Contract No.: W912DQ-08-D-0048
Task Order YW06

Final
Middle Fork Water Treatment Plant and Reservoir Condition Technical Memorandum

U.S. Army Corps of Engineers
Kansas City District

Northwest Missouri Regional Water Supply Transmission System Study Phase V

June 2012

US Army Corps of Engineers
Kansas City District

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CDM Smith

Northwest Missouri Regional Water Supply
Transmission System Study
Phase V

Final
Middle Fork Water Treatment Plant and Reservoir
Condition Technical Memorandum

June 2012

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Acronyms/Abbreviations

°F	degrees Fahrenheit
ACH	Aluminum chloride hydroxide sulfate
CDM Smith	CDM Federal Programs Corporation
cfs	cubic feet per second
Commission	Great Northwest Wholesale Water Commission
CSR	Code of State Regulations
CT	contact time
CY	cubic yards
DIP	ductile iron pipe
El.	elevation
gpd	gallons per day
gpm	gallon per minute
H	horizontal
H&H	hydrologic and hydraulic
mg	million gallons
MDNR	Missouri Department of Natural Resources
MFWC	Middle Fork Water Company
NAVD88	North American vertical datum 1988
OPC	opinion of probable cost
PAS	Planning Assistance to States
ppd	pounds per day
ppm	parts per million
PMP	Probable Maximum Precipitation
PVC	polyvinyl chloride
RESOP	Reservoir Operation Study Computer Program
RSMo	Revised Statutes Missouri
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geologicial Survey
SDFP	Spillway Design Flood Precipitation Value
SWD	sidewater depth
TM	Technical Memorandum
V	vertical
VFDs	variable frequency drives
WSEs	water surface elevations
WTP	Water Treatment Plant

Executive Summary

Under the Planning Assistance to States (PAS) cost share agreement between the U.S. Army Corps of Engineers (USACE) and the Missouri Department of Natural Resources (MDNR) Water Resources Center, CDM Federal Programs Corporation (CDM Smith) was requested to provide engineering and technical support services to the Kansas City District for Phase V of the Northwest Missouri Regional Water Supply Study. The objective of this Technical Memorandum (TM) is to provide a Middle Fork Water Treatment Plant (WTP) and Reservoir Condition Assessment.

The Middle Fork Water Company owns and operates a 700 gallon per minute (gpm) WTP and Stanberry Lake (otherwise known as Lake Elizabeth or Middle Fork Reservoir) in rural Gentry County Missouri, directly supplying the cities of Grant City and Stanberry. Both the Lake and the WTP were constructed in 1992. The WTP system is a single-train conventional clarification plant with rapid-rate dual-media filtration for treating surface water. The plant typically operates 6 to 10 hours daily, producing an average of 321,600 gallons per day(gpd) in 2010. Figure ES-1 illustrates the flow path and treatment chemicals used at the WTP.

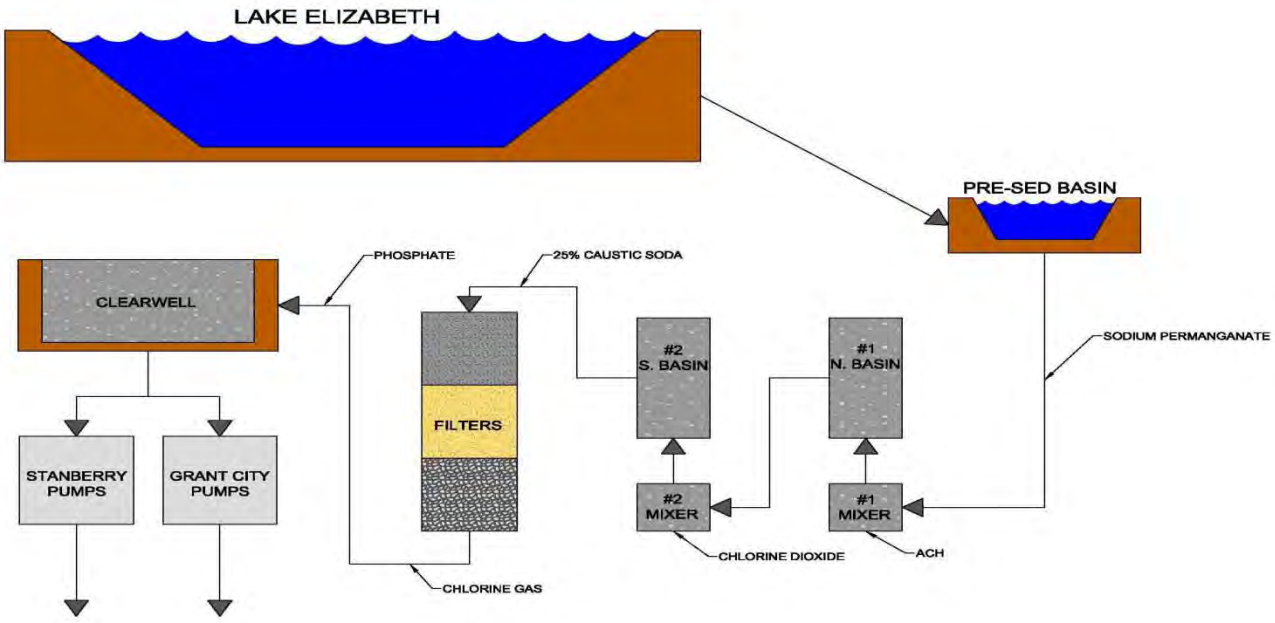

Figure ES.1 – MFWC WTP Schematic

In general, the WTP was found to be in good condition for its age with no finished water quality concerns. There were recommended improvements to the facility to address some redundancy and maintenance concerns for the plant. The improvements and opinion of probable cost for those improvements are summarized in Table ES.1.

Table ES.1 – MFWC WTP Improvements and Opinion of Probable Cost

Item	Cost
Backup Power	$65,000
Partitioning Pre-sedimentation Basin	$75,000
Raw Water Intake Renovations	$290,000
Chemical Containment	$45,000
High Service Pump Sump/Clearwell Extension	$132,000
Filter Rehabilitation	$32,000
Concrete and Coating Repair	$45,000
Instrumentation and Telemetry	$350,000
Subtotal	$1,034,000
Engineering, Legal, and Contingencies[1]	$465,000
Total Opinion of Probable Costs	$1,500,000

[1] Engineering, Legal, and Contingencies assumed to be 45-percent of subtotal.

Stanberry Lake is approximately 155 surface acres, with approximately 1,040 acre-feet of storage at full pool. The earthen dam is approximately 1,000 feet long and 34.5 feet high and is "non-regulated" by the State of Missouri. The contributing watershed is approximately 6.3 square miles of mostly pasture and forested area, with some land in cultivated agricultural use. Also constructed at the lake site is a single 3.5 surface acre earthen pre-sedimentation basin with approximately 20 acre-feet of storage. Stanberry Lake Dam was found to be in satisfactory condition at the time of inspection (November 10, 2011). A dam judged to be in satisfactory condition has minor operational and maintenance deficiencies. Table ES.2 summarizes the recommended improvements and additional studies recommended for Stanberry Lake along with a preliminary opinion of probable cost.

Table ES.2 Opinion of Probable Construction Cost for Stanberry Lake Repairs

Description	Cost
Studies and Analyses	
Perform a topographic survey	$6,000 - $8,000
Complete hydrologic and hydraulic studies	$20,000 - $25,000
Evaluate the feasibility of installing a low-level outlet at the primary spillway	$8,000 - $12,000
Recurrent Maintenance Recommendations (Assumed to be performed by MFWC personnel)[2]	
Perform regular maintenance	$ N/A
Remove animals and fill burrows	$ N/A
Fill voids behind discharge channel sidewalls	$ N/A
Place additional riprap on the upstream slope	$3,000 - $8,000
Recommendations, Maintenance, and Minor Repair	
Backfill areas of erosion	$6,000 - $ 10,000
Repair or replace existing precast concrete intake structure	$5,000 - $ 20,000
Remedial Modification Recommendations	
Remedial measures to address spillway capacity	TBD (based on H/H Analyses)
Subtotal	$48,000 - $75,000
Engineering, Legal, Contingencies1	$21,600 - $33,900
Total Opinion of Probable Construction Cost	$70,000 - $110,000

[1] Engineering, Legal, and Contingencies assumed to be 45-percent of subtotal.
[2] Not included in overall project cost.

A model was developed of the upstream drainage area to determine whether expansion of the reservoir was a feasible alternative. Two alternatives were identified for reservoir expansion. First, the existing dam height could be raised to increase the storage volume. The second alternative would be to construct a second dam upstream of the existing reservoir. Table ES.3 summarizes the existing firm yield capacity of Stanberry Lake and the possible increased capacity for the two expansion alternatives.

Table ES.3 Water Supply Firm Yield for All Analyses

Scenario	White Cloud Creek Gauge Firm Yield Average GPD*
Existing Conditions	386,000
Raised Dam	558,000
Additional Upstream Reservoir	559,000

* Existing Average Demand is 315,000 gpd.

The opinion of probable cost for the upstream reservoir alternative is $13.05 million.

In additions, a groundwater well is located near the WTP. Preliminary testing indicated that it may be able to produce an additional 300 gallons per minute. The well testing conducted at the time does not meet the current requirements to verify the flow rate. Additional testing and well development would be required before the capacity of the well can be verified. Additionally, the aquifer capacity to serve as a long-term water supply source is unknown. The cost for developing the well, not including aquifer testing, is $673,000. The opinion of probable cost for the WTP to treat the additional capacity of either the groundwater or surface water source is between $1.2 and $3 million, respectively.

Due to the high cost of reservoir improvements and the concerns of non-adequate groundwater, it is not recommended to expand the WTP at this time. Based on the current operation and maintenance costs for the WTP, an estimated $62,500 annual maintenance costs, and debt service to cover the sales cost of the WTP (a range of values was assumed) and the estimated opinion of probable cost, the range of water sales costs anticipated could vary between $3.20 to $3.90 per 1,000 gallons.

A bathymetric study is being conducted to evaluate the state of siltation in the Stanberry Lake. The results of that survey will be presented in a separate report.

Section 1
Introduction

Under the Planning Assistance to States (PAS) cost share agreement between the U.S. Army Corps of Engineers (USACE) and the Missouri Department of Natural Resources (MDNR) Water Resources Center, CDM Federal Programs Corporation (CDM Smith) was requested to provide engineering and technical support services to the Kansas City District for Phase V of the Northwest Missouri Regional Water Supply Study. The objectives of Phase V are to provide:

- Middle Fork Water Treatment Plant (WTP) and Reservoir Condition Assessment Technical Memorandum (TM)
- New WTP Feasibility Study TM
- Regional Economic Benefit Analysis TM
- Stage 1 Pipeline Preliminary Engineering Report Addendum
- Stage 1 Pipeline Base Mapping

This TM serves as the Middle Fork WTP and Reservoir Condition Assessment TM prepared for the Great Northwest Wholesale Water Commission (Commission).

Funding for this study was provided through the USACE PAS Program, Section 22 of the Water Resources Development Act of 1974 (Public Law 93-251) as amended to assist the States in the preparation of comprehensive plans for the development, utilization and conservation of water and related land resources, and Section 319 of the Water Resources Development Act of 1990 (Public Law 101-640). The MDNR, as the non-Federal sponsor of the PAS agreement, utilized State general revenue funds for 50-percent of this study's cost. CDM Smith and Bartlett & West completed the work under this agreement. Special recognition should also be given to the important role the Middle Fork Water Company (MFWC) and the Northwest Regional Council of Governments made by supporting communication with the Commission over the course of the project.

1.1 Purpose

This TM is meant to provide information to the Commission regarding the existing conditions of both the Middle Fork WTP and Reservoir, determine if there is enough water supply to expand the facilities, and provide a feasibility level description and cost to expand the facility to maximum capacity.

This TM is broken into the following sections:

- Section 2 – Water Treatment Plant Condition Assessment
- Section 3 – Stanberry Lake Condition Assessment
- Section 4 - Available Water Supply Analysis

- Section 5 – WTP and Stanberry Lake Expansion Feasibility
- Section 6 - Conclusions

1.2 Middle Fork WTP and Reservoir Description

The MFWC operates a 700 gallon per minute (gpm) WTP and Stanberry Lake (otherwise known as Lake Elizabeth or Middle Fork Reservoir) in rural Gentry County Missouri, directly supplying the cities of Grant City and Stanberry. Both the Lake and the WTP were constructed in 1992. The Middle Fork WTP and Stanberry Lake are located in Gentry County at 2961 U.S. Highway 169, Gentry, Missouri, 64453. The dam is located on Linn Creek approximately 1.2 miles upstream of the confluence of Linn Creek and the Middle Fork Grand River. The approximate coordinates of the dam are latitude N 40.2886 degrees and longitude W 94.4325 degrees as shown on Figure 1.1.

The contact information for MFWC, the Owner's, and care takers of this facility is:

Middle Fork Water Company
Brock Pfost, P.E.
2961 U.S. Highway 169
Gentry, Missouri 64453
Phone: 660-448-2111
Emergency Phone: 660-582-2580

The WTP system consists of raw water storage, water treatment, potable water storage, and pumping facilities with transmission and distribution of the finished water performed by the purchasing entities. The average daily use is about 350,000 gallons per day (gpd), with a maximum use of approximately 450,000 gpd.

Stanberry Lake is approximately 155 surface acres, with approximately 1,050 acre-feet of storage at full pool. The earthen dam is approximately 1,000 feet long and 34.5 feet high. The contributing watershed is approximately 6.6 square miles of mostly pasture and forested area, with some land in cultivated agricultural use. Also constructed at the lake site is a single 3.5 surface acre earthen pre-sedimentation basin with approximately 20 acre-feet of storage.

Missouri Dam Safety Laws and Regulations define jurisdictional dams as any artificial or man-made barrier which does or may impound water and is 35 feet or more in height (Section 236.400(5) Revised Statutes Missouri [RSMo]). Dam height is described as the difference in the elevation of either the natural bed of the stream or watercourse, or the lowest point on the toe of the dam and the dam crest elevation (10 Code of State Regulations [CSR] 22-1.020(24)). As such, Stanberry Lake Dam is a non-jurisdictional dam.

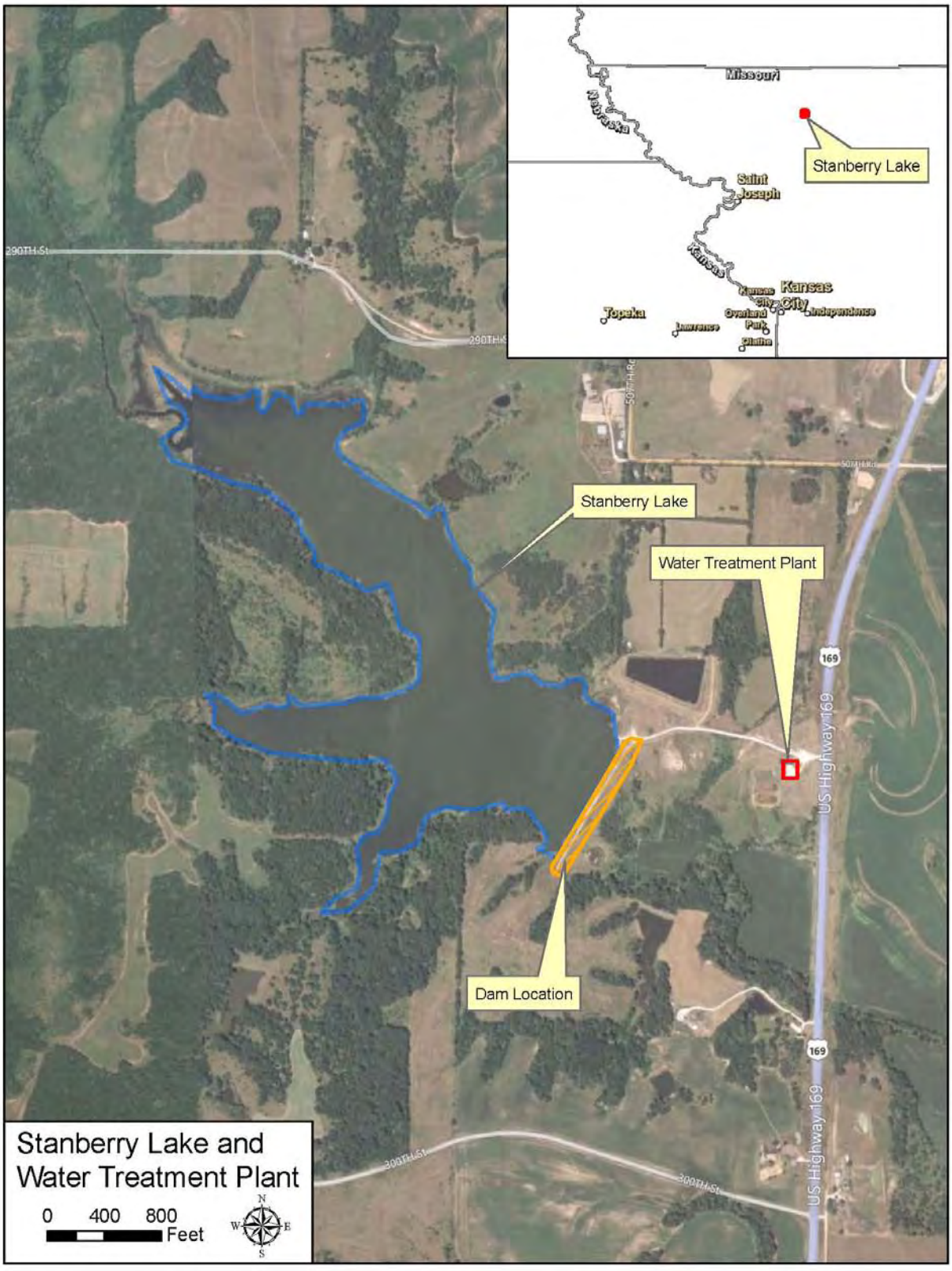

Figure 1.1 Stanberry Lake and Water Treatment Plant

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Section 2
Water Treatment Plant Existing Conditions

2.1 Introduction

The WTP is a single-train conventional clarification plant with rapid-rate dual-media filtration for treating surface water constructed in 1992. The plant operates at approximately 700 gpm and typically operates 6 to 10 hours daily, producing an average of 321,600 gpd in 2010. Figure 2.1 illustrates the overall process schematic for the WTP. A summary of raw water quality can be found in Appendix A.

The water distribution system is wholly owned by the purchasing entities starting at the exit of their respective flowmeters. No information was provided regarding current pipe materials, routing, or condition.

The following describes the individual unit processes at the WTP and summarizes the existing condition of each item. Photos of key items at the WTP are included in Appendix B. Data presented was provided by MFWC or observed during the site visit on November 10, 2011.

2.2 Stanberry Lake Intake

Elevations in this report are referenced to North American Vertical Datum 1988 (NAVD88), except where otherwise noted. The surface water intake is located near the center of the dam. The wetwell is constructed of a 27-foot-deep, 5-foot-diameter precast concrete manhole with a concrete base. Water is delivered into the wetwell from 12-inch-diameter radial intake pipes located at elevations 894, 879, and 874 feet (5, 10, and 15 feet depth below normal pool, respectively). Each intake pipe end is capped with a 12-inch-diameter wire-wrapped drum screens with 1/8-inch slot spacing. The lowest of the intakes is covered with sediment and is no longer in service. During drought events, the highest intake has been above the pool level, with the middle intake visible from the surface.

Water is pumped from the intake wetwell to the pre-sedimentation basins using a 5-hp low-lift submersible pump rated for approximately 700 gpm. This pump is manually operated as needed to maintain adequate water level in the pre-sedimentation basin.

As described in Section 2.8, potassium permanganate or sodium permanganate can be fed at the intake as needed for taste and odor control.

2.3 Pre-Sedimentation Basin

Water is pumped from the reservoir to the pre-sedimentation basin. The intended use of a pre-sedimentation basin is to allow settling of heavy particles and sediment. Proper design and use of a basin reduces the severity and frequency of spikes of poor water quality associated with rain and runoff events. The single earthen basin is approximately 9.15 million gallons (mg), or 3.5 surface acres with a design depth of 6 feet. The detention time is approximately 30 days when the facility is operated at an average treatment rate of 300,000 gpd.

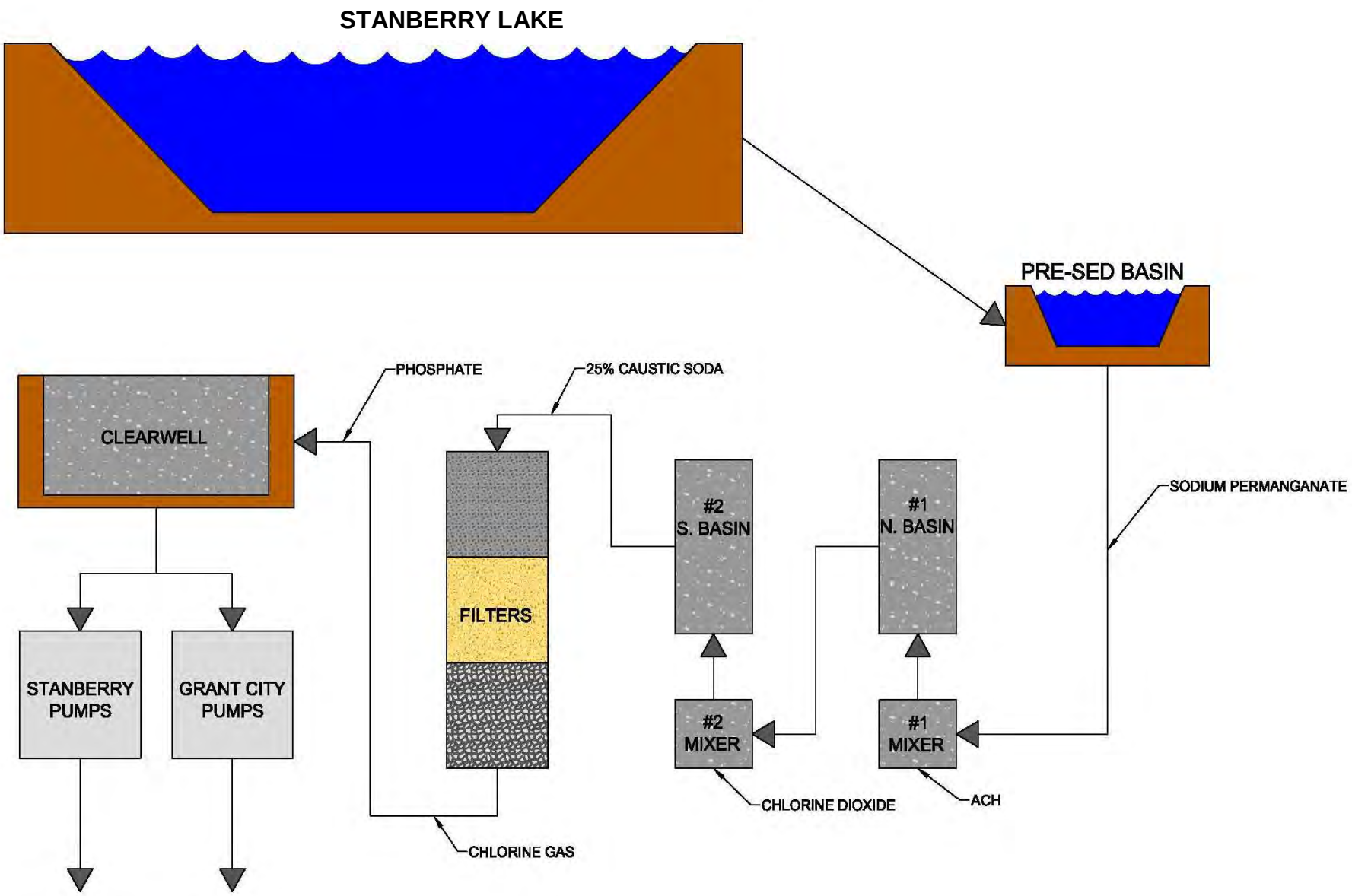

Figure 2.1 Water Treatment Plant Schematic

An intake similar in design to the Stanberry Lake intake is located in the southeast corner of the basin. Intake pipes are located at 915, 912, and 908 feet and the normal pool elevation is 916 feet. From the intake, water flows into an 11-foot-deep, 5-foot-diameter precast manhole, where it flows by gravity to the treatment facility through a 12-inch-diameter polyvinyl chloride (PVC) pipeline. The flowrate to the plant is controlled by a modulating valve mounted in the yard piping near the plant building.

2.4 Rapid Mix, Flocculation, and Sedimentation

Most chemicals in the treatment process are fed using the primary and secondary rapid mix basins. The primary rapid-mix basin precedes the primary flocculation basin. Aluminum chloride hydroxide sulfate (ACH) is fed into this basin at feed rates ranging from 65 parts per million (ppm) to 111 ppm. At 700 gpm, the contact time in this basin is approximately 35 seconds and a high-energy flash mixer is used to keep the basin well-mixed.

Water leaves the primary rapid-mix basin through a sidewall port and is transferred to the primary flocculation chamber. This rectangular basin is approximately 14 feet long and 20 feet wide, with an average sidewater depth (SWD) of 9-feet 6-inches. At 700 gpm, the contact time in this basin is approximately 30 minutes. A flocculation paddle is installed in this basin to maintain proper energy levels for optimal floc production. The secondary flocculation chamber is of the same size and construction.

From the primary flocculation basin, water passes through a picket baffle fence to a 100-foot-long by 20-foot-wide exterior primary sedimentation basin, with a sloped floor and average SWD of approximately 14 feet. Detention time in this basin is 5 hours at 700 gpm, with an average horizontal flow velocity of 0.33 feet per minute.

The primary sedimentation effluent is collected in a submerged orifice launder and piped back to the secondary rapid mixer in the treatment building. Chlorine dioxide is fed into this basin at feed rates ranging from 0.64 ppm to 0.89 ppm. At 700 gpm, the contact time in this basin is approximately 35 seconds and is the same size as the primary rapid-mix tank. No mixer is currently equipped in this basin. After the rapid mix tank, the water goes to the secondary flocculation basin and then through a picket baffle fence to an exterior secondary sedimentation basin. The primary and secondary sedimentation basins have the same geometry and flow characteristics. Water from this basin is collected using a submerged orifice launderer and piped to the filter influent header.

2.5 Disinfection

Primary disinfection in the existing process is achieved using chlorine dioxide. The chlorine dioxide is generated by a chlorine dioxide generator using gas chlorine and liquid sodium chlorite (25-percent by weight). The current feed range for chlorine dioxide is 0.64 to 0.89 ppm, varied seasonally to maintain adequate contact time (CT) values according to raw water temperature.

Secondary (residual) disinfection in the existing system is achieved by feeding gas chlorine from 150-pound cylinders contained in a dedicated storage room. Gas chlorine is fed through bottle-mounted vacuum regulators to an ejector where the chlorine is carried, in partial solution, to the feed points. Chlorine is currently fed into the filter effluent at 3 to 4 ppm (28-32 pounds per day (ppd)), varied seasonally to maintain adequate distribution residual.

Although actual chlorine usage is only 5 to 8 ppd, the current chlorine usage rate is approximately 28 to 32 pounds projected over a 24-hour operation day. This rate is near the recommended maximum withdrawal rate of 40 pounds per 24-hour day from a single 150-pound cylinder. Feeding at a higher rate than recommended encourages excessive cylinder cooling and freezing in the nozzle, eventually creating a self-limiting condition where additional feed rate increases are not possible. If higher rates are required, consideration should be made for operating two cylinders in parallel to prevent cylinder freezing and premature chlorination equipment failure.

2.6 Filters

Following sedimentation, the water is filtered using a conventional rapid-rate dual-media filter system. Three filters are used, each 15 feet long by 7 feet 6inches wide to provide an effective filter area of 112.5 square feet. Assuming a process flowrate of 700 gpm, the filtration rate with all three filters in service is approximately 2.1 gpm per square foot. With one filter offline, the filtration rate is 3.1 gpm per square foot. MDNR design criteria currently sets the design filtration rate at 2.0 gpm per square foot. To remain in compliance with this requirement, the filters must be backwashed either when the WTP is not running, or when the WTP production rate is reduced to 350 gpm.

The media bed was originally equipped with 18 inches of media support gravel, followed by 18 inches of filter sand, and capped with 12 inches of anthracite. The overflow edge of the stainless steel washwater collection troughs is located approximately 2 feet 4 -inches above the design media level, allowing for almost 100-percent bed expansion during backwashes.

The underdrain is a header-and-lateral system with an 8-inch-diameter perforated ductile iron pipe (DIP) header running the length of the filter, and 2-inch-diameter perforated PVC laterals connected to the header 8 inches apart. The underdrain system is bedded to the springline with sand-cement grout.

Filter face piping consists of 10-inch-diameter DIP header piping and 8-inch-diameter DIP collector or branch piping to each filter. Each filter effluent outlet also has a 2-inch-diameter filter-to-waste pipe directly connected to the washwater drain piping.

Each filter is equipped with an 8-inch-diameter vent tied into the filter effluent piping. Upon inspection, the vents showed no indication of protection from direct contamination. The vents should be protected from insect and animal entry using a minimum 18-mesh non-corrodible screen, and consideration of using air-vacuum release valves should be examined in this application to protect against possible contamination of finished water.

Filter control is established using the traditional rate-of-flow control methodology. In this method of control, effluent flow from the underdrains is throttled using control valves linked to floats. As filter headloss increases, the effluent control valve opens to allow the flowrate to remain near constant. When the headloss reaches a pre-determined maximum level, the filter is taken offline and backwashed. Backwash is a water-only backwash using a single dedicated backwash pump.

Although a detailed evaluation of the media was not conducted, the facility operator reports the media is original to the plant, so its current service life is about 19 years. Media in service this long becomes rounded and fractured and has typically reached its expected replacement life. Using this rule-of-thumb approach, the media at the Middle Fork facility is likely due for replacement.

2.7 Clearwell and High Service Pumps

A 340,000-gallon onsite clearwell stores finished water until it is pumped to the transmission system. The clearwell is a partially buried rectangular tank constructed from cast-in-place reinforced concrete. The tank is configured in such a way that it can be divided nearly in half for maintenance or water age concerns. The original design included vertical turbine lineshaft pumps with their suction and bowls hanging into the clearwell. Only one vertical turbine high service pump and the backwash pump remain in this configuration; the rest have been converted to submersible pumps. Since no sump was provided for the pumps, the clearwell has been limited to the amount of drawdown can be used. With submersible pumps and their bottom-mounted motor, this problem has become even further aggravated, with less than half of the storage available as drawdown.

2.8 Chemical Feed Systems

Table 2.1 below outlines the various chemicals fed at the facility. The liquid chemicals are all stored in polyethylene tanks, and all without any secondary spill containment.

Table 2.1 Chemical Systems

Chemical Name	Use	Feed Point	Typical Dosage	Storage Location
Sodium Permanganate	Taste & Odor, Total Organic Carbon Reduction	Intake	20-25 ppm	Intake Chemical Enclosure
Aluminum Chloride Hydroxide Sulfate	Coagulant	Primary Rapid Mix	65-120 ppm	Chemical Room
Sodium Chlorite	Chlorine Dioxide Generation	Chlorine Dioxide Generator		Chemical Room
Chlorine Dioxide	Primary Disinfectant	Secondary Rapid Mix	0.6-1.0 ppm	N/A
Caustic Soda	pH Adjustment	Filter Influent	15-20 ppm	Secondary Flocculation Basin
Chlorine Gas	Chlorine Dioxide Generation	Chlorine Dioxide Generator		Chlorine Room
Chlorine Gas	Secondary Disinfectant	Filter Effluent	3-4 ppm	Chlorine Room
Sodium Hexametaphosphate	Scale Inhibitor	Filter Effluent	3-4 ppm	Chemical Room

2.9 Electrical, Plumbing, and Mechanical

No major electrical issues were uncovered by the field investigation. Any rehabilitation or replacement of the high-service or intake pumps should include variable frequency drives (VFDs) in place of fixed speed starters and pump control valves for pump modulation. Beside the soft-start capabilities provided by VFDs, the efficiencies from running pumps at reduced speeds rather than throttling using valves help reduce energy usage and cause the pumps to run in optimal pump conditions. VFDs also allow the operator to better manage flowrates and optimize pumping schedules.

Plumbing and mechanical systems in the facility are adequate. Mechanical ventilation was provided as required to maintain humidity and temperature control. Humidity in the filter room could be further controlled by using dehumidification or air-conditioning units, if desired. The ventilation system in the high service pump room may need to be modified to accommodate the additional heat created by VFDs, if they're installed, but if a new high service pumping facility is constructed, this recommendation obviously becomes irrelevant.

2.10 Recommended Improvements and Opinion of Probable Cost

The following improvements are recommended to improve the existing condition of the WTP.

2.10.1 Backup Power

The present facility doesn't have an onsite generator or any provisions for a quick connection to a portable unit. Since water is delivered from the pre-sedimentation basin through the entire treatment process without re-pumping, clean water can be put in the clearwell without large electrical inputs. Running the high-service pumps, on the other hand, is necessary to distribute finished water to the system and would require a significant generator. The opinion of probable cost (OPC) below illustrates the costs to add facilities for semi-permanent backup power at the treatment facility. The project would consist of a trailer-mounted generator, a manual transfer switch, and other electrical modifications necessary. The estimated construction cost for this project, including the generator, is approximately $65,000.

2.10.2 Pre-sedimentation Basin Modifications and Maintenance

Pre-sedimentation basins with 24 to 48 hours of storage are an asset to most surface WTPs. This amount of storage allows for some turbidity reduction and buffers the process from weather induced or turnover-related spikes in turbidity. As operated, the pre-sedimentation basin provides approximately 30 days of storage. Basins with this much storage often see the water quality revert back to that common in reservoirs due to algae regrowth and wave action mixing.

The figure and OPC below illustrate a project that would partition the existing basin into two smaller basins with 24 to 48 hours of storage each while preserving the full volume of the existing basin. By constructing two smaller basins from the existing large basin, one basin can be out of service for maintenance while the other remains in operation. Sediment accumulation should also be removed from the basins during construction of the partition berm.

Along with this project, a piping modification is recommended that will allow the intake pumps to feed directly to the treatment plant. This piping modification, along with VFD's running the intake pumps, will allow additional operator flexibility. Using the new bypass piping, operator can choose to feed directly from the reservoir during maintenance or when water quality is found to actually degrade in the pre-sedimentation basins.

The estimated construction cost for this project, including piping, dredging and revetment, and an earthen partition berm is $75,000. See Figure 2.2 for illustration.

2.10.3 Raw Water Intake Renovation

As recommended in the January 7, 2011 letter from David Williams to Brock Pfost included in Appendix C, renovations should be constructed at the raw water intake. These renovations should focus on recovering intake flexibility, safely housing chemical storage, and increasing pumping flexibility.

The letter previously referenced recommends a floating intake system. This type of intake prevents issues seen in the current fixed-depth intake system, including intakes being buried in sediment or left out of the water when lake levels decline. Floating intakes can have snorkel-type draft tubes with variable level adjustment for targeting the highest-quality strata in the reservoir.

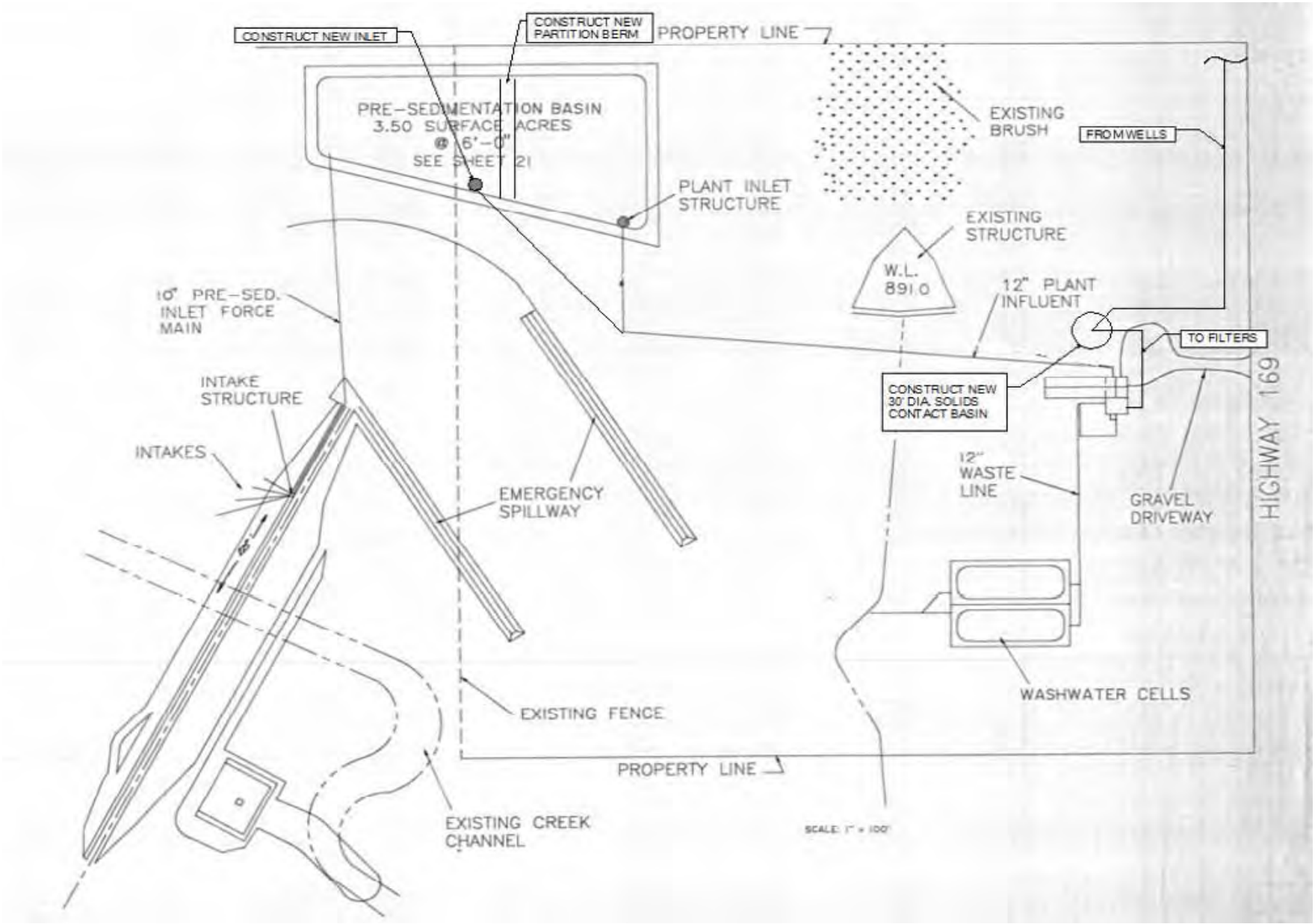

Figure 2.2 Pre-Sedimentation Basin Improvements

A heated chemical storage facility, at least 150 square feet, should be constructed at the site to prevent ice buildup in the wetwell and protect the pump, chemical storage and feed equipment, and electrical gear. If a building were to be constructed on top of the dam near the intake wetwell, proper care should be taken to ensure adequate foundation design to protect the building foundation and dam integrity. An opinion of probable costs for the intake renovation projects is shown in Table 2.2.

Table 2.2 Opinion of Probable Cost for Raw Water Intake Renovations

Description	Unit Price	Quantity	Units	Extension
Floating Intake w/ Adj. Draft Tube	$175,000	LUMP SUM		$175,000
Chemical Building	$65,000	LUMP SUM		$65,000
Misc Piping	$12,000	LUMP SUM		$12,000
VFD	$7,500	LUMP SUM		$7,500
Electrical	$15,000	LUMP SUM		$15,000
Instrumentation and Control	$15,000	LUMP SUM		$15,000
Subtotal				$290,000

2.10.4 Chemical Containment

In the event of a tank rupture or overfill, secondary chemical containment prevents chemical spills from becoming widespread. This reduces exposure and slipping hazards in the storage room, along with preventing issues from mixing reactive chemicals. Typical design practices utilize containment vessels capable of storing 150 percent of the contained volume. There is currently no secondary chemical containment provided for liquid chemical storage in the facility.

In the chemical room, a raised, grated floor with containment cells below can be constructed. Existing unused equipment, including the unused alum feeder, should be demolished from the room to allow space for the containment modifications. The estimated construction cost for this project, including concrete containment walls and grated platforms is $45,000.

2.10.5 High Service Pump Sump/Clearwell Extension

As previously described, due to required pump submergence levels and pump intake elevation, the high service pumps are incapable of accessing the full storage capacity of the clearwell. One solution that has been identified is abandoning the existing high service pumps and constructing an adjacent wetwell property designed for submersible pump installation. Along with construction of a wetwell, the high service pumps would be manifolded together, with their output controlled using variable frequency drives. If submersible pumps continue to be used, a “pitless” style discharge manifold could be created that would help reduce the need for a building over the pumps. An OPC for the project is provided in Table 2.3.

Table 2.3 Opinion of Probable Cost for High Service Pump Sump/Clearwell Extension

Description	Unit Price	Quantity	Units	Extension
Concrete Pump Wetwell	$65,000	LUMP SUM		$65,000
Misc Piping	$12,000	LUMP SUM		$12,000
VFD	$7,500	4	EA	$30,000
Electrical	$15,000	LUMP SUM		$15,000
Instrumentation and Control	$10,000	LUMP SUM		$10,000
Subtotal				$132,000

2.10.6 Filter Rehabilitation and Media Replacement

As previously described, the filter media has reached the end of its expected life and is due for replacement. Media replacement projects are rather routine, with only removal and subsequent media placement steps, but any time the media is removed, underdrain, washtrough, and face piping maintenance should be performed. The estimated cost for media replacement and fixed equipment rehabilitation is $32,000.

2.10.7 Concrete and Coating Repair and Replacement

Structural reinforced concrete in the facility is generally in good condition, with two notable exceptions. Considerable damage to the loading dock face has occurred, exposing reinforcing steel. The concrete in this area should be scarified to remove loose material and patched to prevent further reinforcing steel corrosion. Dock bumpers should be installed to prevent further damage.

The joint where the secondary clarifier south wall meets the treatment building is exhibiting some basin leakage and damage that is currently cosmetic in nature. The concrete in this area should be repaired and sealed with a patching compound to prevent corrosion to reinforcing steel. External reinforcement of this area may be necessary to prevent future damage.

Coating failure is apparent in many areas of the facility, especially in the humid environment in the filter piping gallery. Piping exhibiting paint failure should be blasted and recoated. Pipe that exhibits more than simple surface corrosion should be replaced. All exposed concrete should be cleaned and brush-blasted prior to coating with a durable epoxy coating. The recoating cost may vary based on the extend of serious pipe corrosion and replacement, but an OPC, assuming no pipe or valve replacement, but including the previously mentioned concrete repairs, is approximately $45,000.

2.10.8 Instrumentation and Telemetry

The current facility has very little online instrumentation and no data collection or historian software. Instrumentation, such as platform scales, online chlorine analyzers, pressure transducers, and electric meters, all work together to provide the operator useful information that can be used to optimize process efficiency, chemical usage, and electrical demand. This information should be collected with data logging software and stored to a database. Data from the database can then be queried to provide trend data in the form of graphs and reports.

The cost for such a system varies widely based on the level of service, including the number of sensors deployed, history resolution and retention time, and the level of sophistication provided in reporting, but could be estimated between $150,000 and $350,000.

