3. Proposed Facility Design Criteria and Requirements

3.1. General Design Criteria

Basic design criteria involving engineering, hydraulics and other miscellaneous factors have been developed and are outlined herein. These various design criteria provide guidelines to develop the preliminary sizing, layouts and designs for the various alternatives for the various water collection, treatment, distribution and storage facilities. In addition, design criteria follow recognized sources such as the *Recommended Standards for Water Works* [1] (frequently referred to as the "Ten States Standards") and other published design criteria and recommendations by regulatory agencies (as appropriate) in South Dakota, Iowa, Minnesota and the United States EPA.

The materials and standards used in construction have a direct impact on construction costs for the proposed water system improvements. The type of treatment system used has an impact on construction costs for the proposed water treatment improvements. This report considers two types of treatment systems, conventional flocculation/sedimentation and microfiltration and multiple pipe materials.

3.1.1. Design Life

The project life of the improvements should be considered in the alternative selection process. Design life for water treatment plant and well structures is typically in the range of 40 to 50 years. The typical design life for pipelines, structures and water reservoirs is approximately 50 years. Process and pump equipment design life is typically 20 to 25 years. The life of submersible pump equipment is typically 10 to 15 years.

3.1.2. Flow Criteria

Chapter 2 details the results of surveys undertaken by Lewis & Clark to determine the water needs of its membership. This approach differs from typical rural water systems. Lewis & Clark is a regional bulk distributor to existing water systems. Water use projections were provided by

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[1] *Recommended Standards for Water Works*, Great Lakes and Upper Mississippi Board of State Public Health and Environmental Managers, 1992 and *Criteria for Design of Public Water Facilities in South Dakota, Supplement to the Recommended Standards for Water Works*, July 1, 1979.

the member systems to meet their needs and water use strategy. Projected water demands of Lewis & Clark member systems are listed in Table 2.4-3.

These existing water systems include distribution and water storage components. Some systems, Sioux Falls for example, will use their Lewis & Clark supply as a supplemental supply to their existing water sources. Other systems will use their Lewis & Clark supply as their primary supply. It is not anticipated that Lewis & Clark water demands will vary significantly due to the member system usage (strongly influenced by Sioux Falls planned usage of its entire reserved capacity) and the buffer of individual members' water storage and distribution systems. In addition to storage within the individual systems, the Lewis & Clark pipeline system will include storage strategically placed along the transmission pipeline route.

3.1.2.1. Well System

The well system should be sized to deliver the currently identified reserved capacity of 27.2 MGD plus additional capacity as described below. Additional capacity in the raw water collection and connecting pipeline system will be provided to account for anticipated water losses in the water treatment process (this will be dependent upon the treatment process selected), operational requirements and anticipated transmission pipeline losses. Further, it is anticipated the well system will be constructed in two or more phases to determine (through experience) acceptable yields and to match the delivery requirements as the project is constructed.

The required well yield is based on delivery of the total reserved capacity demand in 24-hours. Anticipated daily water treatment plant waste stream flow is projected to range from 0.2 to 2.8 MGD. Transmission pipeline system losses are anticipated to be 5% of the total reserved capacity demand (1.36 MGD). The calculated demand capacity would range from 28.8 to 31.4 MGD with anticipated losses included, depending upon treatment process selected. Therefore, the well system should have the ability to provide approximately 29 to 32 MGD flow to the water treatment plant. This is subject to change and is highly dependent upon the actual well yields.

Depending upon the yield of the individual wells, it would be desirable to have the ability to provide some redundancy of supply. Redundancy of supply would accomplish several project goals and requirements, including:

- Provide ability to cycle wells to extend life of the pumps and other equipment;
- Provide greater security of the supply in the event of prolonged drought and low water conditions in the Missouri River;
- Provide separation between wells to provide better security of the water supply from potential contamination or impacts caused by flooding conditions;
- Provide the ability to isolate wells from the system and still maintain the ability to provide at least 29 to 32 MGD to the treatment plant in the event a well is compromised or inoperative; and
- Provide the ability to remove a well from service in order to conduct preventative maintenance to make repairs.

Currently, it is envisioned that a well system in the Mulberry Point area (Sites A, B, C and D) will produce approximately 22.5 to 26 MGD, under seasonal average conditions. Yield will depend upon seasonal river stage, ground water temperature and recharge conditions. Another area north and west of Mulberry Point could be developed, however the potential yield per well is less than that of wells in the Mulberry Point area.[2, 3]

The well system should have the ability to deliver at least 29 to 32 MGD with the highest yielding well in standby mode.

3.1.2.2. Raw Water Pipeline System

The main raw water pipeline system should be sized to deliver the currently identified reserved capacity (plus operational water requirements and anticipated transmission pipeline losses) of the approximate range of 29 to 32 MGD – the same as the well system. The lateral system (lines connecting individual wells to the main pipeline) should be sized to match the estimated capacity of the individual wells.

Actual lateral and connecting line sizing will be based on the results of production pump test well investigations at the individual well sites. The main line from the laterals to the water treatment plant will be based on a delivery capacity of at least 29 to 32 MGD.

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[2] *Report of Site B Mulberry Point Hydrogeologic Investigation to Determine Water Supply Development Potential From Radial Collector Well for Lewis & Clark Rural Water System*, December, 2001, Layne Christensen Company.

[3] *Responses to VE Study – Final Engineering Report (1/8/02)*, March 20, 2001, Banner Associates, Inc. and HDR Engineering, Inc.

3.1.2.3. Water Treatment Facilities

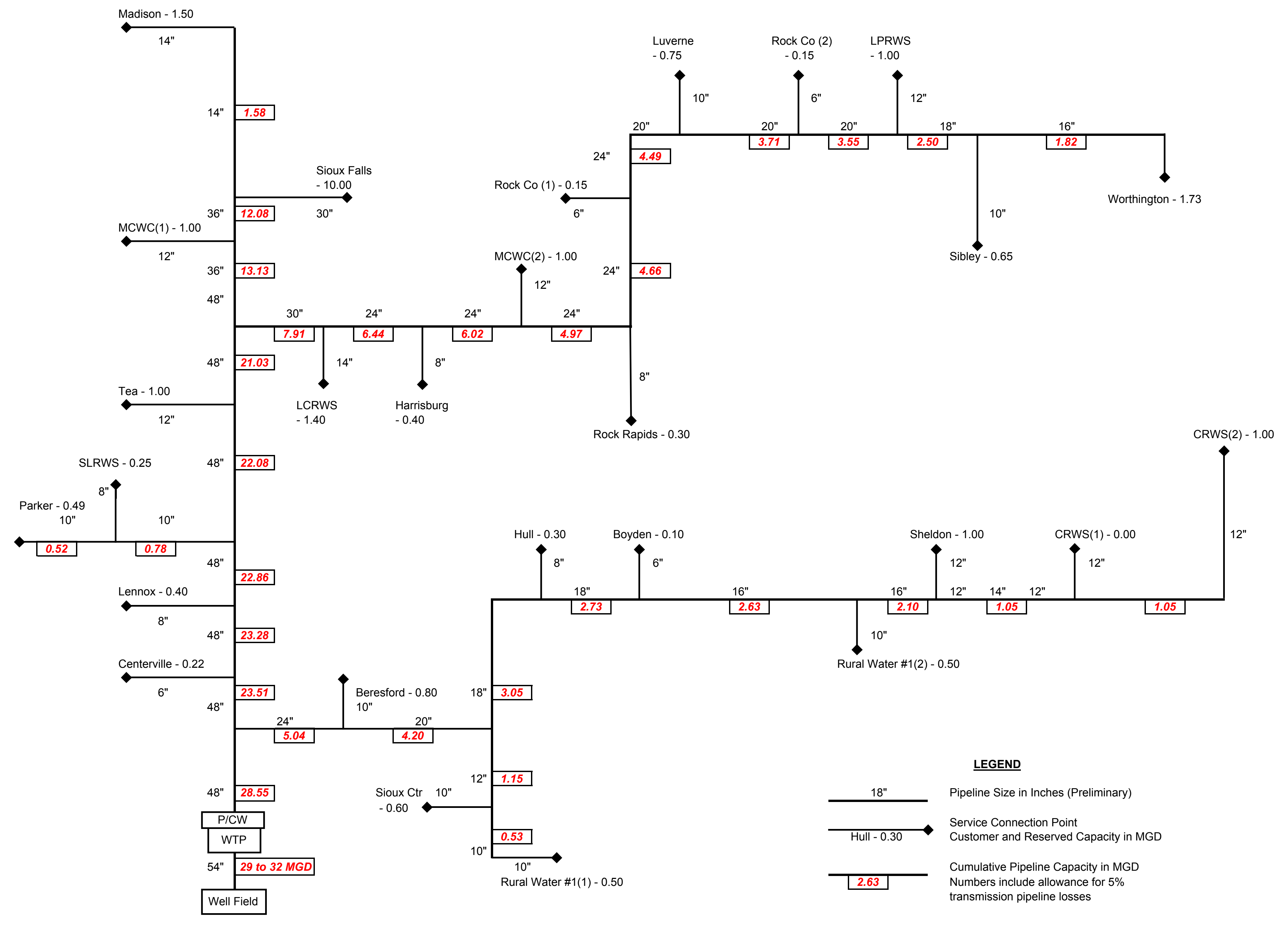
The water treatment facilities should be sized to deliver the currently identified reserved capacity of 27.2 MGD in 24 hours plus anticipated transmission pipeline losses and water treatment plant process losses and uses. Anticipated daily water treatment plant waste stream flow is projected to range from 0.2 to 2.8 MGD, depending upon treatment process selected. Transmission pipeline system losses are anticipated to be 5% of the total reserved capacity demand (1.36 MGD). Total treatment plant capacity should provide the capacity to deliver 28.6 MGD, over a 24-hour period, to the treated water transmission pipeline system.

