement of the dam designed and constructed as outlined above would be on the order of 2 to 3 feet in the valley floor area where the natural soils are more compressible and the height of the dam will be greater, and 6 to 18 inches along the valley walls. These settlements would be anticipated to occur over a 3 to 12 month period after completion of construction. We recommend over-building the crest of the dam (using a "camber") to compensate for the anticipated settlement. Also, a system of instrumentation should be installed during construction to monitor the settlement and pore water pressures within the dam during and after construction.

Additional Subsurface Investigation and Testing

The subsurface exploration completed to date and this preliminary report are intended to aid in design of the project. Once final plans are to be prepared, additional subsurface investigation, laboratory testing, and geotechnical engineering analysis will be necessary. The additional subsurface investigation should be planned to provide more information on subsurface conditions west of the creek (extensive tree clearing will required), the variability of depth to bedrock in borrow areas and along the centerline of the dam, and horizontal extent of alluvial sands near the proposed dam location.

If a borrow source is identified in the area west of the creek, the final phase of the subsurface investigation should target that area.

No significant shallow permeable bedrock formations, such as limestone and sandstone, are present at the site. Therefore, in-situ permeability testing using packers in boreholes does not appear to be warranted. Depending on design methods proposed to control seepage beneath the embankment through the alluvial sand deposits, installation of wells for pumping tests could be considered to assess the permeabilities of the sands.

To better monitor fluctuation of groundwater levels in the valley floor, piezometers should be installed in that area.

It is recommended that the long-term (drained) shear strength of the fill material be tested in the laboratory using triaxial compression tests on remolded, recompacted samples. Tests should be completed on samples compacted at approximately 95 percent compaction and at various moisture contents. The long-term shear strength of the in-situ soils, especially the softer sandy alluvial soils, would best be measured using borehole shear tests.

To better evaluate the potential for long term settlements of the natural soils at the site, consolidation tests should be completed on the alluvial clay soils.

Lastly, to allow for an analysis of the dam's internal seepage, permeability tests should be completed on remolded, recompacted samples of the fill material. Flexible wall permeameter tests would be most suitable for this testing. Tests should be completed on samples compacted at approximately 95 percent compaction and at various moisture contents.

Construction Services

The following section outlines geotechnical engineering and construction testing services necessary to implement the recommendations presented in this report.

1. An experienced engineering technician should observe the subgrade for the proposed dam immediately following stripping to identify areas requiring undercutting and to evaluate the suitability of the exposed surface for fill placement.

2. An experienced engineer or geologist should observe the materials exposed along the dam abutments and seepage cut-off trench. Where unsuitable conditions are observed, remedial procedures can be established in the field to avoid construction delays.

3. An experienced engineering technician should monitor and test all fill to determine whether the type of material, moisture content and degree of compaction are within recommended limits.

4. It is recommend that pneumatic piezometers and settlement plates be installed and monitored during and after construction.

GENERAL COMMENTS

The analysis and recommendations presented in this preliminary report are based in part upon the data obtained from the borings performed at the indicated locations and from any other information discussed in this report. This report does not reflect any variations which may occur between borings or across the site. The nature and extent of such variations may not become evident until construction. If variations then appear evident, it will be necessary to reevaluate the recommendations of this preliminary report.

It is recommended that the geotechnical engineer be provided the opportunity to review the plans and specifications so that comments can be made regarding the interpretation and implementation of our geotechnical recommendations in the design and specifications. Once a final subsurface investigation and final designs are completed, it is further recommended that the geotechnical engineer be retained for testing and observation during construction phases to help determine that the design requirements are fulfilled.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No other warranty, expressed or implied, is made. In the event that any changes in the nature, design or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this preliminary report shall not be considered valid unless the changes are reviewed and the conclusions of this report modified or verified in writing by the geotechnical engineer.

The scope of our services did not include any environmental assessment or investigation for the presence of hazardous or toxic materials in the soil, surface water, groundwater or air, on or below or around this site.

APPENDIX

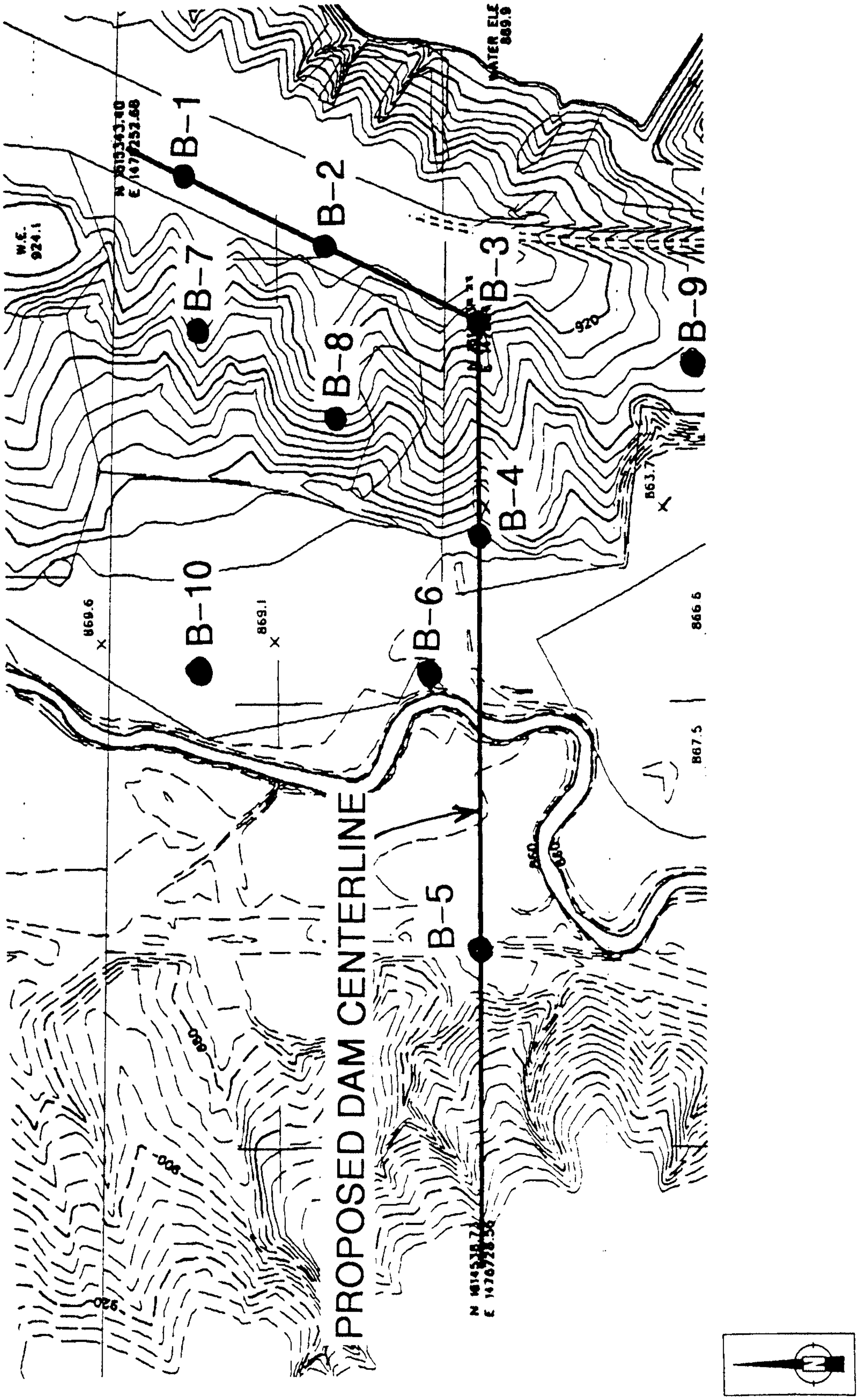

Figure 1. Approximate Boring Locations and General Site Layout

Sullivan County Dam
Sullivan Count, Missouri
NOT TO SCALE

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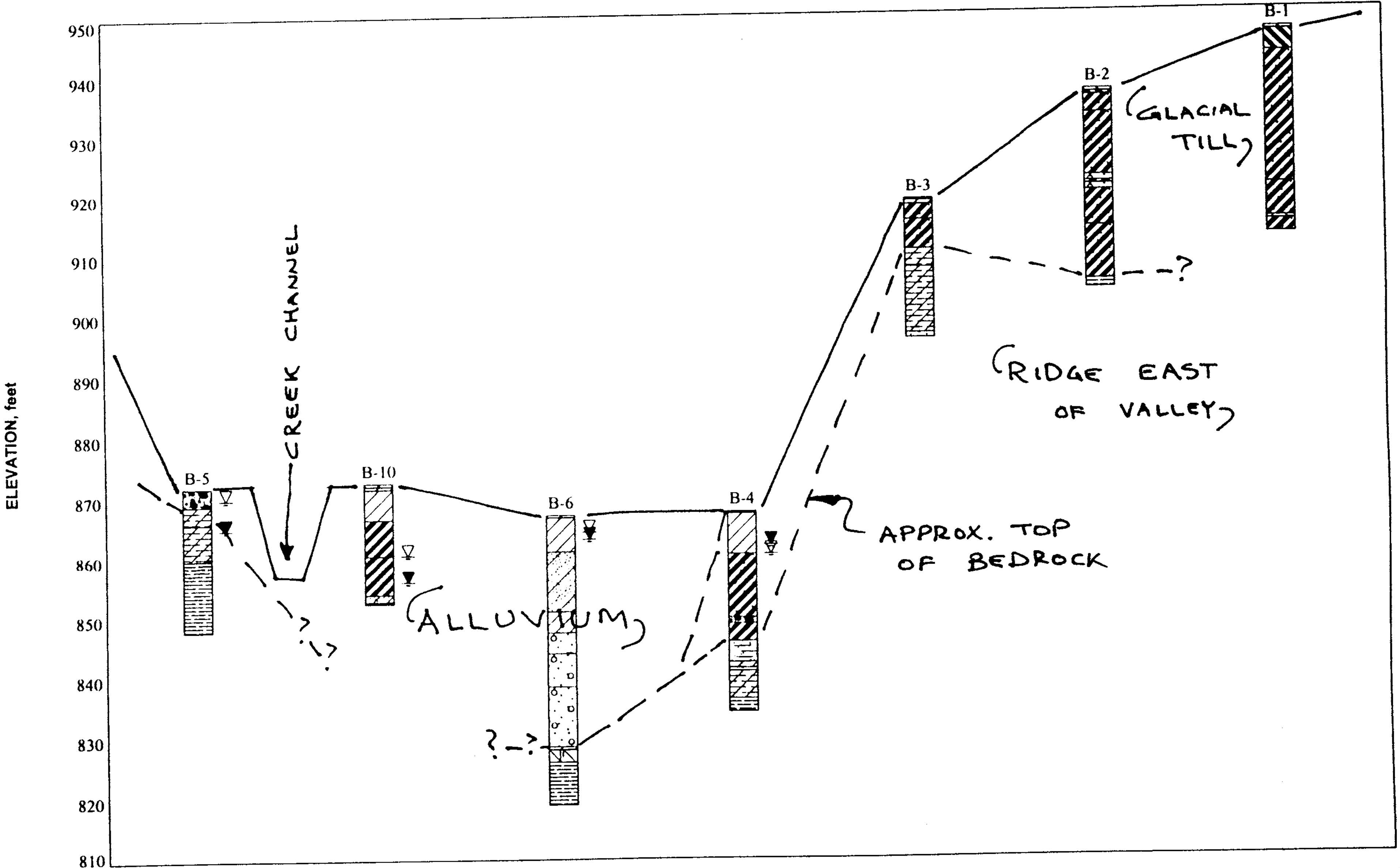
Approved By: SAW

Job No.: 1025193



GENERALIZED SUBSURFACE PROFILE

SECTION 1

Sullivan County Dam

Sullivan County, Missouri

Approved By: SAW

Job No.: 1025193

NOTES

1. See attached legend sheet.
2. Data concerning the various strata have been obtained at boring locations only. The stratigraphy between borings may vary from that shown.
3. For strata details in full, see boring logs appended to this report.

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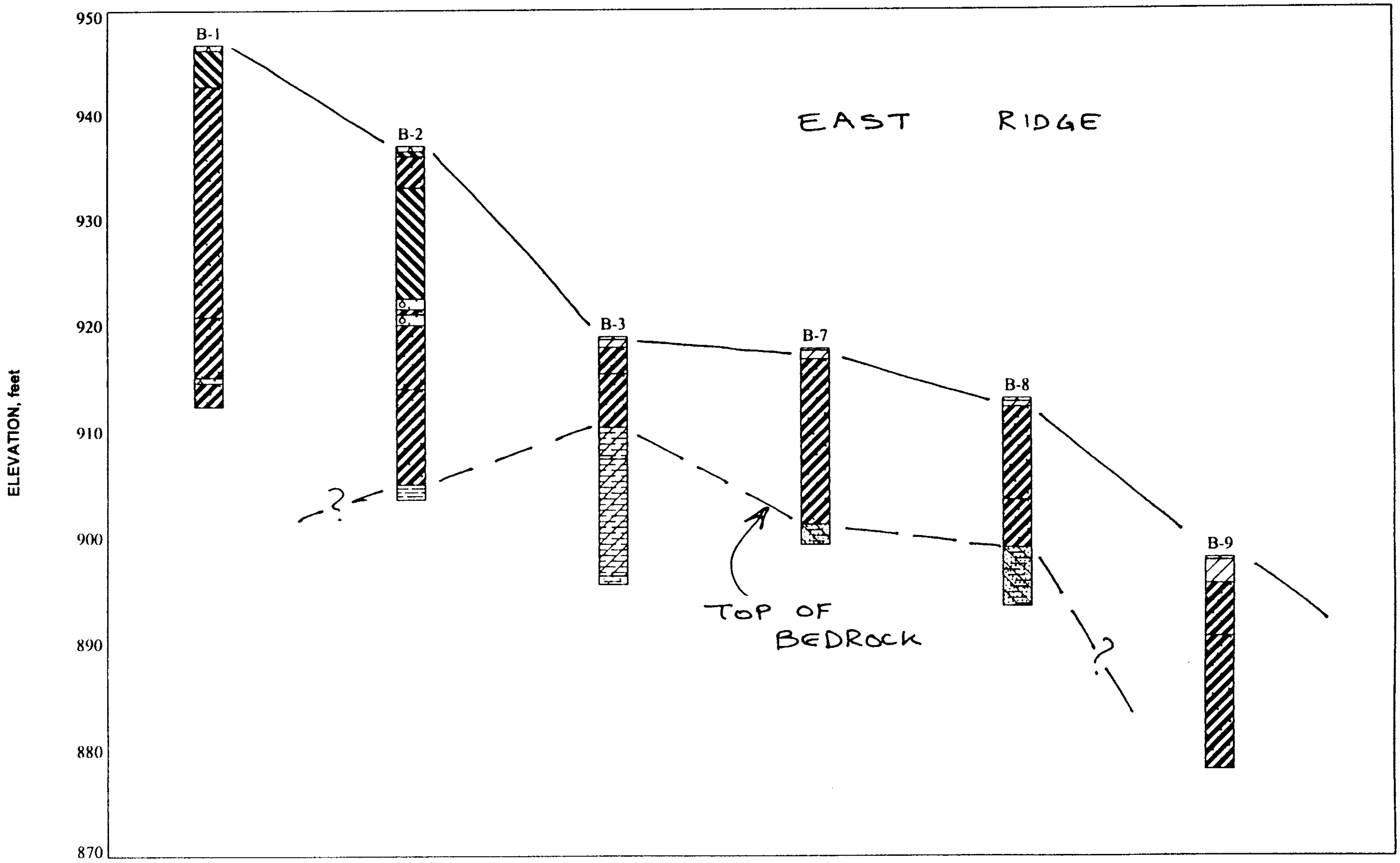

GENERALIZED SUBSURFACE PROFILE

SECTION 2

Sullivan County Dam

Sullivan County, Missouri

Approved By: SAW

Job No.: 1025193

NOTES

1. See attached legend sheet.
2. Data concerning the various strata have been obtained at boring locations only. The stratigraphy between borings may vary from that shown.
3. For strata details in full, see boring logs appended to this report.

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LOG OF BORING NO. B-1

Page 1 of 2

OWNER/CLIENT	PROJECT NAME **Sullivan County Dam**
ARCHITECT/ENGINEER **Burns & McDonnell**	LOCATION **Sullivan County, Missouri**

SAMPLE NO.	SAMPLE TYPE	RECOVERY, IN.	STANDARD PENETRATION, BLOWS/FT.	UNCONFINED STRENGTH, PSF	DRY DENSITY, PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG
	PA							▨
1	ST	1		*2000		27.5	CL CH	▨
2	ST	8		4450	106	22.2	CH	▨
	PA							▨
3	ST	6		5330	104	22.8	CH	▨
	PA							▨
4	ST	11		6310	105	22.4	CH	▨
	PA							▨
5	ST	12		5920	107	22.0	CH	▨
								▨

DEPTH, FT.: 5 – 10 – 15 – 20 –

DESCRIPTION

Surface Elevation: 947

0.5 TOPSOIL 946.3

LEAN TO FAT CLAY, yellow brown, stiff

4.0 942.8

FAT CLAY, yellow brown and gray, very stiff, trace to some sand, trace gravel, with sandy seams (till)

*Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	BORING STARTED 5-21-02		
⊻ Dry W.D.	BORING COMPLETED 5-21-02		
⊻ Dry A.B.	DRILL RIG CME 55	DRILLER AN	
Backfilled @ Completion	APPROVED SAW	JOB NO. 1025193	

GeoSystems
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LOG OF BORING NO. B-1

Page 2 of 2

OWNER/CLIENT	PROJECT NAME **Sullivan County Dam**
ARCHITECT/ENGINEER **Burns & McDonnell**	LOCATION **Sullivan County, Missouri**

SAMPLE NO.	SAMPLE TYPE	RECOVERY, IN.	STANDARD PENETRATION, BLOWS/FT.	UNCONFINED STRENGTH, PSF	DRY DENSITY, PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.	DESCRIPTION
	PA									
6	ST	13		7080	109	20.7	CH			
									25	
										26.0 920.8
	PA									
										FAT CLAY, dark gray, hard, some sand, some gravel (till)
7	SS	17	74			10.9				
									30	
	PA									
										31.7 915.1
										32.2 SAND, very dense, coarse grained 914.6
										FAT SANDY CLAY, dark gray, hard, trace gravel (till)
8	SS	17	90/11"			9.0				
										34.4 912.4
										BOTTOM OF BORING

ATTERBERG LIMITS

Sample 5, Depth 18-20 feet

LL	PL	PI
51	18	33

*Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS				
⊻ Dry W.D.	BORING STARTED	5-21-02		
▼ Dry A.B.	BORING COMPLETED	5-21-02		
	DRILL RIG	CME 55	DRILLER	AN
Backfilled @ Completion	APPROVED	SAW	JOB NO.	1025193

GeoSystems
ENGINEERING INC.

LOG OF BORING NO. B-2

OWNER/CLIENT	PROJECT NAME **Sullivan County Dam**
ARCHITECT/ENGINEER **Burns & McDonnell**	LOCATION **Sullivan County, Missouri**

SAMPLE NO.	SAMPLE TYPE	RECOVERY, IN.	STANDARD PENETRATION, BLOWS/FT.	UNCONFINED STRENGTH, PSF	DRY DENSITY, PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.
	PA								
1	ST	5		1980	88	31.5	CH		
2	ST	7		3960	103	23.7	CL CH		5
	PA								
3	ST	7		7330	108	21.2	CL CH		10
	PA								
4	ST	12		4880	110	20.6	CL CH		15
	PA								
5	SS	17	35			10.1	CH		20

*Calibrated Penetrometer

DESCRIPTION

Surface Elevation: 937

0.5	TOPSOIL	936.5
1.0	LEAN TO FAT CLAY, yellow brown	936.0
	FAT CLAY, yellow brown, medium to stiff, trace sand, trace gravel (till)	
4.0		933.0
	LEAN TO FAT CLAY, yellow brown and gray, stiff, trace sand, trace gravel, with sandy seams (till)	
14.5		922.5
	SAND, light brown, fine	
15.5		921.5
16.0	SANDY CLAY	921.0
	SAND, yellow brown, fine to medium grained	
17.0		920.0
	FAT SANDY CLAY, yellow brown, hard, trace sand, trace gravel, trace lignite (till)	

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS		
∇ **Dry W.D.**	BORING STARTED **5-21-02**	
▼ **Dry A.B.**	BORING COMPLETED **5-21-02**	
	DRILL RIG **CME 55**	DRILLER **AN**
Backfilled @ Completion	APPROVED **SAW**	JOB NO. **1025193**

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LOG OF BORING NO. B-2

Page 2 of 2

OWNER/CLIENT	PROJECT NAME **Sullivan County Dam**
ARCHITECT/ENGINEER **Burns & McDonnell**	LOCATION **Sullivan County, Missouri**

SAMPLE NO.	SAMPLE TYPE	RECOVERY, IN.	STANDARD PENETRATION, BLOWS/FT.	UNCONFINED STRENGTH, PSF	DRY DENSITY, PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.	DESCRIPTION
	PA							▨		23.0 914.0
6	SS	17	59			9.5	CH	▨		FAT SANDY CLAY, dark gray, hard, trace gravel (till)
	PA							▨	25	
7	SS	17	68			9.3	CH	▨		
	PA							▨	30	32.0 905.0
								▤		**SHALE, gray, hard, sandy
8	SS	4	50/4"			9.4		▤		33.4 903.6

BOTTOM OF BORING

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples would be required for exact classification.

ATTERBERG LIMITS

Sample 4, Depth 13-15 feet

LL	PL	PI
49	22	27

*Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	BORING STARTED **5-21-02**		
⊻ **Dry W.D.**	BORING COMPLETED **5-21-02**		
▼ **Dry A.B.**	DRILL RIG **CME 55**	DRILLER **AN**	
Backfilled @ Completion	APPROVED **SAW**	JOB NO. **1025193**	

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LOG OF BORING NO. B-3

Page 1 of 2

OWNER/CLIENT	PROJECT NAME **Sullivan County Dam**
ARCHITECT/ENGINEER **Burns & McDonnell**	LOCATION **Sullivan County, Missouri**

SAMPLE NO.	SAMPLE TYPE	RECOVERY, IN.	STANDARD PENETRATION, BLOWS/FT.	UNCONFINED STRENGTH, PSF	DRY DENSITY, PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.
	PA								
1	ST	6		2980	108	19.5	CH		
2	ST	7		12200	125	12.7	CH		5
	PA								
3	ST	8		4580	121	12.6	CH		10
	PA								
4	SS	4	50/4"			12.1			
	PA								15
5	SS	3	50/3"			11.2			
	PA								20

*Calibrated Penetrometer

DESCRIPTION

Surface Elevation: 919

0.3	TOPSOIL	918.5
1.0	LEAN CLAY, light gray brown	917.8
3.5	FAT SANDY CLAY, yellow brown and rust, stiff, with fine sand spans (till)	915.3
8.5	FAT CLAY, brown, hard to very stiff, trace sand, trace gravel (till)	910.3
11.5	**HIGHLY WEATHERED SHALE, yellow brown, sandy	907.3
	**WEATHERED SHALE, yellow brown to gray brown, soft, sandy	

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	BORING STARTED	5-28-02	
∇ Dry W.D.	BORING COMPLETED	5-28-02	
▼ Dry A.B.	DRILL RIG CME 300	DRILLER AN	
Backfilled @ Completion	APPROVED SAW	JOB NO. 1025193	

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ENGINEERING INC.

LOG OF BORING NO. B-3

Page 2 of 2

OWNER/CLIENT	PROJECT NAME **Sullivan County Dam**
ARCHITECT/ENGINEER **Burns & McDonnell**	LOCATION **Sullivan County, Missouri**

SAMPLE NO.	SAMPLE TYPE	RECOVERY, IN.	STANDARD PENETRATION, BLOWS/FT.	UNCONFINED STRENGTH, PSF	DRY DENSITY, PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.	DESCRIPTION	
									22.5		896.3
6	SS	3	50/3"			11.4			23.3	**SANDSTONE, yellow brown, poorly cemented to cemented	895.5

BOTTOM OF BORING

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples would be required for exact classification.

*Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS			
⊻ Dry W.D.	BORING STARTED	5-28-02	
⊻ Dry A.B.	BORING COMPLETED	5-28-02	
	DRILL RIG CME 300	DRILLER AN	
Backfilled @ Completion	APPROVED SAW	JOB NO. 1025193	

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LOG OF BORING NO. B-4

Page 1 of 2

OWNER/CLIENT

PROJECT NAME
Sullivan County Dam

ARCHITECT/ENGINEER
Burns & McDonnell

LOCATION
Sullivan County, Missouri

SAMPLE NO.	SAMPLE TYPE	RECOVERY, IN.	STANDARD PENETRATION, BLOWS/FT.	UNCONFINED STRENGTH, PSF	DRY DENSITY, PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL
	PA						
1	ST	12		1160	103	24.9	CL
2	ST	6		4330	102	23.5	CL
	PA						
3	ST	15		1980	104	22.0	CL
	PA						
4	ST	15		2640	106	22.3	CH
	PA						
5	ST	8				12.9	GW
				*6000	106	22.4	CH

*Calibrated Penetrometer

DEPTH, FT.: 5, 10, 15, 20

DESCRIPTION

Surface Elevation: 867

Depth	Description	Elevation
0.3	TOPSOIL	867.0
	LEAN CLAY, gray brown and brown, medium to very stiff (loess)	
7.0		860.3
	FAT CLAY, yellow brown and gray brown, medium to stiff, trace sand, with fine sand seams (till)	
17.5		849.8
	GRAVEL, red, with clay (till)	
18.5		848.8
	FAT CLAY, olive gray, hard	

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS

∇ 7.0 W.D.

▼ 5.5 A.B.

Backfilled @ Completion

BORING STARTED 5-29-02

BORING COMPLETED 5-29-02

DRILL RIG CME 300

DRILLER AN

APPROVED SAW

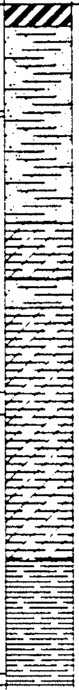
JOB NO. 1025193

GeoSystems ENGINEERING INC.

LOG OF BORING NO. B-4

Page 2 of 2

OWNER/CLIENT	PROJECT NAME **Sullivan County Dam**
ARCHITECT/ENGINEER **Burns & McDonnell**	LOCATION **Sullivan County, Missouri**



SAMPLE NO.	SAMPLE TYPE	RECOVERY, IN.	STANDARD PENETRATION, BLOWS/FT.	UNCONFINED STRENGTH, PSF	DRY DENSITY, PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.	DESCRIPTION
	PA									21.5 845.8 **SANDSTONE, yellow brown
6	SS	0	50/0"			15.6				
	PA								25	25.0 842.3 **WEATHERED SHALE, gray, soft 26.0 841.3 26.5 **SANDSTONE, yellow brown 840.8 **WEATHERED SHALE, gray, moderately hard
7	SS	4	50/4"			16.0				
	PA								30	31.0 836.3 **SHALE, gray, moderately hard
8	SS	2	50/2"			15.5				33.2 834.1

BOTTOM OF BORING

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples would be required for exact classification.

ATTERBERG LIMITS

Sample 1, Depth 1-3 feet

LL	PL	PI
36	21	15

*Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	BORING STARTED **5-29-02**		
▽ 7.0 W.D.	BORING COMPLETED **5-29-02**		
▼ 5.5 A.B.	DRILL RIG **CME 300**	DRILLER **AN**	
Backfilled @ Completion	APPROVED **SAW**	JOB NO. **1025193**	

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LOG OF BORING NO. B-5

Page 1 of 2

OWNER/CLIENT	PROJECT NAME **Sullivan County Dam**
ARCHITECT/ENGINEER **Burns & McDonnell**	LOCATION **Sullivan County, Missouri**

SAMPLE NO.	SAMPLE TYPE	RECOVERY, IN.	STANDARD PENETRATION, BLOWS/FT.	UNCONFINED STRENGTH, PSF	DRY DENSITY, PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.	DESCRIPTION **Surface Elevation: 872**
	PA									FILL, gravel, (railroad ballast) ∇
									3.0	869.0
1	ST	11		2890	106	22.5				
				6870	119	17.6			5	**HIGHLY WEATHERED SHALE, maroon, soft, blocky
									6.0	866.0
	PA									**WEATHERED SHALE, light gray, soft ▼
2	SS	15	33			17.7				
	PA								10	
									12.0	860.0
3	SS	16	60			15.9				**SHALE, gray and maroon, soft to moderately hard, slightly weathered
	PA								15	
4	SS	10	50/5"			13.4				
									20	

*Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS				
∇ 2.0 W.D.	BORING STARTED	5-30-02		
▼ 7.0 A.B.	BORING COMPLETED	5-30-02		
	DRILL RIG	CME 300	DRILLER	AN
Backfilled @ Completion	APPROVED	SAW	JOB NO.	1025193

GeoSystems ENGINEERING INC.

GSE2* 1025193.GPJ GEOSYSTM.GDT 6/13/02

LOG OF BORING NO. B-5

OWNER/CLIENT

PROJECT NAME **Sullivan County Dam**

ARCHITECT/ENGINEER **Burns & McDonnell**

LOCATION **Sullivan County, Missouri**

SAMPLE NO.	SAMPLE TYPE	RECOVERY, IN.	STANDARD PENETRATION, BLOWS/FT.	UNCONFINED STRENGTH, PSF	DRY DENSITY, PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.	DESCRIPTION
	PA							▤		
5	SS	9	50/5"			18.2		▤		24.0 848.0
										BOTTOM OF BORING **Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples would be required for exact classification.

*Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS			
⊻ 2.0 W.D.	BORING STARTED 5-30-02		
⊻ 7.0 A.B.	BORING COMPLETED 5-30-02		
	DRILL RIG CME 300	DRILLER AN	
Backfilled @ Completion	APPROVED SAW	JOB NO. 1025193	

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LOG OF BORING NO. B-6

Page 1 of 3

OWNER/CLIENT	PROJECT NAME **Sullivan County Dam**
ARCHITECT/ENGINEER **Burns & McDonnell**	LOCATION **Sullivan County, Missouri**

SAMPLE NO.	SAMPLE TYPE	RECOVERY, IN.	STANDARD PENETRATION, BLOWS/FT.	UNCONFINED STRENGTH, PSF	DRY DENSITY, PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL
	PA						
1	ST	3		*1000		23.0	CL
2	ST	22		1620	99	24.9	CL
	PA						
3	ST	16		830	109	20.0	SC
	PA						
4	ST	21		570	99	27.1	SC
	PA						
5	ST	19		840	88	34.4	CL

*Calibrated Penetrometer

DESCRIPTION

Surface Elevation: 867

DEPTH, FT.	DESCRIPTION	
0.4	TOPSOIL	866.6
	LEAN CLAY, dark gray brown, medium, silty, trace to some sand (alluvium) ▽ ▼	
6.0		861.0
	CLAYEY SAND, dark brown and gray, medium dense, fine grained (alluvium)	
16.0		851.0
	SILTY CLAY, gray, soft, trace sand, trace organics (alluvium)	
19.5		847.5
	SAND, fine grained	

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS			
▽ 2.8 W.D.	BORING STARTED 5-30-02		
▼ 4.0 A.B.	BORING COMPLETED 5-30-02		
	DRILL RIG CME 300	DRILLER AN	
Backfilled @ Completion	APPROVED SAW	JOB NO. 1025193	

GeoSystems
ENGINEERING INC.

LOG OF BORING NO. B-6

Page 2 of 3

OWNER/CLIENT	PROJECT NAME **Sullivan County Dam**
ARCHITECT/ENGINEER **Burns & McDonnell**	LOCATION **Sullivan County, Missouri**

SAMPLE NO.	SAMPLE TYPE	RECOVERY, IN.	STANDARD PENETRATION, BLOWS/FT.	UNCONFINED STRENGTH, PSF	DRY DENSITY, PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.	DESCRIPTION
	PA									23.0 — 844.0
6	ST	8		*0		20.5	SP			SAND, gray, fine grained, with clay (alluvium)
	PA								25	28.5 — 838.5
7	SS	7	2			19.2	SP			
	PA								30	SAND, gray, fine grained, trace gravel, trace clay (alluvium)
8	SS	9	15			19.2	SP			
	PA								35	38.5 — 828.5
9	SS	9	52			15.2				39.0 **HIGHLY WEATHERED SHALE, gray 828.0 **HIGHLY WEATHERED LIMESTONE
	PA								40	41.0 — 826.0

*Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	BORING STARTED 5-30-02		
⊻ 2.8 W.D.	BORING COMPLETED 5-30-02		
▼ 4.0 A.B.	DRILL RIG CME 300	DRILLER AN	
Backfilled @ Completion	APPROVED SAW	JOB NO. 1025193	

GeoSystems
ENGINEERING INC.

LOG OF BORING NO. B-6

OWNER/CLIENT	PROJECT NAME **Sullivan County Dam**
ARCHITECT/ENGINEER **Burns & McDonnell**	LOCATION **Sullivan County, Missouri**

SAMPLE NO.	SAMPLE TYPE	RECOVERY, IN.	STANDARD PENETRATION, BLOWS/FT.	UNCONFINED STRENGTH, PSF	DRY DENSITY, PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.	DESCRIPTION
										**SHALE, maroon, moderately hard to hard, with calcareous seams
~~10~~	~~SS~~	~~0~~	~~50/0"~~							
11	AS					21.4			45	
										48.0 819.0
~~12~~	~~SS~~	~~0~~	~~50/0"~~							

BOTTOM OF BORING

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples would be required for exact classification.

ATTERBERG LIMITS

Sample 2, Depth 3-5 feet

LL	PL	PI
49	22	27

*Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS		
∇ 2.8 W.D.	BORING STARTED 5-30-02	
▼ 4.0 A.B.	BORING COMPLETED 5-30-02	
	DRILL RIG CME 300	DRILLER AN
Backfilled @ Completion	APPROVED SAW	JOB NO. 1025193

GeoSystems ENGINEERING INC.

LOG OF BORING NO. B-7

Page 1 of 2

OWNER/CLIENT	PROJECT NAME **Sullivan County Dam**
ARCHITECT/ENGINEER **Burns & McDonnell**	LOCATION **Sullivan County, Missouri**

SAMPLE NO.	SAMPLE TYPE	RECOVERY, IN.	STANDARD PENETRATION, BLOWS/FT.	UNCONFINED STRENGTH, PSF	DRY DENSITY, PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.
	PA							▨	
1	ST	10		3220	115	17.0	CH	▨	
2	ST	9		11400	124	13.7	CH	▨	
	PA							▨	5
3	ST	23		9620	123	12.1	CH	▨	
	PA							▨	10
4	ST	10		15070	127	11.9	CH	▨	15
	PA							▨ ▩	
5	SS	4	50/4"			15.1		▩	

DESCRIPTION

Depth	Description	Elevation
	Surface Elevation:	**918**
0.2	TOPSOIL	917.5
1.0	LEAN CLAY, brown	916.7
	FAT CLAY, yellow brown and gray, trace sand, trace gravel (till)	
16.5	**WEATHERED SANDSTONE, yellow brown and brown, poorly cemented	901.2
18.4		899.3

BOTTOM OF BORING

**Rock classification is based on drilling characteristics and visual observation of

*Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS				
▽ Dry W.D.	BORING STARTED	5-29-02		
▼ Dry A.B.	BORING COMPLETED	5-29-02		
Backfilled @ Completion	DRILL RIG	CME 300	DRILLER	AN
	APPROVED	SAW	JOB NO.	1025193

GeoSystems
ENGINEERING INC.

LOG OF BORING NO. B-7

OWNER/CLIENT	PROJECT NAME **Sullivan County Dam**
ARCHITECT/ENGINEER **Burns & McDonnell**	LOCATION **Sullivan County, Missouri**

SAMPLE NO.	SAMPLE TYPE	RECOVERY, IN.	STANDARD PENETRATION, BLOWS/FT.	UNCONFINED STRENGTH, PSF	DRY DENSITY, PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.	DESCRIPTION
										disturbed samples. Core samples would be required for exact classification.

*Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS			
∇ Dry W.D.	BORING STARTED	5-29-02	
▼ Dry A.B.	BORING COMPLETED	5-29-02	
	DRILL RIG CME 300	DRILLER AN	
Backfilled @ Completion	APPROVED SAW	JOB NO. 1025193	

GeoSystems ENGINEERING INC.

LOG OF BORING NO. B-8

Page 1 of 2

OWNER/CLIENT	PROJECT NAME **Sullivan County Dam**
ARCHITECT/ENGINEER **Burns & McDonnell**	LOCATION **Sullivan County, Missouri**

SAMPLE NO.	SAMPLE TYPE	RECOVERY, IN.	STANDARD PENETRATION, BLOWS/FT.	UNCONFINED STRENGTH, PSF	DRY DENSITY, PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.	**DESCRIPTION** **Surface Elevation: 913**
	PA							▨		0.3 TOPSOIL 912.7 0.8 LEAN CLAY, brown 912.2
1	ST	6		3260	100	23.9	CH	▨		FAT CLAY, yellow brown and red brown, stiff to very stiff, trace sand, trace gravel (till)
2	ST	24		3330	114	16.3	CH	▨		
	PA							▨	5	
3	ST	6		6470	120	14.6	CH	▨		9.5 903.5
	PA							▨	10	FAT CLAY, brown, very stiff, some sand (residual)
4	ST	9		*7000	112	14.2	CH	▨		14.0 899.0
	PA							▨	15	**HIGHLY WEATHERED SANDSTONE, yellow brown and gray brown, poorly cemented
5	SS	17	45			14.1		▨		19.5 893.5
										BOTTOM OF BORING

*Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	BORING STARTED	5-29-02		
∇ Dry W.D.	BORING COMPLETED	5-29-02		
▼ Dry A.B.	DRILL RIG	CME 300	DRILLER	AN
Backfilled @ Completion	APPROVED	SAW	JOB NO.	1025193

GeoSystems ENGINEERING INC.

GSE2* 1025193.GPJ GEOSYSTM.GDT 6/13/02

LOG OF BORING NO. B-8

Page 2 of 2

OWNER/CLIENT

PROJECT NAME
Sullivan County Dam

ARCHITECT/ENGINEER
Burns & McDonnell

LOCATION
Sullivan County, Missouri

SAMPLE NO.	SAMPLE TYPE	RECOVERY, IN.	STANDARD PENETRATION, BLOWS/FT.	UNCONFINED STRENGTH, PSF	DRY DENSITY, PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.	DESCRIPTION
										**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples would be required for exact classification.

*Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS	BORING STARTED 5-29-02		
⊻ Dry W.D.	BORING COMPLETED 5-29-02		
⊻ Dry A.B.	DRILL RIG CME 300	DRILLER AN	
Backfilled @ Completion	APPROVED SAW	JOB NO. 1025193	

GeoSystems
ENGINEERING INC.

GSE2* 1025193.GPJ GEOSYSTM.GDT 6/13/02

LOG OF BORING NO. B-9

Page 1 of 1

OWNER/CLIENT	PROJECT NAME **Sullivan County Dam**
ARCHITECT/ENGINEER **Burns & McDonnell**	LOCATION **Sullivan County, Missouri**

SAMPLE NO.	SAMPLE TYPE	RECOVERY, IN.	STANDARD PENETRATION, BLOWS/FT.	UNCONFINED STRENGTH, PSF	DRY DENSITY, PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.
	PA							▨	
1	ST	6		2730	95	25.6	CL	▨	
2	ST	9		2830	119	13.8	CH	▨	5
	PA							▨	
3	ST	6		10530	116	15.3	CH	▨	10
	PA							▨	
4	ST	7		11960	114	18.2	CH	▨	15
	PA							▨	
5	ST	8		13290	118	14.7	CH	▨	20

*Calibrated Penetrometer

DESCRIPTION

Surface Elevation: 898

0.3 TOPSOIL 897.8

LEAN CLAY, yellow brown, stiff (loess)

2.5 895.6

FAT CLAY, yellow brown to brown, stiff, trace sand, trace gravel (till)

7.5 890.6

FAT CLAY, brown, hard, trace to some sand, trace gravel (till)

20.0 878.1

BOTTOM OF BORING

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS

∇ Dry W.D.

▼ Dry A.B.

Backfilled @ Completion

BORING STARTED 5-28-02	
BORING COMPLETED 5-28-02	
DRILL RIG CME 300	DRILLER AN
APPROVED SAW	JOB NO. 1025193

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LOG OF BORING NO. B-10

Page 1 of 2

OWNER/CLIENT	PROJECT NAME **Sullivan County Dam**
ARCHITECT/ENGINEER **Burns & McDonnell**	LOCATION **Sullivan County, Missouri**

SAMPLE NO.	SAMPLE TYPE	RECOVERY, IN.	STANDARD PENETRATION, BLOWS/FT.	UNCONFINED STRENGTH, PSF	DRY DENSITY, PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL
	PA						
1	ST	8		1010	101	25.8	CL
2	ST	10		3950	93	29.5	CL
	PA						
3	ST	4		*4000	102	23.6	CH
	PA						
4	ST	10		1010	96	28.6	CH
	PA						
5	ST	18		640	101	25.2	SC

*Calibrated Penetrometer

DESCRIPTION

Surface Elevation: 873

DEPTH, FT.	DESCRIPTION	
0.5	TOPSOIL	872.0
1.0	LEAN CLAY, gray brown	871.5
	LEAN CLAY, dark gray brown, medium to stiff, silty, trace sand (alluvium)	
6.0		866.5
	FAT CLAY, gray and brown, very stiff	
12.0		∇ 860.5
	FAT CLAY, gray and brown, medium to soft	▼
18.5		854.0
	CLAYEY SAND, brown and gray, medium dense, fine grained (alluvium)	
19.7		852.8
20.0	SAND, gray, fine grained	852.5

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS				
∇ 12.0 W.D.	BORING STARTED	5-30-02		
▼ 16.5 A.B.	BORING COMPLETED	5-30-02		
	DRILL RIG	CME 300	DRILLER	AN
Backfilled @ Completion	APPROVED	SAW	JOB NO.	1025193

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LOG OF BORING NO. B-10

Page 2 of 2

OWNER/CLIENT	PROJECT NAME **Sullivan County Dam**
ARCHITECT/ENGINEER **Burns & McDonnell**	LOCATION **Sullivan County, Missouri**

SAMPLE NO.	SAMPLE TYPE	RECOVERY, IN.	STANDARD PENETRATION, BLOWS/FT.	UNCONFINED STRENGTH, PSF	DRY DENSITY, PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, FT.	DESCRIPTION
										BOTTOM OF BORING

*Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be gradual.

WATER LEVEL OBSERVATIONS
∇ 12.0 W.D.
▼ 16.5 A.B.
Backfilled @ Completion

BORING STARTED	5-30-02		
BORING COMPLETED	5-30-02		
DRILL RIG	CME 300	DRILLER	AN
APPROVED	SAW	JOB NO.	1025193

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GSE2* 1025193.GPJ GEOSYSTM.GDT 6/13/02

MOISTURE-DENSITY RELATIONSHIP
ASTM D698, D1557, D4718 &D2216

Source of Material **Composite of Auger Cuttings, B-8 & B-9, 1 - 18 Feet**

Sample Description **Lean to Fat Clay w/Trace Fine Sand, Light Brown**

Sample Designation **A** Date **6/3/2002**

Test Method **ASTM D-698A (Standard)**

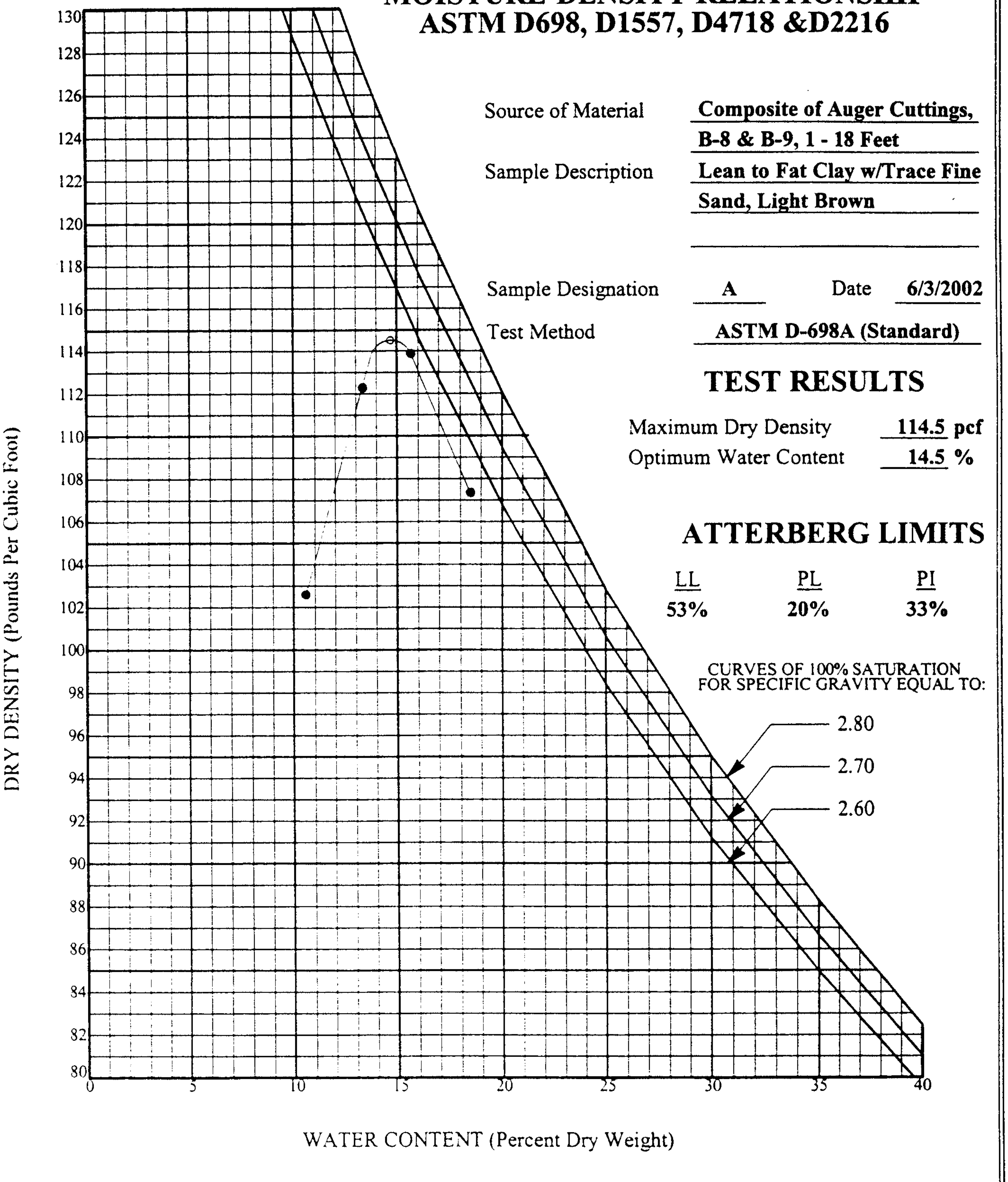
TEST RESULTS

Maximum Dry Density **114.5** **pcf**

Optimum Water Content **14.5** **%**

ATTERBERG LIMITS

LL	PL	PI
53%	20%	33%



Sullivan County Dam

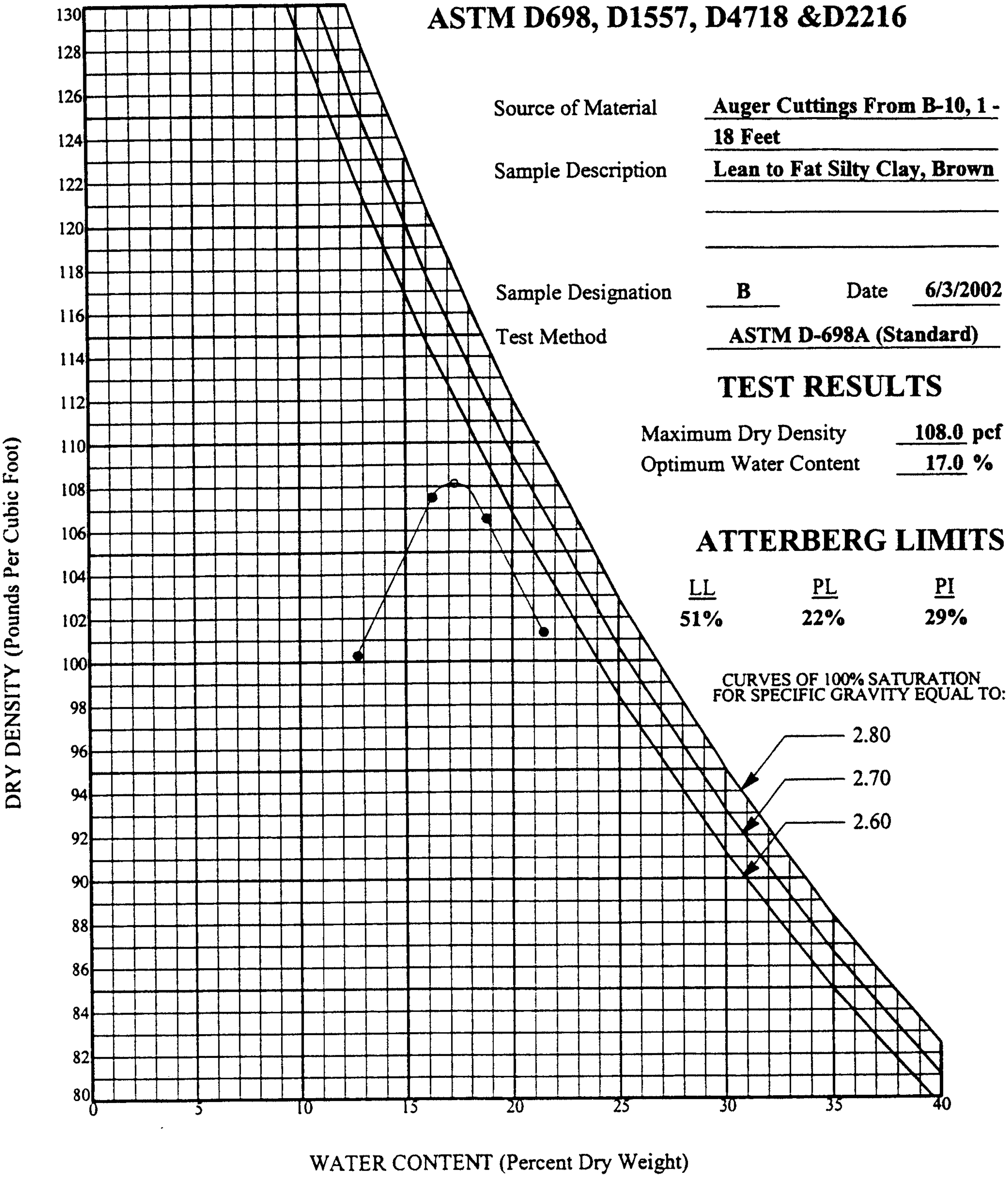
Sullivan County, Missouri

Approved By: SAW

Job No.: 1025193

GeoSystems ENGINEERING INC.