2.10.9 Opinion of Probable Cost

The OPC for the improvements outlined above are summarized in Table 2.4 below.

Table 2.4 WTP Existing Conditions Opinion of Probable Cost

Item	Cost
Backup Power	$65,000
Partitioning Pre-sedimentation Basin	$75,000
Raw Water Intake Renovations	$290,000
Chemical Containment	$45,000
High Service Pump Sump/Clearwell Extension	$132,000
Filter Rehabilitation	$32,000
Concrete and Coating Repair	$45,000
Instrumentation and Telemetry	$350,000
Subtotal	$1,034,000
Engineering, Legal, and Contingencies[1]	$465,000
Total Opinion of Probable Costs	$1,500,000

[1] Engineering, Legal, and Contingencies assumed to be 45-percent of subtotal.

2.11 2011 Operation and Maintenance Costs

MFWC provided the 2011 operation and maintenance costs. These costs were grouped into the following categories and are summarized in Table 2.5

Table 2.5 2011 Operation and Maintenance Costs

	2011 Operating and Maintenance Costs
Payroll	$50,220
Chemicals	$72,398
Power	$26,932
Admin	$24,378
Maintenance	$19,807
Total	$193,735

Section 3
Stanberry Lake Existing Conditions

On November 10, 2011, CDM Smith conducted a visual inspection of the Stanberry Lake Dam located in Gentry, Missouri. This inspection was not intended to substitute for a detailed engineering study and evaluation. In reviewing this report, it should be noted that the reported conditions of the dam are based on field observations of existing conditions at the time of inspection, in addition to other data made available to the inspectors.

It is also important to note that the condition of a dam depends on several internal and external variables, and is constantly changing. It would be inaccurate to assume that the description of dam conditions contained herein will continue to represent the actual conditions of the dam at some point in the future. Thorough care and inspection will help to ensure that unsafe conditions will be detected in the future.

The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to evaluate if the dam poses hazards to human life or property. Subsurface explorations, analytical evaluations such as slope stability or hydrologic and hydraulic (H&H) analysis were not done and are beyond the scope of this inspection. Recommendations for required maintenance and repairs are based on the visual inspection. Recommendations for further detailed investigations, if considered required, are also part of this report.

To provide the reader with a better understanding of the report, definitions of commonly used terms associated with dams are provided in Appendix D. Many of these terms may be included in this report. The terms are presented under common categories associated with dams which include: 1) orientation; 2) dam components; 3) size classification; 4) hazard classification; and 5) general. As defined in Appendix D standard terminology for noting orientation of specific observations at dams are referred to as upstream or downstream, and as left or right. The terms left and right refer to the directions observed when looking downstream.

3.1 Dam Description

The Stanberry Lake Dam is owned and operated by MFWC and was constructed in 1992 as an earthen dam. The lake is located on a tributary to Middle Fork Grand River about 10 miles northeast of Stanberry, Missouri. Inflow to the upper reservoir is from Linn Creek, with a drainage area of approximately 6.3 square miles.

The dam is approximately 1,000 feet long and the crest of the dam is approximately 20 feet wide. The crest elevation of the earth embankment is elevation (El.) 896.7, with a maximum height of approximately 34.5 feet. Construction drawings indicate that the upstream slope is approximately 2.5 horizontal (H) to 1 vertical (V) (2.5H:1V); however, some areas were measured at 2H:1V. The upstream slope of the dam is typically covered with 6- to 12-inch-diameter riprap. The downstream slope is approximately 3H:1V and is covered with brush and grass approximately 30 inches high. There is a 15-foot-wide bench at about El. 876.8. A typical cross-section of the Dam is shown in Figure 3.1.

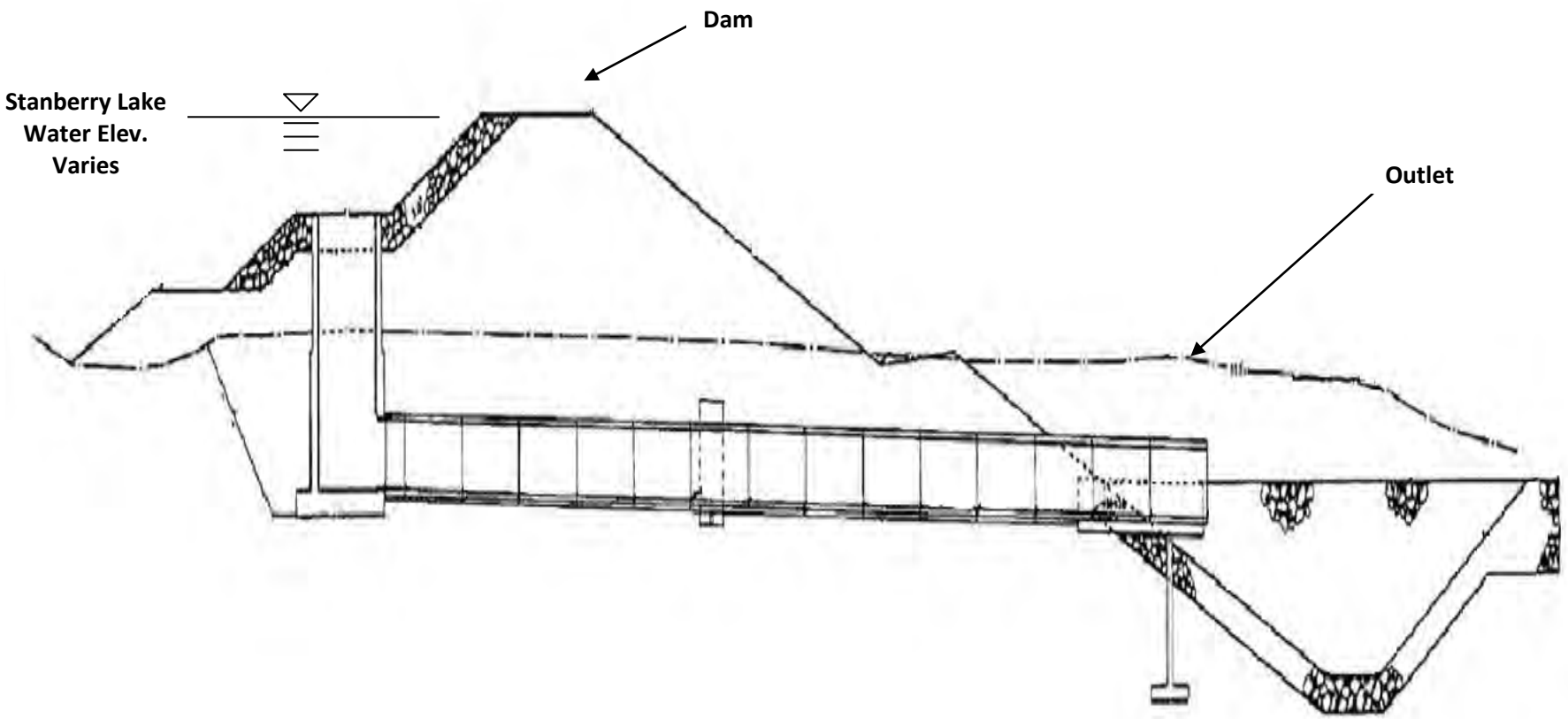

Figure 3.1 Typical Cross Section Through Drop Inlet Spillway – Stanberry Lake Dam

The water level in the Lake is controlled by a 12-foot by 6-foot concrete drop-inlet (primary) spillway. The primary spillway is located on the upstream slope near the right side of the dam. A 250-foot-long auxiliary spillway is situated at the left abutment of the dam. The total discharge capacity is approximately 4,000 cubic feet per second (cfs).

The drop inlet discharges into a 66-inch-diameter precast concrete pipe, with an upstream invert of 867.0 that runs through the dam and discharges at El. 864.2 to a plunge basin immediately downstream of the dam. The water from the plunge basin flows into Linn Creek through a stone-lined channel. Construction plans show the primary spillway discharge pipe with a filter diaphragm located approximately 32 feet downstream of the center of the embankment crest.

3.1.1 Operations and Maintenance

The dam and site are monitored on a daily basis by MFWC personnel. Permanent MFWC staff are responsible for the routine maintenance of the dam and appurtenant structures. The reservoir level is monitored and recorded on 15-minute intervals by U.S. Geological Survey (USGS) gaging station 06896189. The USGS gage datum is the NAVD 88. The gaging station also provides reservoir storage and surface area based on USGS recorded water surface levels. The gaging station period of record began in March 2007.

3.1.2 MDNR Size Classification

Missouri Dam Safety Laws and Regulations define jurisdictional dams as any artificial or man-made barrier which does or may impound water and is 35 feet or more in height (Section 236.400(5) RSMo.). The structural height of the Stanberry Lake Dam is approximately 34.5 feet. Stanberry Lake Dam is a non-jurisdictional dam.

3.1.3 MDNR Hazard Potential Classification

Laws pertaining to Missouri dam safety are found in Sections 236.400 - 236.500 of the RSMo. - enacted in 1889 and last amended in 1993. Rules are found in 10 CSR 22-1.010 to 10 CSR 22-4.020. The hazard classification criteria are defined in the Rules as the "downstream environmental zone." Three environmental classes are defined:

1. Class I - Contains 10 or more permanent dwellings or any public building
2. Class II - Contains 1 to 9 permanent dwellings or 1 or more campgrounds with permanent water, sewer, and electrical services or 1 or more industrial buildings
3. Class III - Everything else

Although Stanberry Lake Dam is a non-jurisdictional dam under Missouri Laws and Regulations, review of State hazard classification criteria finds the Stanberry Lake Dam to be a Class III hazard potential dam. The dam is located immediately upstream of U.S. Highway 169. It appears that a failure of the dam at maximum pool may cause damage to the highway and utilities located along the highway right-of-way. In addition, a breach would cause significant interruption to the MFWC treatment plant. It appears that a breach of the Stanberry Dam would not impact any permanent dwellings or public buildings. Therefore, Stanberry Lake Dam should be considered a Class III hazard potential dam.

3.1.4 Pertinent Engineering Data

The pertinent engineering data presented herein are based on observations and measurements performed during the CDM Smith inspection and by data contained in previous reports. Elevations are referenced to NAVD 88.

The following reservoir elevations in Table 3.1, surface area, and storage volumes are estimated based on USGS topographic maps, and existing drawings and studies.

Table 3.1 Reservoir Elevations, Surface Area, and Storage Volume

Condition/Pool Level	Elevation (feet)	Surface Area (acres)	Storage Volume (acre-feet)
Primary Spillway EL (Normal)	889.3*	140	1,00
Auxiliary Spillway EL	893.4	210	1,600
Crest EL (Maximum)**	896.7	280	2.3

* Primary Spillway Elevation taken from survey completed for this task order.
** Surface Area and Volume approximated.

The following elevations in Table 3.2 are based on information included on construction documents and field measurements.

Table 3.2 Reservoir Expanded Elevations

Item	Elevation (feet)
Top of Dam	896.7
Spillway Design Flood*	100-year
Normal Pool	890.0
Primary Spillway Crest	890.0
Auxiliary Spillway	893.4
Upstream Water at Time of Inspection	887.2
Discharge Pipe inlet elevation	867.0
Discharge Pipe outlet elevation	864.2

* No hydrologic or hydraulic analyses were completed as part of this study.

Drawings, daily construction reports, and material test reports were provided to CDM Smith at the time of the inspection and are included in Appendix F. Operating records provided for the Stanberry Lake Dam were limited to water level and related storage volumes and impoundment surface.

See Table 3.3 Summary Data Table for summary of pertinent engineering data.

Table 3.3 Summary Data Table

Report Data	Data Provided by the Inspecting Engineer
National ID #	NA
Dam Name	Stanberry Lake Dam
Dam Name (Alternate)	Lake Elizabeth Dam
River Name	Linn Creek
Impoundment Name	Stanberry Lake, Lake Elizabeth, Linn Creek Lake, Middle Fork Reservoir
Hazard Class	Class III
Size Class	NA
Dam Type	Earth Embankment
Dam Purpose	Water Supply
Height of Dam (feet)	34.5
Drainage Area (square miles)	6.3
Reservoir Surface Area (sq. mi.)	0.22
Normal Impoundment Volume (acre-feet)	1040
Max Impoundment Volume (top of dam) acre-feet)	1625
SDF Impoundment Volume* (acre-feet)	1353
Primary Spillway Type	Drop Inlet
Spillway Length (feet)	45
Freeboard at Normal Pool (feet)	5
Primary Spillway Capacity* (cfs)	400
Auxiliary Spillway Capacity* (cfs)	3,600
Low-Level Outlet Capacity* (cfs)	0
Spillway Design Flood* (flow rate - cfs)	4,000
Winter Drawdown (feet below normal pool)	0
Drawdown Impoundment Vol. (acre-feet)	0
Public Road on Crest	No
Public Bridge over Spillway	No
EAP Date (if applicable)	Not available
Date of Field Inspection	11/10/2011
Consultant Firm Name	CDM Smith
Inspecting Engineer	William Friers, Stephen Whiteside
Engineer Phone Number	518 782-4513

* Volume approximated

3.2 Visual Inspection

Stanberry Lake Dam was inspected on November 10, 2011. At the time of the inspection, the weather was clear and the temperature was approximately 45 degrees Fahrenheit (°F). A site sketch and notes are shown on Figure 3.2. Photographs to document the current conditions of the dam were taken during the inspection and are included in Appendix B. The locations of the photographs are shown in Figure 3.3. Underwater areas were not inspected. A copy of the inspection checklist is included in Appendix E.

Stanberry Lake Dam was found to be in SATISFACTORY condition at the time of inspection. A dam judged to be in satisfactory condition has minor operational and maintenance deficiencies. The deficiencies that were noted include:

- Areas of erosion on upstream slope observed; 3-feet high x 4-feet deep accompanied by steep embankment slopes (2H:1V)
- Slope erosion on the right side and rear of the primary spillway (drop inlet)
- Tall grass, brush, and saplings were observed growing in the riprap on the upstream slope
- Animal burrows observed on the upstream and downstream slopes
- Tire rutting; approximately 8-inches deep on left half of the crest and on downstream bench, with some puddles
- There is no low-level outlet for the dam. A low-level outlet would allow the care taker to lower the reservoir below normal pool stage for lake management purposes, routine repairs, or dam safety purposes.
- Cracks and deterioration on the exterior of the water intake structure observed near the base of the structure.
- Numerous trees, up to 4 inches in diameter, observed on the lower section of the downstream slope
- Erosion of material from within the plunge basin, appears to have increased the structural height of the dam

The majority of the crest (Photographs 5, 6, and 7) of the dam was straight with no signs of misalignment, sloughing, or settlement. The upstream slope (Photographs 8, 9, 12, and 15) generally appeared to be stable. Some brush was observed on the upstream slope, but it did not obstruct viewing the slope. The downstream slope (Photographs 4, 16, and 17) above El. 876.8 appeared to be approximately 3H:1V and was covered predominantly with tall brush and grass. A 15-foot-wide bench, at about El. 876.8, had extensive tire ruts, approximately 8 inches deep (Photographs 4, 18, 19, and 22). Otherwise, the bench was generally covered with well established grass. The downstream slope, below El. 876.8 was approximately 3H:1V and was generally overgrown with tall brush, grass, and trees up to 4 inches in diameter (Photograph 20). Several animal burrows were observed on the lower slope (Photograph 21).

An erosion rill was observed on the downstream embankment slope, to the right of the primary spillway outlet (Photograph 26). In addition, a 6-inch-diameter animal burrow was observed on the slope left of the 6-foot-diameter primary spillway outlet pipe (Photograph 23 and 24). The abutment contacts appear to have a good transition into the natural topography (Photographs 1 and 7).

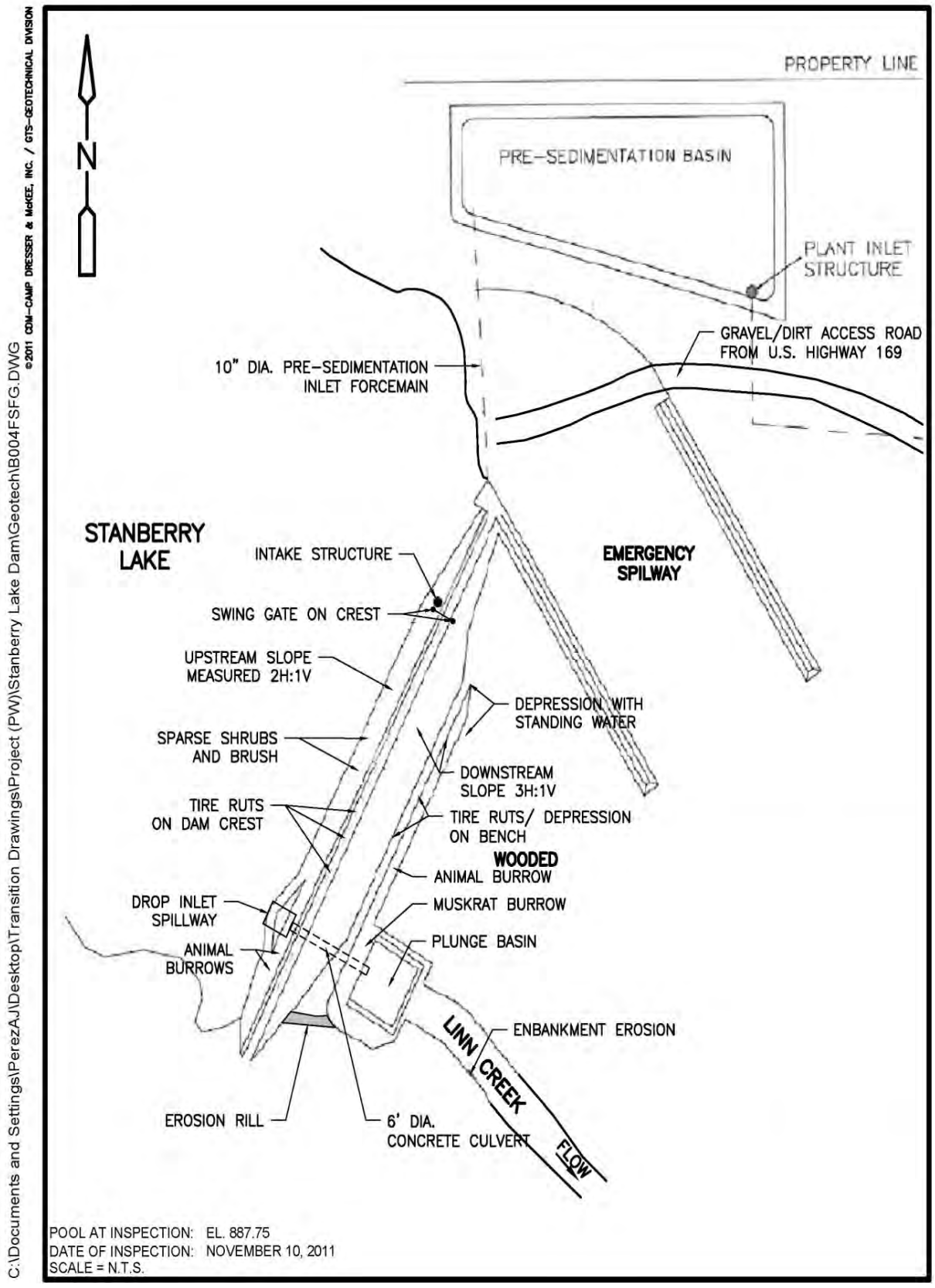

Figure 3.2 Field Sketch and Notes - Stanberry Lake Dam

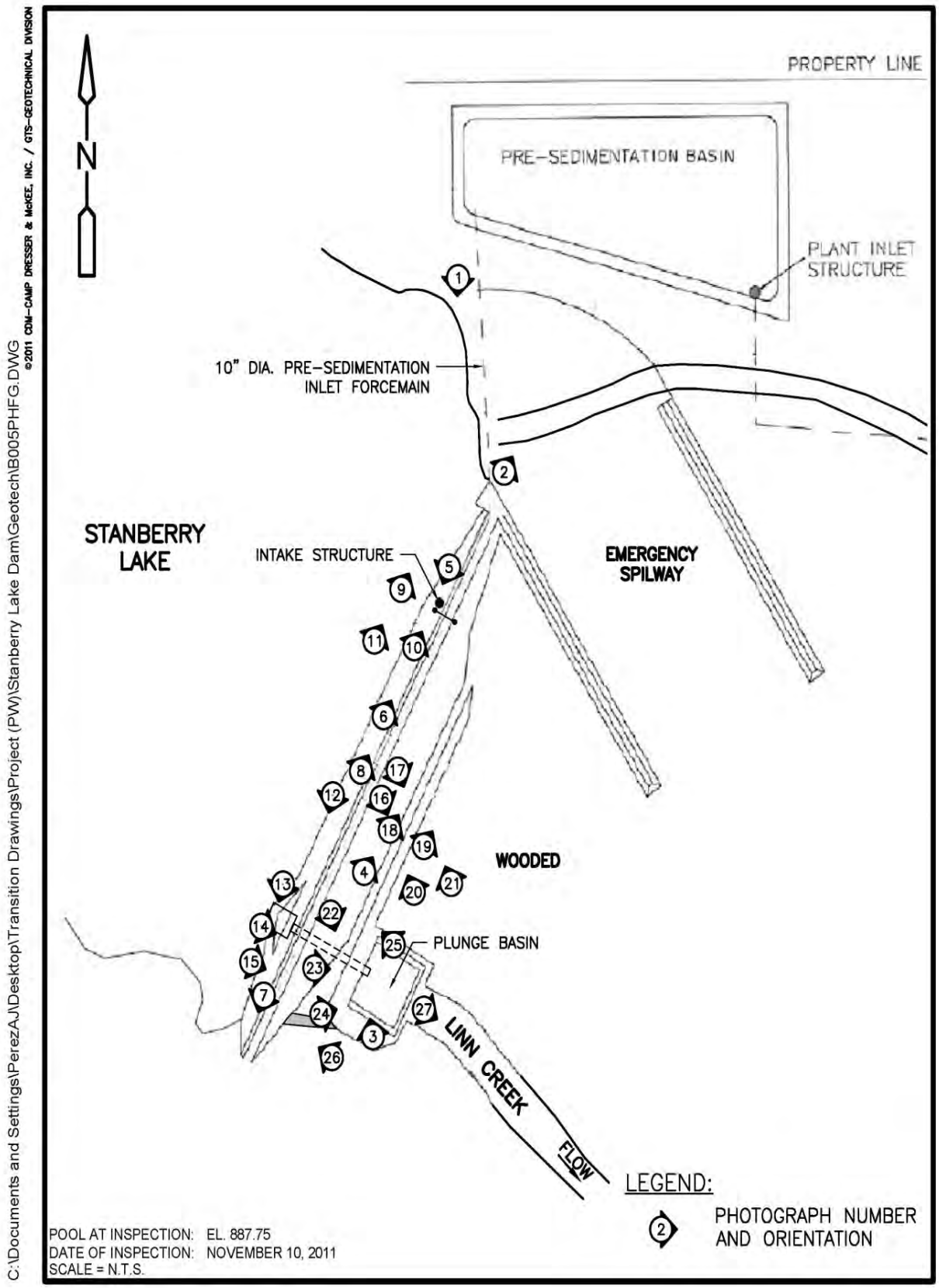

Figure 3.3 Photograph Locations Plan - Stanberry Lake Dam

The caretaker reported the 6-inch-diameter foundation drain installed along the length of the toe of the downstream slope and the pipe from the filter diaphragm discharge adjacent to the primary spillway outlet pipe. The caretaker indicated that limited water flows have been observed discharging from the pipe intermittently. The foundation drain discharges to the plunge basin, left of the primary spillway discharge pipe (Photograph 28). The drain pipe was not observed during the inspection.

No wet areas were observed at the dam toe or within the downstream area.

3.2.1 Appurtenant Structures

The concrete primary spillway on the upstream slope of the dam was in good condition (Photographs 13, and 14). The water level at the time of the inspection was approximately El. 887.75.

The interior of 66-inch-diameter primary spillway discharge pipe was not inspected because of restricted access. The section of exposed pipe seen on the downstream slope of the dam appeared to be in good condition (Photographs 20 and 21). The downstream channel was free of debris. The left and right banks of the discharge channel were eroded approximately 150 feet from the toe of the dam (Photograph 27).

The water supply intake structure, located on the upstream slope of the dam, is approximately 400 feet from the left abutment (Photograph 10). Concrete near the base of the intake has cracked to a depth of approximately 3 inches. It appears as though efforts have been made to patch the damaged area, however the attempted repairs have also failed (Photograph 11).

3.2.2 Downstream Area

U.S. Highway 169 is approximately 0.3 mile downstream of the dam. It appears that a failure of the dam at maximum pool may cause damage to the highway and utilities located along the highway right-of-way. In addition, a breach would cause significant interruption to the MFWC treatment plant. It appears that a breach of the Stanberry Lake Dam would not impact any permanent dwellings or public buildings.

3.2.3 Reservoir Area

Stanberry Lake's western shoreline is wooded while the balance is grassland.

3.2.4 Caretaker Interview

A caretaker interview was held during the inspection with the MFWC staff who accompanied the inspection team. MFWC staff present during the inspection included Brock Pfost, P.E. and the plant operator. Information collected during discussions with the MFWC personnel are reflected in other pertinent sections of this report.

3.3 Operation and Maintenance Procedures

The MFWC staffs the filtration plant located downstream of the dam. Although Stanberry Lake Dam does not have written operating procedures, the dam is observed on a daily basis. MFWC performs general maintenance for the dam, which includes mowing, minor tree removal and removal of debris from the primary spillway and water intake structure. MFWC removes brush and trees from the dam approximately once every year or as needed. Stanberry Lake Dam does not have written operating procedures. An Emergency Action Plan is not in place for Stanberry Lake Dam. An early warning system is in place via daily monitoring by plant staff. MDNR strongly recommends that an operating and energy action plans be prepared.

Routine maintenance efforts include those activities that should be performed regularly (monthly and/or annually) and that usually can be completed by the dam owner/caretaker. Typically, no engineering design support is required for these activities. These maintenance efforts and the suggested frequency are as follows:

Within the first quarter of the year and as-needed afterward:

1. Cut brush/vegetation regularly; common methods for control of vegetation include the use of weed trimmers or power brush-cutters and mowers.

2. Regrade the surface of the embankment crest and bench to eliminate ruts, potholes and provide proper drainage, provided that the freeboard is not reduced.

3. All burrowing animals should be removed and all burrow holes backfilled with compacted select fill

4. Place additional riprap on the upstream slope, in areas that have sustained minor damage To restore the original riprap protection

3.4 Hydraulic and Hydrologic Data

H&H analyses for Stanberry Lake Dam were not provided to CDM Smith and apparently are not available. CDM Smith recommends that a hydrologic and hydraulic analysis be performed to determine the overtopping potential for the dam for the 100-year flood event.

The dam currently does not have a low-level outlet to lower the reservoir for maintenance or in case of an emergency. It is recommended that the feasibility of constructing a low-level outlet be evaluated or the possibility of doing emergency pumping or siphon to lower the lake level if needed.

3.5 Structural and Seepage Stability

During the inspection, areas of uneven slope consisting of erosion rills, and several animal burrows were observed on the downstream slope. A detailed stability or seepage analysis that includes an evaluation of the dam under various loading and existing phreatic conditions was not performed. MDNR recommends these analyses be conducted prior to negotiating a purchase of the lake.

The MFWC caretaker indicated the auxiliary spillway has been activated on several occasions, with depth of flow estimated at approximately 2 feet. It is recommended to conduct an H&H analysis to estimate the potential of overtopping the dam during the 100-year flood event. It is also recommended a topographic survey of the dam be performed to confirm critical elevations of the dam and spillways required for the H & H analysis.

3.6 Recommendations, Maintenance, and Minor Repairs

The remaining deficiencies noted are generally considered either maintenance or minor repair items. Correction of the deficiencies typically does not require a dam safety permit.

1. Backfill erosion rills on the downstream slope and erosion of the upstream slope with compacted select fill to mitigate further erosion and to preserve the stability of the embankment.

2. Repair or replace existing precast concrete water supply intake structure.

3.6.1 Remedial Modification Recommendations

None of the deficiencies are considered to be an immediate threat to the dam. The extent of remedial measures for the dam and spillways should be based on the results of future H&H analyses. No alternatives are presented for the recommendations offered above. It should be noted that some of the recommendations noted above could be undertaken by the MFWC personnel to save cost.

3.7 Opinion of Probable Construction Cost

Costs for the repairs are estimated based on comparison with similar repairs for other dams. The actual cost of the repairs can vary depending on contracting procedures required by MFWC as well as other factors. These costs should be considered very preliminary and should be confirmed by obtaining estimates from local contractors. The costs provided are physical costs of the repairs and do not include costs for construction contingencies, engineering services, or permitting.

None of the deficiencies are considered an immediate threat to the dam; however, the issues will likely become worse with time if left unresolved. Table 3.4 summarizes the OPC for this project.

Table 3.4 Opinion of Probable Construction Cost for Stanberry Lake Repairs

Description	Cost
Studies and Analyses	
Perform a topographic survey	$6,000 - $8,000
Complete hydrologic and hydraulic studies	$20,000 - $25,000
Evaluate the feasibility of installing a low-level outlet at the primary spillway	$8,000 - $12,000
Recurrent Maintenance Recommendations (Assumed to be performed by MFWC personnel)[2]	
Perform regular maintenance	$ N/A
Remove animals and fill burrows	$ N/A
Fill voids behind discharge channel sidewalls	$ N/A
Place additional riprap on the upstream slope	$3,000 - $8,000
Recommendations, Maintenance, and Minor Repair	
Backfill areas of erosion	$6,000 - $ 10,000
Repair or replace existing precast concrete intake structure	$5,000 - $ 20,000
Remedial Modification Recommendations	
Remedial measures to address spillway capacity	TBD (based on H/H Analyses)
Subtotal	$48,000 - $75,000
Engineering, Legal, Contingencies[1]	$21,600 - 33,900
Total Opinion of Probable Construction Cost	$70,000 - $110,000

[1] Engineering, Legal, and Contingencies assumed to be 45-percent of subtotal
[2] Not included in overall project cost

It is assumed that regular maintenance, removing and filling burrow holes, re-seeding bare areas, and filling voids behind the discharge channel sidewalls could be completed by MFWC personnel and therefore cost estimates for such items were not provided.

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Section 4
Stanberry Lake Water Supply Analysis

This section summarizes the water supply analysis completed for Stanberry Lake in northwest Missouri. The drainage area to the reservoir is 6.3 square miles, and is mostly composed of grassland and cultivated farmland. The lake has a storage volume of 1,040 acre-feet at the assumed primary spillway elevation of 890 feet. A survey was completed after the water supply analysis was completed which reported the spillway elevation to be at 889.2 feet. Because modeling was completed at monthly intervals, it was determined that this difference in spillway elevations did not introduce significant error into the analysis. The average existing water demand from the reservoir is 315,000 gpd.

The goal of this water supply analysis was to evaluate existing conditions and to investigate if the reservoir could be expanded to allow for a higher water demand. To accomplish these goals, a spreadsheet model of Stanberry Lake was created. This model was then used to analyze three scenarios:

- Existing conditions, which calculated firm yield for the lake with 2012 survey data incorporated.
- Raised dam scenario, which evaluated a scenario in which the existing dam is raised 18 feet.
- Additional upstream reservoir scenario, which evaluated a scenario in which a new dam and water supply reservoir is constructed upstream of Stanberry Lake.

The Existing Conditions Analysis was completed for two time periods. The first time period ("Time Period 1") was from October 1948 until December 1960, and includes the drought of record for northwest Missouri, where Stanberry Lake is located. The second time period ("Time Period 2") was from July 2002 to December 2011, and represents a normal hydrologic period at Stanberry Lake.

The Raised Dam and Additional Upstream Reservoir scenarios were both modeled for Time Period 1 only. Time Period 2 was used to calibrate the existing conditions model.

4.1 Existing Conditions Analysis

The goals of the existing conditions analysis were:

- To create a spreadsheet reservoir model and calibrate it to observed water surface elevations (WSEs).
- To find firm yield, which is here defined as the maximum water supply demand that does not cause a modeled storage volume of less than 20 acre-feet during the drought of record (Time Period 1). This firm yield was compared to the MDNR water supply study completed in 2001 for verification.

The USGS installed a gauge at Stanberry Lake (Gauge 06896189) which has a record of daily water surface elevations extending from March 31, 2007 to the present day. The WSEs simulated by the model during Time Period 2 were compared to the WSEs observed by the USGS gauge to calibrate the model. The model accounted for losses to seepage, evaporation, the spillway, and water supply demand.

No streamflow gauge exists to record the quantity of inflows to Stanberry Lake, so the analyses were completed with two different surrogate inflow sources. The locations of these gauges are shown in Figure 4-1. The first was USGS Gauge 06820000 at White Cloud Creek near Maryville, Missouri. The drainage area to this gauge has a similar land use to the drainage area into Stanberry Lake. The drainage area to the gauge is 6.0 square miles and the record from the gauge includes measured streamflow for only Time Period 1.

The other gauge used was USGS Gauge 06897000, located on East Fork Big Creek near Bethany, Missouri. This gauge includes measured streamflow for both Time Period 1 and Time Period 2. As a result, this gauge was used to calibrate the model. This gauge has a drainage area of 95.0 square miles with similar land use as the drainage area to Stanberry Lake. To account for the difference in drainage area size, streamflows were weighted by drainage area acreage.

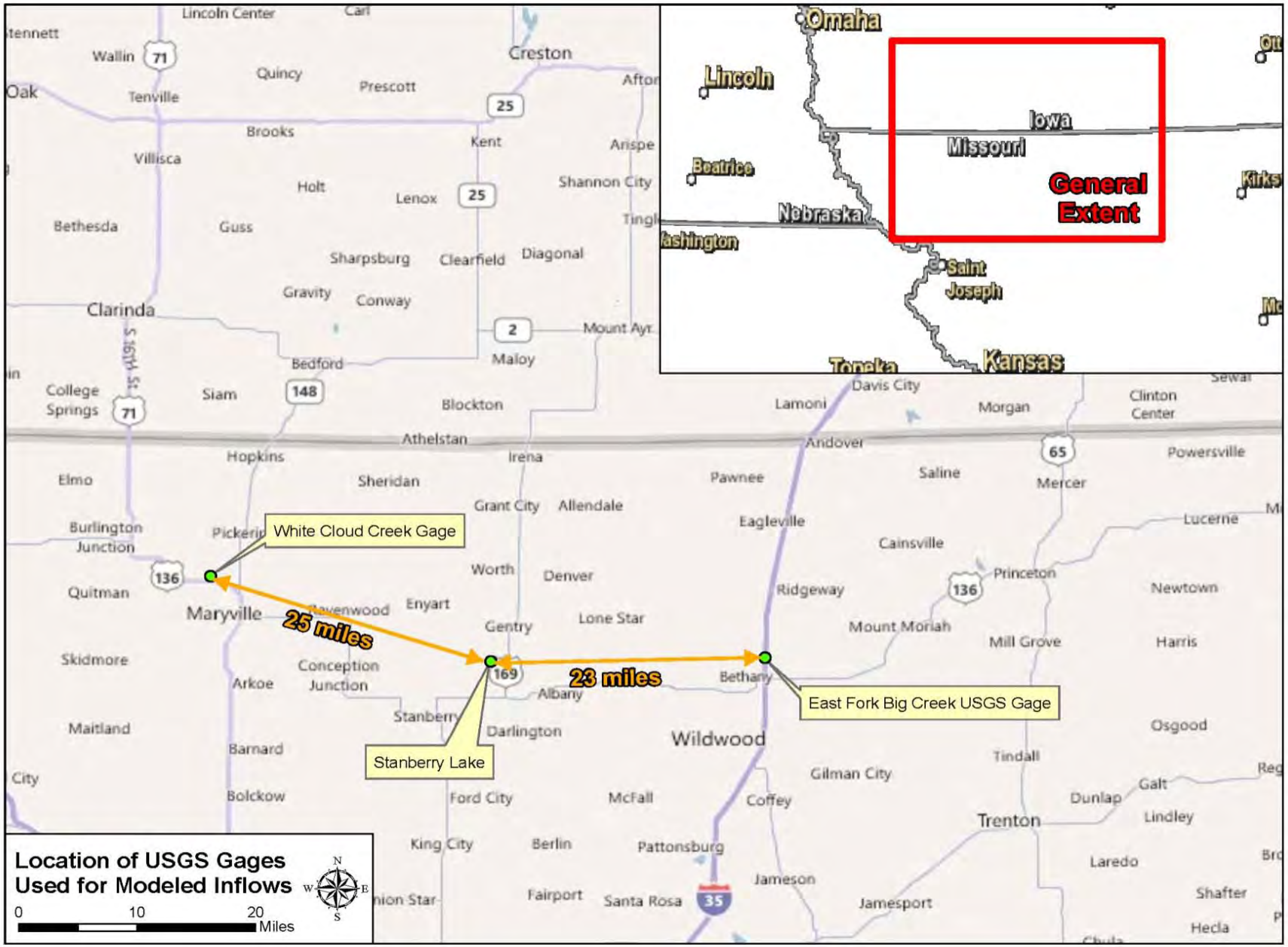

Figure 4.1 Location of USGS Gauges

4.1.1 Model Validation – Comparison 2001 MDNR Analysis of Stanberry Lake and to USGS Gauge

The Missouri Water Supply Study, dated June 28, 2011, developed by MDNR and authored by Jerry Edwards, Sherry Chen, and Steve McIntosh (http://dnr.mo.gov/env/wrc/drought/resopreports.htm) titled "Middle Fork Grand River Stanberry, Missouri Water Supply Study" documents a water supply analysis of Stanberry Lake completed by the MDNR in 2001. This analysis used the Reservoir Operation Study Computer Program (RESOP) software developed by the USDA's Natural Resources Conservation Service. The MDNR report is attached to this memorandum as Appendix F.

Table 4.1 shows the assumptions made for the MDNR study of Stanberry Lake completed in 2001. Similar assumptions were made for this study to create the spreadsheet model of the lake in order to verify its results against the MDNR results.

Table 4.1 Comparison of Assumptions

Category	MDNR Assumption	Current Study Assumption
Evaporation	Averaged monthly pan evaporation converted to potential evaporation for 1952 and 1961 from USDA climate stations at Spickard, Missouri and Lakeside, Missouri	Averaged monthly pan evaporation converted to potential evaporation for all available data from USDA climate station at Lakeside, Missouri
Seepage	A minimum seepage of 0 inches per month near minimum pool and maximum of 2.5 inches per month at full pool	A constant seepage rate of 3 inches per month at all water surface elevations
Minimum Pool Storage	20 acre-feet	20 acre-feet
Maximum Pool Storage (Existing Conditions)	1,625 acre-feet	1,625 acre-feet
Elevation-Storage Curve	USGS Survey completed in 2000, which included bathymetry and ground survey	USGS Survey completed in 2000, which included bathymetry and ground survey
Duration of Analysis	January 1951 - December 1959 (includes drought of record)	October 1948 - December 1960 (Time Step 1, includes drought of record); November 2004 - December 2011 (Time Step 2)
Inflow	USGS Gauge 06820000 at White Cloud Creek	USGS Gauge 06820000 at White Cloud Creek & USGS Gauge 06897000 at East Fork Big Creek
Current Water Supply Demand	Daily use of 350,000 gpd	Varied monthly usage based on seasonality, averaged at 315,000 gpd

The MDNR analysis found firm yield for existing conditions only, and did not evaluate any alternative scenarios. The firm yield calculated by the MDNR study of Stanberry Lake was 381,100 gpd. Using the assumptions shown in Table 4.1, the spreadsheet model created for this study found a firm yield of 386,000 gpd, closely matching the results of the 2001 MDNR study.

To further validate the model, the water surface elevations, which had been calculated at monthly time steps, were compared to the average of the water surface elevations recorded by the USGS gauge. The results of this comparison showed an average of 0.5 feet difference between the observed and modeled data. Because the spreadsheet model showed a small difference from observed water surfaces, and because the firm yield calculated by the model closely matched the results of the MDNR analysis, the spreadsheet model was considered calibrated.

4.1.2 Sedimentation Analysis

The sedimentation of Stanberry Lake was analyzed based on bathymetric data collected in the years 2000 and 2012. The bathymetry survey from 2000 was completed by the USGS in support of a water supply analysis completed by the MDNR. The 2012 survey was completed in March 2012 by Powell & Associates under the Phase V Missouri Regional Water Supply Transmission System Study contract.

The 2012 survey was completed using a boat fitted with a small electric motor, as a larger outboard motor could have introduced error into the survey equipment's readings. The survey equipment used was a sonar unit manufactured by Ohmex Instrumentation called the SonarMite version 3.1 Echo Sounder. Elevations were established using the Topcon HiPer GPS unit. Data from field equipment were imported for use in a personal computer system using the software Carlson Survey Plus.

To complete the survey of Stanberry Lake, cross sections traversing the lake were first completed. The boat was able to access the entire lake, including shallow areas. To complete the survey, a land survey was completed at the water's edge to an elevation of approximately 888 feet.

Both sets of data were available in comma delimited format. These datasets included survey points by X and Y coordinates in the Missouri State Plane – West (feet, 1983) projection system and the ground elevation associated with the points. The comma delimited files were imported to ArcGIS version 10 and used to create a digital elevation model using the 3D Analyst extension.

The available data for the 2000 survey included bathymetric elevation data to 884 feet. The USGS developed a curve relating WSE to surface area and another curve relating WSE to storage volume to describe the extent and volume of water able to be impounded by the Stanberry Lake dam. This curve, which was used by the MDNR, extends to an elevation of 893.4 feet, and it is assumed that the USGS completed a land survey to quantify storage from elevation 884 feet to 893.4 feet. These two curves were created again using the 2012 bathymetric survey data. Table 4.2 below compares these curves for the years 2000 and 2012 surveys. The total reduction in storage volume caused by sedimentation at the assumed spillway elevation of 890 feet was calculated based on these curves, and the results are shown in Table 4.3.

Table 4.2. Comparison of Storage Volumes for Bathymetric Surveys

Elevation, feet	2000 USGS Bathymetry Survey Surface Area, acres	2012 Bathymetry Survey Surface Area, acres	2000 USGS Bathymetry Survey Storage Volume, acre-ft	2012 Bathymetry Survey Storage Volume, acre-ft	Percent Reduction in Storage	Comment
868	0.1	0.01	0.1	0.00	97.0%	
870	1.7	0.3	1.0	0.2	81.5%	
872	5.7	2.0	7.3	2.1	72.0%	
874	14.2	9.8	27.5	12.9	53.2%	
874.5	16.8*	11.9*	37.2*	20.0*	46.2%	
876	24.4	18.2	65.4	40.6	37.8%	
878	35.2	30.4	125.1	90.0	28.0%	
880	48.4	41.6	208.9	161.7	22.6%	
882	58.9	53.0	316.7	256.9	18.9%	
884	69.4	62.4	443.3	372.2	16.0%	Limit of 2000 USGS Bathymetric Survey
886	71.4	77.8	599.9	516.0	14.0%	
888	86.7	93.4	795.2	687.7	13.5%	Limit of 2012 Bathymetric Survey
890**	109.0	118.7	1,040.7	900.0	13.5%	
892***	138.5	175.1	1,170.3	1,352.9	0.0%	
893.4***	175.1	206.1	1,405.6	1,625.0	0.0%	

*Values for storage volume at water surface elevation 874.5 feet found by linear interpolation.