3.1.2.4. Treated Water Transmission, Pumping and Storage Facilities

Lewis & Clark will deliver each system's reserved capacity at a uniform rate over a 24-hour period. To meet the peak day demand, pumping from the clearwell into the treated water transmission system would occur over a 24-hour period. Pumping at a rate of approximately 19,850 gpm would provide the total peak day system demand of approximately 28.6 MGD. The required pipeline capacity decreases along the transmission pipeline route at member system turnouts. Figure 3.1-1 is a system schematic showing the capacity of the transmission pipeline system required to meet member system total reserved capacity demands. The flow rates shown on Figure 3.1-1 include a 5% loss factor throughout the system.

Main line booster pump stations, as required along the transmission pipeline route, should be sized to match the total reserved capacity of the systems downstream of the booster pump station plus an allowance for 5% loss. Service connection booster pump stations, if required, should match the reserved capacity of the member system.

Criteria used to determine total system storage is based on the *Recommended Standards for Water Works*, which recommends "... the minimum storage capacity for systems not providing fire protection shall be equal to the average daily consumption." Storage within the transmission system will not be designed for fire flows. Due to the nature of the Lewis & Clark system, and the different water use strategies of its member systems, the average daily water demand method will not be used. It is envisioned that Lewis & Clark's average day demand will be essentially the same as the peak demand as the system matures. Therefore, it is recommended the total storage in the transmission pipeline system be sized to provide approximately 29 to 30 MG. This amount is slightly higher than the total reserved capacity



Banner Associates, Inc.
HDR Engineering, Inc.
TRC Mariah Associates Inc.

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FIGURE 3.1-1

Lewis & Clark Rural Water System Schematic Showing Reserved Capacity Requirements

of approximately 27.2 MG. Individual storage reservoirs should be sized to provide emergency storage equal to the maximum day demand (total reserved capacity) on the branch of the pipeline served by that reservoir, if possible.

3.2. Well System

The proposed facility design criteria and general requirements for the well system are discussed below. The well field will include radial collector wells or a combination of collector, vertical, and angle wells.

3.2.1. Well Types Evaluated

3.2.1.1. Radial Collector Wells

Horizontal radial collector wells are comprised of a large diameter reinforced concrete caisson that serves as a wet well/pumping station. The collector is equipped with a series of well screens that are projected horizontally into the aquifer from near the bottom of the caisson. The caisson is constructed to the desired depth using the open-end caisson sinking method and a bottom-sealing plug is poured to make the caisson watertight. The radial collectors can be installed at one or more elevations and may be placed in a variety of patterns and lengths depending upon aquifer characteristics and project requirements. The caisson is extended above known or anticipated flood elevations and the well is typically completed with a pump house and controls.

The collector type of well was evaluated for the Lewis & Clark Rural Water System for several reasons. First, maximum yields, typically exceeding the yield of several vertical wells, can be achieved because the horizontal position of the laterals allows for greater drawdown and because of the large effective well radius. Potential yield can be further enhanced by induced infiltration of surface water and water quality may be improved due to natural filtration. Also, because the lengths of the lateral well screens are not restricted by aquifer thickness, increased screen open area results in a highly efficient well with low entrance velocities and minimal maintenance. Finally, the higher collector yield typically results in optimization of pumping efficiency, operations, and maintenance as compared to multiple individual vertical wells.

Pump house facilities will be constructed on top of the caisson and will contain the pumps/motors, electrical switchgear and discharge piping.

General collector well construction guidelines are summarized below:

- The top of caisson will be at least three feet above the 100-year flood level.
- The caisson wall is to be reinforced to withstand the forces it will be subjected to from the aquifer material and water.
- Radial collectors should be constructed in areas and at depths approved by the regulatory agency.
- Provisions will be made so that radial collectors are essentially horizontal.
- The top of caisson shall be covered with a watertight floor.
- All openings in the caisson floor must be curbed and protected from the entrance of foreign material.
- Pump discharge piping shall not penetrate the caisson walls.
- Provisions will be made for periodic measurement of water levels in the well.
- Each radial collector will have provisions to isolate it from the caisson.
- Radial collector screens will be constructed of materials resistant to damage by chemical action of groundwater or cleaning operations.
- Maximum screen entrance velocity should not exceed 0.03 FPS, assuming 50 percent of the screen openings are plugged.

3.2.1.2. Vertical and Angle Wells

Vertical and angle wells will be evaluated as alternatives to the collector well design. Vertical and angle wells are less expensive to construct. However, since their production capacity is less, substantially more vertical and angle wells would be required as compared to the collector well.

Vertical wells and angle wells could be constructed to gain maximum benefit of both groundwater and surface water from the river. Vertical wells would be constructed adjacent to the river while angle wells would be constructed under the riverbed to maximize production.

General vertical and angle well construction guidelines are summarized below:

- The top of well casing will be at least three feet above the 100-year flood level and at least 18 inches above final grade elevation.
- Wells must be sealed near the surface to prevent the entrance of surface water.
- Casing and screen should be constructed of materials resistant to damage by chemical action of groundwater or cleaning operations.
- Maximum screen entrance velocity should be limited to 0.1 feet/second; assuming 50 percent of the screen openings are plugged.
- Angle wells can be installed at an angle of 45 degrees or greater (as measured from the vertical) to extend from a bank under a stream or river.

3.2.2. Land Requirements and Well Field Protection

The land on which the wells are to be located, as well as land around each well, should be owned (or in the case of State Land, a long-term lease) by Lewis & Clark and will include land for the well and pump house, wellhead protection, access to the well, and well collector piping and other utilities. To meet these objectives, up to 4 to 5 acres of land at each site may be required.

The well field is near an agriculturally developed area resulting in potential sources of groundwater contamination. The Missouri River, fed by surface runoff, does experience elevated levels of agricultural chemicals such as atrazine, particularly during the spring. The land application of agricultural chemicals also poses a threat to groundwater quality through leaching by precipitation infiltration.

Safeguarding the wells from all potential contamination sources is impractical and impossible. By spreading the wells out to as large of an area as possible, there is flexibility in the well field management and groundwater quality produced. Good well field management practices will aid in the blended quality of the raw water reaching its destination.

3.2.3. Pumps

The pumps proposed for the collector and vertical wells are the vertical turbine line shaft type. Major advantages of vertical turbine pumps in high capacity wells are:

- They are highly reliable over long periods of time if properly designed and maintained.
- Motor repairs are made easily because of aboveground installation.

- Motors are not susceptible to failure caused by fluctuations in electric current.
- Overall pump-motor efficiency is very high.
- Electrical problems due to wiring and complete submersion in water are minimal.

Submersible pumps will be used for the angle wells. This is the only type of pump that will work when installed at an angle.

3.2.4. Electrical Distribution

Planning and layout of the electrical distribution system for the well field must consider the source of commercial electrical energy and what type and capacity is to be provided for standby capability. Also, environmental concerns and agency requirements dictate use of underground power sources to most of the sites adjacent to the Missouri River.

3.2.5. Telemetry and Controls

The capability and reliability of each well is determined by the integrity of the electrical distribution system design and the electrical controls at each well. It is an integrated system and it must be designed with flexibility and redundancy capabilities. The control system will be designed to allow the well pumps to be operated on site or remotely from the water treatment plant. Several well and pump operating parameters will be monitored remotely and on site as well.

3.2.6. Access

Access roads to each well will be constructed to allow convenient access from State Highway 19 and other roadways, as applicable.

3.2.7. Reliability

The well field would normally supply average day demand to the water treatment plant at all times. However, due to clearwell storage and reservoirs in the distribution system, the minimum supply to the WTP is 15 to 17 MGD. This system has more finished water storage than normal and discussion with the power utility indicates outage should be relatively short. This will be accomplished by building redundancy into the well system and pumps and by providing standby electrical generation capability.