MOISTURE-DENSITY RELATIONSHIP
ASTM D698, D1557, D4718 &D2216



Source of Material	**Auger Cuttings From B-10, 1 - 18 Feet**
Sample Description	**Lean to Fat Silty Clay, Brown**
Sample Designation	**B**
Date	**6/3/2002**
Test Method	**ASTM D-698A (Standard)**

TEST RESULTS

Maximum Dry Density **108.0** pcf

Optimum Water Content **17.0** %

ATTERBERG LIMITS

LL	PL	PI
51%	22%	29%

Sullivan County Dam

Sullivan County, Missouri

Approved By: SAW

Job No.: 1025193

GeoSystems
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Unconfined Compressive Strength Tests on Remolded, Recompacted On-Site Glacial Till Clay. Bulk sample of auger cuttings was collected from Borings B-8 and B-9 at depth of 1 to 18 feet.

Percent Compaction (relative to max. dry density)	Moisture (relative to optimum)	Unconfined Compressive Strength
95.1 %	-3.2 %	8,990 psf
96.0 %	-0.8 %	7,280 psf
95.6 %	-0.1 %	5,890 psf
95.7 %	+2.4 %	3,630 psf

GENERAL NOTES

DRILLING NOTES

WATER LEVEL MEASUREMENTS

Water levels indicated on the boring logs are levels measured in the borings at the times indicated. In permeable materials, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater levels is not possible with only short-term observations.

WATER LEVEL OBSERVATION DESIGNATION

W.D.	While Drilling
A.B.	After Boring
B.C.R.	Before Casing Removal
A.C.R.	After Casing Removal
24 hr.	Water level taken approximately 24 hrs. after boring completion

DRILLING AND SAMPLING SYMBOLS

AS	Auger Sample
CS	Continuous Sampler
DB	Diamond Bit -NX unless otherwise noted
HA	Hand Auger
HS	Hollow Stem Auger
PA	Power Auger
RB	Rock Bit
SS*	Split-Barrel
ST	Shelby Tube - 2" (51mm) unless otherwise noted
WB	Wash Bore

*The Standard Penetration Test is conducted in conjunction with the split-barrel sampling procedure. The "N" value corresponds to the number of blows required to drive the last 1 foot (0.3m) of an 18 in. (0.46m) long, 2 in. (51mm) O.D. split-barrel sampler with a 140 lb. (63.5 kg) hammer falling a distance of 30 in. (0.76m). The Standard Penetration Test is carried out according to ASTM D-1586. (See "N" Value below.)

SOIL PROPERTIES & DESCRIPTIONS

TEXTURE

PARTICLE	SIZE	
Clay	< 0.002 mm	(< 0.002 mm)
Silt	< #200 Sieve	(0.075 mm)
Sand	#4 to #200 Sieve	(4.75 to 0.075 mm)
Gravel	3 in. to #4 Sieve	(75 mm to 4.75 mm)
Cobbles	12 in. to 3 in.	(300 mm to 75 mm)
Boulders	> 12 in.	(300 mm)

COMPOSITION

SAND & GRAVEL

Description	% by Dry Weight
trace	< 15
with	15 - 29
modifer	> 30

FINES

Description	% by Dry Weight
trace	< 5
with	5 - 12
modifier	> 12

Soil descriptions are based on the Unified Soil Classification System (USCS) as outlined in ASTM Designations D-2487 and D-2488. The USCS group symbol shown on the boring logs correspond to the group names listed below. The description includes soil constituents, consistency, relative density, color and other appropriate descriptive terms. Geologic description of bedrock, when encountered, also is shown in the description column.

GROUP SYMBOL	GROUP NAME	GROUP SYMBOL	GROUP NAME
GW	Well Graded Gravel	CL	Lean Clay
GP	Poorly Graded Gravel	ML	Silt
GM	Silty Gravel	OL	Organic Clay or Silt
GC	Clayey Gravel	CH	Fat Clay
SW	Well Graded Sand	MH	Elastic Silt
SP	Poorly Graded Sand	OH	Organic Clay or Silt
SM	Silty Sand	PT	Peat
SC	Clayey Sand	CL-CH	Lean to Fat Clay

COHESIVE SOILS

CONSISTENCY	UNCONFINED COMPRESSIVE STRENGTH (Qu) (psf)	(kPa)
Very Soft	< 500	(< 24)
Soft	500 - 1000	(24 - 48)
Medium	1001 - 2000	(48 - 96)
Stiff	2001 - 4000	(96 - 192)
Very Stiff	4001 - 8000	(192 - 383)
Hard	> 8001	(> 383)

PLASTICITY

Description	Liquid Limit (%)
Lean	< 45%
Lean to Fat	45 to 49%
Fat	≥ 50%

COHESIONLESS SOILS

RELATIVE DENSITY	"N" VALUE*
Very Loose	0 - 3
Loose	4 - 9
Medium Dense	10 - 29
Dense	30 - 49
Very Dense	≥ 50

BEDROCK PROPERTIES & DESCRIPTIONS

ROCK QUALITY DESIGNATION (RQD**)

DESCRIPTION OF ROCK QUALITY	RQD (%)
Very Poor	0 - 25
Poor	25 - 50
Fair	50 - 75
Good	75 - 90
Excellent	90 - 100

**RQD is defined as the total length of sound core pieces, 4 inches (102mm) or greater in length, expressed as a percentage of the total length cored. RQD provides an indication of the integrity of the rock mass and relative extent of seams and bedding planes.

DEGREE OF WEATHERING

Slightly Weathered	Slight decomposition of parent material in joints and seams.
Weathered	Well-developed and decomposed joints and seams.
Highly Weathered	Rock highly decomposed, may be extremely broken.

SOLUTION AND VOID CONDITIONS

Solid	Contains no voids.
Vuggy	Containing small pits or cavities < 1/2" (13mm).
Porous	Containing numerous voids which may be interconnected.
Cavernous	Containing cavities, sometimes quite large.

When classification of rock materials has been estimated from disturbed samples, core samples and petrographic analysis may reveal other rock types.

HARDNESS & DEGREE OF CEMENTATION

LIMESTONE	
Hard	Difficult to scratch with knife.
Moderately Hard	Can scratch with knife but not with fingernail.
Soft	Can be scratched with fingernail.
SHALE	
Hard	Can scratch with knife but not with fingernail.
Moderately Hard	Can be scratched with fingernail.
Soft	Can be molded easily with fingers.
SANDSTONE	
Well Cemented	Capable of scratching a knife blade.
Cemented	Can be scratched with knife.
Poorly Cemented	Can be broken apart easily with fingers.

BEDDING CHARACTERISTICS

TERM	THICKNESS (inches)	THICKNESS (mm)
Very Thick Bedded	> 36	> 915
Thick Bedded	12 - 36	305 - 915
Medium Bedded	4 - 12	102 - 305
Thin Bedded	1 - 4	25 - 102
Very Thin Bedded	0.4 - 1	10 - 25
Laminated	0.1 - 0.4	2.5 - 10
Thinly Laminated	< 0.1	< 2.5

Bedding Planes	Planes dividing the individual layers, beds or strata of rocks.
Joint	Fracture in rock, generally more or less vertical or transverse to the bedding.
Seam	Applies to bedding plane with an unspecified degree of weathering.

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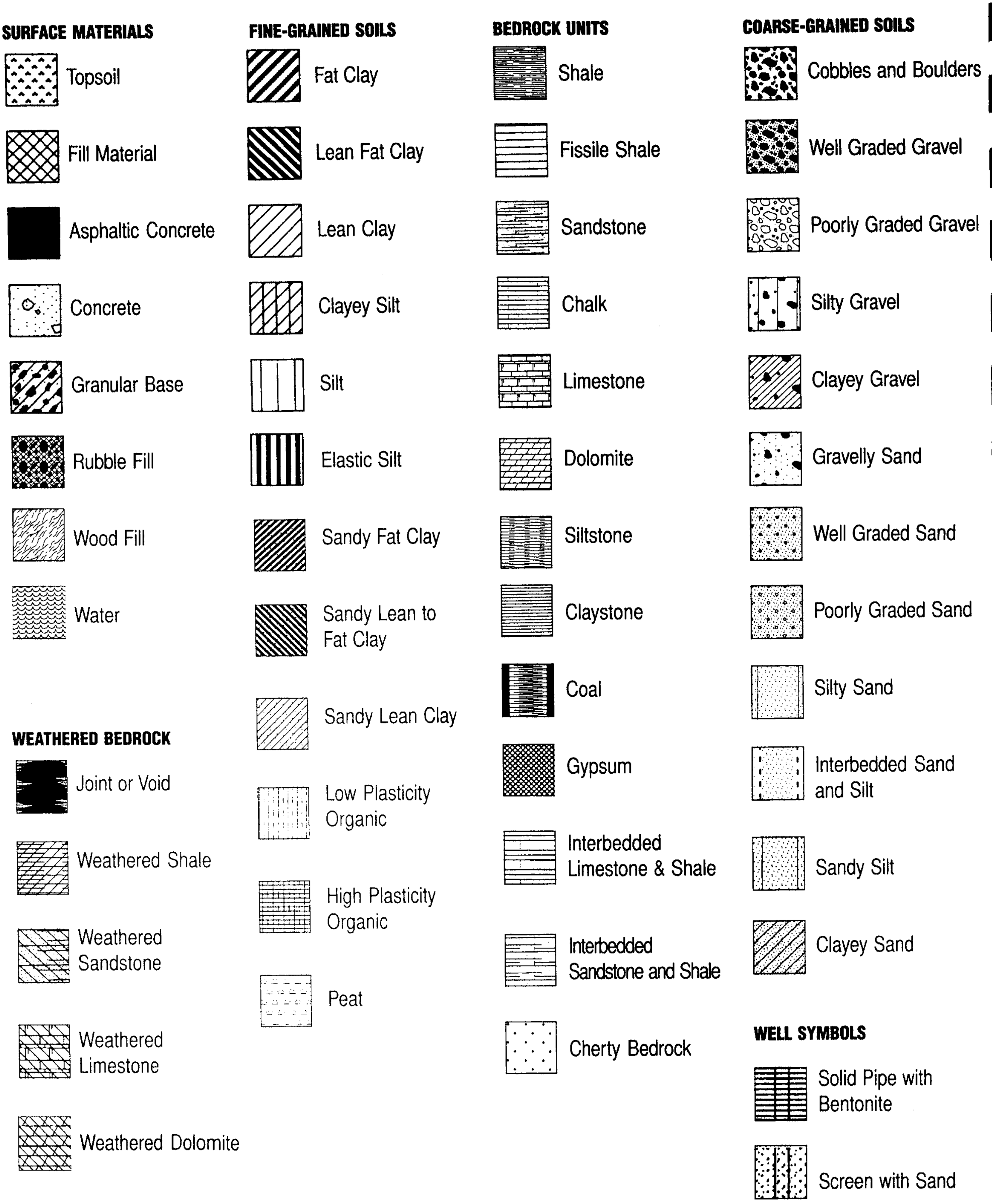
BORING LOG SYMBOLS



SURFACE MATERIALS

- Topsoil
- Fill Material
- Asphaltic Concrete
- Concrete
- Granular Base
- Rubble Fill
- Wood Fill
- Water

WEATHERED BEDROCK

- Joint or Void
- Weathered Shale
- Weathered Sandstone
- Weathered Limestone
- Weathered Dolomite

FINE-GRAINED SOILS

- Fat Clay
- Lean Fat Clay
- Lean Clay
- Clayey Silt
- Silt
- Elastic Silt
- Sandy Fat Clay
- Sandy Lean to Fat Clay
- Sandy Lean Clay
- Low Plasticity Organic
- High Plasticity Organic
- Peat

BEDROCK UNITS

- Shale
- Fissile Shale
- Sandstone
- Chalk
- Limestone
- Dolomite
- Siltstone
- Claystone
- Coal
- Gypsum
- Interbedded Limestone & Shale
- Interbedded Sandstone and Shale
- Cherty Bedrock

COARSE-GRAINED SOILS

- Cobbles and Boulders
- Well Graded Gravel
- Poorly Graded Gravel
- Silty Gravel
- Clayey Gravel
- Gravelly Sand
- Well Graded Sand
- Poorly Graded Sand
- Silty Sand
- Interbedded Sand and Silt
- Sandy Silt
- Clayey Sand

WELL SYMBOLS

- Solid Pipe with Bentonite
- Screen with Sand

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Appendix B

Preliminary Geotechnical Analyses

PRELIMINARY GEOTECHNICAL ANALYSES

SULLIVAN COUNTY DAM

SULLIVAN COUNTY, MISSOURI

Job No. 35191

October 22, 2003

GeoSystems/KLEINFELDER
an employee owned company

October 22, 2003

Mr. David Silverstein
Burns & McDonnell
9400 Ward Parkway
Kansas City, Missouri 64114

RE: Preliminary Geotechnical Analyses
Sullivan County Dam
Sullivan County, Missouri
Project No. 35191

Dear Mr. Silverstein:

We have completed our preliminary geotechnical analyses for the proposed Sullivan County Dam. The analyses included preliminary evaluations of slope stability and underseepage of the proposed dam, geotechnical / geological analyses of the proposed spillway alignment, and planning for the final phase of the subsurface investigation at the site. Each item is summarized in the following attachments:

Attachment 1: Slope Stability Analyses

Attachment 2: Underseepage Analyses

Attachment 3: Evaluation of Spillway

Attachment 4: Recommendations for Additional Subsurface Investigation

Attachment 5: Drawings

If you have any questions concerning our analyses, please let us know.

Respectfully submitted,
GeoSystems / Kleinfelder

Steve Wendland

Steve Wendland, P.E.
Area Manager

Glen Ferguson

Glen Ferguson, Ph.D., P.E.
Chief Regional Geotechnical Engineer

SAW/EGF:sw

ATTACHMENT 1
SLOPE STABILITY ANALYSES

Preliminary Slope Stability Analyses

Steve Wendland – GeoSystems / Kleinfelder – October 14, 2003

Objective:

Calculate preliminary factor of safety for slope stability of proposed dam. Analyze end-of-construction, long-term (steady state seepage), seismic, and rapid drawdown of reservoir conditions.

References:

1. GeoSystems, *Subsurface Exploration and Preliminary Geotechnical Report*, Job No. 1025193, June 14, 2002

2. *Earth Dams and Reservoirs,* Technical Release No. 60 210-VI, Revised Oct. 1985, US Dept. of Agriculture, Soil Conservation Service

3. 2000 International Building Code

The following cases will be analyzed:

Graphical summaries of input and output for each case are attached in numerical (by case number) order. Figure 1 (copy attached) shows the geometry of the dam used in these analyses. The analyses include all cases required by Reference 2 (see pages 5-4 and 5-5).

Case 1A – End of construction, downstream face. For graphical summary of input, see Figure 2. For graphical summary of output, see Figure 3.

Case 1B – End of construction, upstream face. For graphical summary of input, see Figure 4. For graphical summary of output, see Figure 5.

Case 2 – Long term (steady state), downstream face. For graphical summary of input, see Figure 6 For graphical summary of output, see Figure 7. Note: analysis of upstream face not required (Ref. 2 page 5-3).

Case 3 – Seismic, downstream face. For graphical summary of input, see Figure 8. For graphical summary of output, see Figure 9. Note: analysis of upstream face not required (Ref. 2 page 5-3).

Case 4 – Rapid drawdown of reservoir, upstream face. For graphical summary of input, see Figure 10. For graphical summary of output, see Figure 11. Note: analysis of the downstream face not required (Ref. 2 page 5-2).

Summary of Results:
Table 1 presents the calculated factors of safety for each case. Details of input, design parameters and assumptions, methods, and output are provided below.

Table 1. Calculated factors of safety.

Case		Calculated F.S.	Minimum F.S.*
1A	End of Construction Downstream	1.40	1.4
1B	End of Construction Upstream	1.81	1.4
2	Long Term (Steady State) Downstream.	1.59	1.5
3	Seismic Downstream	1.25	1.1
4	Rapid Drawdown of Reservoir Upstream	1.21	1.2

* Based on Table 5-2 of Reference 2.

All calculated factors of safety exceed the required minimums. The following factors should be considered when completing the final analyses.

1. For Cases 1A and 1B, the factor of safety is very dependant on the shear strengths input for the natural alluvial soils just below the dam. During the final phase of the subsurface investigation, exploration and testing of the soils to depths of 20 to 25 feet will be very important.

2. For Cases 2, 3, and 4, the factor of safety is very dependant on the shear strength of the fill in the dam shells. Testing of this material will be important in the final phase of the geotechnical analysis.

3. Steeper slopes (3H:1V) would only be stable if some of the softer alluvial soils were overexcavated and replaced with controlled fill. That would be difficult with the site's relatively high water table. Also, as discussed below, the NRSC wants to limit slopes to no steeper than 4H:1V.

Geotechnical Parameters for Design

The area of the dam can be divided into three areas of differing subsurface conditions: west abutment, creek valley, and east abutment. For these slope stability analyses, the creek valley area will control the slope stability analyses. This judgment is based on the presence of deeper, lower strength alluvial soils in the creek valley versus stiffer clay soils in the abutments. Also, bedrock is significantly shallower and the embankment will not be as high in the abutment areas. Therefore, no stability analysis is completed here for the portions of the dam in the abutment areas.

For these preliminary analyses, geotechnical parameters were estimated for the natural soils, bedrock, and the embankment fill. The parameters were developed using data from the preliminary subsurface investigation (Ref. 1). Where no test data was available, parameters were estimated using the available data and our previous experience with materials of this type. Table 2 summarizes the design parameters used for the slope stability analyses. The "undrained" strength parameters are used in the end of construction cases (1A and 1B). The "drained" strength parameters are used for all other cases, which represent long term cases.

Borings B-6 and B-10 were located within the creek valley area and were the primary basis for the development of the parameters for the natural soils. For the embankment fill, test data presented on page 14 of Reference 1 was a primary source of data.

The parameters in Table 2 will be verified or adjusted based on the results of the final subsurface investigation at the site. Recommendations for the scope that is needed during that investigation in order to provide the needed data are presented in a separate document. This final investigation would provide the data required by Table 5-2 of Reference 2.

Table 2. Geotechnical Parameters for Slope Stability Analyses.

Design Depth below current grade	Fill / Soil / Rock Type	Moist/ Saturated Unit Weight (pcf)	Undrained Strength Parameters		Drained Strength Parameters		Soil No. in Computer Model
			Shear Strength (s_u) (psf)	Friction Angle (phi) (degrees)	Effective Cohesion (c') (psf)	Effective Friction Angle (phi') (degrees)	
	Reservoir Water	62.4	0	0	0	0	1
Fill	Shells at upstream and downstream face	125	2,000	0	200	24	2 and 4
Fill	Finger sand drains in downstream shell	125	1,600	6	125	25	3
Fill	Chimney sand drain	125	0	31	0	31	5
Fill	Impermeable clay core	125	1,600	0	200	22	6
0 to 6 feet	Alluvial Lean Clay	125	600	0	100	18	7
6 to 20	Interlayered Alluvial Clay, Silt, and Sand	125	500	8	40	22	8
20 to 45	Alluvial Sand	120	0	30	0	30	9
45 to 50	Gravel or highly weathered limestone	130	0	36	0	36	10
50+	Shale bedrock	140	6,000	0	5,000	10	11

Assumptions and information:

1. Analysis was completed using SLOPE/W program published by Geo-Slope International using the Spencer method, which uses both moment and force equilibrium.

2. The internal zoning of the embankment is shown on Figure 1. It is planned to consist of a core consisting of clay fill compacted at slightly higher moisture contents to provide a relatively impermeable section. The internal core will have slopes of 1H:2V, a width of 30 feet at its top, and a top at elevation 928.0 feet (maximum water level in the reservoir). Just downstream of the core will be a chimney drain and finger drains (see items 7 and 8 below). Along, the remainder of the dam, the upstream and downstream "shells", will be constructed of compacted clay fill with some rock fragments, compacted at slightly lower moisture contents to provide higher strengths. The dam slopes will be no steeper than 4H:1V at the request of representatives of the NRCS.

3. For the end of construction cases (1A and 1B), the reservoir level is set at the top of the conservation pool – Elevation 910.0 feet. For this short term analysis, it is assumed that the reservoir would not be at higher elevations for any extended period of time. The phreatic surface (water level inside the dam) for this analysis is modeled simply by staying at elevation 910.0 feet from the upstream face to the chimney drain within the dam. The phreatic surface then follows the chimney and finger drains within the downstream portion of the dam and is set at the ground surface downstream of the dam. In reality the phreatic surface would likely be lower than the reservoir elevation. This is a conservative simplification.

4. For the long term case (2) and seismic case (3), Reference 2 (page 5-3) requires the water level to be set at the "principal spillway crest". For this project, the elevation of the auxiliary spillway is at elevation 915.0 feet. In the model, the reservoir is set at elevation 920.0 feet, a level which would be held for several days after a Probable Maximum Flood rainfall event. The phreatic surface for this analysis is modeled simply by staying at elevation 920.0 feet from the upstream face to the chimney drain within the dam. The phreatic surface then follows the chimney and finger drains within the downstream portion of the dam and is set at the ground surface downstream of the dam. In reality the phreatic surface would likely be lower than the reservoir elevation. This is a conservative simplification.

5. For the rapid drawdown case (4), Reference 2 (page 5-2) requires use of a reservoir level being suddenly dropped from "emergency spillway crest" to the "lowest gated or ungated outlet." Here, that is taken to be a drop from elevation 920.0 feet to elevation 885.0 feet (the top of the "sediment pool"). Reference 2 page 5-4 calls for dropping the water level to the lowest outlet, which this would approximate. The phreatic surface for this analysis is modeled as above in the long term case (see item 4 above). This model assumes that the reservoir is drained so rapidly that the water within the dam does not have sufficient time to react. In reality the phreatic surface would drop as the reservoir drops, but at a much slower rate. This is a conservative simplification.

6. For Case 3, the seismic case, the soil parameters used in the model are from a drained condition (Case 2), as directed by Reference 2 page 5-5.

7. A chimney drain consisting of sand fill is planned just downstream of the impermeable clay core. It will be 4 feet wide. Because it is relatively narrow, it has little impact on the slope stability analysis.

8. A series of finger drains are planned to provide an outlet to the downstream toe of the embankment for water collected in the chimney drain (see item 7 above). These drains will be 3 feet thick and 5 feet wide and spaced at 20 feet (center to center). In between the finger drains will be embankment fill. Therefore, this soil "layer" is modeled as a mixture of clay and sand soils.

9. The ground surface at the upstream and downstream toe of the dam is modeled as elevation 860.0 feet. This is approximately the lowest point in the valley (bottom of the creek channel). Throughout most of the valley area, the ground surface will be closer to elevation 864 to 868 feet. This is a conservative simplification. The final plans will likely call for removing and recompacting 2 to 5 feet of the natural soils below the embankment. That preparation of the subgrade is not addressed in this preliminary analysis as a conservative simplification.

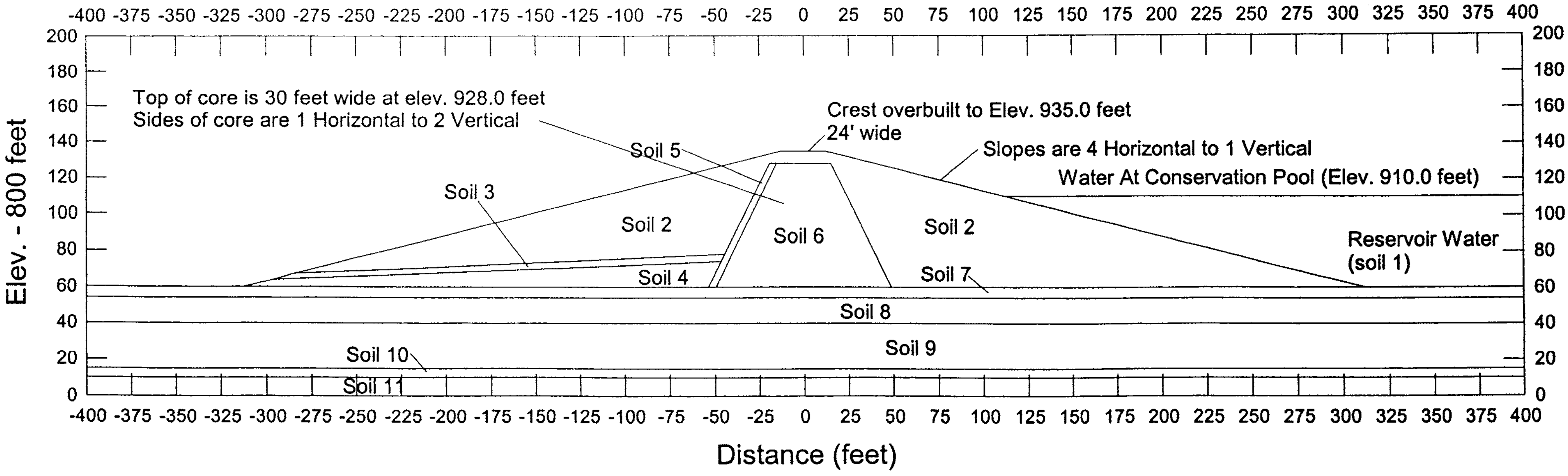
10. The width of the dam crest is 24 feet. The top of dam has been set at elevation 933.0 feet by Burns & McDonnell. The embankment will be over-built a few feet to make up for anticipated long-term settlement of the fill and underlying natural soils. For these analyses, it is estimated that the overbuilding will set the crest at elevation 935.0 feet. The final analyses will address the anticipated settlement in more detail. The analyses are completed using this overbuilt elevation. If the dam settles to a lower elevation, that would make this assumption conservative.

11. For Case 3 (Seismic), the model uses a pseudo-static acceleration. Reference 2 Figure 4-1 places the site in Zone 1 which corresponds to an acceleration of 0.05g. As an alternative and more current guide, Reference 3 page 335 recommends an acceleration (1.0 sec duration) of 0.06g. For this analysis, the higher 0.06g value is used.

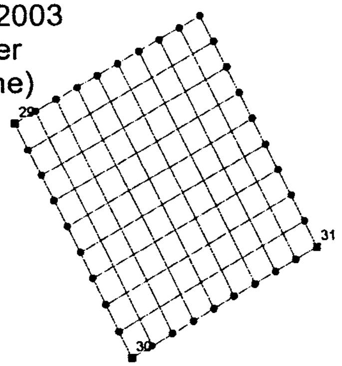
12. A slurry wall will be put under the dam to limit seepage. It would have no significant impact on the slope stability and therefore is not included in this model.

Soil 1 = reservoir water
Soil 2 = upstream and downstream shells of dam (clay fill with some rock fragments, -2% to +4% moisture)
Soil 3 = finger drains in downstream shell (3 feet thick, strips of sand fill 5 feet wide sloped at 5%, spaced at 20 feet center to center, material between them is clay fill - soil 2)
Soil 4 = downstream shell under finger drains (same material as Soil 2)
Soil 5 = chimney drain downstream of core (sand fill, 4 feet wide)
Soil 6 = low permeability core (clay fill, 0 to +4% moisture)
Soil 7 = lean clays (natural soils at ground surface)
Soil 8 = interlayered silts, sands, and clays (natural alluvial soils)
Soil 9 = alluvial sand
Soil 10 = highly weathered limestone or alluvial gravel
Soil 11 = shale bedrock

Figure 1. Geometry of Dam for Preliminary Analyses



Description: Sullivan County Dam - Preliminary - 4H:1V slopes
Comments: Case 1A - End of Construction - Downstream Face
File Name: Case 1A.slz
Last Saved Date: 10/13/2003
Analysis Method: Spencer
Seismic Coefficient: (none)



Soil: 2
Description: Embankment Fill - Shells
Unit Weight: 125
Cohesion: 2000
Phi: 0

Soil: 7
Description: Alluvial Lean Clay
Unit Weight: 125
Cohesion: 850
Phi: 0

Soil: 9
Description: Alluvial Sand
Unit Weight: 120
Cohesion: 0
Phi: 30

Soil: 6
Description: Embankment Fill - Low Perm Core
Unit Weight: 125
Cohesion: 1600
Phi: 0

Soil: 8
Description: Interlayered clay and sand
Unit Weight: 125
Cohesion: 500
Phi: 8

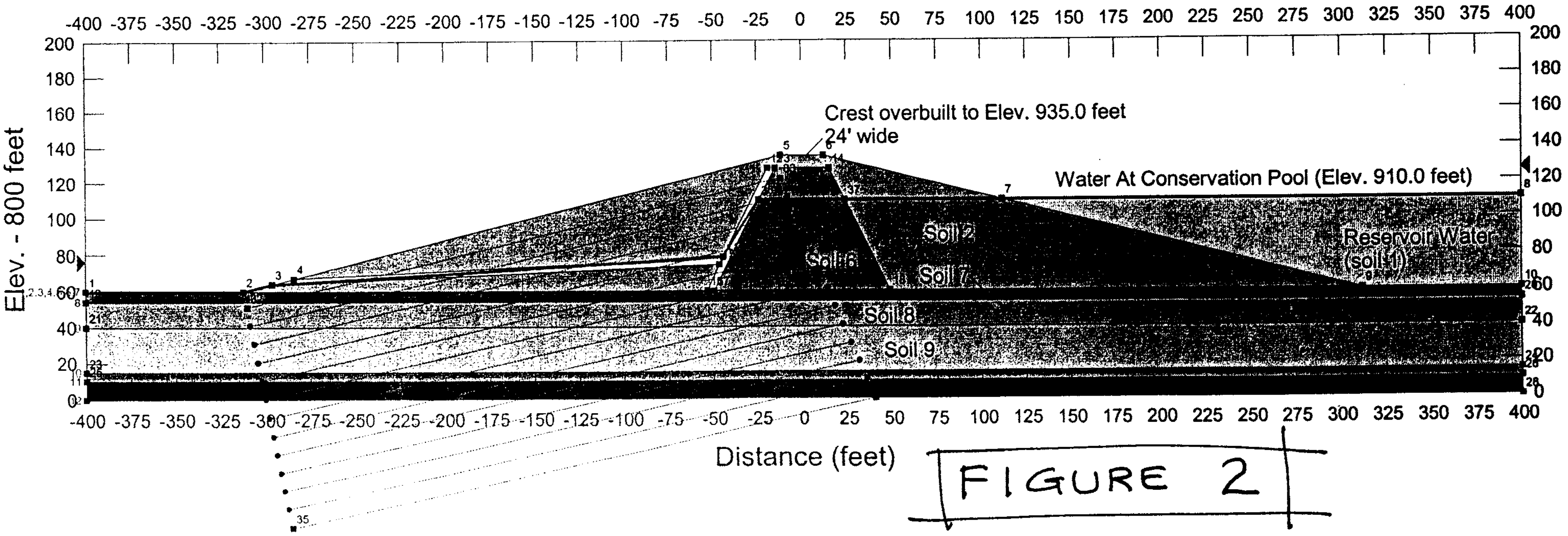
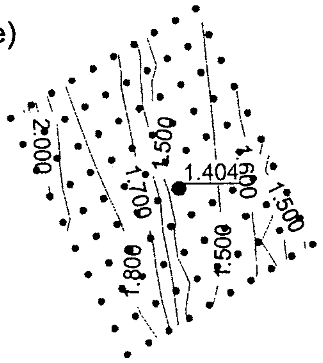


FIGURE 2

Description: Sullivan County Dam - Preliminary - 4H:1V slopes
Comments: Case 1A - End of Construction - Downstream Face
File Name: Case 1A.slz
Last Saved Date: 10/13/2003
Analysis Method: Spencer
Seismic Coefficient: (none)



Soil: 2
Description: Embankment Fill - Shells
Unit Weight: 125
Cohesion: 2000
Phi: 0

Soil: 6
Description: Embankment Fill - Low Perm Core
Unit Weight: 125
Cohesion: 1600
Phi: 0

Soil: 7
Description: Alluvial Lean Clay
Unit Weight: 125
Cohesion: 850
Phi: 0

Soil: 8
Description: Interlayered clay and sand
Unit Weight: 125
Cohesion: 500
Phi: 8

Soil: 9
Description: Alluvial Sand
Unit Weight: 120
Cohesion: 0
Phi: 30

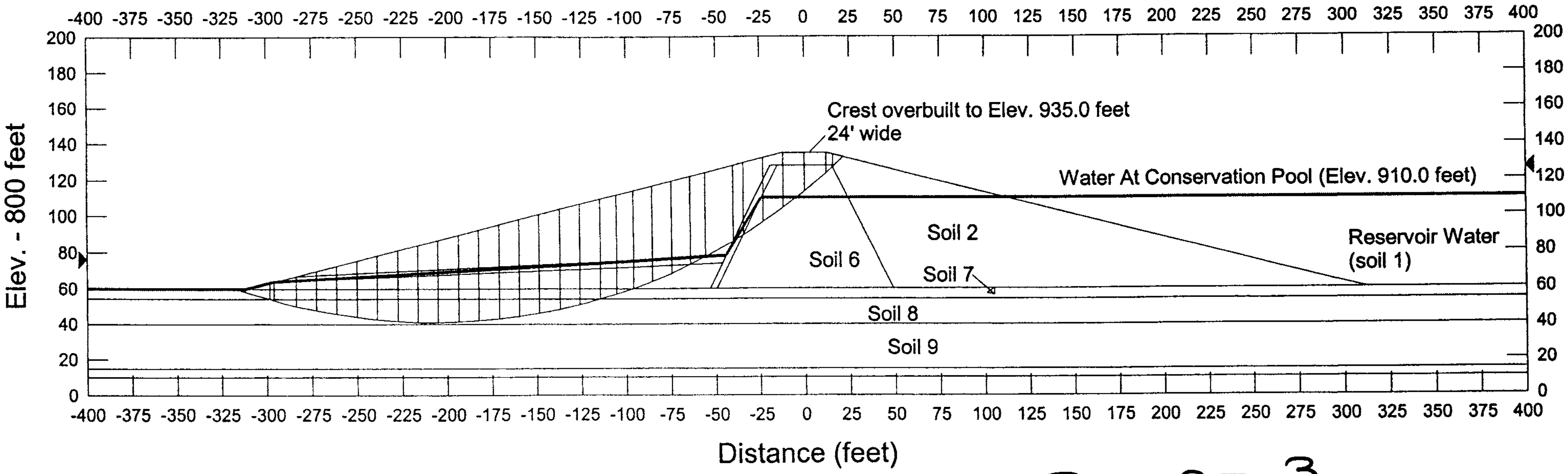


FIGURE 3

Description: Sullivan County Dam - Preliminary - 4H:1V slopes
Comments: Case 1B - End of Construction - Upstream Face
File Name: Case 1B.slz
Last Saved Date: 10/14/2003
Analysis Method: Spencer
Seismic Coefficient: (none)

Soil: 2
Description: Embankment Fill - Shells
Unit Weight: 125
Cohesion: 2000
Phi: 0

Soil: 6
Description: Embankment Fill - Low Perm Core
Unit Weight: 125
Cohesion: 1600
Phi: 0

Soil: 7
Description: Alluvial Lean Clay
Unit Weight: 125
Cohesion: 850
Phi: 0

Soil: 8
Description: Interlayered clay and sand
Unit Weight: 125
Cohesion: 500
Phi: 8

Soil: 9
Description: Alluvial Sand
Unit Weight: 120
Cohesion: 0
Phi: 30

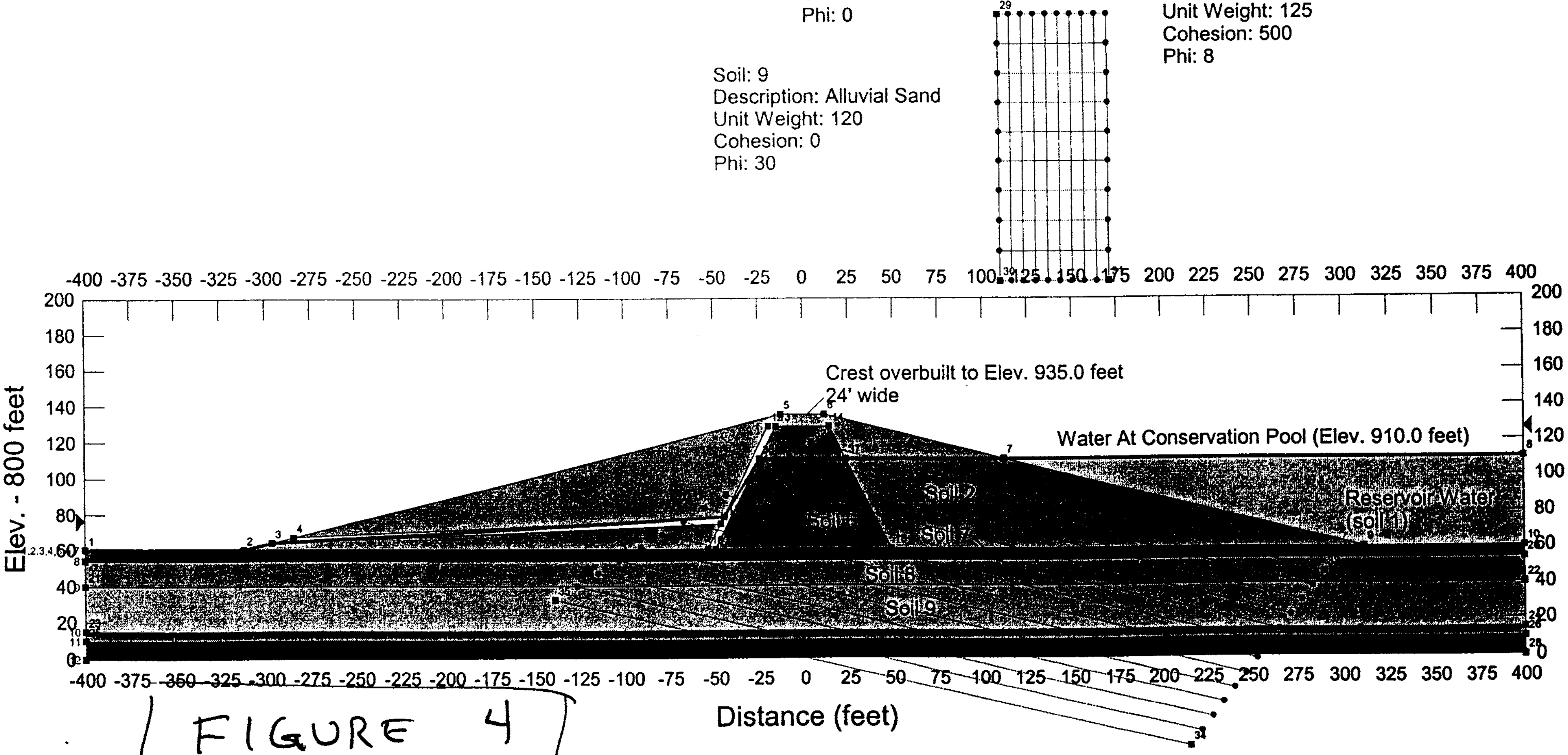


FIGURE 4

Description: Sullivan County Dam - Preliminary - 4H:1V slopes
Comments: Case 1B - End of Construction - Upstream Face
File Name: Case 1B.slz
Last Saved Date: 10/14/2003
Analysis Method: Spencer
Seismic Coefficient: (none)

Soil: 2
Description: Embankment Fill - Shells
Unit Weight: 125
Cohesion: 2000
Phi: 0

Soil: 6
Description: Embankment Fill - Low Perm Core
Unit Weight: 125
Cohesion: 1600
Phi: 0

Soil: 7
Description: Alluvial Lean Clay
Unit Weight: 125
Cohesion: 850
Phi: 0

Soil: 8
Description: Interlayered clay and sand
Unit Weight: 125
Cohesion: 500
Phi: 8

Soil: 9
Description: Alluvial Sand
Unit Weight: 120
Cohesion: 0
Phi: 30

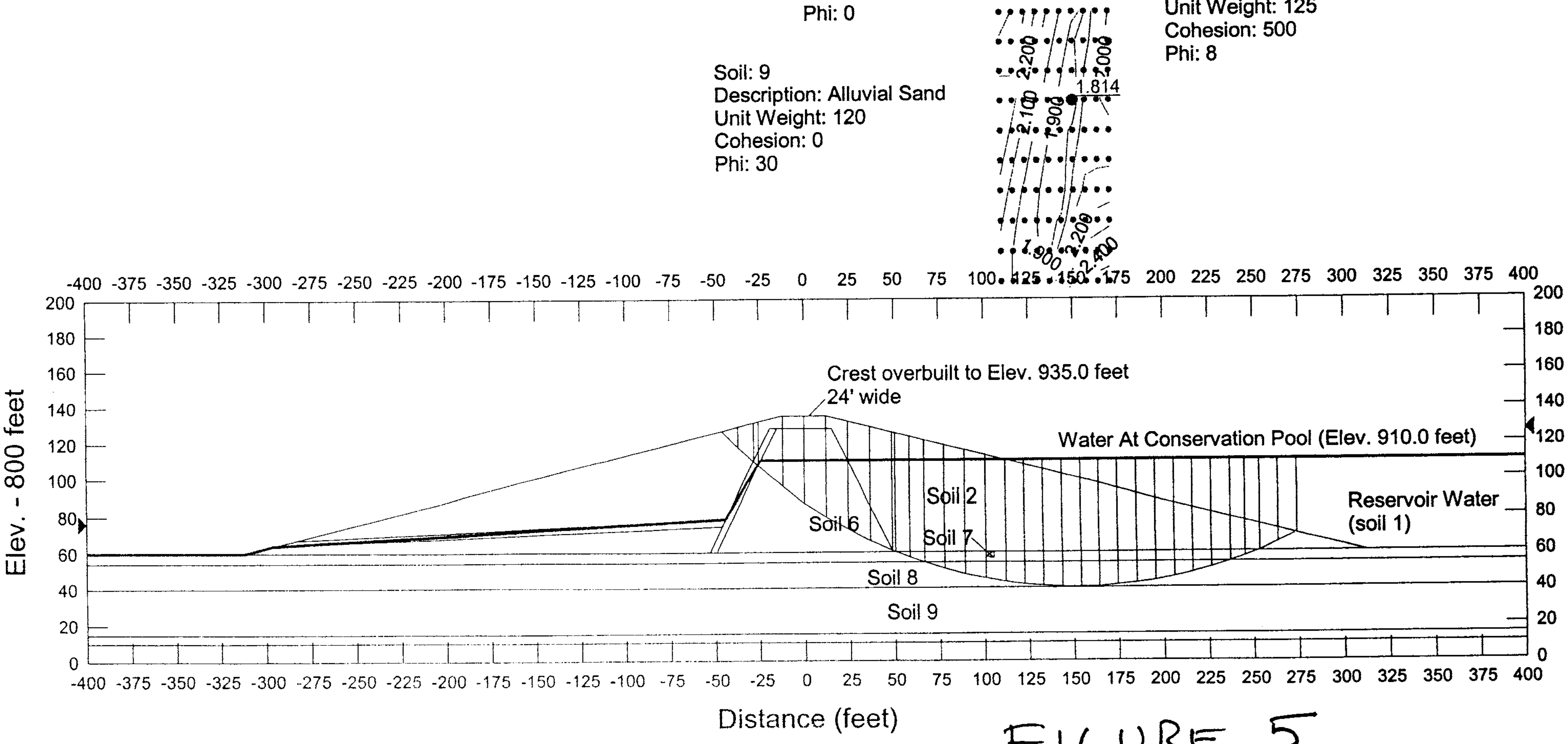


FIGURE 5

Description: Sullivan County Dam - Preliminary - 4H:1V slopes
Comments: Case 2 - Long Term (steady state) - Downstream Face
File Name: Case 2.slz
Last Saved Date: 10/14/2003
Analysis Method: Spencer
Seismic Coefficient: (none)

Soil: 2
Description: Embankment Fill - Shells
Unit Weight: 125
Cohesion: 200
Phi: 24

Soil: 6
Description: Embankment Fill - Low Perm Core
Unit Weight: 125
Cohesion: 200
Phi: 22

Soil: 7
Description: Alluvial Lean Clay
Unit Weight: 125
Cohesion: 100
Phi: 18

Soil: 8
Description: Interlayered clay and sand
Unit Weight: 125
Cohesion: 40
Phi: 22