**The 2012 storage volumes reported were calculated using the 2000 survey storage value. This value was reduced by 13.5% based on the reduction observed at elevation 888 feet.

***The storage values for the 2000 USGS survey were used in the 2012 bathymetry curve without reduction due to sediment, as the primary spillway, which is at invert 889.2 feet, prevents water surfaces higher than 890 feet for the majority of the year. This limits sedimentation at these elevations.

Table 4.3. Sedimentation Occurring between the Years 2000 and 2012 Based on Bathymetric Survey Data

Survey	Storage Volume at Water Surface Elevation of 890 feet, acre-feet
2000 USGS Survey	1,040
2012 Survey	900
Sedimentation Rate	11.7 acre-feet/year

4.1.3 Updated Existing Conditions Firm Yield

The curves relating WSE to surface area and WSE to storage volume for the 2012 survey were input to the spreadsheet model and firm yield calculated. This resulted in a firm yield of 361,000 gpd, a loss of 25,000 gpd compared to the firm yield of 386,000 previously calculated using the 2000 survey data. This loss indicated that sedimentation has reduced the water supply demand which can be drawn from the lake.

4.2 Evaluation of Alternatives to Increase Firm Yield

Two scenarios were analyzed to evaluate their capacity to increase firm yield at Stanberry Lake. The first alternative was to raise the existing dam 18 feet, allowing additional water to be impounded. The second alternative was to construct an additional reservoir upstream of Stanberry Lake.

4.2.1 Raised Dam Scenario Analysis

The goal of the Raised Dam Scenario Analysis was to evaluate if a water demand higher than the existing conditions firm yield could be sustained by the reservoir if the top of dam were to be raised to an elevation of 912 feet. This scenario is shown in Figure 4.2. At the maximum water surface of 912 feet, the reservoir inundates an area of 470 acres. This area of inundation is shown in Figure 4.2 as well. This scenario was analyzed by extending the calibrated existing conditions spreadsheet reservoir model to reflect the raised dam based on a 30-meter USGS digital elevation model.

4.2.2 Additional Upstream Reservoir Scenario Analysis

The goal of the Additional Upstream Reservoir analysis was to evaluate if a water demand higher than the existing conditions firm yield could be sustained by the existing reservoir if an additional reservoir were constructed upstream. The location and extent of the additional upstream reservoir is shown in Figure 4.3. The area of inundation shown in Figure 4.3 is for the maximum water surface, and encompasses 190 acres.

This analysis was accomplished by modifying the calibrated existing conditions spreadsheet reservoir model. The addition of the upstream reservoir split the drainage area between the two reservoirs. The area draining to the hypothetical, upstream reservoir was 3.74 square miles (57 percent of the total drainage area), and the area draining to the downstream, existing reservoir was 2.86 square miles (43 percent of the total drainage area).

The downstream reservoir was kept at a pool elevation 2 feet below the spillway by discharging stored water to it from the upstream reservoir. When insufficient water was available in the upstream reservoir to keep the downstream reservoir at this pool elevation, all available volume in the upstream reservoir was discharged to the downstream reservoir. If the downstream reservoir received inflows which caused it to have a pool elevation greater than 2 feet below the spillway, the excess volume was assumed to be pumped to the upstream reservoir. Volume escaping the upstream reservoir through the spillway was assumed to be discharged to the downstream reservoir. No other operational rules were applied.

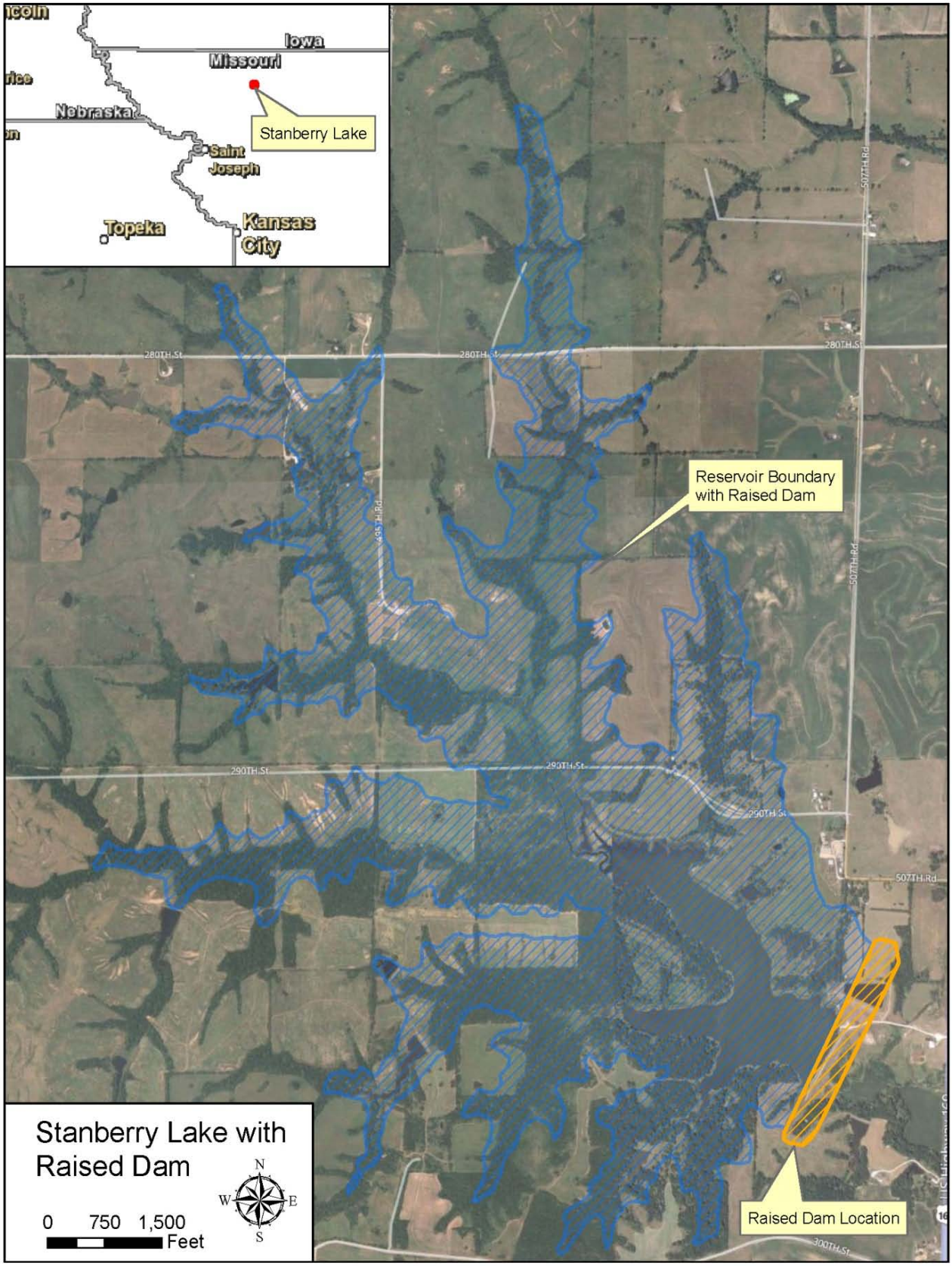

Figure 4.2 Stanberry Lake with Raised Dam General Location and Layout

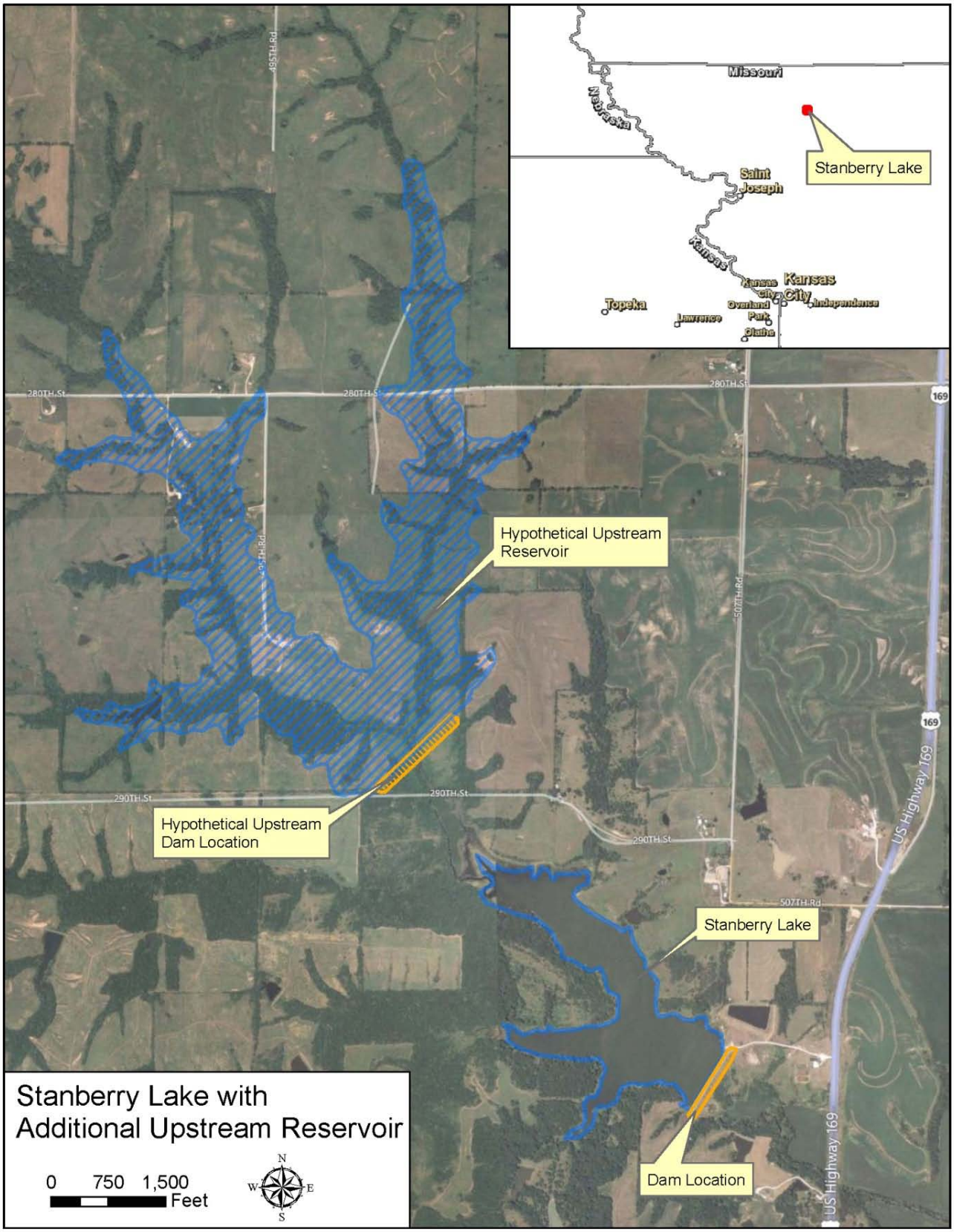

Figure 4.3 Stanberry Lake with Additional Upstream Reservoir General Location and Layout

4.3 Results and Recommendations

The calibrated existing conditions spreadsheet model which used the WSE to surface area and the WSE to storage volume relations calculated from the 2012 survey data was modified to model the Alternatives scenarios. The firm yields for all scenarios, including existing conditions, are summarized in Table 4.4 below.

Table 4.4 Water Supply Firm Yield for All Analyses

Scenario	White Cloud Creek Gauge Firm Yield Average GPD*
Existing Conditions	361,000
Raised Dam	560,000
Additional Upstream Reservoir	583,000

*Existing Average Demand is 315,000 gpd.

The firm yields from the White Cloud Creek gauge analysis were lower than for East Fork Big Creek, and are the recommended firm yields to be used to guide further analyses and design. This is because the drainage area to the White Cloud Creek gauge was similar in land use and topology to the drainage area to Stanberry Lake.

In addition, as previously stated, the East Fork Big Creek gauge is likely to reflect baseflow which the White Cloud Creek gauge did not experience due to its smaller acreage. Because the size of the drainage area to Stanberry Lake and the White Cloud Creek gauge are similar, the White Cloud Creek gauge more accurately reflects baseflow to Stanberry Lake.

The White Cloud Creek gauge may therefore give a more realistic firm yield for each modeled scenario, and makes more conservative assumptions that the East Fork Big Creek gauge analyses. It is recommended that increases at Stanberry Lake in water demand use the White Cloud Creek gauge analyses firm yields as a basis for increasing demand as shown in Table 4.4.

4.3.1 Raised Dam versus Additional Upstream Reservoir

Firm yields for both scenarios were similar, as both scenarios increase storage capacity. The additional upstream reservoir scenario offered operational flexibility, resulting in a higher firm yield. It must be noted that the operational rules assumed for the Additional Upstream Reservoir scenario were key in obtaining firm yield. If these rules are not followed, a different firm yield is expected and the analysis must be completed again to estimate firm yield for the scenario.

4.3.2 Projected Firm Yields

The firm yields for the existing Stanberry Lake scenario were projected 30 years into the future. This analysis assumed that neither of the alternatives outlined in Sections 2.3 and 2.4 were implemented, and that sedimentation continues to occur at the rates observed between the years 2000 and 2012. The results of this analysis are reported in Table 4.5 and shown in Figure 4.4. The analysis shows that sedimentation will reduce firm yield such that the lake will not be able to meet existing daily demand sometime between 2022 and 2032.

Table 4.5 Projected Water Supply Firm Yield Assuming No Improvement to Existing Reservoir and Historical Sedimentation Rate

Scenario	White Cloud Creek Gauge Firm Yield Average GPD*
Existing Conditions	361,000
Projected 2022 Firm Yield Based on Sedimentation Rate in Table 4.2	336,000
Projected 2032 Firm Yield Based on Sedimentation Rate in Table 4.2	290,000
Projected 2042 Firm Yield Based on Sedimentation Rate in Table 4.2	222,000

*Existing Average Demand is 315,000 gpd.

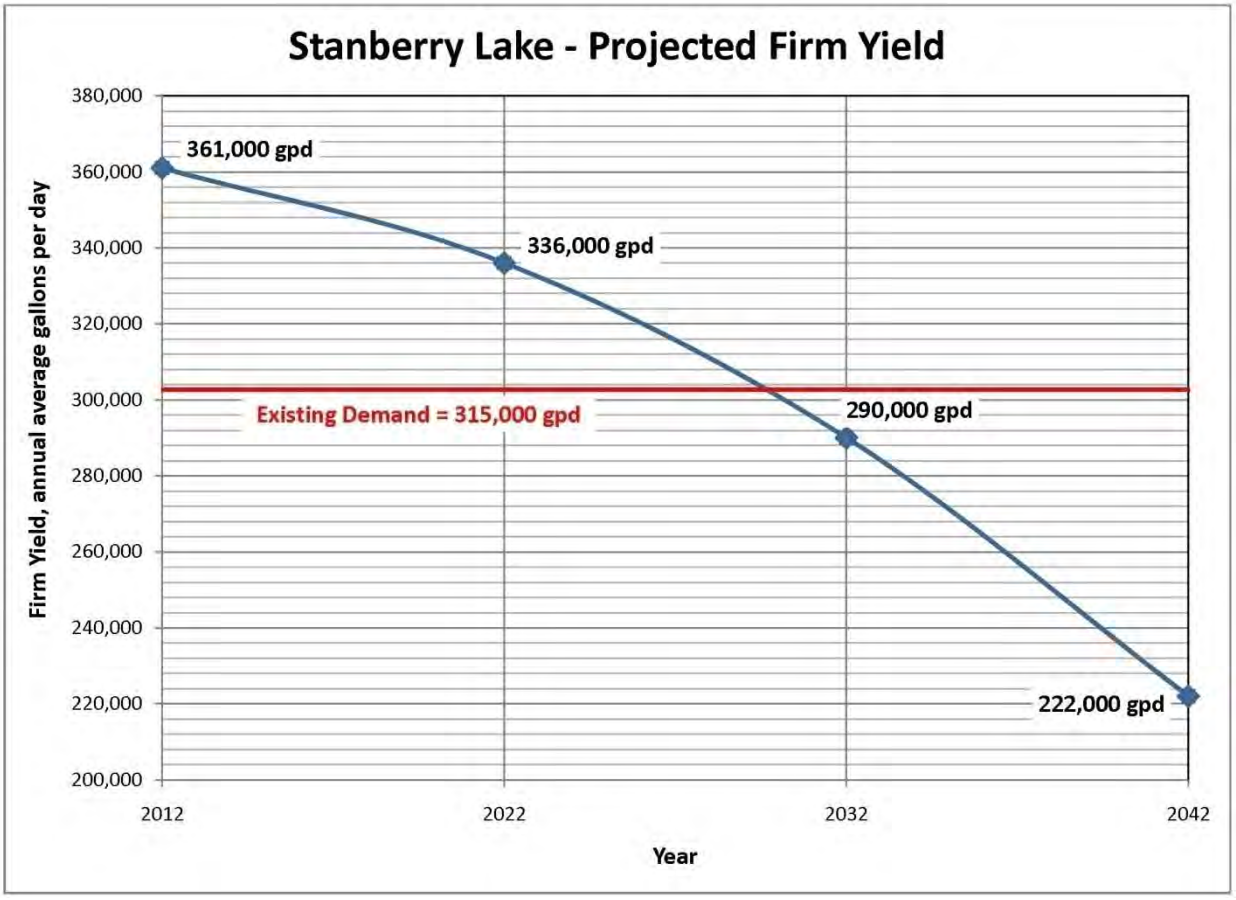

Figure 4.4 Projected Firm Yield for Stanberry Lake

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Section 5
Middle Fork Reservoir and WTP Expansion Feasibility

Based on the results of Section 4, this section outlines a conceptual or feasibility level approach to the improvements for providing additional potable water to other water utilities in the vicinity. A planning-level opinion of probable construction cost for the WTP and new dam are provided. Elevations are referenced to NAVD 88.

5.1 Stanberry Lake Improvements

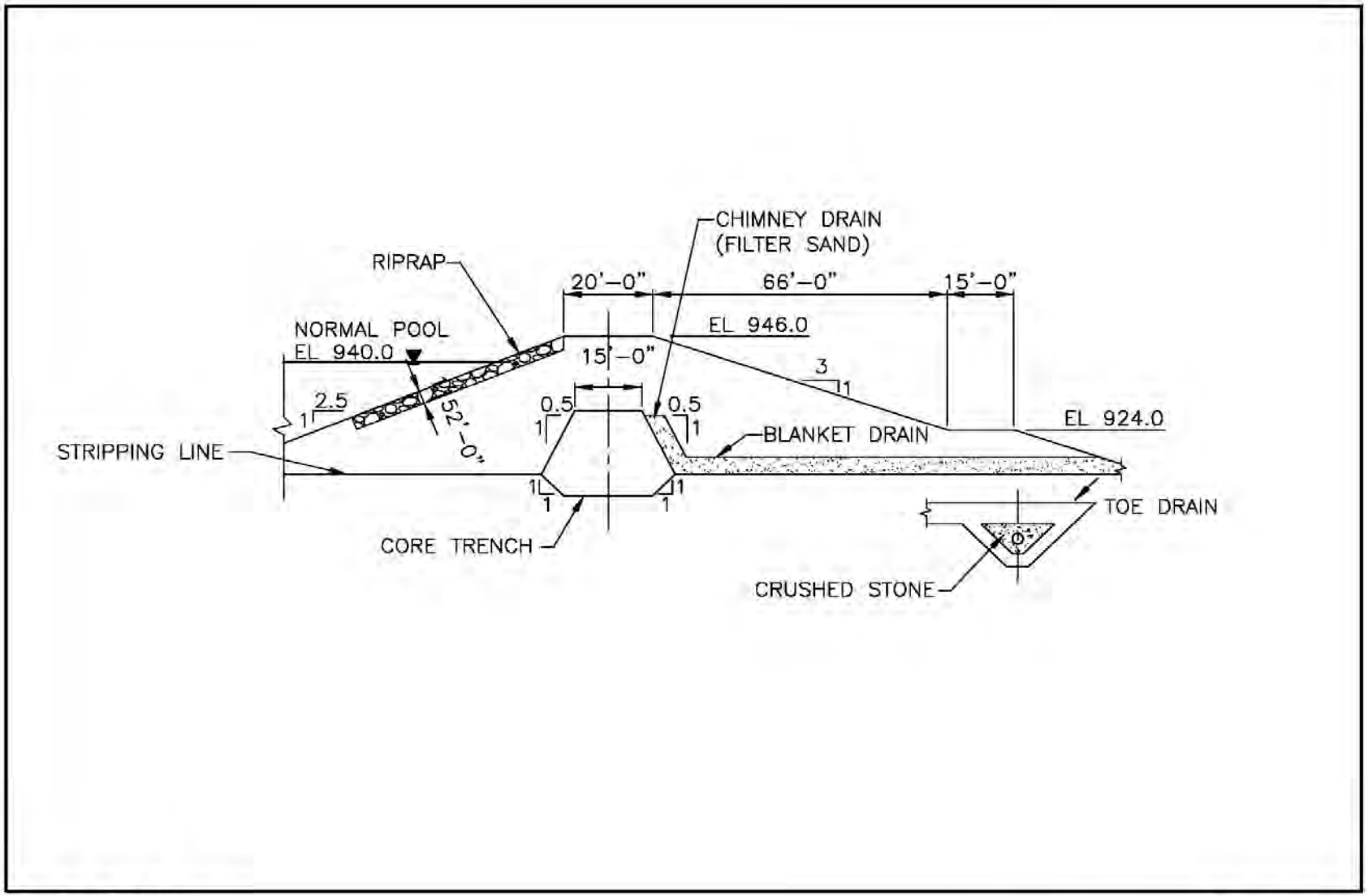
Conceptual-level design of the dam and spillway was required to estimate quantities and feature dimensions to be used in the planning-level opinion of probable construction cost. Design was in general compliance with Missouri Dam Safety Laws and Regulations found in Sections 236.400 to 236.500 of the RSMo. – enacted in 1889 and last amended in 1993, and Rules found in the 10 CSR 22-1.010 to 10 CSR 22-4.020. This section summarizes the assumptions and methodology used in the conceptual-level design of the dam and spillway.

5.1.1 Dam

Field reports provided by MFWC from the construction of the existing dam indicate the earth embankment was constructed as a homogenous earth fill structure utilizing silty-clay found in the vicinity of the dam. It is assumed, due to the close proximity of the proposed dam to the existing dam that similar material will be available for construction.

The upstream reservoir dam will be approximately 50 feet high and 1,300 feet long, with the crest at El. 946.0. The typical dam cross section shown on Figure 5.1 was generated based on the limited geotechnical and geologic information that was available and with consideration of the existing dam's construction. Construction drawings for the existing dam indicate a "core trench" extends the full length of the dam, founded in a layer of inorganic clay of low to medium plasticity.

The embankment core will consist of compacted silty clay, with material properties similar to existing. The core trench will be extended the full length of the embankment, founded in the layer of inorganic clay to control seepage under the dam.



CDM Smith

Figure No. 5-1
Proposed New Dam Cross Section
JAN 2012

5.1.2 Spillway Configuration

The upstream reservoir dam will have a drop-inlet primary spillway and an auxiliary spillway. The primary spillway will be sized to convey flows resulting from the 100-year storm event, as required by Missouri CSR's for an environmental class III dam. The spillway crest will be at El. 940.0 and sized to achieve a 2-foot or greater freeboard from the maximum water surface elevation for the 100-year storm event. For planning purposes it is assumed that the primary spillway will be similar to the existing Stanberry Lake Dam's primary spillway. The length of the primary spillway is 60 feet and the length of the auxiliary spillway is 150 feet.

The primary spillway consists of a gate house with 100-foot-long footbridge extending from the dam to the gate house. The intake structure will run vertically to a free-flow conduit under the dam embankment. A terminal structure is located at the downstream end of the free-flow conduit.

Missouri, 10 CRS 22-2.040(1) states if conditions change in a zone and the environmental class is changed, the dam owner must meet the new standards and criteria. The Spillway Design Flood Precipitation Value (SDFP) for an environmental Class I dam is 0.75 of the Probable Maximum Precipitation (PMP) and the SPFD for an environmental Class II dam is 0.5 PMP. The required design acceleration for earthquake design for new dams greater than 50 feet in height are 0.75, 0.5 and 0.4 probable maximum acceleration for Class I, Class II, and Class III dams respectively. Accordingly, if the environmental class of the dam changes in the future as the result of development in the environmental zone, the more-stringent design criteria will become effective.

5.1.3 Low-Level Outlet

The primary spillway would include a low-level outlet conduit located at the base of the structure. The conveyance conduit is estimated to be constructed of reinforced concrete. The low-level outlet is to be used to lower the reservoir below normal pool stage during construction and for lake management purposes, routine repairs, or dam safety purposes. The low-level outlet will include a vertical slide gate located upstream of the inlet of the primary spillway drain pipe.

5.1.4 Reservoir Opinion of Probable Cost

The OPC includes costs for the materials and labor involved in completing the following activities.

Site Preparation - Activities performed as part of site preparation include mobilization and demobilization, temporary diversion of water around the construction area, clearing, grubbing, and demolition of structures within the project area.

Mobilization and Demobilization - Mobilization and demobilization includes the costs associated with getting the necessary equipment and materials to the site. Mobilization and demobilization costs were included as part of the planning-level contingency.

Temporary Diversion - Provisions must be made for diverting water around the work site during construction. Provisions must be made for diverting water around the dam during construction. Diversion of water is typically provided by an earthen cofferdam with a conveyance structure around the dam during construction of the spillway and outlet structure. The cofferdam is sized to control both low flows and flood flows from the 5-, 10-, or 25-year frequency floods. For the purposes of this planning-level cost estimate, the cost of temporary diversion was estimated as a lump sum about of $1.0 million. This estimate was based on estimated costs for temporary diversion for similar reservoir projects.

Clearing, Grubbing, and Demolition - Site preparation includes clearing, grubbing, and grading for a construction access road and along the dam length. Site preparation also involves the cutting of vegetation within the footprint of the permanent pool. The area of the footprint of the permanent pool consists of those lands integral with the reservoir below the proposed normal water level El. 940.0'. The area of clearing for the dam was calculated for a dam crest width of 20 feet; and embankment slopes of 3H:1V (downstream) and 2.5H:1V (upstream) slope. The calculated dam width was then multiplied by the length of dam to arrive at the area of clearing.

Erosion and Sedimentation Control - Erosion and sedimentation control measures are required to reduce the potential for the discharge of sediment from the site downstream. Erosion and sedimentation controls include silt fence installation, sedimentation basins, and grassing. The length of silt fence installation was estimated based on the length of the dam. Area of grassing was estimated as the area of clearing for the dam plus an area equal to 15 acres to reflect grassing around the perimeter of the open water area.

Excavation and Compacted Fill - The extent of earthwork required for the spillway construction was determined based on soil boring logs included on the Middle Fork Water Company construction plans for the existing dam. Fill material is required for construction of the homogenous earthfill structure. The embankment will consist of compacted silty-clay with a calculated volume of approximately 385,000 cubic yards (CY). Volume is the in-place estimate of volume and was increased in the cost estimate to account for compaction. The in-place volumes were multiplied by 1.4 and 1.2 for imported material and on-site material, respectively. A larger multiplier is used for imported material because of the loss of volume that occurs during transport. Imported material is assumed to have a haul distance of less than 4 miles.

Dam Face Protection - Riprap rock will be required at the upstream face of the dam to protect it from wave erosion. The quantity of rock was calculated using the length of the dam, riprap thickness of 3 feet, and length of upstream slope from the top of dam to 10 feet below the normal pool elevation.

Primary Spillway and Low-Level Outlet - The cost estimate of the construction of the drop-inlet primary spillway was determined for a spillway configuration similar to the existing Stanberry Lake drop inlet spillway, utilizing cast-in-place concrete construction. The spillway estimate includes a stilling basin at the lower end of the spillway to dissipate the energy of the water, and cast-in-place abutment walls. The cost estimate also included construction of the low-level outlet with a vertical slide gate located upstream of the inlet of the primary spillway drain pipe, and a gate house with a 100-foot-long footbridge extending from the dam to the gate house.

Excavation and Fill - The extent of earthwork required for the spillway construction was determined based on soil boring logs included on the MFWC construction plans for the existing dam. The bottom of the spillway is to be founded in a layer of inorganic clay of low to medium plasticity, approximately 6 feet below existing grade.

Miscellaneous Instrumentation - Miscellaneous instrumentation should be installed to monitor the function and safety of the dam after construction and during operations. The following amount and type of measurement and control instrumentation was estimated: 3 benchmarks, 10 piezometers, 3 inclinometers, and 5 settlement plates.

Other Costs - Other costs associated with the construction of new reservoirs typically include the cost of land acquisition, transportation infrastructure relocation, home and private structure buyout, electric transmission line, and gas pipeline relocation.

Land Acquisition Costs - Acquisition of some land within the permanent pool and around the perimeter of the lake within the elevation of the top of dam will still be required. The quantity of land to be acquired was determined by using a ground elevation model obtained from the USGS of the area surrounding the reservoir. Areas were calculated at two-foot intervals from El. 912 to 946 using the 3D Analyst extension in ARCGIS 9.3.1. Land values from Gentry County in which the land acquisition areas are located were used to create an estimated land acquisition cost. The estimated land acquisition costs were determined using real estate websites (the referenced websites are listed at the bottom of Table 3 -7) to find properties with acreage for sale in Gentry County. The purchase cost per acre was based upon undeveloped properties listed for sale. The list price was divided by the property acreage to determine an approximate cost per acre for each property. The median cost for all the counties were averaged this value was used as the cost per acreage for all land acquisitions. Table 5.1 shows the sizes of listed properties, list price, price per acre and the median price per acre, for Gentry County. The estimated cost of land acquisition is based on the total acreage of the reservoirs footprint multiplied by the overall average cost of acreage of the combined counties.

Table 5.1 Land Acquisition Property Cost Data

County	Property Size Acres	List Price	Total Cost per Acre
Gentry[1,2]	120	$240,000	$2,000
	106	$243,000	$2,300
	160	$287,200	$1,800
	340	$833,000	$1,600
	105	$262,000	$2,500
	197	$492,500	$2,500
		Median Cost per Acre	$2,150

[1] Source:www.landwatch.com [2] Source:www.landwatch.com

Relocations - The footprint of the proposed new reservoir will inundate three residences; two on 495 Road, and one south of 280 Street. A 0.1-mile section of 280 Street will inundated by the reservoir. The reservoir project will require construction of a bridge to span 280 Street over the reservoir. No federal or state highways will require rerouting as a result of the reservoir project.

Table 5.2 summarizes the results of the planning-level opinion of probable cost. Construction costs were estimated using a unit cost for fill material where 25 percent of the material for dam construction is imported and 75 percent is available within the project site. Appendix G includes the detailed breakdown on the construction cost estimate. Cost opinions reflect the following assumptions:

- No excavation in rock is required.
- 2011 dollars (rounded to two significant figures).
- No property acquisition estimated for replacement of transportation facilities and utilities.

- Dam volume based on topographic map provided by MFWC.

Quantities were considered in-place volume and factors were applied to indicate compaction. Cost of compensation for the loss of current and future oil and gas production profits were not estimated. Values of the rights or extraction of resources were not considered when determining land value.

Table 5.2 Planning Level Opinion of Probable Construction Costs

Item	Probable Cost
Reservoir Site Preparation	$1,230,000
Erosion and Sediment Control	$58,000
Excavation	$82,000
Dam	$5,560,000
Spillway Structure	$570,000
Chimney, Toe & Blanket Drains	$1,400,000
Miscellaneous Instrumentation	$50,000
Mobilization	$50,000
Subtotal	$9,000,000
Engineering, Legal, and Contingencies[1]	$4,050,000
Total Opinion of Probable Cost	$13,050,000

[1] Engineering, Legal, and Contingencies assumed to be 45-percent of subtotal.

5.2 WTP Expansion

With the raised dam or second reservoir, the additional supply capacity could be used to serve Commission members in Northwestern Missouri. In addition to the surface water supply, MFWC also provided information on a potential groundwater supply in the area.

5.2.1 Groundwater Sources

Previous groundwater investigations in the area have revealed an alluvial groundwater supply along the Middle Fork of the Grand River. The drilling report estimates a safe yield from this supply of 300 gpm. No geochemistry analysis was conducted, but from accounts of other groundwater supplies in the area, it appears the only potential contaminant concerns are iron and manganese. Upon review by MDNR, it was determined that the additional well yield test does not meet current requirements. A new draw down test would be required to verify this capacity. Further, the long-term viability of the aquifer in this location is unknown and in the region is considered questionable. Testing to verify the aquifer viability would also be recommended prior to developing a groundwater well in this location. See Appendix H for a copy of the 1993 Layne Report.

Development of additional capacity using this source could be an inexpensive method for providing additional finished water to the system. If iron and manganese are indeed the only pollutants, pre-oxidation of dissolved constituents can be started at the wellhead using chlorine.

The oxidized water can then be fed into a dedicated clarifier, with or without softening, then to the filter influent, with filtration of remaining iron and manganese solids taking place in the existing media filters. This would also provide a barrier against other contamination risks that may develop in the source water.

Although a large amount of uncertainly still exists regarding a groundwater supply, an opinion of probable costs for groundwater well development and transmission piping is shown below. Additional investigation, including possible transmission pipe routing, test pumping and preliminary well design, and a detailed examination of groundwater chemistry would need to be conducted to further develop a more reliable cost opinion provided in Table 5.3.

Table 5.3 Groundwater Supply Opinion of Probable Costs

Description	Unit Price	Quantity	Units	Extension
Groundwater Well (<100' Deep)	$90,000	2	Ea	$180,000
Pitless Adapter, Submersible Pump, Electrical	$25,000	2	Ea	$50,000
8" dia. Cl. 160 PVC Transmission Pipeline	$6.50	5000	Feet	$33,000
Access Road, Sitework, Fencing	$30,000	2	Sites	$60,000
Electrical, including Standby Generator	$65,000	LUMP SUM		$65,000
Subtotal				$388,000
Hydrogeologic Investigation and Test Pumping				$75,000
Engineering, Legal, Contingencies[1]				$210,000
Total Opinion of Probable Construction Cost				$673,000

[1] Engineering, Legal, and Contingencies assumed to be 45 percent of subtotal.

5.2.2 Potential Expansion Improvements

As shown in Section 4.2, potential exists to expand the safe yield of the surface water supply from a present average day capacity of 386,000 gpd to 558,000 gpd. Assuming a peak day to average day ratio of 2.0, the expanded capacity of 775 gpm, a gain of 240 gpm from present day peak day capacity, just exceeds the 24-hour design capacity of the treatment plant. These relatively meager gains in capacity, along with the cost outlined in Table 5.2 for expansion of the surface water supply result in a high cost per gpm of additional capacity.

A comparable gain in firm raw water capacity may be achieved for less cost by utilizing groundwater. Given the poor track record of groundwater supplies in Northwest Missouri, it won't likely be identified as a primary supply, but rather as a supplemental and emergency supply source to be used during maintenance of surface water treatment portions of the plant and when demand requires its use. If testing proves 300 gpm to be a safe yield from the groundwater supply, the total peak day capacity when used in conjunction with surface water would be 835 gpm. If reservoir yield is evaluated on an annual basis, with groundwater utilized to offset surface water usage during off peak times to maximize reservoir storage, this rate could be even higher.

Additional capacity would require expansion of the physical plant. Dedicated groundwater clarification/sedimentation capacity could be constructed using a solids contact basin. Sized for a conservative 0.5 gpm per square feet surface overflow, the solids contact basin would be 30-feet diameter. Solids contact basins combine mixing, flocculation, and clarification steps in one basin by use of a zoned tank. The solids contact basin would be designed to achieve partial iron and manganese removal, and if desired, softening, by clarification. Water from the new solids contact basin would then be combined with surface water secondary clarifier effluent for filtration.

Additional filter capacity could be gained in a number of ways. First, additional media filters, similar in design to the existing filters, could be constructed. If the same filter configuration were to be used, with a per-filter area of 112.5 square feet and observing a 2.0 gpm per square foot filter rate with one filter out of service, five filters would be required. Two filters would be operated along with the existing three filters to provide the added capacity.

Another alternative to constructing additional filters is to use the existing filter tanks with submerged membranes. These use vacuum pumps to pull filtrate through the semi-permeable membrane and typically require less footprint per unit of output as compared to media filters. For the purposes of this study, it is assumed that two racks of membranes could be operated, in a redundant fashion, to produce 835 gpm of treatment capacity. These units would be constructed inside of the existing filter cells, eliminating the requirement to expand the building footprint to gain filter capacity.

OPCs are provided for each alternative as follows in Tables 5.4 and Table 5.5.

Table 5.4 Media Filtration Plant Improvements

Description	Unit Price	Quantity	Units	Extension
Solids Contact Basin Concrete	$175,000	LUMP SUM		$175,000
Solids Contact Basin Equipment	$340,000	LUMP SUM		$340,000
Solids Contact Basin Piping	$15,000	LUMP SUM		$15,000
Filter Concrete	$85,000	LUMP SUM		$85,000
Filter Building - Steel Frame	$140.00	500	SF	$70,000
Filter Equipment and Media	$275.00	224	SF	$60,000
Filter Piping	$25,000	LUMP SUM		$25,000
Misc Piping	$5,000	LUMP SUM		$5,000
Electrical	$26,000	LUMP SUM		$26,000
Instrumentation and Control	$45,000	LUMP SUM		$45,000
Subtotal				$848,000
Engineering, Legal, Contingencies[1]				$382,000
Total Opinion of Probable Construction Cost				$1,230,000

[1] Engineering, Legal, and Contingencies assumed to be 45-percent of subtotal.

Table 5.5 Plant Expansion Membrane Option

Description	Unit Price	Quantity	Units	Extension
Solids Contact Basin Concrete	$175,000	LUMP SUM		$175,000
Solids Contact Basin Equipment	$340,000	LUMP SUM		$340,000
Solids Contact Basin Piping	$15,000	LUMP SUM		$15,000
Submerged Membrane Filters	$650,000	2	EA	$1,300,000
Filter Permeate Pumps	$25,000	2	EA	$50,000
Ancillary Filter Equipment	$75,000	LUMP SUM		$75,000
Filter Piping	$25,000	LUMP SUM		$25,000
Misc Piping	$5,000	LUMP SUM		$5,000
Existing Primary Basin Conversion	$17,500	LUMP SUM		$18,000
Electrical	$44,000	LUMP SUM		$44,000
Instrumentation and Control	$45,000	LUMP SUM		$45,000
Subtotal				$2,090,000
Engineering, Legal, Contingencies[1]				$940,000
Total Opinion of Probable Construction Cost				$3,030,000

[1] Engineering, Legal, and Contingencies assumed to be 45-percent of subtotal.

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Section 6
Conclusions

Generally, the WTP and reservoir are in good condition and well-maintained for the age of the facilities. The OPC to address the WTP improvements for the existing conditions is $1.5 million. The OPC to address the reservoir improvements is up to $110,000. For a total OPC to the WTP and Reservoir of $1.61 million dollars to maintain the current capacity.

If the Commission purchases MFWC and expands the facility to maximize the water supply source, the feasibility level opinion of probable cost is provided in Table 6.1 below:

Table 6.1 Feasibility Opinion of Probable Cost for Expansion

Item	Cost
Groundwater Well Installation	$673,000
Upstream Reservoir	$13,050,000
Plant Expansion Option 1 – Media Filtration	$1,230,000
Plant Expansion Option 2 – Membrane Filtration	$3,030,000

Table 6.2 provides the current and proposed future yield of the reservoir and plant.

Table 6.2 Current and Proposed Future Capacity

	Water Supply Yield (gpd)	WTP Finished Water Yield (gpd)[1]
Current	386,000	347,000
Expansion	558,000	502,000

[1] Finished water yield is assumed to be 90-percent of the water supply yield

Due to the questions regarding long term viability of groundwater in the area and the high cost for reservoir expansion for such a small capacity increase, it is not recommended to invest in further expanding the plant.

Should the Commission consider purchasing and operating the Middle Fork Water Company Reservoir and WTP, an anticipated cost of service would vary between $3.20 and $3.90 per 1,000 gallons based on the following assumptions:

- Financing the debt service and recommended repairs through MDNR State Revolving Fund Loan program at 2-percent interest over 20 years.
- The operation costs were increased by 5-percent.
- Maintenance costs were assumed to be $62,500 per year.

- These costs were based on an assumed average daily water sale of 350,000 gpd.

A range of sale prices were used to determine the range in sale costs. The actual sale cost should be determined through negotiations with MFWC and the costs for selling water re-calculated.

Appendix A

Water Quality Data

MIDDLE FORK WATER COMPANY

PLANT
HWY 169 S - BOX 80
GENTRY, MO 64453
660/448-2111

OFFICE
BOX 468
MARYVILLE, MO 64468
660/582-4111

Mrs. Debbie Roach, Mayor
City of Grant City
P.O. Box 398
Grant City, MO 64456

4.12.11
FAXED

April 12, 2011

RE: Consumer Confidence Report

Enclosed is our information to aid you in preparing this years Consumer Confidence Report for your customers.

Your source of water is surface water runoff from the Linn Creek watershed that is collected and stored in the Linn Creek reservoir located three miles South of Gentry, MO, just upstream from where Linn Creek crosses Highway 169.

Also included is the annual Contaminants Report as provided by the MoDNR. This includes Regulated Contaminants, Turbidity, and Optional Contaminants.

Thank you,

Eric Carmichael
Office Manager
Middle Fork Water Company

MIDDLE FORK WATER COMPANY

PLANT
HWY 169 S - BOX 80
GENTRY, MO 64453
660/448-2111

OFFICE
BOX 468
MARYVILLE, MO 64468
660/582-4111

Mr. Terry Raymond
City of Stanberry
130 W. 1st
Stanberry, MO 64489

4-12-11
FAXED

April 12, 2011

RE: Consumer Confidence Report

Enclosed is our information to aid you in preparing this years Consumer Confidence Report for your customers.

Your source of water is surface water runoff from the Linn Creek watershed that is collected and stored in the Linn Creek reservoir located three miles South of Gentry, MO, just upstream from where Linn Creek crosses Highway 169.

Also included is the annual Contaminants Report as provided by the MoDNR. This includes Regulated Contaminants, Turbidity, and Optional Contaminants.

Thank you,

Eric Carmichael
Office Manager
Middle Fork Water Company

MIDDLE FORK WATER CO

MO1070639

2010 Annual Water Quality Report

(Reseller Report)

Regulated Contaminants

Inorganic	Units	MCL	MCLG	Level Found	Range of Detections	Violation	Sample Year
BARIUM	ppm	2	2	0.0417	0.0417	No	2010
Sources of Barium							
Discharge of drilling wastes; Discharge from metal refineries; Erosion of natural deposits							
CARBON, TOTAL ORGANIC (TOC)	ppm			4.9388	2.17-8.04	No	2010
Sources of Carbon, Total Organic (toc)							
Naturally present in the environment.							
CHLORITE	ppb	1000	800	0.2788	nd-0.66	No	2010
Sources of Chlorite							
By-product of drinking water disinfection							
FLUORIDE	ppm	4	4	0.0300	0.03	No	2010
Sources of Fluoride							
Erosion of natural deposits; Water additive which promotes strong teeth; Discharge from fertilizer and aluminum factories							
NITRATE+NITRITE (AS N)	ppm	10	10	0.1000	0.1	No	2010
Sources of Nitrate+nitrite (as N)							
Runoff from fertilizer use; Leaching from septic tanks, sewage; Erosion of natural deposits							
NITRITE (AS N)	ppm	1	1	0.3000	0.3	No	2008
Sources of Nitrite (as N)							
Runoff from fertilizer use; Leaching from septic tanks, sewage; Erosion of natural deposits							

Turbidity

Turbidity is a measure of cloudiness of water. We monitor turbidity because it is a good indicator of the effectiveness of our filtration system.