3.3. Raw and Treated Water Transmission Pipeline Systems

The following are basic criteria proposed for design of the raw and treated water transmission pipeline systems. The design and construction period for this project could extend over several years. Products and materials continually evolve in the water industry and new materials and products that may be available in the future should not be discounted if not listed herein.

The raw and treated water transmission pipeline systems include the following major components:

- Raw water transmission pipeline system, including laterals to the individual wells;
- Treated water transmission pipeline system;
- Main line booster pumping stations;
- Service line booster pumping stations;
- Water storage reservoirs;
- Service connections at each member system's turnout (service connection functions include flow measurement, telemetry, backflow prevention, and possible addition of chemicals - chlorine, ammonia, pH adjustment);
- Telemetry and control system; and
- Various pipeline appurtenances and other design features.

3.3.1. Pipeline Sizing Criteria

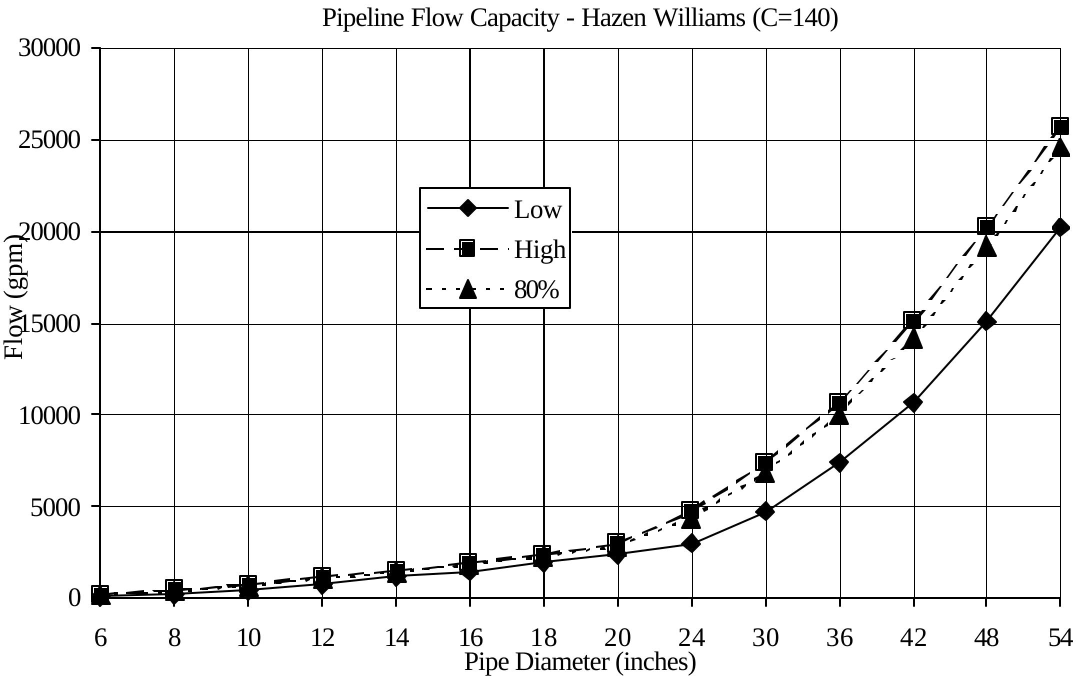
Preliminary pipeline sizing was performed based on the following general criteria (final line sizing is based on the results of hydraulic network modeling discussed in Section 5.4):

- Head loss was limited to less than 4 feet per 1000 feet (approximately 9 psi per mile);
- Pipeline flow velocity was limited to less than 4 feet per second; and
- Hazen-Williams formula loss coefficient, C = 140.
- Limit flow to 80% of range before upsizing pipe.

Table 3.3-1 identifies maximum flow rates associated with a given pipe diameter under these criteria. At the high end of the range of flows for each pipe size, the operation and maintenance costs resulted in the equivalent cost equal to those for the next size pipe at the low end of the range of pipe flow for that pipe size. Engineering judgment was used to select the next larger pipe size when the required flow was more than 80% of the maximum value in the range listed.

Table 3.3-1
Pipe Flow Hydraulic Characteristics Table and Graph

	Flow Range for Pipe		80% of flow range			
Pipe Dia (In)	Low Flow (gpm)	High Flow (gpm)	gpm	MGD	Head loss per 1000' (ft)	Velocity (ft/sec)
6	83	215	189	0.272	3.2	2.2
8	216	440	395	0.569	3.3	2.7
10	441	750	688	0.991	3.4	3.1
12	751	1,180	1,094	1.576	3.5	3.5
14	1,181	1,480	1,420	2.045	3.2	3.6
16	1,481	1,930	1,840	2.650	2.7	3.6
18	1,931	2,390	2,298	3.309	2.3	3.5
20	2,391	2,980	2,862	4.122	2.1	3.6
24	2,981	4,740	4,388	6.319	1.5	3.4
30	4,741	7,410	6,876	9.902	1.1	3.4
36	7,411	10,690	10,034	14.449	0.9	3.4
42	10,691	15,100	14,218	20.474	0.8	3.5
48	15,101	20,240	19,212	27.666	0.7	3.6
54	20,241	25,700	24,608	35.436	0.6	3.6



Based on the above criteria, maximum head loss was the controlling factor for smaller diameter pipe (6" through 10"). Velocity was the limiting factor for the larger diameter pipe (See table in Appendix A-3). Table 3.3-1 also illustrates head loss and velocity at 80% of the maximum value in the range.

The Lewis & Clark system is a transmission pipeline with no individual service taps, therefore the pipeline can be operated at higher pressures. Pipelines must maintain a minimum pressure of 20 psi (pounds per square inch) at service connection points, with a desirable maximum design working pressure less than approximately 250 psi (some short sections of line immediately downstream of pump stations exceed 250 psi). Most of the pipeline would be operated at pressures less than 150 psi. Some portions of the pipeline route (river crossings or areas immediately downstream of some booster pump stations for example) may experience pressures between 175 to 250 psi for short reaches – this will be considered in final design wall thickness requirements. Pipe wall thickness (or pressure class) should be selected to account for higher operating pressures to account for unexpected future system demands that would require higher pressure operation. Surge pressure allowances (see Section 3.3.4.6) should be included in the design of the pipelines.

Individual service lines to deliver water to member system water towers (or to meet distribution system pressure) require a delivery pressure of approximately 50 to 70 psi. Systems that take delivery at ground storage reservoirs and clearwells will require a lower delivery pressure, but not less than the minimum system pressure of 20 psi. Some of the rural water system members require a delivery pressure between 100 to 125 psi.

3.3.2. Pipeline Materials

Selection of pipe material also affects development of opinions of probable construction cost, pipeline operation and maintenance. The following materials have been considered for buried piping for the majority of the project. Actual material selection will be dependent upon conditions for each segment of the project and will be evaluated in accordance with project requirements. In most cases, alternate materials will be bid to provide a competitive bidding environment.

For pipe sizes in the range of 4" to 12", the most economical pipe material is typically PVC (polyvinyl chloride). PVC pipe may also be considered for 14" to 18" diameter lines for this project. However, steel or ductile iron pipe should be used for 14" to 18" diameter lines where the operating or surge pressures exceed the recommendations for PVC pipe materials. For pipe sizes 18" and above, the recommended pipe material is typically ductile iron or steel based on economics and surge considerations.

The pressure class or wall thickness of pipe should be selected based on expected operating pressure plus surge pressure for each individual section of pipeline. In areas where there is a significant possibility of increasing flow rates in the future, the pressure class of the pipe should be designed for potential future conditions.

3.3.2.1. PVC Pipe

The standard for PVC pipe will be AWWA C900 for diameters up to 12". Also, AWWA C909, PVCO (molecularly oriented polyvinyl chloride) pipe may also be specified for diameters up to 12”. Allowable pressure class for pipe will be in accordance with applicable design standards and project requirements, as appropriate.

Another PVC manufacturing standard typically seen on rural water projects is ASTM 2241. AWWA C900 is a more stringent standard than ASTM 2241 and is more appropriate for the larger pipe sizes and operating pressures proposed for the Lewis & Clark project. Allowable pressure for ASTM 2241 pipe is typically down rated to 67% (used by RUS) or 75% of the rated pressure class to provide for an accommodation for a lower factor of safety and no surge allowance built into the pipe. Therefore, it is recommended the ASTM 2241 standard not be used for the Lewis & Clark project.

AWWA C905 is applicable for PVC pipe sizes 14" through 48" diameter. AWWA C905 pipe may be considered for 14" to 18" diameter lines for this project – larger diameters may also be considered depending upon pipeline operating and surge pressure. However, steel or ductile iron pipe should be used for pipe diameters greater than 12" where operating or surge pressures exceed the recommendations for AWWA C905 PVC pipe materials.

Installation of PVC pipe would be in accordance with AWWA C605. Fittings for PVC pipe would be ductile iron. Corrosion control measures for fittings will be recommended based on actual soils and other conditions for each segment of the project.