Soil: 9
Description: Alluvial Sand
Unit Weight: 120
Cohesion: 0
Phi: 30

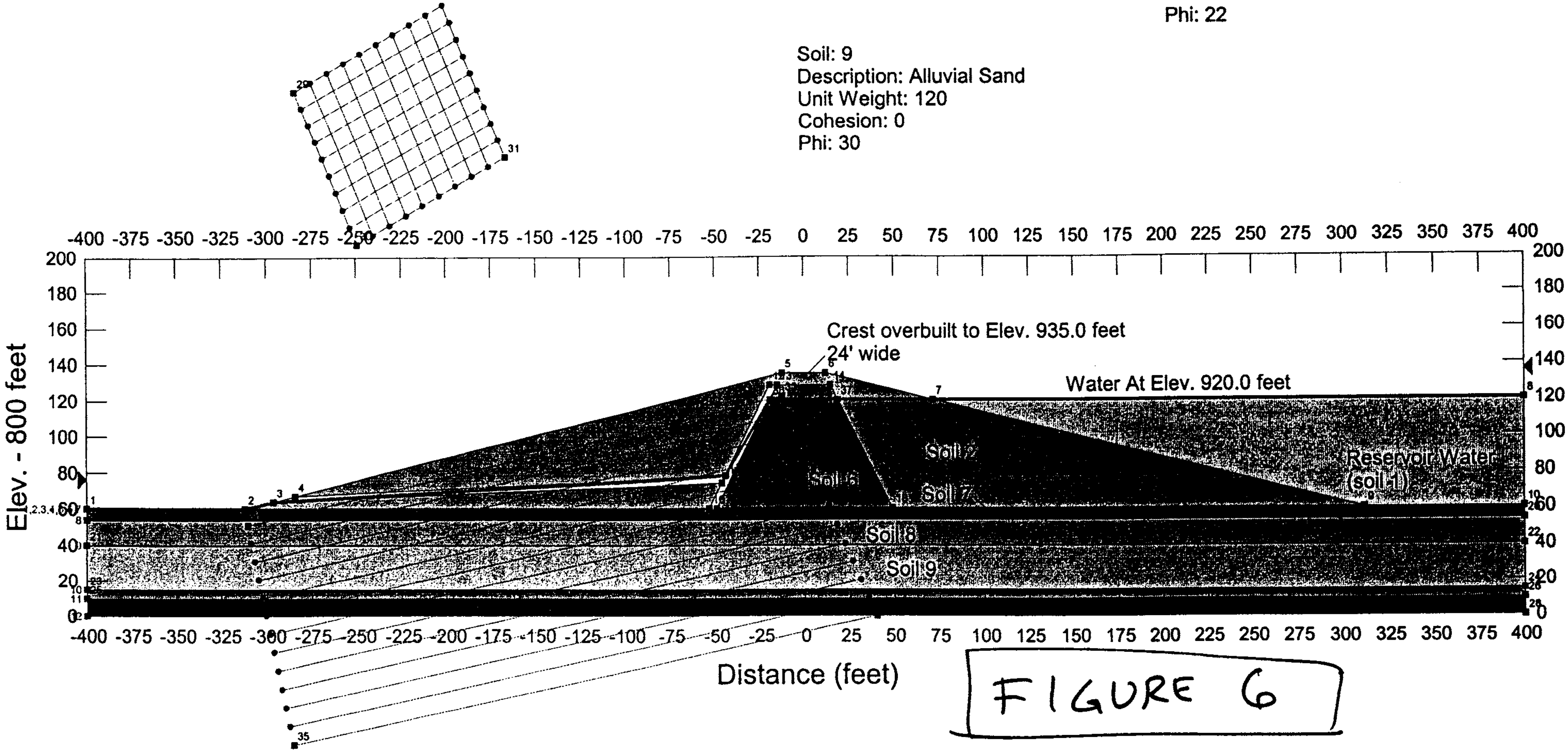


FIGURE 6

Description: Sullivan County Dam - Preliminary - 4H:1V slopes
Comments: Case 2 - Long Term (steady state) - Downstream Face
File Name: Case 2.slz
Last Saved Date: 10/14/2003
Analysis Method: Spencer
Seismic Coefficient: (none)

Soil: 2
Description: Embankment Fill - Shells
Unit Weight: 125
Cohesion: 200
Phi: 24

Soil: 7
Description: Alluvial Lean Clay
Unit Weight: 125
Cohesion: 100
Phi: 18

Soil: 9
Description: Alluvial Sand
Unit Weight: 120
Cohesion: 0
Phi: 30

Soil: 6
Description: Embankment Fill - Low Perm Core
Unit Weight: 125
Cohesion: 200
Phi: 22

Soil: 8
Description: Interlayered clay and sand
Unit Weight: 125
Cohesion: 40
Phi: 22

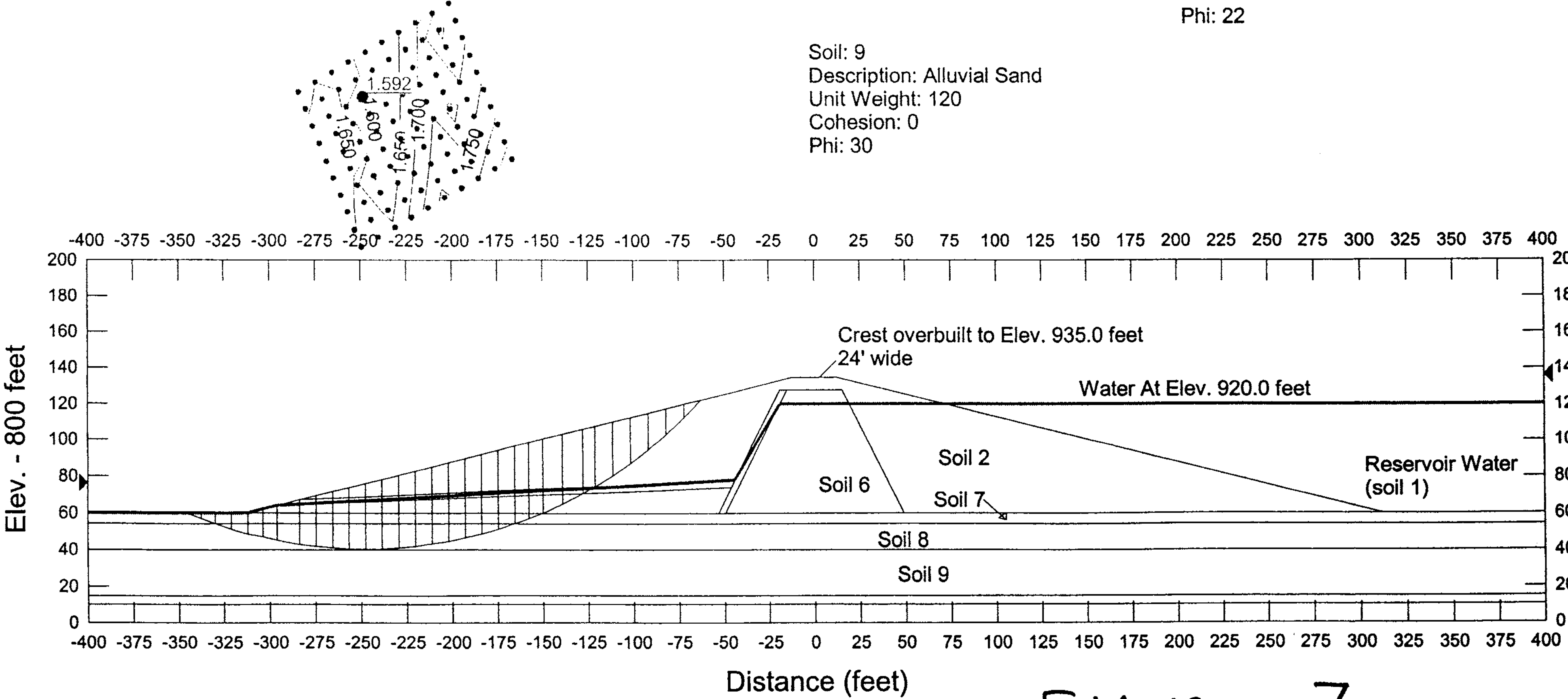


FIGURE 7

Description: Sullivan County Dam - Preliminary - 4H:1V slopes
Comments: Case 3 - Seismic (0.06g) - Downstream Face
File Name: Case 3.slz
Last Saved Date: 10/14/2003
Analysis Method: Spencer
Seismic Coefficient: Horizontal

Soil: 2
Description: Embankment Fill - Shells
Unit Weight: 125
Cohesion: 200
Phi: 24

Soil: 6
Description: Embankment Fill - Low Perm Core
Unit Weight: 125
Cohesion: 200
Phi: 22

Soil: 7
Description: Alluvial Lean Clay
Unit Weight: 125
Cohesion: 100
Phi: 18

Soil: 8
Description: Interlayered clay and sand
Unit Weight: 125
Cohesion: 40
Phi: 22

Soil: 9
Description: Alluvial Sand
Unit Weight: 120
Cohesion: 0
Phi: 30

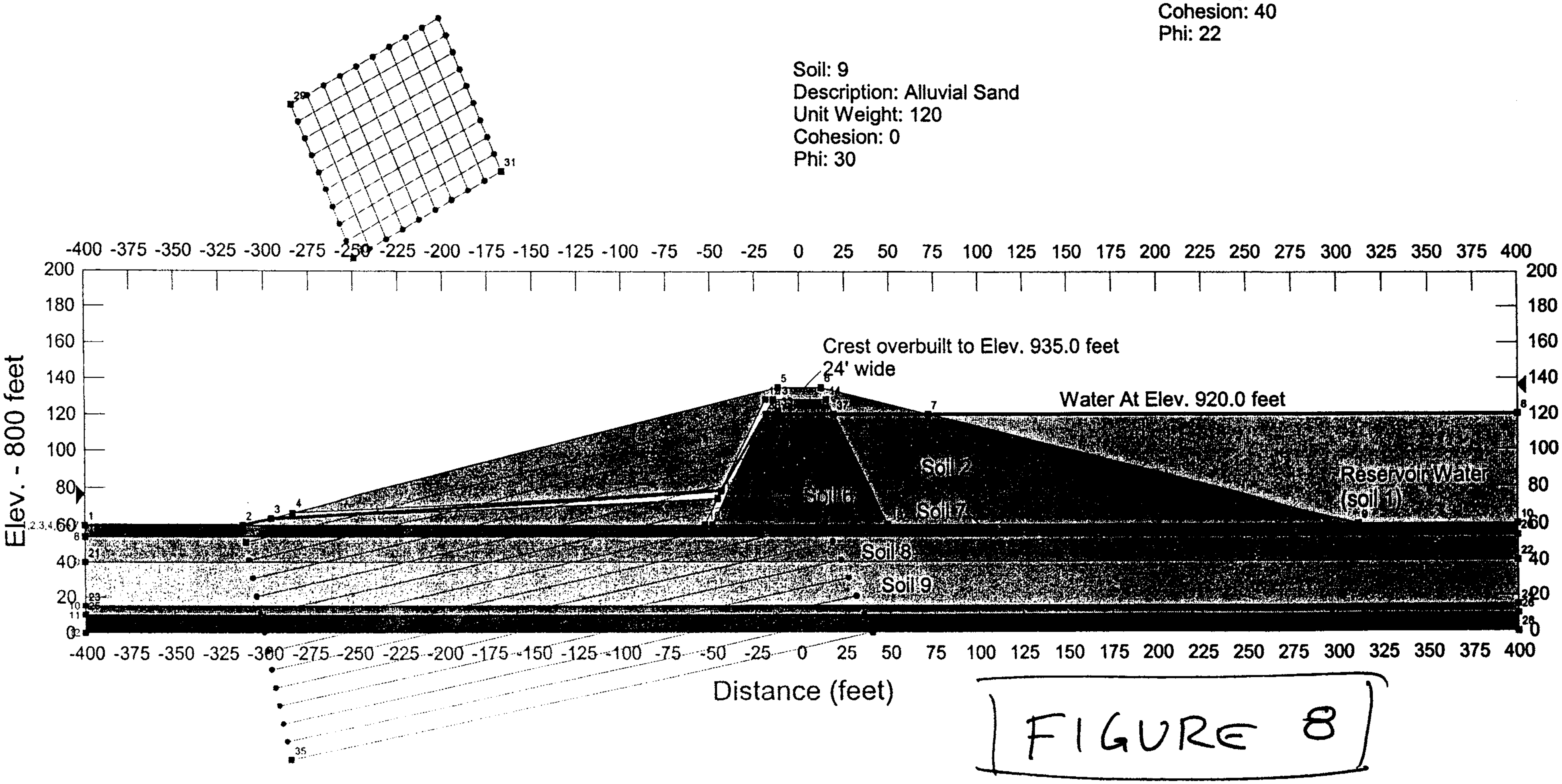


FIGURE 8

Description: Sullivan County Dam - Preliminary - 4H:1V slopes
Comments: Case 3 - Seismic (0.06g) - Downstream Face
File Name: Case 3.slz
Last Saved Date: 10/14/2003
Analysis Method: Spencer
Seismic Coefficient: Horizontal

Soil: 2
Description: Embankment Fill - Shells
Unit Weight: 125
Cohesion: 200
Phi: 24

Soil: 6
Description: Embankment Fill - Low Perm Core
Unit Weight: 125
Cohesion: 200
Phi: 22

Soil: 7
Description: Alluvial Lean Clay
Unit Weight: 125
Cohesion: 100
Phi: 18

Soil: 8
Description: Interlayered clay and sand
Unit Weight: 125
Cohesion: 40
Phi: 22

Soil: 9
Description: Alluvial Sand
Unit Weight: 120
Cohesion: 0
Phi: 30

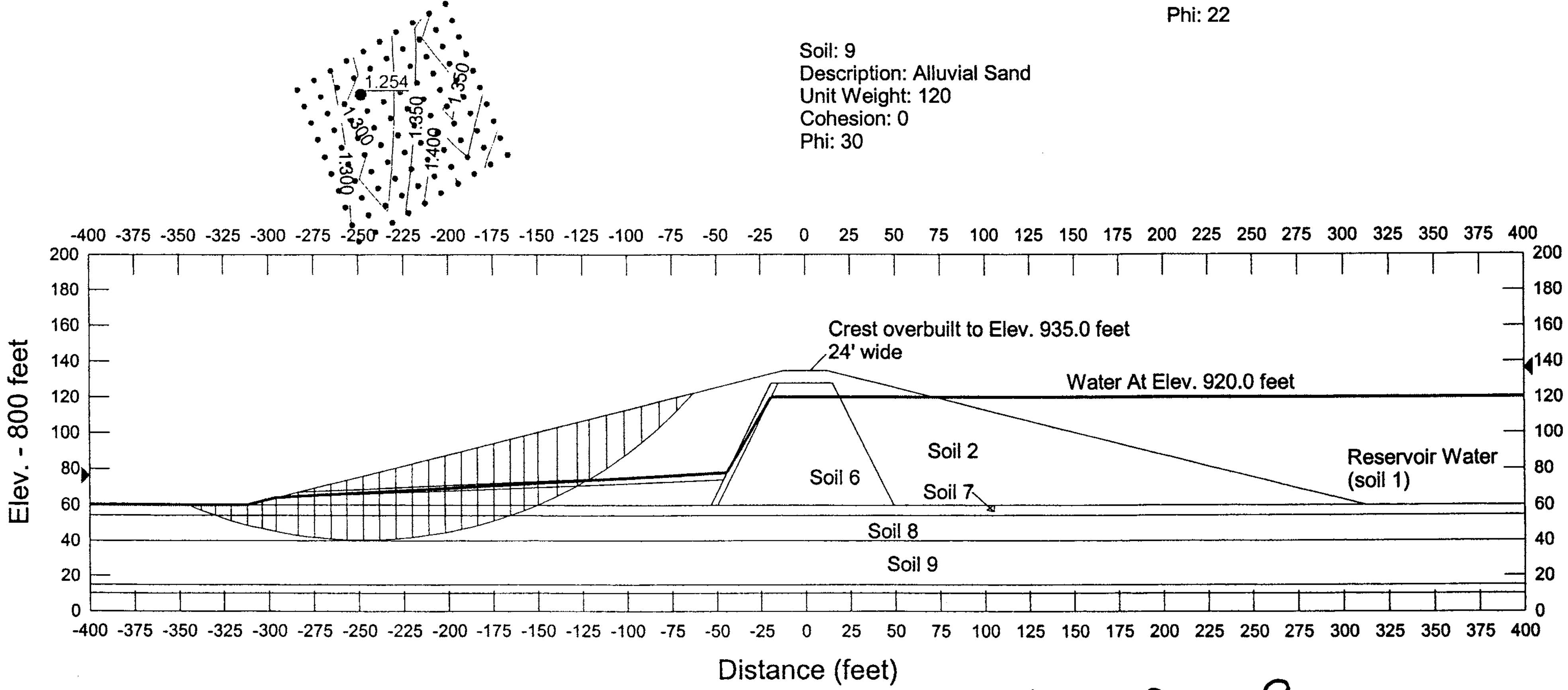


FIGURE 9

Description: Sullivan County Dam - Preliminary - 4H:1V slopes
Comments: Case 4 - Rapid Drawdown - Upstream Face
File Name: Case 4.slz
Last Saved Date: 10/14/2003
Analysis Method: Spencer
Seismic Coefficient: (none)

Soil: 2
Description: Embankment Fill - Shells
Unit Weight: 125
Cohesion: 200
Phi: 24

Soil: 6
Description: Embankment Fill - Low Perm Core
Unit Weight: 125
Cohesion: 200
Phi: 22

Soil: 7
Description: Alluvial Lean Clay
Unit Weight: 125
Cohesion: 100
Phi: 18

Soil: 8
Description: Interlayered clay and sand
Unit Weight: 125
Cohesion: 40
Phi: 22

Soil: 9
Description: Alluvial Sand
Unit Weight: 120
Cohesion: 0
Phi: 30

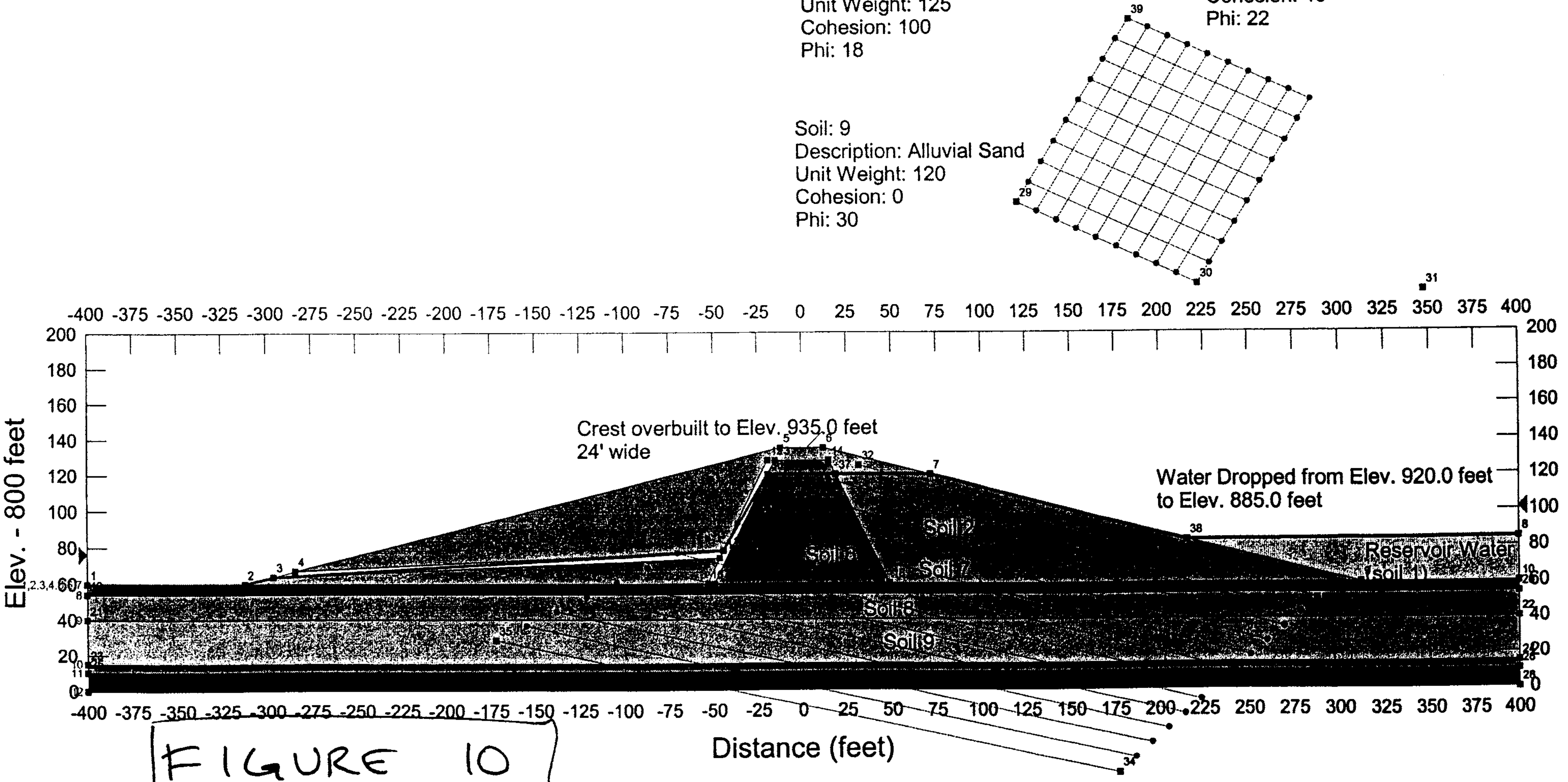


FIGURE 10

Description: Sullivan County Dam - Preliminary - 4H:1V slopes
Comments: Case 4 - Rapid Drawdown - Upstream Face
File Name: Case 4.slz
Last Saved Date: 10/14/2003
Analysis Method: Spencer
Seismic Coefficient: (none)

Soil: 2
Description: Embankment Fill - Shells
Unit Weight: 125
Cohesion: 200
Phi: 24

Soil: 6
Description: Embankment Fill - Low Perm Core
Unit Weight: 125
Cohesion: 200
Phi: 22

Soil: 7
Description: Alluvial Lean Clay
Unit Weight: 125
Cohesion: 100
Phi: 18

Soil: 8
Description: Interlayered clay and sand
Unit Weight: 125
Cohesion: 40
Phi: 22

Soil: 9
Description: Alluvial Sand
Unit Weight: 120
Cohesion: 0
Phi: 30

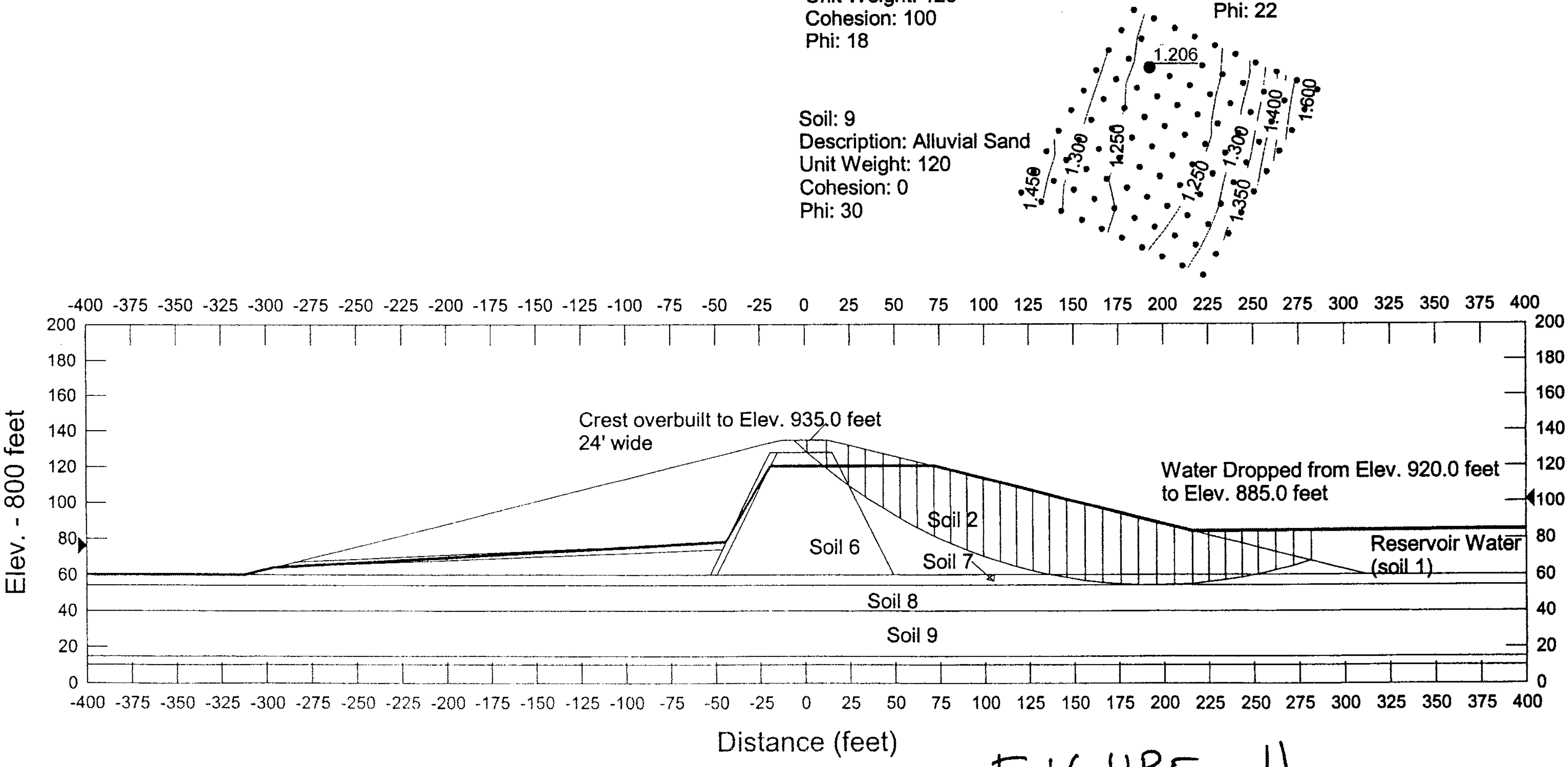


FIGURE 11

ATTACHMENT 2
UNDERSEEPAGE ANALYSES

Preliminary Underseepage Analyses
Steve Wendland – GeoSystems / Kleinfelder – October 21, 2003

Objective:

Complete underseepage analysis to determine if seepage reduction measures are necessary and to evaluate proposed sizing of chimney and finger drains within the dam.

References:

1. GeoSystems, *Subsurface Exploration and Preliminary Geotechnical Report*, Job No. 1025193, June 14, 2002

2. *Earth Dams and Reservoirs,* Technical Release No. 60 210-VI, Revised Oct. 1985, US Dept. of Agriculture, Soil Conservation Service

The following cases will be analyzed:

Graphical summaries of input and output for each case are attached in numerical (by case number) order. Figures 1 and 12 show the geometry of the dam used in these analyses.

Case 1 – Dam at Maximum Height along Creek Alignment without Slurry Wall. Figure 2 shows set up of problem. Figure 3 shows graphical output presenting seepage vectors and flow through flux sections. Figure 4 is graphical output showing total head contours within the dam. Figure 5 in graphical output showing location of phreatic surface ("water table") within the dam. Figure 6 is graphical output showing vertical gradients for water seeping under the dam.

Case 2 – Dam at Maximum Height along Creek Alignment **with** Slurry Wall. Figure 7 shows set up of problem. Figure 8 shows graphical output presenting seepage vectors and flow through flux sections. Figure 9 is graphical output showing total head contours within the dam. Figure 10 in graphical output showing location of phreatic surface ("water table") within the dam. Figure 11 is graphical output showing vertical gradients for water seeping under the dam.

Case 3 – Dam near Middle of East Abutment without Grout Curtain. Figure 13 shows set up of problem. Figure 14 shows graphical output presenting seepage vectors and flow through flux sections. Figure 15 is graphical output showing total head contours within the dam. Figure 16 in graphical output showing location of phreatic surface ("water table") within the dam. Figure 17 is graphical output showing vertical gradients for water seeping under the dam.

Case 4 – Dam near Middle of East Abutment **with** Grout Curtain. Figure 18 shows set up of problem. Figure 19 shows graphical output presenting seepage vectors and flow through flux sections. Figure 20 is graphical output showing total head contours within the dam. Figure 21 in graphical output showing location of phreatic surface ("water table") within the dam. Figure 22 is graphical output showing vertical gradients for water seeping under the dam.

Summary of Results:

Case 1 indicates that without a slurry wall below the dam:

- Water seeping out at the downstream toe of the dam has a vertical gradient as high as 1.5 (see Figure 6). Values above 1.0 indicate that the seepage would erode the soil. Vertical gradients should be less than 0.7 at the toe of the dam. Therefore, based on this model the dam would experience significant seepage induced erosion at the toe.
- The phreatic surface within the downstream portion of the dam will be 15 feet above the finger drains and will exit the downstream dam face well above the finger drains (see Figure 5), neither of which are acceptable. To eliminate the seepage out of the dam face it would be necessary to increase the size of the internal drains if a slurry wall was not installed below the dam.
- Seepage below the dam will be approximately 4.37 cubic feet per day per horizontal foot of the dam (see Figure 3). The portion of the dam in the valley floor will be approximately 1,000 feet long, which would result in a loss of approximately 4,400 cubic feet (33,000 gallons) per day from the reservoir. While not excessive, it is high.
- Seepage at the end of the finger drains at the downstream toe of the dams will be approximately 0.84 cubic feet per day per horizontal foot of dam (see Figure 3), an acceptably low number.

Based on the seepage gradients at the downstream toe of the dam and the seepage out of the downstream face of the dam, it would not be acceptable to construct the dam without seepage reduction measures such as a slurry wall.

Case 2 indicates that with a slurry wall:

- Seepage gradients at the toe of the dam are reduced to no greater than 0.2 (see Figure 11), well within acceptable limits. While much higher gradients occur at the top of the slurry wall, this area is well within the center of the dam and would not cause an erosion concern.

- The phreatic surface within the downstream portion of the dam is lowered to below the finger drains (see Figure 10) and is not exiting along the downstream face of the dam. Therefore, little to no seepage along the downstream face of the dam would be expected.
- Seepage under the dam is 0.51 cubic feet per day per horizontal foot of dam, an approximately 88 percent reduction. Seepage out of the finger drains is reduced to a very small number. (see Figure 8)

Overall, the presence of the slurry wall brings the seepage gradients to within acceptable limits and corrects the concern with seepage on the downstream face of the dam.

Case 3 indicates that if sandstone layers are present within the east abutment and no grout curtain is installed within them or the overlying glacial till soils:

- The proposed internal drains (chimney drain and finger drains) within the dam will control seepage within the dam. The phreatic surface in the downstream portion of the dam will be below the finger drains and will not exit on the downstream face of the dam. (see Figure 16).
- Seepage within the finger drains would be low. Seepage under the dam (through the glacial till soils and sandstone bedrock) would be approximately 0.35 cubic feet per day per horizontal foot of the dam, not a high number. (see Figure 14)
- Seepage gradients within the dam would be low. However, seepage gradients within the natural slopes below the downstream toe of the dam would be as high as 0.55 (see Figure 17). This gradient is high, but not above acceptable limits. It could be reduced by installing subsurface drain lines ("French" drains) within the soil in the area.

Overall, based on this preliminary assessment, installation of seepage reduction measures (such as grouting the sandstone and till) in the east abutment does not appear to be necessary. It is likely that springs would occur on the natural ground surface downhill from the embankment. The springs could be controlled, if desired, by installation of subsurface drains in the area. There is very little subsurface data available to evaluate the permeability and continuity of the sandstone layers within the Pleasanton Shale at the ridge along the east abutment. Once the final subsurface investigation has been completed at the site, it will be necessary to re-evaluate this analysis.

Case 4 indicates that if a grout curtain were installed within the sandstone layers and the glacial till soils:

- Seepage within the finger drains would be low. Seepage under the dam would be approximately 0.29 cubic feet per day per horizontal foot of the dam, not a high number, a 17% reduction from Case 3 without the grout curtain. (see Figure 19)
- Just as with Case 3, the position of the phreatic surface within the downstream portion of the dam is not of concern (see Figure 21).
- Seepage gradients remain relatively unchanged from Case 3, with maximum values of approximately 0.5 (see Figure 22).

Overall, the grout curtain provides little improvement. However, if the sandstone layers are more permeable or more widespread than modeled here, if the glacial till soils have more sand seams, or if the soil mantle is thinner than currently anticipated, then this preliminary analysis may not be accurate.

The following factors should be considered when completing the final analyses.

1. For Cases 1 and 2, the analyses are controlled by the presence of the alluvial sands within the creek valley. The depth and continuity of these sands must be thoroughly evaluated by the final phase of the subsurface investigation. However, it is unlikely that the recommended slurry wall would be made unnecessary by the findings of that final subsurface investigation.

2. For Cases 3 and 4, the thickness of the soil mantle overlying the interlayered shale and sandstone bedrock is limiting the seepage through the sandstone layers. The final phase of the subsurface investigation should better evaluate the soil thickness and consistency on the ridge at the east abutment.

Geotechnical Parameters for Design

The area of the dam can be divided into three areas of differing subsurface conditions: west abutment, creek valley, and east abutment. For these underseepage analyses, the creek valley area will likely be the worst case due to the deep alluvial soils, but the presence of glacial till soils and sandstone layers within the bedrock of the east abutment may also be of concern. The west abutment is of less concern because it is on a much wider ridge, but very little subsurface information is currently available in that area.

For these preliminary analyses, geotechnical parameters were estimated for the natural soils, bedrock, and the embankment fill. The parameters were developed using data from the preliminary subsurface investigation (Ref. 1). Where no test data was available, parameters were estimated using the available data and our previous experience with materials of this type. Tables 2 and 3 summarize the design parameters used for the underseepage analyses. Borings B-6 and B-10 were located within the creek valley area and were the primary basis for the development of the parameters for the natural soils in Cases 1 and 2. For Cases 3 and 4, Borings B-1 to B-4 and B-7 to B-9 were used.

The parameters in Tables 2 and 3 will be verified or adjusted based on the results of the final subsurface investigation at the site. Recommendations for the scope that is needed during that investigation in order to provide the needed data are presented in a separate document.

Table 2. Geotechnical Parameters for Underseepage Analyses – Cases 1 and 2

Design Depth below current grade	Fill / Soil / Rock Type	Horizontal Permeability (feet / day) / (cm / sec)*	Ratio of Horizontal to Vertical Permeability
Fill	Shells at upstream and downstream face	0.0285 / 1 x 10-6	1:1
Fill	Finger sand drains in downstream shell	0.75 / 2.6 x 10-4	1:1
Fill	Chimney sand drain	2.85 / 1 x 10-3	1:1
Fill	Impermeable clay core	0.00285 / 1 x 10-7	1:1
0 to 6 feet	Alluvial lean clay	0.0285 / 1 x 10-5	2:1
6 to 20	Interlayered alluvial clay, silt, and sand	0.285 / 1 x 10-4	10:1
20 to 45	Alluvial sand	2.85 / 1 x 10-3	2:1
45 to 50	Gravel or highly weathered limestone	2.85 / 1 x 10-3	2:1
50+	Shale bedrock	Modeled as impermeable	n/a
n/a	Slurry wall	0.000285 / 1 x 10-8	1:1

* Data was input into program using feet per day. cm / sec equivalents are provided here for reference.

Table 3. Geotechnical Parameters for Underseepage Analyses – Cases 3 and 4

Design Depth below current grade	Fill / Soil / Rock Type	Horizontal Permeability (feet / day) / (cm / sec)*	Ratio of Horizontal to Vertical Permeability
Fill	Shells at upstream and downstream face	0.0285 / 1 x 10-6	1:1
Fill	Finger sand drains in downstream shell	0.75 / 2.6 x 10-4	1:1
Fill	Chimney sand drain	2.85 / 1 x 10-3	1:1
Fill	Impermeable clay core	0.00285 / 1 x 10-7	1:1
0 to 12 feet	Glacial till soils	0.0285 / 1 x 10-5	2:1
12 to 20 and 30 to 38	Sandstone	0.285 / 1 x 10-4	10:1
20 to 30	Upper shale	0.00285 / 1 x 10-7	1:1
38+	Lower shale bedrock	Modeled as impermeable	n/a
n/a	Grout curtain	0.0285 / 1 x 10-6	1:1

* Data was input into program using feet per day. cm / sec equivalents are provided here for reference.

Assumptions and information:

1. Analysis was completed using SEEP/W program version 5.1 published by Geo-Slope International.

2. See the slope stability analysis (Attachment 1) for details regarding the geometry of the dam, including the internal drains.

3. Based on information from Burns & McDonnell, the maximum water level in the reservoir will be elevation 928.0 feet, but water will only be present at or near that level for only a few hours. For these analyses, the water level in the reservoir has been set at elevation 925.0 feet. Even at 925.0 feet, the water level would be at or near this elevation for a short period of time (less than a few days) and seepage

under and through the dam would not likely have time to react to this raised water level. Therefore, use of this elevation in the analyses should be conservative. The normal pool will be at elevation 910.0 feet. The program models the water level by keeping the total head constant at elevation 925 feet (125 feet in the model) at all nodes within the reservoir.

4. Well downstream of the dam, it is estimated that the static water level will be 5 feet below the ground surface. No water is allowed to pond on the ground surface downstream of the dam or on the downstream face of the dam.

5. In Cases 1 and 2, it is assumed that no significant groundwater volume will flow through the shale bedrock. In Cases 3 and 4, an upper layer of shale with a low permeability is included in the model, but for deeper shale it is assumed that no significant groundwater would flow through the shale.

6. For Case 2, the slurry wall is set to be 5 feet wide and will be constructed approximately 5 feet up into the embankment fill. The slurry wall would continue down to top of bedrock.

7. For Case 4, the grout curtain is set to be 15 feet wide. The grout curtain would not make any significant change to the permeability of the shale bedrock, as it is already relatively impermeable. It would only improve the sandstone and sandy portions of the glacial till. For this model, the grout curtain is modeled as going 26 feet into the bedrock. Once the final subsurface investigation is completed and the elevations of the sandstone layers are better established, a maximum depth of the grout curtain would be established.

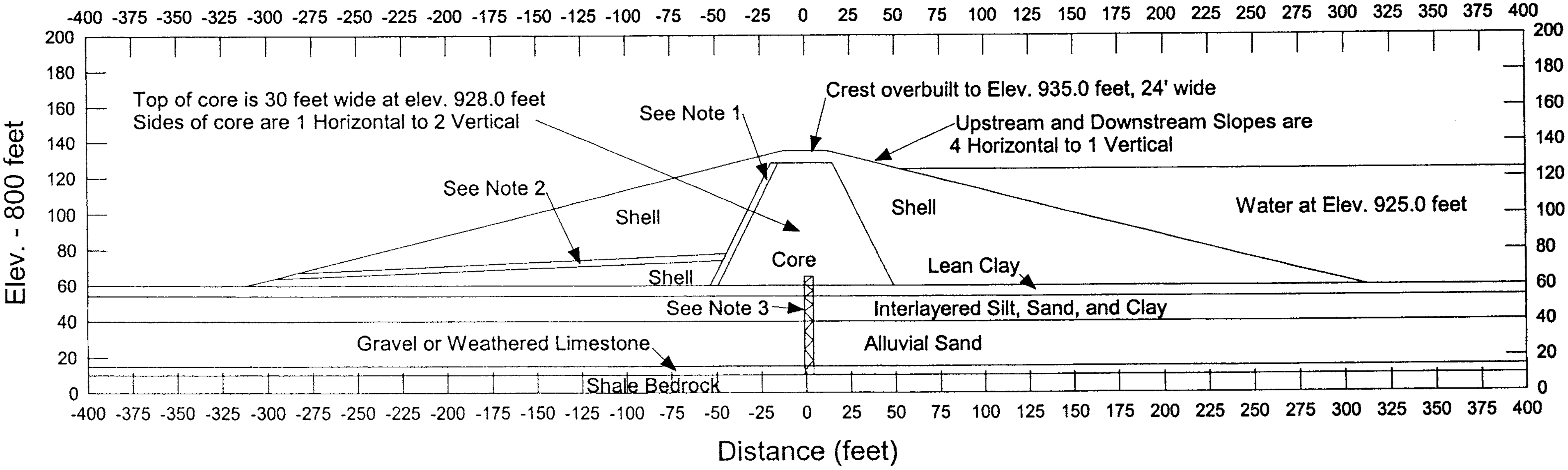
8. For Cases 3 and 4, the ground surface on the east ridge is modeled as having a 6 Horizontal to 1 Vertical slope. Most of the site is actually sloped at a shallower grade, but this steeper grade shortens the flow path of water seeping under the dam and is therefore a conservative model.

Figure 1. Geometry of Dam for Preliminary Analyses Cases 1 and 2

Note 1: Chimney drain is sand fill 4 feet wide on downstream face of core.

Note 3: Slurry wall in Case 2 is 5 feet wide from 5 feet into core to top of bedrock

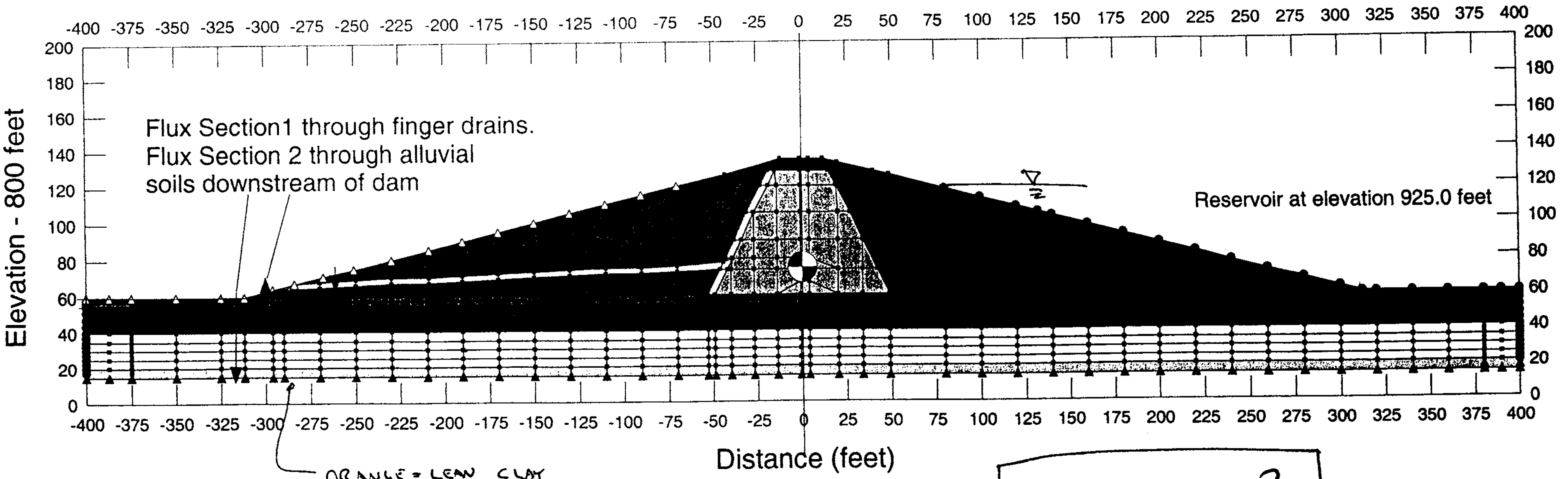
Note 2: Finger drains are 3 feet deep, 5 feet wide strips spaced at 20 feet center to center, sloped at 5% grade towards toe. Between strips and below them is typical fill for dam shells.