Percentage of samples in compliance with Std.	*Month Occurred*	*Violation*	*Highest Single Measurement for the year*	*Month Occurred*	*Sources*
100	n/a	No			Soil runoff

MIDDLE FORK WATER CO

MO1070639

2010 Annual Water Quality Report

(Reseller Report)

Optional Monitoring (not required by EPA)

Optional Contaminants

Monitoring is not required for optional contaminants.

Inorganic	*Units*	*Level Found*	*Range of Detections*	*Sample Year*
ALKALINITY, CACO3 STABILITY	ppm	126.0000	126	2010
ALKALINITY, TOTAL	ppm	93.0000	76-106	2010
ALUMINUM	ppb	201.0000	201	2010
CALCIUM	ppm	27.0000	27	2010
CHLORIDE	ppm	30.7000	30.7	2010
HARDNESS, CARBONATE	ppm	89.2000	89.2	2010
MAGNESIUM	ppm	5.3000	5.3	2010
MANGANESE	ppb	4.4600	4.46	2010
PH		7.5800	7.58	2010
POTASSIUM	ppm	2.7600	2.76	2010
SODIUM	ppm	16.7000	16.7	2010
SOLIDS, TOTAL DISSOLVED (TDS)	ppm	130.0000	130	2010
SULFATE	ppm	11.8000	11.8	2010
ZINC	ppb	2.6700	2.67	2010
Volatile Organic	*Units*	*Level Found*	*Range of Detections*	*Sample Year*
BROMOCHLOROACETIC ACID	ppb	5.8431	3.75-7.94	2010
BROMODICHLOROACETIC ACID	ppb	3.8750	1.8-6.64	2010
BROMODICHLOROMETHANE	ppb	10.7476	4.63-14.9	2010
CHLORODIBROMOACETIC ACID	ppb	0.1900	nd-1.74	2010
CHLORODIBROMOMETHANE	ppb	2.0318	1.04-2.65	2010
CHLOROFORM	ppb	53.4471	20.2-109	2010
DIBROMOACETIC ACID	ppb	0.6550	nd-1.07	2010
DICHLOROACETIC ACID	ppb	29.4625	11.8-53.4	2010
TRICHLOROACETIC ACID	ppb	16.8119	6.59-24.4	2010

MIDDLE FORK WATER CO

MO1070639

2010 Annual Water Quality Report

(Reseller Report)

MIDDLE FORK

The Department of Natural Resources conducted an assessment of our source water to determine its susceptibility to contamination. All surface water sources are vulnerable to land use activities within their watershed. This is why all surface water in Missouri must be treated in dual treatment trains with barriers in place for potential microbiological and chemical contaminants. The assessment is a delineation of our watershed(s) and an inventory of the potential contaminants found within the watershed(s). If you want to know more about the assessment or wish to participate on a watershed protection team to protect this valuable resource, then please call 660-448-2111 .

Contaminants Report

Definitions:

MCLG: Maximum Contaminant Level Goal, or the level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety.
MCL: Maximum Contaminant Level, or the highest level of a contaminant that is allowed in drinking water. MCLs are set as close to the MCLGs as feasible using the best available treatment technology.

AL: Action Level, or the concentration of a contaminant which, when exceeded, triggers treatment or other requirements which a water system must follow..
TT: Treatment Technique, or a required process intended to reduce the level of a contaminant in drinking water.
90th percentile: For lead and Copper testing. 10% of test results are above this level and 90% are below this level.
Level Found: is the average of all test results for a particular contaminant.
Range of Detections: Shows the lowest and highest levels found during a testing period, if only one sample was taken, then this number equals the Level Found .
MRLDG: Maximum Residual Disinfectant Level Goal, or the level of a drinking water disinfectant below which there is no known or expected risk to health.
MRDL: Maximum Residual Disinfectant Level, or the highest level of a disinfectant allowed in drinking water.

Abbreviations:

PPB: parts per billion or micrograms per liter.

ppm: parts per million or milligrams per liter.

n/a: not applicable.

NTU: Nephelometric Turbidity Unit, used to measure cloudiness in drinking water.

MFL: million fibers per liter, used to measure asbestos concentration.

nd: not detectable at testing limits.

The state has reduced monitoring requirements for certain contaminants to less often than once per year because the concentrations of these contaminants are not expected to vary significantly from year to year. Records with a sample year more than one year old are still considered representative.

Regulated Contaminants

Disinfection By-Products	*Units*	*MCL*	*MCLG*	*Level Found*	*Range of Detections*	*Violation*	*Sample Year*
TOTAL HALOACETIC ACIDS (HAA5)	ppb	60	0	46.9438	21-78.5	No	2010
Sources of Total Haloacetic Acids (haa5)							
By-product of drinking water disinfection							
TOTAL TRIHALOMETHANES (TTHM)	ppb	80	n/a	68.3250	25.9-124	Yes	2010
Sources of Total Trihalomethanes (tthm)							
By-product of drinking water chlorination							

Turbidity

Turbidity is a measure of cloudiness of water. We monitor turbidity because it is a good indicator of the effectiveness of our filtration system.

Percentage of samples in compliance with Std	Month Occurred	Violation	Highest Single Measurement for the Year	Month Occurred	Sources
100%	N/A	No	0.288	MAY	Soil Runoff

Appendix B

WTP and Reservoir Photos

Rapid Rate Filters

Filter Face Piping

Treatment Building – From Southwest

Loading Dock – Note Damage

Lab Counter and Online Chlorine and Turbidity Analyzer

Reservoir and Intake Wetwell

Chlorine Dioxide Generator

Secondary Sedimentation Basin – From East

Rapid Mix Basins

High Service Pump Pipe Manifold

Chlorine Vacuum Regulators

Stanberry Lake Dam
Gentry, MO.

Photograph 1: Overview of dam from upstream

Photograph 2: Overview of auxiliary spillway

Stanberry Lake Dam
Gentry, MO.

Photograph 3: Overview of dam from downstream

Photograph 4: Downstream slope and bench looking north

Stanberry Lake Dam
Gentry, MO.

Photograph 5: Crest looking south

Photograph 6: Crest looking north

Stanberry Lake Dam
Gentry, MO.

Photograph 7: Crest contact with right abutment.

Photograph 8: Upstream slope looking north

Photograph 9: Vegetation on upstream slope

Photograph 10: Intake structure

Photograph 11: Cracks at base of intake structure

Photograph 12: Upstream slope, riprap and debris

Photograph 13: Primary spillway looking south

Photograph 14: Primary spillway looking north

Photograph 15: Animal burrows on upstream slope

Photograph 16: Overview of downstream area

Photograph 17: Downstream slope looking south

Photograph 18: Bench looking north

Photograph 19: Bench looking south

Photograph 20: Vegetation on lower downstream slope

Photograph 21: Animal burrow on lower downstream slope

Photograph 22: Overview of plunge basin

Photograph 23: Restored plunge basin embankment and outlet channel

Photograph 24: Primary spillway outlet to plunge basin

Photograph 25: Animal burrow in embankment

Photograph 26: Erosion rill in downstream slope above plunge basin

Photograph 27: Downstream channel

Photograph 28: Foundation drain discharge

Appendix C

Memorandum from David Williams, dated January 7, 2011

January 7, 2011

To: Brock Pfost

From: David Williams DLW

Subject: Middle Fork Water Company

Recently you asked if I would provide my thoughts as to what current improvements could be made so that Middle Fork Water Company's water treatment plant could continue into the future as a viable source of drinking water for Northwest Missouri. Middle Fork Water Company was one of seven water systems identified by the Northwest Missouri Water Partnership Team as a potential supplier of drinking water into the long term future. It was know that all seven identified systems would require upgrades, modifications, and an increase in capacities in order to meet those future needs of the area served. The following comments are my personal opinion and are being offered due to my knowledge of the Middle Fork water plant and forty plus years in the drinking water field.

Source Water and Future Supply

The current source of water supplying the treatment plant is Linn Creek Reservoir. It is 155 acres in size and at full pool would contain approximately 342 million gallons of water. In 2003 – 2004 a reasonably severe drought was experienced in Northwest Missouri. During that drought the existing four and eight foot depth intake pipes were exposed and water was drawn through the third and final intake pipe at the twelve foot level. At that time the twelve foot pipe was visible through approximately two to three feet of water above it. With that information I offer the following.

Additional source should be considered in the future. There could be two possible solutions to this. First, a second reservoir could be constructed upstream in the same watershed. It would serve as a collection point that could provide water to supplement Linn Creek Reservoir as needed. A second possibility would be the development of groundwater wells in the Middle Fork of the Grand River bottoms that could provide water directly to the water treatment plant or serve as a supplemental supply to reservoir. You have already substantiated that this is a viable option due to your previous test drilling at the time to 2004 drought. As I recall a test site was located approximately three quarters of a mile from the treatment plant that was capable of providing 315 gpm.

Lake Intake, Lake Pumps, and Pre-sedimentation Pond

1. Consideration should be given to constructing a new intake system versus the existing three fixed intake pipes. A floating intake with a winch, cable, and flexible intake hose is felt to be a better system. It allows staff the ability to adjust the level at which source water is drawn. Therefore after jar testing the appropriate level with the best treatable water quality can be utilized.

2. A new building should be constructed near the lake to house the lake pumps and accommodate suitable space for any pretreatment chemicals that are used. This building should be insulated and heated for winter as well as ventilated well for cooling in the summer. It should be sized adequately for housing all equipment, storage and containment of chemicals, and working area space for staff's safety. Backup power should be provided on site.
3. Piping from this new pump house should allow for the water being delivered directly to the treatment plant or to the pre-sedimentation pond. The existing two acre pre-sedimentation pond that is currently being used might have a lesser degree of quality water then the lake. Samples could be analyzed from both the lake and the pond to actually see which quality is the better. The water with the lower amount of precursor organics that form TTHMs and HAA5s should be the water of choice.
4. Both the lake and the pre-sedimentation pond are known to have some degree of silt buildup. I believe they have been in service approximately twenty years so dredging or some type of silt removal could be considered.

Treatment Plant

1. A new conventional primary treatment basin could be considered. It could be located immediately north and adjacent to the two existing basins (primary and secondary). The new basin could be sized to accommodate increased capacity for future needs. The current plant design is 700 gallons per minute. If the new basin was designed for a 1000 gpm it would initially greatly enhance the water's detention time as well as the surface settling rate and the weir overflow rate. Also with that design the plant would increase from 1.0 MGD to approximately 1.5 MGD. The existing basins should stay in service allowing the primary now to become the secondary settling basin, and the current secondary basin would become a polishing basin and a basin for achieving the required CT for chlorine contact. All basins should be covered with enclosed roofs to prevent sunlight contact thus reducing algae (organic) issues with DBP formation.
2. The existing conventional rapid rate gravity filters sufficient. In the future if needed there is adequate property to add an additional filter room immediately east of where the filters are now located. There is the need to totally rebuild all three filters during any upgrade project. This would include; remove and replace all support gravel and media, inspect and repair as needed the filter underdrains, and paint the filter structures and all associated filter piping.
3. The finished water clearwell has an approximate holding capacity of 350,000 gallons. The entirety of this volume of water is not usable due to the location and manor in which high service pumps are positioned. An adjacent, adjoining wet-well could be constructed that would position the pump intakes at a lower level than the floor of the existing clearwell. If this was done the existing pump room could be converted to an ammonia feed room. Middle Fork will probably want to consider converting the disinfectant used from free chlorine as is done now to chloramine disinfection. Two reasons for this are; it will halt the formation of TTHMs at the plant and also can provide a viable disinfectant residual for greater

distances in larger distribution systems. If Middle Fork Water Company provides water in the future to the regionalized efforts of Northwest Missouri it will be a needed change for the water to be compatible for blending with other sources.

4. The intent of the foregoing changes could allow the following. Primary treatment and settling (turbidity and organic precursor removal) would be done in basins #1 and #2. They are the proposed basin and the current primary basin. Basin #3 (currently the secondary basin) would be where chlorine would be injected to provide break point chlorination. A study would need to be performed to assure required CT values are met. The free chlorine residual would pass through the three filters to deter any algae or bacterial growth problems. Ammonia would be injected at entry to the clearwell and would allow the formation of chloramines prior to being pumped to distribution systems.

Regulatory Concerns: Public Drinking Water

As it is known and understood there are no new regulations in the near and immediate future that will impact the Middle Fork Water Company. Currently Middle Fork is in the last few months of crytosporidium monitoring required by Long Term 2 of the Enhanced Surface Water Treatment Rule. Analytical results to date have been favorable and indicate there shouldn't be a negative impact to the treatment plant process. Conclusion of the testing period will be the final determination.

Regulatory Concerns: Water Pollution

This topic concerns the waste water holding ponds for the water plant. There is new regulation at hand regarding the permits on water plant ponds/lagoons. Staff should become familiar with the permitting requirements and proceed accordingly. This change involves monitoring requirements, discharge limits, and removal and disposal of the materials that settle and accumulate.

Closing

Previous items referenced are the large segments of a potential upgrade at the Middle Fork Water Company's treatment plant. Many finalizing details would need to be determined and included in the project. It would be crucial to do an in-depth engineering study. With that in mind all engineering, plans, and specifications would have to be compliant with Missouri's "Public Drinking Regulations" and project work would need to conform to the "Design Guide for Community Water Systems".

The foregoing upgrades in my opinion are the larger components that would allow Middle Fork Water Company to continue providing long-term, quality drinking water to Northwest Missouri. It appears to me that the existing treatment facility is located on a site and in a configuration that would allow the fore mentioned upgrades to be done in a cost effective manner.

Please advise me should there be questions or if I can be of any further assistance.

Appendix D

Common Dam Safety Definitions

Appendix D
Common Dam Safety Definitions

The words and terms listed below, as used in this plan, shall have the following meanings, unless the context clearly indicates otherwise.

Orientation

Upstream – Shall mean the side of the dam that borders the impoundment.

Downstream – Shall mean the high side of the dam, the side opposite the upstream side.

Right – Shall mean the area to the right when looking in the downstream direction.

Left – Shall mean the area to the left when looking in the downstream direction.

Dam Components

Dam – Shall mean any artificial barrier, including appurtenant works, which impounds or diverts water.

Dam Height – Shall mean the difference in the elevation of either the natural bed of the stream or watercourse, or the lowest point on the toe of the dam and the dam crest elevation.

Embankment – Shall mean the fill material, usually earth or rock, placed with sloping sides, such that it forms a permanent barrier that impounds water.

Crest – Shall mean the top of the dam, usually provides a road or path across the dam.

Abutment – Shall mean that part of a valley side against which a dam is constructed. An artificial abutment is sometimes constructed as a concrete gravity section, to take the thrust of an arch dam where there is no suitable natural abutment.

Appurtenant Works – Shall mean structures, either in dams or separate there from. including but not be limited to, spillways; reservoirs and their rims; low level outlet works; and water conduits including tunnels, pipelines, or penstocks, either through the dams or their abutments.

Spillway – Shall mean a structure over or through which water flows are discharged. If the flow is controlled by gates or boards, it is a controlled spillway; if the fixed elevation of the spillway crest controls the level of the impoundment, it is an uncontrolled spillway.

Jurisdictional – Missouri Dam Safety Laws and Regulations define jurisdictional dams as any artificial or man-made barrier which does or may impound water and is 35 feet or more in height (Section 236.400(5) RS Missouri).

Hazard Classification

High Hazard (Class I) – Shall mean dams located where failure will likely cause loss of life and serious damage to home(s), industrial or commercial facilities, important public utilities, main highway(s) or railroad(s).

Significant Hazard (Class II – Shall mean dams located where failure may cause loss of life and damage to home(s), industrial or commercial facilities, secondary highway(s) or railroad(s), or cause the interruption of the use or service of relatively important facilities.

Low Hazard (Class III) – Dams located where failure may cause minimal property damage to others. Loss of life is not expected.

General

EAP – Emergency Action Plan - Shall mean a predetermined plan of action to be taken to reduce the potential for property damage and/or loss of life in an area affected by an impending dam break

Freeboard – Shall mean the vertical distance between the reservoir surface elevation and the top of the dam

Owner/Operator – Person/entity, who owns, controls, operates, maintains, and manages the dam

O&M Manual – Operations and Maintenance Manual; A document identifying routine maintenance and operational procedures under normal and storm conditions

Normal Pool – Shall mean the elevation of the impoundment during normal operating conditions

Acre-foot – Shall mean a unit of volumetric measure that would cover one acre to a depth of one foot. It is equal to 43,560 cubic feet. On million U.S. gallons = 3.068 acre feet

Height of Dam – Shall mean the vertical distance from the lowest portion of the natural ground, including any stream channel, along the downstream toe of the dam to the crest of the dam

Spillway Design Flood (SDF) – Shall mean the flood used in the design of a dam and its appurtenant works particularly for sizing the spillway and outlet works, and for determining maximum temporary storage and height of dam requirements

Condition Rating

Unsafe – Major structural, operational, and maintenance deficiencies exist under normal operating conditions.

Poor – Significant structural, operation and maintenance deficiencies are clearly recognized for normal loading conditions.

Fair – Significant operational and maintenance deficiencies, no structural deficiencies. Potential deficiencies exist under unusual loading conditions that may realistically occur. This rating can be used when uncertainties exist as to critical parameters.

Satisfactory – Minor operational and maintenance deficiencies.

Good – No existing or potential deficiencies recognized. Safe performance is expected under all loading including SDF.

Appendix E

Stanberry Dam Inspection Checklist

Dam Evaluation Summary Detail Sheet

1. NID ID:	**NA**	**4. Inspection Date:**	**November 10, 2011**
2. Dam Name:	**Stanberry Lake Dam**	**5. Last Insp. Date:**	**NA**
3. Dam Location:	**#REF!**	**6. Next Inspection:**	**November 10, 2016**
7. Inspector:	**William J. Friers**		
8. Consultant:	**CDM**		
9. Hazard Code:	**0**	**9a. Is Hazard Code Change Requested?:**	**No**
10. Insp. Frequency:	**#N/A**	**11. Overall Physical Condition of Dam:**	**SATISFACTORY**
12. Spillway Capacity (% SDF)	**0-50% of the SDF or Unknown**		

E1. Design Methodology:	**3**	**E7. Low-Level Discharge Capacity:**	**0**
E2. Level of Maintenance:	**3**	**E8. Low-Level Outlet Physical Condition:**	**4**
E3. Emergency Action Plan:	**2**	**E9. Spillway Design Flood Capacity:**	**1**
E4. Embankment Seepage:	**5**	**E10. Overall Physical Condition of the Dam:**	**4**
E5. Embankment Condition:	**4**	**E11. Estimated Repair Cost:**	**$0**
E6. Concrete Condition:	**3**		

Evaluation Description

E1: DESIGN METHODOLOGY
1. Unknown Design – no design records available
2. No design or post-design analyses
3. No analyses, but dam features appear suitable
4. Design or post design analysis show dam meets most criteria
5. State of the art design – design records available & dam meets all criteria

E2: LEVEL OF MAINTENANCE
1. Dam in disrepair, no evidence of maintenance, no O&M manual
2. Dam in poor level of upkeep, very little maintenance, no O&M manual
3. Dam in fair level of upkeep, some maintenance and standard procedures
4. Adequate level of maintenance and standard procedures
5. Dam well maintained, detailed maintenance plan that is executed

E3: EMERGENCY ACTION PLAN
1. No plan or idea of what to do in the event of an emergency
2. Some idea but no written plan
3. No formal plan but well thought out
4. Available written plan that needs updating
5. Detailed, updated written plan available and filed with MADCR, annual training

E4: SEEPAGE (Embankments, Foundations, & Abutments)
1. Severe piping and/or seepage with no monitoring
2. Evidence of monitored piping and seepage
3. No piping but uncontrolled seepage
4. Minor seepage or high volumes of seepage with filtered collection
5. No seepage or minor seepage with filtered collection

E5: EMBANKMENT CONDITION (See Note 1)
1. Severe erosion and/or large trees
2. Significant erosion or significant woody vegetation
3. Brush and exposed embankment soils, or moderate erosion
4. Unmaintained grass, rodent activity and maintainable erosion
5. Well maintained healthy uniform grass cover

E6: CONCRETE CONDITION (See Note 2)
1. Major cracks, misalignment, discontinuities causing leaks, seepage or stability concerns
2. Cracks with misalignment inclusive of transverse cracks with no misalignment but with potential for significant structural degradation
3. Significant longitudinal cracking and minor transverse cracking
4. Spalling and minor surface cracking
5. No apparent deficiencies

E7: LOW-LEVEL OUTLET DISCHARGE CAPACITY
1. No low level outlet, no provisions (e.g. pumps, siphons) for emptying pond
2. No operable outlet, plans for emptying pond, but no equipment
3. Outlet with insufficient drawdown capacity, pumping equipment available
4. Operable gate with sufficient drawdown capacity
5. Operable gate with capacity greater than necessary

E8: LOW-LEVEL OUTLET PHYSICAL CONDITION
1. Outlet inoperative needs replacement, non-existent or inaccessible
2. Outlet inoperative needs repair
3. Outlet operable but needs repair
4. Outlet operable but needs maintenance
5. Outlet and operator operable and well maintained

E9: SPILLWAY DESIGN FLOOD CAPACITY
1. 0 - 50% of the SDF or unknown
2. 50-90% of the SDF
3. 90 - 100% of the SDF
4. >100% of the SDF with actions required by caretaker (e.g. open outlet)
5. >100% of the SDF with no actions required by caretaker

E10: OVERALL PHYSICAL CONDITION OF DAM
1. UNSAFE – Major structural, operational, and maintenance deficiencies exist under normal operating conditions
2. POOR - Significant structural, operation and maintenance deficiencies are clearly recognized under normal loading conditions
3. FAIR - Significant operational and maintenance deficiencies, no structural deficiencies. Potential deficiencies exist under unusual loading conditions that may realistically occur. Can be used when uncertainties exist as to critical parameters
4. SATISFACTORY - Minor operational and maintenance deficiencies. Infrequent hydrologic events would probably result In deficiencies.
5. GOOD - No existing or potential deficiencies recognized. Safe performance is expected under all loading including SDF

E11: ESTIMATED REPAIR COST

Estimation of the total cost to address all identified structural, operational, maintenance deficiencies. Cost shall be developed utilizing standard estimating guides and procedures

Changes/Deviations to Database Information since Last Inspection

Commonwealth of Massachusetts DCR Dam Safety Inspection Checklist

Instructions

This spreadsheet contains macros to facilitate correct data entry. You must enable macros in Excel for the spreadsheet to function properly. If you did not enable macros when opening this spreadsheet, do so now by selecting Tools - Macro - Security, Medium, then close and restart Excel. Click on Enable Macros when opening the checklist.

All of the worksheets (tabs) are protected to restrict data entry to the proper cells. If you need to make modifications, select Tools - Protection - Unprotect Sheet; a password is not required.

Enter data on Sheets 1, 2 and 3 first in that order. In general, data are entered only once, on the first sheet on which they appear. Repeated data entries on subsequent sheets are generated automatically. In cases where two data items are linked (e.g., Condition Code and Condition Description), only one data item can be entered, the other is generated automatically. The entire Summary Detail sheet (to be inserted at the front of the Phase I report) is generated automatically. Most of the Dam Data Summary Sheet (Summary Data Table in Section 1 of the report) is generated automatically. The remaining sheets can be completed in any order.

Be careful to only check one box when using the checkboxes.

Contact Tom Famulari at the Office of Dam Safety if you have any questions about using this checklist. Tom can be reached at 617-626-1367, tom.famulari@state.ma.us

1.1 Summary Data Table

Required Phase I Report Data	Data Provided by the Inspecting Engineer
National ID #	NA
Dam Name	Stanberry Lake Dam
Dam Name (Alternate)	Lake Elizabeth Dam
River Name	Linn Creek
Impoundment Name	Stanberry Lake, Lake Elizabeth, Linn Creek Lake
Hazard Class	0
Size Class	0
Dam Type	Earth Embankment
Dam Purpose	Water Supply
Structural Height of Dam (feet)	34.5
Hydraulic Height of Dam (feet)	32
Drainage Area (sq. mi.)	6.3
Reservoir Surface Area (sq. mi.)	0.22
Normal Impoundment Volume (acre-feet)	1040
Max Impoundment Volume ((top of dam) acre-feet)	1625
SDF Impoundment Volume* (acre-feet)	1040
Spillway Type	Drop Inlet
Spillway Length (feet)	45
Freeboard at Normal Pool (feet)	5
Principal Spillway Capacity* (cfs)	400
Auxiliary Spillway Capacity* (cfs)	3600
Low-Level Outlet Capacity* (cfs)	0
Spillway Design Flood* (flow rate - cfs)	Unknown
Winter Drawdown (feet below normal pool)	0
Drawdown Impoundment Vol. (acre-feet)	0
Latitude	40.2886
Longitude	94.4325
City/Town	Gentry, MO
County Name	Gentry
Public Road on Crest	No
Public Bridge over Spillway	No
EAP Date (if applicable)	None available
Owner Name	Middle Fork Water Company
Owner Address	2961 U.S. Highway 169
Owner Town	Gentry, MO 64453
Owner Phone	(660) 448-2111
Owner Emergency Phone	(660) 582-2580
Owner Type	Private
Caretaker Name	Brock Pfost, P.E.
Caretaker Address	2961 U.S. Highway 169
Caretaker Town	Gentry, MO 64453
Caretaker Phone	(660) 448-2111
Caretaker Emergency Phone	(660) 582-2580
Date of Field Inspection	11/10/2011
Consultant Firm Name	CDM
Inspecting Engineer	William Friers, Stephen Whiteside
Engineer Phone Number	518 782-4513

*In the event a hydraulic and hydrologic analysis has not been completed for the dam, indicate "No H&H" in this table, recommendation section shall include specific recommendation to hire a qualified dam engineering consultant to conduct analysis to determine spillway adequacy in conformance with 302 CMR 10.00.

DAM DEFICIENCIES

Dam Name Stanberry Lake Dam
NID ID # NA

Copy and paste to this spreadsheet the dam deficiencies enumerated in Section 3 of the Phase I Dam Safety Inspection Report. Put each deficiency in a separate cell. This sheet does not need to be printed out. It is for the internal use of DCR. This Excel spreadsheet must be submitted on a CD with the PDF of the report.

Deficiency No.	Description
1	Areas of erosion on upstream slope observed; 3 feet high x 4 feet deep accompanied by steep embankment slopes (2H:1V)
2	Upstream slope erosion around the perimeter of the primary spillway.
3	Animal burrows observed on the upstream and downstream embankment slopes
4	Tire rutting; approximately 8 inches deep on left half of the crest and on downstream embankment bench , with some puddles
5	There is no low-level outlet for the dam.
6	Tall grass, brush and saplings were observed to be growing in the riprap on the upstream slope.
7	Concrete cracks and deterioration on the exterior of the water intake structure observed near the base of the structure. Cracks extend approximately 3 inches in depth.
8	Numerous trees up to 4-inch-diameter are present on the lower section of the downstream embankment slope
9	Erosion of material from within the plunge basin appears to have increased the structural height of the dam.

DAM SAFETY INSPECTION CHECKLIST

NAME OF DAM: Stanberry Lake Dam

STATE ID #: NA

REGISTERED: ☐ YES ☑ NO

NID ID #: NA

STATE SIZE CLASSIFICATION:

STATE HAZARD CLASSIFICATION:

CHANGE IN HAZARD CLASSIFICATION REQUESTED?: No

DAM LOCATION INFORMATION

CITY/TOWN: Gentry, MO

COUNTY: Gentry

DAM LOCATION: 2961 U.S. Highway 169
(street address if known)

ALTERNATIVE DAM NAME: Lake Elizabeth Dam

USGS QUAD.: Gentry

LAT.: 40.2886

LONG.: 94.4325

DRAINAGE BASIN: Upper Grand

RIVER: Linn Creek

IMPOUNDMENT NAME(S): Stanberry Lake, Lake Elizabeth, Linn Creek Lake

GENERAL DAM INFORMATION

TYPE OF DAM: Earth Embankment

OVERALL LENGTH (FT): 1,000

PURPOSE OF DAM: Water Supply

NORMAL POOL STORAGE (ACRE-FT): 1,040

YEAR BUILT: 1992

MAXIMUM POOL STORAGE (ACRE-FT): 1,625

STRUCTURAL HEIGHT (FT): 34.5

EL. NORMAL POOL (FT): 890.0

HYDRAULIC HEIGHT (FT): 32.0

EL. MAXIMUM POOL (FT): 896.7

FOR INTERNAL MADCR USE ONLY

FOLLOW-UP INSPECTION REQUIRED: ☐ YES ☑ NO

CONDITIONAL LETTER: ☐ YES ☑ NO

NAME OF DAM: Stanberry Lake Dam | STATE ID #: NA

INSPECTION DATE: November 10, 2011 | NID ID #: NA

INSPECTION SUMMARY

DATE OF INSPECTION: November 10, 2011 | DATE OF PREVIOUS INSPECTION: NA

TEMPERATURE/WEATHER: 45° F; Windy; Clear | ARMY CORPS PHASE I: ☐ YES ☑ NO | If YES, date

CONSULTANT: CDM | PREVIOUS DCR PHASE I: ☐ YES ☑ NO | If YES, date

BENCHMARK/DATUM: MSL

OVERALL PHYSICAL CONDITION OF DAM: SATISFACTORY | DATE OF LAST REHABILITATION: Unknown

SPILLWAY CAPACITY: 0-50% of the SDF or Unknown

EL. POOL DURING INSP.: 887.25 | EL. TAILWATER DURING INSP.: NA

PERSONS PRESENT AT INSPECTION

NAME	TITLE/POSITION	REPRESENTING
Stephen Whiteside	VP Geotechnical Services	CDM
William Friers	Sr. Civil Engineer	CDM
Danny	Plant Operator	Middle Fork Water Co.

EVALUATION INFORMATION

	Click on box to select E-code		Click on box to select E-code
E1) TYPE OF DESIGN	3	E8) LOW-LEVEL OUTLET CONDITION	4
E2) LEVEL OF MAINTENANCE	3	E9) SPILLWAY DESIGN FLOOD CAPACITY	1
E3) EMERGENCY ACTION PLAN	2	E10) OVERALL PHYSICAL CONDITION	4
E4) EMBANKMENT SEEPAGE	5	E11) ESTIMATED REPAIR COST	
E5) EMBANKMENT CONDITION	4	ROADWAY OVER CREST	NO
E6) CONCRETE CONDITION	3	BRIDGE NEAR DAM	NO
E7) LOW-LEVEL OUTLET CAPACITY			

NAME OF INSPECTING ENGINEER: William J. Friers | SIGNATURE:

NAME OF DAM: Stanberry Lake Dam

STATE ID #: NA

INSPECTION DATE: November 10, 2011

NID ID #: NA

OWNER:	ORGANIZATION	Middle Fork Water Company	CARETAKER:	ORGANIZATION	Middle Fork Water Company
	NAME/TITLE	Brock Pfost, P.E.		NAME/TITLE	Brock Pfost, P.E.
	STREET	2961 U.S. Highway 169		STREET	2961 U.S. Highway 169
	TOWN, STATE, ZIP	Gentry, MO 64453		TOWN, STATE, ZIP	Gentry, MO 64453
	PHONE	(660) 448-2111		PHONE	(660) 448-2111
	EMERGENCY PH. #	(660) 582-2580		EMERGENCY PH. #	(660) 582-2580
	FAX	(660) 582-4115		FAX	(660) 582-4115
	EMAIL	whitecld@unitedsky.net		EMAIL	whitecld@unitedsky.net
	OWNER TYPE	Private			

PRIMARY SPILLWAY TYPE: Drop Inlet

SPILLWAY LENGTH (FT): 45

SPILLWAY CAPACITY (CFS): 400

AUXILIARY SPILLWAY TYPE: Side Channel

AUX. SPILLWAY CAPACITY (CFS): 3,600

NUMBER OF OUTLETS: None

OUTLET(S) CAPACITY (CFS): 0

TYPE OF OUTLETS: NA

TOTAL DISCHARGE CAPACITY (CFS): 4,000

DRAINAGE AREA (SQ MI): 6.3

SPILLWAY DESIGN FLOOD (PERIOD/CFS): Unknown

HAS DAM BEEN BREACHED OR OVERTOPPED ☐ YES ☑ NO IF YES, PROVIDE DATE(S)

FISH LADDER (LIST TYPE IF PRESENT)

DOES CREST SUPPORT PUBLIC ROAD? ☐ YES ☑ NO IF YES, ROAD NAME:

PUBLIC BRIDGE WITHIN 50' OF DAM? ☐ YES ☑ NO IF YES, ROAD/BRIDGE NAME:

MHD BRIDGE NO. (IF APPLICABLE)

NAME OF DAM: Stanberry Lake Dam STATE ID #: NA

INSPECTION DATE: November 10, 2011 NID ID #: NA

EMBANKMENT (CREST)

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
CREST	1. SURFACE TYPE	Grass covered			
	2. SURFACE CRACKING	No			
	3. SINKHOLES, ANIMAL BURROWS	No			
	4. VERTICAL ALIGNMENT (DEPRESSIONS	Good			
	5. HORIZONTAL ALIGNMENT	Good			
	6. RUTS AND/OR PUDDLES	Tire rutting; approximately 8 inches deep on left half of the crest, with some puddles			
	7. VEGETATION (PRESENCE/CONDITION)	Established turf; grass cut to approximately 4 inches			
	8. ABUTMENT CONTACT	Good			

ADDITIONAL COMMENTS: Crest width = 20 feet; Crest slopes slightly towards upstream side
Vehicle access to the crest is restricted to authorized personnel with a cable barrier on left side of embankment and a swing gate located near the center of the dam

NAME OF DAM: Stanberry Lake Dam STATE ID #: NA

INSPECTION DATE: November 10, 2011 NID ID #: NA

EMBANKMENT (D/S SLOPE)

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
D/S SLOPE	1. WET AREAS (NO FLOW)	Area immediately below toe has some standing water; likely surface run-off	x		
	2. SEEPAGE	None observed			
	3. SLIDE, SLOUGH, SCARP	None observed			
	4. EMB.-ABUTMENT CONTACT	Good			
	5. SINKHOLE/ANIMAL BURROWS	Two burrows observed in lower embankment slope.			x
	6. EROSION	None observed			
	7. UNUSUAL MOVEMENT	None observed			
	8. VEGETATION (PRESENCE/CONDITION)	Upper embankment slope and bench covered with brush & grass (to 30-inches-high)			x
		Lower embankment slope covered with brush and brambles with numerous trees up			x
		to 4-inch-diameter			

ADDITIONAL COMMENTS:

NAME OF DAM: Stanberry Lake Dam STATE ID #: NA

INSPECTION DATE: November 10, 2011 NID ID #: NA

EMBANKMENT (U/S SLOPE)

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
U/S SLOPE	1. SLIDE, SLOUGH, SCARP	None			
	2. SLOPE PROTECTION TYPE AND COND.	6" to 12" riprap armoring; sparse in areas			x
	3. SINKHOLE/ANIMAL BURROWS	Several small animal burrows observed on the upper third of the embankment slope			x
	4. EMB.-ABUTMENT CONTACT	Good			
	5. EROSION	Areas of erosion (3 feet high x 4 feet deep) between El. 890 and 893		x	x
	6. UNUSUAL MOVEMENT	None			
	7. VEGETATION (PRESENCE/CONDITION)	Grass and brush to 30 inches high; a cluster of 2-inch-diameter saplings			x

ADDITIONAL COMMENTS: Sapling cluster located to the left of the USGS gage. Design slope is 2.5H:1V; Slope of 2H:1V observed in some areas to the left of the intake structure

NAME OF DAM: Stanberry Lake Dam STATE ID #: NA

INSPECTION DATE: November 10, 2011 NID ID #: NA

INSTRUMENTATION

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
INSTR.	1. PIEZOMETERS				
	2. OBSERVATION WELLS				
	3. STAFF GAGE AND RECORDER	USGS Gage Station 06896189 is located near the center of the dam.			
	4. WEIRS				
	5. INCLINOMETERS				
	6. SURVEY MONUMENTS				
	7. DRAINS				
	8. FREQUENCY OF READINGS				
	9. LOCATION OF READINGS				

ADDITIONAL COMMENTS: USGS records the Lake's water surface elevation on 15-minute intervals.

NAME OF DAM: Stanberry Lake Dam STATE ID #: NA

INSPECTION DATE: November 10, 2011 NID ID #: NA

DOWNSTREAM MASONRY WALLS

AREA INSPECTED	CONDITION	OBSERVATIONS			NO ACTION	MONITOR	REPAIR
D/S WALLS	1. WALL TYPE						
	2. WALL ALIGNMENT						
	3. WALL CONDITION						
	4. HEIGHT: TOP OF WALL TO MUDLINE	min:	max:	avg:			
	5. SEEPAGE OR LEAKAGE						
	6. ABUTMENT CONTACT						
	7. EROSION/SINKHOLES BEHIND WALL						
	8. ANIMAL BURROWS						
	9. UNUSUAL MOVEMENT						
	10. WET AREAS AT TOE OF WALL						

ADDITIONAL COMMENTS: No masonry walls

NAME OF DAM: Stanberry Lake Dam STATE ID #: NA

INSPECTION DATE: November 10, 2011 NID ID #: NA

UPSTREAM MASONRY WALLS

AREA INSPECTED	CONDITION	OBSERVATIONS			NO ACTION	MONITOR	REPAIR
U/S WALLS	1. WALL TYPE						
	2. WALL ALIGNMENT						
	3. WALL CONDITION						
	4. HEIGHT: TOP OF WALL TO MUDLINE	min:	max:	avg:			
	5. ABUTMENT CONTACT						
	6. EROSION/SINKHOLES BEHIND WALL						
	7. ANIMAL BURROWS						
	8. UNUSUAL MOVEMENT						

ADDITIONAL COMMENTS: No masonry walls

NAME OF DAM: Stanberry Lake Dam STATE ID #: NA

INSPECTION DATE: November 10, 2011 NID ID #: NA

DOWNSTREAM AREA

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
D/S AREA	1. ABUTMENT LEAKAGE	No			
	2. FOUNDATION SEEPAGE	No			
	3. SLIDE, SLOUGH, SCARP	No			
	4. WEIRS	No			
	5. DRAINAGE SYSTEM	Foundation drainage system shown on plans, with discharge to plunge basin.		x	
	6. INSTRUMENTATION	No			
	7. VEGETATION	Brush and trees			
	8. ACCESSIBILITY	Access over bench on downstream slope and ATV trails from 300 Street			
	9. DOWNSTREAM HAZARD DESCRIPTION	U.S. Highway 169 is approximately 0.3 miles southeast of the dam.			
	10. DATE OF LAST EAP UPDATE	None available			

ADDITIONAL COMMENTS:

Caretaker reported periodic water discharge from drainage system; not observed during inspection

NAME OF DAM: Stanberry Lake Dam STATE ID #: NA

INSPECTION DATE: November 10, 2011 NID ID #: NA

MISCELLANEOUS

AREA INSPECTED	CONDITION	OBSERVATIONS
MISC.	1. RESERVOIR DEPTH (AVG)	Bathymetric survey July 2000; Average depth approximately 10 feet
	2. RESERVOIR SHORELINE	Vegetated; brush and trees
	3. RESERVOIR SLOPES	Approximately 2H:1V
	4. ACCESS ROADS	Access road from U.S. 169 is unpaved and rough with large potholes
	5. SECURITY DEVICES	Cable across left end of crest limits vehicle access to authorized personnel; Swing gate on crest
	6. VANDALISM OR TRESPASS	☐ YES ☑ NO WHAT:
	7. AVAILABILITY OF PLANS	☑ YES ☐ NO DATE: 11/19/1991
	8. AVAILABILITY OF DESIGN CALCS	☐ YES ☑ NO DATE:
	9. AVAILABILITY OF EAP/LAST UPDATE	☐ YES ☑ NO DATE: None available
	10. AVAILABILITY OF O&M MANUAL	☐ YES ☑ NO DATE:
	11. CARETAKER/OWNER AVAILABLE	☑ YES ☐ NO DATE: November 10, 2011
	12. CONFINED SPACE ENTRY REQUIRED	☐ YES ☑ NO PURPOSE:

ADDITIONAL COMMENTS: Daily construction reports were provided by the Owner with soil data including embankment material classification, in-place density, moisture content and percent compaction.

Raw water intake located in the reservoir consists of a pre-cast concrete pipe section with three manually operated valves, located near center of the dam. Water is pumped from the reservoir to the pre-sed basin approximately 1,000 feet to the north

NAME OF DAM: Stanberry Lake Dam STATE ID #: NA

INSPECTION DATE: November 10, 2011 NID ID #: NA

PRIMARY SPILLWAY

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
SPILLWAY	SPILLWAY TYPE	Drop Inlet			
	WEIR TYPE	12-inch-wide crest			
	SPILLWAY CONDITION	Some scour observed around inlet structure			
	TRAINING WALLS	No			
	SPILLWAY CONTROLS AND CONDITION	None			
	UNUSUAL MOVEMENT	No			
	APPROACH AREA	Minor woody debris around base of inlet structure			
	DISCHARGE AREA	Pipe discharges to plunge basin, approximately 70 feet long			
	DEBRIS	No			
	WATER LEVEL AT TIME OF INSPECTION	887.25			

ADDITIONAL COMMENTS: Missouri DNR performed a visual inspection of the dam earlier this year and advised the Owner that erosion of the plunge basin had increased to effective structural height of the dam to over 40 feet. Owner subsequently placed concrete wall/slab demolition debris around the downstream face of the basin, with the intention of reducing the height of the dam.

NAME OF DAM: Stanberry Lake Dam STATE ID #: NA

INSPECTION DATE: November 10, 2011 NID ID #: NA

AUXILIARY SPILLWAY

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
SPILLWAY	SPILLWAY TYPE	Side channel			
	WEIR TYPE	250-foot-wide open field to discharge area			
	SPILLWAY CONDITION	Good			
	TRAINING WALLS	Berm on the right side terminates upstream of the toe of the dam			
	SPILLWAY CONTROLS AND CONDITION	None			
	UNUSUAL MOVEMENT	None			
	APPROACH AREA	Clear			
	DISCHARGE AREA	Generally clear; a 36-inch-diameter tree located approximatey 200 feet downstream			
	DEBRIS	None			
	WATER LEVEL AT TIME OF INSPECTION	887.25			

ADDITIONAL COMMENTS:

NAME OF DAM: Stanberry Lake Dam STATE ID #: NA

INSPECTION DATE: November 10, 2011 NID ID #: NA

OUTLET WORKS

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
OUTLET WORKS	TYPE				
	INTAKE STRUCTURE				
	TRASHRACK				
	PRIMARY CLOSURE				
	SECONDARY CLOSURE				
	CONDUIT				
	OUTLET STRUCTURE/HEADWALL				
	EROSION ALONG TOE OF DAM				
	SEEPAGE/LEAKAGE				
	DEBRIS/BLOCKAGE				
	UNUSUAL MOVEMENT				
	DOWNSTREAM AREA				
	MISCELLANEOUS				

ADDITIONAL COMMENTS: No low-level outlet.