3.3.2.2. Ductile Iron Pipe

For all pipe sizes, ductile iron pipe with cement mortar lining, should be considered and bid. The accepted standard for ductile iron pipe is AWWA C151 and cement mortar lining is AWWA C104. Pipe pressure class and other design considerations are included in AWWA C150. Installation would be in accordance with AWWA C600. AWWA provides other standards for fittings, gasketed joints and polyethylene encasement in the "C100" series of standards.

A valuable resource for design and construction of ductile iron pipe is DIPRA (Ductile Iron Pipe Research Association). DIPRA provides resources to the designer regarding other design details and considerations including hydraulic analysis, thrust restraint, surge evaluation and corrosion control measures.

Corrosion control measures will be recommended based on actual soils and other conditions for each segment of the project. Refer to section 3.3.4.5.

3.3.2.3. Steel Pipe

For pipe sizes 14" and above, steel pipe with cement mortar lining, should be considered and bid. Steel pipe should be fabricated in accordance with AWWA C200 and cement mortar lining as detailed in AWWA C205. Pipe wall thickness, installation and other design considerations are included in AWWA Manual of Practice M11. AWWA provides other standards for fittings, field welding, tape wrap and other coatings in the "C200" series of standards.

Typically, steel pipe is provided with a tape wrap coating system. Recently, many manufacturers have been providing a factory applied polyurethane coating with heat shrink sleeves at the joints. It is strongly recommended the polyurethane coating system be considered for steel pipe. It is also recommended to consider use of polyurethane for lining in lieu of cement mortar lining.

Corrosion control measures will be recommended based on actual soils and other conditions for each segment of the project. Refer to section 3.3.4.5.

3.3.2.4. Concrete Cylinder Pipe

Concrete cylinder pipe is a general designation given to pipe manufactured with a watertight steel cylinder and reinforcing or presetressing wire, all embedded in a rich concrete or mortar encasement. There are presently three types being produced in the United States and Canada: reinforced concrete cylinder pipe (AWWA C300); prestressed concrete cylinder pipe (AWWA C301); and pretensioned concrete cylinder pipe (AWWA C303).[4] Additional details are included in AWWA Manual of Practice M9. This pipe is available in sizes of 16" diameter and larger.

AWWA C301 prestressed concrete cylinder pipe has been provided on recent water projects. Reports of problems with failures due to corrosion have been reported. Currently, Reclamation has imposed a moratorium against use of AWWA C301 pipe material due to poor performance on some of its projects.

Therefore, this pipe material (concrete cylinder pipe) will not be considered for this project.

3.3.3. Pipeline Installation

Installation will be by trenching methods due to the larger diameters to be used on this project. Frost depth in the Water Service Area ranges from 5.5 to 6.5 feet. Pipeline depths are recommended to be 6' to 6.5', minimum, based on pipe size. Deeper bury depths may be required in farmland areas where field drainpipes have been installed to lower ground water – it is understood the field drainpipes are buried at relatively shallow depths. The Lewis & Clark pipeline would be installed below the field drainpipes. This will be particularly true for the larger diameter pipe. Pipeline bedding, backfill and compaction should be in accordance with recommendations provided by the respective AWWA, ASTM or Reclamation standard.

Pipeline construction standards for transmission lines will require a carefully graded vertical profile to avoid abrupt changes in alignment that could trap air at high points. Pipelines (=14" diameter) will be laid to line and grade. Air release valves will be installed at high points since there are no services through which air can be removed (see Section 3.3.4.2).

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[4] *External Corrosion – Introduction to Chemistry and Control*, AWWA Manual of Practice M27

Typically, the transmission pipeline will be located in an easement on private property parallel to a roadway. When possible, the pipeline alignment will be designed to avoid wetlands, buildings, other improvements, cultural resources and other obstructions.

3.3.4. Pipeline Appurtenances

Various types of control valves and metering devices play an integral role in the proper operation of a water system. The valves provide not only for flow control, but safeguard the pipe from damage and provide for proper operation and maintenance.

3.3.4.1. Isolation Valves

Valves along the main pipeline will allow isolation of various segments of the pipeline for operation and maintenance. The transmission pipeline will have isolation valves placed at approximately 2 to 5-mile intervals, as appropriate. Isolation valves on 24” and larger lines would be used judiciously due to cost considerations. The valves will be resilient seat gate valves with a small diameter bypass line to allow for pressure equalization during opening and closing of the valves. Bypass piping at the valves would not be placed on lines smaller than 14-inch diameter unless line pressure dictates otherwise. Butterfly valves (and other valve types) will be considered on a case-by-case basis.

Isolation valves will also be installed on longer service lines. Isolation valve spacing on service lines would be at approximately 1 to 2-mile intervals. Valve spacing intervals will be evaluated for each service line during final design should this spacing not be appropriate.

Isolation valves will be provided at locations of branches in the system to other transmission lines, service connection lines, reservoirs, booster pump stations and service connection buildings. Air release/air vacuum valve location criteria will also be considered when choosing locations for isolation valves. Design of service connection buildings and booster pump stations will incorporate isolation valves for the transmission or service pipeline. Along the transmission pipeline, and where possible, valves will be located adjacent to roadway crossings to permit access to the valves. Larger diameter (>14” diameter) valves will be installed in precast reinforced concrete vaults or manholes. For smaller diameter lines, (14” and smaller), direct bury valves will be considered on a case-by-case basis.

Isolation valves (other pipeline appurtenances and changes in direction) will require thrust restraint and other appropriate design considerations to account for unbalanced forces in the pipeline system. Appropriate design considerations include anchorages, concrete thrust blocks and restrained joints. The type of joint restraint will depend upon the type of pipe used.

3.3.4.2. Air Release/Air Vacuum Valves

Variations in terrain features will require numerous air release and air vacuum valves for this system. Trapped air at high points in the system can result in flows being throttled as the water "squeezes" by the air bubble. Movement of air pockets in the pipe may result in surges or pressure fluctuations. Placement of combination air release/air vacuum (ARV) valves at high points prevents this from happening. Also, with adequately located valves, air is easily purged after repairing a pipeline break to restore normal operation quickly. The combination valve also acts as a vacuum break to prevent collapse or damage to the line should a break occur in a lower location. Combination ARV valves will be placed at significant high points (or breaks in grade) in the system and at approximately ½-mile intervals on flatter runs or uniformly sloping grades. ARV’s will be individually sized for each pipeline segment. ARV’s will be located in precast concrete vaults for the larger ARV’s, and manholes or similar enclosures for smaller valves.

3.3.4.3. Blowoff Valves and Hydrants

Blowoff valves will typically be located at low points near creek crossings or other drainages to provide a means to flush the pipe for maintenance reasons, or drain the pipe at a controlled location in the event of a break. Blowoff valves for the larger transmission pipelines will require a gate or plug valve and related piping to control releases due to the volume of flow to be discharged in a reasonable period of time.

Smaller transmission and service lines (14” and smaller), will typically require a 2, 3 or 4½-inch flushing hydrant. Rip rap and other erosion control measures will be required to protect the drainage and the pipeline.

3.3.4.4. Master Meters

Metering of a water system provides a means of checking the balance between water produced and water "sold". This not only provides an accounting function, but also helps identify areas suspected of experiencing high loss rates. The recommended locations for master meters includes the well pumping stations, high service pumps at the water treatment plant, booster pump stations, out of reservoirs and at service connections. Wherever possible, meter locations will be combined with other functions (booster pump stations, etc.). However, if a meter is to be located at a remote location without other support systems, the meter will be housed in a precast concrete vault or manhole.

3.3.4.5. Corrosion Control Measures

Deterioration of pipelines, valves, pumps and associated equipment due to external corrosion is an important concern for water utilities. Determination of the needs for specific corrosion control measures is dependant upon several factors, including:

- Soils conditions, including naturally corrosive soils;
- Dissimilar metals in contact with each other;
- Contamination of soil with refuse, cinders; corrosive material and salts;
- Soil moisture conditions and fluctuations;
- Presence of anaerobic conditions or where microbiological induced corrosion (MIC) may occur;
- Stray current from other sources (including interference from other cathodic protection systems);
- Level of service (function) and importance of the proposed facility;
- Design life; and
- Proposed construction materials.

The required level of corrosion control measures is often times a controversial issue. Material suppliers and corrosion control experts disagree in the requirements for various materials. Also, various utility industries view the need for corrosion control measures differently based on their experience and value of their products.

Other factors to be considered in the operation of a corrosion control program are the responsibilities and implications for operation and maintenance of the completed system. The system must be periodically monitored and the results analyzed. The utility owning the system must be attentive to notice changes in the system that may indicate potentially corrosive situations. Also, the utility may be legally responsible for any damage or accidents to other underground utilities impacted by its system.