Description: Sullivan County Dam - Preliminary Underseepage Analysis
Comments: Case 1 - Max Height of Dam - Reservoir to Elev 925.0'
File Name: Case 1.sez
Last Saved Date: 10/17/2003
Analysis Type: Steady-State
Analysis View: 2-D

CASE 1

No slurry wall under dam



ORANGE = LEAN CLAY
BROWN = INTERLAYERED SILT, SAND, CLAY
YELLOW = ALLUVIAL SAND
GRAY = GRAVEL, OR HIGHLY WEATHERED LIMESTONE

FIGURE 2

Description: Sullivan County Dam - Preliminary Underseepage Analysis
Comments: Case 1 - Max Height of Dam - Reservoir to Elev. 925.0'
File Name: Case 1.sez
Last Saved Date: 10/17/2003
Analysis Type: Steady-State
Analysis View: 2-D

No slurry wall under dam

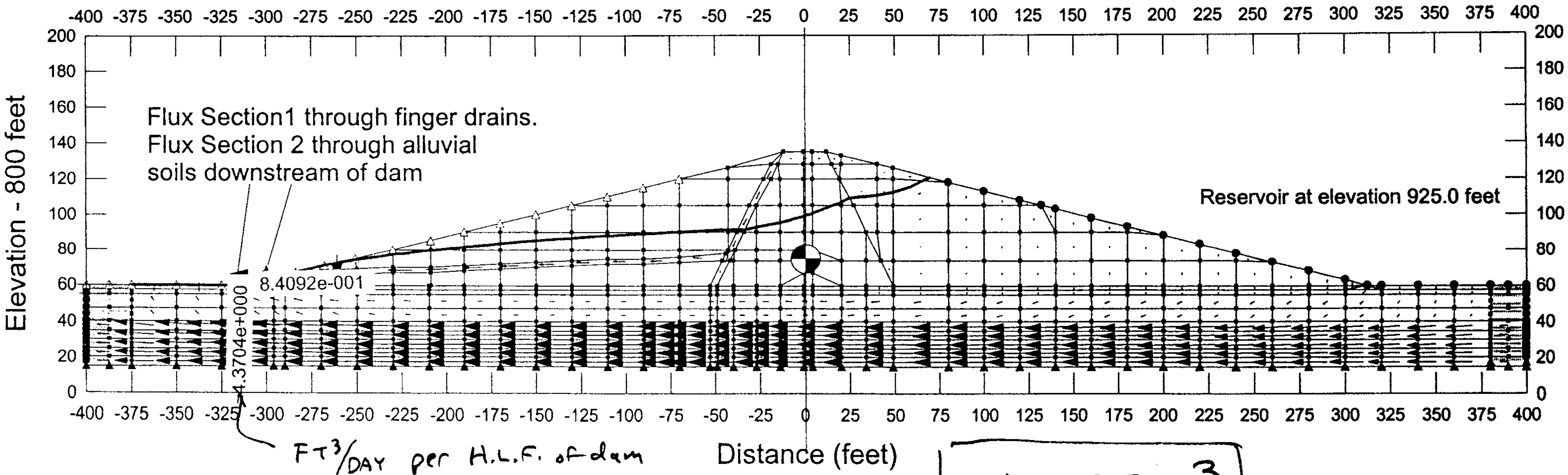


FIGURE 3

Description: Sullivan County Dam - Preliminary Underseepage Analysis
Comments: Case 1 - Max Height of Dam - Elev. 925.0' for Reservoir
File Name: Case 1.sez
Last Saved Date: 10/17/2003
Analysis Type: Steady-State
Analysis View: 2-D

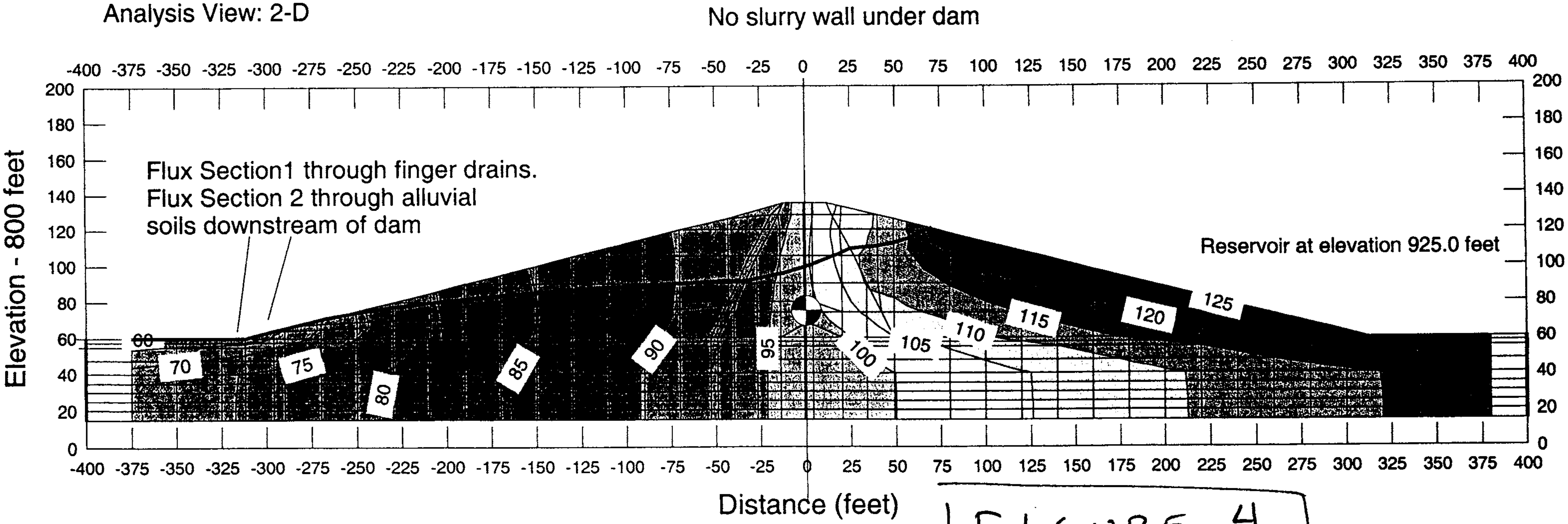


FIGURE 4

Description: Sullivan County Dam - Preliminary Underseepage Analysis
Comments: Case 1 - Max Height of Dam - Reservoir to Elev. 925.0 feet
File Name: Case 1.sez
Last Saved Date: 10/17/2003
Analysis Type: Steady-State
Analysis View: 2-D

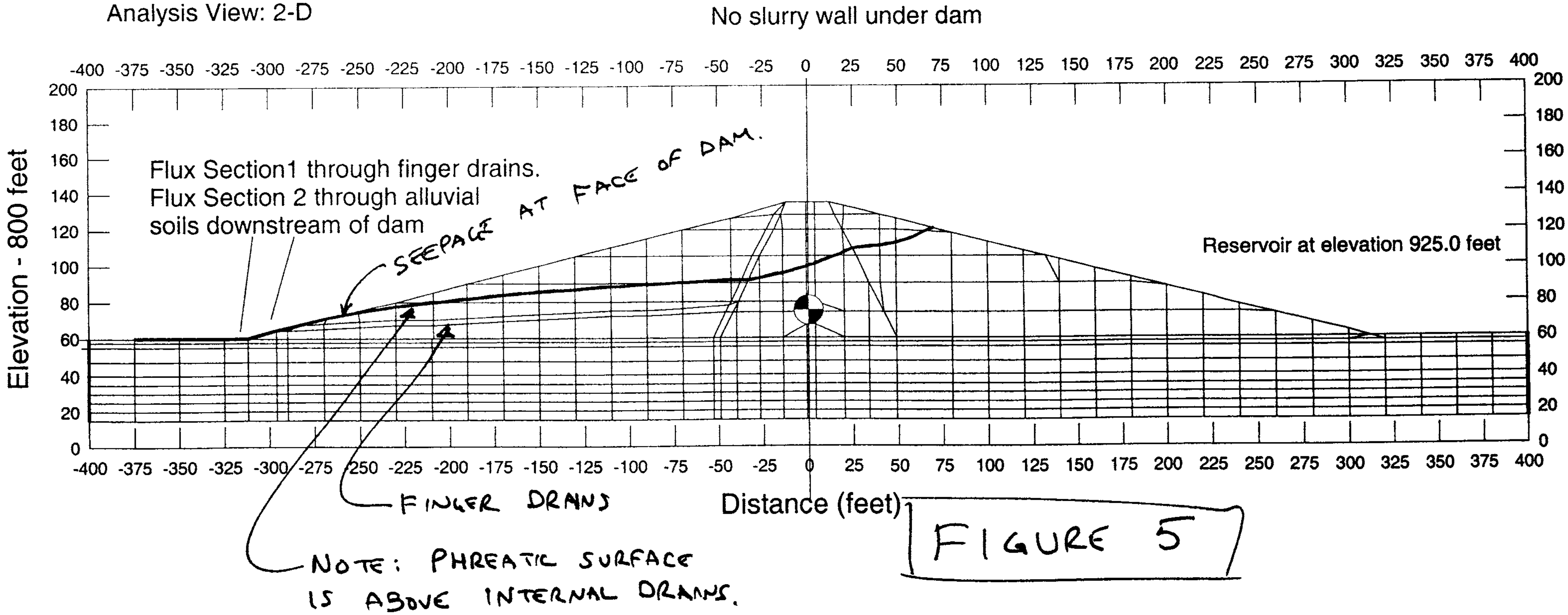


FIGURE 5

Description: Sullivan County Dam - Preliminary Underseepage Analysis
Comments: Case 1 - Max Height of Dam - Reservoir to Elev. 925.0'
File Name: Case 1.sez
Last Saved Date: 10/17/2003
Analysis Type: Steady-State
Analysis View: 2-D

No slurry wall under dam

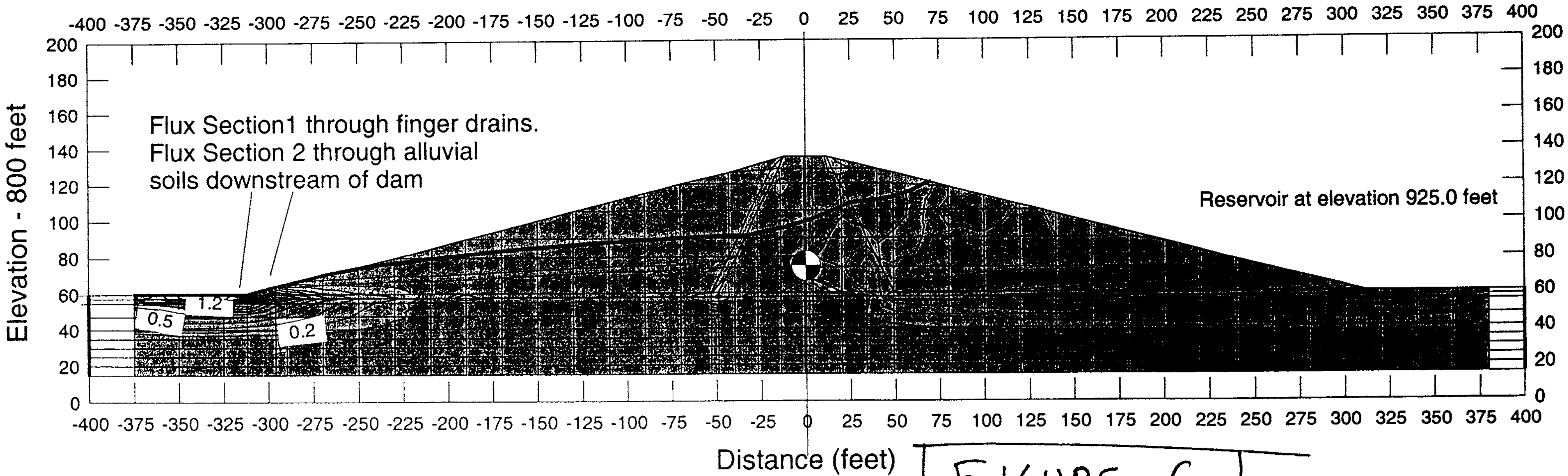
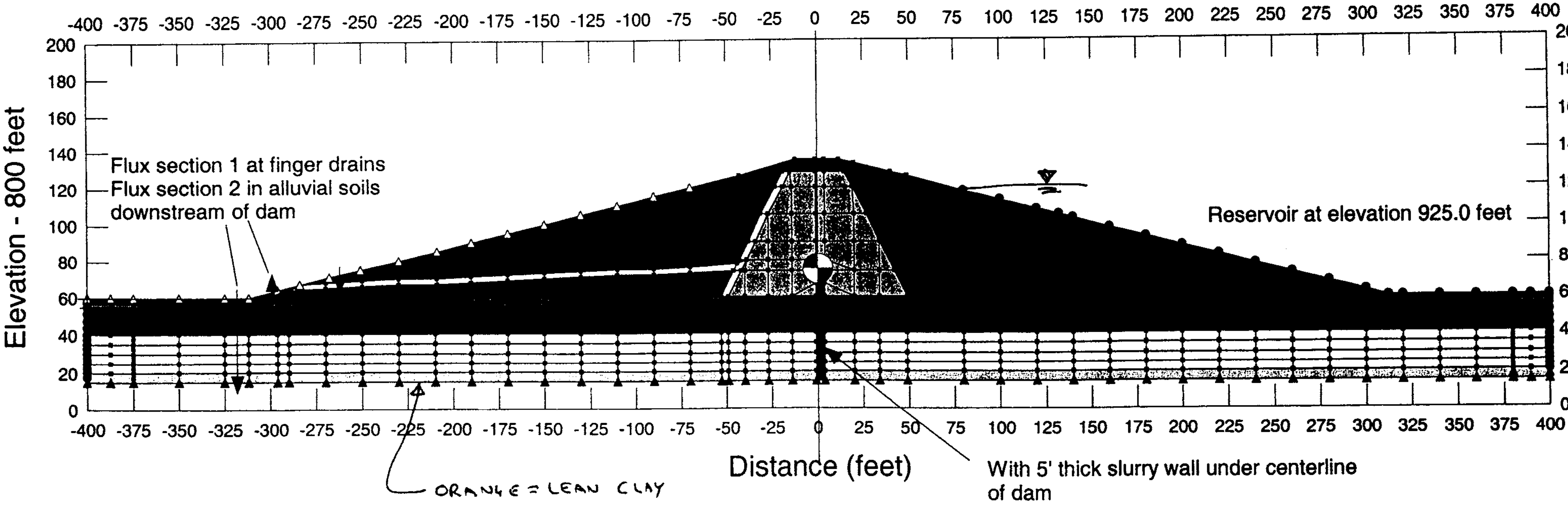


FIGURE 6

Description: Sullivan County Dam - Preliminary Underseepage Analysis
Comments: Case 2 - Max Height of Dam - Reservoir to Elev 925.0 feet, with slurry wall
File Name: Case 2.sez
Last Saved Date: 10/17/2003
Analysis Type: Steady-State
Analysis View: 2-D

CASE 2



ORANGE = LEAN CLAY
BROWN = INTERLAYERED SILT, SAND, CLAY
YELLOW = ALLUVIAL SAND
GRAY = GRAVEL OR HIGHLY WEATHERED LIMESTONE

FIGURE 7

Description: Sullivan County Dam - Preliminary Underseepage Analysis
Comments: Case 2 - Max Height of Dam - Reservoir to Elev 925.0 feet, with slurry wall
File Name: Case 2.sez
Last Saved Date: 10/17/2003
Analysis Type: Steady-State
Analysis View: 2-D

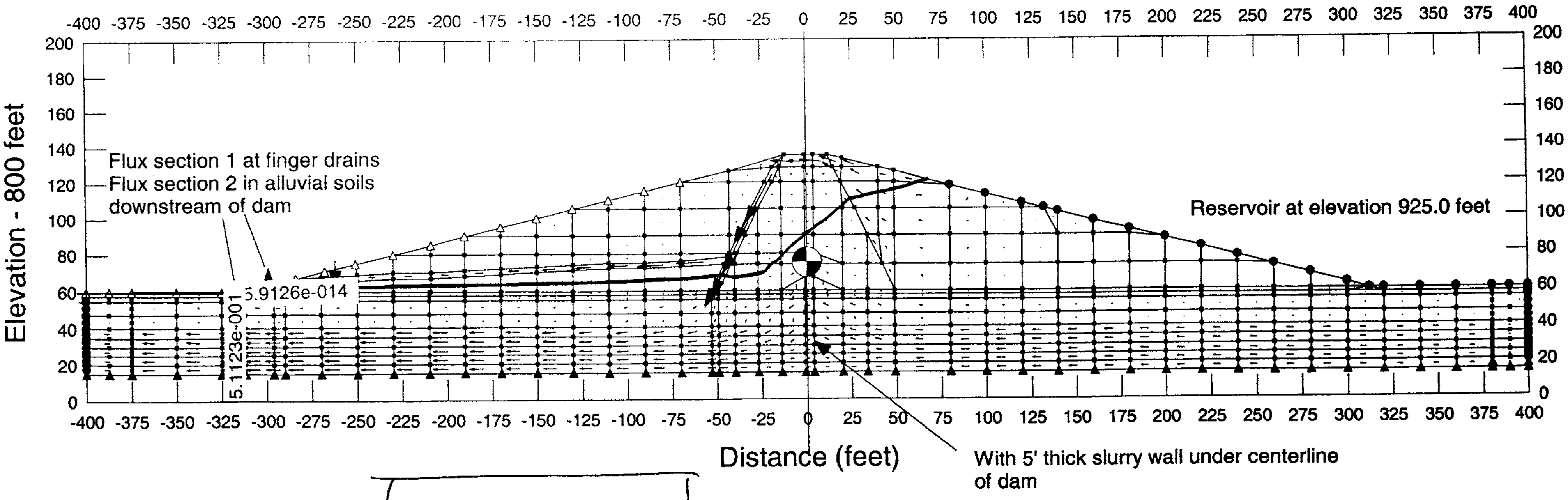


FIGURE 8

Description: Sullivan County Dam - Preliminary Underseepage Analysis
Comments: Case 2 - Max Height of Dam - Reservoir to Elev 925.0 feet, with slurry wall
File Name: Case 2.sez
Last Saved Date: 10/17/2003
Analysis Type: Steady-State
Analysis View: 2-D

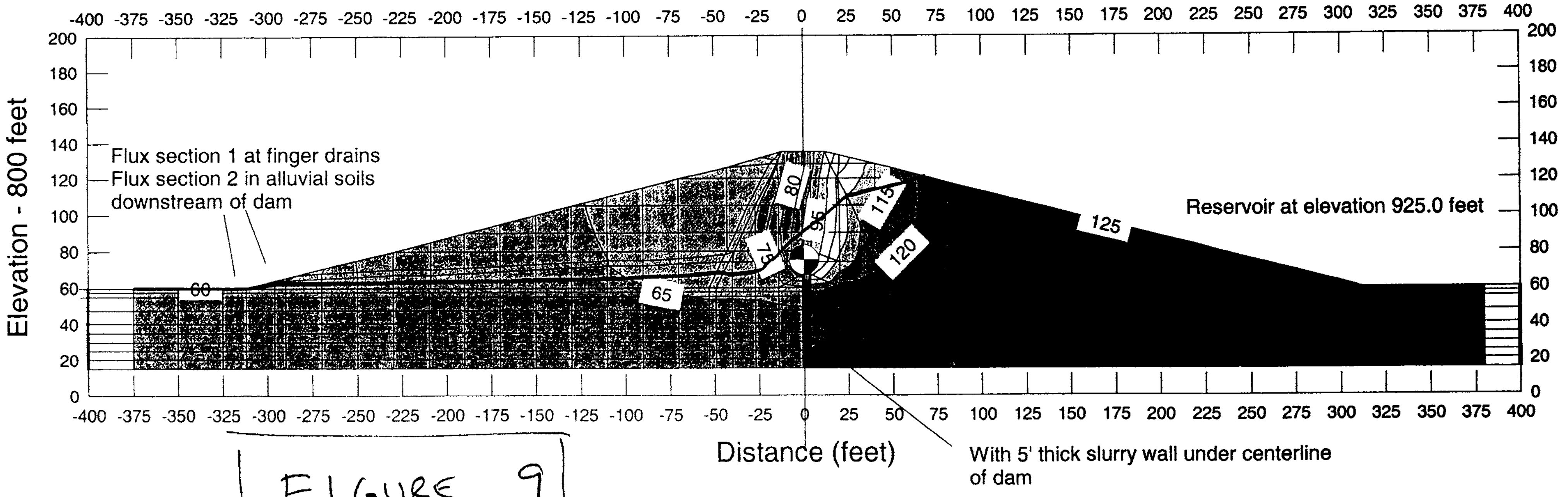


FIGURE 9

Description: Sullivan County Dam - Preliminary Underseepage Analysis
Comments: Case 2 - Max Height of Dam - Reservoir to Elev 925.0 feet, with slurry wall
File Name: Case 2.sez
Last Saved Date: 10/17/2003
Analysis Type: Steady-State
Analysis View: 2-D

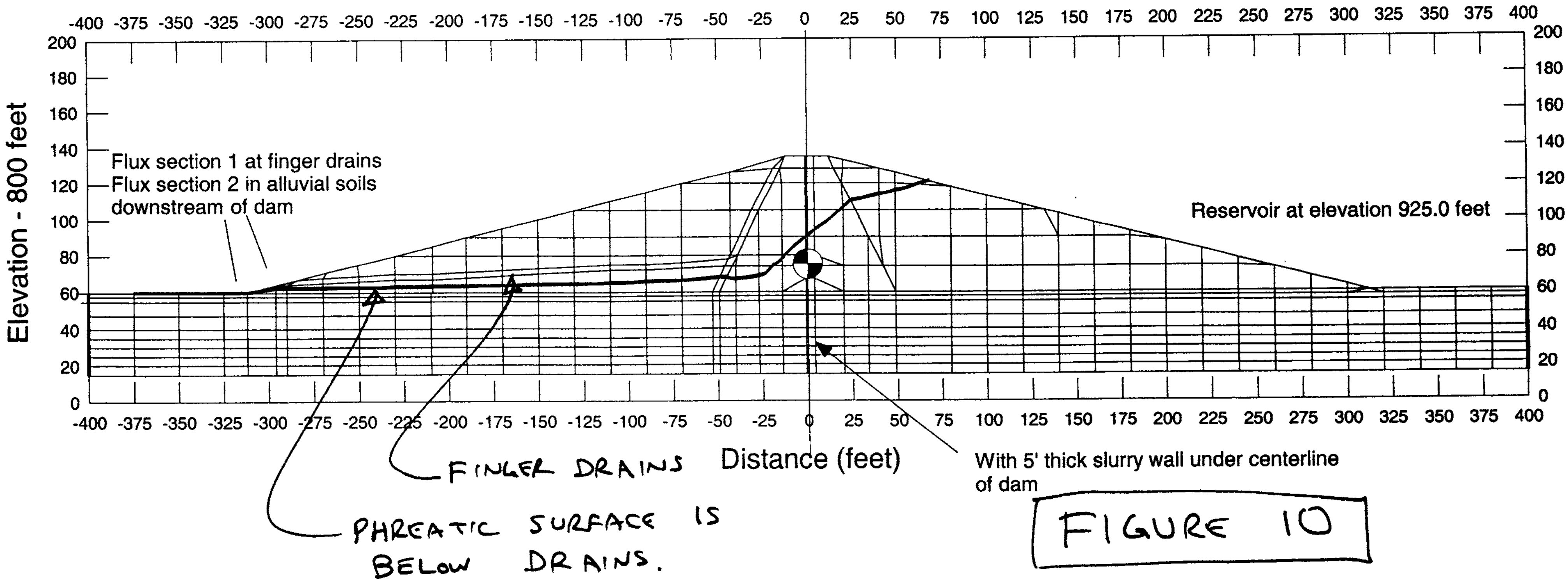
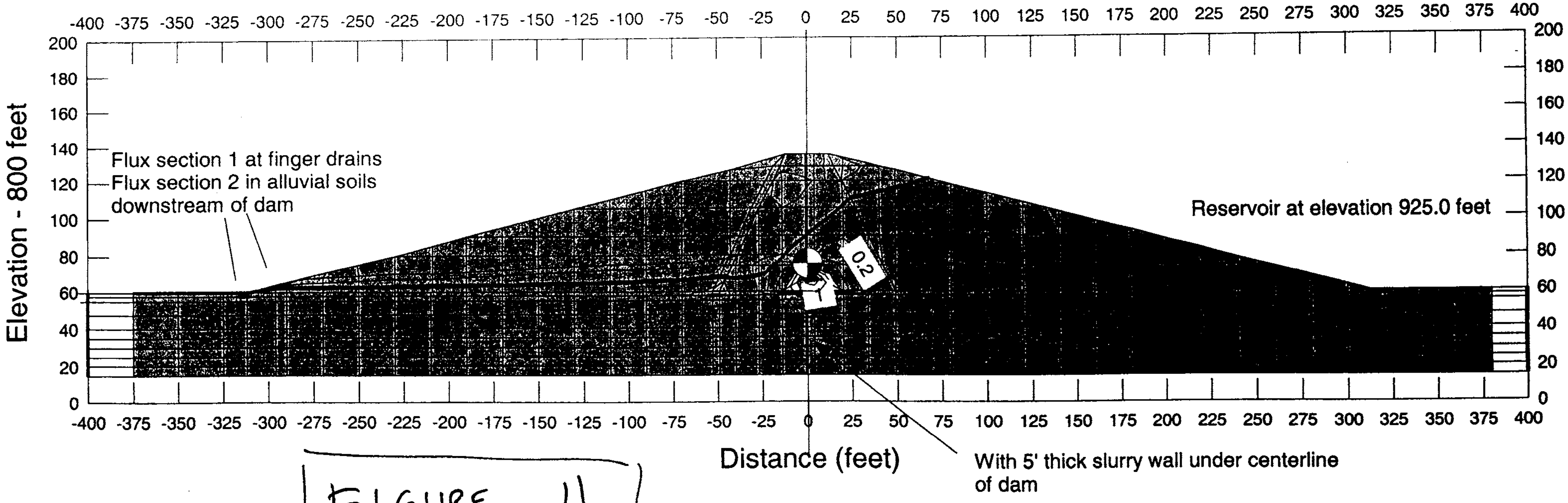


FIGURE 10

Description: Sullivan County Dam - Preliminary Underseepage Analysis
Comments: Case 2 - Max Height of Dam - Reservoir to Elev 925.0 feet, with slurry wall
File Name: Case 2.sez
Last Saved Date: 10/17/2003
Analysis Type: Steady-State
Analysis View: 2-D



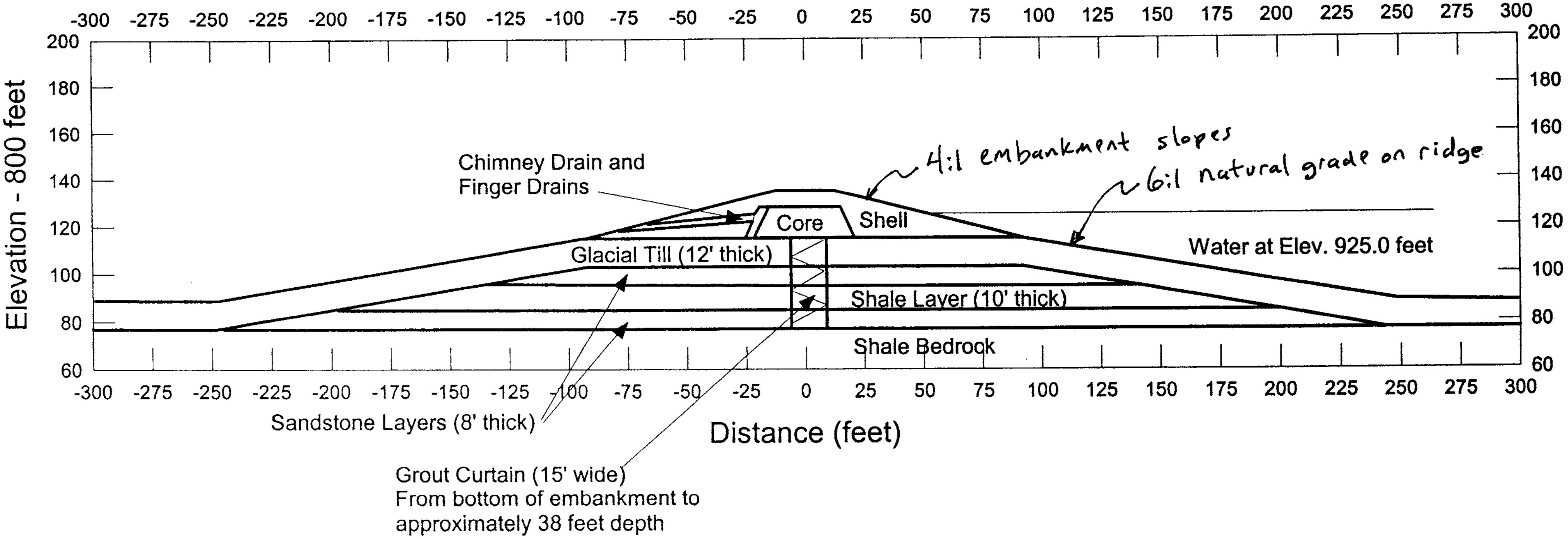
Flux section 1 at finger drains
Flux section 2 in alluvial soils
downstream of dam

Reservoir at elevation 925.0 feet

With 5' thick slurry wall under centerline
of dam

FIGURE 11

Figure 12. Geometry of Dam for Preliminary Cases 3 and 4
(Ridge along east abutment of dam)



Description: Sullivan County Dam - Preliminary Underseepage Analysis
Comments: Case 3 - Abutment with Sandstone Layers - Reservoir to Elev 925.0 feet
File Name: Case 3.sez
Last Saved Date: 10/17/2003
Analysis Type: Steady-State
Analysis View: 2-D

CASE 3

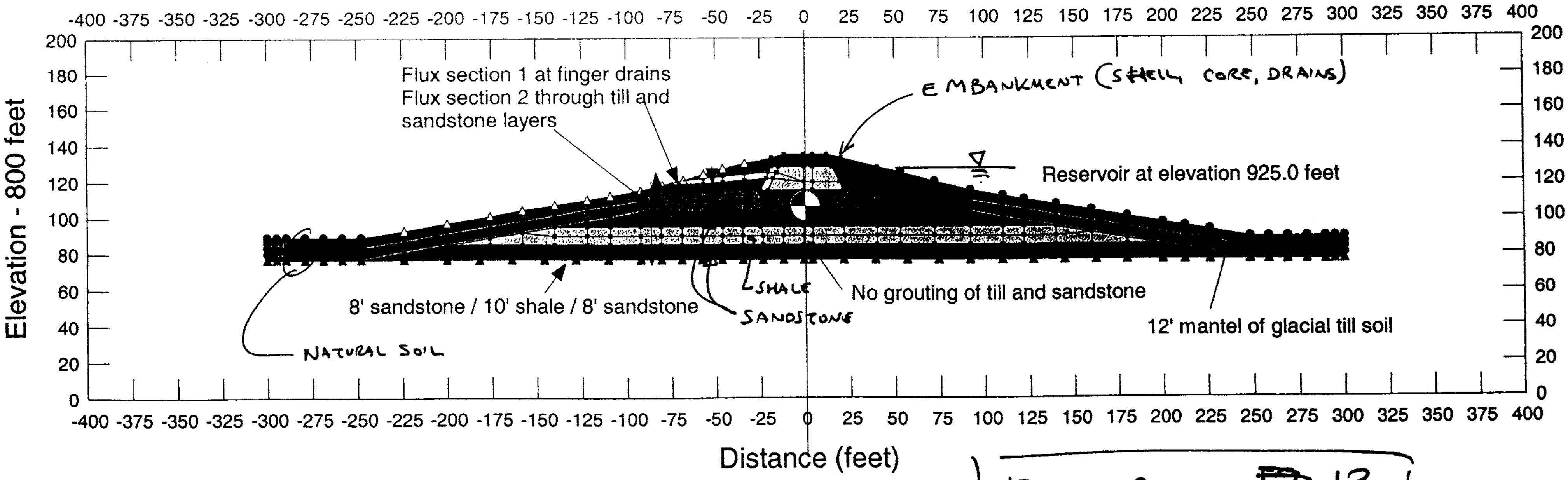


FIGURE ~~B~~ 13

Description: Sullivan County Dam - Preliminary Underseepage Analysis
Comments: Case 3 - Abutment with Sandstone Layers - Reservoir to Elev 925.0 feet
File Name: Case 3.sez
Last Saved Date: 10/17/2003
Analysis Type: Steady-State
Analysis View: 2-D

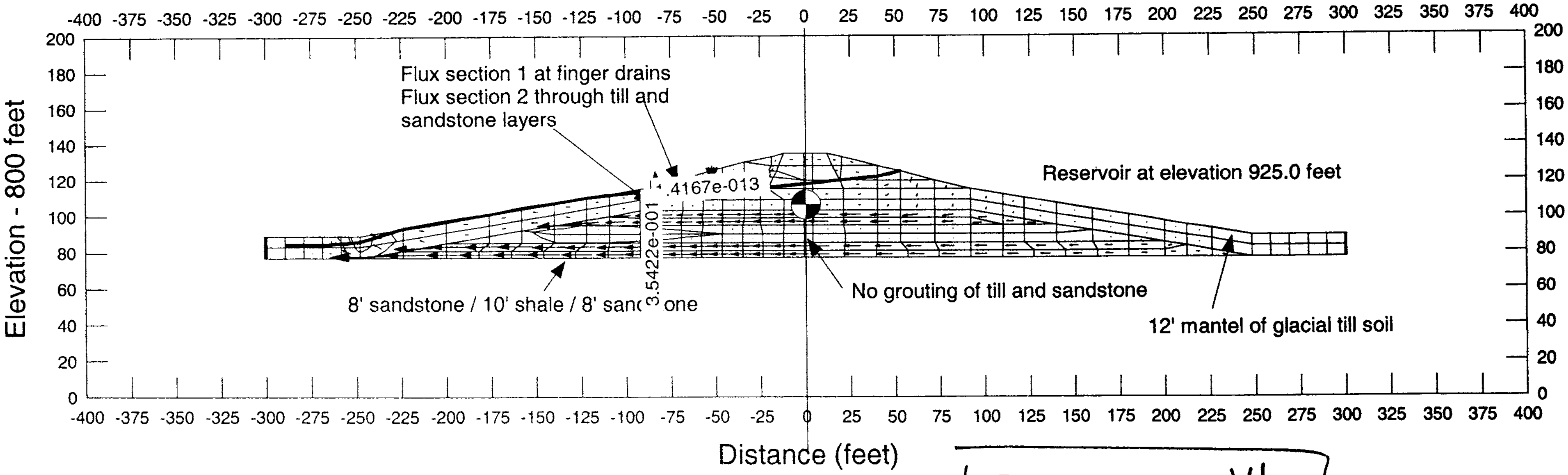


FIGURE 14

Description: Sullivan County Dam - Preliminary Underseepage Analysis
Comments: Case 3 - Abutment with Sandstone Layers - Reservoir to Elev 925.0 feet
File Name: Case 3.sez
Last Saved Date: 10/17/2003
Analysis Type: Steady-State
Analysis View: 2-D

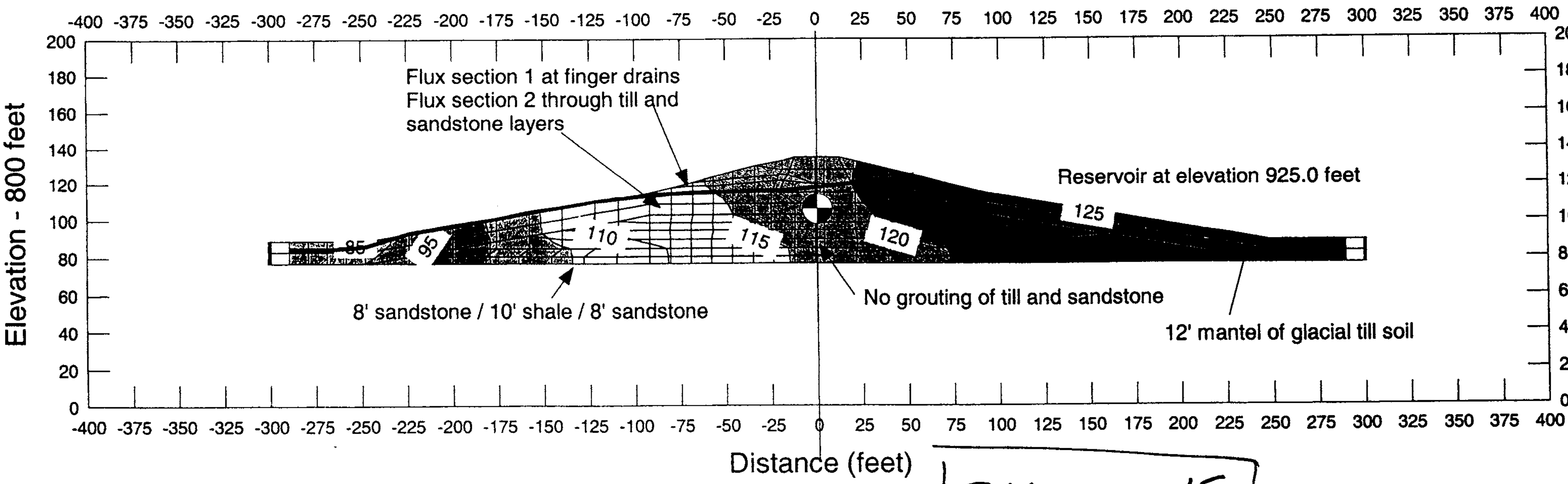


FIGURE 15

Description: Sullivan County Dam - Preliminary Underseepage Analysis
Comments: Case 3 - Abutment with Sandstone Layers - Reservoir to Elev 925.0 feet
File Name: Case 3.sez
Last Saved Date: 10/17/2003
Analysis Type: Steady-State
Analysis View: 2-D

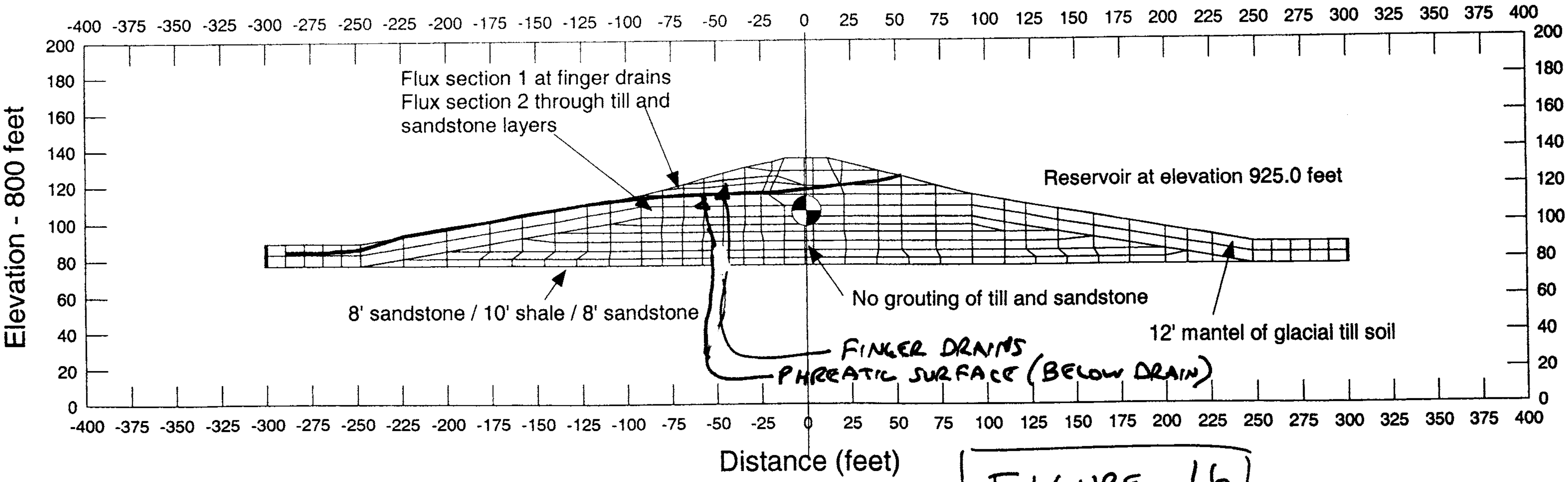


FIGURE 16

Description: Sullivan County Dam - Preliminary Underseepage Analysis
Comments: Case 3 - Abutment with Sandstone Layers - Reservoir to Elev 925.0 feet
File Name: Case 3.sez
Last Saved Date: 10/17/2003
Analysis Type: Steady-State
Analysis View: 2-D

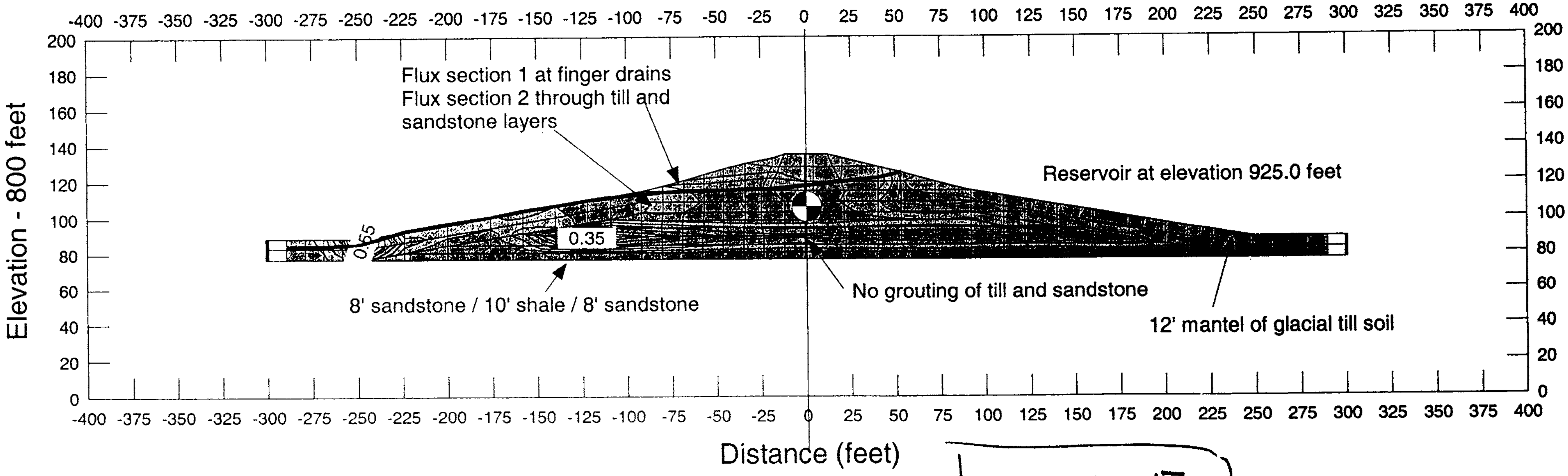


FIGURE 17.

Description: Sullivan County Dam - Preliminary Underseepage Analysis
Comments: Case 4 - Abutment with S'stone Layers - Reservoir to Elev 925.0 feet - grouted
File Name: Case 4a.sez
Last Saved Date: 10/17/2003
Analysis Type: Steady-State
Analysis View: 2-D

CASE 4

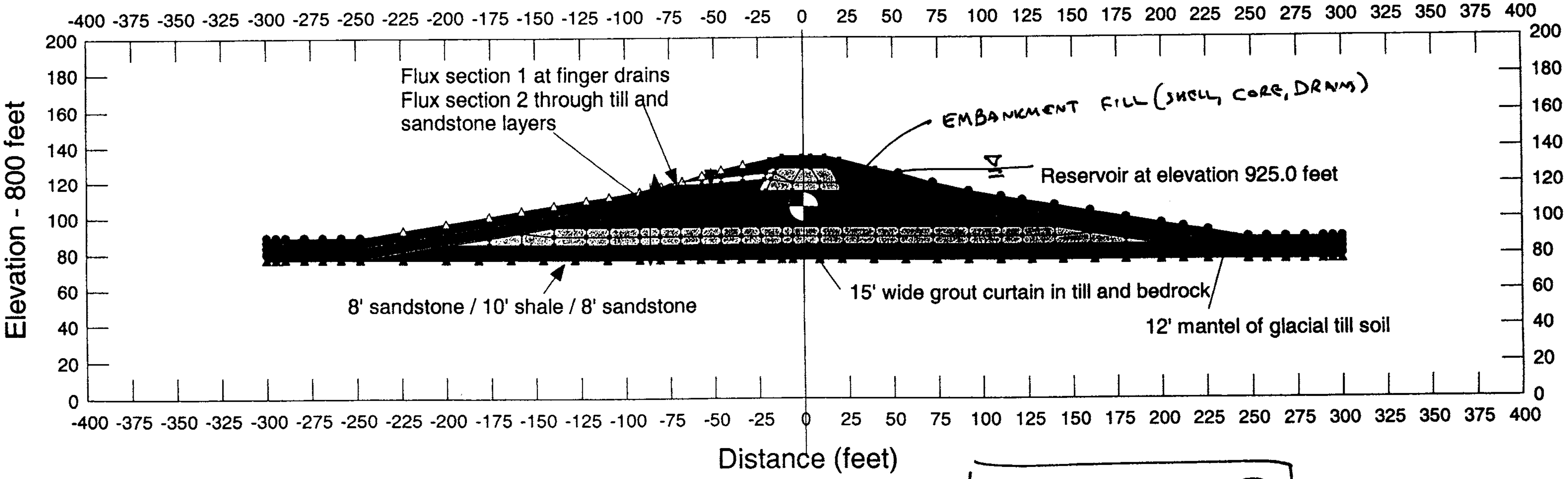


FIGURE 18

Description: Sullivan County Dam - Preliminary Underseepage Analysis
Comments: Case 4 - Abutment with S'stone Layers - Reservoir to Elev 925.0 feet - grouted
File Name: Case 4a.sez
Last Saved Date: 10/17/2003
Analysis Type: Steady-State
Analysis View: 2-D

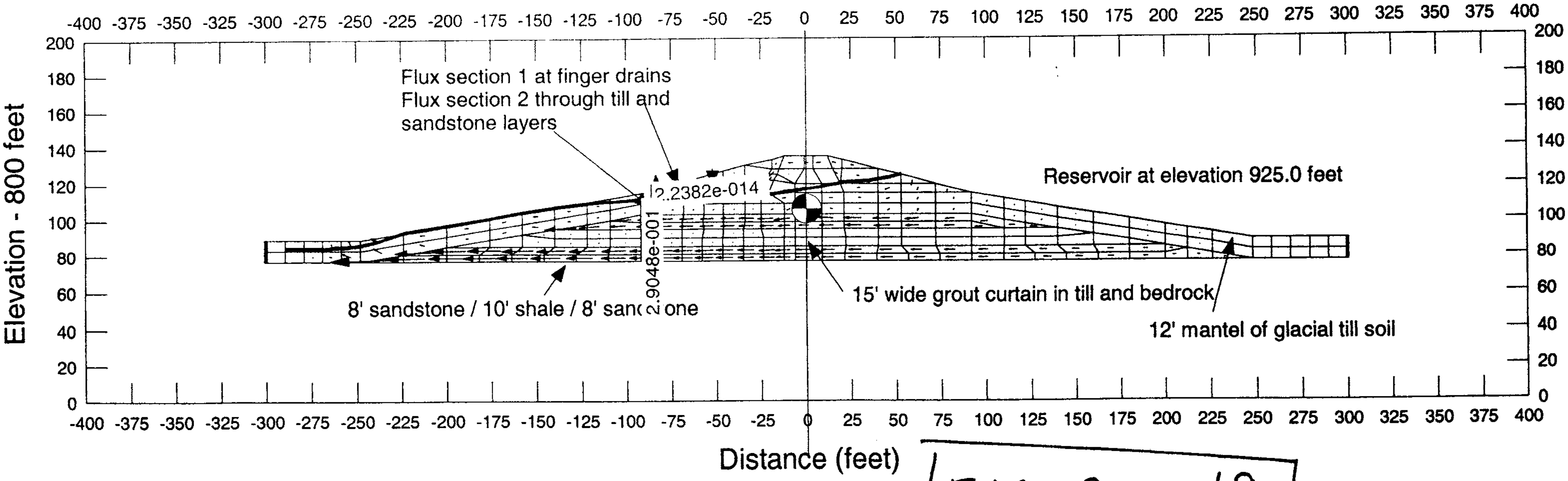


FIGURE 19

Description: Sullivan County Dam - Preliminary Underseepage Analysis
Comments: Case 4 - Abutment with S'stone Layers - Reservoir to Elev 925.0 feet - grouted
File Name: Case 4a.sez
Last Saved Date: 10/17/2003
Analysis Type: Steady-State
Analysis View: 2-D

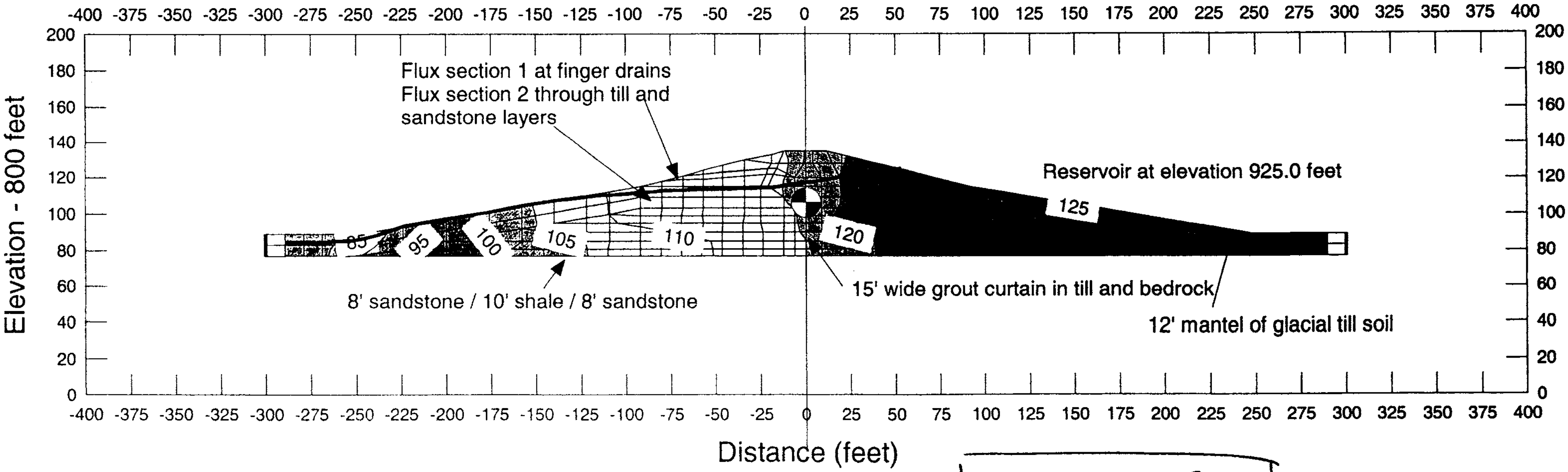


FIGURE 20

Description: Sullivan County Dam - Preliminary Underseepage Analysis
Comments: Case 4 - Abutment with S'stone Layers - Reservoir to Elev 925.0 feet - grouted
File Name: Case 4a.sez
Last Saved Date: 10/17/2003
Analysis Type: Steady-State
Analysis View: 2-D

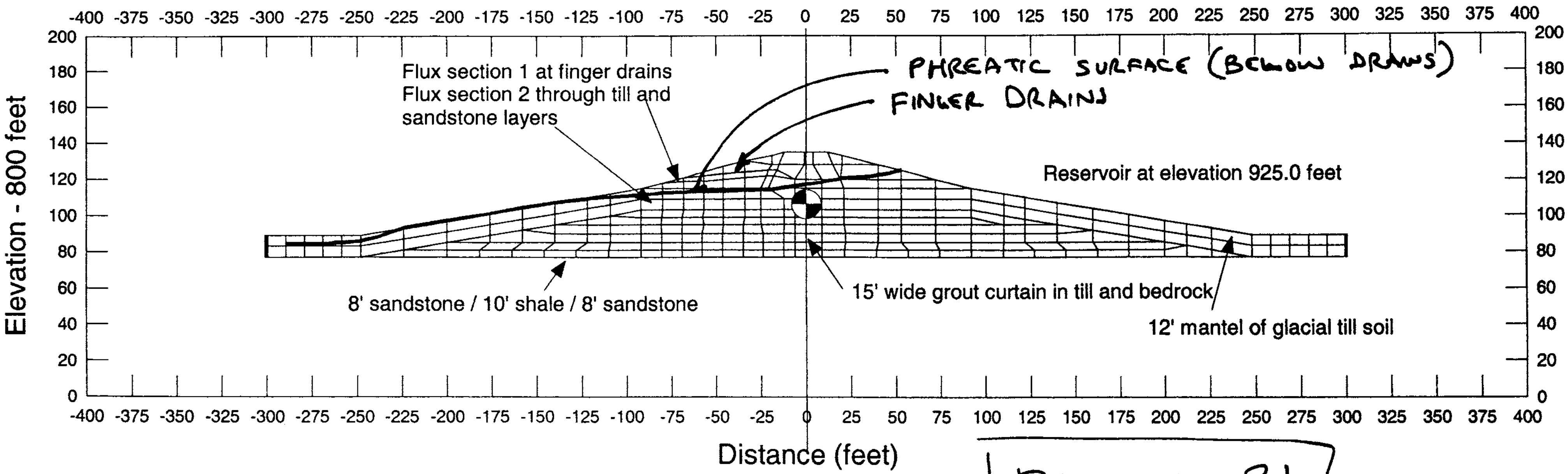


FIGURE 21

Description: Sullivan County Dam - Preliminary Underseepage Analysis
Comments: Case 4 - Abutment with S'stone Layers - Reservoir to Elev 925.0 feet - grouted
File Name: Case 4a.sez
Last Saved Date: 10/17/2003
Analysis Type: Steady-State
Analysis View: 2-D

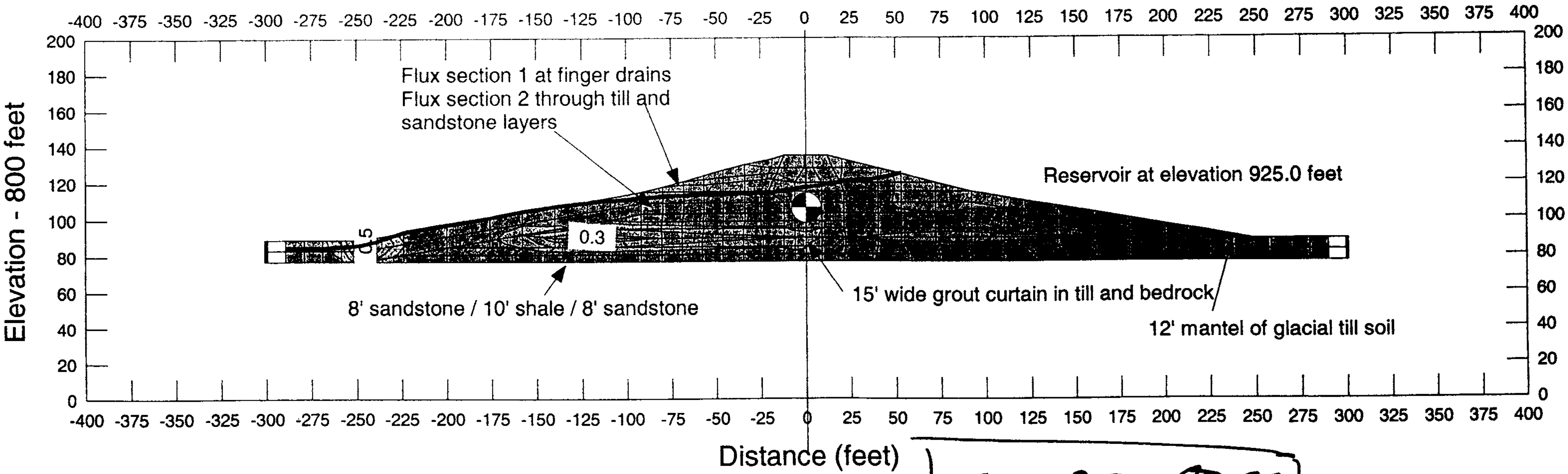


FIGURE 22

ATTACHMENT 3
EVALUATION OF SPILLWAY

Sullivan County Dam
Project No. 35191

GeoSystems/KLEINFELDER
an employee owned company

Preliminary Geotechnical Analysis of Proposed Spillway Alignment
Steve Wendland – GeoSystems / Kleinfelder – October 21, 2003
Page 1 of 1

Objective:
To evaluate geotechnical / geological concerns with proposed spillway alignment through west abutment of the proposed dam.