NAME OF DAM: Stanberry Lake Dam STATE ID #: NA

INSPECTION DATE: November 10, 2011 NID ID #: NA

CONCRETE/MASONRY DAMS

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
GENERAL	TYPE				
	AVAILABILITY OF PLANS				
	AVAILABILITY OF DESIGN CALCS				
	PIEZOMETERS				
	OBSERVATION WELLS				
	INCLINOMETERS				
	SEEPAGE GALLERY				
	UNUSUAL MOVEMENT				

ADDITIONAL COMMENTS: NA

NAME OF DAM: Stanberry Lake Dam STATE ID #: NA

INSPECTION DATE: November 10, 2011 NID ID #: NA

CONCRETE/MASONRY DAMS (CREST)

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
CREST	TYPE				
	SURFACE CONDITIONS				
	CONDITIONS OF JOINTS				
	UNUSUAL MOVEMENT				
	HORIZONTAL ALIGNMENT				
	VERTICAL ALIGNMENT				

ADDITIONAL COMMENTS: NA

NAME OF DAM: Stanberry Lake Dam STATE ID #: NA

INSPECTION DATE: November 10, 2011 NID ID #: NA

CONCRETE/MASONRY DAMS (DOWNSTREAM FACE)

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
D/S FACE	TYPE				
	SURFACE CONDITIONS				
	CONDITIONS OF JOINTS				
	UNUSUAL MOVEMENT				
	ABUTMENT CONTACT				
	LEAKAGE				

ADDITIONAL COMMENTS: NA

NAME OF DAM: Stanberry Lake Dam STATE ID #: NA

INSPECTION DATE: November 10, 2011 NID ID #: NA

CONCRETE/MASONRY DAMS (UPSTREAM FACE)

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
U/S FACE	TYPE				
	SURFACE CONDITIONS				
	CONDITIONS OF JOINTS				
	UNUSUAL MOVEMENT				
	ABUTMENT CONTACTS				

ADDITIONAL COMMENTS: NA

Appendix F

USGS 2001 Report

Middle Fork Grand River
Stanberry, Missouri
Water Supply Study

Middle Fork Lake is privately owned by “Middle Fork Water Company” to supply water to Stanberry and other communities, as well as rural water district. The lake is located on a tributary to Middle Fork Grand River about 10 miles north east of Stanberry.

The average daily use is about 350,000 gallons per day.

The drainage area of the lake is 4037 acres (6.3 square miles).

Middle Fork Lake analysis consisted of using the NRCS's computer program called "RESOP". Following is the data and procedures for input to the program.

STO-AREA Elevation-Storage and Elevation-Area data were determined from July 26, 2000 survey made by USGS.

Middle Fork Grand River Lake

Elevation (feet)	Area (acres)	Storage (ac-ft)	
868.0	0.12	0.08	
870.0	1.70	0.99	Intake elevation
872.0	5.70	7.32	
874.0	14.23	27.49	
876.0	24.36	65.35	
878.0	35.20	125.05	
880.0	48.37	208.90	
882.0	58.86	316.71	
884.0	69.36	443.30	
884.1	71.44	450.30	Water Surface on 7/26/2000
886.0	86.65	599.87	
888.0	108.97	794.15	
890.0	138.51	1040.67	
892.0	175.09	1352.91	
893.4	206.11	1625.01	

Spillway Elevation = 893.4 Feet mean sea level
Intake Elevation = 870. Feet mean sea level

LIMITS Maximum Pool storage 1625 Ac.Ft.
Minimum Pool storage 20 Ac.Ft.

Starting storage was considered at measured pool (7/26/2000).

The drainage area of the lake is 4037 acres (6.3 square miles).

GENERAL The adjustment to convert from pan evaporation to lake evaporation was made for the control word EVAP. The factors were monthly values. As a result a factor of 100 was used.

The record period of drought is in the 1950's.
Analysis began in January 1951 and ended December 1959.

SEEPAGE The reservoir seepage varied from 0 seepage near empty to a maximum of 2.5 inch per month when at full pool. The material in the dam is compacted earth of clayey soils.

RAINFALL Rainfall data came from the White Cloud Creek near Maryville, MO. rain gage for the period 1952 through 1960.

RUNOFF This is the runoff into the lake from its drainage area. Monthly runoff volumes in watershed inches were determined at the White Cloud Creek stream gage. The drainage area is 6.0 square miles. White Cloud Creek gage is located west of Maryville.

EVAP. -- Pan evaporation at the Lakeside gaging station were used as a base because it has data for year around evaporation. This data was updated with gage data from stations at Spickard. The average data from 1952 and 1961 were used when there are no data available from both stations. The monthly adjustment factors to convert from pan to lake evaporation was applied at this step.

DEMAND Determined from city records. The average daily use is about 350,000 gallons per day and maximum is 450,000 GPD. (from Bill Hills)

MIDDLE FORK GRAND RIVER

Water Supply Study

Regional Water Supply Lake

Storage Volume

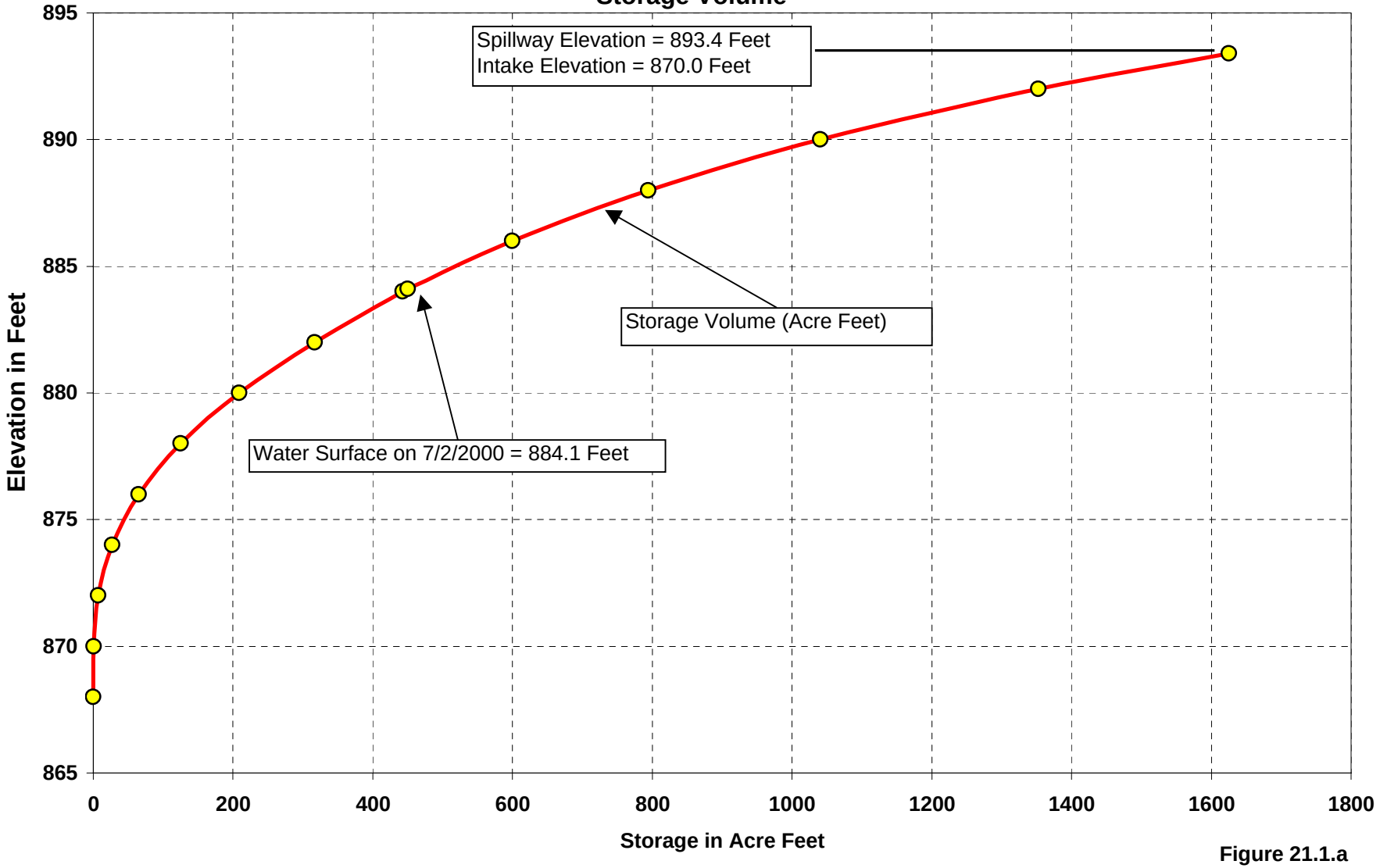


Figure 21.1.a

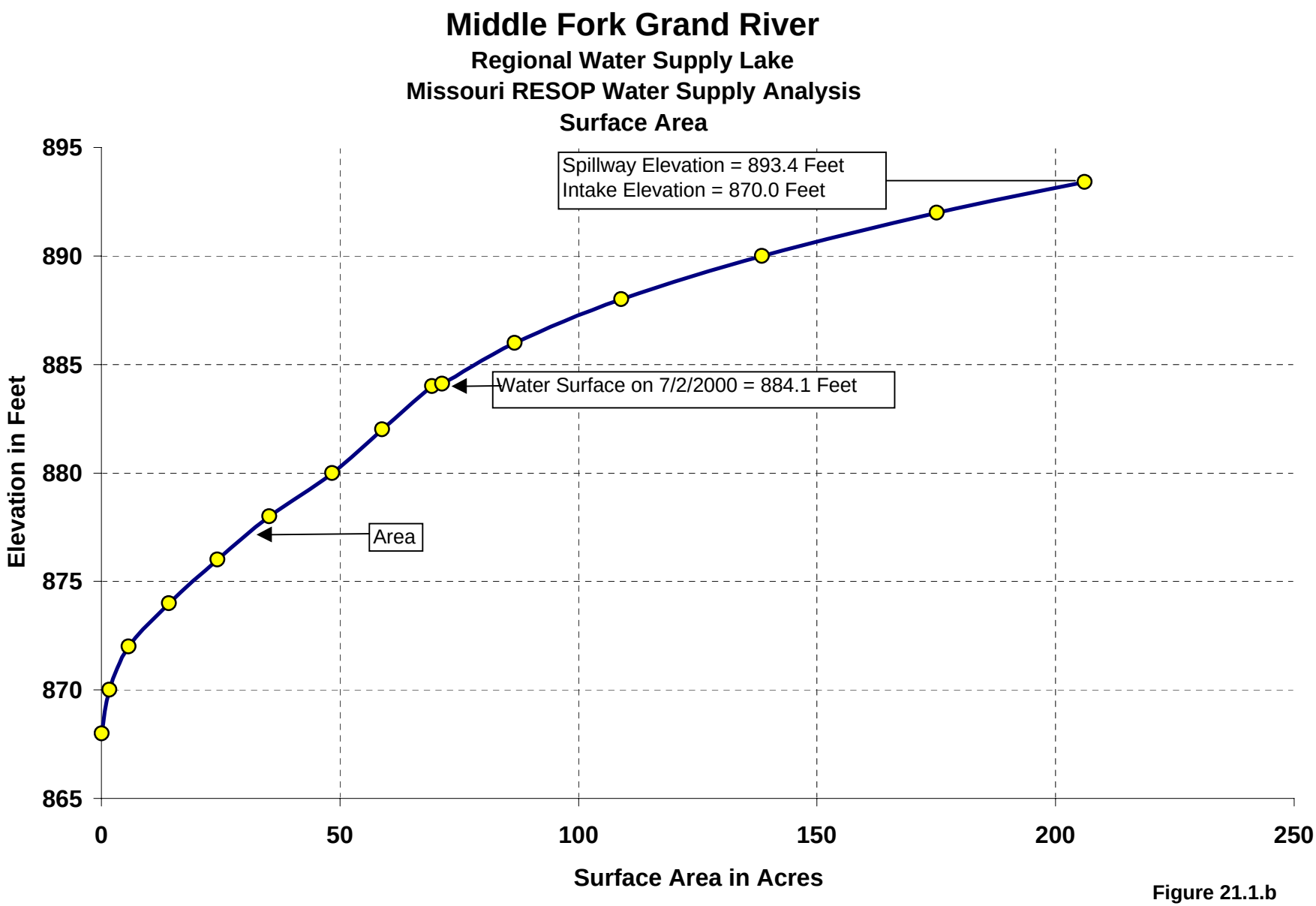

Middle Fork Grand River
Regional Water Supply Lake
Missouri RESOP Water Supply Analysis
Surface Area
Spillway Elevation = 893.4 Feet
Intake Elevation = 870.0 Feet
Water Surface on 7/2/2000 = 884.1 Feet
Area
Elevation in Feet
895
890
885
880
875
870
865
0
50
100
150
200
250
Surface Area in Acres

Figure 21.1.b

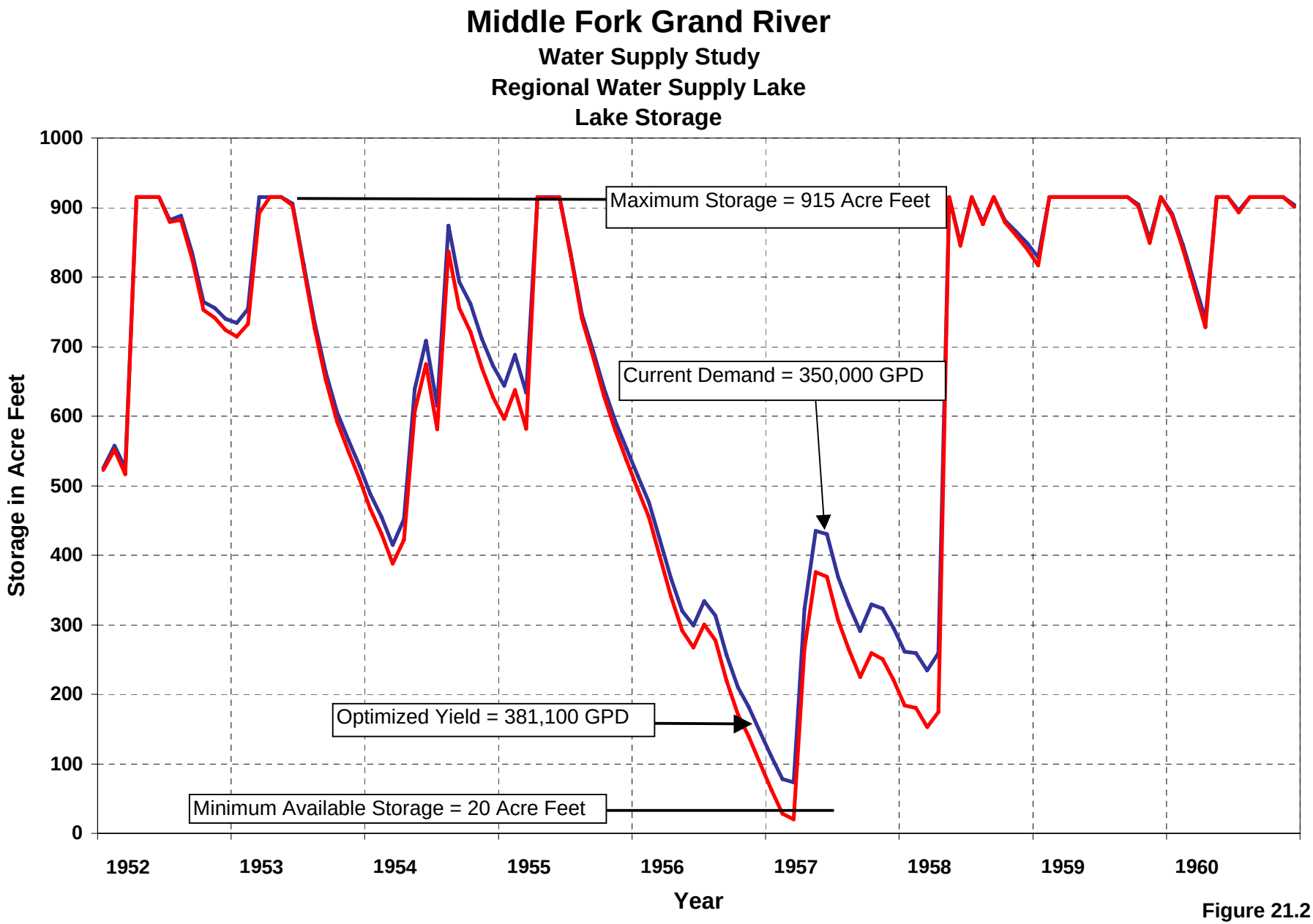

Middle Fork Grand River
Water Supply Study
Regional Water Supply Lake
Lake Storage
Storage in Acre Feet
1000
900
800
700
600
500
400
300
200
100
0
Maximum Storage = 915 Acre Feet
Current Demand = 350,000 GPD
Optimized Yield = 381,100 GPD
Minimum Available Storage = 20 Acre Feet
1952
1953
1954
1955
1956
1957
1958
1959
1960
Year

Figure 21.2

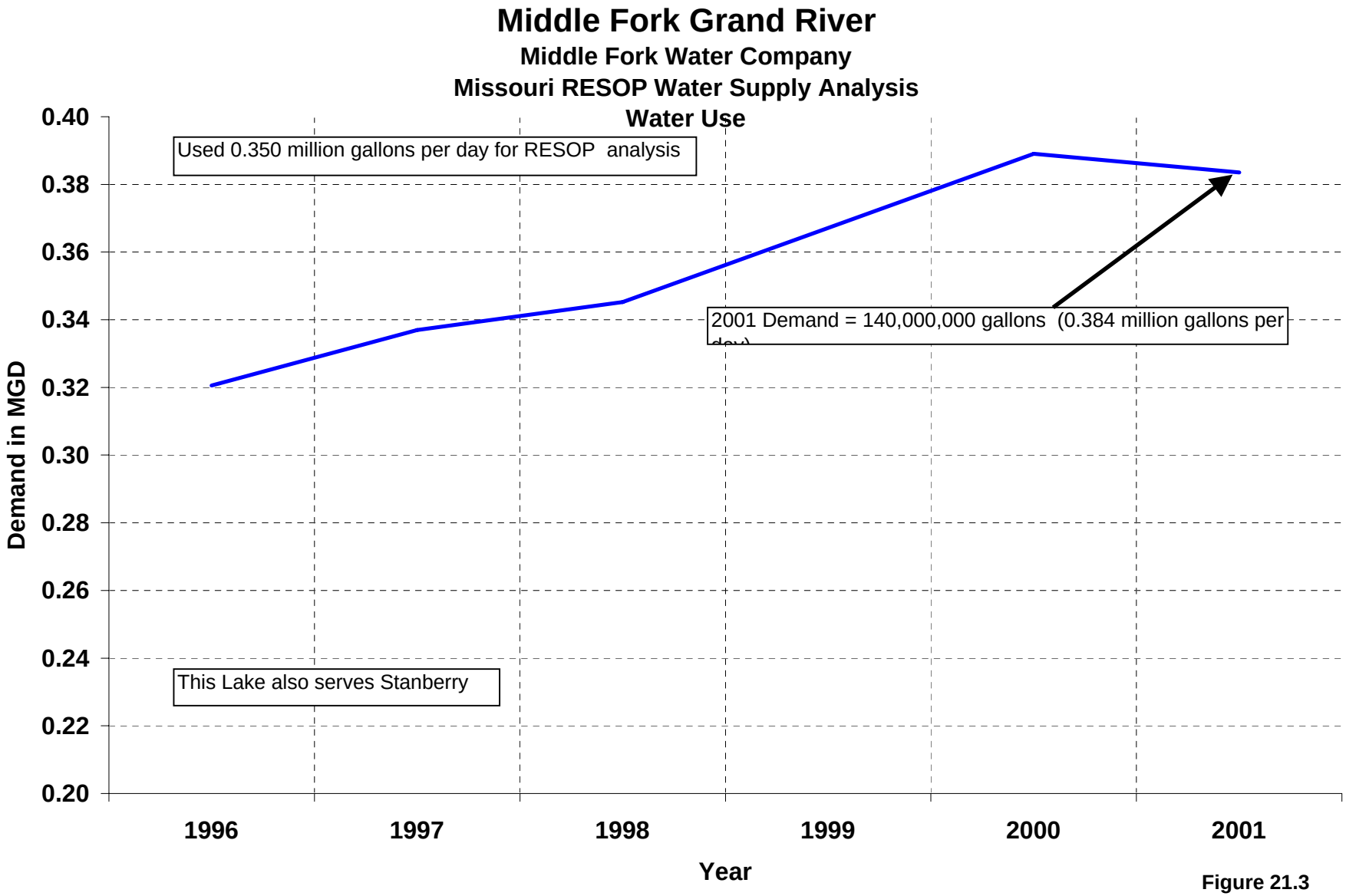
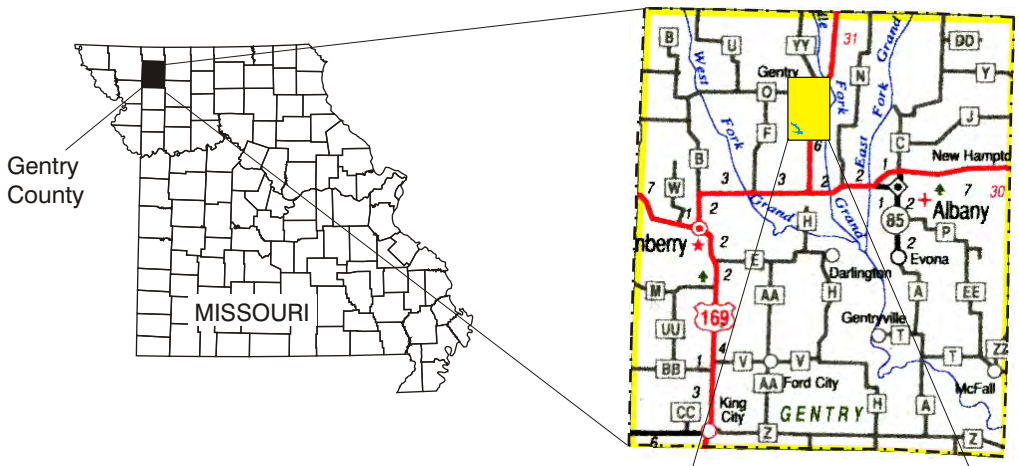

Middle Fork Grand River
Middle Fork Water Company
Missouri RESOP Water Supply Analysis
Water Use
Used 0.350 million gallons per day for RESOP analysis
2001 Demand = 140,000,000 gallons (0.384 million gallons per
This Lake also serves Stanberry
Demand in MGD
0.40
0.38
0.36
0.34
0.32
0.30
0.28
0.26
0.24
0.22
0.20
1996
1997
1998
1999
2000
2001
Year

Figure 21.3

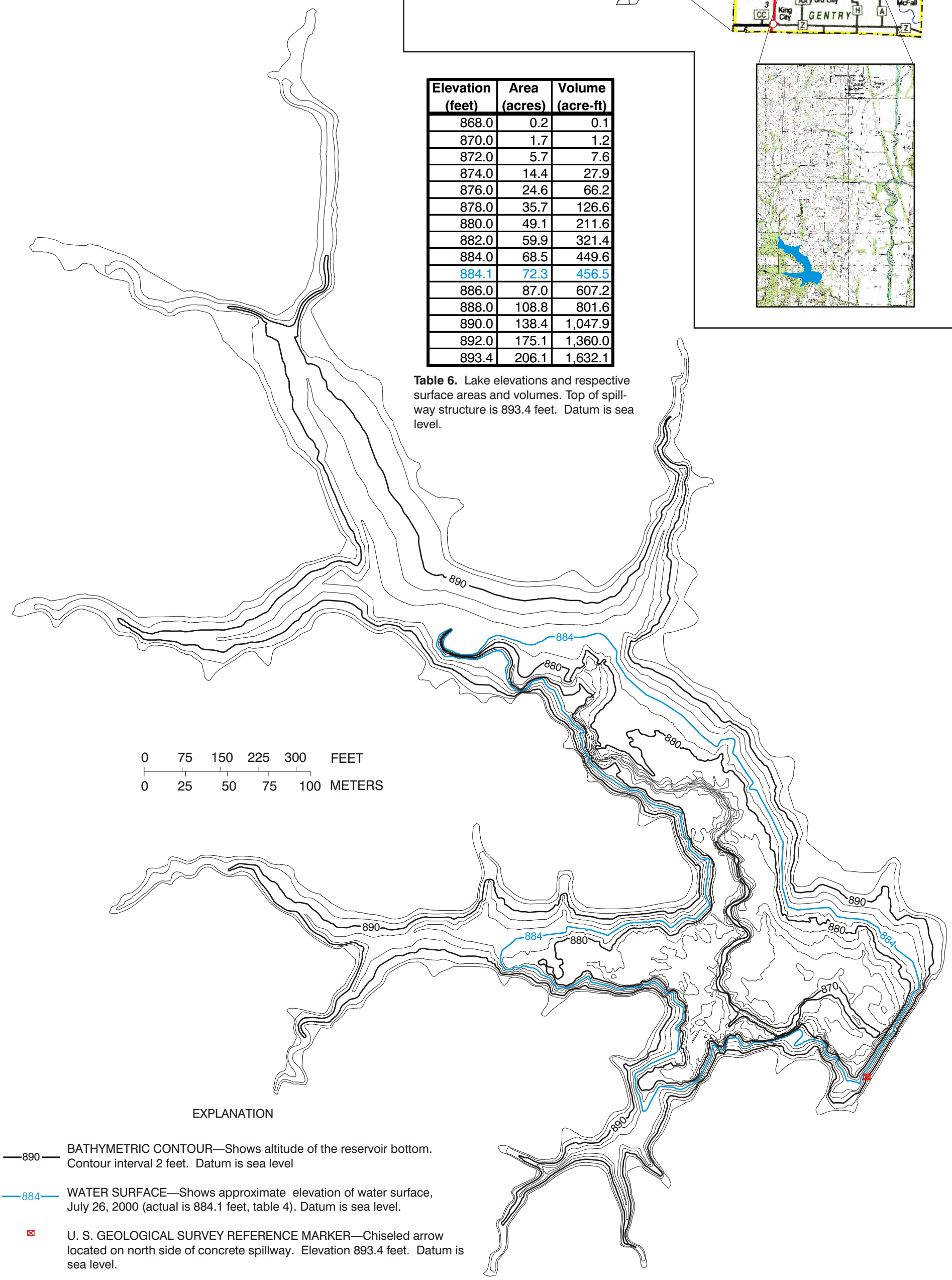
STANBERRY LAKE

LOCATION MAP



Elevation (feet)	Area (acres)	Volume (acre-ft)
868.0	0.2	0.1
870.0	1.7	1.2
872.0	5.7	7.6
874.0	14.4	27.9
876.0	24.6	66.2
878.0	35.7	126.6
880.0	49.1	211.6
882.0	59.9	321.4
884.0	68.5	449.6
884.1	72.3	456.5
886.0	87.0	607.2
888.0	108.8	801.6
890.0	138.4	1,047.9
892.0	175.1	1,360.0
893.4	206.1	1,632.1

Table 6. Lake elevations and respective surface areas and volumes. Top of spillway structure is 893.4 feet. Datum is sea level.



USGS science for a changing world

Figure 21.4 Bathymetric map and area/volume table of Middle Fork Water Company Lake Intake near Stanberry, Missouri.

Appendix G

Opinion of Probable Cost

Upstream Reservoir Dam

Planning Level Opinion of Probable Construction Costs

Spreadsheet Level			Unit	Takeoff Quantity	Unit Cost	Total Amount
20	RESERVOIR SITE PREPARATION					
	01000	Temporary Diversion				
	20.01000.3105	Stormwater Management	ls	1	$1,000,000	$1,000,000
	01000	Temporary Diversion				$1,000,000
	02230	Clearing and Grubbing				
	20.02230.3105	Clear & Grub Along Dam Embankment	Acre	7	$6,275	$43,925
	20.02230.3110	Clear & Grub Under Permanent Pool	Acre	210	$895	$187,950
	20.02230.3115	Property Acquisition	Acre	0		$0
	02230	Clearing and Grubbing				$231,875
	02235	Demo Roads, Railroads etc				
	20.02235.3105	Demo Local/Rural Roads	mi	0.0	$420,000	$0
	20.02235.3110	Demo Federal Roads	mi	0	N/A	$0
	20.02235.3115	Demo Railroads	mi	0	N/A	$0
	20.02235.3120	Demo Electric Transmission	mi	0.0	$65,000	$0
	02235	Demo Roads, Railroads etc				$0
	20	**RESERVOIR SITE PREPARATION TOTAL**				**$1,231,875**
25	EROSION AND SEDIMENT CONTROL					
	02850	Erosion and Sediment Control				
	25.02850.3105	Silt Fence	lf	3,100	$2.55	$7,905
	02850	Erosion and Sediment Control				$7,905
	02950	Site Restoration & Rehabilitation				
	25.02950.3110	Grassing	sf	1,002,000	$0.05	$50,100
	02950	Site Restoration & Rehabilitation				$50,100
	25	**EROSION AND SEDIMENT CONTROL TOTAL**				**$58,005**
30	EXCAVATION					
	02300	Earthwork				
	30.02300.3105	Excavation - Stripping	cy	15,200	$3.20	$48,640
	30.02300.3110	Excavation - Dam	cy	5,200	$3.45	$17,940
	30.02300.3120	Excavation - Spillway	cy	100	$3.45	$345
	30.02300.3125	Excavation - Auxillary Spillway	cy	5,600	$2.60	$14,560
	30.02300.31325	Excavation - Presedimentaion Basin Removal	cy	0	$3.45	$0
	02300	Earthwork				$81,485
	30	**EXCAVATION TOTAL**				**$81,485**
35	COMPACTED FILL					
	02300	Earthwork				
	35.02300.3105	Compacted Fill - Random (75% On Site Material)	cy	288,750	$4.60	$1,328,250
	35.02300.3106	Compacted Fill - Random (25% Import Material)	cy	96,250	$29.60	$2,849,000
	35.02300.3115	Dam Face Protection (Riprap)	cy	19,500	$70.80	$1,380,600
	02300	Earthwork				$5,557,850
	35	**COMPACTED FILL TOTAL**				**$5,557,850**
40	SPILLWAY STRUCTURE					
	02450	Foundation & Load Bearing Elements				
	40.02450.3105	Prestressed Concrete Piles & Pile Caps	ea	0	$22	$0
	40.02450.3115	12" Precast Piling	ea	0	$3,725	$0
	02450	Foundation & Load Bearing Elements				$0
	03000	Concrete Spillway Structure				

	40.03000.3105	Cast-in-place concrete spillway	cy	190	$500	$95,000
	40.03000.3115	6-foot-diameter Concrete Pipe	lf	430	$525	$225,750
	40.03000.3125	Stilling basin	cy	330	$500	$165,000
	03000	Concrete Spillway Structure				$485,750
	03001	Concrete; Low-level outlet				
	40.03001.3105	Outlet structure	cy	0	$750	$0
	40.03001.3115	Downstream retaining wall	cy	0	$500	$0
	40.03001.3125	Gate house	cy	15	$500	$7,500
	40.03001.3135	Access Bridge to Gate house	cy	21	$500	$10,500
	030010	Concrete; Low-level outlet				$18,000
	11280	Gates				
	40.11280.3105	6' x 6' Sluice Gate	ea	1	$65,000	$65,000
	11280	Gates				$65,000
	40	**SPILLWAY STRUCTURE**				**$568,750**
45	CHIMNEY, TOE & BLANKET DRAINS					
	2700	Flexible Base				
	45.02700.3105	Toe Drain	lf	1,300	$24	$31,200
	45.02700.3110	Chimney Drain	cy	9,250	$50	$462,500
	45.02700.3115	Blanket Drain	cy	18,100	$50	$905,000
	2700	Flexible Base				$1,398,700
	45	**CHIMNEY, TOE & BLANKET DRAINS**				**$1,398,700**
50	MISCELLANEOUS INSTRUMENTATION					
	13400	Measurement and control Instrumentation				
	50.13400.3105	Benchmarks	ea	2	675	$1,350
	50.13400.3110	Piezometers	ea	10	$3,400	$34,000
	50.13400.3115	Inclinometers	ea	3	$3,400	$10,200
	50.13400.3120	Settlement Plates	ea	5	$200	$1,000
	13400	Measurement and control Instrumentation				$46,550
	50	**MISCELLANEOUS INSTRUMENTATION TOTAL**				**$46,550**

Subtotal	**$8,993,215**
Engineering (10%)	$899,322
Permitting (2%)	$179,864
Sales Tax (4.2 %)	$377,715
Mobilization	$50,000
Contractor Markup (10%)	$899,322
Contingency (30%)	$2,697,965
Total	**$14,097,402**

Appendix H

1993 Layne Report

Layne-Western *a division of Layne Christensen Company*

620 South 38th Street • P. O. Box 6126 • Kansas City, Kansas 66106 • (913) 321-5000

May 21, 2004

Brock Pfost, PE
Middlefork Water Company
26101 Hallmark Road
Maryville, Missouri 64468

Dear Mr. Pfost:

Layne-Western was contracted by Middlefork Water Company (Middlefork) to conduct groundwater exploration near their water treatment plant. Middlefork's current supply is from a surface water reservoir located near their plant. Last summer the reservoir level was a concern and a decision was made to find a supplemental groundwater source. The project objective was to find an economical groundwater source of 300 gallons per minute (gpm).

1. Groundwater Exploration

1.1 Review of Existing Publications and Drilling Logs

1.1.1 Existing Publications

A review of existing publications was conducted. A bedrock map resulting from a test drilling program conducted in the 1950s was found that showed a deep bedrock valley south and a shallower bedrock valley to the east of the water treatment plant. The contoured map indicated an ancient alluvial system buried by glacial till. All available publications indicated that these two bedrock valleys had a high likelihood of having sufficient groundwater resources to meet the project objective.

1.1.2 Existing Test Hole and Well Logs

The Wellhead Protection Section of the Geological Survey and Resource Assessment Division of the Missouri Department of Natural Resources as well as the Kansas Geological Survey were queried for boring information in and around the target exploration area. This information was obtained and reviewed with the intent to guide the exploration work. There was little information available and in some cases information on borings spotted on bedrock maps (March, 1963, Missouri Geological Survey) were missing from the data sets provided. In other cases the information provided was duplicated and contradictory.

1.2 Test Hole Drilling

Ten test holes were drilled between 2/11/04 and 4/07/04. The boring logs are attached to this report. The approximate drilling locations are shown on Figure 1. Initially the drilling work was centered on "Carmack Junction" or the intersection of Missouri Highways 136 and 169, south of Middlefork's water treatment plant. The intent was to find sand and gravel within the mapped bedrock valley (1963, MGS). Six test holes were drilled in this area. All sites confirmed the presence of a bedrock valley but found little sand and gravel. After disappointing results, a decision was made to move east of the water treatment plant to another but smaller mapped bedrock valley. This smaller valley was mapped as a tributary the previous east west trending bedrock valley. Four more test holes were drilled in this area.

The tenth test hole (10-04) encountered the following: 20 feet of top soil and silty clay; 14 feet (20 to 34 feet bgs) of fine to medium sand and medium to coarse sand and gravel; 41 feet (34 to 75 feet bgs) of sandy clay with trace boulders and lenses of fine sand; 40 (75 to 115 feet bgs) feet of fine to medium sand and gravel with lenses of sandy clay and fine sand; 10 feet (115 to 125 feet bgs) of fine sand with a trace medium and coarse sand and clay; 35.5 feet (125 to 160.5 feet bgs) of sandy clay. Shale bedrock was encountered at 160.5 feet bgs.

Formation samples collected from the wash bore and by a split spoon sampler from TH 10-04 were submitted to a geotechnical laboratory for analysis of grainsize distribution. The grainsize plots are attached to this report.

1.3 Aquifer Pumping Test

1.3.1 Test Well and Piezometer Construction

A six-inch diameter test well was constructed at the site of test hole 10-04. The well was screened from 75 to 115 feet bgs. The test well was developed by pumping until the discharge was visibly clear of suspended material. A piezometer was installed for the purpose of measuring water level drawdown in the aquifer during a pumping test. The piezometer was located approximately 150 feet south of the test well. The piezometer was screened from 100 to 120 feet bgs.

1.3.2 Pumping Test Execution

A 300-minute constant rate pumping test was initiated at 0807 on 4/15/04 at a rate of 292 gallons per minute (gpm). By the end of the test, the pumping rate had declined to 268 gpm due to increasing head conditions. The test well and piezometer were equipped with pressure transducers and computer data loggers. As a back up, manual measurements of water level were made throughout the test. The manual measurements were made using an electric water level meter and were reverenced from the top of the well casing. The equipment measured and recorded water level drawdown at one-minute intervals throughout the test and subsequent recovery period. Water level recovery was monitored in the wells for 862 minutes following shut down of the pump.

Fine sand was detected in the pumping test discharge. A sample of the sand was collected and submitted for grain size analysis. The grain size distribution plot is attached to this report.

1.3.3 Pumping Test Data and Analysis

A static water level of 3.5 feet was measured in the test well before the test. The top of the aquifer is at 75 feet bgs. The aquifer is under confining or artesian conditions. The pumping water level measured at the end of 600 minutes was 43.9 feet or a water level drawdown of 40.4 feet. The water level drawdown in the pumping well recorded by the installed transducer was 39.83 feet. The water level drawdown in the piezometer was 17.02 feet by the end of the test pumping period. The water level data is attached to this report.

The water level drawdown data was analyzed for aquifer parameters of transmissivity and storativity. Transmissivity is defined as the rate of flow in gallons per minute through the vertical section of an aquifer one foot wide and extending the full saturated height of an aquifer under a hydraulic gradient of one. Storage coefficient of an aquifer represents the volume of water released from storage per unit of aquifer storage area per unit change in head. Storage coefficients are much lower in confined aquifers because they are not drained during pumping, and any water released from storage is obtained primarily by compression of the aquifer and expansion of water when pumped. During pumping, the pressure is reduced in the aquifer, but the aquifer is not dewatered. Typical storage coefficients for confined aquifers ranges from 10^{-5} to 10^{-3}.

The aquifer transmissivity, from the time-drawdown analysis, was determined to be between 4,900 and 7,400 gallons per day per foot of aquifer width (gpd/ft). Calculated storage coefficient values were on the order of 10^{-3}. The Cooper-Jacob analytical method was used in the parameter evaluation and is appropriate for confined aquifers as found at the test well site. The time-drawdown plots are attached to this report.

2. Report Conclusions and Recommendations

From the investigative work performed the following conclusions and recommendations can be made:

- The bedrock paleotopographic surface shows an irregular surface suggestive of an ancient alluvial system. A previously mapped bedrock valley was located.
- The bedrock valley to the south of Middlefork's water treatment plant contained very sandy clay with thin lenses of sand and gravel. No significant aquifer material was found in this location.
- The shallower bedrock valley to the east of Middlefork's water treatment plant contained mostly sandy clay with thin lenses of sand and gravel. A location toward the river found sufficient sand and gravel to meet the project objectives. This aquifer is confined and appears to be limited in aerial extent.
- The aquifer test performed on a test well located in this aquifer indicated that a properly designed well could meet the desired 300 gpm production. The presence of a barrier boundary suggests the aquifer is limited in aerial extent. During the short test the water level in the test well did not stabilize nor did the cone of depression reach an apparent source of leakage or recharge.
- After completion of the first well, a longer aquifer test should be conducted to verify both well spacing and better define aquifer hydraulic boundaries.

2.1 Well Sustained Capacity

This well site appears to be capable of supporting a long-term production rate of approximately 200,000 gallons per day (gpd) or 300 gpm for up to 11 hours each day. The data indicates a confined aquifer with limited aerial extent of significant aquifer thickness. This was substantiated by the test hole drilling. Based on standard industry practice of spacing wells based on 10% mutual drawdown interference, additional well should be spaced 2,500 feet.

2.2 Recommended Well Design

The permanent well should be proceeded by a test hole to adjust the well design for site-specific aquifer conditions. It is recommended that the borehole geophysical logs (using gamma and resistivity tools) be performed on the test hole to define sand intervals.

The presence of fine sand in the test discharge is a concern and was considered in the recommended well design. Based on the drilling information and the pumping test results, it is recommended that a 24-inch diameter well is drilled and a 12-inch diameter screen and casing be installed. The screen length should be 40 feet set between 75 and 115 feet bgs. A five-foot sump is recommended below the screen from 115 to 120 feet bgs. The screen slot size should be 0.040 inch. The gavel pack installed between the borehole wall and the screen should be an appropriately graded gravel pack consisting of well-rounded quartz grains as supplied from Colorado Silica.