One of the main issues facing the Lewis & Clark project is the corrosion control measures required for ductile iron pipe vs. steel pipe. There is, relatively speaking, basic agreement in the requirements for steel pipe. However, there is a wide disparity in the opinion of the appropriate corrosion control measures for ductile iron pipe. The main areas of contention are the use of joint bonding, cathodic protection and/or tightly bonded coatings vs. the typical use of polyethylene encasement.

Current Reclamation corrosion design guidelines allow for the use of either polyethylene encasement or bonded coatings for ductile iron pipe depending on size and soil resistivity. Reclamation requires corrosion monitoring systems on all ductile iron pipe. They require use of cathodic protection for both polyethylene encased and tight bonded coated ductile iron pipe on M&I (municipal and industrial) projects if the probability of soil resistivities is below 3,000 ohm-cm for more that 10% of the time. In corrosive soils below 2,000 ohm-cm, they do not allow use of polyethylene encasement on ductile iron pipe larger than 24" inside diameter or for pipe heavier than 150 pounds per foot but require tightly bonded coatings and cathodic protection. For steel pipelines, if the 10% probability of soil resistivity is above 2,000 ohm-cm, the use of bonded dielectric coatings is required. If the 10% probability of soil resistivity is below 2,000 ohm-cm soil, then tight bonded coatings and cathodic protection are required for steel pipe. Reclamation's current guidelines for ductile iron and steel pipe are listed in Table 3.3-2.[5]

Table 3.3-2
Reclamation's Recommended Corrosion Prevention Criteria
and Requirements for Ductile Iron Pipe [5]

	Soil Resistivity 10% Probability Value (ohm-cm)		Corrosion Measures Required	
External Protection	Irrigation	M&I	Corrosion Monitoring System	Cathodic Protection System
Ductile Iron - Polyethylene Encasement	>1,500	>3,000	x	
	≤1,500	≤3,000	x	x
Ductile Iron - Bonded Dielectric	>1,000	>2,000	x	
	≤1,000	≤2,000	x	x
Steel - Bonded Dielectric	>1,000	>2,000	x	
	≤1,000	≤2,000	x	x

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[5] *Recommended Corrosion Prevention Criteria and Requirements*, US Bureau of Reclamation.

Table 3.3-3 provides an example of corrosion control measures that could be required for certain corrosivity conditions (other factors may also apply).[6] Actual criteria will be developed during the design process as additional information regarding soils and other conditions affecting corrosion control are determined.

Table 3.3-3

Example of Design Criteria for Transmission Pipeline Corrosion Control Measures [6]

Soil Resistivity Range (ohm-cm)	Corrosivity Rating	Steel Pipe	Ductile Iron Pipe
0 - 1,000	Extremely Corrosive	Joint bonds, insulators, test stations, tightly bonded coatings and cathodic protection	Joint bonds, insulators, test stations, tightly bonded coatings and cathodic protection
1,001 - 3,000	Very Corrosive	Joint bonds, insulators, test stations, tightly bonded coatings and cathodic protection	Joint bonds, insulators, test stations, polyethylene encasement (or tightly bonded coatings?) and cathodic protection
3,001 - 5,000	Corrosive	Joint bonds, insulators, test stations, tightly bonded coatings and cathodic protection	Joint bonds, insulators, test stations, polyethylene encasement (and cathodic protection?)
5,001 - 10,000	Moderately Corrosive	Joint bonds, insulators, test stations, tightly bonded coatings and cathodic protection	Joint bonds, insulators, test stations and polyethylene encasement
Over 10,001	Mildly Corrosive	Joint bonds, insulators, test stations, tightly bonded coatings and cathodic protection	Polyethylene encasement

Prior to commencing final design for the individual pipeline segments, an overall soils and stray current survey will be undertaken to determine corrosion potential for the entire project area, in general terms. A request has been made to DIPRA to perform a general survey and analysis for a portion of the project in accordance with the procedures outlined in AWWA C105. In addition to this information, additional corrosion testing and analysis will be included as part of the geotechnical investigations planned for this project.

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[6] Excerpted and modified from *Corrosion Consideration of Ductile Iron Pipe – A Consultant's Perspective*, presented at NACE International Western Regional Conference, October 1-3, 2001, Bill Spickelmire.

Several questions remain to be resolved regarding corrosion control measures required for this project and further field work and consultations are required. Based upon this additional information, a final design corrosion control measures table, similar to Table 3.3-3 will be prepared. During final design of each pipeline segment, a more detailed soil resistivity and conditions survey will be undertaken to further refine the actual corrosion control requirements for each segment.

3.3.4.6. Surge Control Measures

Surge pressure allowances should be included in the design of the pipelines. Analysis of pressure surges in pipelines (water hammer) can be complex and have several causes. The most common causes of surge pressures in pipeline systems include: operating a valve in the system; stopping or starting of pumps; and rupturing a pipeline.

A key method to reduce the potential of high surge pressures is to maintain low velocity in the transmission pipeline. Section 3.3.1 provides additional details regarding limitation of velocity and head loss for pipeline sizing criteria. Table 3.3-4 is a simplified calculation to illustrate resulting surge pressures if head loss is 4 feet per 1000 feet (top table) and if surge pressure is limited to 80 psi (bottom table). This table is based on 200 psi ductile iron pipe – similar tables can be developed for other pipe materials and pressure classes of pipe.

The pipeline sizing criteria used in Table 3.3-1 would limit velocity to less than either condition shown in Table 3.3-4 thus indicating surge pressure should be less than 80 psi, generally.

Control valves can also cause surges in a pipeline system if the rate of opening or closing is too rapid. System valves should be opened and closed according to predetermined rates by an actuator.

Other project features will be included to further limit and control surge pressure in the pipeline system, especially related to pumping operations. These measures could include: pump control and surge suppressor and anticipator valves; combination vacuum/air release valves; air chambers (accumulator); and surge blow-off valves. Further evaluation and consultation will be required to develop surge control measures. During final design, a detailed evaluation will be undertaken to further refine the surge control requirements for each segment and pump station.

Table 3.3-4.
Pipeline Surge Pressure

Resultant Surge Pressure if Head Loss is Held to 4' per 1,000'						
Pipe Diameter (Inches)	Pipe I. D. 200 psi	Wall Thickness (Inches)	Maximum Flow (gpm)	Maximum Flow (MGD)	Velocity Ft/Sec	Surge Pressure (psi)
14 D.I.	14.70	0.30	2,341	3.37	4.42	85.96
16 D.I.	16.76	0.32	3,305	4.76	4.81	90.98
18 D.I.	18.82	0.34	4,483	6.46	5.17	95.72
20 D.I.	20.88	0.36	5,891	8.48	5.52	100.24
24 D.I.	25.06	0.37	9,520	13.71	6.19	105.04
30 D.I.	31.24	0.42	16,998	24.48	7.11	115.49
36 D.I.	37.46	0.47	27,402	39.46	7.98	125.17
42 D.I.	43.46	0.52	40,502	58.32	8.76	134.20
48 D.I.	49.64	0.58	57,456	82.74	9.53	144.15
54 D.I.	56.26	0.65	79,860	115.00	10.31	155.07

Resultant Flow if Surge Pressure is Held to 80 psi						
Pipe Diameter (Inches)	Pipe I. D. 200 PSI	Wall Thickness (Inches)	Maximum Flow (gpm)	Maximum Flow (MGD)	Velocity (ft/sec)	Surge Pressure (psi)
14 D.I.	14.70	0.30	2,179	3.14	4.12	80.04
16 D.I.	16.76	0.32	2,909	4.19	4.23	80.08
18 D.I.	18.82	0.34	3,754	5.41	4.33	80.17
20 D.I.	20.88	0.36	4,707	6.78	4.41	80.08
24 D.I.	25.06	0.37	7,256	10.45	4.72	80.07
30 D.I.	31.24	0.42	11,778	16.96	4.93	80.03
36 D.I.	37.36	0.47	17,426	25.09	5.10	80.13
42 D.I.	43.46	0.52	24,182	34.82	5.23	80.12
48 D.I.	49.64	0.58	31,910	45.95	5.29	80.06
54 D.I.	56.26	0.65	41,221	59.36	5.32	80.05

3.3.4.7. Emergency Connections

The City of Sioux Falls has requested the ability to tap the Lewis & Clark pipeline at alternate locations in the event of an emergency. The emergency connection would consist of a tee in the pipeline with a valve and a blind flange. Sioux Falls has requested emergency connection points at two locations. The most likely locations would be at the intersections of West 26th Street/Ellis Road and at Minnesota/85th Street. These taps are fairly inexpensive. It would be appropriate to place tees with blind flanges at other locations along the pipeline route to interface with other water utilities (members and non-member systems).