Analysis:
It has been proposed by Burns & McDonnell that the emergency spillway for the reservoir be routed through the west abutment of the dam. From a geotechnical / geological perspective, the proposed route would be acceptable provided the following issues are addressed.

We have limited subsurface information in this area from one soil boring and observations of rock outcrops in the field. Based on that information, the subsurface conditions consist of a thin mantle of clay soil overlying shale bedrock at a shallow depth (0 to 8 feet below current grades). The final phase of the subsurface investigation will provide significantly more subsurface data for the area. If this final phase indicates significantly different subsurface conditions, it will be necessary to re-analyze the proposed spillway alignment.

Any channel cut through this ridge would be excavated into shale bedrock. The shale is the Pleasanton Formation and has several sandstone seams and layers. Excavation of the shale bedrock should not be difficult in this large, open excavation. However, higher capacity excavators with rock teeth may be necessary to make the excavation in some isolated harder areas or in thicker sandstone layers.

Although the shale has some sandstone seams that would be more durable, the majority of this shale unit would deteriorate when exposed to seasonal wetting and drying, frost, or high velocity flows. Exposure to the elements would cause the shale to soften and crack. After the weathering, the shale would easily erode at higher flow velocities. Also, the thin bedding of the shale bedrock would allow erosion of large masses along the bedding planes.

We understand that current plans call for the flow velocities in the spillway channel to be no greater than 6 feet per second. Based on Table 7-2 of *Earth Dams and Reservoirs,* Technical Release No. 60 210-VI, Revised Oct. 1985, US Dept. of Agriculture, Soil Conservation Service (which is a governing design guide for this project), a flow of 6 feet per second would be an acceptable upper limit for an unlined spillway in shale bedrock.

If higher velocities were to occur in the spillway channel, it would be necessary to suitably armor the exposed surface using rip rap or concrete, depending on flow velocities. Otherwise, plans for significant maintenance to the spillway after major flow events should be planned. If the reservoir is designed so that high velocity flows were very rare, then the long-term costs of that maintenance could be tolerable and economical compared to the cost of constructing and maintaining the armoring on the channel.

ATTACHMENT 4
RECOMMENDATIONS FOR ADDITIONAL SUBSURFACE INVESTIGATION

General Recommendations for Additional Subsurface Exploration and Testing

To verify or better establish the parameters calculated or estimated here, the final phase of subsurface investigation will include additional borings, field testing, and laboratory testing. The scope of that work will be prepared with these parameters in mind. The scope should include:

For the west abutment area:

Once access for a drill rig has been cleared through the woods for a drill rig, 5 additional borings are recommended: 3 along the centerline, 1 upstream, and 1 downstream. Each boring should be continued approximately 20 feet into bedrock, with at least 2 of the borings using rock coring (instead of augering) in the bedrock. If depth to bedrock is shallow or variable, additional auger probes (borings without samples) could be considered to better define the depth to bedrock in the area.

To measure the effective (drained) shear strength of the clay soils and weathered shale bedrock, borehole shear tests are recommended within the borings. Undrained triaxial compression tests (UU tests) should be completed to measure the undrained strength of the clay soils. A limited number (one?) of drained triaxial tests (CU bar) should be completed on clay samples to confirm the results of the borehole shear tests.

If any clay soils are encountered that are not very stiff or hard, consolidation tests should also be completed on those soils to provide data for long-term settlement analysis of the embankment. Permeability tests should be completed on representative clay samples for seepage analyses. Unconfined compressive strength tests should be completed on samples of rock core.

For the central valley area:

Once access is cleared west of the creek, 5 additional borings are recommended: 1 on the center line east of the creek, 2 on the centerline west of the creek, 1 upstream and west of the creek, and 1 downstream of the centerline. Each boring would be continued approximately 10 feet into bedrock using augers or to auger refusal on harder bedrock. Piezometers should be installed in 2 of the boreholes to allow for long term monitoring of groundwater levels.

To better define the interlayering of the alluvial soils, a series of 4 piezocone soundings to a depth of 40 to refusal are recommended on or near the centerline. These soundings will provide continuous evaluation of the soil which will provide for a much better definition of the layering of the silt, clay, and sand alluvium in the valley. These tests will also allow for a more accurate underseepage analysis and for collection of better data for evaluating the shear strength, permeability, and compressibility of the alluvial soils.

To measure the effective (drained) shear strength of the clay soils, borehole shear tests are recommended within the borings. Undrained triaxial compression tests (UU tests) should be completed to measure the undrained strength of the clay soils. A limited number (one?) of drained triaxial tests (CU bar) should be completed on clay samples to confirm the results of the borehole shear tests.

Consolidation tests should be completed on samples of the softer clay soils to provide data for long-term settlement analysis of the embankment. Sieve analyses should be completed on samples of sand to better determine its classification and permeability. Permeability tests should be completed on representative clay samples for use in seepage analyses.

For the east abutment area:

Two (2) additional borings are recommended in this area to allow for in-situ testing and collection of samples for additional laboratory testing. Each boring should be continued approximately 20 feet into bedrock, using rock coring (instead of augering) in the bedrock to allow for better determination of the presence of sandstone seams within the shale bedrock.

To measure the effective (drained) shear strength of the clay soils and weathered shale bedrock, borehole shear tests are recommended within the borings. Undrained triaxial compression tests (UU tests) should be completed to measure the undrained strength of the clay soils. A limited number (one?) of drained triaxial tests (CU bar) should be completed on clay samples to confirm the results of the borehole shear tests.

Consolidation tests should also be completed on the softer clay soils (loess) to provide data for long-term settlement analysis of the embankment. Permeability tests should be completed on representative clay samples for seepage analyses. Unconfined compressive strength tests should be completed on samples of rock core.

Because seepage through the ridge at the east abutment is a significant concern at this stage of the project, it is recommended that field permeability testing (packer pressure testing in the boreholes) be planned in the proposed boreholes to evaluate the underseepage potential for the shale/sandstone bedrock at the site. This test is completed by pumping water under high pressure into the borehole and monitoring the flow of that water into the surrounding bedrock. If a significant volume of water seeps out of the borehole, then there is a higher potential for seepage of reservoir water through this abutment.

For the embankment fill material:

Bulk samples of potential borrow areas should be collected and tested for shear strength, permeability, and erosion potential. Currently, potential borrow areas could include the ridge along the east abutment (inside the reservoir area or downstream of the dam), the valley floor upstream of the dam, and the spillway. The valley floor will not provide a good source of borrow as water table is only a few feet below the ground surface. The location of the spillway has not been determined yet. To collect the bulk samples, it is recommended that test pits be excavated in these areas with a back hoe. Remolded and recompacted samples should be tested for undrained and drained shear strength (UU and CU bar triaxial tests), permeability at various moisture contents, and pinhole dispersion tests to measure potential for internal erosion of the fill.

For the spillway area:

Once the spillway alignment has been determined, a subsurface exploration program should be developed for that area.

Potential Borrow Areas:

If potential borrow areas other than those that have already been investigated are to be considered, subsurface exploration program should be developed for those areas.

Other Possible Tests:

To better evaluate the settlement of the harder soils and bedrock, pressuremeter testing could be completed in the field to directly measure an elastic modulus of each material. However, that testing is not recommended as those parameters could be conservatively estimated without an adverse impact on the design and analyses.

Sheet 1. Preliminary Cross Section of Dam near Center Line of Creek (Maximum Height Embankment)

Note 1: Fill in core will consist of clay soil, 0 to +4% moisture, 95% standard Proctor compaction (no rock fragments). Top at elevation 928.0 feet and 30 feet wide. Side slopes of core are sloped at 2H: 1V.

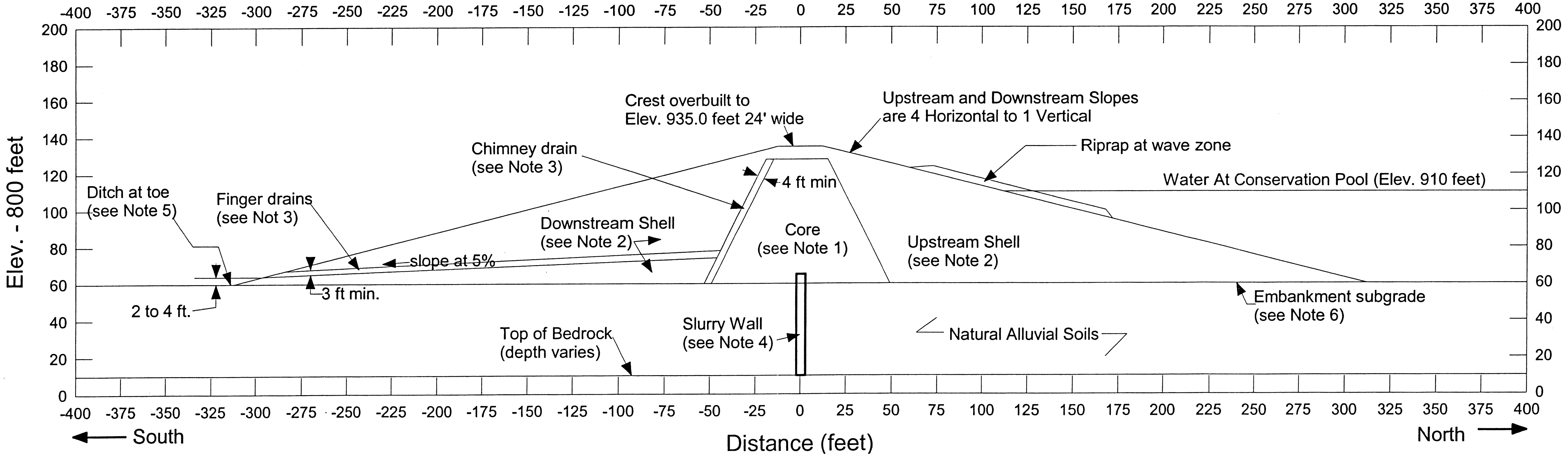
Note 2: Fill in upstream and downstream shells of dam will consist of clay with some rock fragments, -2% to +2% moisture, 95% standard Proctor compaction. Rock fragments shall be well graded in size and no larger than 24 inch nominal diameter.

Note 3: See Sheet 3 for additional finger drain and chimney drain details.

Note 4: Slurry wall is to be 5 feet minimum width, installed to top of bedrock across valley floor, and extend 5 feet into core of embankment.

Note 5: Construct ditch at downstream toe of embankment to collect runoff from face of dam and seepage from finger drains and direct it to creek. Rock lining may be necessary.

Note 6: Embankment subgrade to be stripped and grubbed prior to placement of fill. Excavation and recompaction of 2 to 5 feet of soil under the embankment should be planned, except where soft soils or shallow groundwater would prevent it.



Sheet 1 of 4

Project No. 35191

Sullivan County Dam
Sullivan County, Missouri

GeoSystems
KLEINFELDER

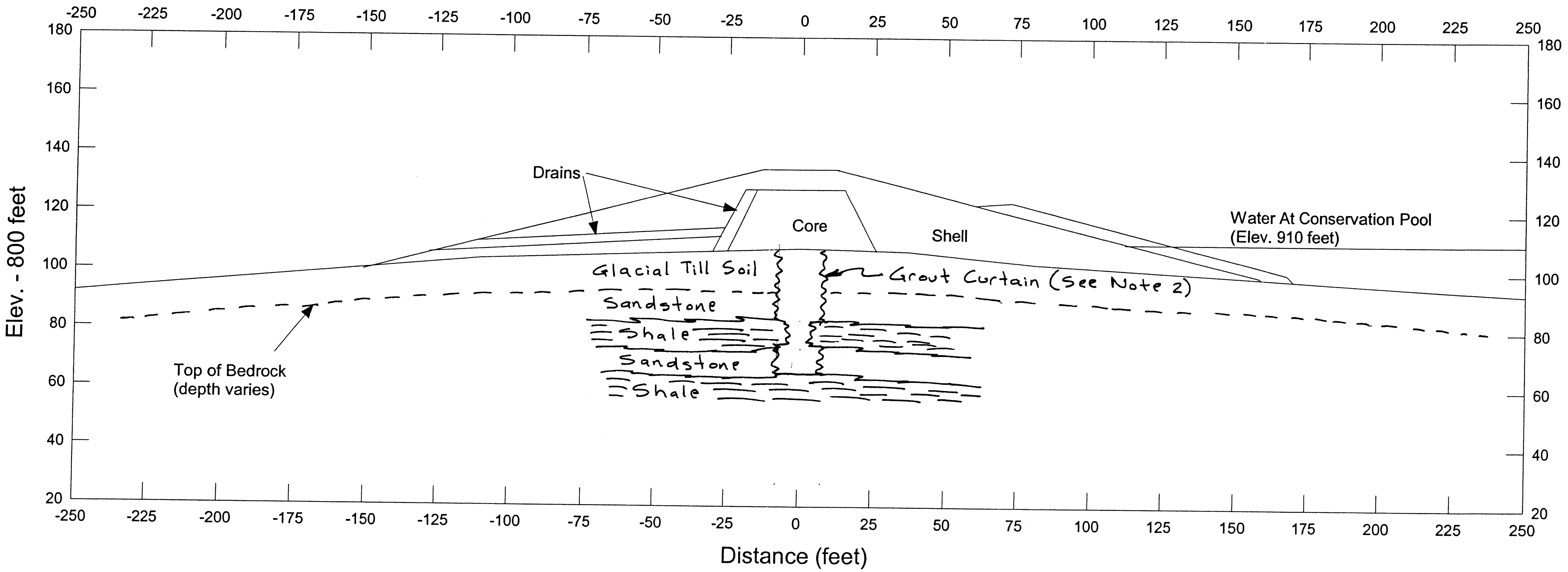
Scale: 1" = 60 feet

Approved By: SAW

Sheet 2. Typical Preliminary Cross Section of Dam at East Abutment

Note 1: All dimensions and details are same as Sheet 1 except as noted here.

Note 2: Grout curtain will consist of 3 rows of pressure grouted holes to create an approximatley 15 feet wide curtain. Depth shown is 40 feet below natural grade but may vary.



Sheet 2 of 4

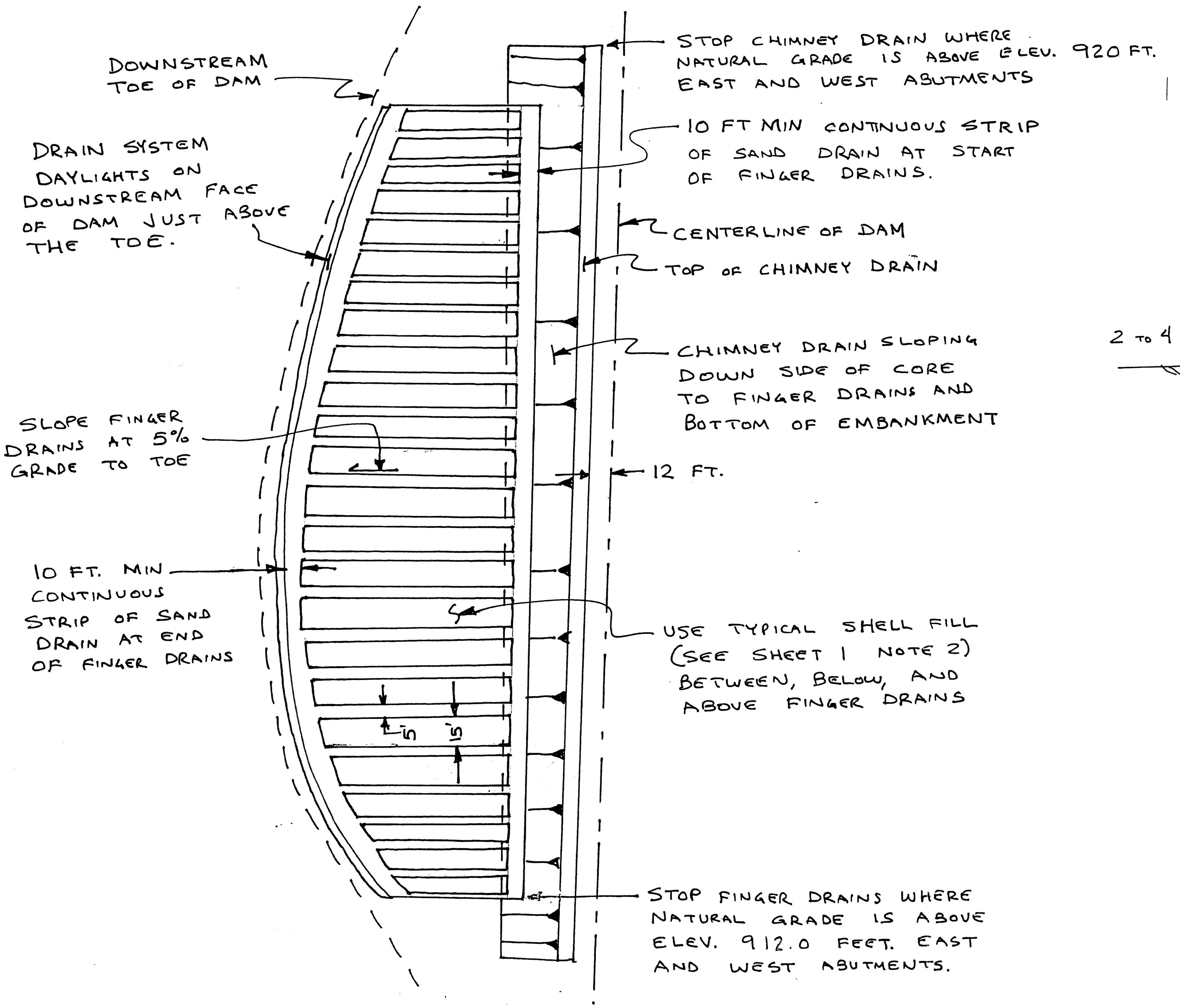
Project No. 35191

Sullivan County Dam
Sullivan County, Missouri

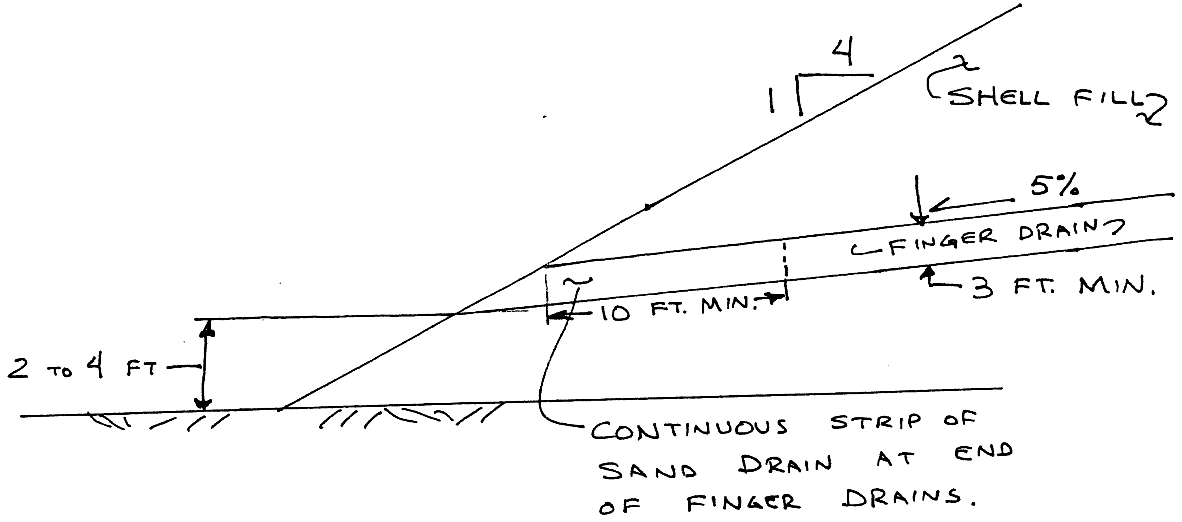
GeoSystems
KLEINFELDER

Scale: **1" = 40 feet**

Approved By: SAW



PLAN VIEW OF CHIMNEY DRAIN AND FINGER DRAINS



CROSS SECTION OF END OF FINGER DRAINS

Sheet 3 of 4

Project No. 35191

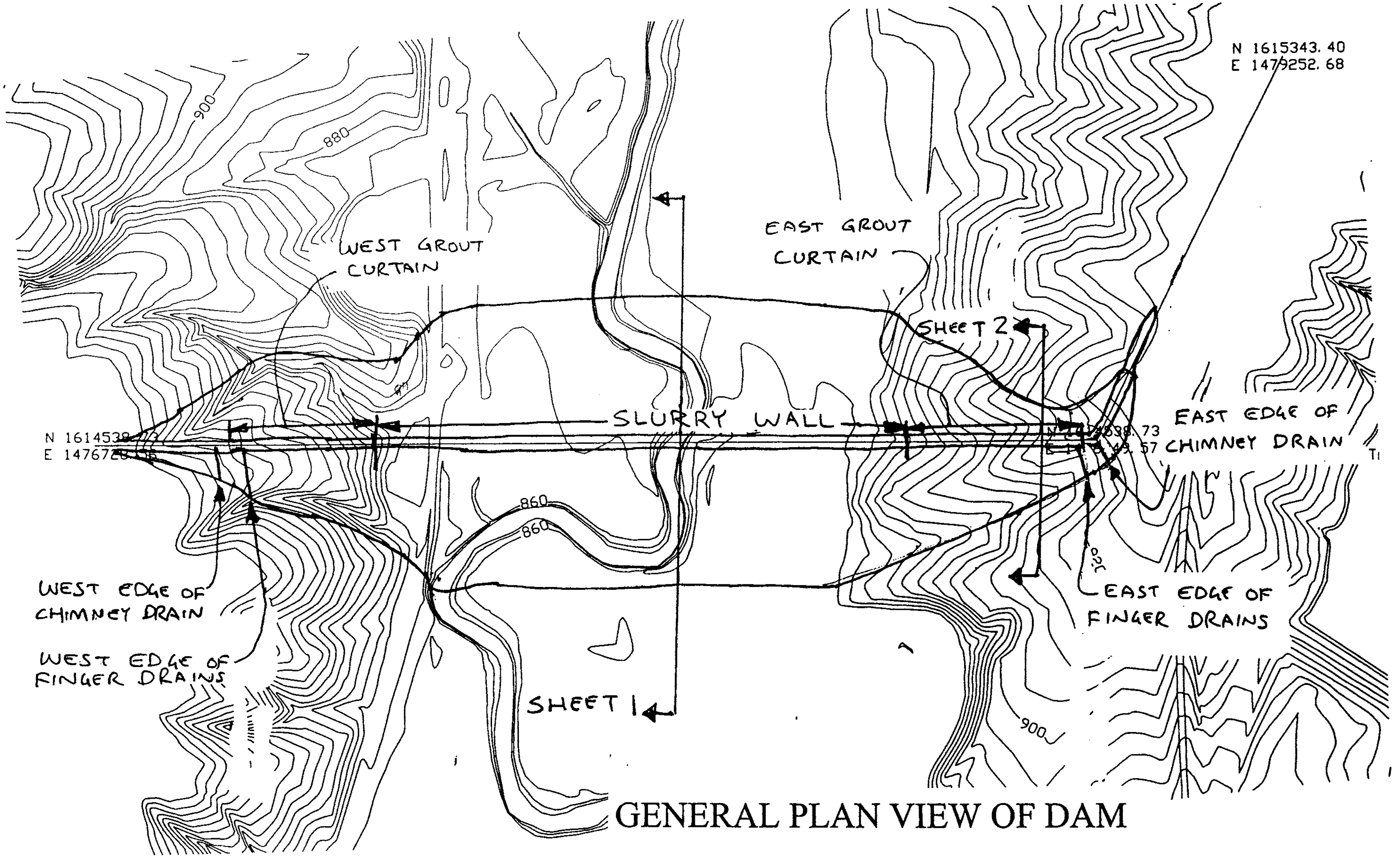
Sullivan County Dam
Sullivan County, Missouri

GeoSystems
KLEINFELDER

Not to Scale

Approved By: SAW

ATTACHMENT 5
DRAWINGS



GENERAL PLAN VIEW OF DAM

Sheet 4 of 4	Project No. 35191
Sullivan County Dam Sullivan County, Missouri	GeoSystems KLEINFELDER
Scale: 1 inch = 300 feet	Approved By: SAW

Appendix C

Economical Analysis Data

Scenario 1

No Milan Industrial User, No Grants

Appendix C
Scenario 1

Table 1
North Central Missouri Regional Water Commission
Projected Water Costs

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Treated Water O&M Cost Including Return	$408,700	$419,300	$429,100	$439,300	$449,800	$426,600	$422,100	$551,800	$573,900	$597,000
Treated Water Debt Service	$320,500	$875,400	$860,700	$846,100	$831,500	$816,900	$724,800	$862,800	$869,900	$877,100
Total Treated Water Costs	$729,200	$1,294,700	$1,289,800	$1,285,400	$1,281,300	$1,243,500	$1,146,900	$1,414,600	$1,443,800	$1,474,100
Treated Water Cost ($/1000 gallons)	$2.5878	$4.5551	$4.4987	$4.4445	$4.3919	$4.2253	$3.8631	$2.9565	$2.9457	$2.9352

Raw Water Cost O&M Cost Including Return	$122,200	$130,500	$138,400	$146,700	$155,400	$123,600	$146,200	$127,200	$130,300	$133,300
Raw Water Debt Service	$38,100	$587,600	$602,300	$616,900	$631,500	$646,100	$738,200	$600,200	$593,100	$585,900
Total Raw Water Costs	$160,300	$718,100	$740,700	$763,600	$786,900	$769,700	$884,400	$727,400	$723,400	$719,200
Raw Water Cost ($/1000 gallons)	$0.6058	$2.5600	$2.4911	$2.4228	$2.3554	$2.1735	$1.7946	$1.4761	$1.4679	$1.4594

Year 1 - 5 Average Water Cost	$/1000 gal
Treated Water Costs	$4.0956
Raw Water Costs	$2.0870

Year 6 - 10 Average Water Cost	$/1000 gal
Treated Water Costs	$3.3852
Raw Water Costs	$1.6743

Appendix C
Scenario 1

Table 1
North Central Missouri Regional Water Commission
Projected Water Costs

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Treated Water O&M Cost Including Return	$621,100	$646,300	$672,900	$700,600	$729,800	$760,500	$801,000	$835,200	$871,000	$908,700
Treated Water Debt Service	$884,400	$891,800	$899,300	$907,000	$914,700	$922,600	$2,326,600	$2,351,900	$2,377,500	$2,403,300
Total Treated Water Costs	$1,505,500	$1,538,100	$1,572,200	$1,607,600	$1,644,500	$1,683,100	$3,127,600	$3,187,100	$3,248,500	$3,312,000
Treated Water Cost ($/1000 gallons)	$2.9246	$2.9138	$2.9034	$2.8929	$2.8825	$2.8724	$5.1941	$5.1492	$5.1040	$5.0584

Raw Water Cost O&M Cost Including Return	$136,400	$139,600	$142,800	$146,100	$149,400	$152,700	$162,800	$166,400	$170,000	$173,600
Raw Water Debt Service	$578,600	$571,200	$563,700	$556,000	$548,300	$540,400	$1,674,900	$1,649,600	$1,624,000	$1,598,200
Total Raw Water Costs	$715,000	$710,800	$706,500	$702,100	$697,700	$693,100	$1,837,700	$1,816,000	$1,794,000	$1,771,800
Raw Water Cost ($/1000 gallons)	$1.4509	$1.4424	$1.4336	$1.4247	$1.4158	$1.4065	$3.7291	$3.6851	$3.6404	$3.5954

Year 11 - 15 Average Water Cost	**$/1000 gal**
Treated Water Costs	$2.9034
Raw Water Costs	$1.4335

Year 16 - 20 Average Water Cost	**$/1000 gal**
Treated Water Costs	$4.6756
Raw Water Costs	$3.2113

Appendix C
Scenario 1

Table 1
North Central Missouri Regional Water Commission
Projected Water Costs

	2024	2025	2026	2027	2028
Treated Water O&M Cost Including Return	$948,000	$989,400	$1,032,800	$1,078,500	$1,126,300
Treated Water Debt Service	$2,429,500	$2,455,900	$2,482,500	$2,509,300	$2,536,400
Total Treated Water Costs	$3,377,500	$3,445,300	$3,515,300	$3,587,800	$3,662,700
Treated Water Cost ($/1000 gallons)	$5.0124	$4.9662	$4.9197	$4.8731	$4.8262
Raw Water Cost O&M Cost Including Return	$177,200	$180,900	$184,600	$188,300	$192,000
Raw Water Debt Service	$1,572,000	$1,545,600	$1,519,000	$1,492,200	$1,465,100
Total Raw Water Costs	$1,749,200	$1,726,500	$1,703,600	$1,680,500	$1,657,100
Raw Water Cost ($/1000 gallons)	$3.5495	$3.5034	$3.4570	$3.4101	$3.3626

Year 21 - 25 Average Water Cost	$/1000 gal
Treated Water Costs	$4.9195
Raw Water Costs	$3.4565

Appendix C
Scenario 1

Table 2
North Central Missouri Regional Water Commission
Inputs and Assumptions

Starting Year	2004

Water Plant Capital

Milan Plant Purchase Capital Requirement	$3,564,500
Milan Plant Purchase Additional Capital	$482,200
Milan Plant Purchase Grant Funding	$0
Milan Plant Purchase Capital less Grants	$4,046,700

Supplemental Pipeline & Intake Capital Requirement	$1,136,000
Pipeline & Intake Grant Funding	$0
Pipeline & Intake Capital less Grants	$1,136,000

Interest Rate for Debt Financing	4.75%
Term of Project Financing - years	25

Phase 1 Capital

Investment Year	2005
Dam and Reservoir Construction Capital	$26,265,000
Dam Construction Grant Funding	$10,699,000
Dam Construction Capital less Grants	$15,566,000
Interest Rate for Debt Financing	5.00%
Term of Project Financing - years	25

Phase 2 Capital

Investment Year	2020
Dam and Reservoir Construction Capital	$32,450,000
Dam Construction Grant Funding	$0
Dam Construction Capital less Grants	$32,450,000
Interest Rate for Debt Financing	6.00%
Term of Project Financing - years	25

Plant O&M

Inflation Rate for Labor/Materials	4.0%
Inflation Rate for Energy	2.5%
Energy Unit Cost ($/kWh)	$0.0690
Average Monthly Energy Use (kWh)	55,000
Demand Charge ($/kW)	$206
Average Demand (kW)	8.50
Other Utility Costs (Gas?)	20,000
Plant Labor	$109,100
City Labor Offset (10%)	-$10,900
Routine Maintenance (1% of Plant Capital)	$35,600
Chemical Costs per Thousand Gallons	$0.275
General and Administration Expenses	$125,000
Lake Lease per Thousand Gallons	$0.150
Renewal & Replacement Fund Requirement	$20,000

Dam & Reservoir O&M

Phase 1	$40,000
Phase 2	$150,000

Water Usage

Milan Treated Water	0.350	[1]
Sullivan County #1 Treated Water	0.328	[1]
Green City Treated Water	0.094	[1]
Milan Industrial User Treated Water	0.000	[1]
Other Treated Water Customers (Begin 2011)	0.490	
PSF Raw Water	0.725	[1]
Milan Water Usage Growth	0.70%	
Sullivan County #1 Water Usage Growth	1.30%	
Green City Water Usage Growth	0.25%	
Raw Water Usage Growth (first 10 years)	6.00%	
Raw Water Usage Growth (after 2010)	0.00%	
Milan Industrial User Water Usage Growth	8.00%	
Milan Industrial User Water Usage Growth (after 2010)	0.00%	
Other Treated Water Growth	5.00%	

Return

Return (% of O&M expense, Years 1-5)	5%
Return (% of O&M expense, Years10 and beyond)	10%

[1] 2002 Average MGD

Appendix C
Scenario 1

Table 3
North Central Missouri Regional Water Commission
Forecast of Operation and Maintenance Expenses

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Treated Water Flow (MGY)	282	284	287	289	292	294	297	478	490	502
Raw Water Flow (MGY)	265	281	297	315	334	354	493	493	493	493
Total Water Flow (MGY)	546	565	584	604	626	648	790	971	983	995
Plant O&M Expenses										
Labor & Burden	$98,200	$102,100	$106,200	$110,400	$114,800	$119,400	$124,200	$129,200	$134,400	$139,800
General & Administrative	$125,000	$130,000	$135,200	$140,600	$146,200	$152,000	$158,100	$164,400	$171,000	$177,800
Electricity Costs	$47,300	$48,900	$50,600	$52,300	$54,100	$56,000	$58,000	$94,400	$99,100	$104,100
Other Utility Costs	$20,000	$20,800	$21,600	$22,500	$23,400	$24,300	$25,300	$26,300	$27,400	$28,500
Routine Maintenance	$35,600	$37,000	$38,500	$40,000	$41,600	$43,300	$45,000	$46,800	$48,700	$50,600
Chemicals	$77,500	$78,200	$78,800	$79,500	$80,200	$80,900	$81,600	$131,600	$134,800	$138,100
Lake Lease	$82,000	$84,700	$87,600	$90,700	$93,900	$0	$0	$0	$0	$0
R&R Fund	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
Phase 1 Dam O&M	$0	$40,000	$41,600	$43,300	$45,000	$46,800	$48,700	$50,600	$52,600	$54,700
Phase 2 Dam O&M	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total O&M Costs	$505,600	$561,700	$580,100	$599,300	$619,200	$542,700	$560,900	$663,300	$688,000	$713,600
Return	$25,300	$28,100	$29,000	$30,000	$31,000	$54,300	$56,100	$66,300	$68,800	$71,400
Total Annual Costs	$530,900	$589,800	$609,100	$629,300	$650,200	$597,000	$617,000	$729,600	$756,800	$785,000
Allocated O&M including Return to Treated Water	$408,700	$419,300	$429,100	$439,300	$449,800	$426,600	$422,100	$551,800	$573,900	$597,000
Allocated O&M including Return to Raw Water	$122,200	$130,500	$138,400	$146,700	$155,400	$123,600	$146,200	$127,200	$130,300	$133,300

No Milan Industrial User, No Grants
Including Phase 1 & 2 Capital

Appendix C
Scenario 1

Table 3
North Central Missouri Regional Water Commission
Forecast of Operation and Maintenance Expenses

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Treated Water Flow (MGY)	515	528	541	556	571	586	602	619	636	655
Raw Water Flow (MGY)	493	493	493	493	493	493	493	493	493	493
Total Water Flow (MGY)	1,008	1,021	1,034	1,049	1,063	1,079	1,095	1,112	1,129	1,148
Plant O&M Expenses										
Labor & Burden	$145,400	$151,200	$157,200	$163,500	$170,000	$176,800	$183,900	$191,300	$199,000	$207,000
General & Administrative	$184,900	$192,300	$200,000	$208,000	$216,300	$225,000	$234,000	$243,400	$253,100	$263,200
Electricity Costs	$109,400	$114,900	$120,900	$127,100	$133,800	$140,900	$148,400	$156,300	$164,700	$173,700
Other Utility Costs	$29,600	$30,800	$32,000	$33,300	$34,600	$36,000	$37,400	$38,900	$40,500	$42,100
Routine Maintenance	$52,600	$54,700	$56,900	$59,200	$61,600	$64,100	$66,700	$69,400	$72,200	$75,100
Chemicals	$141,600	$145,200	$148,900	$152,800	$156,900	$161,100	$165,600	$170,200	$175,000	$180,100
Lake Lease	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
R&R Fund	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
Phase 1 Dam O&M	$56,900	$59,200	$61,600	$64,100	$66,700	$69,400	$72,200	$75,100	$78,100	$81,200
Phase 2 Dam O&M	$0	$0	$0	$0	$0	$0	$150,000	$156,000	$162,200	$168,700
Total O&M Costs	$740,400	$768,300	$797,500	$828,000	$859,900	$893,300	$1,078,200	$1,120,600	$1,164,800	$1,211,100
Return	$74,000	$76,800	$79,800	$82,800	$86,000	$89,300	$107,800	$112,100	$116,500	$121,100
Total Annual Costs	$814,400	$845,100	$877,300	$910,800	$945,900	$982,600	$1,186,000	$1,232,700	$1,281,300	$1,332,200
Allocated O&M including Return to Treated Water	$621,100	$646,300	$672,900	$700,600	$729,800	$760,500	$801,000	$835,200	$871,000	$908,700
Allocated O&M including Return to Raw Water	$136,400	$139,600	$142,800	$146,100	$149,400	$152,700	$162,800	$166,400	$170,000	$173,600

Appendix C
Scenario 1

Table 3
North Central Missouri Regional Water Commission
Forecast of Operation and Maintenance Expenses

Year	2024	2025	2026	2027	2028	Total
Treated Water Flow (MGY)	674	694	715	736	759	
Raw Water Flow (MGY)	493	493	493	493	493	
Total Water Flow (MGY)	1,167	1,187	1,207	1,229	1,252	
Plant O&M Expenses						
Labor & Burden	$215,300	$223,900	$232,900	$242,200	$251,900	$4,090,200
General & Administrative	$273,700	$284,600	$296,000	$307,800	$320,100	$5,202,700
Electricity Costs	$183,100	$193,200	$204,000	$215,500	$227,500	$3,078,200
Other Utility Costs	$43,800	$45,600	$47,400	$49,300	$51,300	$832,700
Routine Maintenance	$78,100	$81,200	$84,400	$87,800	$91,300	$1,482,400
Chemicals	$185,300	$190,800	$196,500	$202,500	$208,700	$3,542,400
Lake Lease	$0	$0	$0	$0	$0	$438,900
R&R Fund	$20,000	$20,000	$20,000	$20,000	$20,000	$500,000
Phase 1 Dam O&M	$84,400	$87,800	$91,300	$95,000	$98,800	$1,565,100
Phase 2 Dam O&M	$175,400	$182,400	$189,700	$197,300	$205,200	$1,586,900
Total O&M Costs	$1,259,100	$1,309,500	$1,362,200	$1,417,400	$1,474,800	$22,319,500
Return	$125,900	$131,000	$136,200	$141,700	$147,500	$2,088,800
Total Annual Costs	$1,385,000	$1,440,500	$1,498,400	$1,559,100	$1,622,300	$24,408,300
Allocated O&M including Return to Treated Water	$948,000	$989,400	$1,032,800	$1,078,500	$1,126,300	$17,439,700
Allocated O&M including Return to Raw Water	$177,200	$180,900	$184,600	$188,300	$192,000	$3,816,600

Appendix C
Scenario 1

Table 4
North Central Missouri Regional Water Commission
Forecast Energy Expenses

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Energy Unit Cost ($/kWh)	$0.0690	0.0707	0.0725	0.0743	0.0762	0.0781	0.0800	0.0820	0.0841	0.0862
Annual Energy Usage (kWh)	660,000	665,700	671,500	677,400	683,300	689,300	695,400	1,120,700	1,148,000	1,176,300
Annual Energy Cost	$45,500	$47,100	$48,700	$50,300	$52,000	$53,800	$55,600	$91,900	$96,500	$101,400
Monthly Demand Charge ($KW)	$206.00	211.15	216.43	221.84	227.39	233.07	238.90	244.87	250.99	257.27
Monthly Peak Demand	8.50	8.71	8.93	9.15	9.38	9.62	9.86	10.10	10.36	10.62
Annual Demand Cost	$1,800	$1,800	$1,900	$2,000	$2,100	$2,200	$2,400	$2,500	$2,600	$2,700
Treated Water Electric Cost	$47,300	$48,900	$50,600	$52,300	$54,100	$56,000	$58,000	$94,400	$99,100	$104,100
Raw Water Electric Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Calculated Electric Cost	$47,300	$48,900	$50,600	$52,300	$54,100	$56,000	$58,000	$94,400	$99,100	$104,100
Total Electric Cost	$47,300	$48,900	$50,600	$52,300	$54,100	$56,000	$58,000	$94,400	$99,100	$104,100
Allocated Treated Water	$47,300	$48,900	$50,600	$52,300	$54,100	$56,000	$58,000	$94,400	$99,100	$104,100
Allocated Raw Water	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

Appendix C
Scenario 1

Table 4
North Central Missouri Regional Water Commission
Forecast Energy Expenses

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Energy Unit Cost ($/kWh)	0.0883	0.0905	0.0928	0.0951	0.0975	0.0999	0.1024	0.1050	0.1076	0.1103
Annual Energy Usage (kWh)	1,205,700	1,236,400	1,268,300	1,301,600	1,336,300	1,372,500	1,410,400	1,449,700	1,490,700	1,533,500
Annual Energy Cost	$106,500	$111,900	$117,700	$123,800	$130,300	$137,200	$144,500	$152,200	$160,400	$169,200
Monthly Demand Charge ($KW)	263.70	270.29	277.05	283.97	291.07	298.35	305.81	313.45	321.29	329.32
Monthly Peak Demand	10.88	11.15	11.43	11.72	12.01	12.31	12.62	12.93	13.26	13.59
Annual Demand Cost	$2,900	$3,000	$3,200	$3,300	$3,500	$3,700	$3,900	$4,100	$4,300	$4,500
Treated Water Electric Cost	$109,400	$114,900	$120,900	$127,100	$133,800	$140,900	$148,400	$156,300	$164,700	$173,700
Raw Water Electric Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Calculated Electric Cost	$109,400	$114,900	$120,900	$127,100	$133,800	$140,900	$148,400	$156,300	$164,700	$173,700
Total Electric Cost	$109,400	$114,900	$120,900	$127,100	$133,800	$140,900	$148,400	$156,300	$164,700	$173,700
Allocated Treated Water	$109,400	$114,900	$120,900	$127,100	$133,800	$140,900	$148,400	$156,300	$164,700	$173,700
Allocated Raw Water	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

Appendix C
Scenario 1

Table 4
North Central Missouri Regional Water Commission
Forecast Energy Expenses

Year	2024	2025	2026	2027	2028
Energy Unit Cost ($/kWh)	0.1131	0.1159	0.1188	0.1218	0.1248
Annual Energy Usage (kWh)	1,578,200	1,624,800	1,673,500	1,724,400	1,777,500
Annual Energy Cost	$178,400	$188,300	$198,800	$210,000	$221,800
Monthly Demand Charge ($KW)	337.55	345.99	354.64	363.51	372.60
Monthly Peak Demand	13.93	14.28	14.63	15.00	15.37
Annual Demand Cost	$4,700	$4,900	$5,200	$5,500	$5,700
Treated Water Electric Cost	$183,100	$193,200	$204,000	$215,500	$227,500
Raw Water Electric Cost	$0	$0	$0	$0	$0
Calculated Electric Cost	$183,100	$193,200	$204,000	$215,500	$227,500
Total Electric Cost	$183,100	$193,200	$204,000	$215,500	$227,500
Allocated Treated Water	$183,100	$193,200	$204,000	$215,500	$227,500
Allocated Raw Water	$0	$0	$0	$0	$0

Appendix C
Scenario 1

Table 5
North Central Missouri Regional Water Commission
Projected Debt Expense

Year	Investment	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Plant Investment	$4,046,700										
Initial Debt Service Payment		$280,000	$280,000	$280,000	$280,000	$280,000	$280,000	$280,000	$280,000	$280,000	$280,000
Initial Debt Service Interest		$192,200	$188,000	$183,700	$179,100	$174,300	$169,300	$164,000	$158,500	$152,800	$146,700
Initial Debt Service Principle		$87,800	$91,900	$96,300	$100,900	$105,700	$110,700	$115,900	$121,400	$127,200	$133,200
Remaining Capital Balance - EOY		$3,958,900	$3,867,000	$3,770,700	$3,669,800	$3,564,100	$3,453,400	$3,337,500	$3,216,100	$3,088,900	$2,955,700

Supplemental Pipeline & Intake	$1,136,000										
Initial Debt Service Payment		$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600
Initial Debt Service Interest		$54,000	$52,800	$51,600	$50,300	$48,900	$47,500	$46,100	$44,500	$42,900	$41,200
Initial Debt Service Principle		$24,600	$25,800	$27,000	$28,300	$29,700	$31,100	$32,500	$34,100	$35,700	$37,400
Remaining Capital Balance - EOY		$1,111,400	$1,085,600	$1,058,600	$1,030,300	$1,000,600	$969,500	$937,000	$902,900	$867,200	$829,800

Phase 1 Dam Investment	$15,566,000										
Dam Debt Service Payment		$0	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400
Dam Debt Service Interest		$0	$762,000	$744,900	$726,900	$708,000	$688,200	$667,400	$645,500	$622,600	$598,500
Dam Debt Service Principle		$0	$342,500	$359,600	$377,600	$396,400	$416,300	$437,100	$458,900	$481,900	$506,000
Remaining Capital Balance - EOY		$0	$15,223,500	$14,863,900	$14,486,300	$14,089,900	$13,673,600	$13,236,500	$12,777,600	$12,295,700	$11,789,700

Appendix C
Scenario 1

Table 5
North Central Missouri Regional Water Commission
Projected Debt Expense

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Plant Investment										
Initial Debt Service Payment	$280,000	$280,000	$280,000	$280,000	$280,000	$280,000	$280,000	$280,000	$280,000	$280,000
Initial Debt Service Interest	$140,400	$133,800	$126,800	$119,500	$111,900	$103,900	$95,600	$86,800	$77,700	$68,000
Initial Debt Service Principle	$139,600	$146,200	$153,100	$160,400	$168,000	$176,000	$184,400	$193,100	$202,300	$211,900
Remaining Capital Balance - EOY	$2,816,100	$2,669,900	$2,516,800	$2,356,400	$2,188,400	$2,012,400	$1,828,000	$1,634,900	$1,432,600	$1,220,700

Supplemental Pipeline & Intake										
Initial Debt Service Payment	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600
Initial Debt Service Interest	$39,400	$37,600	$35,600	$33,600	$31,400	$29,200	$26,800	$24,400	$21,800	$19,100
Initial Debt Service Principle	$39,200	$41,000	$43,000	$45,000	$47,200	$49,400	$51,800	$54,200	$56,800	$59,500
Remaining Capital Balance - EOY	$790,600	$749,600	$706,600	$661,600	$614,400	$565,000	$513,200	$459,000	$402,200	$342,700

Phase 1 Dam Investment										
Dam Debt Service Payment	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400
Dam Debt Service Interest	$573,200	$546,600	$518,700	$489,400	$458,700	$426,400	$392,500	$356,900	$319,500	$280,300
Dam Debt Service Principle	$531,300	$557,800	$585,700	$615,000	$645,700	$678,000	$711,900	$747,500	$784,900	$824,200
Remaining Capital Balance - EOY	$11,258,400	$10,700,600	$10,114,900	$9,499,900	$8,854,200	$8,176,200	$7,464,300	$6,716,800	$5,931,900	$5,107,700