Respectfully Submitted,

Martha Silks
Consulting Hydrogeologist

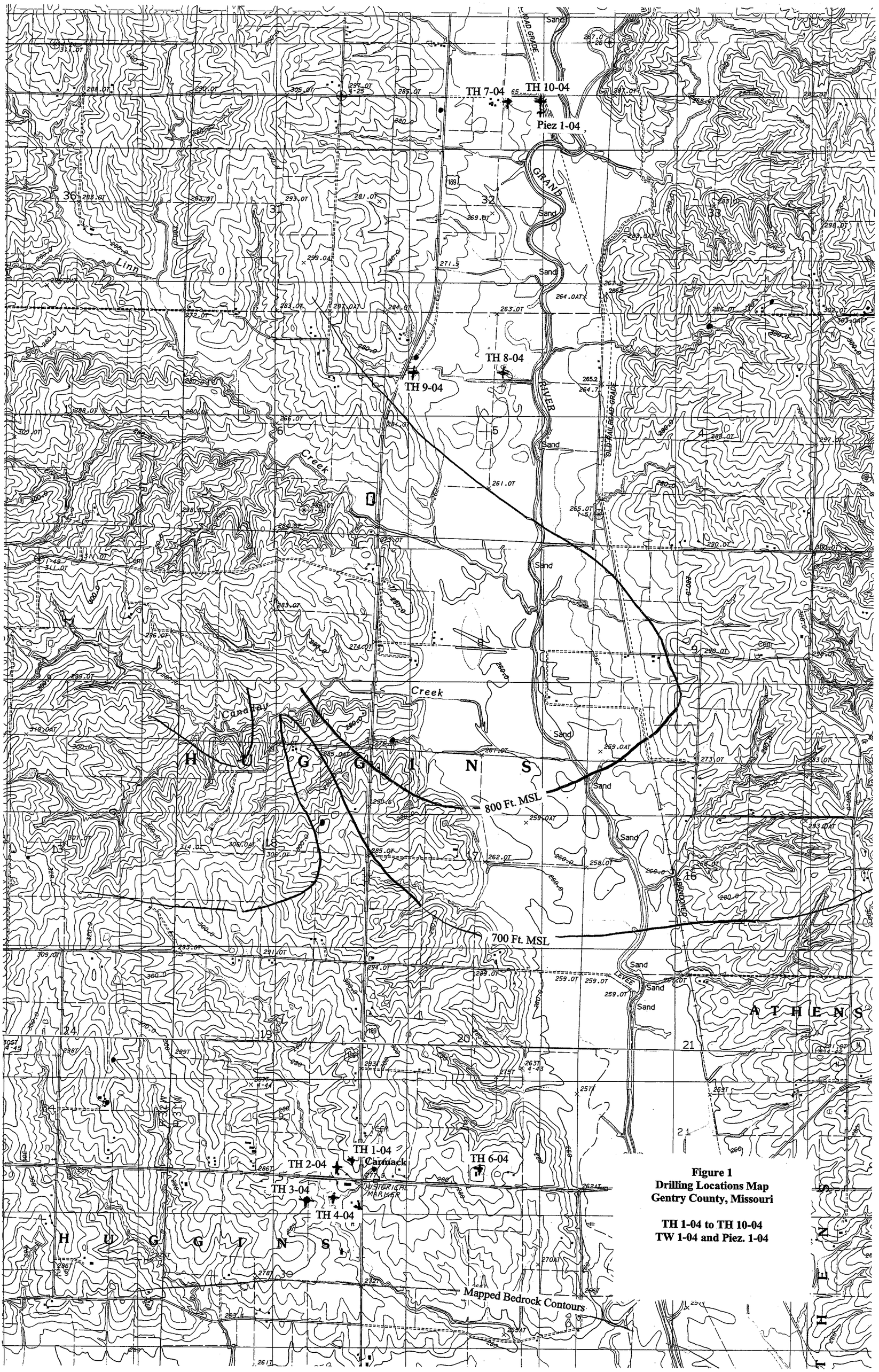


Figure 1
Drilling Locations Map
Gentry County, Missouri

TH 1-04 to TH 10-04
TW 1-04 and Piez. 1-04

TEST HOLE REPORT

LAYNE-WESTERN COMPANY

CONTRACT NAME: MIDDLEFORK WATER COMPANY

JOB NO.: 486100 DATE: 02/11/04

LOCATION: GENTRY STATE: MO

TEST HOLE NO: 1-04

DRILLER: R BOWLES

LOCATION:

TEST LOG

FROM	TO	MARSH FUNNEL VISCOSITY SECONDS	MUD PIT LOSS INCHES	STATIC WATER LEVEL _____ MEASURED _____ HOUR AFTER COMPLETION FORMATION
0.0	1.5			GRASS - TOPSOIL
1.5	4.0			DARK BROWN CLAY
4.0	8.0			MED TO DARK BROWN SILTY CLAY
8.0	17.0			BROWN TO GREY SILTY CLAY
17.0	19.0			TAN SANDY SILTY CLAY
19.0	24.0			MED TO DARK GREY SILTY SANDY CLAY
24.0	35.0			TAN SILTY CLAY TO GREY SILTY CLAY
35.0	44.0			BLUEISH GREY SILTY CLAY
44.0	49.0			BROWN SILTY SANDY CLAY
49.0	49.5			GREY CLAY
49.5	51.0			MED TO COARSE WITH FINES
51.0	176.0			DARK GREY SILTY CLAY
176.0	191.0			DARK GREY CLAY WITH FINE SAND & SILT
191.0	207.0			DARK GREY SILTY CLAY
207.0	216.0			MED TO FINE SAND WITH CLAY

TEST HOLE REPORT

LAYNE-WESTERN COMPANY

CONTRACT NAME: MIDDLEFORK WATER COMPANY

JOB NO.: 486100 DATE: 02/11/04

LOCATION: GENTRY STATE: MO

TEST HOLE NO: 1-04

DRILLER: R BOWLES

LOCATION:

TEST LOG

FROM	TO	MARSH FUNNEL VISCOSITY SECONDS	MUD PIT LOSS INCHES	STATIC WATER LEVEL _____ MEASURED _____ HOURS AFTER COMPLETION FORMATION
216.0	222.0			GREY CLAY FINE SAND
222.0	224.0			GREY CLAY FINE SAND TRACE WOOD WITH FINES
224.0	263.0			VERY FINE SANDY CLAY
263.0	272.6	29	2"	FINE TO VERY FINE WITH CLAY
272.6	TD			LIMESTONE (WHITE)

NOTES: SIZE OF PIT PORTABLE DEEP

TEST HOLE REPORT

LAYNE-WESTERN COMPANY

CONTRACT NAME: MIDDLEFORK WATER COMPANY

JOB NO.: 486065 DATE: 02/18/04

LOCATION: GENTRY STATE: MO

TEST HOLE NO: 2-04

DRILLER: R CROWL

LOCATION: 720' W 169 & 136 INTERS, 223' N OF 169 & 136 INTERS.

TEST LOG

FROM	TO	MARSH FUNNEL VISCOSITY SECONDS	MUD PIT LOSS INCHES	STATIC WATER LEVEL _____ MEASURED _____ HOUR AFTER COMPLETION FORMATION
0.0	1.5	31	6"	TOPSOIL
1.5	17.0	31	6"	LIGHT BROWN SILTY CLAY
17.0	22.0	31	6"	BROWN FINE SAND TRACE OF GRAVEL
22.0	34.0	31	6"	GREY SILTY CLAY STIFF
34.0	41.0	35	4"	GREY MED TO COARSE SAND & GRAVEL TR OF FINES
41.0	43.0	32	6"	GREY SILTY CLAY STIFF
43.0	51.0	32	6"	GREY SILTY CLAY WITH BOULDERS
51.0	175.0	32	6"	GREY SILTY FINE SANDY CLAY
175.0	185.0	35	4"	GREY SILTY CLAY WITH BOULDERS
185.0	190.0	35	4"	GREY MED TO FINE SAND TR OF CLAY HEAVY BOULDERS
190.0	247.0	35	4"	GREY SILTY SANDY CLAY
247.0	250.0	35	4"	DARK GREY LIMESTONE WITH LIGHT GREY SHALE SEAMS
250.0	TD			

TEST HOLE REPORT

LAYNE-WESTERN COMPANY

CONTRACT NAME: MIDDLEFORK WATER COMPANY

JOB NO.: 486065 DATE: 02/19/04

LOCATION: GENTRY STATE: MO

TEST HOLE NO: 3-04

DRILLER: R CROWL

LOCATION: 2100' W 169 & 136 INTERS, 250' S OF 136

TEST LOG

FROM	TO	MARSH FUNNEL VISCOSITY SECONDS	MUD PIT LOSS INCHES	STATIC WATER LEVEL _____ MEASURED _____ HOUR AFTER COMPLETION FORMATION
0.0	1.0	32	6"	TOPSOIL
1.0	6.5	32	6"	BROWN SILTY CLAY
6.5	7.5	32	6"	ORANGE BROWN SILTY CLAY & GRAVEL
7.5	16.5	32	6"	GREY BROWN SILTY CLAY
16.5	20.0	32	6"	LIGHT GREY SILTY CLAY STIFF
20.0	23.0	32	6"	BROWN MED SAND & GRAVEL TR OF FINES BOULDERS & CLAY
23.0	24.0	32	6"	GREY BROWN SILTY CLAY
24.0	45.0	32	6"	DARK GREY FINE SANDY CLAY
45.0	58.0	32	6"	DARK GREY VERY SANDY CLAY & GRAVEL TR OF BOULDERS & COBBLES.
58.0	267.0	33	4"	DARK GREY FINE SANDY SILTY CLAY TR OF GRAVEL
267.0	273.0	33	4"	DARK GREY MED SANDY CLAY W BOULDERS
273.0	278.0	33	4"	DARK GREY SANDY CLAY
278.0	280.0	33	4"	DARK GREY LIMESTONE WITH LIGHT GREY SHALE SEAMS
280.0	TD			

TEST HOLE REPORT

LAYNE-WESTERN COMPANY

CONTRACT NAME: MIDDLEFORK WATER COMPANY

JOB NO.: 486065 DATE: 02/24/04

LOCATION: GENTRY STATE: MO

TEST HOLE NO: 4-04

DRILLER: R CROWL

LOCATION: 2/10 MI W 169 & 136 INTERS 800' S 136

TEST LOG

FROM	TO	MARSH FUNNEL VISCOSITY SECONDS	MUD PIT LOSS INCHES	STATIC WATER LEVEL _____ MEASURED _____ HOUR AFTER COMPLETION FORMATION
0.0	1.0	31	8"	TOPSOIL
1.0	6.0	31	8"	LIGHT BROWN SILTY CLAY
6.0	15.0	31	8"	YELLOW BROWN SILTY SANDY CLAY TR OF GRAVEL
15.0	23.0	31	8"	LIGHT GREY SILTY SANDY CLAY
23.0	43.0	31	8"	GREY BROWN VERY SANDY CLAY W COBBLES
43.0	53.0	31	8"	BROWN MED TO FINE SAND TR OF GRAVEL & CLAY
53.0	55.0	32	6"	DARK BROWN SANDY SILTY CLAY
55.0	79.0	32	6"	DARK GREY SILTY SANDY CLAY
79.0	85.0	32	6"	GREY MED TO FINE SAND WI CLAY TR OF COARSE & GRAVEL
85.0	146.0	32	6"	GREY FINE SANDY CLAY
146.0	150.0	32	6"	GREY MED SAND WI FINES TR OF COARSE & CLAY
150.0	225.0	31	6"	GREY SANDY CLAY TR OF COBBLES
225.0	235.0	37	2"	GREY SANDY YELLOWISH CLAY W COBBLES
235.0	247.0	37	2"	GREY VERY SANDY CLAY W COBBLES TR OF COARSE MED TO FINE SAND
247.0	251.0	37	2"	GREY SANDY CLAY W COBBLES

TEST HOLE REPORT

LAYNE-WESTERN COMPANY

CONTRACT NAME: MIDDLEFORK WATER COMPANY

JOB NO.: 486065 DATE: 02/24/04

LOCATION: GENTRY STATE: MO

TEST HOLE NO: 4-04

DRILLER: R CROWL

LOCATION: 2/10 MI W 169 & 136 INTERS 800' S 136

TEST LOG

FROM	TO	MARSH FUNNEL VISCOSITY SECONDS	MUD PIT LOSS INCHES	STATIC WATER LEVEL _____ MEASURED _____ HOURS AFTER COMPLETION FORMATION
251.0	277.0			GREY VERY SANDY CLAY MED TO FINE W COARSE & COBBLES
277.0	288.0			DARK GREY LIMESTONE W LIT GREY SHALE SEAMS
280.0	TD			

NOTES: SIZE OF PIT PORTABLE DEEP

TEST HOLE REPORT

LAYNE-WESTERN COMPANY

CONTRACT NAME: MIDDLEFORK WATER COMPANY

JOB NO.: 486100 DATE: 03/01/04

LOCATION: CARMACK STATE: MO

TEST HOLE NO: 5-04

DRILLER: R CROWL

LOCATION: 823' S OF CENTERLINE 136 HWY, 47' W CENTERLINE H HWY

TEST LOG

FROM	TO	MARSH FUNNEL VISCOSITY SECONDS	MUD PIT LOSS INCHES	STATIC WATER LEVEL _____ MEASURED _____ HOUR AFTER COMPLETION FORMATION
0.0	3.5	31	8"	TOPSOIL
3.5	8.0	31	8"	BROWN SILTY SANDY CLAY
8.0	13.0	31	8"	BROWN MED TO FINE SAND W CLAY & GRAVEL
13.0	17.0	31	8"	LIGHT GREY FINE SANDY SILTY CLAY
17.0	25.0	31	8"	BROWN MED TO FINE SAND TR CLAY, GRAVEL & COBBLES
25.0	28.0	31	8"	YELLOW BROWN SANDY SILTY CLAY
28.0	125.0	31	4"	DARK GREY SILTY SANDY CLAY
125.0	170.0	31	4"	DARK GREY VERY SAND SILTY CLAY
170.0	195.0	31	4"	DARK GREY SANDY CLAY TR COBBLES
195.0	209.0	34	2"	DARK GREY SANDY CLAY W COBBLES
209.0	211.0	34	2"	GREY MED TO FINE SAND TR CLAY
211.0	223.0	34	2"	DARK GREY SANDY CLAY
223.0	234.0	34	2"	DARK GREY SANDY CLAY TR COBBLES
234.0	245.0	34	2"	GREY MED TO FINE SANDY CLAY W COARSE, GRAVEL & COBBLES
245.0	247.0	34	2"	GREY MED TO FINE SANDY CLAY W COARSE, GRAVEL & COBBLES

SS -80-110-127

TEST HOLE REPORT

LAYNE-WESTERN COMPANY

CONTRACT NAME: MIDDLEFORK WATER COMPANY

JOB NO.: 486100 DATE: 03/01/04

LOCATION: CARMACK STATE: MO

TEST HOLE NO: 5-04

DRILLER: R CROWL

LOCATION: 823' S OF CENTERLINE 136 HWY, 47' W CENTERLINE H HWY

TEST LOG

FROM	TO	MARSH FUNNEL VISCOSITY SECONDS	MUD PIT LOSS INCHES	STATIC WATER LEVEL _____ MEASURED _____ HOURS AFTER COMPLETION FORMATION
247.0	262.0	34	2"	GREY MED TO FINE SANDY CLAY W COARSE, GRAVEL & COBBLES
262.0	265.0	34	2"	MED TO COARSE SAND & GRAVEL W CLAY & COBBLES
265.0	267.0	34	2"	DARK GREY LIMESTONE WITH LIGHT GREY SHALE SEAMS
267.0	TD			

NOTES: SIZE OF PIT PORTABLE DEEP

TEST HOLE REPORT

LAYNE-WESTERN COMPANY

CONTRACT NAME: MIDDLEFORK WATER COMPANY

JOB NO.: 486100 DATE: 03/01/04

LOCATION: CARMACK STATE: MO

TEST HOLE NO: 6-04

DRILLER: R CROWL

LOCATION: 5/10 MI E OF 136 & 169 N INTERS. 47' N 136 HWY CENTERLINE

TEST LOG

FROM	TO	MARSH FUNNEL VISCOSITY SECONDS	MUD PIT LOSS INCHES	STATIC WATER LEVEL _____ MEASURED _____ HOUR AFTER COMPLETION FORMATION
0.0	1.0	33	4"	TOPSOIL
1.0	21.0	33	4"	BROWN SANDY SILTY CLAY
21.0	30.0	33	4"	GREY BROWN SANDY SILTY CLAY
30.0	37.0	33	4"	BROWN SANDY SILTY CLAY TR OF COBBLES & GRAVEL
37.0	49.0	33	4"	LIGHT GREY BROWN SANDY SILTY CLAY
49.0	50.0	33	4"	BROWN FINE SAND
50.0	55.0	33	4"	ORANGE BROWN VERY SANDY CLAY TR OF COBBLES
55.0	66.0	33	4"	DARK GREY SANDY CLAY
66.0	70.0	33	4"	BROWN MED TO COARSE SAND & GRAVEL WITH FINES
70.0	101.0	33	4"	DARK GREY SANDY CLAY
101.0	121.0	33	2"	GREY FINE TO MED SAND WITH CLAY
121.0	260.0	30	4"	DARK GREY FINE SANDY CLAY W/ FINE TO MED SAN SEAMS TR OF COBBLES
260.0	313.0	30	4"	DARK GREY MED TO FINE SANDY CLAY W/ COBBLES
313.0	315.0	30	4"	DARK GREY LIMESTONE W/ LIGHT GREY SHALE SEAMS
315.0	TD			

TEST HOLE REPORT

LAYNE-WESTERN COMPANY

CONTRACT NAME: MIDDLEFORK WATER COMPANY

JOB NO.: 486100 DATE: 03/23/04

LOCATION: GENTRY STATE: MO

TEST HOLE NO: 7-04

DRILLER: R CROWL

LOCATION: 5 MILES N OF 136 & 169 N INTERSECTION

TEST LOG

FROM	TO	MARSH FUNNEL VISCOSITY SECONDS	MUD PIT LOSS INCHES	STATIC WATER LEVEL _____ MEASURED _____ HOUR AFTER COMPLETION FORMATION
0.0	2.5	30	3	TOP SOIL
2.5	8.0	30	3	DARK BROWN SILTY CLAY
8.0	14.0	30	3	DARK GREY SILTY CLAY
14.0	16.0	30	3	LIGHT GREY SILTY CLAY WITH ORANGE BROWN IRON STAIN
16.0	18.0	30	3	GREY SILTY CLAY
18.0	20.0	30	3	BROWN SILTY CLAY
20.0	23.0	30	3	GREY SILTY CLAY
23.0	28.0	30	3	BROWN VERY SOFT CLAYEY SILT
28.0	31.0	30	3	GREY BROWN SANDY SILT
31.0	47.0	30	3	GREY SILTY CLAY
47.0	59.0	30	3	GREY FINE SANDY CLAY
59.0	60.0	30	3	GREY MED TO COARSE SAND
60.0	79.0	31	4	GREY FINE SANDY CLAY WITH TR OF MED TO COARSE & GRAVEL
79.0	81.0	31	4	GREY SILTY CLAY & BOULDERS
81.0	90.0	31	4	GREY FINE SANDY CLAY TR COBBLES

TEST HOLE REPORT

LAYNE-WESTERN COMPANY

CONTRACT NAME: MIDDLEFORK WATER COMPANY

JOB NO.: 486100 DATE: 03/23/04

LOCATION: GENTRY STATE: MO

TEST HOLE NO: 7-04

DRILLER: R CROWL

LOCATION: 5 MILES N OF 136 & 169 N INTERSECTION

TEST LOG

FROM	TO	MARSH FUNNEL VISCOSITY SECONDS	MUD PIT LOSS INCHES	STATIC WATER LEVEL _____ MEASURED _____ HOURS AFTER COMPLETION FORMATION
90.0	102.0	31	4	GREY FINE SANDY CLAY
102.0	103.0	31	4	GREY VERY CLAYEY MED SAND W/ BOULDERS
103.0	104.0	31	4	DARK GREY TO BLACK BOULDERS
104.0	110.0	31	4	GREY MED TO COARSE SAND WITH FINES, CLAY & BOULDERS
110.0	111.0	SS-1 57	100/4"	DARK GREY CLAYEY VERY FINE SANDY SILT
111.0	112.0			DARK GREY CLAYEY VERY FINE SANDY SILT
112.0	115.0			GREY MED TO FINE SAND WITH CLAY
115.0	120.0			GREY FINE SAND WITH CLAY
120.0	127.0			DARK GREY CLAYEY SILT WITH SMALL MED SAND LENSES TR OF BOULDERS
127.0	134.0			DARK GREY FINE SANDY CLAY
134.0	143.0			DARK GREY CLAY TRACES OF BOULDERS
143.0	146.0			LIGHT GREY VERY SANDY CLAY
146.0	149.0			DARK GREY SANDY CLAY
149.0	154.0			LIGHT GREY SHALE
154.0	TD			

NOTES: SIZE OF PIT PORTABLE DEEP

TEST HOLE REPORT

LAYNE-WESTERN COMPANY

CONTRACT NAME: MIDDLEFORK WATER COMPANY

JOB NO.: 486100 DATE: 03/24/03

LOCATION: GENTRY STATE: MO

TEST HOLE NO: 8-04

DRILLER: R CROWL

LOCATION: 3.7 MILES N FROM 136 & 169 N INTERSECTION 5/10 E

TEST LOG

FROM	TO	MARSH FUNNEL VISCOSITY SECONDS	MUD PIT LOSS INCHES	STATIC WATER LEVEL _____ MEASURED _____ HOUR AFTER COMPLETION FORMATION
0.0	1.5	31	6"	TOP SOIL
1.5	17.0	31	6"	DARK BROWN SILTY CLAY
17.0	19.0	31	6"	DARK GREY SILTY CLAY
19.0	25.0	31	6"	GREY MED TO FINE SAND TR OF CLAY COARSE & GRAVEL
25.0	28.0	31	6"	COARSE TO GRAVEL WITH MED TO FINE
28.0	42.0	31	6"	DARK GREY SILTY CLAY
42.0	59.0	31	6"	DARK GREY FINE SANDY CLAY
59.0	70.0	31	6"	DARK GREY VERY SANDY CLAY
70.0	72.0	31	6"	GREY MED TO FINE SAND WITH COARSE VERY LOOSE
72.0	117.0	36	2	GREY SANDY CLAY
117.0	125.0	36	2	GREY VERY SANDY CLAY TR OF COBBLES
125.0	128.0	36	2	GREY VERY FINE SAND TR OF COBBLES
128.0	134.0	36	2	GREY SANDY CLAY WITH SMALL FINE SAND LENSES
134.0	139.0	36	2	LIGHT GREY SHALE
139.0	TD	36	2	

TEST HOLE REPORT

LAYNE-WESTERN COMPANY

CONTRACT NAME: MIDDLEFORK WATER COMPANY

JOB NO.: 486100 DATE: 03/25/04

LOCATION: GENTRY STATE: MO

TEST HOLE NO: 9-04

DRILLER: R CROWL

LOCATION: 3.7 MILES N FROM 136 & 169 N INTERSECTION 400 FT E

TEST LOG

FROM	TO	MARSH FUNNEL VISCOSITY SECONDS	MUD PIT LOSS INCHES	STATIC WATER LEVEL _____ MEASURED _____ HOUR AFTER COMPLETION FORMATION
0.0	1.5	32	6	TOP SOIL
1.5	17.0	32	6	DARK BROWN SILTY CLAY
17.0	19.0	32	6	DARK GREY SILTY CLAY
19.0	24.0	32	6	BLUE GREY FINE TO MED SAND TR OF CLAY AND COARSE
24.0	27.0	32	6	BLUE GREY MED TO FINE TR OF COARSE
27.0	32.0	38	4	COARSE TO GRAVEL WITH MED SAND TR OF FINES
32.0	46.0	36	2	DARK GREY SILTY CLAY
46.0	59.0	36	2	GREY MED TO COARSE SAND AND CLAY WITH FINES
59.0	75.0	36	2	DARK GREY SANDY CLAY
75.0	88.0	33	1	DARK GREY VERY SANDY CLAY W SMALL FINE TO MED SAND SEAM
88.0	92.0	33	1	DARK GREY SANDY CLAY WITH BOULDERS
92.0	94.0	33	1	GREY BROWN LIMESTONE
94.0	95.5	33	1	DARK GREY TO BLACK SHALE
95.5	96.5	33	1	GREY LIMESTONE HARD
96.5	TD	33	1	

TEST HOLE REPORT

LAYNE-WESTERN COMPANY

CONTRACT NAME: MIDDLEFORK WATER COMPANY

JOB NO.: 486100 DATE: 04/07/04

LOCATION: GENTRY STATE: MO

TEST HOLE NO: 10-04

DRILLER: R CROWL

LOCATION: FROM 169 N & 136 INTERS, 5 MI N ON 169, 2284' E OF 169

TEST LOG

FROM	TO	MARSH FUNNEL VISCOSITY SECONDS	MUD PIT LOSS INCHES	STATIC WATER LEVEL _____ MEASURED _____ HOUR AFTER COMPLETION FORMATION
0.0	1.5	31	3"	TOPSOIL
1.5	5.0	31	3"	DARK GREY BROWN SILTY CLAY
5.0	16.0	31	3"	LIGHT GREY BROWN SILTY CLAY
16.0	20.0	31	3"	DARK GREY SILTY CLAY
20.0	24.5	31	3"	GREY FINE TO MED SAND
24.5	28.0	31	3"	GREY MED TO COARSE SAND & GRAVEL
28.0	30.0	31	3"	GREY MED TO FINE
30.0	34.0	31	3"	GREY MED TO COARSE SAND & GRAVEL
34.0	57.0	28	3"	GREY SILTY CLAY WITH TR OF BOULDERS
57.0	73.0	28	3"	DARK GREY SANDY CLAY TR OF BOULDERS
73.0	74.0	28	3"	GREY FINE SAND
74.0	75.0	28	3"	DARK GREY SANDY CLAY
75.0	80.0	28	3"	GREY FINE TO MED SAND W/ MED TO COARSE TR OF GRAVEL
80.0	84.0	28	3"	GREY MED SAND W/ FINE & COARSE TR OF CLAY & BOULDERS
84.0	87.0	28	3"	GREY SANDY CLAY W/ BOULDERS & MED TO COARSE SAND & GRAVEL

TEST HOLE REPORT

LAYNE-WESTERN COMPANY

CONTRACT NAME: MIDDLEFORK WATER COMPANY

JOB NO.: 486100 DATE: 04/07/04

LOCATION: GENTRY STATE: MO

TEST HOLE NO: 10-04

DRILLER: R CROWL

LOCATION: FROM 169 N & 136 INTERS, 5 MI N ON 169, 2284' E OF 169

TEST LOG

FROM	TO	MARSH FUNNEL VISCOSITY SECONDS	MUD PIT LOSS INCHES	STATIC WATER LEVEL _____ MEASURED _____ HOURS AFTER COMPLETION FORMATION
87.0	90.0	28	3"	GREY MED TO COARSE SAND & GRAVEL W/ BOULDERS TR OF CLAY & FINES
90.0	90.1	SS-1 22	100/0.4"	GREY CLAY & ROCK W/ MED TO COARSE SAND
90.1	97.0	28	2"	COARSE TO GRAVEL W/ LOTS OF BOULDERS & MED TO COARSE TR OF CLAY
97.0	98.0	28	2"	GREY FINE SAND
98.0	101.0	28	2"	GREY SANDY CLAY
101.0	106.0	28	2"	GREY FINE TO MED SAND WITH CLAY
106.0	111.0	31	1.5"	BLACK VERY FINE SANDY CLAY TR OF GRAVEL & MED TO COARSE
111.0	115.0	31	1.5"	GREY COARSE TO GRAVEL W/ MED TO FINE & CLAY
115.0	125.0	31	1.5"	GREY FINE SAND TR OF MED TO COARSE & CLAY
125.0	129.0	31	1"	GREY SANDY CLAY W/ MED TO COARSE SAND LAYERS
129.0	153.5	31	1"	GREY SANDY CLAY TR OF BOULDERS
153.5	155.0	31	1"	LIGHT GREY LIMESTONE BOULDERS HARD
155.0	160.5	31	1"	DARK GREY SANDY CLAY TR OF BOULDERS
160.5	165.0	31	1"	LIGHT GREY SHALE HARD
165.0	TD			

NOTES: SIZE OF PIT PORTABLE DEEP

TEST HOLE REPORT

LAYNE-WESTERN COMPANY

CONTRACT NAME: MIDDLEFORK WATER COMPANY

JOB NO.: 486100 DATE: 04/08/04

LOCATION: GENTRY STATE: MO

TEST HOLE NO: PIEZOMETER-04

DRILLER: R CROWL

LOCATION: 150' SE OF TH-10-04

TEST LOG

FROM	TO	MARSH FUNNEL VISCOSITY SECONDS	MUD PIT LOSS INCHES	STATIC WATER LEVEL _____ MEASURED _____ HOUR AFTER COMPLETION FORMATION
0.0	2.0	29	3"	TOP SOIL
2.0	4.0	29	3"	DARK BROWN SILTY CLAY
4.0	10.0	29	3"	GREY SILTY CLAY
10.0	18.0	29	3"	BROWN SILTY CLAY
18.0	24.0	29	3"	GREY FINE SAND
24.0	34.0	32	2"	GREY FINE TO MED SAND TR OF COARSE & GRAVEL
34.0	40.0	32	2"	DARK GREY SILTY SANDY CLAY
40.0	61.0	32	2"	DARK GREY SANDY CLAY WITH BOULDERS
61.0	63.5	32	2"	GREY FINE TO MED SAND
63.5	81.0	32	2"	GREY SANDY CLAY & GRAVEL
81.0	85.0	28	2"	GREY FINE SAND & CLAY WITH BOULDERS
85.0	95.0	28	2"	GREY FINE SANDY CLAY WITH BOULDERS & GRAVEL
95.0	99.0	28	2"	GREY SANDY CLAY
99.0	111.0	28	2"	GREY FINE SAND WITH CLAY SEAMS
111.0	120.0	28	2"	GREY FINE SANDY CLAY W/ MED TO COARSE SAND & GRAVEL
120.0	TD			

PIEZOMETER DRAWING ON BACK

~~WELL TREATMENT~~

Layne-Western Company, Inc.

1. CUSTOMER: MIDDLEFORK WATER COMPANY
2. LOCATION: 5 MILES N OF 169 N & 136 INTERSECTION
3. DATE: 04/14/04 FOREMAN'S NAME: R CROWL
4. WELL NO.: TEST HOLE 1-04 TEST Well TEST pumping
   DRILLED: 04/13/04
   LAST TREATED:
5. PUMP NO
   COLUMN SETTING ____ FT.
   BOWL/MOTOR ____ FT.
   SUCTION ____ FT.
   TOTAL LENGTH ____ FT.
6. AIR LINE
   LENGTH ____ FT.
   STATIC GAGE READING ____ FT.
   STATIC LEVEL 7.0 FT.

TEST BEFORE TREATMENT	ORIFICE 4--X--3 IN. READ.	GPM	AIRLINE GAUGE READING	TESTING WATER LEVEL	DRAW DOWN	DISCHARGE PRESSURE FT.	SPECIFIC CAPACITY GPM/FT.
	5	88		14	7		12.5
	23	190		25	18		10.5
	51	283		34.5	27.5		10.2
RECOVERY	5 MINS.	X	X	12	X	X	X
	15 MINS.	X	X	7	X	X	X

TEST AFTER TREATMENT							
RECOVERY	MINS.	X	X	X	X	X	X
	MINS.	X	X	X	X	X	X

TREATMENT

LAYNITE TREATMENT

1. ____ LBS. P-6 IN ____ GALLONS WATER PLUS ____ LBS.
   HTH PLUS ____ FOLLOWED BY ____ GALS. WATER
2. SURGED ____ HOURS IN ____ MIN. CYCLE
3. PUMPING TO WASTE
   DARK COLOR ____ MINS. MED. COLOR ____ MINS
   CLEAR AFTER ____ MINS. TOTAL TIME ____ MINS

ACID TREATMENT

1 ____ GALS. OF ____ % ACID, INHIBITED AND
   STABILIZED FOLLOWED BY ____ GALS. WATER
2. SURGED ____ HRS IN ____ MIN. CYCLES.
3. PUMPING TO WASTE
   DARK COLOR ____ MINS. MED. COLOR ____ MINS
   CLEAR AFTER ____ MINS. TOTAL TIME ____ MINS

AQUIFER TEST

NAME: MIDDLEFORK WATER CO

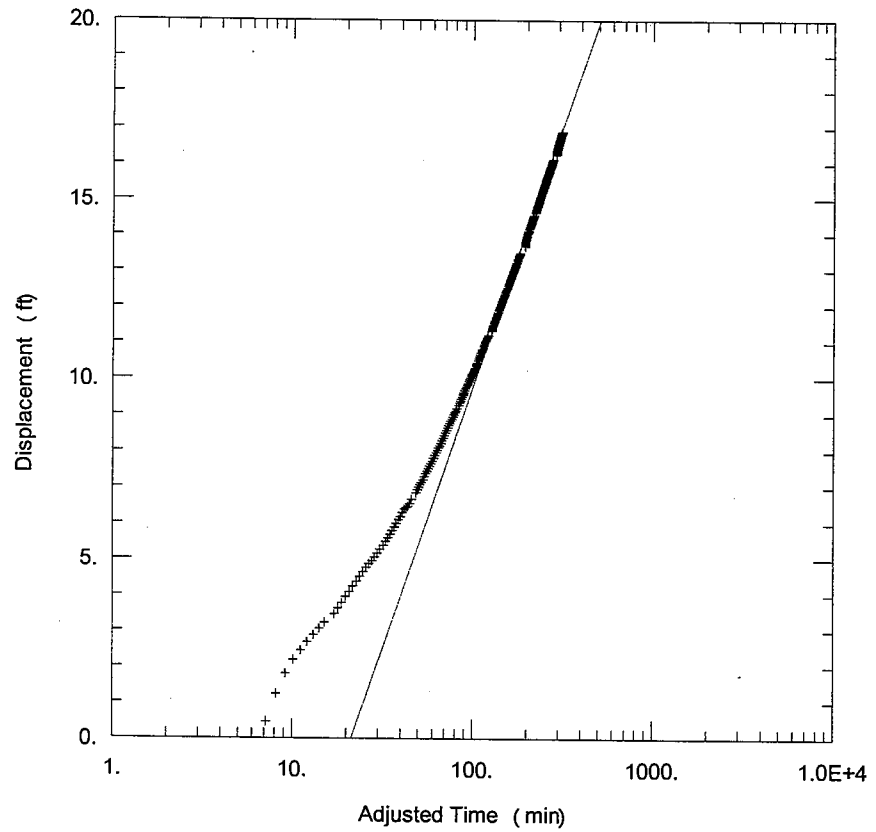
WELL NO. TEST WELL 1-04

LOCATION: TH-10-04

DATE: JOB NO. 486100

CONSTANT RATE TEST

TIME OF DAY	ELAPSED TIME IN MINUTES	AIRLINE READING	WATER LEVEL BELOW MS PT	DRAWDOWN IN FEET	PUMPING RATE OF TEST WELL
7:45	S.W.L.	3.5	3.5		
8:00	0	3.5	3.5		292
8:01	1	25	25	21.5	292
8:02	2	26.5	26.5	23.0	292
8:03	3	27.8	27.8	24.3	292
8:04	4	28.6	28.6	25.1	292
8:05	5	29.5	29.5	26.0	287
8:07	7	30.4	30.4	27.9	287
8:09	9	31.3	31.3	28.2	287
8:11	11	31.9	31.9	28.4	287
8:15	15	33.1	33.1	29.7	281
8:20	20	33.9	33.9	30.4	281
8:25	25	34.8	34.8	31.3	281
8:30	30	35.4	35.4	31.9	280
8:35	35	35.9	35.9	32.4	280
8:40	40	36.4	36.4	32.9	280
8:45	45	36.8	36.8	33.3	277
8:50	50	37.2		33.7	277
9:00	60	37.8		34.3	277
9:10	70	38.4		34.9	277
9:20	80	38.81		35.31	276
9:30	90	39.35		35.85	276
9:40	100	39.76		36.26	276
10:00	120	40.38		36.88	274
10:30	150	41.30		37.80	274
11:00	180	42.0		38.5	271
11:30	210	42.2		38.7	270
12:00	240	42.76		39.26	270
12:30	270	43.35		39.85	268
1:00	300	43.9		40.4	268
RECOVERY	30 SECONDS	30 SECONDS		24.3	
1:01	1	25.75		22.25	
1:02	2	23.71		20.21	
1:03	3	22.0		18.5	
1:04	4	21.32		17.8	
1:05	5	20.52		17.02	
1:07	7	19.4		15.9	
1:09	9	18.56		15.06	
1:11	11	17.9		14.4	
1:15	15	16.85		13.35	
1:30	30	14.6		11.10	
1:45	45	13.3		9.8	
2:00	60	12.6		9.1	
2:30	90	11.3		7.8	
3:00	120	10.55		7.05	
3:30	150	9.95		6.45	
4:00	180	9.5		6.00	
4:30	210	9.1		5.6	



MIDDLEFORK WATER COMPANY

Data Set: \...\OBwell.aqt
Date: 05/10/04 Time: 14:53:26

PROJECT INFORMATION

Company: Chatman & Associates, Inc.
Client: Middlefork Water Company
Project: 20037.00012
Location: Gentry County, Missouri
Test Well: Test Well 1-04

SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Jacob

T = 4864.3 gal/day/ft
S = 0.0009622

AQUIFER DATA

Saturated Thickness: 42. ft

Anisotropy Ratio (Kz/Kr): 1.

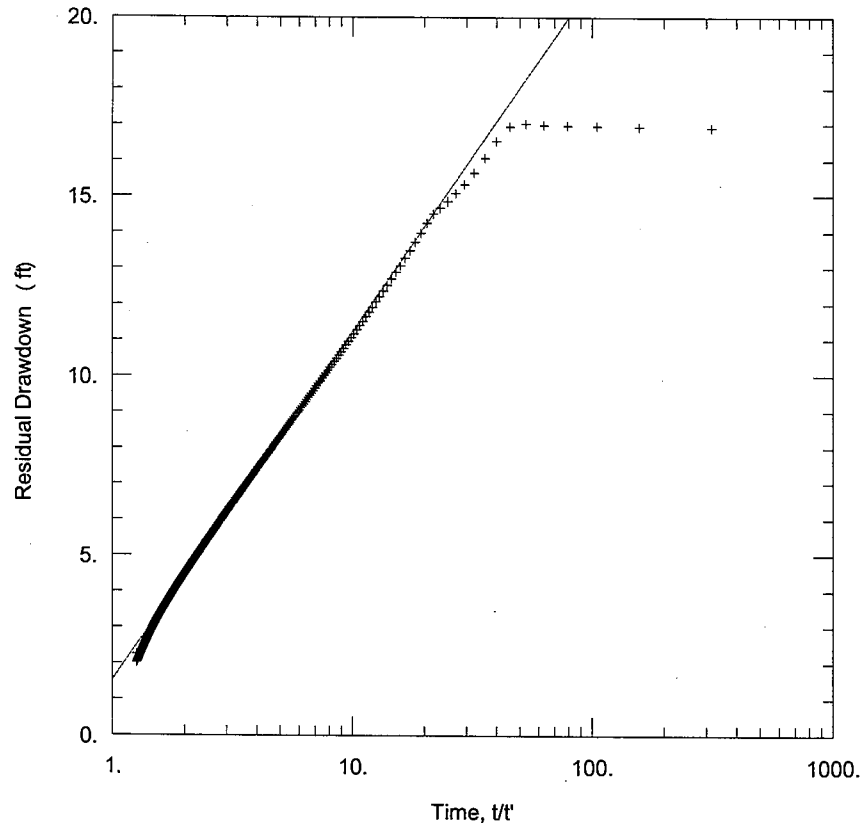
WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
TW 1-04	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
+ Piez	150	0



MIDDLEFORK WATER COMPANY

Data Set: \...\OBwell.aqt
Date: 05/10/04 Time: 14:53:48

PROJECT INFORMATION

Company: Chatman & Associates, Inc.
Client: Middlefork Water Company
Project: 20037.00012
Location: Gentry County, Missouri
Test Well: Test Well 1-04

SOLUTION

Aquifer Model: Confined
Solution Method: Theis (Recovery)

T = 7284.2 gal/day/ft
S/S' = 0.6974

AQUIFER DATA

Saturated Thickness: 42. ft

Anisotropy Ratio (Kz/Kr): 1.

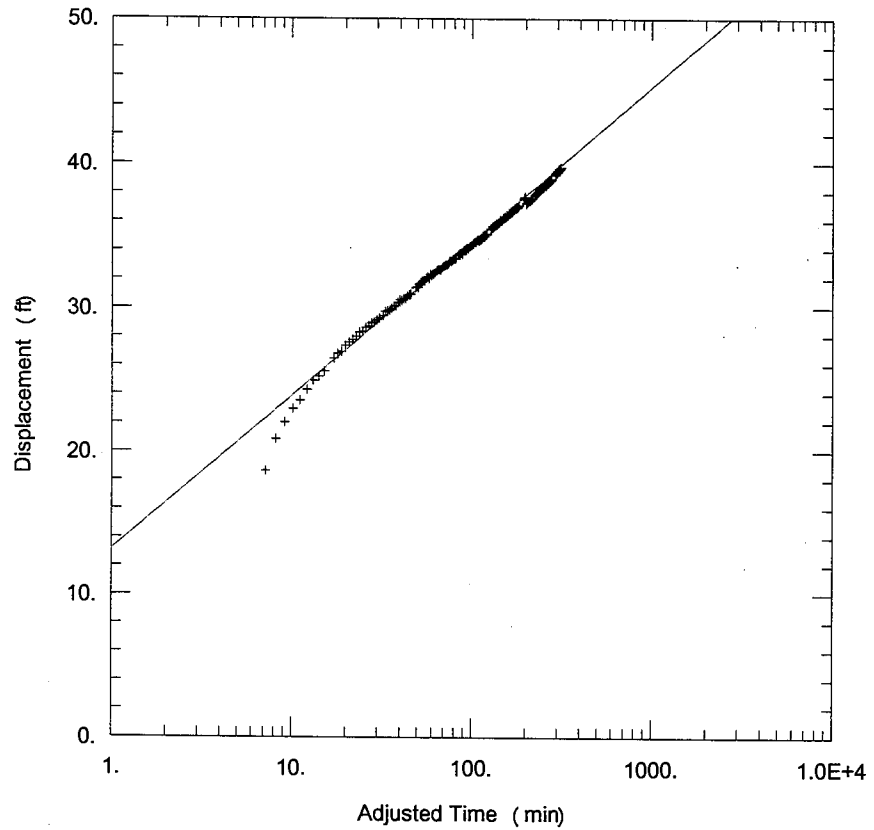
WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
TW 1-04	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
+ Piez	150	0



MIDDLEFORK WATER COMPANY

Data Set: \...\Testwell.aqt
Date: 05/10/04 Time: 13:22:50

PROJECT INFORMATION

Company: Chatman & Associates, Inc.
Client: Middlefork Water Company
Project: 20037.00012
Location: Gentry County, Missouri
Test Well: Test Well 1-04

SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Jacob

T = 6601.5 gal/day/ft
S = 1.304

AQUIFER DATA

Saturated Thickness: 42. ft

Anisotropy Ratio (Kz/Kr): 1.