3.3.5. Crossings

The pipelines will cross streets, roads, highways, railroads, other pipelines, telephone and fiber optic lines, overhead and buried power lines, streams, rivers and wetland areas. A key project layout criterion will be to avoid encroachment of wetland and riparian areas, as much as is practicable. Stream crossings, where feasible geologically and not limited by larger pipe sizes, will be constructed using directional drilling techniques to avoid open cut construction in the stream channels to eliminate temporary water quality degradation, the risk involved with stream diversion and to avoid excavation of stream banks. Most of the smaller, intermittent and ephemeral stream crossings may be crossed using open cut techniques, if acceptable under the authorizing permits for the project. Use of directional drilling at streams may also minimize, if not eliminate, approval time associated with the Section 404 Permit process.

Larger diameter pipe (>18 to 24” diameter) stream crossings will be made using open cut techniques. Crossings will require a portion of the channel to be diverted to allow “construction in the dry” while maintaining channel flows. Channel diversion should be accomplished using portable dam technology to avoid, as much as possible, construction of earthen dikes within the channel. Channel crossings would be made during low flow periods and acceptable crossing times would be coordinated with state fishery agencies.

Pipe joints should be restrained in the section of pipe within the crossing to a reasonable distance outside the bank area for most of the intermittent and all of the perennial stream crossings. Provision should also be provided for movement (river crossing ball joint pipe, for example) where the restrained section of crossing pipe ties into the main pipeline.

Highway and active railroad crossings will be made by boring or jacking methods for state highways and most other hard surfaced roads. Most highway departments and railroads require installation of steel casing. Requirements for crossing gravel-surfaced roads vary by the local entity responsible for maintenance, i.e. state, county, township or city. Unpaved gravel or dirt roads will be crossed either by boring/jacking, directional drilling or by open-cut trenching – the crossing method will depend upon the level of traffic disruption, requirements of the responsible entity, economics and construction needs. Depending on the level of service and the condition of minor paved roads and agency requirements, these may also be constructed using open-cut trenching with compacted fill and pavement patch repair. Pipe encasement would not be provided unless required by the crossing permit or if it is appropriate for the construction technique.

Currently, it is known that three of the major highways in the project area will be reconstructed in the next few years. It would be desirable to coordinate pipeline design activities with the state highway departments to install casing pipe by open cut methods during road reconstruction to significantly reduce bored highway crossing costs. These highways include State Highway 60 in Iowa (near Sheldon and Sibley), State Highway 19 in South Dakota (north of Vermillion) and Interstate Highway 29 through Sioux Falls.

Appendix A-3 includes a table detailing stream and road crossing through the project area. The table in the appendix is the basis of the opinion of probable construction cost for these items.

The pipeline will cross high voltage overhead power transmission lines. Also, the pipelines will also cross numerous overhead and buried power distribution lines. There are numerous phone company and fiber optic lines. Utility owners will be contacted to determine their requirements. Crossings will be in accordance with utility company requirements. Some crossings may require permits.

The Lewis & Clark pipeline will also cross gas and petroleum product transmission lines. Pipeline owners will be contacted to determine their requirements and if impressed current (or other) cathodic protection systems are in place. It will be important to account for the influence of the foreign pipeline's cathodic protection system (or Lewis & Clark's impact).

Lewis & Clark's pipelines will also cross other municipal and rural water system pipelines and distribution systems. Also, the Lewis & Clark system will also cross sanitary sewer and storm drainage piping. Crossing details will be in accordance with common practice and state environmental regulations.

As mentioned in Section 3.3.3, landowners have indicated the presence of field drainpipes in certain areas to lower ground water. It is understood the field drainpipes are buried at relatively shallow depths – if this understanding is correct, the Lewis & Clark pipeline would be installed below the field drainpipes. Appropriate repairs will be made to the intersecting field drainpipes before the pipeline is backfilled.

3.3.6. Storage Reservoirs

Storage reservoirs for the Lewis & Clark project are planned to be ground storage reservoirs. Consideration should be given to both factory-coated, bolted steel tanks and wire-wound prestressed concrete tanks. Factory coating for bolted steel tanks should include glass coating on the interior surfaces. Other factory applied interior coating systems that provide extended service life would also be considered during final design.

Both tank designs would be acceptable and the final selection of materials would be governed by economics of construction at the time of final design and bidding. Typically, the initial construction cost of a steel reservoir is less than a prestressed concrete reservoir. However, a life cycle cost evaluation may favor the prestressed concrete design due to reduced maintenance, primarily painting and cathodic protection. It is still recommended that both steel and concrete reservoirs be advanced for consideration during the final design. A life cycle cost analysis will be performed and a decision will be made during final design whether to bid either tank design or only one design. Welded steel reservoirs were considered and rejected due to life-cycle cost considerations (see Section 4.5.1.5).

Standards governing reservoirs are covered in the AWWA “D100” series. AWWA D103 is the standard for factory-coated bolted steel tanks. AWWA standard D110 is the standard for wire-and strand-wound circular prestressed-concrete tanks.

3.3.7. Chlorine Booster Stations

It is anticipated that chlorine booster stations may be required at various points throughout the system to maintain adequate chlorine residual at all points. Maintaining proper chlorine residual is essential for minimizing the potential for bacterial contamination that could occur after treatment. The chlorine residual at any point is a function of temperature, water chemistry and time in the system.

If new demands develop slowly, the time water is in the system could be considerably longer than at full development. As flows increase, chlorine booster stations may not be required. Therefore at this point in time, it is difficult to predict where (or if) additional chlorine will be required, particularly since Lewis & Clark will utilize a combined chlorine residual system. To minimize costs, chlorine residual monitoring and chlorine addition will be accomplished at selected main line and service line booster pump stations and at selected service connections. It is recommended these facilities be designed with this in mind, however the actual chlorination equipment would not be installed until the new distribution system is in operation and residual testing indicates it is warranted.

The recommended chlorination system is a sodium hypochlorite solution feed system. A sodium hypochlorite solution feed system is preferred instead of a chlorine gas system as it would significantly reduce the hazards, equipment and physical plant requirements associated with gas systems. Sodium hypochlorite solution would be delivered and stored on site. System operators will need to monitor sodium hypochlorite solution levels and age – shelf life is a concern.

3.3.8. Booster Pumping Equipment and Pump House Design

The difference in flow rates between member systems and Lewis & Clark production will be made up by drawing down the storage facilities during a peak day. The booster pump stations will not necessarily be operated to respond to peaking of individual member systems' demands. Pumping rates in the transmission system are planned to match the peak day rate (reserved capacity) of the downstream member systems plus transmission pipeline loss. The pump stations may have to be configured to have the capacity to handle a variety of flow demands – however it is currently envisioned the pump stations will deliver at peak demand rates and run time will be adjusted. This flow condition, and perhaps other scenarios, should be evaluated during final design to take into account the lower demands anticipated during the early years of project operation before full demands develop.

Booster pump stations will be designed to deliver the peak day rate with at least one pump out of service (the largest pump for stations with various sized pumps). Each station will have a minimum of two service pumps to provide redundancy and the ability to cycle run time on pumps. Some pump stations may also require a "jockey pump" to provide a low rate flow in order to maintain pressure in the transmission pipeline system (after the main pumps shut off), to meet pressure requirements of members systems between pump stations or reservoirs or to meet system operating requirements. Final design activities will include an analysis to select an efficient combination and types of pumps.

The transmission system will include two classifications of booster pump stations: main line pump stations and service line pump stations. Each booster pump station would consist of a structure adequately sized to house and maintain the following equipment:

- Pumps, piping and control/isolation/air valves;
- Control panels;
- Flow meter(s);
- Hydraulic surge protection equipment;
- Instrumentation and telemetry equipment;
- Back-up power at selected pump stations; and
- Chemical feed equipment at selected pump stations.

Booster pump stations will be above ground block or pre-cast concrete buildings. The use of above ground pump stations significantly reduces safety concerns and should eliminate OSHA regulatory documentation and entry permits involved with confined space entry. Prefabricated pump stations will be considered. Prefabricated pump stations offer several advantages, primarily to the construction contractor, including: 1) delegation of coordination to the pump station supplier; 2) use of consistent and compatible equipment; and 3) speed and simplicity of installation for the construction contractor. Booster pumping stations will be sized and located to limit discharge pressure to less than 250 psi (exception: the booster station west of Sioux Falls pressure will be approximately 300 to 310 psi). Most of the pump stations will have a discharge pressure of between 175 to 225 psi.

Pumps will be horizontal split case centrifugal pumps for pumps greater than approximately 50 horsepower. Vertical turbine pumps (can unit) would be used for sizes less than 50 horsepower. This 50 horsepower break point is somewhat dependent upon a number of factors and the use of either pump type should be determined during final design based on economics, reliability and operational requirements.

During final design, consideration will be given to prefabricated direct bury pump station units for smaller main and service line booster pump stations (pumps less than 15 to 20 horsepower).

However, direct bury pump stations will not be considered for locations where chemical feed equipment could be required.