Appendix C
Scenario 1

Table 5
North Central Missouri Regional Water Commission
Projected Debt Expense

Year	2024	2025	2026	2027	2028	Total
Plant Investment						
Initial Debt Service Payment	$280,000	$280,000	$280,000	$280,000	$280,000	$7,000,000
Initial Debt Service Interest	$58,000	$47,400	$36,400	$24,800	$12,700	$2,952,300
Initial Debt Service Principle	$222,000	$232,500	$243,600	$255,200	$267,300	$4,046,600
Remaining Capital Balance - EOY	$998,700	$766,200	$522,600	$267,400	$100	
Supplemental Pipeline & Intake						
Initial Debt Service Payment	$78,600	$78,600	$78,600	$78,600	$78,600	$1,965,000
Initial Debt Service Interest	$16,300	$13,300	$10,200	$7,000	$3,600	$829,100
Initial Debt Service Principle	$62,300	$65,300	$68,400	$71,600	$75,000	$1,135,900
Remaining Capital Balance - EOY	$280,400	$215,100	$146,700	$75,100	$100	
Phase 1 Dam Investment						
Dam Debt Service Payment	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$26,505,600
Dam Debt Service Interest	$239,100	$195,800	$150,400	$102,700	$52,600	$11,266,800
Dam Debt Service Principle	$865,400	$908,600	$954,100	$1,001,800	$1,051,900	$15,240,100
Remaining Capital Balance - EOY	$4,242,300	$3,333,700	$2,379,600	$1,377,800	$325,900	

Appendix C
Scenario 1

Table 6
North Central Missouri Regional Water Commission
Projected Water Sales

Type	Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Treated Water	Milan	127.8	128.6	129.5	130.5	131.4	132.3	133.2	134.1	135.1	136.0
	Sullivan County #1	119.7	121.3	122.9	124.5	126.1	127.7	129.4	131.0	132.8	134.5
	Green City	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.4	34.4
	Milan Industrial User	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Other Treated Water Cust.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	179.0	187.9	197.3
Total Treated Water		281.8	284.2	286.7	289.2	291.7	294.3	296.9	478.5	490.1	502.2
Raw Water	PSF	264.6	280.5	297.3	315.2	334.1	354.1	492.8	492.8	492.8	492.8
Total Water		546.4	564.7	584.0	604.4	625.8	648.4	789.7	971.3	982.9	995.0
Percent Treated Water		51.6%	50.3%	49.1%	47.9%	46.6%	45.4%	37.6%	49.3%	49.9%	50.5%
Percent Raw Water		48.4%	49.7%	50.9%	52.1%	53.4%	54.6%	62.4%	50.7%	50.1%	49.5%

Appendix C
Scenario 1

Table 6
North Central Missouri Regional Water Commission
Projected Water Sales

Type	Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Treated Water	Milan	137.0	137.9	138.9	139.9	140.9	141.8	142.8	143.8	144.8	145.9
	Sullivan County #1	136.2	138.0	139.8	141.6	143.4	145.3	147.2	149.1	151.1	153.0
	Green City	34.4	34.4	34.4	34.4	34.4	34.4	34.5	34.5	34.5	34.5
	Milan Industrial User	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Other Treated Water Cust.	207.2	217.5	228.4	239.8	251.8	264.4	277.6	291.5	306.1	321.4
Total Treated Water		514.8	527.9	541.5	555.7	570.5	586.0	602.2	618.9	636.5	654.7
Raw Water	PSF	492.8	492.8	492.8	492.8	492.8	492.8	492.8	492.8	492.8	492.8
Total Water		1,007.6	1,020.7	1,034.3	1,048.5	1,063.3	1,078.8	1,095.0	1,111.7	1,129.3	1,147.5
Percent Treated Water		51.1%	51.7%	52.4%	53.0%	53.7%	54.3%	55.0%	55.7%	56.4%	57.1%
Percent Raw Water		48.9%	48.3%	47.6%	47.0%	46.3%	45.7%	45.0%	44.3%	43.6%	42.9%

Appendix C
Scenario 1

Table 6
North Central Missouri Regional Water Commission
Projected Water Sales

Type	Year	2024	2025	2026	2027	2028
Treated Water	Milan	146.9	147.9	148.9	150.0	151.0
	Sullivan County #1	155.0	157.0	159.1	161.1	163.2
	Green City	34.5	34.5	34.5	34.5	34.5
	Milan Industrial User	0.0	0.0	0.0	0.0	0.0
	Other Treated Water Cust.	337.5	354.3	372.1	390.7	410.2
Total Treated Water		673.8	693.7	714.5	736.3	758.9
Raw Water	PSF	492.8	492.8	492.8	492.8	492.8
Total Water		1,166.6	1,186.5	1,207.3	1,229.1	1,251.7
Percent Treated Water		57.8%	58.5%	59.2%	59.9%	60.6%
Percent Raw Water		42.2%	41.5%	40.8%	40.1%	39.4%

Scenario 2

No Milan Industrial User, With 30% Plant Grant

Appendix C
Scenario 2

Table 1
North Central Missouri Regional Water Commission
Projected Water Costs

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Treated Water O&M Cost Including Return	$408,700	$419,300	$429,100	$439,300	$449,800	$426,600	$422,100	$551,800	$573,900	$597,000
Treated Water Debt Service	$236,500	$791,400	$776,700	$762,100	$747,500	$732,900	$640,800	$778,800	$785,900	$793,100
Total Treated Water Costs	$645,200	$1,210,700	$1,205,800	$1,201,400	$1,197,300	$1,159,500	$1,062,900	$1,330,600	$1,359,800	$1,390,100
Treated Water Cost ($/1000 gallons)	$2.2897	$4.2596	$4.2057	$4.1541	$4.1040	$3.9398	$3.5801	$2.7810	$2.7743	$2.7680

Raw Water Cost O&M Cost Including Return	$122,200	$130,500	$138,400	$146,700	$155,400	$123,600	$146,200	$127,200	$130,300	$133,300
Raw Water Debt Service	$38,100	$587,600	$602,300	$616,900	$631,500	$646,100	$738,200	$600,200	$593,100	$585,900
Total Raw Water Costs	$160,300	$718,100	$740,700	$763,600	$786,900	$769,700	$884,400	$727,400	$723,400	$719,200
Raw Water Cost ($/1000 gallons)	$0.6058	$2.5600	$2.4911	$2.4228	$2.3554	$2.1735	$1.7946	$1.4761	$1.4679	$1.4594

Year 1 - 5 Average Water Cost	$/1000 gal
Treated Water Costs	$3.8026
Raw Water Costs	$2.0870

Year 6 - 10 Average Water Cost	$/1000 gal
Treated Water Costs	$3.1686
Raw Water Costs	$1.6743

Appendix C
Scenario 2

Table 1
North Central Missouri Regional Water Commission
Projected Water Costs

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Treated Water O&M Cost Including Return	$621,100	$646,300	$672,900	$700,600	$729,800	$760,500	$801,000	$835,200	$871,000	$908,700
Treated Water Debt Service	$800,400	$807,800	$815,300	$823,000	$830,700	$838,600	$2,242,600	$2,267,900	$2,293,500	$2,319,300
Total Treated Water Costs	$1,421,500	$1,454,100	$1,488,200	$1,523,600	$1,560,500	$1,599,100	$3,043,600	$3,103,100	$3,164,500	$3,228,000
Treated Water Cost ($/1000 gallons)	$2.7614	$2.7547	$2.7483	$2.7417	$2.7352	$2.7290	$5.0546	$5.0135	$4.9720	$4.9301

Raw Water Cost O&M Cost Including Return	$136,400	$139,600	$142,800	$146,100	$149,400	$152,700	$162,800	$166,400	$170,000	$173,600
Raw Water Debt Service	$578,600	$571,200	$563,700	$556,000	$548,300	$540,400	$1,674,900	$1,649,600	$1,624,000	$1,598,200
Total Raw Water Costs	$715,000	$710,800	$706,500	$702,100	$697,700	$693,100	$1,837,700	$1,816,000	$1,794,000	$1,771,800
Raw Water Cost ($/1000 gallons)	$1.4509	$1.4424	$1.4336	$1.4247	$1.4158	$1.4065	$3.7291	$3.6851	$3.6404	$3.5954

Year 11 - 15 Average Water Cost	$/1000 gal
Treated Water Costs	$2.7483
Raw Water Costs	$1.4335

Year 16 - 20 Average Water Cost	$/1000 gal
Treated Water Costs	$4.5398
Raw Water Costs	$3.2113

No Milan Industrial User, With 30% Plant Grant
Including Phase 1 & 2 Capital

Appendix C
Scenario 2

Table 1
North Central Missouri Regional Water Commission
Projected Water Costs

	2024	2025	2026	2027	2028
Treated Water O&M Cost Including Return	$948,000	$989,400	$1,032,800	$1,078,500	$1,126,300
Treated Water Debt Service	$2,345,500	$2,371,900	$2,398,500	$2,425,300	$2,452,400
Total Treated Water Costs	$3,293,500	$3,361,300	$3,431,300	$3,503,800	$3,578,700
Treated Water Cost ($/1000 gallons)	$4.8877	$4.8452	$4.8021	$4.7590	$4.7155

Raw Water Cost O&M Cost Including Return	$177,200	$180,900	$184,600	$188,300	$192,000
Raw Water Debt Service	$1,572,000	$1,545,600	$1,519,000	$1,492,200	$1,465,100
Total Raw Water Costs	$1,749,200	$1,726,500	$1,703,600	$1,680,500	$1,657,100
Raw Water Cost ($/1000 gallons)	$3.5495	$3.5034	$3.4570	$3.4101	$3.3626

Year 21 - 25 Average Water Cost	$/1000 gal
Treated Water Costs	$4.8019
Raw Water Costs	$3.4565

Appendix C
Scenario 2

Table 2
North Central Missouri Regional Water Commission
Inputs and Assumptions

Starting Year	2004

Water Plant Capital

Milan Plant Purchase Capital Requirement	$3,564,500
Milan Plant Purchase Additional Capital	$482,200
Milan Plant Purchase Grant Funding	$1,214,010
Milan Plant Purchase Capital less Grants	$2,832,690

Supplemental Pipeline & Intake Capital Requirement	$1,136,000
Pipeline & Intake Grant Funding	$0
Pipeline & Intake Capital less Grants	$1,136,000

Interest Rate for Debt Financing	4.75%
Term of Project Financing - years	25

Phase 1 Capital

Investment Year	2005
Dam and Reservoir Construction Capital	$26,265,000
Dam Construction Grant Funding	$10,699,000
Dam Construction Capital less Grants	$15,566,000
Interest Rate for Debt Financing	5.00%
Term of Project Financing - years	25

Phase 2 Capital

Investment Year	2020
Dam and Reservoir Construction Capital	$32,450,000
Dam Construction Grant Funding	$0
Dam Construction Capital less Grants	$32,450,000
Interest Rate for Debt Financing	6.00%
Term of Project Financing - years	25

Plant O&M

Inflation Rate for Labor/Materials	4.0%
Inflation Rate for Energy	2.5%
Energy Unit Cost ($/kWh)	$0.0690
Average Monthly Energy Use (kWh)	55,000
Demand Charge ($/kW)	$206
Average Demand (kW)	8.50
Other Utility Costs (Gas?)	20,000
Plant Labor	$109,100
City Labor Offset (10%)	-$10,900
Routine Maintenance (1% of Plant Capital)	$35,600
Chemical Costs per Thousand Gallons	$0.275
General and Administration Expenses	$125,000
Lake Lease per Thousand Gallons	$0.150
Renewal & Replacement Fund Requirement	$20,000

Dam & Reservoir O&M

Phase 1	$40,000
Phase 2	$150,000

Water Usage

Milan Treated Water	0.350	[1]
Sullivan County #1 Treated Water	0.328	[1]
Green City Treated Water	0.094	[1]
Milan Industrial User Treated Water	0.000	[1]
Other Treated Water Customers (Begin 2011)	0.490	
PSF Raw Water	0.725	[1]
Milan Water Usage Growth	0.70%	
Sullivan County #1 Water Usage Growth	1.30%	
Green City Water Usage Growth	0.25%	
Raw Water Usage Growth (first 10 years)	6.00%	
Raw Water Usage Growth (after 2010)	0.00%	
Milan Industrial User Water Usage Growth	8.00%	
Milan Industrial User Water Usage Growth (after 2010)	0.00%	
Other Treated Water Growth	5.00%	

Return

Return (% of O&M expense, Years 1-5)	5%
Return (% of O&M expense, Years10 and beyond)	10%

[1] 2002 Average MGD

Appendix C
Scenario 2

Table 3
North Central Missouri Regional Water Commission
Forecast of Operation and Maintenance Expenses

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Treated Water Flow (MGY)	282	284	287	289	292	294	297	478	490	502
Raw Water Flow (MGY)	265	281	297	315	334	354	493	493	493	493
Total Water Flow (MGY)	546	565	584	604	626	648	790	971	983	995
Plant O&M Expenses										
Labor & Burden	$98,200	$102,100	$106,200	$110,400	$114,800	$119,400	$124,200	$129,200	$134,400	$139,800
General & Administrative	$125,000	$130,000	$135,200	$140,600	$146,200	$152,000	$158,100	$164,400	$171,000	$177,800
Electricity Costs	$47,300	$48,900	$50,600	$52,300	$54,100	$56,000	$58,000	$94,400	$99,100	$104,100
Other Utility Costs	$20,000	$20,800	$21,600	$22,500	$23,400	$24,300	$25,300	$26,300	$27,400	$28,500
Routine Maintenance	$35,600	$37,000	$38,500	$40,000	$41,600	$43,300	$45,000	$46,800	$48,700	$50,600
Chemicals	$77,500	$78,200	$78,800	$79,500	$80,200	$80,900	$81,600	$131,600	$134,800	$138,100
Lake Lease	$82,000	$84,700	$87,600	$90,700	$93,900	$0	$0	$0	$0	$0
R&R Fund	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
Phase 1 Dam O&M	$0	$40,000	$41,600	$43,300	$45,000	$46,800	$48,700	$50,600	$52,600	$54,700
Phase 2 Dam O&M	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total O&M Costs	$505,600	$561,700	$580,100	$599,300	$619,200	$542,700	$560,900	$663,300	$688,000	$713,600
Return	$25,300	$28,100	$29,000	$30,000	$31,000	$54,300	$56,100	$66,300	$68,800	$71,400
Total Annual Costs	$530,900	$589,800	$609,100	$629,300	$650,200	$597,000	$617,000	$729,600	$756,800	$785,000
Allocated O&M including Return to Treated Water	$408,700	$419,300	$429,100	$439,300	$449,800	$426,600	$422,100	$551,800	$573,900	$597,000
Allocated O&M including Return to Raw Water	$122,200	$130,500	$138,400	$146,700	$155,400	$123,600	$146,200	$127,200	$130,300	$133,300

Appendix C
Scenario 2

Table 3
North Central Missouri Regional Water Commission
Forecast of Operation and Maintenance Expenses

Year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Treated Water Flow (MGY)	515	528	541	556	571	586	602	619	636	655
Raw Water Flow (MGY)	493	493	493	493	493	493	493	493	493	493
Total Water Flow (MGY)	1,008	1,021	1,034	1,049	1,063	1,079	1,095	1,112	1,129	1,148
Plant O&M Expenses										
Labor & Burden	$145,400	$151,200	$157,200	$163,500	$170,000	$176,800	$183,900	$191,300	$199,000	$207,000
General & Administrative	$184,900	$192,300	$200,000	$208,000	$216,300	$225,000	$234,000	$243,400	$253,100	$263,200
Electricity Costs	$109,400	$114,900	$120,900	$127,100	$133,800	$140,900	$148,400	$156,300	$164,700	$173,700
Other Utility Costs	$29,600	$30,800	$32,000	$33,300	$34,600	$36,000	$37,400	$38,900	$40,500	$42,100
Routine Maintenance	$52,600	$54,700	$56,900	$59,200	$61,600	$64,100	$66,700	$69,400	$72,200	$75,100
Chemicals	$141,600	$145,200	$148,900	$152,800	$156,900	$161,100	$165,600	$170,200	$175,000	$180,100
Lake Lease	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
R&R Fund	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
Phase 1 Dam O&M	$56,900	$59,200	$61,600	$64,100	$66,700	$69,400	$72,200	$75,100	$78,100	$81,200
Phase 2 Dam O&M	$0	$0	$0	$0	$0	$0	$150,000	$156,000	$162,200	$168,700
Total O&M Costs	$740,400	$768,300	$797,500	$828,000	$859,900	$893,300	$1,078,200	$1,120,600	$1,164,800	$1,211,100
Return	$74,000	$76,800	$79,800	$82,800	$86,000	$89,300	$107,800	$112,100	$116,500	$121,100
Total Annual Costs	$814,400	$845,100	$877,300	$910,800	$945,900	$982,600	$1,186,000	$1,232,700	$1,281,300	$1,332,200
Allocated O&M including Return to Treated Water	$621,100	$646,300	$672,900	$700,600	$729,800	$760,500	$801,000	$835,200	$871,000	$908,700
Allocated O&M including Return to Raw Water	$136,400	$139,600	$142,800	$146,100	$149,400	$152,700	$162,800	$166,400	$170,000	$173,600

Appendix C
Scenario 2

Table 3
North Central Missouri Regional Water Commission
Forecast of Operation and Maintenance Expenses

Year	2024	2025	2026	2027	2028	Total
Treated Water Flow (MGY)	674	694	715	736	759	
Raw Water Flow (MGY)	493	493	493	493	493	
Total Water Flow (MGY)	1,167	1,187	1,207	1,229	1,252	
Plant O&M Expenses						
Labor & Burden	$215,300	$223,900	$232,900	$242,200	$251,900	$4,090,200
General & Administrative	$273,700	$284,600	$296,000	$307,800	$320,100	$5,202,700
Electricity Costs	$183,100	$193,200	$204,000	$215,500	$227,500	$3,078,200
Other Utility Costs	$43,800	$45,600	$47,400	$49,300	$51,300	$832,700
Routine Maintenance	$78,100	$81,200	$84,400	$87,800	$91,300	$1,482,400
Chemicals	$185,300	$190,800	$196,500	$202,500	$208,700	$3,542,400
Lake Lease	$0	$0	$0	$0	$0	$438,900
R&R Fund	$20,000	$20,000	$20,000	$20,000	$20,000	$500,000
Phase 1 Dam O&M	$84,400	$87,800	$91,300	$95,000	$98,800	$1,565,100
Phase 2 Dam O&M	$175,400	$182,400	$189,700	$197,300	$205,200	$1,586,900
Total O&M Costs	$1,259,100	$1,309,500	$1,362,200	$1,417,400	$1,474,800	$22,319,500
Return	$125,900	$131,000	$136,200	$141,700	$147,500	$2,088,800
Total Annual Costs	$1,385,000	$1,440,500	$1,498,400	$1,559,100	$1,622,300	$24,408,300
Allocated O&M including Return to Treated Water	$948,000	$989,400	$1,032,800	$1,078,500	$1,126,300	$17,439,700
Allocated O&M including Return to Raw Water	$177,200	$180,900	$184,600	$188,300	$192,000	$3,816,600

Appendix C
Scenario 2

Table 4
North Central Missouri Regional Water Commission
Forecast Energy Expenses

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Energy Unit Cost ($/kWh)	$0.0690	0.0707	0.0725	0.0743	0.0762	0.0781	0.0800	0.0820	0.0841	0.0862
Annual Energy Usage (kWh)	660,000	665,700	671,500	677,400	683,300	689,300	695,400	1,120,700	1,148,000	1,176,300
Annual Energy Cost	$45,500	$47,100	$48,700	$50,300	$52,000	$53,800	$55,600	$91,900	$96,500	$101,400
Monthly Demand Charge ($KW)	$206.00	211.15	216.43	221.84	227.39	233.07	238.90	244.87	250.99	257.27
Monthly Peak Demand	8.50	8.71	8.93	9.15	9.38	9.62	9.86	10.10	10.36	10.62
Annual Demand Cost	$1,800	$1,800	$1,900	$2,000	$2,100	$2,200	$2,400	$2,500	$2,600	$2,700
Treated Water Electric Cost	$47,300	$48,900	$50,600	$52,300	$54,100	$56,000	$58,000	$94,400	$99,100	$104,100
Raw Water Electric Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Calculated Electric Cost	$47,300	$48,900	$50,600	$52,300	$54,100	$56,000	$58,000	$94,400	$99,100	$104,100
Total Electric Cost	$47,300	$48,900	$50,600	$52,300	$54,100	$56,000	$58,000	$94,400	$99,100	$104,100
Allocated Treated Water	$47,300	$48,900	$50,600	$52,300	$54,100	$56,000	$58,000	$94,400	$99,100	$104,100
Allocated Raw Water	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

No Milan Industrial User, With 30% Plant Grant
Including Phase 1 & 2 Capital

Appendix C
Scenario 2

Table 4
North Central Missouri Regional Water Commission
Forecast Energy Expenses

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Energy Unit Cost ($/kWh)	0.0883	0.0905	0.0928	0.0951	0.0975	0.0999	0.1024	0.1050	0.1076	0.1103
Annual Energy Usage (kWh)	1,205,700	1,236,400	1,268,300	1,301,600	1,336,300	1,372,500	1,410,400	1,449,700	1,490,700	1,533,500
Annual Energy Cost	$106,500	$111,900	$117,700	$123,800	$130,300	$137,200	$144,500	$152,200	$160,400	$169,200
Monthly Demand Charge ($KW)	263.70	270.29	277.05	283.97	291.07	298.35	305.81	313.45	321.29	329.32
Monthly Peak Demand	10.88	11.15	11.43	11.72	12.01	12.31	12.62	12.93	13.26	13.59
Annual Demand Cost	$2,900	$3,000	$3,200	$3,300	$3,500	$3,700	$3,900	$4,100	$4,300	$4,500
Treated Water Electric Cost	$109,400	$114,900	$120,900	$127,100	$133,800	$140,900	$148,400	$156,300	$164,700	$173,700
Raw Water Electric Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Calculated Electric Cost	$109,400	$114,900	$120,900	$127,100	$133,800	$140,900	$148,400	$156,300	$164,700	$173,700
Total Electric Cost	$109,400	$114,900	$120,900	$127,100	$133,800	$140,900	$148,400	$156,300	$164,700	$173,700
Allocated Treated Water	$109,400	$114,900	$120,900	$127,100	$133,800	$140,900	$148,400	$156,300	$164,700	$173,700
Allocated Raw Water	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

Appendix C
Scenario 2

Table 4
North Central Missouri Regional Water Commission
Forecast Energy Expenses

Year	2024	2025	2026	2027	2028
Energy Unit Cost ($/kWh)	0.1131	0.1159	0.1188	0.1218	0.1248
Annual Energy Usage (kWh)	1,578,200	1,624,800	1,673,500	1,724,400	1,777,500
Annual Energy Cost	$178,400	$188,300	$198,800	$210,000	$221,800
Monthly Demand Charge ($KW)	337.55	345.99	354.64	363.51	372.60
Monthly Peak Demand	13.93	14.28	14.63	15.00	15.37
Annual Demand Cost	$4,700	$4,900	$5,200	$5,500	$5,700
Treated Water Electric Cost	$183,100	$193,200	$204,000	$215,500	$227,500
Raw Water Electric Cost	$0	$0	$0	$0	$0
Calculated Electric Cost	$183,100	$193,200	$204,000	$215,500	$227,500
Total Electric Cost	$183,100	$193,200	$204,000	$215,500	$227,500
Allocated Treated Water	$183,100	$193,200	$204,000	$215,500	$227,500
Allocated Raw Water	$0	$0	$0	$0	$0

Appendix C
Scenario 2

Table 5
North Central Missouri Regional Water Commission
Projected Debt Expense

Year	Investment	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Plant Investment	$2,832,690										
Initial Debt Service Payment		$196,000	$196,000	$196,000	$196,000	$196,000	$196,000	$196,000	$196,000	$196,000	$196,000
Initial Debt Service Interest		$134,600	$131,600	$128,600	$125,400	$122,000	$118,500	$114,800	$111,000	$106,900	$102,700
Initial Debt Service Principle		$61,400	$64,300	$67,400	$70,600	$74,000	$77,500	$81,100	$85,000	$89,000	$93,300
Remaining Capital Balance - EOY		$2,771,290	$2,706,990	$2,639,590	$2,568,990	$2,494,990	$2,417,490	$2,336,390	$2,251,390	$2,162,390	$2,069,090

Supplemental Pipeline & Intake	$1,136,000										
Initial Debt Service Payment		$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600
Initial Debt Service Interest		$54,000	$52,800	$51,600	$50,300	$48,900	$47,500	$46,100	$44,500	$42,900	$41,200
Initial Debt Service Principle		$24,600	$25,800	$27,000	$28,300	$29,700	$31,100	$32,500	$34,100	$35,700	$37,400
Remaining Capital Balance - EOY		$1,111,400	$1,085,600	$1,058,600	$1,030,300	$1,000,600	$969,500	$937,000	$902,900	$867,200	$829,800

Phase 1 Dam Investment	$15,566,000										
Dam Debt Service Payment		$0	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400
Dam Debt Service Interest		$0	$762,000	$744,900	$726,900	$708,000	$688,200	$667,400	$645,500	$622,600	$598,500
Dam Debt Service Principle		$0	$342,500	$359,600	$377,600	$396,400	$416,300	$437,100	$458,900	$481,900	$506,000
Remaining Capital Balance - EOY		$0	$15,223,500	$14,863,900	$14,486,300	$14,089,900	$13,673,600	$13,236,500	$12,777,600	$12,295,700	$11,789,700

Appendix C
Scenario 2

Table 5
North Central Missouri Regional Water Commission
Projected Debt Expense

Year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Plant Investment										
Initial Debt Service Payment	$196,000	$196,000	$196,000	$196,000	$196,000	$196,000	$196,000	$196,000	$196,000	$196,000
Initial Debt Service Interest	$98,300	$93,600	$88,800	$83,700	$78,400	$72,800	$66,900	$60,800	$54,400	$47,600
Initial Debt Service Principle	$97,700	$102,300	$107,200	$112,300	$117,600	$123,200	$129,100	$135,200	$141,600	$148,400
Remaining Capital Balance - EOY	$1,971,390	$1,869,090	$1,761,890	$1,649,590	$1,531,990	$1,408,790	$1,279,690	$1,144,490	$1,002,890	$854,490

Supplemental Pipeline & Intake										
Initial Debt Service Payment	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600
Initial Debt Service Interest	$39,400	$37,600	$35,600	$33,600	$31,400	$29,200	$26,800	$24,400	$21,800	$19,100
Initial Debt Service Principle	$39,200	$41,000	$43,000	$45,000	$47,200	$49,400	$51,800	$54,200	$56,800	$59,500
Remaining Capital Balance - EOY	$790,600	$749,600	$706,600	$661,600	$614,400	$565,000	$513,200	$459,000	$402,200	$342,700

Phase 1 Dam Investment										
Dam Debt Service Payment	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400
Dam Debt Service Interest	$573,200	$546,600	$518,700	$489,400	$458,700	$426,400	$392,500	$356,900	$319,500	$280,300
Dam Debt Service Principle	$531,300	$557,800	$585,700	$615,000	$645,700	$678,000	$711,900	$747,500	$784,900	$824,200
Remaining Capital Balance - EOY	$11,258,400	$10,700,600	$10,114,900	$9,499,900	$8,854,200	$8,176,200	$7,464,300	$6,716,800	$5,931,900	$5,107,700

Appendix C
Scenario 2

Table 5
North Central Missouri Regional Water Commission
Projected Debt Expense

Year	2024	2025	2026	2027	2028	Total
Plant Investment						
Initial Debt Service Payment	$196,000	$196,000	$196,000	$196,000	$196,000	$4,900,000
Initial Debt Service Interest	$40,600	$33,200	$25,500	$17,400	$8,900	$2,067,000
Initial Debt Service Principle	$155,400	$162,800	$170,500	$178,600	$187,100	$2,832,600
Remaining Capital Balance - EOY	$699,090	$536,290	$365,790	$187,190	$90	
Supplemental Pipeline & Intake						
Initial Debt Service Payment	$78,600	$78,600	$78,600	$78,600	$78,600	$1,965,000
Initial Debt Service Interest	$16,300	$13,300	$10,200	$7,000	$3,600	$829,100
Initial Debt Service Principle	$62,300	$65,300	$68,400	$71,600	$75,000	$1,135,900
Remaining Capital Balance - EOY	$280,400	$215,100	$146,700	$75,100	$100	
Phase 1 Dam Investment						
Dam Debt Service Payment	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$26,505,600
Dam Debt Service Interest	$239,100	$195,800	$150,400	$102,700	$52,600	$11,266,800
Dam Debt Service Principle	$865,400	$908,600	$954,100	$1,001,800	$1,051,900	$15,240,100
Remaining Capital Balance - EOY	$4,242,300	$3,333,700	$2,379,600	$1,377,800	$325,900	

Appendix C
Scenario 2

Table 6
North Central Missouri Regional Water Commission
Projected Water Sales

Type	Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Treated Water	Milan	127.8	128.6	129.5	130.5	131.4	132.3	133.2	134.1	135.1	136.0
	Sullivan County #1	119.7	121.3	122.9	124.5	126.1	127.7	129.4	131.0	132.8	134.5
	Green City	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.4	34.4
	Milan Industrial User	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Other Treated Water Cust.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	179.0	187.9	197.3
Total Treated Water		281.8	284.2	286.7	289.2	291.7	294.3	296.9	478.5	490.1	502.2
Raw Water	PSF	264.6	280.5	297.3	315.2	334.1	354.1	492.8	492.8	492.8	492.8
Total Water		546.4	564.7	584.0	604.4	625.8	648.4	789.7	971.3	982.9	995.0
Percent Treated Water		51.6%	50.3%	49.1%	47.9%	46.6%	45.4%	37.6%	49.3%	49.9%	50.5%
Percent Raw Water		48.4%	49.7%	50.9%	52.1%	53.4%	54.6%	62.4%	50.7%	50.1%	49.5%

Appendix C
Scenario 2

Table 6
North Central Missouri Regional Water Commission
Projected Water Sales

Type	Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Treated Water	Milan	137.0	137.9	138.9	139.9	140.9	141.8	142.8	143.8	144.8	145.9
	Sullivan County #1	136.2	138.0	139.8	141.6	143.4	145.3	147.2	149.1	151.1	153.0
	Green City	34.4	34.4	34.4	34.4	34.4	34.4	34.5	34.5	34.5	34.5
	Milan Industrial User	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Other Treated Water Cust.	207.2	217.5	228.4	239.8	251.8	264.4	277.6	291.5	306.1	321.4
Total Treated Water		514.8	527.9	541.5	555.7	570.5	586.0	602.2	618.9	636.5	654.7
Raw Water	PSF	492.8	492.8	492.8	492.8	492.8	492.8	492.8	492.8	492.8	492.8
Total Water		1,007.6	1,020.7	1,034.3	1,048.5	1,063.3	1,078.8	1,095.0	1,111.7	1,129.3	1,147.5
Percent Treated Water		51.1%	51.7%	52.4%	53.0%	53.7%	54.3%	55.0%	55.7%	56.4%	57.1%
Percent Raw Water		48.9%	48.3%	47.6%	47.0%	46.3%	45.7%	45.0%	44.3%	43.6%	42.9%

Appendix C
Scenario 2

Table 6
North Central Missouri Regional Water Commission
Projected Water Sales

Type	Year	2024	2025	2026	2027	2028
Treated Water	Milan	146.9	147.9	148.9	150.0	151.0
	Sullivan County #1	155.0	157.0	159.1	161.1	163.2
	Green City	34.5	34.5	34.5	34.5	34.5
	Milan Industrial User	0.0	0.0	0.0	0.0	0.0
	Other Treated Water Cust.	337.5	354.3	372.1	390.7	410.2
Total Treated Water		673.8	693.7	714.5	736.3	758.9
Raw Water	PSF	492.8	492.8	492.8	492.8	492.8
Total Water		1,166.6	1,186.5	1,207.3	1,229.1	1,251.7
Percent Treated Water		57.8%	58.5%	59.2%	59.9%	60.6%
Percent Raw Water		42.2%	41.5%	40.8%	40.1%	39.4%

Scenario 3

No Milan Industrial User, With 50% Plant Grant

Appendix C
Scenario 3

Table 1
North Central Missouri Regional Water Commission
Projected Water Costs

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Treated Water O&M Cost Including Return	$408,700	$419,300	$429,100	$439,300	$449,800	$426,600	$422,100	$551,800	$573,900	$597,000
Treated Water Debt Service	$180,500	$735,400	$720,700	$706,100	$691,500	$676,900	$584,800	$722,800	$729,900	$737,100
Total Treated Water Costs	$589,200	$1,154,700	$1,149,800	$1,145,400	$1,141,300	$1,103,500	$1,006,900	$1,274,600	$1,303,800	$1,334,100
Treated Water Cost ($/1000 gallons)	$2.0910	$4.0625	$4.0104	$3.9604	$3.9120	$3.7496	$3.3915	$2.6639	$2.6600	$2.6565
Raw Water Cost O&M Cost Including Return	$122,200	$130,500	$138,400	$146,700	$155,400	$123,600	$146,200	$127,200	$130,300	$133,300
Raw Water Debt Service	$38,100	$587,600	$602,300	$616,900	$631,500	$646,100	$738,200	$600,200	$593,100	$585,900
Total Raw Water Costs	$160,300	$718,100	$740,700	$763,600	$786,900	$769,700	$884,400	$727,400	$723,400	$719,200
Raw Water Cost ($/1000 gallons)	$0.6058	$2.5600	$2.4911	$2.4228	$2.3554	$2.1735	$1.7946	$1.4761	$1.4679	$1.4594

Year 1 - 5 Average Water Cost	$/1000 gal
Treated Water Costs	$3.6073
Raw Water Costs	$2.0870

Year 6 - 10 Average Water Cost	$/1000 gal
Treated Water Costs	$3.0243
Raw Water Costs	$1.6743

Appendix C
Scenario 3

Table 1
North Central Missouri Regional Water Commission
Projected Water Costs

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Treated Water O&M Cost Including Return	$621,100	$646,300	$672,900	$700,600	$729,800	$760,500	$801,000	$835,200	$871,000	$908,700
Treated Water Debt Service	$744,400	$751,800	$759,300	$767,000	$774,700	$782,600	$2,186,600	$2,211,900	$2,237,500	$2,263,300
Total Treated Water Costs	$1,365,500	$1,398,100	$1,432,200	$1,467,600	$1,504,500	$1,543,100	$2,987,600	$3,047,100	$3,108,500	$3,172,000
Treated Water Cost ($/1000 gallons)	$2.6526	$2.6486	$2.6449	$2.6410	$2.6371	$2.6334	$4.9616	$4.9231	$4.8840	$4.8446

Raw Water Cost O&M Cost Including Return	$136,400	$139,600	$142,800	$146,100	$149,400	$152,700	$162,800	$166,400	$170,000	$173,600
Raw Water Debt Service	$578,600	$571,200	$563,700	$556,000	$548,300	$540,400	$1,674,900	$1,649,600	$1,624,000	$1,598,200
Total Raw Water Costs	$715,000	$710,800	$706,500	$702,100	$697,700	$693,100	$1,837,700	$1,816,000	$1,794,000	$1,771,800
Raw Water Cost ($/1000 gallons)	$1.4509	$1.4424	$1.4336	$1.4247	$1.4158	$1.4065	$3.7291	$3.6851	$3.6404	$3.5954

Year 11 - 15 Average Water Cost	$/1000 gal
Treated Water Costs	$2.6448
Raw Water Costs	$1.4335

Year 16 - 20 Average Water Cost	$/1000 gal
Treated Water Costs	$4.4493
Raw Water Costs	$3.2113

Appendix C
Scenario 3

Table 1
North Central Missouri Regional Water Commission
Projected Water Costs

	2024	2025	2026	2027	2028
Treated Water O&M Cost Including Return	$948,000	$989,400	$1,032,800	$1,078,500	$1,126,300
Treated Water Debt Service	$2,289,500	$2,315,900	$2,342,500	$2,369,300	$2,396,400
Total Treated Water Costs	$3,237,500	$3,305,300	$3,375,300	$3,447,800	$3,522,700
Treated Water Cost ($/1000 gallons)	$4.8046	$4.7644	$4.7238	$4.6829	$4.6417

Raw Water Cost O&M Cost Including Return	$177,200	$180,900	$184,600	$188,300	$192,000
Raw Water Debt Service	$1,572,000	$1,545,600	$1,519,000	$1,492,200	$1,465,100
Total Raw Water Costs	$1,749,200	$1,726,500	$1,703,600	$1,680,500	$1,657,100
Raw Water Cost ($/1000 gallons)	$3.5495	$3.5034	$3.4570	$3.4101	$3.3626

Year 21 - 25 Average Water Cost	$/1000 gal
Treated Water Costs	$4.7235
Raw Water Costs	$3.4565

Appendix C
Scenario 3

Table 2
North Central Missouri Regional Water Commission
Inputs and Assumptions

Starting Year	2004

Water Plant Capital

Milan Plant Purchase Capital Requirement	$3,564,500
Milan Plant Purchase Additional Capital	$482,200
Milan Plant Purchase Grant Funding	$2,023,350
Milan Plant Purchase Capital less Grants	$2,023,350

Supplemental Pipeline & Intake Capital Requirement	$1,136,000
Pipeline & Intake Grant Funding	$0
Pipeline & Intake Capital less Grants	$1,136,000

Interest Rate for Debt Financing	4.75%
Term of Project Financing - years	25

Phase 1 Capital

Investment Year	2005
Dam and Reservoir Construction Capital	$26,265,000
Dam Construction Grant Funding	$10,699,000
Dam Construction Capital less Grants	$15,566,000
Interest Rate for Debt Financing	5.00%
Term of Project Financing - years	25

Phase 2 Capital

Investment Year	2020
Dam and Reservoir Construction Capital	$32,450,000
Dam Construction Grant Funding	$0
Dam Construction Capital less Grants	$32,450,000
Interest Rate for Debt Financing	6.00%
Term of Project Financing - years	25

Plant O&M

Inflation Rate for Labor/Materials	4.0%
Inflation Rate for Energy	2.5%
Energy Unit Cost ($/kWh)	$0.0690
Average Monthly Energy Use (kWh)	55,000
Demand Charge ($/kW)	$206
Average Demand (kW)	8.50
Other Utility Costs (Gas?)	20,000
Plant Labor	$109,100
City Labor Offset (10%)	-$10,900
Routine Maintenance (1% of Plant Capital)	$35,600
Chemical Costs per Thousand Gallons	$0.275
General and Administration Expenses	$125,000
Lake Lease per Thousand Gallons	$0.150
Renewal & Replacement Fund Requirement	$20,000

Dam & Reservoir O&M

Phase 1	$40,000
Phase 2	$150,000

Water Usage

Milan Treated Water	0.350	[1]
Sullivan County #1 Treated Water	0.328	[1]
Green City Treated Water	0.094	[1]
Milan Industrial User Treated Water	0.000	[1]
Other Treated Water Customers (Begin 2011)	0.490	
PSF Raw Water	0.725	[1]
Milan Water Usage Growth	0.70%	
Sullivan County #1 Water Usage Growth	1.30%	
Green City Water Usage Growth	0.25%	
Raw Water Usage Growth (first 10 years)	6.00%	
Raw Water Usage Growth (after 2010)	0.00%	
Milan Industrial User Water Usage Growth	8.00%	
Milan Industrial User Water Usage Growth (after 2010)	0.00%	
Other Treated Water Growth	5.00%	

Return

Return (% of O&M expense, Years 1-5)	5%
Return (% of O&M expense, Years10 and beyond)	10%

[1] 2002 Average MGD

Appendix C
Scenario 3

Table 3
North Central Missouri Regional Water Commission
Forecast of Operation and Maintenance Expenses

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Treated Water Flow (MGY)	282	284	287	289	292	294	297	478	490	502
Raw Water Flow (MGY)	265	281	297	315	334	354	493	493	493	493
Total Water Flow (MGY)	546	565	584	604	626	648	790	971	983	995
Plant O&M Expenses										
Labor & Burden	$98,200	$102,100	$106,200	$110,400	$114,800	$119,400	$124,200	$129,200	$134,400	$139,800
General & Administrative	$125,000	$130,000	$135,200	$140,600	$146,200	$152,000	$158,100	$164,400	$171,000	$177,800
Electricity Costs	$47,300	$48,900	$50,600	$52,300	$54,100	$56,000	$58,000	$94,400	$99,100	$104,100
Other Utility Costs	$20,000	$20,800	$21,600	$22,500	$23,400	$24,300	$25,300	$26,300	$27,400	$28,500
Routine Maintenance	$35,600	$37,000	$38,500	$40,000	$41,600	$43,300	$45,000	$46,800	$48,700	$50,600
Chemicals	$77,500	$78,200	$78,800	$79,500	$80,200	$80,900	$81,600	$131,600	$134,800	$138,100
Lake Lease	$82,000	$84,700	$87,600	$90,700	$93,900	$0	$0	$0	$0	$0
R&R Fund	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
Phase 1 Dam O&M	$0	$40,000	$41,600	$43,300	$45,000	$46,800	$48,700	$50,600	$52,600	$54,700
Phase 2 Dam O&M	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total O&M Costs	$505,600	$561,700	$580,100	$599,300	$619,200	$542,700	$560,900	$663,300	$688,000	$713,600
Return	$25,300	$28,100	$29,000	$30,000	$31,000	$54,300	$56,100	$66,300	$68,800	$71,400
Total Annual Costs	$530,900	$589,800	$609,100	$629,300	$650,200	$597,000	$617,000	$729,600	$756,800	$785,000
Allocated O&M including Return to Treated Water	$408,700	$419,300	$429,100	$439,300	$449,800	$426,600	$422,100	$551,800	$573,900	$597,000
Allocated O&M including Return to Raw Water	$122,200	$130,500	$138,400	$146,700	$155,400	$123,600	$146,200	$127,200	$130,300	$133,300

Appendix C
Scenario 3

Table 3
North Central Missouri Regional Water Commission
Forecast of Operation and Maintenance Expenses

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Treated Water Flow (MGY)	515	528	541	556	571	586	602	619	636	655
Raw Water Flow (MGY)	493	493	493	493	493	493	493	493	493	493
Total Water Flow (MGY)	1,008	1,021	1,034	1,049	1,063	1,079	1,095	1,112	1,129	1,148
Plant O&M Expenses										
Labor & Burden	$145,400	$151,200	$157,200	$163,500	$170,000	$176,800	$183,900	$191,300	$199,000	$207,000
General & Administrative	$184,900	$192,300	$200,000	$208,000	$216,300	$225,000	$234,000	$243,400	$253,100	$263,200
Electricity Costs	$109,400	$114,900	$120,900	$127,100	$133,800	$140,900	$148,400	$156,300	$164,700	$173,700
Other Utility Costs	$29,600	$30,800	$32,000	$33,300	$34,600	$36,000	$37,400	$38,900	$40,500	$42,100
Routine Maintenance	$52,600	$54,700	$56,900	$59,200	$61,600	$64,100	$66,700	$69,400	$72,200	$75,100
Chemicals	$141,600	$145,200	$148,900	$152,800	$156,900	$161,100	$165,600	$170,200	$175,000	$180,100
Lake Lease	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
R&R Fund	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
Phase 1 Dam O&M	$56,900	$59,200	$61,600	$64,100	$66,700	$69,400	$72,200	$75,100	$78,100	$81,200
Phase 2 Dam O&M	$0	$0	$0	$0	$0	$0	$150,000	$156,000	$162,200	$168,700
Total O&M Costs	$740,400	$768,300	$797,500	$828,000	$859,900	$893,300	$1,078,200	$1,120,600	$1,164,800	$1,211,100
Return	$74,000	$76,800	$79,800	$82,800	$86,000	$89,300	$107,800	$112,100	$116,500	$121,100
Total Annual Costs	$814,400	$845,100	$877,300	$910,800	$945,900	$982,600	$1,186,000	$1,232,700	$1,281,300	$1,332,200
Allocated O&M including Return to Treated Water	$621,100	$646,300	$672,900	$700,600	$729,800	$760,500	$801,000	$835,200	$871,000	$908,700
Allocated O&M including Return to Raw Water	$136,400	$139,600	$142,800	$146,100	$149,400	$152,700	$162,800	$166,400	$170,000	$173,600

Appendix C
Scenario 3

Table 3
North Central Missouri Regional Water Commission
Forecast of Operation and Maintenance Expenses

Year	2024	2025	2026	2027	2028	Total
Treated Water Flow (MGY)	674	694	715	736	759	
Raw Water Flow (MGY)	493	493	493	493	493	
Total Water Flow (MGY)	1,167	1,187	1,207	1,229	1,252	
Plant O&M Expenses						
Labor & Burden	$215,300	$223,900	$232,900	$242,200	$251,900	$4,090,200
General & Administrative	$273,700	$284,600	$296,000	$307,800	$320,100	$5,202,700
Electricity Costs	$183,100	$193,200	$204,000	$215,500	$227,500	$3,078,200
Other Utility Costs	$43,800	$45,600	$47,400	$49,300	$51,300	$832,700
Routine Maintenance	$78,100	$81,200	$84,400	$87,800	$91,300	$1,482,400
Chemicals	$185,300	$190,800	$196,500	$202,500	$208,700	$3,542,400
Lake Lease	$0	$0	$0	$0	$0	$438,900
R&R Fund	$20,000	$20,000	$20,000	$20,000	$20,000	$500,000
Phase 1 Dam O&M	$84,400	$87,800	$91,300	$95,000	$98,800	$1,565,100
Phase 2 Dam O&M	$175,400	$182,400	$189,700	$197,300	$205,200	$1,586,900
Total O&M Costs	$1,259,100	$1,309,500	$1,362,200	$1,417,400	$1,474,800	$22,319,500
Return	$125,900	$131,000	$136,200	$141,700	$147,500	$2,088,800
Total Annual Costs	$1,385,000	$1,440,500	$1,498,400	$1,559,100	$1,622,300	$24,408,300
Allocated O&M including Return to Treated Water	$948,000	$989,400	$1,032,800	$1,078,500	$1,126,300	$17,439,700
Allocated O&M including Return to Raw Water	$177,200	$180,900	$184,600	$188,300	$192,000	$3,816,600

Appendix C
Scenario 3

Table 4
North Central Missouri Regional Water Commission
Forecast Energy Expenses

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Energy Unit Cost ($/kWh)	$0.0690	0.0707	0.0725	0.0743	0.0762	0.0781	0.0800	0.0820	0.0841	0.0862
Annual Energy Usage (kWh)	660,000	665,700	671,500	677,400	683,300	689,300	695,400	1,120,700	1,148,000	1,176,300
Annual Energy Cost	$45,500	$47,100	$48,700	$50,300	$52,000	$53,800	$55,600	$91,900	$96,500	$101,400
Monthly Demand Charge ($KW)	$206.00	211.15	216.43	221.84	227.39	233.07	238.90	244.87	250.99	257.27
Monthly Peak Demand	8.50	8.71	8.93	9.15	9.38	9.62	9.86	10.10	10.36	10.62
Annual Demand Cost	$1,800	$1,800	$1,900	$2,000	$2,100	$2,200	$2,400	$2,500	$2,600	$2,700
Treated Water Electric Cost	$47,300	$48,900	$50,600	$52,300	$54,100	$56,000	$58,000	$94,400	$99,100	$104,100
Raw Water Electric Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Calculated Electric Cost	$47,300	$48,900	$50,600	$52,300	$54,100	$56,000	$58,000	$94,400	$99,100	$104,100
Total Electric Cost	$47,300	$48,900	$50,600	$52,300	$54,100	$56,000	$58,000	$94,400	$99,100	$104,100
Allocated Treated Water	$47,300	$48,900	$50,600	$52,300	$54,100	$56,000	$58,000	$94,400	$99,100	$104,100
Allocated Raw Water	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

Appendix C
Scenario 3

Table 4
North Central Missouri Regional Water Commission
Forecast Energy Expenses