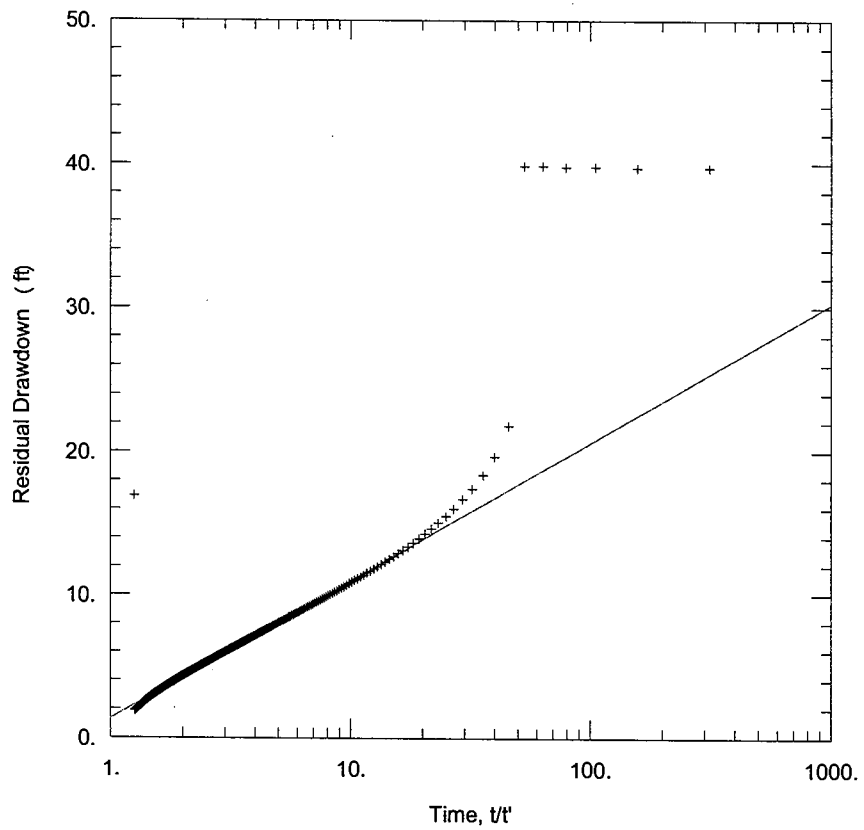
WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
TW 1-04	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
+ Test Well	0.25	0



MIDDLEFORK WATER COMPANY

Data Set: \...\Testwell.aqt
Date: 05/10/04 Time: 13:25:32

PROJECT INFORMATION

Company: Chatman & Associates, Inc.
Client: Middlefork Water Company
Project: 20037.00012
Location: Gentry County, Missouri
Test Well: Test Well 1-04

SOLUTION

Aquifer Model: Confined
Solution Method: Theis (Recovery)

T = 7326.2 gal/day/ft
S/S' = 0.7329

AQUIFER DATA

Saturated Thickness: 42. ft

Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
TW 1-04	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
+ Test Well	0.25	0

Date	Clock Time	Test Duration (minutes)	Test Well Water Level Drawdown (feet)	Piezometer Water Level Drawdown (feet)
4/15/2004	8:07:00	0	19.943	0.48
4/15/2004	8:08:00	1	22.346	1.314
4/15/2004	8:09:00	2	23.602	1.941
4/15/2004	8:10:00	3	24.582	2.34
4/15/2004	8:11:00	4	25.201	2.627
4/15/2004	8:12:00	5	26.008	2.871
4/15/2004	8:13:00	6	26.666	3.077
4/15/2004	8:14:00	7	26.967	3.277
4/15/2004	8:15:00	8	27.38	3.468
4/15/2004	8:16:00	9	27.728	3.639
4/15/2004	8:17:00	10	28.114	3.808
4/15/2004	8:18:00	11	28.241	3.97
4/15/2004	8:19:00	12	28.699	4.14
4/15/2004	8:20:00	13	28.923	4.28
4/15/2004	8:21:00	14	29.108	4.451
4/15/2004	8:22:00	15	29.352	4.591
4/15/2004	8:23:00	16	29.645	4.731
4/15/2004	8:24:00	17	29.7	4.866
4/15/2004	8:25:00	18	29.998	4.988
4/15/2004	8:26:00	19	30.117	5.099
4/15/2004	8:27:00	20	30.321	5.19
4/15/2004	8:28:00	21	30.375	5.295
4/15/2004	8:29:00	22	30.539	5.406
4/15/2004	8:30:00	23	30.699	5.528
4/15/2004	8:31:00	24	30.756	5.626
4/15/2004	8:32:00	25	31.065	5.745
4/15/2004	8:33:00	26	31.116	5.85
4/15/2004	8:34:00	27	31.141	5.947
4/15/2004	8:35:00	28	31.277	6.061
4/15/2004	8:36:00	29	31.463	6.163
4/15/2004	8:37:00	30	31.504	6.261
4/15/2004	8:38:00	31	31.737	6.371
4/15/2004	8:39:00	32	31.903	6.463
4/15/2004	8:40:00	33	31.892	6.58
4/15/2004	8:41:00	34	32.005	6.685
4/15/2004	8:42:00	35	32.014	6.727
4/15/2004	8:43:00	36	32.19	6.76
4/15/2004	8:44:00	37	32.296	6.842
4/15/2004	8:45:00	38	32.327	6.96
4/15/2004	8:46:00	39	32.438	7.069
4/15/2004	8:47:00	40	32.519	7.166
4/15/2004	8:48:00	41	32.458	7.239
4/15/2004	8:49:00	42	32.702	7.308
4/15/2004	8:50:00	43	32.816	7.377
4/15/2004	8:51:00	44	32.893	7.448
4/15/2004	8:52:00	45	32.925	7.541

4/15/2004	8:53:00	46	32.956	7.628
4/15/2004	8:54:00	47	33.128	7.694
4/15/2004	8:55:00	48	33.216	7.772
4/15/2004	8:56:00	49	33.114	7.845
4/15/2004	8:57:00	50	33.374	7.916
4/15/2004	8:58:00	51	33.337	7.992
4/15/2004	8:59:00	52	33.439	8.074
4/15/2004	9:00:00	53	33.474	8.154
4/15/2004	9:01:00	54	33.542	8.229
4/15/2004	9:02:00	55	33.662	8.294
4/15/2004	9:03:00	56	33.698	8.369
4/15/2004	9:04:00	57	33.757	8.422
4/15/2004	9:05:00	58	33.701	8.493
4/15/2004	9:06:00	59	33.754	8.573
4/15/2004	9:07:00	60	33.883	8.644
4/15/2004	9:08:00	61	33.993	8.711
4/15/2004	9:09:00	62	34.025	8.784
4/15/2004	9:10:00	63	34.092	8.862
4/15/2004	9:11:00	64	34.095	8.933
4/15/2004	9:12:00	65	34.124	8.999
4/15/2004	9:13:00	66	34.201	9.062
4/15/2004	9:14:00	67	34.363	9.126
4/15/2004	9:15:00	68	34.356	9.186
4/15/2004	9:16:00	69	34.376	9.25
4/15/2004	9:17:00	70	34.494	9.308
4/15/2004	9:18:00	71	34.519	9.368
4/15/2004	9:19:00	72	34.59	9.416
4/15/2004	9:20:00	73	34.501	9.479
4/15/2004	9:21:00	74	34.69	9.539
4/15/2004	9:22:00	75	34.701	9.603
4/15/2004	9:23:00	76	34.764	9.66
4/15/2004	9:24:00	77	34.807	9.723
4/15/2004	9:25:00	78	34.852	9.783
4/15/2004	9:26:00	79	34.737	9.836
4/15/2004	9:27:00	80	34.911	9.891
4/15/2004	9:28:00	81	35.024	9.951
4/15/2004	9:29:00	82	35.005	10.009
4/15/2004	9:30:00	83	35.098	10.06
4/15/2004	9:31:00	84	35.123	10.107
4/15/2004	9:32:00	85	35.186	10.155
4/15/2004	9:33:00	86	35.192	10.213
4/15/2004	9:34:00	87	35.138	10.266
4/15/2004	9:35:00	88	35.31	10.317
4/15/2004	9:36:00	89	35.321	10.375
4/15/2004	9:37:00	90	35.402	10.424
4/15/2004	9:38:00	91	35.377	10.471
4/15/2004	9:39:00	92	35.481	10.508
4/15/2004	9:40:00	93	35.479	10.55
4/15/2004	9:41:00	94	35.589	10.599
4/15/2004	9:42:00	95	35.603	10.65
4/15/2004	9:43:00	96	35.63	10.695
4/15/2004	9:44:00	97	35.65	10.746

4/15/2004	9:45:00	98	35.772	10.808
4/15/2004	9:46:00	99	35.741	10.863
4/15/2004	9:47:00	100	35.748	10.917
4/15/2004	9:48:00	101	35.693	10.97
4/15/2004	9:49:00	102	35.79	11.023
4/15/2004	9:50:00	103	35.813	11.068
4/15/2004	9:51:00	104	35.826	11.121
4/15/2004	9:52:00	105	35.878	11.167
4/15/2004	9:53:00	106	36.054	11.214
4/15/2004	9:54:00	107	36.034	11.261
4/15/2004	9:55:00	108	36.129	11.307
4/15/2004	9:56:00	109	36.007	11.356
4/15/2004	9:57:00	110	36.133	11.396
4/15/2004	9:58:00	111	36.151	11.434
4/15/2004	9:59:00	112	36.135	11.478
4/15/2004	10:00:00	113	36.189	11.52
4/15/2004	10:01:00	114	36.298	11.565
4/15/2004	10:02:00	115	36.219	11.611
4/15/2004	10:03:00	116	36.323	11.658
4/15/2004	10:04:00	117	36.3	11.7
4/15/2004	10:05:00	118	36.426	11.738
4/15/2004	10:06:00	119	36.361	11.778
4/15/2004	10:07:00	120	36.483	11.815
4/15/2004	10:08:00	121	36.46	11.858
4/15/2004	10:09:00	122	36.546	11.902
4/15/2004	10:10:00	123	36.53	11.944
4/15/2004	10:11:00	124	36.534	11.984
4/15/2004	10:12:00	125	36.568	12.024
4/15/2004	10:13:00	126	36.629	12.066
4/15/2004	10:14:00	127	36.591	12.104
4/15/2004	10:15:00	128	36.685	12.153
4/15/2004	10:16:00	129	36.708	12.19
4/15/2004	10:17:00	130	36.737	12.233
4/15/2004	10:18:00	131	36.733	12.273
4/15/2004	10:19:00	132	36.774	12.315
4/15/2004	10:20:00	133	36.904	12.355
4/15/2004	10:21:00	134	36.859	12.397
4/15/2004	10:22:00	135	36.852	12.432
4/15/2004	10:23:00	136	36.884	12.472
4/15/2004	10:24:00	137	36.925	12.512
4/15/2004	10:25:00	138	36.972	12.552
4/15/2004	10:26:00	139	37.071	12.592
4/15/2004	10:27:00	140	37.051	12.632
4/15/2004	10:28:00	141	37.024	12.67
4/15/2004	10:29:00	142	37.15	12.71
4/15/2004	10:30:00	143	37.094	12.747
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4/15/2004	10:32:00	145	37.233	12.812
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4/15/2004	10:34:00	147	37.254	12.887
4/15/2004	10:35:00	148	37.237	12.925
4/15/2004	10:36:00	149	37.226	12.963

4/15/2004	10:37:00	150	37.406	12.996
4/15/2004	10:38:00	151	37.363	13.036
4/15/2004	10:39:00	152	37.341	13.076
4/15/2004	10:40:00	153	37.408	13.111
4/15/2004	10:41:00	154	37.386	13.147
4/15/2004	10:42:00	155	37.514	13.182
4/15/2004	10:43:00	156	37.442	13.218
4/15/2004	10:44:00	157	37.496	13.256
4/15/2004	10:45:00	158	37.573	13.282
4/15/2004	10:46:00	159	37.604	13.318
4/15/2004	10:47:00	160	37.605	13.351
4/15/2004	10:48:00	161	37.614	13.387
4/15/2004	10:49:00	162	37.688	13.42
4/15/2004	10:50:00	163	37.744	13.453
4/15/2004	10:51:00	164	37.74	13.489
4/15/2004	10:52:00	165	37.702	13.522
4/15/2004	10:53:00	166	37.693	13.562
4/15/2004	10:54:00	167	37.846	13.593
4/15/2004	10:55:00	168	37.842	13.626
4/15/2004	10:56:00	169	37.754	13.662
4/15/2004	10:57:00	170	37.808	13.695
4/15/2004	10:58:00	171	37.869	13.726
4/15/2004	10:59:00	172	37.95	13.759
4/15/2004	11:00:00	173	37.902	13.79
4/15/2004	11:01:00	174	37.918	13.828
4/15/2004	11:02:00	175	38.01	13.864
4/15/2004	11:03:00	176	37.986	13.899
4/15/2004	11:04:00	177	38.056	13.93
4/15/2004	11:05:00	178	38.064	13.966
4/15/2004	11:06:00	179	38.051	13.997
4/15/2004	11:07:00	180	38.133	14.026
4/15/2004	11:08:00	181	38.132	14.061
4/15/2004	11:09:00	182	38.013	14.094
4/15/2004	11:10:00	183	38.018	14.117
4/15/2004	11:11:00	184	37.666	14.157
4/15/2004	11:12:00	185	37.625	14.194
4/15/2004	11:13:00	186	37.702	14.214
4/15/2004	11:14:00	187	37.724	14.241
4/15/2004	11:15:00	188	37.781	14.272
4/15/2004	11:16:00	189	37.763	14.31
4/15/2004	11:17:00	190	37.756	14.334
4/15/2004	11:18:00	191	37.814	14.367
4/15/2004	11:19:00	192	37.803	14.39
4/15/2004	11:20:00	193	37.86	14.418
4/15/2004	11:21:00	194	37.859	14.449
4/15/2004	11:22:00	195	37.826	14.478
4/15/2004	11:23:00	196	37.841	14.503
4/15/2004	11:24:00	197	37.934	14.534
4/15/2004	11:25:00	198	37.963	14.563
4/15/2004	11:26:00	199	37.956	14.592
4/15/2004	11:27:00	200	37.956	14.62
4/15/2004	11:28:00	201	38.037	14.647

4/15/2004	11:29:00	202	38.008	14.676
4/15/2004	11:30:00	203	38.017	14.705
4/15/2004	11:31:00	204	38.071	14.729
4/15/2004	11:32:00	205	38.094	14.758
4/15/2004	11:33:00	206	38.117	14.789
4/15/2004	11:34:00	207	38.107	14.818
4/15/2004	11:35:00	208	38.159	14.847
4/15/2004	11:36:00	209	38.179	14.876
4/15/2004	11:37:00	210	38.242	14.904
4/15/2004	11:38:00	211	38.202	14.927
4/15/2004	11:39:00	212	38.242	14.955
4/15/2004	11:40:00	213	38.322	14.982
4/15/2004	11:41:00	214	38.287	15.013
4/15/2004	11:42:00	215	38.358	15.035
4/15/2004	11:43:00	216	38.299	15.062
4/15/2004	11:44:00	217	38.3	15.093
4/15/2004	11:45:00	218	38.295	15.115
4/15/2004	11:46:00	219	38.428	15.144
4/15/2004	11:47:00	220	38.43	15.168
4/15/2004	11:48:00	221	38.424	15.195
4/15/2004	11:49:00	222	38.491	15.226
4/15/2004	11:50:00	223	38.498	15.248
4/15/2004	11:51:00	224	38.539	15.279
4/15/2004	11:52:00	225	38.501	15.306
4/15/2004	11:53:00	226	38.501	15.328
4/15/2004	11:54:00	227	38.535	15.357
4/15/2004	11:55:00	228	38.622	15.379
4/15/2004	11:56:00	229	38.606	15.408
4/15/2004	11:57:00	230	38.649	15.433
4/15/2004	11:58:00	231	38.616	15.461
4/15/2004	11:59:00	232	38.713	15.481
4/15/2004	12:00:00	233	38.676	15.508
4/15/2004	12:01:00	234	38.707	15.535
4/15/2004	12:02:00	235	38.686	15.557
4/15/2004	12:03:00	236	38.728	15.581
4/15/2004	12:04:00	237	38.758	15.608
4/15/2004	12:05:00	238	38.813	15.634
4/15/2004	12:06:00	239	38.829	15.661
4/15/2004	12:07:00	240	38.84	15.683
4/15/2004	12:08:00	241	38.863	15.71
4/15/2004	12:09:00	242	38.863	15.734
4/15/2004	12:10:00	243	38.823	15.756
4/15/2004	12:11:00	244	38.787	15.783
4/15/2004	12:12:00	245	38.964	15.805
4/15/2004	12:13:00	246	38.933	15.832
4/15/2004	12:14:00	247	38.929	15.856
4/15/2004	12:15:00	248	38.946	15.878
4/15/2004	12:16:00	249	38.992	15.903
4/15/2004	12:17:00	250	39.019	15.925
4/15/2004	12:18:00	251	39.001	15.95
4/15/2004	12:19:00	252	38.942	15.976
4/15/2004	12:20:00	253	39.009	16

4/15/2004	12:21:00	254	39.071	16.023
4/15/2004	12:22:00	255	39.124	16.047
4/15/2004	12:23:00	256	39.113	16.069
4/15/2004	12:24:00	257	39.142	16.096
4/15/2004	12:25:00	258	39.127	16.116
4/15/2004	12:26:00	259	39.179	16.142
4/15/2004	12:27:00	260	39.192	16.167
4/15/2004	12:28:00	261	39.174	16.189
4/15/2004	12:29:00	262	39.199	16.211
4/15/2004	12:30:00	263	39.264	16.236
4/15/2004	12:31:00	264	39.219	16.253
4/15/2004	12:32:00	265	39.289	16.278
4/15/2004	12:33:00	266	39.293	16.305
4/15/2004	12:34:00	267	39.325	16.331
4/15/2004	12:35:00	268	39.338	16.349
4/15/2004	12:36:00	269	39.258	16.373
4/15/2004	12:37:00	270	39.32	16.393
4/15/2004	12:38:00	271	39.41	16.413
4/15/2004	12:39:00	272	39.383	16.438
4/15/2004	12:40:00	273	39.408	16.46
4/15/2004	12:41:00	274	39.378	16.48
4/15/2004	12:42:00	275	39.467	16.511
4/15/2004	12:43:00	276	39.441	16.526
4/15/2004	12:44:00	277	39.441	16.548
4/15/2004	12:45:00	278	39.406	16.573
4/15/2004	12:46:00	279	39.449	16.597
4/15/2004	12:47:00	280	39.524	16.622
4/15/2004	12:48:00	281	39.529	16.637
4/15/2004	12:49:00	282	39.576	16.657
4/15/2004	12:50:00	283	39.576	16.675
4/15/2004	12:51:00	284	39.66	16.699
4/15/2004	12:52:00	285	39.54	16.724
4/15/2004	12:53:00	286	39.637	16.744
4/15/2004	12:54:00	287	39.61	16.764
4/15/2004	12:55:00	288	39.677	16.79
4/15/2004	12:56:00	289	39.671	16.813
4/15/2004	12:57:00	290	39.661	16.833
4/15/2004	12:58:00	291	39.726	16.852
4/15/2004	12:59:00	292	39.744	16.875
4/15/2004	13:00:00	293	39.752	16.895
4/15/2004	13:01:00	294	39.74	16.912
4/15/2004	13:02:00	295	39.729	16.937
4/15/2004	13:03:00	296	39.79	16.955
4/15/2004	13:04:00	297	39.776	16.972
4/15/2004	13:05:00	298	39.855	16.995
4/15/2004	13:06:00	299	39.83	17.023
4/15/2004	13:07:00	300	21.797	16.941
4/15/2004	13:08:00	301	19.664	16.537
4/15/2004	13:09:00	302	18.361	16.069
4/15/2004	13:10:00	303	17.406	15.661
4/15/2004	13:11:00	304	16.645	15.332
4/15/2004	13:12:00	305	16.018	15.077

4/15/2004	13:13:00	306	15.482	14.853
4/15/2004	13:14:00	307	15.026	14.671
4/15/2004	13:15:00	308	14.619	14.509
4/15/2004	13:16:00	309	14.256	14.25
4/15/2004	13:17:00	310	13.933	13.979
4/15/2004	13:18:00	311	13.643	13.726
4/15/2004	13:19:00	312	13.375	13.488
4/15/2004	13:20:00	313	13.129	13.273
4/15/2004	13:21:00	314	12.899	13.064
4/15/2004	13:22:00	315	12.685	12.883
4/15/2004	13:23:00	316	12.492	12.696
4/15/2004	13:24:00	317	12.305	12.523
4/15/2004	13:25:00	318	12.131	12.357
4/15/2004	13:26:00	319	11.964	12.201
4/15/2004	13:27:00	320	11.81	12.055
4/15/2004	13:28:00	321	11.659	11.911
4/15/2004	13:29:00	322	11.521	11.775
4/15/2004	13:30:00	323	11.376	11.649
4/15/2004	13:31:00	324	11.25	11.518
4/15/2004	13:32:00	325	11.128	11.398
4/15/2004	13:33:00	326	11.007	11.285
4/15/2004	13:34:00	327	10.892	11.169
4/15/2004	13:35:00	328	10.786	11.061
4/15/2004	13:36:00	329	10.675	10.961
4/15/2004	13:37:00	330	10.575	10.863
4/15/2004	13:38:00	331	10.473	10.761
4/15/2004	13:39:00	332	10.376	10.666
4/15/2004	13:40:00	333	10.281	10.577
4/15/2004	13:41:00	334	10.19	10.488
4/15/2004	13:42:00	335	10.104	10.401
4/15/2004	13:43:00	336	10.021	10.317
4/15/2004	13:44:00	337	9.935	10.237
4/15/2004	13:45:00	338	9.856	10.157
4/15/2004	13:46:00	339	9.775	10.08
4/15/2004	13:47:00	340	9.702	10.006
4/15/2004	13:48:00	341	9.625	9.929
4/15/2004	13:49:00	342	9.553	9.856
4/15/2004	13:50:00	343	9.486	9.787
4/15/2004	13:51:00	344	9.415	9.716
4/15/2004	13:52:00	345	9.345	9.651
4/15/2004	13:53:00	346	9.282	9.58
4/15/2004	13:54:00	347	9.222	9.52
4/15/2004	13:55:00	348	9.155	9.456
4/15/2004	13:56:00	349	9.09	9.396
4/15/2004	13:57:00	350	9.031	9.334
4/15/2004	13:58:00	351	8.972	9.272
4/15/2004	13:59:00	352	8.915	9.216
4/15/2004	14:00:00	353	8.859	9.159
4/15/2004	14:01:00	354	8.8	9.105
4/15/2004	14:02:00	355	8.748	9.048
4/15/2004	14:03:00	356	8.69	8.994
4/15/2004	14:04:00	357	8.641	8.946

4/15/2004	14:05:00	358	8.59	8.89
4/15/2004	14:06:00	359	8.539	8.839
4/15/2004	14:07:00	360	8.487	8.788
4/15/2004	14:08:00	361	8.45	8.744
4/15/2004	14:09:00	362	8.403	8.69
4/15/2004	14:10:00	363	8.352	8.644
4/15/2004	14:11:00	364	8.309	8.597
4/15/2004	14:12:00	365	8.264	8.553
4/15/2004	14:13:00	366	8.217	8.506
4/15/2004	14:14:00	367	8.172	8.462
4/15/2004	14:15:00	368	8.131	8.415
4/15/2004	14:16:00	369	8.088	8.373
4/15/2004	14:17:00	370	8.047	8.335
4/15/2004	14:18:00	371	8.002	8.289
4/15/2004	14:19:00	372	7.964	8.249
4/15/2004	14:20:00	373	7.921	8.207
4/15/2004	14:21:00	374	7.883	8.167
4/15/2004	14:22:00	375	7.843	8.136
4/15/2004	14:23:00	376	7.812	8.096
4/15/2004	14:24:00	377	7.769	8.058
4/15/2004	14:25:00	378	7.733	8.013
4/15/2004	14:26:00	379	7.699	7.98
4/15/2004	14:27:00	380	7.662	7.942
4/15/2004	14:28:00	381	7.63	7.905
4/15/2004	14:29:00	382	7.587	7.865
4/15/2004	14:30:00	383	7.556	7.836
4/15/2004	14:31:00	384	7.522	7.8
4/15/2004	14:32:00	385	7.49	7.767
4/15/2004	14:33:00	386	7.454	7.732
4/15/2004	14:34:00	387	7.425	7.696
4/15/2004	14:35:00	388	7.39	7.663
4/15/2004	14:36:00	389	7.356	7.629
4/15/2004	14:37:00	390	7.324	7.601
4/15/2004	14:38:00	391	7.293	7.567
4/15/2004	14:39:00	392	7.261	7.543
4/15/2004	14:40:00	393	7.235	7.507
4/15/2004	14:41:00	394	7.205	7.472
4/15/2004	14:42:00	395	7.176	7.441
4/15/2004	14:43:00	396	7.149	7.414
4/15/2004	14:44:00	397	7.12	7.383
4/15/2004	14:45:00	398	7.088	7.356
4/15/2004	14:46:00	399	7.064	7.328
4/15/2004	14:47:00	400	7.032	7.294
4/15/2004	14:48:00	401	7.006	7.265
4/15/2004	14:49:00	402	6.981	7.239
4/15/2004	14:50:00	403	6.953	7.214
4/15/2004	14:51:00	404	6.924	7.183
4/15/2004	14:52:00	405	6.897	7.157
4/15/2004	14:53:00	406	6.871	7.132
4/15/2004	14:54:00	407	6.846	7.106
4/15/2004	14:55:00	408	6.819	7.079
4/15/2004	14:56:00	409	6.797	7.052

4/15/2004	14:57:00	410	6.774	7.024
4/15/2004	14:58:00	411	6.747	7.001
4/15/2004	14:59:00	412	6.724	6.977
4/15/2004	15:00:00	413	6.694	6.95
4/15/2004	15:01:00	414	6.673	6.93
4/15/2004	15:02:00	415	6.65	6.899
4/15/2004	15:03:00	416	6.625	6.877
4/15/2004	15:04:00	417	6.602	6.853
4/15/2004	15:05:00	418	6.582	6.828
4/15/2004	15:06:00	419	6.559	6.806
4/15/2004	15:07:00	420	6.532	6.782
4/15/2004	15:08:00	421	6.507	6.759
4/15/2004	15:09:00	422	6.487	6.742
4/15/2004	15:10:00	423	6.465	6.713
4/15/2004	15:11:00	424	6.44	6.691
4/15/2004	15:12:00	425	6.424	6.673
4/15/2004	15:13:00	426	6.399	6.646
4/15/2004	15:14:00	427	6.378	6.626
4/15/2004	15:15:00	428	6.359	6.604
4/15/2004	15:16:00	429	6.333	6.589
4/15/2004	15:17:00	430	6.317	6.569
4/15/2004	15:18:00	431	6.297	6.542
4/15/2004	15:19:00	432	6.282	6.531
4/15/2004	15:20:00	433	6.26	6.504
4/15/2004	15:21:00	434	6.237	6.484
4/15/2004	15:22:00	435	6.216	6.458
4/15/2004	15:23:00	436	6.201	6.44
4/15/2004	15:24:00	437	6.181	6.424
4/15/2004	15:25:00	438	6.156	6.409
4/15/2004	15:26:00	439	6.142	6.389
4/15/2004	15:27:00	440	6.12	6.364
4/15/2004	15:28:00	441	6.101	6.347
4/15/2004	15:29:00	442	6.075	6.329
4/15/2004	15:30:00	443	6.07	6.32
4/15/2004	15:31:00	444	6.056	6.293
4/15/2004	15:32:00	445	6.032	6.271
4/15/2004	15:33:00	446	6.019	6.249
4/15/2004	15:34:00	447	6.003	6.233
4/15/2004	15:35:00	448	5.972	6.216
4/15/2004	15:36:00	449	5.954	6.202
4/15/2004	15:37:00	450	5.938	6.18
4/15/2004	15:38:00	451	5.926	6.167
4/15/2004	15:39:00	452	5.911	6.147
4/15/2004	15:40:00	453	5.89	6.125
4/15/2004	15:41:00	454	5.869	6.109
4/15/2004	15:42:00	455	5.851	6.091
4/15/2004	15:43:00	456	5.836	6.074
4/15/2004	15:44:00	457	5.815	6.058
4/15/2004	15:45:00	458	5.803	6.038
4/15/2004	15:46:00	459	5.787	6.025
4/15/2004	15:47:00	460	5.775	6.005
4/15/2004	15:48:00	461	5.756	5.989

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4/15/2004	15:50:00	463	5.726	5.963
4/15/2004	15:51:00	464	5.706	5.945
4/15/2004	15:52:00	465	5.695	5.927
4/15/2004	15:53:00	466	5.679	5.923
4/15/2004	15:54:00	467	5.663	5.9
4/15/2004	15:55:00	468	5.656	5.88
4/15/2004	15:56:00	469	5.636	5.865
4/15/2004	15:57:00	470	5.622	5.858
4/15/2004	15:58:00	471	5.595	5.838
4/15/2004	15:59:00	472	5.59	5.821
4/15/2004	16:00:00	473	5.579	5.807
4/15/2004	16:01:00	474	5.557	5.794
4/15/2004	16:02:00	475	5.552	5.776
4/15/2004	16:03:00	476	5.53	5.761
4/15/2004	16:04:00	477	5.514	5.747
4/15/2004	16:05:00	478	5.498	5.732
4/15/2004	16:06:00	479	5.471	5.718
4/15/2004	16:07:00	480	5.458	5.705
4/15/2004	16:08:00	481	5.451	5.696
4/15/2004	16:09:00	482	5.442	5.678
4/15/2004	16:10:00	483	5.426	5.667
4/15/2004	16:11:00	484	5.415	5.652
4/15/2004	16:12:00	485	5.403	5.639
4/15/2004	16:13:00	486	5.386	5.621
4/15/2004	16:14:00	487	5.377	5.612
4/15/2004	16:15:00	488	5.361	5.599
4/15/2004	16:16:00	489	5.345	5.587
4/15/2004	16:17:00	490	5.334	5.568
4/15/2004	16:18:00	491	5.323	5.559
4/15/2004	16:19:00	492	5.311	5.543
4/15/2004	16:20:00	493	5.304	5.53
4/15/2004	16:21:00	494	5.284	5.516
4/15/2004	16:22:00	495	5.273	5.503
4/15/2004	16:23:00	496	5.261	5.492
4/15/2004	16:24:00	497	5.248	5.481
4/15/2004	16:25:00	498	5.235	5.468
4/15/2004	16:26:00	499	5.226	5.454
4/15/2004	16:27:00	500	5.214	5.445
4/15/2004	16:28:00	501	5.201	5.432
4/15/2004	16:29:00	502	5.198	5.421
4/15/2004	16:30:00	503	5.178	5.412
4/15/2004	16:31:00	504	5.171	5.397
4/15/2004	16:32:00	505	5.156	5.383
4/15/2004	16:33:00	506	5.145	5.374
4/15/2004	16:34:00	507	5.129	5.363
4/15/2004	16:35:00	508	5.126	5.346
4/15/2004	16:36:00	509	5.108	5.337
4/15/2004	16:37:00	510	5.101	5.321
4/15/2004	16:38:00	511	5.086	5.312
4/15/2004	16:39:00	512	5.081	5.303
4/15/2004	16:40:00	513	5.068	5.297

4/15/2004	16:41:00	514	5.059	5.279
4/15/2004	16:42:00	515	5.05	5.266
4/15/2004	16:43:00	516	5.034	5.255
4/15/2004	16:44:00	517	5.025	5.246
4/15/2004	16:45:00	518	5.014	5.235
4/15/2004	16:46:00	519	5.002	5.221
4/15/2004	16:47:00	520	4.991	5.212
4/15/2004	16:48:00	521	4.98	5.203
4/15/2004	16:49:00	522	4.969	5.195
4/15/2004	16:50:00	523	4.962	5.179
4/15/2004	16:51:00	524	4.955	5.166
4/15/2004	16:52:00	525	4.942	5.155
4/15/2004	16:53:00	526	4.926	5.148
4/15/2004	16:54:00	527	4.926	5.141
4/15/2004	16:55:00	528	4.91	5.132
4/15/2004	16:56:00	529	4.896	5.112
4/15/2004	16:57:00	530	4.888	5.106
4/15/2004	16:58:00	531	4.881	5.095
4/15/2004	16:59:00	532	4.87	5.075
4/15/2004	17:00:00	533	4.859	5.077
4/15/2004	17:01:00	534	4.849	5.064
4/15/2004	17:02:00	535	4.841	5.057
4/15/2004	17:03:00	536	4.83	5.044
4/15/2004	17:04:00	537	4.82	5.033
4/15/2004	17:05:00	538	4.811	5.024
4/15/2004	17:06:00	539	4.802	5.013
4/15/2004	17:07:00	540	4.793	5.004
4/15/2004	17:08:00	541	4.786	4.999
4/15/2004	17:09:00	542	4.768	4.984
4/15/2004	17:10:00	543	4.766	4.979
4/15/2004	17:11:00	544	4.755	4.97
4/15/2004	17:12:00	545	4.744	4.957
4/15/2004	17:13:00	546	4.732	4.948
4/15/2004	17:14:00	547	4.726	4.939
4/15/2004	17:15:00	548	4.721	4.93
4/15/2004	17:16:00	549	4.712	4.919
4/15/2004	17:17:00	550	4.699	4.91
4/15/2004	17:18:00	551	4.69	4.902
4/15/2004	17:19:00	552	4.685	4.89
4/15/2004	17:20:00	553	4.672	4.882
4/15/2004	17:21:00	554	4.665	4.873
4/15/2004	17:22:00	555	4.658	4.866
4/15/2004	17:23:00	556	4.651	4.857
4/15/2004	17:24:00	557	4.642	4.846
4/15/2004	17:25:00	558	4.631	4.839
4/15/2004	17:26:00	559	4.625	4.828
4/15/2004	17:27:00	560	4.618	4.822
4/15/2004	17:28:00	561	4.608	4.811
4/15/2004	17:29:00	562	4.597	4.802
4/15/2004	17:30:00	563	4.591	4.795
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4/15/2004	17:32:00	565	4.573	4.777

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4/15/2004	17:34:00	567	4.557	4.757
4/15/2004	17:35:00	568	4.548	4.751
4/15/2004	17:36:00	569	4.541	4.742
4/15/2004	17:37:00	570	4.534	4.733
4/15/2004	17:38:00	571	4.525	4.728
4/15/2004	17:39:00	572	4.518	4.722
4/15/2004	17:40:00	573	4.511	4.711
4/15/2004	17:41:00	574	4.505	4.704
4/15/2004	17:42:00	575	4.495	4.695
4/15/2004	17:43:00	576	4.486	4.688
4/15/2004	17:44:00	577	4.478	4.675
4/15/2004	17:45:00	578	4.473	4.671
4/15/2004	17:46:00	579	4.462	4.669
4/15/2004	17:47:00	580	4.453	4.66
4/15/2004	17:48:00	581	4.449	4.646
4/15/2004	17:49:00	582	4.439	4.64
4/15/2004	17:50:00	583	4.431	4.631
4/15/2004	17:51:00	584	4.426	4.624
4/15/2004	17:52:00	585	4.417	4.617
4/15/2004	17:53:00	586	4.41	4.611
4/15/2004	17:54:00	587	4.406	4.602
4/15/2004	17:55:00	588	4.39	4.6
4/15/2004	17:56:00	589	4.39	4.584
4/15/2004	17:57:00	590	4.381	4.578
4/15/2004	17:58:00	591	4.377	4.571
4/15/2004	17:59:00	592	4.368	4.562
4/15/2004	18:00:00	593	4.358	4.555
4/15/2004	18:01:00	594	4.352	4.546
4/15/2004	18:02:00	595	4.341	4.538
4/15/2004	18:03:00	596	4.338	4.535
4/15/2004	18:04:00	597	4.331	4.526
4/15/2004	18:05:00	598	4.323	4.518
4/15/2004	18:06:00	599	4.318	4.511
4/15/2004	18:07:00	600	4.311	4.502
4/15/2004	18:08:00	601	4.302	4.495
4/15/2004	18:09:00	602	4.296	4.489
4/15/2004	18:10:00	603	4.286	4.482
4/15/2004	18:11:00	604	4.28	4.473
4/15/2004	18:12:00	605	4.275	4.467
4/15/2004	18:13:00	606	4.268	4.458
4/15/2004	18:14:00	607	4.259	4.458
4/15/2004	18:15:00	608	4.253	4.447
4/15/2004	18:16:00	609	4.246	4.44
4/15/2004	18:17:00	610	4.243	4.429
4/15/2004	18:18:00	611	4.234	4.424
4/15/2004	18:19:00	612	4.226	4.415
4/15/2004	18:20:00	613	4.217	4.411
4/15/2004	18:21:00	614	4.212	4.402
4/15/2004	18:22:00	615	4.205	4.398
4/15/2004	18:23:00	616	4.199	4.391
4/15/2004	18:24:00	617	4.192	4.384

4/15/2004	18:25:00	618	4.185	4.376
4/15/2004	18:26:00	619	4.182	4.369
4/15/2004	18:27:00	620	4.172	4.362
4/15/2004	18:28:00	621	4.167	4.358
4/15/2004	18:29:00	622	4.16	4.349
4/15/2004	18:30:00	623	4.154	4.342
4/15/2004	18:31:00	624	4.147	4.336
4/15/2004	18:32:00	625	4.144	4.331
4/15/2004	18:33:00	626	4.135	4.322
4/15/2004	18:34:00	627	4.127	4.318
4/15/2004	18:35:00	628	4.122	4.309
4/15/2004	18:36:00	629	4.115	4.304
4/15/2004	18:37:00	630	4.108	4.296
4/15/2004	18:38:00	631	4.103	4.293
4/15/2004	18:39:00	632	4.097	4.287
4/15/2004	18:40:00	633	4.09	4.278
4/15/2004	18:41:00	634	4.086	4.269
4/15/2004	18:42:00	635	4.079	4.267
4/15/2004	18:43:00	636	4.074	4.262
4/15/2004	18:44:00	637	4.065	4.253
4/15/2004	18:45:00	638	4.061	4.247
4/15/2004	18:46:00	639	4.056	4.24
4/15/2004	18:47:00	640	4.049	4.236
4/15/2004	18:48:00	641	4.042	4.227
4/15/2004	18:49:00	642	4.036	4.222
4/15/2004	18:50:00	643	4.033	4.216
4/15/2004	18:51:00	644	4.024	4.211
4/15/2004	18:52:00	645	4.018	4.205
4/15/2004	18:53:00	646	4.013	4.196
4/15/2004	18:54:00	647	4.009	4.193
4/15/2004	18:55:00	648	4.002	4.187
4/15/2004	18:56:00	649	3.997	4.18
4/15/2004	18:57:00	650	3.989	4.176
4/15/2004	18:58:00	651	3.984	4.167
4/15/2004	18:59:00	652	3.977	4.162
4/15/2004	19:00:00	653	3.973	4.156
4/15/2004	19:01:00	654	3.966	4.151
4/15/2004	19:02:00	655	3.962	4.145
4/15/2004	19:03:00	656	3.955	4.138
4/15/2004	19:04:00	657	3.95	4.134
4/15/2004	19:05:00	658	3.944	4.127
4/15/2004	19:06:00	659	3.939	4.122
4/15/2004	19:07:00	660	3.931	4.116
4/15/2004	19:08:00	661	3.926	4.111
4/15/2004	19:09:00	662	3.921	4.105
4/15/2004	19:10:00	663	3.915	4.098
4/15/2004	19:11:00	664	3.91	4.091
4/15/2004	19:12:00	665	3.905	4.087
4/15/2004	19:13:00	666	3.899	4.082
4/15/2004	19:14:00	667	3.894	4.076
4/15/2004	19:15:00	668	3.889	4.071
4/15/2004	19:16:00	669	3.883	4.065

4/15/2004	19:17:00	670	3.88	4.058
4/15/2004	19:18:00	671	3.874	4.054
4/15/2004	19:19:00	672	3.867	4.047
4/15/2004	19:20:00	673	3.862	4.043
4/15/2004	19:21:00	674	3.856	4.038
4/15/2004	19:22:00	675	3.851	4.034
4/15/2004	19:23:00	676	3.844	4.027
4/15/2004	19:24:00	677	3.84	4.02
4/15/2004	19:25:00	678	3.837	4.016
4/15/2004	19:26:00	679	3.829	4.011
4/15/2004	19:27:00	680	3.824	4.005
4/15/2004	19:28:00	681	3.82	4
4/15/2004	19:29:00	682	3.813	3.996
4/15/2004	19:30:00	683	3.807	3.989
4/15/2004	19:31:00	684	3.804	3.983
4/15/2004	19:32:00	685	3.798	3.978
4/15/2004	19:33:00	686	3.793	3.974
4/15/2004	19:34:00	687	3.788	3.969
4/15/2004	19:35:00	688	3.784	3.963
4/15/2004	19:36:00	689	3.777	3.956
4/15/2004	19:37:00	690	3.771	3.952
4/15/2004	19:38:00	691	3.768	3.947
4/15/2004	19:39:00	692	3.763	3.943
4/15/2004	19:40:00	693	3.759	3.938
4/15/2004	19:41:00	694	3.752	3.932
4/15/2004	19:42:00	695	3.748	3.927
4/15/2004	19:43:00	696	3.743	3.923
4/15/2004	19:44:00	697	3.738	3.916
4/15/2004	19:45:00	698	3.734	3.912
4/15/2004	19:46:00	699	3.729	3.905
4/15/2004	19:47:00	700	3.723	3.9
4/15/2004	19:48:00	701	3.718	3.896
4/15/2004	19:49:00	702	3.714	3.892
4/15/2004	19:50:00	703	3.709	3.887
4/15/2004	19:51:00	704	3.704	3.88
4/15/2004	19:52:00	705	3.7	3.876
4/15/2004	19:53:00	706	3.695	3.872
4/15/2004	19:54:00	707	3.689	3.867
4/15/2004	19:55:00	708	3.686	3.863
4/15/2004	19:56:00	709	3.68	3.858
4/15/2004	19:57:00	710	3.677	3.854
4/15/2004	19:58:00	711	3.671	3.847
4/15/2004	19:59:00	712	3.666	3.841
4/15/2004	20:00:00	713	3.662	3.836
4/15/2004	20:01:00	714	3.657	3.834
4/15/2004	20:02:00	715	3.651	3.829
4/15/2004	20:03:00	716	3.647	3.823
4/15/2004	20:04:00	717	3.642	3.821
4/15/2004	20:05:00	718	3.639	3.814
4/15/2004	20:06:00	719	3.633	3.807
4/15/2004	20:07:00	720	3.628	3.805
4/15/2004	20:08:00	721	3.624	3.803

4/15/2004	20:09:00	722	3.619	3.794
4/15/2004	20:10:00	723	3.614	3.789
4/15/2004	20:11:00	724	3.61	3.787
4/15/2004	20:12:00	725	3.604	3.783
4/15/2004	20:13:00	726	3.601	3.776
4/15/2004	20:14:00	727	3.597	3.772
4/15/2004	20:15:00	728	3.592	3.767
4/15/2004	20:16:00	729	3.588	3.763
4/15/2004	20:17:00	730	3.584	3.758
4/15/2004	20:18:00	731	3.581	3.754
4/15/2004	20:19:00	732	3.575	3.747
4/15/2004	20:20:00	733	3.572	3.745
4/15/2004	20:21:00	734	3.566	3.741
4/15/2004	20:22:00	735	3.563	3.736
4/15/2004	20:23:00	736	3.559	3.734
4/15/2004	20:24:00	737	3.554	3.727
4/15/2004	20:25:00	738	3.548	3.725
4/15/2004	20:26:00	739	3.545	3.721
4/15/2004	20:27:00	740	3.541	3.716
4/15/2004	20:28:00	741	3.535	3.712
4/15/2004	20:29:00	742	3.532	3.705
4/15/2004	20:30:00	743	3.528	3.701
4/15/2004	20:31:00	744	3.523	3.698
4/15/2004	20:32:00	745	3.519	3.694
4/15/2004	20:33:00	746	3.514	3.69
4/15/2004	20:34:00	747	3.511	3.685
4/15/2004	20:35:00	748	3.507	3.681
4/15/2004	20:36:00	749	3.502	3.678
4/15/2004	20:37:00	750	3.498	3.672
4/15/2004	20:38:00	751	3.495	3.67
4/15/2004	20:39:00	752	3.489	3.663
4/15/2004	20:40:00	753	3.487	3.658
4/15/2004	20:41:00	754	3.483	3.656
4/15/2004	20:42:00	755	3.478	3.652
4/15/2004	20:43:00	756	3.474	3.647
4/15/2004	20:44:00	757	3.471	3.641
4/15/2004	20:45:00	758	3.465	3.639
4/15/2004	20:46:00	759	3.462	3.634
4/15/2004	20:47:00	760	3.458	3.63
4/15/2004	20:48:00	761	3.453	3.627
4/15/2004	20:49:00	762	3.449	3.621
4/15/2004	20:50:00	763	3.446	3.619
4/15/2004	20:51:00	764	3.441	3.614
4/15/2004	20:52:00	765	3.439	3.612
4/15/2004	20:53:00	766	3.435	3.605
4/15/2004	20:54:00	767	3.431	3.603
4/15/2004	20:55:00	768	3.428	3.599
4/15/2004	20:56:00	769	3.422	3.594
4/15/2004	20:57:00	770	3.419	3.59
4/15/2004	20:58:00	771	3.415	3.585
4/15/2004	20:59:00	772	3.411	3.583
4/15/2004	21:00:00	773	3.408	3.579