In most cases, the location of booster pump stations for this project is fairly flexible. However, stations must be located in order to not allow the inlet pressure (or high points along the pipeline) to drop below 20 psi if possible (some variations may occur). Locations should also provide adequate access for operation and maintenance.

It is possible in some locations to incorporate two, or more, project requirements into one structure. For example, in one location it is possible to incorporate a service line booster into a main line booster pump station building. The functions of a service connection can be combined with a service line booster station at several locations. Also, provision for chemical feed (particularly for boosting chlorine residual) may be incorporated into some booster pump stations.

3.3.9. Service Connections

A structure will be required at each member's service connection to house various equipment. As mentioned in paragraph 3.3.8, some service connection functions can be incorporated into other project structures. Also, where delivery is made to a member's water treatment facility, certain functions (especially chemical storage and feed equipment) may be housed in the member's facility.

A service connection facility would include the following components:

- Flow meter;
- Control and isolation valves;
- Backflow prevention valve;
- Hydraulic surge protection equipment;
- Piping;
- Instrumentation, telemetry and control equipment; and
- Chemical feed equipment as required.

Piping configurations and equipment requirements at each member's service connection must be determined on a case-by-case basis, as each system's connection requirements are unique.

Pipeline and pump station design criteria will include allowance for pressure losses across meters, backflow prevention valves and rate of flow controllers.

The service connections fall into three general categories: delivery to a clearwell or ground storage reservoir at a water treatment facility; delivery to a ground storage reservoir, standpipe or elevated tank; or into a water main pipeline. Table 2.4-5 provides a listing of each member's service connection description and pressure requirements.

As mentioned in paragraph 3.3.7, chlorine booster stations may be required to maintain adequate chlorine residual. Ammonia feed may also be required. In systems where Lewis & Clark water will be blended with an existing supply, pH adjustment may be required prior to delivery to the member. The blending analysis for each member is included in Section 5.5.

Service connection buildings will be above ground block or precast concrete buildings. Delivery pressures are generally less than 70 psi, with the exception of some of the rural water systems where delivery is made to a distribution system with pressures between 100 to 125 psi. During final design, consideration will be given to fabricated direct bury units for smaller (less than 1 MGD) service connections. However, direct bury connections will not be considered for locations where chemical feed equipment could be required.

3.3.10. Electrical Service and Emergency Power

Power loss at booster pump stations can be a result of many causes: weather related, power system failures or accidental interruption. Due to the extent of the water transmission pipeline system and the number of electrical utility companies that would provide power to the project, it is unlikely power would be unavailable throughout the entire pipeline system. Storage reservoirs have been placed throughout the transmission pipeline system to provide flow under gravity conditions to most of the member systems should an interruption of electrical service occur.

Standby power will be provided at the water treatment plant for operation of the plant and high service pumps to permit delivery of average day flows. It is recommended standby power generators be included at selected mainline booster pump stations in the interior of the transmission pipeline system. Standby power should be provided at strategic locations in the well field. It is further recommended Lewis & Clark procure and maintain one or two trailer mounted portable electric generators that could be used for emergency power supply at other pump stations and the well field.

3.3.11. Telemetry and Controls

The proposed water supply system will be equipped with a Supervisory Control and Data Acquisition (SCADA) system that will permit monitoring and control of remote pump stations, valves, meters, and reservoirs from a master control panel as well as the remote sites. The remote sites will be connected to the master via a data communication system. Typical instrumentation and control devices at a site are summarized as follows:

Typical process instrumentation at a remote site:

- Flowmeter
- Suction and discharge pressure transmitters
- Chlorine residual analyzer (total chlorine residual)
- pH monitor (at more distant service points)
- Level transmitter (in customer's reservoir or water tower designated as controlling level)

Other instrumentation and devices for panels at remote sites:

- Unauthorized entrance or intrusion sensor
- Building high/low temperature sensors
- Utility power status (including voltage and phase monitoring)
- Generator status (if required)
- Chemical feed pumps for supplemental chlorination or pH adjustment

Booster pump and valve control for remote booster station and control valve sites:

- Monitor operating status of each booster pump - typically 2 to 3 pumps
- Monitor valve position of isolation valves - typically 6 isolation valves
- Monitor valve position of surge control valves - typically 2 to 3 valves

Communications systems required at each remote site:

- Radio telemetry for local communications with reservoir
- UHF radio, microwave, fiber optic or data line connection to computer network for Lewis & Clark Rural Water System

Type of hardware anticipated for Local Control Panel:

- PLC - typically Control Logix, or equal
- HMI - color CRT, either touch screen or keypad version
- Radio - local communications - spread spectrum

- Computer network interface - fiber optic junction, data line connection or data radio

A schematic of the arrangement of the telemetry and control system at a remote site is presented in Figure 3.3-1, Schematic of Controls and Instrumentation at Remote Sites. A preliminary listing of the remote sites and the control and instrumentation functions at each of those sites is included in Appendix A-3.

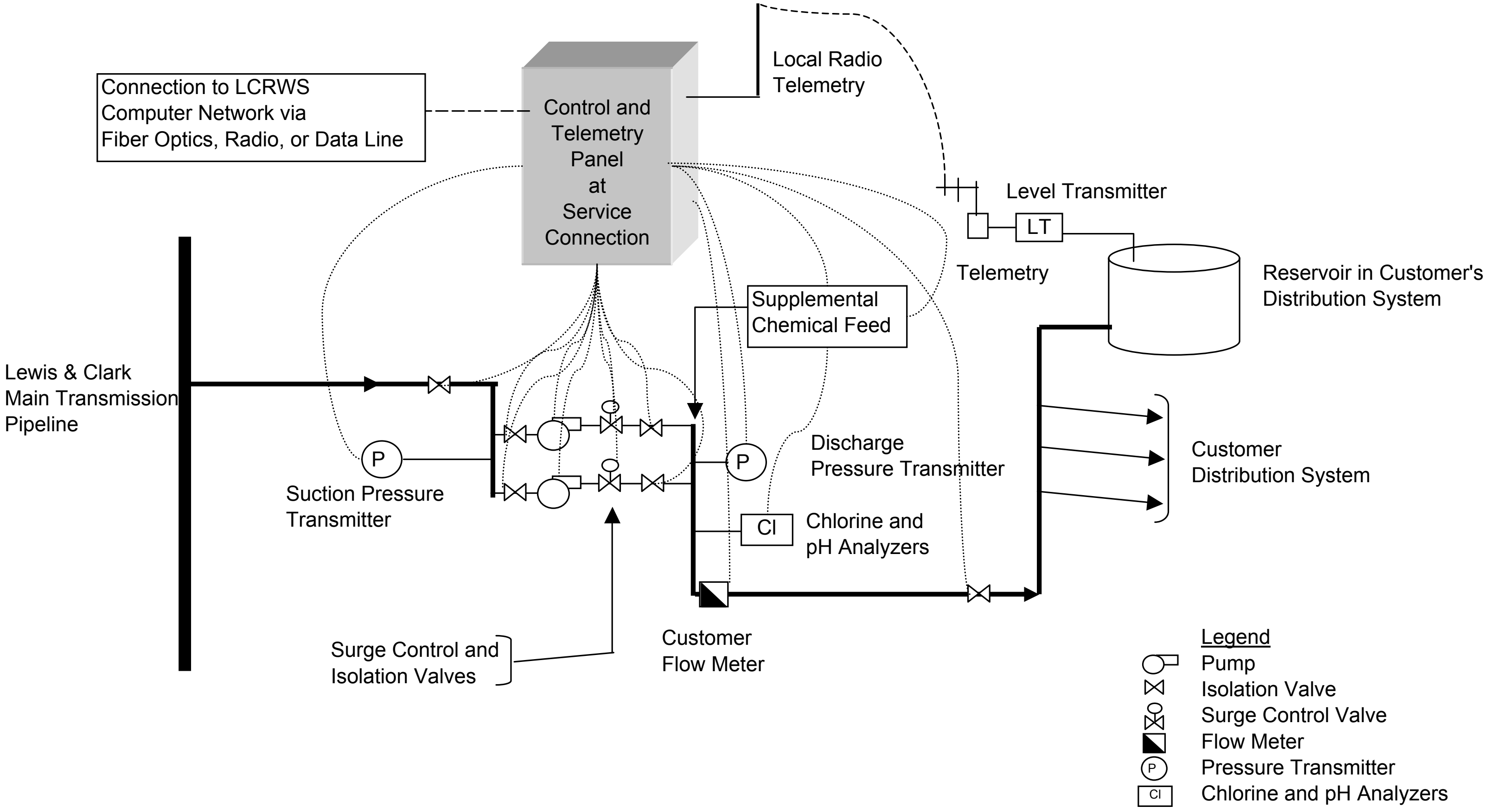
The bulk of the project construction will be based on the traditional design/bid competitive bid method of delivery. One exception to be considered is for the acquisition of equipment and construction for the telemetry and control system. It will be important for the telemetry and control system equipment to be provided by a single source for a project of this complexity. This importance is compounded by the fact the project construction will take several years. It is suggested the telemetry and controls contractor be solicited through a competitive bid or negotiation with the intent of issuing an indefinite delivery type of contract early in the project.