Year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Energy Unit Cost ($/kWh)	0.0883	0.0905	0.0928	0.0951	0.0975	0.0999	0.1024	0.1050	0.1076	0.1103
Annual Energy Usage (kWh)	1,205,700	1,236,400	1,268,300	1,301,600	1,336,300	1,372,500	1,410,400	1,449,700	1,490,700	1,533,500
Annual Energy Cost	$106,500	$111,900	$117,700	$123,800	$130,300	$137,200	$144,500	$152,200	$160,400	$169,200
Monthly Demand Charge ($KW)	263.70	270.29	277.05	283.97	291.07	298.35	305.81	313.45	321.29	329.32
Monthly Peak Demand	10.88	11.15	11.43	11.72	12.01	12.31	12.62	12.93	13.26	13.59
Annual Demand Cost	$2,900	$3,000	$3,200	$3,300	$3,500	$3,700	$3,900	$4,100	$4,300	$4,500
Treated Water Electric Cost	$109,400	$114,900	$120,900	$127,100	$133,800	$140,900	$148,400	$156,300	$164,700	$173,700
Raw Water Electric Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Calculated Electric Cost	$109,400	$114,900	$120,900	$127,100	$133,800	$140,900	$148,400	$156,300	$164,700	$173,700
Total Electric Cost	$109,400	$114,900	$120,900	$127,100	$133,800	$140,900	$148,400	$156,300	$164,700	$173,700
Allocated Treated Water	$109,400	$114,900	$120,900	$127,100	$133,800	$140,900	$148,400	$156,300	$164,700	$173,700
Allocated Raw Water	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

Appendix C
Scenario 3

Table 4
North Central Missouri Regional Water Commission
Forecast Energy Expenses

Year	2024	2025	2026	2027	2028
Energy Unit Cost ($/kWh)	0.1131	0.1159	0.1188	0.1218	0.1248
Annual Energy Usage (kWh)	1,578,200	1,624,800	1,673,500	1,724,400	1,777,500
Annual Energy Cost	$178,400	$188,300	$198,800	$210,000	$221,800
Monthly Demand Charge ($KW)	337.55	345.99	354.64	363.51	372.60
Monthly Peak Demand	13.93	14.28	14.63	15.00	15.37
Annual Demand Cost	$4,700	$4,900	$5,200	$5,500	$5,700
Treated Water Electric Cost	$183,100	$193,200	$204,000	$215,500	$227,500
Raw Water Electric Cost	$0	$0	$0	$0	$0
Calculated Electric Cost	$183,100	$193,200	$204,000	$215,500	$227,500
Total Electric Cost	$183,100	$193,200	$204,000	$215,500	$227,500
Allocated Treated Water	$183,100	$193,200	$204,000	$215,500	$227,500
Allocated Raw Water	$0	$0	$0	$0	$0

Appendix C
Scenario 3

Table 5
North Central Missouri Regional Water Commission
Projected Debt Expense

Year	Investment	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Plant Investment	$2,023,350										
Initial Debt Service Payment		$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000
Initial Debt Service Interest		$96,100	$94,000	$91,800	$89,600	$87,200	$84,700	$82,000	$79,300	$76,400	$73,400
Initial Debt Service Principle		$43,900	$46,000	$48,100	$50,400	$52,800	$55,300	$58,000	$60,700	$63,600	$66,600
Remaining Capital Balance - EOY		$1,979,450	$1,933,450	$1,885,350	$1,834,950	$1,782,150	$1,726,850	$1,668,850	$1,608,150	$1,544,550	$1,477,950

Supplemental Pipeline & Intake	$1,136,000										
Initial Debt Service Payment		$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600
Initial Debt Service Interest		$54,000	$52,800	$51,600	$50,300	$48,900	$47,500	$46,100	$44,500	$42,900	$41,200
Initial Debt Service Principle		$24,600	$25,800	$27,000	$28,300	$29,700	$31,100	$32,500	$34,100	$35,700	$37,400
Remaining Capital Balance - EOY		$1,111,400	$1,085,600	$1,058,600	$1,030,300	$1,000,600	$969,500	$937,000	$902,900	$867,200	$829,800

Phase 1 Dam Investment	$15,566,000										
Dam Debt Service Payment		$0	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400
Dam Debt Service Interest		$0	$762,000	$744,900	$726,900	$708,000	$688,200	$667,400	$645,500	$622,600	$598,500
Dam Debt Service Principle		$0	$342,500	$359,600	$377,600	$396,400	$416,300	$437,100	$458,900	$481,900	$506,000
Remaining Capital Balance - EOY		$0	$15,223,500	$14,863,900	$14,486,300	$14,089,900	$13,673,600	$13,236,500	$12,777,600	$12,295,700	$11,789,700

Appendix C
Scenario 3

Table 5
North Central Missouri Regional Water Commission
Projected Debt Expense

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Plant Investment										
Initial Debt Service Payment	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000
Initial Debt Service Interest	$70,200	$66,900	$63,400	$59,800	$56,000	$52,000	$47,800	$43,400	$38,800	$34,000
Initial Debt Service Principle	$69,800	$73,100	$76,600	$80,200	$84,000	$88,000	$92,200	$96,600	$101,200	$106,000
Remaining Capital Balance - EOY	$1,408,150	$1,335,050	$1,258,450	$1,178,250	$1,094,250	$1,006,250	$914,050	$817,450	$716,250	$610,250
Supplemental Pipeline & Intake										
Initial Debt Service Payment	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600
Initial Debt Service Interest	$39,400	$37,600	$35,600	$33,600	$31,400	$29,200	$26,800	$24,400	$21,800	$19,100
Initial Debt Service Principle	$39,200	$41,000	$43,000	$45,000	$47,200	$49,400	$51,800	$54,200	$56,800	$59,500
Remaining Capital Balance - EOY	$790,600	$749,600	$706,600	$661,600	$614,400	$565,000	$513,200	$459,000	$402,200	$342,700
Phase 1 Dam Investment										
Dam Debt Service Payment	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400
Dam Debt Service Interest	$573,200	$546,600	$518,700	$489,400	$458,700	$426,400	$392,500	$356,900	$319,500	$280,300
Dam Debt Service Principle	$531,300	$557,800	$585,700	$615,000	$645,700	$678,000	$711,900	$747,500	$784,900	$824,200
Remaining Capital Balance - EOY	$11,258,400	$10,700,600	$10,114,900	$9,499,900	$8,854,200	$8,176,200	$7,464,300	$6,716,800	$5,931,900	$5,107,700

Appendix C
Scenario 3

Table 5
North Central Missouri Regional Water Commission
Projected Debt Expense

Year	2024	2025	2026	2027	2028	Total
Plant Investment						
Initial Debt Service Payment	$140,000	$140,000	$140,000	$140,000	$140,000	$3,500,000
Initial Debt Service Interest	$29,000	$23,700	$18,200	$12,400	$6,300	$1,476,400
Initial Debt Service Principle	$111,000	$116,300	$121,800	$127,600	$133,600	$2,023,400
Remaining Capital Balance - EOY	$499,250	$382,950	$261,150	$133,550	-$50	
Supplemental Pipeline & Intake						
Initial Debt Service Payment	$78,600	$78,600	$78,600	$78,600	$78,600	$1,965,000
Initial Debt Service Interest	$16,300	$13,300	$10,200	$7,000	$3,600	$829,100
Initial Debt Service Principle	$62,300	$65,300	$68,400	$71,600	$75,000	$1,135,900
Remaining Capital Balance - EOY	$280,400	$215,100	$146,700	$75,100	$100	
Phase 1 Dam Investment						
Dam Debt Service Payment	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$26,505,600
Dam Debt Service Interest	$239,100	$195,800	$150,400	$102,700	$52,600	$11,266,800
Dam Debt Service Principle	$865,400	$908,600	$954,100	$1,001,800	$1,051,900	$15,240,100
Remaining Capital Balance - EOY	$4,242,300	$3,333,700	$2,379,600	$1,377,800	$325,900	

Appendix C
Scenario 3

Table 6
North Central Missouri Regional Water Commission
Projected Water Sales

Type	Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Treated Water	Milan	127.8	128.6	129.5	130.5	131.4	132.3	133.2	134.1	135.1	136.0
	Sullivan County #1	119.7	121.3	122.9	124.5	126.1	127.7	129.4	131.0	132.8	134.5
	Green City	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.4	34.4
	Milan Industrial User	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Other Treated Water Cust.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	179.0	187.9	197.3
Total Treated Water		281.8	284.2	286.7	289.2	291.7	294.3	296.9	478.5	490.1	502.2
Raw Water	PSF	264.6	280.5	297.3	315.2	334.1	354.1	492.8	492.8	492.8	492.8
Total Water		546.4	564.7	584.0	604.4	625.8	648.4	789.7	971.3	982.9	995.0
Percent Treated Water		51.6%	50.3%	49.1%	47.9%	46.6%	45.4%	37.6%	49.3%	49.9%	50.5%
Percent Raw Water		48.4%	49.7%	50.9%	52.1%	53.4%	54.6%	62.4%	50.7%	50.1%	49.5%

Appendix C
Scenario 3

Table 6
North Central Missouri Regional Water Commission
Projected Water Sales

Type	Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Treated Water	Milan	137.0	137.9	138.9	139.9	140.9	141.8	142.8	143.8	144.8	145.9
	Sullivan County #1	136.2	138.0	139.8	141.6	143.4	145.3	147.2	149.1	151.1	153.0
	Green City	34.4	34.4	34.4	34.4	34.4	34.4	34.5	34.5	34.5	34.5
	Milan Industrial User	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Other Treated Water Cust.	207.2	217.5	228.4	239.8	251.8	264.4	277.6	291.5	306.1	321.4
Total Treated Water		514.8	527.9	541.5	555.7	570.5	586.0	602.2	618.9	636.5	654.7
Raw Water	PSF	492.8	492.8	492.8	492.8	492.8	492.8	492.8	492.8	492.8	492.8
Total Water		1,007.6	1,020.7	1,034.3	1,048.5	1,063.3	1,078.8	1,095.0	1,111.7	1,129.3	1,147.5
Percent Treated Water		51.1%	51.7%	52.4%	53.0%	53.7%	54.3%	55.0%	55.7%	56.4%	57.1%
Percent Raw Water		48.9%	48.3%	47.6%	47.0%	46.3%	45.7%	45.0%	44.3%	43.6%	42.9%

No Milan Industrial User, With 50% Plant Grant
Including Phase 1 & 2 Capital

Appendix C
Scenario 3

Table 6
North Central Missouri Regional Water Commission
Projected Water Sales

Type	**Year**	**2024**	**2025**	**2026**	**2027**	**2028**
Treated Water	Milan	146.9	147.9	148.9	150.0	151.0
	Sullivan County #1	155.0	157.0	159.1	161.1	163.2
	Green City	34.5	34.5	34.5	34.5	34.5
	Milan Industrial User	0.0	0.0	0.0	0.0	0.0
	Other Treated Water Cust.	337.5	354.3	372.1	390.7	410.2
Total Treated Water		673.8	693.7	714.5	736.3	758.9
Raw Water	PSF	492.8	492.8	492.8	492.8	492.8
Total Water		1,166.6	1,186.5	1,207.3	1,229.1	1,251.7
Percent Treated Water		57.8%	58.5%	59.2%	59.9%	60.6%
Percent Raw Water		42.2%	41.5%	40.8%	40.1%	39.4%

Scenario 4

With Milan Industrial User, No Grants

Appendix C
Scenario 4

Table 1
North Central Missouri Regional Water Commission
Projected Water Costs

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Treated Water O&M Cost Including Return	$482,700	$500,800	$518,800	$537,600	$557,700	$602,800	$688,300	$794,500	$817,600	$841,600
Treated Water Debt Service	$328,000	$994,200	$986,800	$979,600	$972,700	$1,045,400	$1,021,000	$1,074,500	$1,077,500	$1,080,500
Total Treated Water Costs	$810,700	$1,495,000	$1,505,600	$1,517,200	$1,530,400	$1,648,200	$1,709,300	$1,869,000	$1,895,100	$1,922,100
Treated Water Cost ($/1000 gallons)	$1.9569	$3.4985	$3.4121	$3.3263	$3.2424	$2.5393	$2.0689	$1.8546	$1.8590	$1.8634
Raw Water Cost O&M Cost Including Return	$107,200	$113,900	$120,100	$126,700	$133,500	$84,300	$94,800	$88,400	$90,700	$93,000
Raw Water Debt Service	$30,600	$468,800	$476,200	$483,400	$490,300	$417,600	$442,000	$388,500	$385,500	$382,500
Total Raw Water Costs	$137,800	$582,700	$596,300	$610,100	$623,800	$501,900	$536,800	$476,900	$476,200	$475,500
Raw Water Cost ($/1000 gallons)	$0.5207	$2.0773	$2.0055	$1.9358	$1.8672	$1.4173	$1.0893	$0.9677	$0.9663	$0.9649

Year 1 - 5 Average Water Cost	$/1000 gal
Treated Water Costs	$3.0873
Raw Water Costs	$1.6813

Year 6 - 10 Average Water Cost	$/1000 gal
Treated Water Costs	$2.0370
Raw Water Costs	$1.0811

Appendix C
Scenario 4

Table 1
North Central Missouri Regional Water Commission
Projected Water Costs

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Treated Water O&M Cost Including Return	$866,600	$892,800	$920,100	$948,600	$978,400	$1,009,700	$1,052,600	$1,087,300	$1,123,300	$1,160,900
Treated Water Debt Service	$1,083,700	$1,086,900	$1,090,200	$1,093,500	$1,096,900	$1,100,500	$2,872,400	$2,883,900	$2,895,800	$2,907,800
Total Treated Water Costs	$1,950,300	$1,979,700	$2,010,300	$2,042,100	$2,075,300	$2,110,200	$3,925,000	$3,971,200	$4,019,100	$4,068,700
Treated Water Cost ($/1000 gallons)	$1.8680	$1.8727	$1.8774	$1.8821	$1.8869	$1.8921	$3.4690	$3.4585	$3.4476	$3.4363
Raw Water Cost O&M Cost Including Return	$95,400	$97,800	$100,400	$102,900	$105,500	$108,100	$115,400	$118,300	$121,300	$124,300
Raw Water Debt Service	$379,300	$376,100	$372,800	$369,500	$366,100	$362,500	$1,129,100	$1,117,600	$1,105,700	$1,093,700
Total Raw Water Costs	$474,700	$473,900	$473,200	$472,400	$471,600	$470,600	$1,244,500	$1,235,900	$1,227,000	$1,218,000
Raw Water Cost ($/1000 gallons)	$0.9633	$0.9616	$0.9602	$0.9586	$0.9570	$0.9550	$2.5254	$2.5079	$2.4899	$2.4716

Year 11 - 15 Average Water Cost	$/1000 gal
Treated Water Costs	$1.8774
Raw Water Costs	$0.9601

Year 16 - 20 Average Water Cost	$/1000 gal
Treated Water Costs	$3.1407
Raw Water Costs	$2.1899

Appendix C
Scenario 4

Table 1
North Central Missouri Regional Water Commission
Projected Water Costs

	2024	2025	2026	2027	2028
Treated Water O&M Cost Including Return	$1,200,200	$1,241,200	$1,284,300	$1,329,200	$1,376,300
Treated Water Debt Service	$2,920,100	$2,932,700	$2,945,500	$2,958,500	$2,971,800
Total Treated Water Costs	$4,120,300	$4,173,900	$4,229,800	$4,287,700	$4,348,100
Treated Water Cost ($/1000 gallons)	$3.4247	$3.4127	$3.4006	$3.3880	$3.3753

Raw Water Cost O&M Cost Including Return	$127,300	$130,400	$133,500	$136,700	$139,900
Raw Water Debt Service	$1,081,400	$1,068,800	$1,056,000	$1,043,000	$1,029,700
Total Raw Water Costs	$1,208,700	$1,199,200	$1,189,500	$1,179,700	$1,169,600
Raw Water Cost ($/1000 gallons)	$2.4527	$2.4334	$2.4138	$2.3939	$2.3734

Year 21 - 25 Average Water Cost	$/1000 gal
Treated Water Costs	$3.4002
Raw Water Costs	$2.4134

Appendix C
Scenario 4

Table 2
North Central Missouri Regional Water Commission
Inputs and Assumptions

Starting Year	2004

Water Plant Capital

Milan Plant Purchase Capital Requirement	$3,564,500
Milan Plant Purchase Additional Capital	$482,200
Milan Plant Purchase Grant Funding	$0
Milan Plant Purchase Capital less Grants	$4,046,700

Supplemental Pipeline & Intake Capital Requirement	$1,136,000
Pipeline & Intake Grant Funding	$0
Pipeline & Intake Capital less Grants	$1,136,000

Interest Rate for Debt Financing	4.75%
Term of Project Financing - years	25

Phase 1 Capital

Investment Year	2005
Dam and Reservoir Construction Capital	$26,265,000
Dam Construction Grant Funding	$10,699,000
Dam Construction Capital less Grants	$15,566,000
Interest Rate for Debt Financing	5.00%
Term of Project Financing - years	25

Phase 2 Capital

Investment Year	2020
Dam and Reservoir Construction Capital	$32,450,000
Dam Construction Grant Funding	$0
Dam Construction Capital less Grants	$32,450,000
Interest Rate for Debt Financing	6.00%
Term of Project Financing - years	25

Plant O&M

Inflation Rate for Labor/Materials	4.0%
Inflation Rate for Energy	2.5%
Energy Unit Cost ($/kWh)	$0.0690
Average Monthly Energy Use (kWh)	55,000
Demand Charge ($/kW)	$206
Average Demand (kW)	8.50
Other Utility Costs (Gas?)	20,000
Plant Labor	$109,100
City Labor Offset (10%)	-$10,900
Routine Maintenance (1% of Plant Capital)	$35,600
Chemical Costs per Thousand Gallons	$0.275
General and Administration Expenses	$125,000
Lake Lease per Thousand Gallons	$0.150
Renewal & Replacement Fund Requirement	$20,000

Dam & Reservoir O&M

Phase 1	$40,000
Phase 2	$150,000

Water Usage

Milan Treated Water	0.350	[1]
Sullivan County #1 Treated Water	0.328	[1]
Green City Treated Water	0.094	[1]
Milan Industrial User Treated Water	0.363	[1]
Other Treated Water Customers (Begin 2011)	0.490	
PSF Raw Water	0.725	[1]
Milan Water Usage Growth	0.70%	
Sullivan County #1 Water Usage Growth	1.30%	
Green City Water Usage Growth	0.25%	
Raw Water Usage Growth (first 10 years)	6.00%	
Raw Water Usage Growth (after 2010)	0.00%	
Milan Industrial User Water Usage Growth	8.00%	
Milan Industrial User Water Usage Growth (after 2010)	0.00%	
Other Treated Water Growth	5.00%	

Return

Return (% of O&M expense, Years 1-5)	5%
Return (% of O&M expense, Years10 and beyond)	10%

[1] 2002 Average MGD

Appendix C
Scenario 4

Table 3
North Central Missouri Regional Water Commission
Forecast of Operation and Maintenance Expenses

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Treated Water Flow (MGY)	414	427	441	456	472	649	826	1,008	1,019	1,032
Raw Water Flow (MGY)	265	281	297	315	334	354	493	493	493	493
Total Water Flow (MGY)	679	708	739	771	806	1,003	1,319	1,501	1,512	1,524
Plant O&M Expenses										
Labor & Burden	$98,200	$102,100	$106,200	$110,400	$114,800	$119,400	$124,200	$129,200	$134,400	$139,800
General & Administrative	$125,000	$130,000	$135,200	$140,600	$146,200	$152,000	$158,100	$164,400	$171,000	$177,800
Electricity Costs	$47,300	$49,900	$52,900	$56,000	$59,400	$82,900	$107,700	$134,200	$139,100	$144,300
Other Utility Costs	$20,000	$20,800	$21,600	$22,500	$23,400	$24,300	$25,300	$26,300	$27,400	$28,500
Routine Maintenance	$35,600	$37,000	$38,500	$40,000	$41,600	$43,300	$45,000	$46,800	$48,700	$50,600
Chemicals	$113,900	$117,500	$121,300	$125,400	$129,800	$178,500	$227,200	$277,100	$280,300	$283,700
Lake Lease	$101,800	$106,200	$110,800	$115,700	$120,900	$0	$0	$0	$0	$0
R&R Fund	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
Phase 1 Dam O&M	$0	$40,000	$41,600	$43,300	$45,000	$46,800	$48,700	$50,600	$52,600	$54,700
Phase 2 Dam O&M	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total O&M Costs	$561,800	$623,500	$648,100	$673,900	$701,100	$667,200	$756,200	$848,600	$873,500	$899,400
Return	$28,100	$31,200	$32,400	$33,700	$35,100	$66,700	$75,600	$84,900	$87,400	$89,900
Total Annual Costs	$589,900	$654,700	$680,500	$707,600	$736,200	$733,900	$831,800	$933,500	$960,900	$989,300
Allocated O&M including Return to Treated Water	$482,700	$500,800	$518,800	$537,600	$557,700	$602,800	$688,300	$794,500	$817,600	$841,600
Allocated O&M including Return to Raw Water	$107,200	$113,900	$120,100	$126,700	$133,500	$84,300	$94,800	$88,400	$90,700	$93,000

Appendix C
Scenario 4

Table 3
North Central Missouri Regional Water Commission
Forecast of Operation and Maintenance Expenses

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Treated Water Flow (MGY)	1,044	1,057	1,071	1,085	1,100	1,115	1,131	1,148	1,166	1,184
Raw Water Flow (MGY)	493	493	493	493	493	493	493	493	493	493
Total Water Flow (MGY)	1,537	1,550	1,564	1,578	1,593	1,608	1,624	1,641	1,659	1,677
Plant O&M Expenses										
Labor & Burden	$145,400	$151,200	$157,200	$163,500	$170,000	$176,800	$183,900	$191,300	$199,000	$207,000
General & Administrative	$184,900	$192,300	$200,000	$208,000	$216,300	$225,000	$234,000	$243,400	$253,100	$263,200
Electricity Costs	$149,800	$155,500	$161,500	$167,700	$174,300	$181,300	$188,500	$196,200	$204,200	$212,600
Other Utility Costs	$29,600	$30,800	$32,000	$33,300	$34,600	$36,000	$37,400	$38,900	$40,500	$42,100
Routine Maintenance	$52,600	$54,700	$56,900	$59,200	$61,600	$64,100	$66,700	$69,400	$72,200	$75,100
Chemicals	$287,100	$290,700	$294,500	$298,400	$302,500	$306,700	$311,100	$315,800	$320,600	$325,600
Lake Lease	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
R&R Fund	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
Phase 1 Dam O&M	$56,900	$59,200	$61,600	$64,100	$66,700	$69,400	$72,200	$75,100	$78,100	$81,200
Phase 2 Dam O&M	$0	$0	$0	$0	$0	$0	$150,000	$156,000	$162,200	$168,700
Total O&M Costs	$926,300	$954,400	$983,700	$1,014,200	$1,046,000	$1,079,300	$1,263,800	$1,306,100	$1,349,900	$1,395,500
Return	$92,600	$95,400	$98,400	$101,400	$104,600	$107,900	$126,400	$130,600	$135,000	$139,600
Total Annual Costs	$1,018,900	$1,049,800	$1,082,100	$1,115,600	$1,150,600	$1,187,200	$1,390,200	$1,436,700	$1,484,900	$1,535,100
Allocated O&M including Return to Treated Water	$866,600	$892,800	$920,100	$948,600	$978,400	$1,009,700	$1,052,600	$1,087,300	$1,123,300	$1,160,900
Allocated O&M including Return to Raw Water	$95,400	$97,800	$100,400	$102,900	$105,500	$108,100	$115,400	$118,300	$121,300	$124,300

Appendix C
Scenario 4

Table 3
North Central Missouri Regional Water Commission
Forecast of Operation and Maintenance Expenses

Year	2024	2025	2026	2027	2028	Total
Treated Water Flow (MGY)	1,203	1,223	1,244	1,266	1,288	
Raw Water Flow (MGY)	493	493	493	493	493	
Total Water Flow (MGY)	1,696	1,716	1,737	1,758	1,781	
Plant O&M Expenses						
Labor & Burden	$215,300	$223,900	$232,900	$242,200	$251,900	$4,090,200
General & Administrative	$273,700	$284,600	$296,000	$307,800	$320,100	$5,202,700
Electricity Costs	$221,400	$230,700	$240,600	$251,000	$261,800	$3,870,800
Other Utility Costs	$43,800	$45,600	$47,400	$49,300	$51,300	$832,700
Routine Maintenance	$78,100	$81,200	$84,400	$87,800	$91,300	$1,482,400
Chemicals	$330,900	$336,300	$342,100	$348,000	$354,300	$6,619,300
Lake Lease	$0	$0	$0	$0	$0	$555,400
R&R Fund	$20,000	$20,000	$20,000	$20,000	$20,000	$500,000
Phase 1 Dam O&M	$84,400	$87,800	$91,300	$95,000	$98,800	$1,565,100
Phase 2 Dam O&M	$175,400	$182,400	$189,700	$197,300	$205,200	$1,586,900
Total O&M Costs	$1,443,000	$1,492,500	$1,544,400	$1,598,400	$1,654,700	$26,305,500
Return	$144,300	$149,300	$154,400	$159,800	$165,500	$2,470,200
Total Annual Costs	$1,587,300	$1,641,800	$1,698,800	$1,758,200	$1,820,200	$28,775,700
Allocated O&M including Return to Treated Water	$1,200,200	$1,241,200	$1,284,300	$1,329,200	$1,376,300	$22,813,900
Allocated O&M including Return to Raw Water	$127,300	$130,400	$133,500	$136,700	$139,900	$2,809,800

Appendix C
Scenario 4

Table 4
North Central Missouri Regional Water Commission
Forecast Energy Expenses

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Energy Unit Cost ($/kWh)	$0.0690	0.0707	0.0725	0.0743	0.0762	0.0781	0.0800	0.0820	0.0841	0.0862
Annual Energy Usage (kWh)	660,000	680,800	703,000	726,700	752,000	1,034,100	1,316,300	1,605,600	1,624,200	1,643,400
Annual Energy Cost	$45,500	$48,100	$51,000	$54,000	$57,300	$80,700	$105,300	$131,700	$136,500	$141,600
Monthly Demand Charge ($KW)	$206.00	211.15	216.43	221.84	227.39	233.07	238.90	244.87	250.99	257.27
Monthly Peak Demand	8.50	8.71	8.93	9.15	9.38	9.62	9.86	10.10	10.36	10.62
Annual Demand Cost	$1,800	$1,800	$1,900	$2,000	$2,100	$2,200	$2,400	$2,500	$2,600	$2,700
Treated Water Electric Cost	$47,300	$49,900	$52,900	$56,000	$59,400	$82,900	$107,700	$134,200	$139,100	$144,300
Raw Water Electric Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Calculated Electric Cost	$47,300	$49,900	$52,900	$56,000	$59,400	$82,900	$107,700	$134,200	$139,100	$144,300
Total Electric Cost	$47,300	$49,900	$52,900	$56,000	$59,400	$82,900	$107,700	$134,200	$139,100	$144,300
Allocated Treated Water	$47,300	$49,900	$52,900	$56,000	$59,400	$82,900	$107,700	$134,200	$139,100	$144,300
Allocated Raw Water	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

Appendix C
Scenario 4

Table 4
North Central Missouri Regional Water Commission
Forecast Energy Expenses

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Energy Unit Cost ($/kWh)	0.0883	0.0905	0.0928	0.0951	0.0975	0.0999	0.1024	0.1050	0.1076	0.1103
Annual Energy Usage (kWh)	1,663,400	1,684,300	1,706,000	1,728,600	1,752,200	1,776,800	1,802,600	1,829,400	1,857,300	1,886,400
Annual Energy Cost	$146,900	$152,500	$158,300	$164,400	$170,800	$177,600	$184,600	$192,100	$199,900	$208,100
Monthly Demand Charge ($KW)	263.70	270.29	277.05	283.97	291.07	298.35	305.81	313.45	321.29	329.32
Monthly Peak Demand	10.88	11.15	11.43	11.72	12.01	12.31	12.62	12.93	13.26	13.59
Annual Demand Cost	$2,900	$3,000	$3,200	$3,300	$3,500	$3,700	$3,900	$4,100	$4,300	$4,500
Treated Water Electric Cost	$149,800	$155,500	$161,500	$167,700	$174,300	$181,300	$188,500	$196,200	$204,200	$212,600
Raw Water Electric Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Calculated Electric Cost	$149,800	$155,500	$161,500	$167,700	$174,300	$181,300	$188,500	$196,200	$204,200	$212,600
Total Electric Cost	$149,800	$155,500	$161,500	$167,700	$174,300	$181,300	$188,500	$196,200	$204,200	$212,600
Allocated Treated Water	$149,800	$155,500	$161,500	$167,700	$174,300	$181,300	$188,500	$196,200	$204,200	$212,600
Allocated Raw Water	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

Appendix C
Scenario 4

Table 4
North Central Missouri Regional Water Commission
Forecast Energy Expenses

Year	2024	2025	2026	2027	2028
Energy Unit Cost ($/kWh)	0.1131	0.1159	0.1188	0.1218	0.1248
Annual Energy Usage (kWh)	1,916,800	1,948,500	1,981,600	2,016,200	2,052,300
Annual Energy Cost	$216,700	$225,800	$235,400	$245,500	$256,100
Monthly Demand Charge ($KW)	337.55	345.99	354.64	363.51	372.60
Monthly Peak Demand	13.93	14.28	14.63	15.00	15.37
Annual Demand Cost	$4,700	$4,900	$5,200	$5,500	$5,700
Treated Water Electric Cost	$221,400	$230,700	$240,600	$251,000	$261,800
Raw Water Electric Cost	$0	$0	$0	$0	$0
Calculated Electric Cost	$221,400	$230,700	$240,600	$251,000	$261,800
Total Electric Cost	$221,400	$230,700	$240,600	$251,000	$261,800
Allocated Treated Water	$221,400	$230,700	$240,600	$251,000	$261,800
Allocated Raw Water	$0	$0	$0	$0	$0

Appendix C
Scenario 4

Table 5
North Central Missouri Regional Water Commission
Projected Debt Expense

Year	Investment	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Plant Investment	$4,046,700										
Initial Debt Service Payment		$280,000	$280,000	$280,000	$280,000	$280,000	$280,000	$280,000	$280,000	$280,000	$280,000
Initial Debt Service Interest		$192,200	$188,000	$183,700	$179,100	$174,300	$169,300	$164,000	$158,500	$152,800	$146,700
Initial Debt Service Principle		$87,800	$91,900	$96,300	$100,900	$105,700	$110,700	$115,900	$121,400	$127,200	$133,200
Remaining Capital Balance - EOY		$3,958,900	$3,867,000	$3,770,700	$3,669,800	$3,564,100	$3,453,400	$3,337,500	$3,216,100	$3,088,900	$2,955,700
Supplemental Pipeline & Intake	$1,136,000										
Initial Debt Service Payment		$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600
Initial Debt Service Interest		$54,000	$52,800	$51,600	$50,300	$48,900	$47,500	$46,100	$44,500	$42,900	$41,200
Initial Debt Service Principle		$24,600	$25,800	$27,000	$28,300	$29,700	$31,100	$32,500	$34,100	$35,700	$37,400
Remaining Capital Balance - EOY		$1,111,400	$1,085,600	$1,058,600	$1,030,300	$1,000,600	$969,500	$937,000	$902,900	$867,200	$829,800
Phase 1 Dam Investment	$15,566,000										
Dam Debt Service Payment		$0	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400
Dam Debt Service Interest		$0	$762,000	$744,900	$726,900	$708,000	$688,200	$667,400	$645,500	$622,600	$598,500
Dam Debt Service Principle		$0	$342,500	$359,600	$377,600	$396,400	$416,300	$437,100	$458,900	$481,900	$506,000
Remaining Capital Balance - EOY		$0	$15,223,500	$14,863,900	$14,486,300	$14,089,900	$13,673,600	$13,236,500	$12,777,600	$12,295,700	$11,789,700

Appendix C
Scenario 4

Table 5
North Central Missouri Regional Water Commission
Projected Debt Expense

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Plant Investment										
Initial Debt Service Payment	$280,000	$280,000	$280,000	$280,000	$280,000	$280,000	$280,000	$280,000	$280,000	$280,000
Initial Debt Service Interest	$140,400	$133,800	$126,800	$119,500	$111,900	$103,900	$95,600	$86,800	$77,700	$68,000
Initial Debt Service Principle	$139,600	$146,200	$153,100	$160,400	$168,000	$176,000	$184,400	$193,100	$202,300	$211,900
Remaining Capital Balance - EOY	$2,816.100	$2,669.900	$2,516,800	$2,356,400	$2,188,400	$2,012,400	$1,828,000	$1,634,900	$1,432,600	$1,220,700

Supplemental Pipeline & Intake										
Initial Debt Service Payment	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600
Initial Debt Service Interest	$39,400	$37,600	$35,600	$33,600	$31,400	$29,200	$26,800	$24,400	$21,800	$19,100
Initial Debt Service Principle	$39,200	$41,000	$43,000	$45,000	$47,200	$49,400	$51,800	$54,200	$56,800	$59,500
Remaining Capital Balance - EOY	$790,600	$749,600	$706,600	$661,600	$614,400	$565,000	$513,200	$459,000	$402,200	$342,700

Phase 1 Dam Investment										
Dam Debt Service Payment	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400
Dam Debt Service Interest	$573,200	$546,600	$518,700	$489,400	$458,700	$426,400	$392,500	$356,900	$319,500	$280,300
Dam Debt Service Principle	$531,300	$557,800	$585,700	$615,000	$645,700	$678,000	$711,900	$747,500	$784,900	$824,200
Remaining Capital Balance - EOY	$11,258,400	$10,700,600	$10,114,900	$9,499,900	$8,854,200	$8,176,200	$7,464,300	$6,716,800	$5,931,900	$5,107,700

Appendix C
Scenario 4

Table 5
North Central Missouri Regional Water Commission
Projected Debt Expense

Year	2024	2025	2026	2027	2028	Total
Plant Investment						
Initial Debt Service Payment	$280,000	$280,000	$280,000	$280,000	$280,000	$7,000,000
Initial Debt Service Interest	$58,000	$47,400	$36,400	$24,800	$12,700	$2,952,300
Initial Debt Service Principle	$222,000	$232,500	$243,600	$255,200	$267,300	$4,046,600
Remaining Capital Balance - EOY	$998,700	$766,200	$522,600	$267,400	$100	
Supplemental Pipeline & Intake						
Initial Debt Service Payment	$78,600	$78,600	$78,600	$78,600	$78,600	$1,965,000
Initial Debt Service Interest	$16,300	$13,300	$10,200	$7,000	$3,600	$829,100
Initial Debt Service Principle	$62,300	$65,300	$68,400	$71,600	$75,000	$1,135,900
Remaining Capital Balance - EOY	$280,400	$215,100	$146,700	$75,100	$100	
Phase 1 Dam Investment						
Dam Debt Service Payment	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$26,505,600
Dam Debt Service Interest	$239,100	$195,800	$150,400	$102,700	$52,600	$11,266,800
Dam Debt Service Principle	$865,400	$908,600	$954,100	$1,001,800	$1,051,900	$15,240,100
Remaining Capital Balance - EOY	$4,242,300	$3,333,700	$2,379,600	$1,377,800	$325,900	

Appendix C
Scenario 4

Table 6
North Central Missouri Regional Water Commission
Projected Water Sales

Type	Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Treated Water	Milan	127.8	128.6	129.5	130.5	131.4	132.3	133.2	134.1	135.1	136.0
	Sullivan County #1	119.7	121.3	122.9	124.5	126.1	127.7	129.4	131.0	132.8	134.5
	Green City	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.4	34.4
	Milan Industrial User	132.5	143.1	154.5	166.9	180.3	354.8	529.3	529.3	529.3	529.3
	Other Treated Water Cust.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	179.0	187.9	197.3
Total Treated Water		414.3	427.3	441.2	456.1	472.0	649.1	826.2	1,007.8	1,019.4	1,031.5
Raw Water	PSF	264.6	280.5	297.3	315.2	334.1	354.1	492.8	492.8	492.8	492.8
Total Water		678.9	707.8	738.6	771.3	806.1	1,003.2	1,319.0	1,500.6	1,512.2	1,524.3
								3.6136637			
Percent Treated Water		61.0%	60.4%	59.7%	59.1%	58.6%	64.7%	62.6%	67.2%	67.4%	67.7%
Percent Raw Water		39.0%	39.6%	40.3%	40.9%	41.4%	35.3%	37.4%	32.8%	32.6%	32.3%

Appendix C
Scenario 4

Table 6
North Central Missouri Regional Water Commission
Projected Water Sales

Type	Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Treated Water	Milan	137.0	137.9	138.9	139.9	140.9	141.8	142.8	143.8	144.8	145.9
	Sullivan County #1	136.2	138.0	139.8	141.6	143.4	145.3	147.2	149.1	151.1	153.0
	Green City	34.4	34.4	34.4	34.4	34.4	34.4	34.5	34.5	34.5	34.5
	Milan Industrial User	529.3	529.3	529.3	529.3	529.3	529.3	529.3	529.3	529.3	529.3
	Other Treated Water Cust.	207.2	217.5	228.4	239.8	251.8	264.4	277.6	291.5	306.1	321.4
Total Treated Water		1,044.1	1,057.2	1,070.8	1,085.0	1,099.8	1,115.3	1,131.5	1,148.2	1,165.8	1,184.0
Raw Water	PSF	492.8	492.8	492.8	492.8	492.8	492.8	492.8	492.8	492.8	492.8
Total Water		1,536.9	1,550.0	1,563.6	1,577.8	1,592.6	1,608.1	1,624.3	1,641.0	1,658.6	1,676.8
Percent Treated Water		67.9%	68.2%	68.5%	68.8%	69.1%	69.4%	69.7%	70.0%	70.3%	70.6%
Percent Raw Water		32.1%	31.8%	31.5%	31.2%	30.9%	30.6%	30.3%	30.0%	29.7%	29.4%

Appendix C
Scenario 4

Table 6
North Central Missouri Regional Water Commission
Projected Water Sales

Type	Year	2024	2025	2026	2027	2028
Treated Water	Milan	146.9	147.9	148.9	150.0	151.0
	Sullivan County #1	155.0	157.0	159.1	161.1	163.2
	Green City	34.5	34.5	34.5	34.5	34.5
	Milan Industrial User	529.3	529.3	529.3	529.3	529.3
	Other Treated Water Cust.	337.5	354.3	372.1	390.7	410.2
Total Treated Water		1,203.1	1,223.0	1,243.8	1,265.6	1,288.2
Raw Water	PSF	492.8	492.8	492.8	492.8	492.8
Total Water		1,695.9	1,715.8	1,736.6	1,758.4	1,781.0
Percent Treated Water		70.9%	71.3%	71.6%	72.0%	72.3%
Percent Raw Water		29.1%	28.7%	28.4%	28.0%	27.7%

Scenario 5

With Milan Industrial User, With 30% Plant Grant

Appendix C
Scenario 5

Table 1
North Central Missouri Regional Water Commission
Projected Water Costs

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Treated Water O&M Cost Including Return	$482,700	$500,800	$518,800	$537,600	$557,700	$602,800	$688,300	$794,500	$817,600	$841,600
Treated Water Debt Service	$244,000	$910,200	$902,800	$895,600	$888,700	$961,400	$937,000	$990,500	$993,500	$996,500
Total Treated Water Costs	$726,700	$1,411,000	$1,421,600	$1,433,200	$1,446,400	$1,564,200	$1,625,300	$1,785,000	$1,811,100	$1,838,100
Treated Water Cost ($/1000 gallons)	$1.7541	$3.3019	$3.2218	$3.1422	$3.0644	$2.4099	$1.9672	$1.7712	$1.7766	$1.7820

Raw Water Cost O&M Cost Including Return	$107,200	$113,900	$120,100	$126,700	$133,500	$84,300	$94,800	$88,400	$90,700	$93,000
Raw Water Debt Service	$30,600	$468,800	$476,200	$483,400	$490,300	$417,600	$442,000	$388,500	$385,500	$382,500
Total Raw Water Costs	$137,800	$582,700	$596,300	$610,100	$623,800	$501,900	$536,800	$476,900	$476,200	$475,500
Raw Water Cost ($/1000 gallons)	$0.5207	$2.0773	$2.0055	$1.9358	$1.8672	$1.4173	$1.0893	$0.9677	$0.9663	$0.9649

Year 1 - 5 Average Water Cost	$/1000 gal
Treated Water Costs	$2.8969
Raw Water Costs	$1.6813

Year 6 - 10 Average Water Cost	$/1000 gal
Treated Water Costs	$1.9414
Raw Water Costs	$1.0811

Appendix C
Scenario 5

Table 1
North Central Missouri Regional Water Commission
Projected Water Costs

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Treated Water O&M Cost Including Return	$866,600	$892,800	$920,100	$948,600	$978,400	$1,009,700	$1,052,600	$1,087,300	$1,123,300	$1,160,900
Treated Water Debt Service	$999,700	$1,002,900	$1,006,200	$1,009,500	$1,012,900	$1,016,500	$2,788,400	$2,799,900	$2,811,800	$2,823,800
Total Treated Water Costs	$1,866,300	$1,895,700	$1,926,300	$1,958,100	$1,991,300	$2,026,200	$3,841,000	$3,887,200	$3,935,100	$3,984,700
Treated Water Cost ($/1000 gallons)	$1.7875	$1.7932	$1.7989	$1.8047	$1.8106	$1.8168	$3.3948	$3.3853	$3.3755	$3.3653
Raw Water Cost O&M Cost Including Return	$95,400	$97,800	$100,400	$102,900	$105,500	$108,100	$115,400	$118,300	$121,300	$124,300
Raw Water Debt Service	$379,300	$376,100	$372,800	$369,500	$366,100	$362,500	$1,129,100	$1,117,600	$1,105,700	$1,093,700
Total Raw Water Costs	$474,700	$473,900	$473,200	$472,400	$471,600	$470,600	$1,244,500	$1,235,900	$1,227,000	$1,218,000
Raw Water Cost ($/1000 gallons)	$0.9633	$0.9616	$0.9602	$0.9586	$0.9570	$0.9550	$2.5254	$2.5079	$2.4899	$2.4716

Year 11 - 15 Average Water Cost	$/1000 gal
Treated Water Costs	$1.7990
Raw Water Costs	$0.9601

Year 16 - 20 Average Water Cost	$/1000 gal
Treated Water Costs	$3.0676
Raw Water Costs	$2.1899

Appendix C
Scenario 5

Table 1
North Central Missouri Regional Water Commission
Projected Water Costs

	2024	2025	2026	2027	2028
Treated Water O&M Cost Including Return	$1,200,200	$1,241,200	$1,284,300	$1,329,200	$1,376,300
Treated Water Debt Service	$2,836,100	$2,848,700	$2,861,500	$2,874,500	$2,887,800
Total Treated Water Costs	$4,036,300	$4,089,900	$4,145,800	$4,203,700	$4,264,100
Treated Water Cost ($/1000 gallons)	$3.3548	$3.3440	$3.3331	$3.3216	$3.3101

Raw Water Cost O&M Cost Including Return	$127,300	$130,400	$133,500	$136,700	$139,900
Raw Water Debt Service	$1,081,400	$1,068,800	$1,056,000	$1,043,000	$1,029,700
Total Raw Water Costs	$1,208,700	$1,199,200	$1,189,500	$1,179,700	$1,169,600
Raw Water Cost ($/1000 gallons)	$2.4527	$2.4334	$2.4138	$2.3939	$2.3734

Year 21 - 25 Average Water Cost	$/1000 gal
Treated Water Costs	$3.3327
Raw Water Costs	$2.4134

Appendix C
Scenario 5

Table 2
North Central Missouri Regional Water Commission Inputs and Assumptions

Starting Year	2004

Water Plant Capital

Milan Plant Purchase Capital Requirement	$3,564,500
Milan Plant Purchase Additional Capital	$482,200
Milan Plant Purchase Grant Funding	$1,214,010
Milan Plant Purchase Capital less Grants	$2,832,690

Supplemental Pipeline & Intake Capital Requirement	$1,136,000
Pipeline & Intake Grant Funding	$0
Pipeline & Intake Capital less Grants	$1,136,000

Interest Rate for Debt Financing	4.75%
Term of Project Financing - years	25

Phase 1 Capital

Investment Year	2005
Dam and Reservoir Construction Capital	$26,265,000
Dam Construction Grant Funding	$10,699,000
Dam Construction Capital less Grants	$15,566,000
Interest Rate for Debt Financing	5.00%
Term of Project Financing - years	25

Phase 2 Capital

Investment Year	2020
Dam and Reservoir Construction Capital	$32,450,000
Dam Construction Grant Funding	$0
Dam Construction Capital less Grants	$32,450,000
Interest Rate for Debt Financing	6.00%
Term of Project Financing - years	25

Plant O&M

Inflation Rate for Labor/Materials	4.0%
Inflation Rate for Energy	2.5%
Energy Unit Cost ($/kWh)	$0.0690
Average Monthly Energy Use (kWh)	55,000
Demand Charge ($/kW)	$206
Average Demand (kW)	8.50
Other Utility Costs (Gas?)	20,000
Plant Labor	$109,100
City Labor Offset (10%)	-$10,900
Routine Maintenance (1% of Plant Capital)	$35,600
Chemical Costs per Thousand Gallons	$0.275
General and Administration Expenses	$125,000
Lake Lease per Thousand Gallons	$0.150
Renewal & Replacement Fund Requirement	$20,000

Dam & Reservoir O&M

Phase 1	$40,000
Phase 2	$150,000

Water Usage

Milan Treated Water	0.350	[1]
Sullivan County #1 Treated Water	0.328	[1]
Green City Treated Water	0.094	[1]
Milan Industrial User Treated Water	0.363	[1]
Other Treated Water Customers (Begin 2011)	0.490	
PSF Raw Water	0.725	[1]
Milan Water Usage Growth	0.70%	
Sullivan County #1 Water Usage Growth	1.30%	
Green City Water Usage Growth	0.25%	
Raw Water Usage Growth (first 10 years)	6.00%	
Raw Water Usage Growth (after 2010)	0.00%	
Milan Industrial User Water Usage Growth	8.00%	
Milan Industrial User Water Usage Growth (after 2010)	0.00%	
Other Treated Water Growth	5.00%	

Return

Return (% of O&M expense, Years 1-5)	5%
Return (% of O&M expense, Years10 and beyond)	10%

[1] 2002 Average MGD

Appendix C
Scenario 5

Table 3
North Central Missouri Regional Water Commission
Forecast of Operation and Maintenance Expenses

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Treated Water Flow (MGY)	414	427	441	456	472	649	826	1,008	1,019	1,032
Raw Water Flow (MGY)	265	281	297	315	334	354	493	493	493	493
Total Water Flow (MGY)	679	708	739	771	806	1,003	1,319	1,501	1,512	1,524

Plant O&M Expenses										
Labor & Burden	$98,200	$102,100	$106,200	$110,400	$114,800	$119,400	$124,200	$129,200	$134,400	$139,800
General & Administrative	$125,000	$130,000	$135,200	$140,600	$146,200	$152,000	$158,100	$164,400	$171,000	$177,800
Electricity Costs	$47,300	$49,900	$52,900	$56,000	$59,400	$82,900	$107,700	$134,200	$139,100	$144,300
Other Utility Costs	$20,000	$20,800	$21,600	$22,500	$23,400	$24,300	$25,300	$26,300	$27,400	$28,500
Routine Maintenance	$35,600	$37,000	$38,500	$40,000	$41,600	$43,300	$45,000	$46,800	$48,700	$50,600
Chemicals	$113,900	$117,500	$121,300	$125,400	$129,800	$178,500	$227,200	$277,100	$280,300	$283,700
Lake Lease	$101,800	$106,200	$110,800	$115,700	$120,900	$0	$0	$0	$0	$0
R&R Fund	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
Phase 1 Dam O&M	$0	$40,000	$41,600	$43,300	$45,000	$46,800	$48,700	$50,600	$52,600	$54,700
Phase 2 Dam O&M	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total O&M Costs	$561,800	$623,500	$648,100	$673,900	$701,100	$667,200	$756,200	$848,600	$873,500	$899,400

Return	$28,100	$31,200	$32,400	$33,700	$35,100	$66,700	$75,600	$84,900	$87,400	$89,900

Total Annual Costs	$589,900	$654,700	$680,500	$707,600	$736,200	$733,900	$831,800	$933,500	$960,900	$989,300

Allocated O&M including Return to Treated Water	$482,700	$500,800	$518,800	$537,600	$557,700	$602,800	$688,300	$794,500	$817,600	$841,600
Allocated O&M including Return to Raw Water	$107,200	$113,900	$120,100	$126,700	$133,500	$84,300	$94,800	$88,400	$90,700	$93,000

Appendix C
Scenario 5

Table 3
North Central Missouri Regional Water Commission
Forecast of Operation and Maintenance Expenses