4/15/2004	21:01:00	774	3.404	3.574
4/15/2004	21:02:00	775	3.399	3.57
4/15/2004	21:03:00	776	3.395	3.565
4/15/2004	21:04:00	777	3.392	3.561
4/15/2004	21:05:00	778	3.388	3.559
4/15/2004	21:06:00	779	3.384	3.554
4/15/2004	21:07:00	780	3.379	3.55
4/15/2004	21:08:00	781	3.377	3.547
4/15/2004	21:09:00	782	3.374	3.543
4/15/2004	21:10:00	783	3.368	3.541
4/15/2004	21:11:00	784	3.364	3.536
4/15/2004	21:12:00	785	3.361	3.532
4/15/2004	21:13:00	786	3.357	3.528
4/15/2004	21:14:00	787	3.355	3.525
4/15/2004	21:15:00	788	3.352	3.521
4/15/2004	21:16:00	789	3.346	3.516
4/15/2004	21:17:00	790	3.343	3.514
4/15/2004	21:18:00	791	3.339	3.51
4/15/2004	21:19:00	792	3.336	3.505
4/15/2004	21:20:00	793	3.332	3.503
4/15/2004	21:21:00	794	3.328	3.496
4/15/2004	21:22:00	795	3.325	3.496
4/15/2004	21:23:00	796	3.321	3.492
4/15/2004	21:24:00	797	3.318	3.488
4/15/2004	21:25:00	798	3.314	3.483
4/15/2004	21:26:00	799	3.31	3.481
4/15/2004	21:27:00	800	3.307	3.476
4/15/2004	21:28:00	801	3.303	3.472
4/15/2004	21:29:00	802	3.298	3.47
4/15/2004	21:30:00	803	3.296	3.463
4/15/2004	21:31:00	804	3.292	3.461
4/15/2004	21:32:00	805	3.289	3.456
4/15/2004	21:33:00	806	3.285	3.454
4/15/2004	21:34:00	807	3.282	3.45
4/15/2004	21:35:00	808	3.278	3.448
4/15/2004	21:36:00	809	3.274	3.443
4/15/2004	21:37:00	810	3.271	3.439
4/15/2004	21:38:00	811	3.267	3.437
4/15/2004	21:39:00	812	3.264	3.432
4/15/2004	21:40:00	813	3.26	3.43
4/15/2004	21:41:00	814	3.256	3.425
4/15/2004	21:42:00	815	3.253	3.423
4/15/2004	21:43:00	816	3.249	3.419
4/15/2004	21:44:00	817	3.246	3.414
4/15/2004	21:45:00	818	3.242	3.412
4/15/2004	21:46:00	819	3.238	3.408
4/15/2004	21:47:00	820	3.235	3.403
4/15/2004	21:48:00	821	3.231	3.399
4/15/2004	21:49:00	822	3.228	3.399
4/15/2004	21:50:00	823	3.224	3.394
4/15/2004	21:51:00	824	3.222	3.39
4/15/2004	21:52:00	825	3.219	3.388

4/15/2004	21:53:00	826	3.215	3.383
4/15/2004	21:54:00	827	3.21	3.381
4/15/2004	21:55:00	828	3.208	3.377
4/15/2004	21:56:00	829	3.204	3.372
4/15/2004	21:57:00	830	3.201	3.37
4/15/2004	21:58:00	831	3.197	3.365
4/15/2004	21:59:00	832	3.195	3.363
4/15/2004	22:00:00	833	3.19	3.359
4/15/2004	22:01:00	834	3.186	3.356
4/15/2004	22:02:00	835	3.184	3.352
4/15/2004	22:03:00	836	3.181	3.348
4/15/2004	22:04:00	837	3.177	3.345
4/15/2004	22:05:00	838	3.174	3.341
4/15/2004	22:06:00	839	3.172	3.337
4/15/2004	22:07:00	840	3.166	3.337
4/15/2004	22:08:00	841	3.165	3.332
4/15/2004	22:09:00	842	3.161	3.33
4/15/2004	22:10:00	843	3.157	3.325
4/15/2004	22:11:00	844	3.154	3.321
4/15/2004	22:12:00	845	3.15	3.317
4/15/2004	22:13:00	846	3.147	3.314
4/15/2004	22:14:00	847	3.145	3.312
4/15/2004	22:15:00	848	3.141	3.31
4/15/2004	22:16:00	849	3.138	3.303
4/15/2004	22:17:00	850	3.134	3.301
4/15/2004	22:18:00	851	3.132	3.299
4/15/2004	22:19:00	852	3.128	3.294
4/15/2004	22:20:00	853	3.125	3.292
4/15/2004	22:21:00	854	3.121	3.288
4/15/2004	22:22:00	855	3.118	3.286
4/15/2004	22:23:00	856	3.116	3.281
4/15/2004	22:24:00	857	3.11	3.279
4/15/2004	22:25:00	858	3.107	3.277
4/15/2004	22:26:00	859	3.105	3.274
4/15/2004	22:27:00	860	3.101	3.27
4/15/2004	22:28:00	861	3.098	3.266
4/15/2004	22:29:00	862	3.094	3.261
4/15/2004	22:30:00	863	3.092	3.259
4/15/2004	22:31:00	864	3.089	3.257
4/15/2004	22:32:00	865	3.085	3.254
4/15/2004	22:33:00	866	3.082	3.25
4/15/2004	22:34:00	867	3.08	3.246
4/15/2004	22:35:00	868	3.077	3.241
4/15/2004	22:36:00	869	3.073	3.239
4/15/2004	22:37:00	870	3.071	3.237
4/15/2004	22:38:00	871	3.066	3.234
4/15/2004	22:39:00	872	3.064	3.23
4/15/2004	22:40:00	873	3.06	3.228
4/15/2004	22:41:00	874	3.056	3.223
4/15/2004	22:42:00	875	3.055	3.221
4/15/2004	22:43:00	876	3.051	3.217
4/15/2004	22:44:00	877	3.047	3.217

4/15/2004	22:45:00	878	3.046	3.212
4/15/2004	22:46:00	879	3.042	3.21
4/15/2004	22:47:00	880	3.038	3.206
4/15/2004	22:48:00	881	3.035	3.203
4/15/2004	22:49:00	882	3.031	3.201
4/15/2004	22:50:00	883	3.029	3.197
4/15/2004	22:51:00	884	3.026	3.192
4/15/2004	22:52:00	885	3.024	3.19
4/15/2004	22:53:00	886	3.02	3.188
4/15/2004	22:54:00	887	3.017	3.186
4/15/2004	22:55:00	888	3.013	3.179
4/15/2004	22:56:00	889	3.012	3.177
4/15/2004	22:57:00	890	3.008	3.172
4/15/2004	22:58:00	891	3.005	3.172
4/15/2004	22:59:00	892	3.003	3.168
4/15/2004	23:00:00	893	2.999	3.163
4/15/2004	23:01:00	894	2.996	3.161
4/15/2004	23:02:00	895	2.994	3.159
4/15/2004	23:03:00	896	2.99	3.154
4/15/2004	23:04:00	897	2.986	3.152
4/15/2004	23:05:00	898	2.984	3.148
4/15/2004	23:06:00	899	2.981	3.148
4/15/2004	23:07:00	900	2.979	3.143
4/15/2004	23:08:00	901	2.975	3.141
4/15/2004	23:09:00	902	2.972	3.135
4/15/2004	23:10:00	903	2.968	3.137
4/15/2004	23:11:00	904	2.966	3.132
4/15/2004	23:12:00	905	2.963	3.128
4/15/2004	23:13:00	906	2.959	3.126
4/15/2004	23:14:00	907	2.957	3.123
4/15/2004	23:15:00	908	2.954	3.119
4/15/2004	23:16:00	909	2.952	3.115
4/15/2004	23:17:00	910	2.948	3.115
4/15/2004	23:18:00	911	2.947	3.11
4/15/2004	23:19:00	912	2.943	3.108
4/15/2004	23:20:00	913	2.94	3.104
4/15/2004	23:21:00	914	2.938	3.101
4/15/2004	23:22:00	915	2.934	3.097
4/15/2004	23:23:00	916	2.931	3.095
4/15/2004	23:24:00	917	2.929	3.092
4/15/2004	23:25:00	918	2.925	3.09
4/15/2004	23:26:00	919	2.922	3.088
4/15/2004	23:27:00	920	2.92	3.083
4/15/2004	23:28:00	921	2.918	3.081
4/15/2004	23:29:00	922	2.915	3.079
4/15/2004	23:30:00	923	2.911	3.074
4/15/2004	23:31:00	924	2.908	3.07
4/15/2004	23:32:00	925	2.904	3.07
4/15/2004	23:33:00	926	2.902	3.068
4/15/2004	23:34:00	927	2.9	3.064
4/15/2004	23:35:00	928	2.895	3.059
4/15/2004	23:36:00	929	2.893	3.057

4/15/2004	23:37:00	930	2.891	3.054
4/15/2004	23:38:00	931	2.888	3.052
4/15/2004	23:39:00	932	2.886	3.05
4/15/2004	23:40:00	933	2.882	3.048
4/15/2004	23:41:00	934	2.879	3.044
4/15/2004	23:42:00	935	2.877	3.041
4/15/2004	23:43:00	936	2.873	3.039
4/15/2004	23:44:00	937	2.873	3.035
4/15/2004	23:45:00	938	2.868	3.032
4/15/2004	23:46:00	939	2.864	3.028
4/15/2004	23:47:00	940	2.862	3.026
4/15/2004	23:48:00	941	2.86	3.024
4/15/2004	23:49:00	942	2.857	3.024
4/15/2004	23:50:00	943	2.853	3.017
4/15/2004	23:51:00	944	2.853	3.017
4/15/2004	23:52:00	945	2.848	3.015
4/15/2004	23:53:00	946	2.846	3.01
4/15/2004	23:54:00	947	2.842	3.008
4/15/2004	23:55:00	948	2.839	3.004
4/15/2004	23:56:00	949	2.837	3.001
4/15/2004	23:57:00	950	2.833	2.997
4/15/2004	23:58:00	951	2.833	2.995
4/15/2004	23:59:00	952	2.83	2.995
4/16/2004	0:00:00	953	2.826	2.99
4/16/2004	0:01:00	954	2.824	2.988
4/16/2004	0:02:00	955	2.821	2.986
4/16/2004	0:03:00	956	2.817	2.981
4/16/2004	0:04:00	957	2.815	2.979
4/16/2004	0:05:00	958	2.814	2.977
4/16/2004	0:06:00	959	2.812	2.975
4/16/2004	0:07:00	960	2.808	2.97
4/16/2004	0:08:00	961	2.806	2.97
4/16/2004	0:09:00	962	2.802	2.966
4/16/2004	0:10:00	963	2.801	2.964
4/16/2004	0:11:00	964	2.797	2.961
4/16/2004	0:12:00	965	2.795	2.959
4/16/2004	0:13:00	966	2.792	2.955
4/16/2004	0:14:00	967	2.79	2.953
4/16/2004	0:15:00	968	2.786	2.95
4/16/2004	0:16:00	969	2.784	2.948
4/16/2004	0:17:00	970	2.781	2.946
4/16/2004	0:18:00	971	2.779	2.941
4/16/2004	0:19:00	972	2.776	2.939
4/16/2004	0:20:00	973	2.772	2.939
4/16/2004	0:21:00	974	2.77	2.933
4/16/2004	0:22:00	975	2.769	2.93
4/16/2004	0:23:00	976	2.765	2.93
4/16/2004	0:24:00	977	2.763	2.926
4/16/2004	0:25:00	978	2.761	2.924
4/16/2004	0:26:00	979	2.759	2.921
4/16/2004	0:27:00	980	2.756	2.919
4/16/2004	0:28:00	981	2.752	2.917

4/16/2004	0:29:00	982	2.751	2.913
4/16/2004	0:30:00	983	2.749	2.913
4/16/2004	0:31:00	984	2.745	2.908
4/16/2004	0:32:00	985	2.743	2.906
4/16/2004	0:33:00	986	2.74	2.901
4/16/2004	0:34:00	987	2.736	2.899
4/16/2004	0:35:00	988	2.736	2.897
4/16/2004	0:36:00	989	2.733	2.895
4/16/2004	0:37:00	990	2.731	2.893
4/16/2004	0:38:00	991	2.727	2.89
4/16/2004	0:39:00	992	2.725	2.888
4/16/2004	0:40:00	993	2.723	2.886
4/16/2004	0:41:00	994	2.72	2.882
4/16/2004	0:42:00	995	2.718	2.879
4/16/2004	0:43:00	996	2.714	2.879
4/16/2004	0:44:00	997	2.713	2.875
4/16/2004	0:45:00	998	2.709	2.873
4/16/2004	0:46:00	999	2.707	2.873
4/16/2004	0:47:00	1000	2.705	2.87
4/16/2004	0:48:00	1001	2.701	2.864
4/16/2004	0:49:00	1002	2.7	2.863
4/16/2004	0:50:00	1003	2.698	2.859
4/16/2004	0:51:00	1004	2.694	2.857
4/16/2004	0:52:00	1005	2.692	2.855
4/16/2004	0:53:00	1006	2.689	2.853
4/16/2004	0:54:00	1007	2.687	2.85
4/16/2004	0:55:00	1008	2.685	2.846
4/16/2004	0:56:00	1009	2.683	2.844
4/16/2004	0:57:00	1010	2.68	2.842
4/16/2004	0:58:00	1011	2.678	2.839
4/16/2004	0:59:00	1012	2.674	2.837
4/16/2004	1:00:00	1013	2.673	2.835
4/16/2004	1:01:00	1014	2.671	2.833
4/16/2004	1:02:00	1015	2.667	2.828
4/16/2004	1:03:00	1016	2.664	2.828
4/16/2004	1:04:00	1017	2.662	2.826
4/16/2004	1:05:00	1018	2.66	2.824
4/16/2004	1:06:00	1019	2.658	2.822
4/16/2004	1:07:00	1020	2.656	2.819
4/16/2004	1:08:00	1021	2.653	2.815
4/16/2004	1:09:00	1022	2.651	2.813
4/16/2004	1:10:00	1023	2.647	2.81
4/16/2004	1:11:00	1024	2.646	2.808
4/16/2004	1:12:00	1025	2.642	2.804
4/16/2004	1:13:00	1026	2.64	2.802
4/16/2004	1:14:00	1027	2.638	2.802
4/16/2004	1:15:00	1028	2.637	2.797
4/16/2004	1:16:00	1029	2.633	2.795
4/16/2004	1:17:00	1030	2.631	2.79
4/16/2004	1:18:00	1031	2.629	2.788
4/16/2004	1:19:00	1032	2.627	2.786
4/16/2004	1:20:00	1033	2.624	2.784

4/16/2004	1:21:00	1034	2.62	2.782
4/16/2004	1:22:00	1035	2.618	2.779
4/16/2004	1:23:00	1036	2.616	2.777
4/16/2004	1:24:00	1037	2.613	2.775
4/16/2004	1:25:00	1038	2.611	2.773
4/16/2004	1:26:00	1039	2.608	2.771
4/16/2004	1:27:00	1040	2.608	2.768
4/16/2004	1:28:00	1041	2.604	2.766
4/16/2004	1:29:00	1042	2.602	2.764
4/16/2004	1:30:00	1043	2.601	2.762
4/16/2004	1:31:00	1044	2.597	2.759
4/16/2004	1:32:00	1045	2.595	2.755
4/16/2004	1:33:00	1046	2.592	2.753
4/16/2004	1:34:00	1047	2.59	2.752
4/16/2004	1:35:00	1048	2.588	2.751
4/16/2004	1:36:00	1049	2.584	2.746
4/16/2004	1:37:00	1050	2.583	2.744
4/16/2004	1:38:00	1051	2.581	2.742
4/16/2004	1:39:00	1052	2.577	2.739
4/16/2004	1:40:00	1053	2.577	2.737
4/16/2004	1:41:00	1054	2.574	2.733
4/16/2004	1:42:00	1055	2.572	2.731
4/16/2004	1:43:00	1056	2.57	2.728
4/16/2004	1:44:00	1057	2.566	2.728
4/16/2004	1:45:00	1058	2.563	2.724
4/16/2004	1:46:00	1059	2.561	2.722
4/16/2004	1:47:00	1060	2.559	2.719
4/16/2004	1:48:00	1061	2.557	2.717
4/16/2004	1:49:00	1062	2.554	2.715
4/16/2004	1:50:00	1063	2.552	2.71
4/16/2004	1:51:00	1064	2.55	2.711
4/16/2004	1:52:00	1065	2.548	2.708
4/16/2004	1:53:00	1066	2.545	2.706
4/16/2004	1:54:00	1067	2.543	2.704
4/16/2004	1:55:00	1068	2.541	2.701
4/16/2004	1:56:00	1069	2.537	2.699
4/16/2004	1:57:00	1070	2.536	2.699
4/16/2004	1:58:00	1071	2.534	2.695
4/16/2004	1:59:00	1072	2.53	2.693
4/16/2004	2:00:00	1073	2.53	2.691
4/16/2004	2:01:00	1074	2.527	2.688
4/16/2004	2:02:00	1075	2.524	2.684
4/16/2004	2:03:00	1076	2.523	2.684
4/16/2004	2:04:00	1077	2.519	2.682
4/16/2004	2:05:00	1078	2.519	2.677
4/16/2004	2:06:00	1079	2.516	2.677
4/16/2004	2:07:00	1080	2.514	2.673
4/16/2004	2:08:00	1081	2.512	2.673
4/16/2004	2:09:00	1082	2.508	2.668
4/16/2004	2:10:00	1083	2.505	2.668
4/16/2004	2:11:00	1084	2.505	2.664
4/16/2004	2:12:00	1085	2.501	2.664

4/16/2004	2:13:00	1086	2.5	2.66
4/16/2004	2:14:00	1087	2.496	2.657
4/16/2004	2:15:00	1088	2.495	2.655
4/16/2004	2:16:00	1089	2.493	2.653
4/16/2004	2:17:00	1090	2.491	2.651
4/16/2004	2:18:00	1091	2.487	2.648
4/16/2004	2:19:00	1092	2.486	2.646
4/16/2004	2:20:00	1093	2.484	2.644
4/16/2004	2:21:00	1094	2.482	2.64
4/16/2004	2:22:00	1095	2.478	2.64
4/16/2004	2:23:00	1096	2.477	2.637
4/16/2004	2:24:00	1097	2.475	2.635
4/16/2004	2:25:00	1098	2.473	2.633
4/16/2004	2:26:00	1099	2.471	2.63
4/16/2004	2:27:00	1100	2.469	2.628
4/16/2004	2:28:00	1101	2.466	2.628
4/16/2004	2:29:00	1102	2.464	2.624
4/16/2004	2:30:00	1103	2.462	2.622
4/16/2004	2:31:00	1104	2.46	2.62
4/16/2004	2:32:00	1105	2.457	2.617
4/16/2004	2:33:00	1106	2.457	2.615
4/16/2004	2:34:00	1107	2.453	2.613
4/16/2004	2:35:00	1108	2.45	2.611
4/16/2004	2:36:00	1109	2.448	2.611
4/16/2004	2:37:00	1110	2.444	2.608
4/16/2004	2:38:00	1111	2.444	2.604
4/16/2004	2:39:00	1112	2.442	2.604
4/16/2004	2:40:00	1113	2.441	2.6
4/16/2004	2:41:00	1114	2.439	2.597
4/16/2004	2:42:00	1115	2.437	2.597
4/16/2004	2:43:00	1116	2.433	2.593
4/16/2004	2:44:00	1117	2.432	2.59
4/16/2004	2:45:00	1118	2.428	2.591
4/16/2004	2:46:00	1119	2.426	2.586
4/16/2004	2:47:00	1120	2.424	2.586
4/16/2004	2:48:00	1121	2.423	2.584
4/16/2004	2:49:00	1122	2.423	2.582
4/16/2004	2:50:00	1123	2.419	2.58
4/16/2004	2:51:00	1124	2.417	2.577
4/16/2004	2:52:00	1125	2.415	2.575
4/16/2004	2:53:00	1126	2.411	2.575
4/16/2004	2:54:00	1127	2.41	2.571
4/16/2004	2:55:00	1128	2.408	2.568
4/16/2004	2:56:00	1129	2.404	2.566
4/16/2004	2:57:00	1130	2.404	2.564
4/16/2004	2:58:00	1131	2.401	2.562
4/16/2004	2:59:00	1132	2.399	2.557
4/16/2004	3:00:00	1133	2.397	2.557
4/16/2004	3:01:00	1134	2.397	2.557
4/16/2004	3:02:00	1135	2.393	2.553
4/16/2004	3:03:00	1136	2.392	2.553
4/16/2004	3:04:00	1137	2.39	2.551

4/16/2004	3:05:00	1138	2.388	2.546
4/16/2004	3:06:00	1139	2.386	2.544
4/16/2004	3:07:00	1140	2.384	2.542
4/16/2004	3:08:00	1141	2.38	2.539
4/16/2004	3:09:00	1142	2.379	2.54
4/16/2004	3:10:00	1143	2.377	2.537
4/16/2004	3:11:00	1144	2.375	2.535
4/16/2004	3:12:00	1145	2.374	2.533
4/16/2004	3:13:00	1146	2.372	2.533
4/16/2004	3:14:00	1147	2.368	2.531
4/16/2004	3:15:00	1148	2.366	2.526
4/16/2004	3:16:00	1149	2.365	2.524
4/16/2004	3:17:00	1150	2.363	2.522
4/16/2004	3:18:00	1151	2.361	2.52
4/16/2004	3:19:00	1152	2.359	2.52
4/16/2004	3:20:00	1153	2.357	2.52
4/16/2004	3:21:00	1154	2.356	2.515
4/16/2004	3:22:00	1155	2.354	2.515
4/16/2004	3:23:00	1156	2.352	2.513
4/16/2004	3:24:00	1157	2.35	2.511
4/16/2004	3:25:00	1158	2.346	2.509
4/16/2004	3:26:00	1159	2.344	2.506
4/16/2004	3:27:00	1160	2.343	2.502
4/16/2004	3:28:00	1161	2.341	2.502
4/16/2004	3:29:00	1162	2.339	2.5
4/16/2004	3:30:00	1163	2.338	2.5
4/16/2004	3:31:00	1164	2.334	2.495
4/16/2004	3:32:00	1165	2.334	2.493
4/16/2004	3:33:00	1166	2.331	2.493
4/16/2004	3:34:00	1167	2.329	2.491
4/16/2004	3:35:00	1168	2.327	2.486
4/16/2004	3:36:00	1169	2.323	2.484
4/16/2004	3:37:00	1170	2.322	2.484
4/16/2004	3:38:00	1171	2.32	2.482
4/16/2004	3:39:00	1172	2.318	2.48
4/16/2004	3:40:00	1173	2.316	2.477
4/16/2004	3:41:00	1174	2.314	2.475
4/16/2004	3:42:00	1175	2.314	2.473
4/16/2004	3:43:00	1176	2.311	2.471
4/16/2004	3:44:00	1177	2.309	2.469
4/16/2004	3:45:00	1178	2.307	2.469
4/16/2004	3:46:00	1179	2.305	2.466
4/16/2004	3:47:00	1180	2.302	2.462
4/16/2004	3:48:00	1181	2.3	2.462
4/16/2004	3:49:00	1182	2.298	2.459
4/16/2004	3:50:00	1183	2.298	2.457
4/16/2004	3:51:00	1184	2.295	2.457
4/16/2004	3:52:00	1185	2.293	2.453
4/16/2004	3:53:00	1186	2.291	2.451
4/16/2004	3:54:00	1187	2.289	2.448
4/16/2004	3:55:00	1188	2.287	2.446
4/16/2004	3:56:00	1189	2.286	2.444

4/16/2004	3:57:00	1190	2.282	2.442
4/16/2004	3:58:00	1191	2.28	2.442
4/16/2004	3:59:00	1192	2.278	2.439
4/16/2004	4:00:00	1193	2.277	2.437
4/16/2004	4:01:00	1194	2.275	2.435
4/16/2004	4:02:00	1195	2.273	2.433
4/16/2004	4:03:00	1196	2.273	2.431
4/16/2004	4:04:00	1197	2.269	2.426
4/16/2004	4:05:00	1198	2.268	2.426
4/16/2004	4:06:00	1199	2.266	2.424
4/16/2004	4:07:00	1200	2.264	2.422
4/16/2004	4:08:00	1201	2.26	2.419
4/16/2004	4:09:00	1202	2.259	2.419
4/16/2004	4:10:00	1203	2.257	2.415
4/16/2004	4:11:00	1204	2.257	2.413
4/16/2004	4:12:00	1205	2.253	2.411
4/16/2004	4:13:00	1206	2.251	2.411
4/16/2004	4:14:00	1207	2.25	2.408
4/16/2004	4:15:00	1208	2.25	2.408
4/16/2004	4:16:00	1209	2.246	2.404
4/16/2004	4:17:00	1210	2.244	2.402
4/16/2004	4:18:00	1211	2.242	2.399
4/16/2004	4:19:00	1212	2.241	2.399
4/16/2004	4:20:00	1213	2.239	2.398
4/16/2004	4:21:00	1214	2.237	2.395
4/16/2004	4:22:00	1215	2.235	2.393
4/16/2004	4:23:00	1216	2.233	2.393
4/16/2004	4:24:00	1217	2.232	2.391
4/16/2004	4:25:00	1218	2.228	2.391
4/16/2004	4:26:00	1219	2.228	2.389
4/16/2004	4:27:00	1220	2.226	2.386
4/16/2004	4:28:00	1221	2.224	2.384
4/16/2004	4:29:00	1222	2.223	2.382
4/16/2004	4:30:00	1223	2.221	2.382
4/16/2004	4:31:00	1224	2.219	2.379
4/16/2004	4:32:00	1225	2.217	2.377
4/16/2004	4:33:00	1226	2.215	2.375
4/16/2004	4:34:00	1227	2.214	2.373
4/16/2004	4:35:00	1228	2.212	2.373
4/16/2004	4:36:00	1229	2.21	2.371
4/16/2004	4:37:00	1230	2.208	2.368
4/16/2004	4:38:00	1231	2.206	2.368
4/16/2004	4:39:00	1232	2.204	2.364
4/16/2004	4:40:00	1233	2.202	2.364
4/16/2004	4:41:00	1234	2.201	2.362
4/16/2004	4:42:00	1235	2.199	2.36
4/16/2004	4:43:00	1236	2.197	2.357
4/16/2004	4:44:00	1237	2.195	2.355
4/16/2004	4:45:00	1238	2.195	2.355
4/16/2004	4:46:00	1239	2.192	2.353
4/16/2004	4:47:00	1240	2.189	2.351
4/16/2004	4:48:00	1241	2.188	2.348

4/16/2004	4:49:00	1242	2.186	2.346
4/16/2004	4:50:00	1243	2.184	2.344
4/16/2004	4:51:00	1244	2.182	2.342
4/16/2004	4:52:00	1245	2.18	2.342
4/16/2004	4:53:00	1246	2.179	2.34
4/16/2004	4:54:00	1247	2.177	2.337
4/16/2004	4:55:00	1248	2.175	2.335
4/16/2004	4:56:00	1249	2.175	2.335
4/16/2004	4:57:00	1250	2.171	2.333
4/16/2004	4:58:00	1251	2.171	2.331
4/16/2004	4:59:00	1252	2.168	2.328
4/16/2004	5:00:00	1253	2.166	2.328
4/16/2004	5:01:00	1254	2.164	2.326
4/16/2004	5:02:00	1255	2.162	2.324
4/16/2004	5:03:00	1256	2.161	2.322
4/16/2004	5:04:00	1257	2.159	2.32
4/16/2004	5:05:00	1258	2.157	2.32
4/16/2004	5:06:00	1259	2.156	2.317
4/16/2004	5:07:00	1260	2.154	2.313
4/16/2004	5:08:00	1261	2.152	2.313
4/16/2004	5:09:00	1262	2.15	2.311
4/16/2004	5:10:00	1263	2.148	2.309
4/16/2004	5:11:00	1264	2.148	2.306
4/16/2004	5:12:00	1265	2.145	2.307
4/16/2004	5:13:00	1266	2.143	2.304
4/16/2004	5:14:00	1267	2.141	2.302
4/16/2004	5:15:00	1268	2.141	2.3
4/16/2004	5:16:00	1269	2.139	2.3
4/16/2004	5:17:00	1270	2.138	2.297
4/16/2004	5:18:00	1271	2.136	2.295
4/16/2004	5:19:00	1272	2.134	2.293
4/16/2004	5:20:00	1273	2.132	2.293
4/16/2004	5:21:00	1274	2.13	2.288
4/16/2004	5:22:00	1275	2.128	2.288
4/16/2004	5:23:00	1276	2.127	2.286
4/16/2004	5:24:00	1277	2.127	2.287
4/16/2004	5:25:00	1278	2.125	2.284
4/16/2004	5:26:00	1279	2.123	2.282
4/16/2004	5:27:00	1280	2.122	2.28
4/16/2004	5:28:00	1281	2.12	2.277
4/16/2004	5:29:00	1282	2.118	2.278
4/16/2004	5:30:00	1283	2.116	2.275
4/16/2004	5:31:00	1284	2.114	2.273
4/16/2004	5:32:00	1285	2.113	2.273
4/16/2004	5:33:00	1286	2.111	2.271
4/16/2004	5:34:00	1287	2.109	2.268
4/16/2004	5:35:00	1288	2.107	2.266
4/16/2004	5:36:00	1289	2.105	2.264
4/16/2004	5:37:00	1290	2.104	2.264
4/16/2004	5:38:00	1291	2.104	2.262
4/16/2004	5:39:00	1292	2.102	2.26
4/16/2004	5:40:00	1293	2.1	2.257

4/16/2004	5:41:00	1294	2.098	2.257
4/16/2004	5:42:00	1295	2.096	2.255
4/16/2004	5:43:00	1296	2.095	2.253
4/16/2004	5:44:00	1297	2.093	2.249
4/16/2004	5:45:00	1298	2.091	2.249
4/16/2004	5:46:00	1299	2.089	2.249
4/16/2004	5:47:00	1300	2.087	2.246
4/16/2004	5:48:00	1301	2.086	2.244
4/16/2004	5:49:00	1302	2.084	2.244
4/16/2004	5:50:00	1303	2.082	2.24
4/16/2004	5:51:00	1304	2.08	2.24
4/16/2004	5:52:00	1305	2.078	2.237
4/16/2004	5:53:00	1306	2.078	2.237
4/16/2004	5:54:00	1307	2.075	2.235
4/16/2004	5:55:00	1308	2.075	2.233
4/16/2004	5:56:00	1309	2.072	2.231
4/16/2004	5:57:00	1310	2.072	2.231
4/16/2004	5:58:00	1311	2.068	2.229
4/16/2004	5:59:00	1312	2.068	2.227
4/16/2004	6:00:00	1313	2.066	2.224
4/16/2004	6:01:00	1314	2.064	2.224
4/16/2004	6:02:00	1315	2.063	2.222
4/16/2004	6:03:00	1316	2.061	2.22
4/16/2004	6:04:00	1317	2.061	2.22
4/16/2004	6:05:00	1318	2.057	2.217
4/16/2004	6:06:00	1319	2.057	2.215
4/16/2004	6:07:00	1320	2.055	2.213
4/16/2004	6:08:00	1321	2.053	2.213
4/16/2004	6:09:00	1322	2.051	2.211
4/16/2004	6:10:00	1323	2.05	2.209
4/16/2004	6:11:00	1324	2.048	2.206
4/16/2004	6:12:00	1325	2.046	2.206
4/16/2004	6:13:00	1326	2.044	2.204
4/16/2004	6:14:00	1327	2.044	2.204
4/16/2004	6:15:00	1328	2.042	2.202
4/16/2004	6:16:00	1329	2.041	2.2
4/16/2004	6:17:00	1330	2.039	2.197
4/16/2004	6:18:00	1331	2.037	2.195
4/16/2004	6:19:00	1332	2.035	2.196
4/16/2004	6:20:00	1333	2.035	2.193
4/16/2004	6:21:00	1334	2.033	2.191
4/16/2004	6:22:00	1335	2.032	2.189
4/16/2004	6:23:00	1336	2.03	2.189
4/16/2004	6:24:00	1337	2.028	2.189
4/16/2004	6:25:00	1338	2.026	2.186
4/16/2004	6:26:00	1339	2.026	2.184
4/16/2004	6:27:00	1340	2.024	2.182
4/16/2004	6:28:00	1341	2.023	2.182
4/16/2004	6:29:00	1342	2.021	2.18
4/16/2004	6:30:00	1343	2.021	2.177
4/16/2004	6:31:00	1344	2.019	2.177
4/16/2004	6:32:00	1345	2.017	2.175

4/16/2004	6:33:00	1346	2.015	2.173
4/16/2004	6:34:00	1347	2.014	2.173
4/16/2004	6:35:00	1348	2.012	2.171
4/16/2004	6:36:00	1349	2.01	2.169
4/16/2004	6:37:00	1350	2.012	2.169
4/16/2004	6:38:00	1351	2.008	2.169
4/16/2004	6:39:00	1352	2.006	2.164
4/16/2004	6:40:00	1353	2.005	2.164
4/16/2004	6:41:00	1354	2.003	2.162
4/16/2004	6:42:00	1355	2.002	2.16
4/16/2004	6:43:00	1356	2.001	2.157
4/16/2004	6:44:00	1357	1.999	2.157
4/16/2004	6:45:00	1358	1.997	2.155
4/16/2004	6:46:00	1359	1.996	2.155
4/16/2004	6:47:00	1360	1.994	2.153
4/16/2004	6:48:00	1361	1.992	2.151
4/16/2004	6:49:00	1362	1.99	2.151
4/16/2004	6:50:00	1363	1.99	2.149
4/16/2004	6:51:00	1364	1.988	2.146
4/16/2004	6:52:00	1365	1.986	2.146
4/16/2004	6:53:00	1366	1.986	2.144
4/16/2004	6:54:00	1367	1.984	2.142
4/16/2004	6:55:00	1368	1.983	2.142
4/16/2004	6:56:00	1369	1.981	2.14
4/16/2004	6:57:00	1370	1.979	2.138
4/16/2004	6:58:00	1371	1.979	2.138
4/16/2004	6:59:00	1372	1.978	2.135
4/16/2004	7:00:00	1373	1.976	2.133
4/16/2004	7:01:00	1374	1.974	2.133
4/16/2004	7:02:00	1375	1.972	2.131
4/16/2004	7:03:00	1376	1.972	2.129
4/16/2004	7:04:00	1377	1.97	2.129
4/16/2004	7:05:00	1378	1.969	2.126
4/16/2004	7:06:00	1379	1.969	2.124
4/16/2004	7:07:00	1380	1.966	2.124
4/16/2004	7:08:00	1381	1.965	2.122
4/16/2004	7:09:00	1382	1.963	2.12
4/16/2004	7:10:00	1383	1.961	2.12
4/16/2004	7:11:00	1384	1.961	2.118
4/16/2004	7:12:00	1385	1.958	2.115
4/16/2004	7:13:00	1386	1.958	2.115
4/16/2004	7:14:00	1387	1.956	2.113
4/16/2004	7:15:00	1388	1.954	2.113
4/16/2004	7:16:00	1389	1.954	2.111
4/16/2004	7:17:00	1390	1.952	2.111
4/16/2004	7:18:00	1391	1.951	2.109
4/16/2004	7:19:00	1392	1.949	2.109
4/16/2004	7:20:00	1393	1.949	2.106
4/16/2004	7:21:00	1394	1.947	2.104
4/16/2004	7:22:00	1395	1.945	2.104
4/16/2004	7:23:00	1396	1.943	2.102
4/16/2004	7:24:00	1397	1.943	2.1

4/16/2004	7:25:00	1398	1.942	2.1
4/16/2004	7:26:00	1399	1.939	2.098
4/16/2004	7:27:00	1400	1.939	2.098
4/16/2004	7:28:00	1401	1.938	2.095
4/16/2004	7:29:00	1402	1.935	2.093
4/16/2004	7:30:00	1403	1.934	2.091
4/16/2004	7:31:00	1404	1.932	2.091
4/16/2004	7:32:00	1405	1.932	2.091
4/16/2004	7:33:00	1406	1.93	2.086
4/16/2004	7:34:00	1407	1.928	2.086
4/16/2004	7:35:00	1408	1.928	2.084
4/16/2004	7:36:00	1409	1.926	2.084
4/16/2004	7:37:00	1410	1.925	2.082
4/16/2004	7:38:00	1411	1.923	2.082
4/16/2004	7:39:00	1412	1.921	2.08
4/16/2004	7:40:00	1413	1.919	2.078
4/16/2004	7:41:00	1414	1.919	2.076
4/16/2004	7:42:00	1415	1.917	2.075
4/16/2004	7:43:00	1416	1.916	2.073
4/16/2004	7:44:00	1417	1.916	2.071
4/16/2004	7:45:00	1418	1.914	2.071
4/16/2004	7:46:00	1419	1.912	2.069
4/16/2004	7:47:00	1420	1.911	2.069
4/16/2004	7:48:00	1421	1.909	2.066
4/16/2004	7:49:00	1422	1.909	2.066
4/16/2004	7:50:00	1423	1.907	2.064
4/16/2004	7:51:00	1424	1.905	2.064
4/16/2004	7:52:00	1425	1.904	2.062
4/16/2004	7:53:00	1426	1.904	2.06
4/16/2004	7:54:00	1427	1.902	2.058
4/16/2004	7:55:00	1428	1.9	2.058
4/16/2004	7:56:00	1429	1.898	2.055
4/16/2004	7:57:00	1430	1.898	2.053
4/16/2004	7:58:00	1431	1.896	2.053
4/16/2004	7:59:00	1432	1.895	2.051
4/16/2004	8:00:00	1433	1.895	2.051
4/16/2004	8:01:00	1434	1.893	2.049
4/16/2004	8:02:00	1435	1.891	2.049
4/16/2004	8:03:00	1436	1.891	2.046
4/16/2004	8:04:00	1437	1.887	2.044
4/16/2004	8:05:00	1438	1.887	2.044
4/16/2004	8:06:00	1439	1.886	2.042
4/16/2004	8:07:00	1440	1.884	2.042
4/16/2004	8:08:00	1441	1.884	2.042
4/16/2004	8:09:00	1442	1.882	2.04
4/16/2004	8:10:00	1443	1.88	2.038
4/16/2004	8:11:00	1444	1.88	2.038
4/16/2004	8:12:00	1445	1.878	2.035
4/16/2004	8:13:00	1446	1.877	2.033
4/16/2004	8:14:00	1447	1.875	2.031
4/16/2004	8:15:00	1448	1.871	2.029
4/16/2004	8:16:00	1449	1.871	2.029

4/16/2004	8:17:00	1450	1.869	2.027
4/16/2004	8:18:00	1451	1.869	2.027
4/16/2004	8:19:00	1452	1.868	2.022
4/16/2004	8:20:00	1453	1.866	2.022
4/16/2004	8:21:00	1454	1.864	2.02
4/16/2004	8:22:00	1455	1.864	2.02
4/16/2004	8:23:00	1456	1.862	2.018
4/16/2004	8:24:00	1457	1.86	2.018
4/16/2004	8:25:00	1458	1.86	2.015
4/16/2004	8:26:00	1459	1.859	2.015
4/16/2004	8:27:00	1460	1.859	2.013
4/16/2004	8:28:00	1461	1.857	2.011
4/16/2004	8:29:00	1462	1.855	2.253

Chatman & Associates incorporated

Consultants, Engineers, Scientists
Environmental, Water Resources,
Data Acquisition

Sheet No. 1

Rev. No.

Job No. 20037 Task No. By WMS Date 5/14/04

Client Middlefork Water Co. Subject Well Design Chk'd. Date

0
- 1.5 TOPSOIL
- 5 DK Grey Brn silty CL
- Lt Grey Brn silty CL
- 16 DK Grey silty CL
- 20 Grey fine to med. SAND
- 24.5 Grey Med. to C. SAND + Gr.
- 28.5 Gred med. to fine SAND
- 30 Grey med. to C. SAND + Gr.
- 34

20

40 Grey silty CL w/ Tr. of Bldrs

57

60 DK Grey sdy Clay, Tr bldrs

73 Grey fine sand
74 DK. Grey sandy CL
75 Grey fine to med. sand, w/ Med. to C., TR Gr.
80 Grey med sand, w/ fine + C. SAND, TR CL + Bldrs
84 Grey sdy CL w/ Bldrs + Med. to C. Sand + Gr.
87 Grey, Med. to C. SAND + Gr, w/ Bldrs, TR CL + fines
90 SS 90-90.1 Grey Clay + rock w/ MED TO C. SAND
Grey Coarse to Gravel w/ Lots Bldrs + Med to C. SAND, TR CL
97 Gray FINE SAND
98
101 Grey SANDY CL
106 Grey FINE TO MED SAND w/ CL
111 Blk V. fn sdy CL TR Gr + MED to C. SAND
115 Grey C. to Gravel w/ Med to fine + Clay

100

120 Grey fine sand, TR MED. to C. SAND + CL

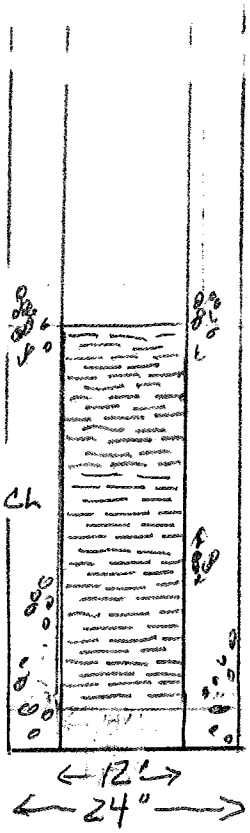
125
129 Grey sdy CL w/ Med to C. SAND Layers

140 Grey sdy CL, Tr bldrs

153.5 Lt. Grey LM Bldrs, HARD
155 DK Grey sdy CL, TR Bldrs
160 160.5 LT Gray shale, HARD
165

Grain Size Distr. Plots

	D50	D30	D70	X5
Discharge sand	.012	.015	.006	.03
SS 90-90.1' bgs	.079	.283	.006	.03
WB 90-95' bgs	.177	.244	.118	.059
WB 95-100' bgs	.069	.177	.009	.046
WB 105-110' bgs	.071	.118	.04	0.2
WB 110-115' bgs	.108	.157	.071	.365



10" pipe size screen 0.04" slot
146 in²/ft * .5 (blockage) = 73 in²/ft
73 in²/ft x 40 ft = 2920 in²
2920 in² x 1 ft²/144 in² = 20.28 ft²
20 ft² x 0.1 ft/sec = 2.0 ft³/sec
2.0 ft³/sec x 7.48 gal/ft³ x 60 sec/min =
897.6 gpm
OK ✓
slot 40
10-20
Colorado Silica

Appendix I

Project References

Appendix I
Project References

The following is a list of references that were located during the file review and were utilized during the preparation of this report and the development of the recommendations presented herein:

- Milkon Corporation Consulting Engineers, Daily Job Reports: July 10, 1992; July 27, 1992; July 31, 1992; August 4, 1992; August 14, 1992; August 20, 1992
- Milkon Corporation Consulting Engineers, Laboratory Compaction Tests: July 13, 1992 (A & B); August 3, 1992 (C)
- Construction Specification for Linn Creek Dam and Reservoir
- Construction Plans for Linn Creek dam and Reservoir, November 1991
- Donaldson Engineering and Const. Co., Project Location and Site Plan, Sheet 1 of 23, December 1991
- USGS Water Data Report 2010, for 06896189 Stanberry Lake, near Gentry, Missouri

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