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Treated Water Flow (MGY)	1,044	1,057	1,071	1,085	1,100	1,115	1,131	1,148	1,166	1,184
Raw Water Flow (MGY)	493	493	493	493	493	493	493	493	493	493
Total Water Flow (MGY)	1,537	1,550	1,564	1,578	1,593	1,608	1,624	1,641	1,659	1,677
Plant O&M Expenses										
Labor & Burden	$145,400	$151,200	$157,200	$163,500	$170,000	$176,800	$183,900	$191,300	$199,000	$207,000
General & Administrative	$184,900	$192,300	$200,000	$208,000	$216,300	$225,000	$234,000	$243,400	$253,100	$263,200
Electricity Costs	$149,800	$155,500	$161,500	$167,700	$174,300	$181,300	$188,500	$196,200	$204,200	$212,600
Other Utility Costs	$29,600	$30,800	$32,000	$33,300	$34,600	$36,000	$37,400	$38,900	$40,500	$42,100
Routine Maintenance	$52,600	$54,700	$56,900	$59,200	$61,600	$64,100	$66,700	$69,400	$72,200	$75,100
Chemicals	$287,100	$290,700	$294,500	$298,400	$302,500	$306,700	$311,100	$315,800	$320,600	$325,600
Lake Lease	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
R&R Fund	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
Phase 1 Dam O&M	$56,900	$59,200	$61,600	$64,100	$66,700	$69,400	$72,200	$75,100	$78,100	$81,200
Phase 2 Dam O&M	$0	$0	$0	$0	$0	$0	$150,000	$156,000	$162,200	$168,700
Total O&M Costs	$926,300	$954,400	$983,700	$1,014,200	$1,046,000	$1,079,300	$1,263,800	$1,306,100	$1,349,900	$1,395,500
Return	$92,600	$95,400	$98,400	$101,400	$104,600	$107,900	$126,400	$130,600	$135,000	$139,600
Total Annual Costs	$1,018,900	$1,049,800	$1,082,100	$1,115,600	$1,150,600	$1,187,200	$1,390,200	$1,436,700	$1,484,900	$1,535,100
Allocated O&M including Return to Treated Water	$866,600	$892,800	$920,100	$948,600	$978,400	$1,009,700	$1,052,600	$1,087,300	$1,123,300	$1,160,900
Allocated O&M including Return to Raw Water	$95,400	$97,800	$100,400	$102,900	$105,500	$108,100	$115,400	$118,300	$121,300	$124,300

Appendix C
Scenario 5

Table 3
North Central Missouri Regional Water Commission
Forecast of Operation and Maintenance Expenses

Year	2024	2025	2026	2027	2028	Total
Treated Water Flow (MGY)	1,203	1,223	1,244	1,266	1,288	
Raw Water Flow (MGY)	493	493	493	493	493	
Total Water Flow (MGY)	1,696	1,716	1,737	1,758	1,781	
Plant O&M Expenses						
Labor & Burden	$215,300	$223,900	$232,900	$242,200	$251,900	$4,090,200
General & Administrative	$273,700	$284,600	$296,000	$307,800	$320,100	$5,202,700
Electricity Costs	$221,400	$230,700	$240,600	$251,000	$261,800	$3,870,800
Other Utility Costs	$43,800	$45,600	$47,400	$49,300	$51,300	$832,700
Routine Maintenance	$78,100	$81,200	$84,400	$87,800	$91,300	$1,482,400
Chemicals	$330,900	$336,300	$342,100	$348,000	$354,300	$6,619,300
Lake Lease	$0	$0	$0	$0	$0	$555,400
R&R Fund	$20,000	$20,000	$20,000	$20,000	$20,000	$500,000
Phase 1 Dam O&M	$84,400	$87,800	$91,300	$95,000	$98,800	$1,565,100
Phase 2 Dam O&M	$175,400	$182,400	$189,700	$197,300	$205,200	$1,586,900
Total O&M Costs	$1,443,000	$1,492,500	$1,544,400	$1,598,400	$1,654,700	$26,305,500
Return	$144,300	$149,300	$154,400	$159,800	$165,500	$2,470,200
Total Annual Costs	$1,587,300	$1,641,800	$1,698,800	$1,758,200	$1,820,200	$28,775,700
Allocated O&M including Return to Treated Water	$1,200,200	$1,241,200	$1,284,300	$1,329,200	$1,376,300	$22,813,900
Allocated O&M including Return to Raw Water	$127,300	$130,400	$133,500	$136,700	$139,900	$2,809,800

Appendix C
Scenario 5

Table 4
North Central Missouri Regional Water Commission
Forecast Energy Expenses

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Energy Unit Cost ($/kWh)	$0.0690	0.0707	0.0725	0.0743	0.0762	0.0781	0.0800	0.0820	0.0841	0.0862
Annual Energy Usage (kWh)	660,000	680,800	703,000	726,700	752,000	1,034,100	1,316,300	1,605,600	1,624,200	1,643,400
Annual Energy Cost	$45,500	$48,100	$51,000	$54,000	$57,300	$80,700	$105,300	$131,700	$136,500	$141,600
Monthly Demand Charge ($KW)	$206.00	211.15	216.43	221.84	227.39	233.07	238.90	244.87	250.99	257.27
Monthly Peak Demand	8.50	8.71	8.93	9.15	9.38	9.62	9.86	10.10	10.36	10.62
Annual Demand Cost	$1,800	$1,800	$1,900	$2,000	$2,100	$2,200	$2,400	$2,500	$2,600	$2,700
Treated Water Electric Cost	$47,300	$49,900	$52,900	$56,000	$59,400	$82,900	$107,700	$134,200	$139,100	$144,300
Raw Water Electric Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Calculated Electric Cost	$47,300	$49,900	$52,900	$56,000	$59,400	$82,900	$107,700	$134,200	$139,100	$144,300
Total Electric Cost	$47,300	$49,900	$52,900	$56,000	$59,400	$82,900	$107,700	$134,200	$139,100	$144,300
Allocated Treated Water	$47,300	$49,900	$52,900	$56,000	$59,400	$82,900	$107,700	$134,200	$139,100	$144,300
Allocated Raw Water	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

Appendix C
Scenario 5

Table 4
North Central Missouri Regional Water Commission
Forecast Energy Expenses

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Energy Unit Cost ($/kWh)	0.0883	0.0905	0.0928	0.0951	0.0975	0.0999	0.1024	0.1050	0.1076	0.1103
Annual Energy Usage (kWh)	1,663,400	1,684,300	1,706,000	1,728,600	1,752,200	1,776,800	1,802,600	1,829,400	1,857,300	1,886,400
Annual Energy Cost	$146,900	$152,500	$158,300	$164,400	$170,800	$177,600	$184,600	$192,100	$199,900	$208,100
Monthly Demand Charge ($KW)	263.70	270.29	277.05	283.97	291.07	298.35	305.81	313.45	321.29	329.32
Monthly Peak Demand	10.88	11.15	11.43	11.72	12.01	12.31	12.62	12.93	13.26	13.59
Annual Demand Cost	$2,900	$3,000	$3,200	$3,300	$3,500	$3,700	$3,900	$4,100	$4,300	$4,500
Treated Water Electric Cost	$149,800	$155,500	$161,500	$167,700	$174,300	$181,300	$188,500	$196,200	$204,200	$212,600
Raw Water Electric Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Calculated Electric Cost	$149,800	$155,500	$161,500	$167,700	$174,300	$181,300	$188,500	$196,200	$204,200	$212,600
Total Electric Cost	$149,800	$155,500	$161,500	$167,700	$174,300	$181,300	$188,500	$196,200	$204,200	$212,600
Allocated Treated Water	$149,800	$155,500	$161,500	$167,700	$174,300	$181,300	$188,500	$196,200	$204,200	$212,600
Allocated Raw Water	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

Appendix C
Scenario 5

Table 4
North Central Missouri Regional Water Commission
Forecast Energy Expenses

Year	**2024**	**2025**	**2026**	**2027**	**2028**
Energy Unit Cost ($/kWh)	0.1131	0.1159	0.1188	0.1218	0.1248
Annual Energy Usage (kWh)	1,916,800	1,948,500	1,981,600	2,016,200	2,052,300
Annual Energy Cost	$216,700	$225,800	$235,400	$245,500	$256,100
Monthly Demand Charge ($KW)	337.55	345.99	354.64	363.51	372.60
Monthly Peak Demand	13.93	14.28	14.63	15.00	15.37
Annual Demand Cost	$4,700	$4,900	$5,200	$5,500	$5,700
Treated Water Electric Cost	$221,400	$230,700	$240,600	$251,000	$261,800
Raw Water Electric Cost	$0	$0	$0	$0	$0
Calculated Electric Cost	$221,400	$230,700	$240,600	$251,000	$261,800
Total Electric Cost	$221,400	$230,700	$240,600	$251,000	$261,800
Allocated Treated Water	$221,400	$230,700	$240,600	$251,000	$261,800
Allocated Raw Water	$0	$0	$0	$0	$0

Appendix C
Scenario 5

Table 5
North Central Missouri Regional Water Commission
Projected Debt Expense

Year	Investment	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Plant Investment	$2,832,690										
Initial Debt Service Payment		$196,000	$196,000	$196,000	$196,000	$196,000	$196,000	$196,000	$196,000	$196,000	$196,000
Initial Debt Service Interest		$134,600	$131,600	$128,600	$125,400	$122,000	$118,500	$114,800	$111,000	$106,900	$102,700
Initial Debt Service Principle		$61,400	$64,300	$67,400	$70,600	$74,000	$77,500	$81,100	$85,000	$89,000	$93,300
Remaining Capital Balance - EOY		$2,771,290	$2,706,990	$2,639,590	$2,568,990	$2,494,990	$2,417,490	$2,336,390	$2,251,390	$2,162,390	$2,069,090
Supplemental Pipeline & Intake	$1,136,000										
Initial Debt Service Payment		$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600
Initial Debt Service Interest		$54,000	$52,800	$51,600	$50,300	$48,900	$47,500	$46,100	$44,500	$42,900	$41,200
Initial Debt Service Principle		$24,600	$25,800	$27,000	$28,300	$29,700	$31,100	$32,500	$34,100	$35,700	$37,400
Remaining Capital Balance - EOY		$1,111,400	$1,085,600	$1,058,600	$1,030,300	$1,000,600	$969,500	$937,000	$902,900	$867,200	$829,800
Phase 1 Dam Investment	$15,566,000										
Dam Debt Service Payment		$0	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400
Dam Debt Service Interest		$0	$762,000	$744,900	$726,900	$708,000	$688,200	$667,400	$645,500	$622,600	$598,500
Dam Debt Service Principle		$0	$342,500	$359,600	$377,600	$396,400	$416,300	$437,100	$458,900	$481,900	$506,000
Remaining Capital Balance - EOY		$0	$15,223,500	$14,863,900	$14,486,300	$14,089,900	$13,673,600	$13,236,500	$12,777,600	$12,295,700	$11,789,700

With Milan Industrial User, With 30% Plant Grant
Including Phase 1 & 2 Capital

Appendix C
Scenario 5

Table 5
North Central Missouri Regional Water Commission
Projected Debt Expense

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Plant Investment										
Initial Debt Service Payment	$196,000	$196,000	$196,000	$196,000	$196,000	$196,000	$196,000	$196,000	$196,000	$196,000
Initial Debt Service Interest	$98,300	$93,600	$88,800	$83,700	$78,400	$72,800	$66,900	$60,800	$54,400	$47,600
Initial Debt Service Principle	$97,700	$102,300	$107,200	$112,300	$117,600	$123,200	$129,100	$135,200	$141,600	$148,400
Remaining Capital Balance - EOY	$1,971,390	$1,869,090	$1,761,890	$1,649,590	$1,531,990	$1,408,790	$1,279,690	$1,144,490	$1,002,890	$854,490

Supplemental Pipeline & Intake										
Initial Debt Service Payment	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600
Initial Debt Service Interest	$39,400	$37,600	$35,600	$33,600	$31,400	$29,200	$26,800	$24,400	$21,800	$19,100
Initial Debt Service Principle	$39,200	$41,000	$43,000	$45,000	$47,200	$49,400	$51,800	$54,200	$56,800	$59,500
Remaining Capital Balance - EOY	$790,600	$749,600	$706,600	$661,600	$614,400	$565,000	$513,200	$459,000	$402,200	$342,700

Phase 1 Dam Investment										
Dam Debt Service Payment	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400
Dam Debt Service Interest	$573,200	$546,600	$518,700	$489,400	$458,700	$426,400	$392,500	$356,900	$319,500	$280,300
Dam Debt Service Principle	$531,300	$557,800	$585,700	$615,000	$645,700	$678,000	$711,900	$747,500	$784,900	$824,200
Remaining Capital Balance - EOY	$11,258,400	$10,700,600	$10,114,900	$9,499,900	$8,854,200	$8,176,200	$7,464,300	$6,716,800	$5,931,900	$5,107,700

Appendix C
Scenario 5

Table 5
North Central Missouri Regional Water Commission
Projected Debt Expense

Year	2024	2025	2026	2027	2028	Total
Plant Investment						
Initial Debt Service Payment	$196,000	$196,000	$196,000	$196,000	$196,000	$4,900,000
Initial Debt Service Interest	$40,600	$33,200	$25,500	$17,400	$8,900	$2,067,000
Initial Debt Service Principle	$155,400	$162,800	$170,500	$178,600	$187,100	$2,832,600
Remaining Capital Balance - EOY	$699,090	$536,290	$365,790	$187,190	$90	
Supplemental Pipeline & Intake						
Initial Debt Service Payment	$78,600	$78,600	$78,600	$78,600	$78,600	$1,965,000
Initial Debt Service Interest	$16,300	$13,300	$10,200	$7,000	$3,600	$829,100
Initial Debt Service Principle	$62,300	$65,300	$68,400	$71,600	$75,000	$1,135,900
Remaining Capital Balance - EOY	$280,400	$215,100	$146,700	$75,100	$100	
Phase 1 Dam Investment						
Dam Debt Service Payment	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$26,505,600
Dam Debt Service Interest	$239,100	$195,800	$150,400	$102,700	$52,600	$11,266,800
Dam Debt Service Principle	$865,400	$908,600	$954,100	$1,001,800	$1,051,900	$15,240,100
Remaining Capital Balance - EOY	$4,242,300	$3,333,700	$2,379,600	$1,377,800	$325,900	

Appendix C
Scenario 5

Table 6
North Central Missouri Regional Water Commission
Projected Water Sales

Type	Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Treated Water	Milan	127.8	128.6	129.5	130.5	131.4	132.3	133.2	134.1	135.1	136.0
	Sullivan County #1	119.7	121.3	122.9	124.5	126.1	127.7	129.4	131.0	132.8	134.5
	Green City	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.4	34.4
	Milan Industrial User	132.5	143.1	154.5	166.9	180.3	354.8	529.3	529.3	529.3	529.3
	Other Treated Water Cust.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	179.0	187.9	197.3
Total Treated Water		414.3	427.3	441.2	456.1	472.0	649.1	826.2	1,007.8	1,019.4	1,031.5
Raw Water	PSF	264.6	280.5	297.3	315.2	334.1	354.1	492.8	492.8	492.8	492.8
Total Water		678.9	707.8	738.6	771.3	806.1	1,003.2	1,319.0	1,500.6	1,512.2	1,524.3
Percent Treated Water		61.0%	60.4%	59.7%	59.1%	58.6%	64.7%	62.6%	67.2%	67.4%	67.7%
Percent Raw Water		39.0%	39.6%	40.3%	40.9%	41.4%	35.3%	37.4%	32.8%	32.6%	32.3%

Appendix C
Scenario 5

Table 6
North Central Missouri Regional Water Commission
Projected Water Sales

Type	Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Treated Water	Milan	137.0	137.9	138.9	139.9	140.9	141.8	142.8	143.8	144.8	145.9
	Sullivan County #1	136.2	138.0	139.8	141.6	143.4	145.3	147.2	149.1	151.1	153.0
	Green City	34.4	34.4	34.4	34.4	34.4	34.4	34.5	34.5	34.5	34.5
	Milan Industrial User	529.3	529.3	529.3	529.3	529.3	529.3	529.3	529.3	529.3	529.3
	Other Treated Water Cust.	207.2	217.5	228.4	239.8	251.8	264.4	277.6	291.5	306.1	321.4
Total Treated Water		1,044.1	1,057.2	1,070.8	1,085.0	1,099.8	1,115.3	1,131.5	1,148.2	1,165.8	1,184.0
Raw Water	PSF	492.8	492.8	492.8	492.8	492.8	492.8	492.8	492.8	492.8	492.8
Total Water		1,536.9	1,550.0	1,563.6	1,577.8	1,592.6	1,608.1	1,624.3	1,641.0	1,658.6	1,676.8
Percent Treated Water		67.9%	68.2%	68.5%	68.8%	69.1%	69.4%	69.7%	70.0%	70.3%	70.6%
Percent Raw Water		32.1%	31.8%	31.5%	31.2%	30.9%	30.6%	30.3%	30.0%	29.7%	29.4%

Appendix C
Scenario 5

Table 6
North Central Missouri Regional Water Commission
Projected Water Sales

Type	Year	2024	2025	2026	2027	2028
Treated Water	Milan	146.9	147.9	148.9	150.0	151.0
	Sullivan County #1	155.0	157.0	159.1	161.1	163.2
	Green City	34.5	34.5	34.5	34.5	34.5
	Milan Industrial User	529.3	529.3	529.3	529.3	529.3
	Other Treated Water Cust.	337.5	354.3	372.1	390.7	410.2
Total Treated Water		1,203.1	1,223.0	1,243.8	1,265.6	1,288.2
Raw Water	PSF	492.8	492.8	492.8	492.8	492.8
Total Water		1,695.9	1,715.8	1,736.6	1,758.4	1,781.0
Percent Treated Water		70.9%	71.3%	71.6%	72.0%	72.3%
Percent Raw Water		29.1%	28.7%	28.4%	28.0%	27.7%

Scenario 6

With Milan Industrial User, With 50% Plant Grant

Appendix C
Scenario 6

Table 1
North Central Missouri Regional Water Commission
Projected Water Costs

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Treated Water O&M Cost Including Return	$482,700	$500,800	$518,800	$537,600	$557,700	$602,800	$688,300	$794,500	$817,600	$841,600
Treated Water Debt Service	$188,000	$854,200	$846,800	$839,600	$832,700	$905,400	$881,000	$934,500	$937,500	$940,500
Total Treated Water Costs	$670,700	$1,355,000	$1,365,600	$1,377,200	$1,390,400	$1,508,200	$1,569,300	$1,729,000	$1,755,100	$1,782,100
Treated Water Cost ($/1000 gallons)	$1.6190	$3.1709	$3.0948	$3.0194	$2.9458	$2.3236	$1.8994	$1.7157	$1.7216	$1.7277
Raw Water Cost O&M Cost Including Return	$107,200	$113,900	$120,100	$126,700	$133,500	$84,300	$94,800	$88,400	$90,700	$93,000
Raw Water Debt Service	$30,600	$468,800	$476,200	$483,400	$490,300	$417,600	$442,000	$388,500	$385,500	$382,500
Total Raw Water Costs	$137,800	$582,700	$596,300	$610,100	$623,800	$501,900	$536,800	$476,900	$476,200	$475,500
Raw Water Cost ($/1000 gallons)	$0.5207	$2.0773	$2.0055	$1.9358	$1.8672	$1.4173	$1.0893	$0.9677	$0.9663	$0.9649

Year 1 - 5 Average Water Cost	$/1000 gal
Treated Water Costs	$2.7700
Raw Water Costs	$1.6813

Year 6 - 10 Average Water Cost	$/1000 gal
Treated Water Costs	$1.8776
Raw Water Costs	$1.0811

Appendix C
Scenario 6

Table 1
North Central Missouri Regional Water Commission
Projected Water Costs

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Treated Water O&M Cost Including Return	$866,600	$892,800	$920,100	$948,600	$978,400	$1,009,700	$1,052,600	$1,087,300	$1,123,300	$1,160,900
Treated Water Debt Service	$943,700	$946,900	$950,200	$953,500	$956,900	$960,500	$2,732,400	$2,743,900	$2,755,800	$2,767,800
Total Treated Water Costs	$1,810,300	$1,839,700	$1,870,300	$1,902,100	$1,935,300	$1,970,200	$3,785,000	$3,831,200	$3,879,100	$3,928,700
Treated Water Cost ($/1000 gallons)	$1.7339	$1.7402	$1.7466	$1.7531	$1.7597	$1.7666	$3.3453	$3.3366	$3.3275	$3.3180

Raw Water Cost O&M Cost Including Return	$95,400	$97,800	$100,400	$102,900	$105,500	$108,100	$115,400	$118,300	$121,300	$124,300
Raw Water Debt Service	$379,300	$376,100	$372,800	$369,500	$366,100	$362,500	$1,129,100	$1,117,600	$1,105,700	$1,093,700
Total Raw Water Costs	$474,700	$473,900	$473,200	$472,400	$471,600	$470,600	$1,244,500	$1,235,900	$1,227,000	$1,218,000
Raw Water Cost ($/1000 gallons)	$0.9633	$0.9616	$0.9602	$0.9586	$0.9570	$0.9550	$2.5254	$2.5079	$2.4899	$2.4716

Year 11 - 15 Average Water Cost	$/1000 gal
Treated Water Costs	$1.7467
Raw Water Costs	$0.9601

Year 16 - 20 Average Water Cost	$/1000 gal
Treated Water Costs	$3.0188
Raw Water Costs	$2.1899

Appendix C
Scenario 6

Table 1
North Central Missouri Regional Water Commission
Projected Water Costs

	2024	2025	2026	2027	2028
Treated Water O&M Cost Including Return	$1,200,200	$1,241,200	$1,284,300	$1,329,200	$1,376,300
Treated Water Debt Service	$2,780,100	$2,792,700	$2,805,500	$2,818,500	$2,831,800
Total Treated Water Costs	$3,980,300	$4,033,900	$4,089,800	$4,147,700	$4,208,100
Treated Water Cost ($/1000 gallons)	$3.3083	$3.2982	$3.2881	$3.2774	$3.2666
Raw Water Cost O&M Cost Including Return	$127,300	$130,400	$133,500	$136,700	$139,900
Raw Water Debt Service	$1,081,400	$1,068,800	$1,056,000	$1,043,000	$1,029,700
Total Raw Water Costs	$1,208,700	$1,199,200	$1,189,500	$1,179,700	$1,169,600
Raw Water Cost ($/1000 gallons)	$2.4527	$2.4334	$2.4138	$2.3939	$2.3734

Year 21 - 25 Average Water Cost	$/1000 gal
Treated Water Costs	$3.2877
Raw Water Costs	$2.4134

Appendix C
Scenario 6

Table 2
North Central Missouri Regional Water Commission
Inputs and Assumptions

Starting Year	2004

Water Plant Capital

Milan Plant Purchase Capital Requirement	$3,564,500
Milan Plant Purchase Additional Capital	$482,200
Milan Plant Purchase Grant Funding	$2,023,350
Milan Plant Purchase Capital less Grants	$2,023,350

Supplemental Pipeline & Intake Capital Requirement	$1,136,000
Pipeline & Intake Grant Funding	$0
Pipeline & Intake Capital less Grants	$1,136,000

Interest Rate for Debt Financing	4.75%
Term of Project Financing - years	25

Phase 1 Capital

Investment Year	2005
Dam and Reservoir Construction Capital	$26,265,000
Dam Construction Grant Funding	$10,699,000
Dam Construction Capital less Grants	$15,566,000
Interest Rate for Debt Financing	5.00%
Term of Project Financing - years	25

Phase 2 Capital

Investment Year	2020
Dam and Reservoir Construction Capital	$32,450,000
Dam Construction Grant Funding	$0
Dam Construction Capital less Grants	$32,450,000
Interest Rate for Debt Financing	6.00%
Term of Project Financing - years	25

Plant O&M

Inflation Rate for Labor/Materials	4.0%
Inflation Rate for Energy	2.5%
Energy Unit Cost ($/kWh)	$0.0690
Average Monthly Energy Use (kWh)	55,000
Demand Charge ($/kW)	$206
Average Demand (kW)	8.50
Other Utility Costs (Gas?)	20,000
Plant Labor	$109,100
City Labor Offset (10%)	-$10,900
Routine Maintenance (1% of Plant Capital)	$35,600
Chemical Costs per Thousand Gallons	$0.275
General and Administration Expenses	$125,000
Lake Lease per Thousand Gallons	$0.150
Renewal & Replacement Fund Requirement	$20,000

Dam & Reservoir O&M

Phase 1	$40,000
Phase 2	$150,000

Water Usage

Milan Treated Water	0.350	[1]
Sullivan County #1 Treated Water	0.328	[1]
Green City Treated Water	0.094	[1]
Milan Industrial User Treated Water	0.363	[1]
Other Treated Water Customers (Begin 2011)	0.490	
PSF Raw Water	0.725	[1]
Milan Water Usage Growth	0.70%	
Sullivan County #1 Water Usage Growth	1.30%	
Green City Water Usage Growth	0.25%	
Raw Water Usage Growth (first 10 years)	6.00%	
Raw Water Usage Growth (after 2010)	0.00%	
Milan Industrial User Water Usage Growth	8.00%	
Milan Industrial User Water Usage Growth (after 2010)	0.00%	
Other Treated Water Growth	5.00%	

Return

Return (% of O&M expense, Years 1-5)	5%
Return (% of O&M expense, Years10 and beyond)	10%

[1] 2002 Average MGD

Appendix C
Scenario 6

Table 3
North Central Missouri Regional Water Commission
Forecast of Operation and Maintenance Expenses

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Treated Water Flow (MGY)	414	427	441	456	472	649	826	1,008	1,019	1,032
Raw Water Flow (MGY)	265	281	297	315	334	354	493	493	493	493
Total Water Flow (MGY)	679	708	739	771	806	1,003	1,319	1,501	1,512	1,524
Plant O&M Expenses										
Labor & Burden	$98,200	$102,100	$106,200	$110,400	$114,800	$119,400	$124,200	$129,200	$134,400	$139,800
General & Administrative	$125,000	$130,000	$135,200	$140,600	$146,200	$152,000	$158,100	$164,400	$171,000	$177,800
Electricity Costs	$47,300	$49,900	$52,900	$56,000	$59,400	$82,900	$107,700	$134,200	$139,100	$144,300
Other Utility Costs	$20,000	$20,800	$21,600	$22,500	$23,400	$24,300	$25,300	$26,300	$27,400	$28,500
Routine Maintenance	$35,600	$37,000	$38,500	$40,000	$41,600	$43,300	$45,000	$46,800	$48,700	$50,600
Chemicals	$113,900	$117,500	$121,300	$125,400	$129,800	$178,500	$227,200	$277,100	$280,300	$283,700
Lake Lease	$101,800	$106,200	$110,800	$115,700	$120,900	$0	$0	$0	$0	$0
R&R Fund	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
Phase 1 Dam O&M	$0	$40,000	$41,600	$43,300	$45,000	$46,800	$48,700	$50,600	$52,600	$54,700
Phase 2 Dam O&M	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total O&M Costs	$561,800	$623,500	$648,100	$673,900	$701,100	$667,200	$756,200	$848,600	$873,500	$899,400
Return	$28,100	$31,200	$32,400	$33,700	$35,100	$66,700	$75,600	$84,900	$87,400	$89,900
Total Annual Costs	$589,900	$654,700	$680,500	$707,600	$736,200	$733,900	$831,800	$933,500	$960,900	$989,300
Allocated O&M including Return to Treated Water	$482,700	$500,800	$518,800	$537,600	$557,700	$602,800	$688,300	$794,500	$817,600	$841,600
Allocated O&M including Return to Raw Water	$107,200	$113,900	$120,100	$126,700	$133,500	$84,300	$94,800	$88,400	$90,700	$93,000

Appendix C
Scenario 6

Table 3
North Central Missouri Regional Water Commission
Forecast of Operation and Maintenance Expenses

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Treated Water Flow (MGY)	1,044	1,057	1,071	1,085	1,100	1,115	1,131	1,148	1,166	1,184
Raw Water Flow (MGY)	493	493	493	493	493	493	493	493	493	493
Total Water Flow (MGY)	1,537	1,550	1,564	1,578	1,593	1,608	1,624	1,641	1,659	1,677

Plant O&M Expenses										
Labor & Burden	$145,400	$151,200	$157,200	$163,500	$170,000	$176,800	$183,900	$191,300	$199,000	$207,000
General & Administrative	$184,900	$192,300	$200,000	$208,000	$216,300	$225,000	$234,000	$243,400	$253,100	$263,200
Electricity Costs	$149,800	$155,500	$161,500	$167,700	$174,300	$181,300	$188,500	$196,200	$204,200	$212,600
Other Utility Costs	$29,600	$30,800	$32,000	$33,300	$34,600	$36,000	$37,400	$38,900	$40,500	$42,100
Routine Maintenance	$52,600	$54,700	$56,900	$59,200	$61,600	$64,100	$66,700	$69,400	$72,200	$75,100
Chemicals	$287,100	$290,700	$294,500	$298,400	$302,500	$306,700	$311,100	$315,800	$320,600	$325,600
Lake Lease	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
R&R Fund	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
Phase 1 Dam O&M	$56,900	$59,200	$61,600	$64,100	$66,700	$69,400	$72,200	$75,100	$78,100	$81,200
Phase 2 Dam O&M	$0	$0	$0	$0	$0	$0	$150,000	$156,000	$162,200	$168,700
Total O&M Costs	$926,300	$954,400	$983,700	$1,014,200	$1,046,000	$1,079,300	$1,263,800	$1,306,100	$1,349,900	$1,395,500
Return	$92,600	$95,400	$98,400	$101,400	$104,600	$107,900	$126,400	$130,600	$135,000	$139,600
Total Annual Costs	$1,018,900	$1,049,800	$1,082,100	$1,115,600	$1,150,600	$1,187,200	$1,390,200	$1,436,700	$1,484,900	$1,535,100
Allocated O&M including Return to Treated Water	$866,600	$892,800	$920,100	$948,600	$978,400	$1,009,700	$1,052,600	$1,087,300	$1,123,300	$1,160,900
Allocated O&M including Return to Raw Water	$95,400	$97,800	$100,400	$102,900	$105,500	$108,100	$115,400	$118,300	$121,300	$124,300

Appendix C
Scenario 6

Table 3
North Central Missouri Regional Water Commission
Forecast of Operation and Maintenance Expenses

Year	2024	2025	2026	2027	2028	Total
Treated Water Flow (MGY)	1,203	1,223	1,244	1,266	1,288	
Raw Water Flow (MGY)	493	493	493	493	493	
Total Water Flow (MGY)	1,696	1,716	1,737	1,758	1,781	
Plant O&M Expenses						
Labor & Burden	$215,300	$223,900	$232,900	$242,200	$251,900	$4,090,200
General & Administrative	$273,700	$284,600	$296,000	$307,800	$320,100	$5,202,700
Electricity Costs	$221,400	$230,700	$240,600	$251,000	$261,800	$3,870,800
Other Utility Costs	$43,800	$45,600	$47,400	$49,300	$51,300	$832,700
Routine Maintenance	$78,100	$81,200	$84,400	$87,800	$91,300	$1,482,400
Chemicals	$330,900	$336,300	$342,100	$348,000	$354,300	$6,619,300
Lake Lease	$0	$0	$0	$0	$0	$555,400
R&R Fund	$20,000	$20,000	$20,000	$20,000	$20,000	$500,000
Phase 1 Dam O&M	$84,400	$87,800	$91,300	$95,000	$98,800	$1,565,100
Phase 2 Dam O&M	$175,400	$182,400	$189,700	$197,300	$205,200	$1,586,900
Total O&M Costs	$1,443,000	$1,492,500	$1,544,400	$1,598,400	$1,654,700	$26,305,500
Return	$144,300	$149,300	$154,400	$159,800	$165,500	$2,470,200
Total Annual Costs	$1,587,300	$1,641,800	$1,698,800	$1,758,200	$1,820,200	$28,775,700
Allocated O&M including Return to Treated Water	$1,200,200	$1,241,200	$1,284,300	$1,329,200	$1,376,300	$22,813,900
Allocated O&M including Return to Raw Water	$127,300	$130,400	$133,500	$136,700	$139,900	$2,809,800

Appendix C
Scenario 6

Table 4
North Central Missouri Regional Water Commission
Forecast Energy Expenses

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Energy Unit Cost ($/kWh)	$0.0690	0.0707	0.0725	0.0743	0.0762	0.0781	0.0800	0.0820	0.0841	0.0862
Annual Energy Usage (kWh)	660,000	680,800	703,000	726,700	752,000	1,034,100	1,316,300	1,605,600	1,624,200	1,643,400
Annual Energy Cost	$45,500	$48,100	$51,000	$54,000	$57,300	$80,700	$105,300	$131,700	$136,500	$141,600
Monthly Demand Charge ($KW)	$206.00	211.15	216.43	221.84	227.39	233.07	238.90	244.87	250.99	257.27
Monthly Peak Demand	8.50	8.71	8.93	9.15	9.38	9.62	9.86	10.10	10.36	10.62
Annual Demand Cost	$1,800	$1,800	$1,900	$2,000	$2,100	$2,200	$2,400	$2,500	$2,600	$2,700
Treated Water Electric Cost	$47,300	$49,900	$52,900	$56,000	$59,400	$82,900	$107,700	$134,200	$139,100	$144,300
Raw Water Electric Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Calculated Electric Cost	$47,300	$49,900	$52,900	$56,000	$59,400	$82,900	$107,700	$134,200	$139,100	$144,300
Total Electric Cost	$47,300	$49,900	$52,900	$56,000	$59,400	$82,900	$107,700	$134,200	$139,100	$144,300
Allocated Treated Water	$47,300	$49,900	$52,900	$56,000	$59,400	$82,900	$107,700	$134,200	$139,100	$144,300
Allocated Raw Water	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

Appendix C
Scenario 6

Table 4
North Central Missouri Regional Water Commission
Forecast Energy Expenses

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Energy Unit Cost ($/kWh)	0.0883	0.0905	0.0928	0.0951	0.0975	0.0999	0.1024	0.1050	0.1076	0.1103
Annual Energy Usage (kWh)	1,663,400	1,684,300	1,706,000	1,728,600	1,752,200	1,776,800	1,802,600	1,829,400	1,857,300	1,886,400
Annual Energy Cost	$146,900	$152,500	$158,300	$164,400	$170,800	$177,600	$184,600	$192,100	$199,900	$208,100
Monthly Demand Charge ($KW)	263.70	270.29	277.05	283.97	291.07	298.35	305.81	313.45	321.29	329.32
Monthly Peak Demand	10.88	11.15	11.43	11.72	12.01	12.31	12.62	12.93	13.26	13.59
Annual Demand Cost	$2,900	$3,000	$3,200	$3,300	$3,500	$3,700	$3,900	$4,100	$4,300	$4,500
Treated Water Electric Cost	$149,800	$155,500	$161,500	$167,700	$174,300	$181,300	$188,500	$196,200	$204,200	$212,600
Raw Water Electric Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Calculated Electric Cost	$149,800	$155,500	$161,500	$167,700	$174,300	$181,300	$188,500	$196,200	$204,200	$212,600
Total Electric Cost	$149,800	$155,500	$161,500	$167,700	$174,300	$181,300	$188,500	$196,200	$204,200	$212,600
Allocated Treated Water	$149,800	$155,500	$161,500	$167,700	$174,300	$181,300	$188,500	$196,200	$204,200	$212,600
Allocated Raw Water	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

Appendix C
Scenario 6

Table 4
North Central Missouri Regional Water Commission
Forecast Energy Expenses

Year	2024	2025	2026	2027	2028
Energy Unit Cost ($/kWh)	0.1131	0.1159	0.1188	0.1218	0.1248
Annual Energy Usage (kWh)	1,916,800	1,948,500	1,981,600	2,016,200	2,052,300
Annual Energy Cost	$216,700	$225,800	$235,400	$245,500	$256,100
Monthly Demand Charge ($KW)	337.55	345.99	354.64	363.51	372.60
Monthly Peak Demand	13.93	14.28	14.63	15.00	15.37
Annual Demand Cost	$4,700	$4,900	$5,200	$5,500	$5,700
Treated Water Electric Cost	$221,400	$230,700	$240,600	$251,000	$261,800
Raw Water Electric Cost	$0	$0	$0	$0	$0
Calculated Electric Cost	$221,400	$230,700	$240,600	$251,000	$261,800
Total Electric Cost	$221,400	$230,700	$240,600	$251,000	$261,800
Allocated Treated Water	$221,400	$230,700	$240,600	$251,000	$261,800
Allocated Raw Water	$0	$0	$0	$0	$0

Appendix C
Scenario 6

Table 5
North Central Missouri Regional Water Commission
Projected Debt Expense

Year	Investment	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Plant Investment	$2,023,350										
Initial Debt Service Payment		$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000
Initial Debt Service Interest		$96,100	$94,000	$91,800	$89,600	$87,200	$84,700	$82,000	$79,300	$76,400	$73,400
Initial Debt Service Principle		$43,900	$46,000	$48,100	$50,400	$52,800	$55,300	$58,000	$60,700	$63,600	$66,600
Remaining Capital Balance - EOY		$1,979,450	$1,933,450	$1,885,350	$1,834,950	$1,782,150	$1,726,850	$1,668,850	$1,608,150	$1,544,550	$1,477,950

Supplemental Pipeline & Intake	$1,136,000										
Initial Debt Service Payment		$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600
Initial Debt Service Interest		$54,000	$52,800	$51,600	$50,300	$48,900	$47,500	$46,100	$44,500	$42,900	$41,200
Initial Debt Service Principle		$24,600	$25,800	$27,000	$28,300	$29,700	$31,100	$32,500	$34,100	$35,700	$37,400
Remaining Capital Balance - EOY		$1,111,400	$1,085,600	$1,058,600	$1,030,300	$1,000,600	$969,500	$937,000	$902,900	$867,200	$829,800

Phase 1 Dam Investment	$15,566,000										
Dam Debt Service Payment		$0	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400
Dam Debt Service Interest		$0	$762,000	$744,900	$726,900	$708,000	$688,200	$667,400	$645,500	$622,600	$598,500
Dam Debt Service Principle		$0	$342,500	$359,600	$377,600	$396,400	$416,300	$437,100	$458,900	$481,900	$506,000
Remaining Capital Balance - EOY		$0	$15,223,500	$14,863,900	$14,486,300	$14,089,900	$13,673,600	$13,236,500	$12,777,600	$12,295,700	$11,789,700

Appendix C
Scenario 6

Table 5
North Central Missouri Regional Water Commission
Projected Debt Expense

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Plant Investment										
Initial Debt Service Payment	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000
Initial Debt Service Interest	$70,200	$66,900	$63,400	$59,800	$56,000	$52,000	$47,800	$43,400	$38,800	$34,000
Initial Debt Service Principle	$69,800	$73,100	$76,600	$80,200	$84,000	$88,000	$92,200	$96,600	$101,200	$106,000
Remaining Capital Balance - EOY	$1,408,150	$1,335,050	$1,258,450	$1,178,250	$1,094,250	$1,006,250	$914,050	$817,450	$716,250	$610,250

Supplemental Pipeline & Intake										
Initial Debt Service Payment	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600	$78,600
Initial Debt Service Interest	$39,400	$37,600	$35,600	$33,600	$31,400	$29,200	$26,800	$24,400	$21,800	$19,100
Initial Debt Service Principle	$39,200	$41,000	$43,000	$45,000	$47,200	$49,400	$51,800	$54,200	$56,800	$59,500
Remaining Capital Balance - EOY	$790,600	$749,600	$706,600	$661,600	$614,400	$565,000	$513,200	$459,000	$402,200	$342,700

Phase 1 Dam Investment										
Dam Debt Service Payment	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400
Dam Debt Service Interest	$573,200	$546,600	$518,700	$489,400	$458,700	$426,400	$392,500	$356,900	$319,500	$280,300
Dam Debt Service Principle	$531,300	$557,800	$585,700	$615,000	$645,700	$678,000	$711,900	$747,500	$784,900	$824,200
Remaining Capital Balance - EOY	$11,258,400	$10,700,600	$10,114,900	$9,499,900	$8,854,200	$8,176,200	$7,464,300	$6,716,800	$5,931,900	$5,107,700

Appendix C
Scenario 6

Table 5
North Central Missouri Regional Water Commission
Projected Debt Expense

Year	2024	2025	2026	2027	2028	Total
Plant Investment						
Initial Debt Service Payment	$140,000	$140,000	$140,000	$140,000	$140,000	$3,500,000
Initial Debt Service Interest	$29,000	$23,700	$18,200	$12,400	$6,300	$1,476,400
Initial Debt Service Principle	$111,000	$116,300	$121,800	$127,600	$133,600	$2,023,400
Remaining Capital Balance - EOY	$499,250	$382,950	$261,150	$133,550	-$50	

Supplemental Pipeline & Intake						
Initial Debt Service Payment	$78,600	$78,600	$78,600	$78,600	$78,600	$1,965,000
Initial Debt Service Interest	$16,300	$13,300	$10,200	$7,000	$3,600	$829,100
Initial Debt Service Principle	$62,300	$65,300	$68,400	$71,600	$75,000	$1,135,900
Remaining Capital Balance - EOY	$280,400	$215,100	$146,700	$75,100	$100	

Phase 1 Dam Investment						
Dam Debt Service Payment	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$1,104,400	$26,505,600
Dam Debt Service Interest	$239,100	$195,800	$150,400	$102,700	$52,600	$11,266,800
Dam Debt Service Principle	$865,400	$908,600	$954,100	$1,001,800	$1,051,900	$15,240,100
Remaining Capital Balance - EOY	$4,242,300	$3,333,700	$2,379,600	$1,377,800	$325,900	

Appendix C
Scenario 6

Table 6
North Central Missouri Regional Water Commission
Projected Water Sales

Type	Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Treated Water	Milan	127.8	128.6	129.5	130.5	131.4	132.3	133.2	134.1	135.1	136.0
	Sullivan County #1	119.7	121.3	122.9	124.5	126.1	127.7	129.4	131.0	132.8	134.5
	Green City	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.4	34.4
	Milan Industrial User	132.5	143.1	154.5	166.9	180.3	354.8	529.3	529.3	529.3	529.3
	Other Treated Water Cust.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	179.0	187.9	197.3
Total Treated Water		414.3	427.3	441.2	456.1	472.0	649.1	826.2	1,007.8	1,019.4	1,031.5
Raw Water	PSF	264.6	280.5	297.3	315.2	334.1	354.1	492.8	492.8	492.8	492.8
Total Water		678.9	707.8	738.6	771.3	806.1	1,003.2	1,319.0	1,500.6	1,512.2	1,524.3
Percent Treated Water		61.0%	60.4%	59.7%	59.1%	58.6%	64.7%	62.6%	67.2%	67.4%	67.7%
Percent Raw Water		39.0%	39.6%	40.3%	40.9%	41.4%	35.3%	37.4%	32.8%	32.6%	32.3%

Appendix C
Scenario 6

Table 6
North Central Missouri Regional Water Commission
Projected Water Sales

Type	Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Treated Water	Milan	137.0	137.9	138.9	139.9	140.9	141.8	142.8	143.8	144.8	145.9
	Sullivan County #1	136.2	138.0	139.8	141.6	143.4	145.3	147.2	149.1	151.1	153.0
	Green City	34.4	34.4	34.4	34.4	34.4	34.4	34.5	34.5	34.5	34.5
	Milan Industrial User	529.3	529.3	529.3	529.3	529.3	529.3	529.3	529.3	529.3	529.3
	Other Treated Water Cust.	207.2	217.5	228.4	239.8	251.8	264.4	277.6	291.5	306.1	321.4
Total Treated Water		1,044.1	1,057.2	1,070.8	1,085.0	1,099.8	1,115.3	1,131.5	1,148.2	1,165.8	1,184.0
Raw Water	PSF	492.8	492.8	492.8	492.8	492.8	492.8	492.8	492.8	492.8	492.8
Total Water		1,536.9	1,550.0	1,563.6	1,577.8	1,592.6	1,608.1	1,624.3	1,641.0	1,658.6	1,676.8
Percent Treated Water		67.9%	68.2%	68.5%	68.8%	69.1%	69.4%	69.7%	70.0%	70.3%	70.6%
Percent Raw Water		32.1%	31.8%	31.5%	31.2%	30.9%	30.6%	30.3%	30.0%	29.7%	29.4%

Appendix C
Scenario 6

Table 6
North Central Missouri Regional Water Commission
Projected Water Sales

Type	Year	2024	2025	2026	2027	2028
Treated Water	Milan	146.9	147.9	148.9	150.0	151.0
	Sullivan County #1	155.0	157.0	159.1	161.1	163.2
	Green City	34.5	34.5	34.5	34.5	34.5
	Milan Industrial User	529.3	529.3	529.3	529.3	529.3
	Other Treated Water Cust.	337.5	354.3	372.1	390.7	410.2
Total Treated Water		1,203.1	1,223.0	1,243.8	1,265.6	1,288.2
Raw Water	PSF	492.8	492.8	492.8	492.8	492.8
Total Water		1,695.9	1,715.8	1,736.6	1,758.4	1,781.0
Percent Treated Water		70.9%	71.3%	71.6%	72.0%	72.3%
Percent Raw Water		29.1%	28.7%	28.4%	28.0%	27.7%

Appendix D

References

REFERENCES

American Meteorological Society, 1959, *Glossary of Meteorology*, Boston, Mass.

Foster, G. L. (1989). *RESNET: A Reservoir Network Simulation Model.* Unpublished master's thesis, University of Kansas: Lawrence.

Hershfield, D. M., 1962, Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years, U.S. Weather Bureau Technical Paper 40, Washington, D.C.

Linsley, R. Jr., Kohler, M. & Paulhus, J. (1982). *Hydrology for engineers.* New York: McGraw-Hill.

McMahon, T. & Mein, R. (1986). *River and reservoir yield.* Littleton, Colorado: Water Resources Publications.

Miller, J. F., 1961, Two- to Ten-Day Precipitation for Return Periods of 2 to 100 Years in the Contiguous United States, U.S. Weather Bureau Technical Paper 49, Washington, D.C.

National Climatic Data Center. (2002). *Cooperative Summary of the Day, TD3200* [CD-ROM]. Asheville, NC: U.S. Department of Commerce, National Oceanic and Atmospheric Administration.

National Oceanic and Atmospheric Administration, 1977, Five- to 60-Minute Precipitation Frequency for the Eastern and Central United States, NOAA Technical Memorandum NWS HYDRO-35, National Weather Service, Silver Spring, Maryland.

National Oceanic and Atmospheric Administration, 1982, Hydrometerological Report No. 52 Application of Probable Maximum Precipitation Estimates, United States East of the 105th Meridian, National Weather Service, Silver Spring, Maryland.

National Oceanic and Atmospheric Administration. (1982). *Evaporation Atlas of the Contiguous 48 United States, NOAA Technical Report NWS 33.* Washington, DC: U.S. Department of Commerce.

Schreiner, Louis C. and John T. Riedel, 1978, Probable Maximum Precipitation Estimates, United States East of the 105th Meridian, Hydrometeorological Report No. 51, National Weather Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Washington, D.C.

U.S. Army Corps of Engineers, February 13-16, 1996, Workshop on Basic HEC-1, U.S. Army Corps of Engineers Detroit District, Indianapolis, Indiana.

U.S. Department of Agriculture, Soil and Conservation Service, Engineering Division, 1985, National Engineering Handbook, Section 4, Hydrology.

U.S. Department of Agriculture, Soil and Conservation Service, Engineering Division, October 1985, Technical Release 60, Earth Dams and Reservoirs.

U.S. Department of Agriculture, Soil Conservation Service, Engineering Division, 1986, Technical Release 55, Urban Hydrology for Small Watersheds.

U.S. Department of the Interior, Bureau of Reclamation, 1987, Design of Small Dams, Denver, CO.

U.S. Geological Survey. (no date-a). *Daily streamflow for the nation: USGS 06900000 Medicine Creek near Galt, MO* [Database]. Retrieved 12 August 2003 from http://uaterdata.usgs.gov/nwis/discharge/?site_no=06900000.

U.S. Geological Survey. (no date-b). *Daily streamflow for the nation: USGS 06901000 Locust Creek near Milan, MO* [Database]. Retrieved 12 August 2003 from http://uaterdata.usgs.gov/nwis/discharge/?site_no=06901000.

U.S. Geological Survey. (no date-c). *Daily streamflow for the nation: USGS 06901500 Locust Creek near Linneus, MO* [Database]. Retrieved 12 August 2003 from http://uaterdata.usgs.gov/nwis/discharge/?site_no=06901500.

U.S. Geological Survey. (no date-d). *Daily streamflow for the nation: USGS 06904500 Chariton River at Novinger, MO* [Database]. Retrieved 12 August 2003 from http://uaterdata.usgs.gov/nwis/discharge/?site_no=06904500.