3.3.12. Land Requirements

The Lewis & Clark project will have to secure a significant number of easements for the construction and operation/maintenance of the transmission pipeline system. The project will also have to purchase parcels of land for construction of reservoirs, buildings, structures and access roads.

3.3.12.1. Pipelines

Temporary construction and permanent operation and maintenance easements will be required for the pipelines. The pipelines will be constructed primarily on privately owned lands. Generally, the pipelines will not be located in road or highway rights-of-way due to conflicts with other utilities and possible disruptions due to potential future road construction. An exception would be if the project would need to occupy a road or highway right-of-way to avoid other obstructions, sensitive areas or for road crossings.



Banner Associates, Inc. **HDR Engineering, Inc.** **TRC Mariah Associates Inc.**	**FINAL ENGINEERING REPORT**	**FIGURE 3.3-1**
	LEWIS AND CLARK RURAL WATER SYSTEM	**Simplified Schematic of Control and Instrumentation System at Service Connection with Booster Pumps**

The easement width will vary based on the size of pipe. To illustrate, a 48" pipe with a bury depth of 6.5' to the top of pipe would require a trench top width of approximately 30' to 35'. An additional 50' (approximately) wide strip would be required to temporarily stockpile material excavated from the trench and provide a buffer zone between the stockpile and the roadway fence. Additional width may be required to segregate and stockpile topsoil. Another 50' (approximately) would be required on the other side of the trench to string and assemble the pipeline. This would provide a construction area width of approximately 150'. In order to provide a level of conservatism, the computed construction width has been expanded by approximately 25' to 50'. Consideration must be made to provide adequate easement width for moving the pipeline within the easement to account for difficult construction conditions and avoidance of wetlands and other obstructions.

A permanent easement will also be required to allow for maintenance of the pipeline. It should be sufficiently wide to permit maintenance crews an adequate work area under adverse weather conditions. Typically, the permanent easement is centered over the pipeline. The temporary construction easement is generally split equally on both sides of the permanent easement – in some cases more construction area is situated on one side of the permanent easement to facilitate construction. Table 3.3-5 provides a guideline for the acquisition of temporary and permanent easements for various size ranges of pipe.

Table 3.3-5
Preliminary Estimate of Required Temporary and
Permanent Pipeline Easement Widths

Pipe Size Range	Temporary Construction Easement Width (ft)	Permanent Easement Width (ft)	Total Easement Width (ft)
42" to 54"	90 to 120	70 to 80	160 to 200
16" to 36"	70 to 90	50 to 60	120 to 150
6" to 14"	30 to 60	30 to 40	60 to 100

Access roads will be required for development of the wells. The roadway would be a private road for access to the pumping plants and well facilities. The collector pipelines can be located in the roadway section or to the side. Lands for this purpose (depending upon current ownership) can be purchased or gained through a permanent easement agreement. Access roads may be required at other project locations to access structures, reservoirs or other project facilities.

3.3.12.2. Reservoirs

Land purchase requirements for water storage reservoirs will vary based on the size of the reservoir. Also, certain reservoir sites may include provision for a booster pump station and land for a project maintenance storage yard. It would benefit the tank fabricator to provide approximately 75’ on each side of the reservoir for construction purposes. At least a 30’ buffer between the reservoir and yard fencing should be provided and purchased. The additional land could be obtained through a construction easement. A minimum set back from roadways of approximately 125’ to 150’ is also recommended.

Table 3.3-6 provides a listing of areas required for construction and operation for various size ground storage reservoirs. Tank diameter is based on the economical tank height for the various sizes – actual reservoir diameters can vary between reservoir suppliers and to meet specific project hydraulics requirements.

Table 3.3-6
Land Area Requirements for Ground Storage Reservoirs

Reservoir Capacity (MGD)	Potential Inside Diameter Range (ft)	Construction Area Required (acres)	Permanent Acquisition Required (acres)
10.0	195 to 212	3.6	2.5
7.5	169 to 184	3.2	2.1
6.0	160 to 179	3.1	2.0
5.0	146 to 164	2.8	1.8
4.0	130 to 146	2.5	1.6
3.0	113 to 131	2.3	1.4
2.0	92 to 117	2.1	1.2
1.5	80 to 101	1.9	1.0
1.0	66 to 83	1.7	0.9

Note Regarding Table 3.3-6: Areas do not include space for pump stations, maintenance and storage yards or other project requirements.

3.3.12.3. Pump Stations and Service Connections

Building size will vary for the various pump stations and service connections. Where possible, main line booster stations will be located at storage reservoir sites. The amount of land required for these structures is relatively small. Land purchase requirements range from 0.2 to 0.3 acres for these structures. This area does not include provision for storage or maintenance yards.

3.3.12.4. Construction Staging Areas and Pipe Yards

Construction of the pipelines and ancillary structures will require temporary construction contractor staging areas for office trailers, equipment storage and maintenance, miscellaneous materials storage and pipe stockpile/laydown yards. Typically, pipe is transported directly to the construction area and strung along the trench in close proximity to its bury site.

There will be several construction contracts issued for the Lewis & Clark project. Each construction contractor will be responsible to secure lands for its staging area in accordance with guidelines and other specified requirements.

Additional information is included in Chapter 2 of the *Draft Environmental Assessment for the Lewis and Clark Rural Water Supply System – South Dakota, Minnesota and Iowa.*

3.4. Water Treatment Plant

The proposed facility design criteria and general requirements for the water treatment plant are discussed below.

3.4.1. Design Standards and Requirements

The basis of design for the water treatment plant will follow recognized sources such as the Ten States Standards and other published design criteria and recommendations by the South Dakota DENR and United States EPA. The treatment plant will be designed and constructed so that the treatment process will:

- Meet all of the requirements of the current Safe Drinking Water Act (SDWA);
- Have the ability to meet SDWA regulations that will be promulgated in the near future;
- Provide 2.5-log removal for *Giardia lamblia* and *Cryptosporidium* prior to disinfection;
- Be able to provide a finished water capacity of 28.6 mgd (includes a 5% pipeline loss);
- Minimize the quantity of waste stream; and

- Be able to treat average day design capacity in the event of utility electrical power failure.

3.4.2. Water Quality Issues

The quality of the Lewis & Clark finished water is significant not only with regard to requirements of the Safe Drinking Water Act (SDWA), but also because of possible chemical differences between Lewis & Clark water and the water currently supplied by the member water systems. Regarding regulatory requirements, the Lewis & Clark finished water will be used to supply water systems located in three states: South Dakota, Iowa and Minnesota. In some instances, one or more of the states may have more stringent requirements than the SDWA.

3.4.2.1. Raw Water Characteristics

The raw water characteristics will be impacted by the surface water in the Missouri River as well as the aquifer characteristics. The raw water quality will be impacted by aquifer characteristics of each production well and seasonal changes in the surface water quality. The movement of the water through the aquifer materials will dampen significant variations in water quality.

Raw water quality data from 1992, 1996, 1997 and 1999 from the Yankton WTP was reviewed to help determine the raw water quality for Lewis & Clark. Yankton's supply is the Missouri River approximately 25 miles upstream of the proposed raw water wells. Additionally, groundwater samples were collected during aquifer pump testing (vertical well installation) in the proximity of a proposed horizontal collector well south of Vermillion. Table 3.4-1 summarizes Missouri river water quality and the analytical results from the ground water samples.

Table 3.4-1
Water Quality from the Missouri River and Groundwater Sampling

Parameter	**Concentration (mg/L)**		
	Missouri River	**WQS-1**	**WQS-2**
Iron	0.18 – 0.51	3.22	3.18
Manganese	0.03 – 0.08	0.41	0.39
Total Hardness	234 – 260	275	272
Total Alkalinity	154 – 163	210	211
pH	8.24 – 8.40	7.42	7.38
Total Dissolved Solids	500 – 509	542	552
Sulfates	221 – 271	208	209
Sodium	68 – 74	56.8	70.5
Chloride	10 – 22.5	14.0	14.0
Fluoride	0.45 – 0.56	0.41	0.40
TOC		2.45	2.45

The estimated raw water quality for Lewis & Clark is based on the test results and the surface water quality in the vicinity. Table 3.4-2 is a summary of the estimated raw water characteristics. The secondary maximum contaminant level (SMCL) for each parameter is also listed for comparison, as applicable. SMCL's are intended for the control of aesthetic factors (not health related) and are therefore considered guidelines rather than regulations.

Table 3.4-2
Estimated Raw Water Characteristics

Parameter	**Concentration (mg/L)**	**SMCL (mg/L)**
Iron	1.0 – 2.0	0.3
Manganese	0.1 – 0.3	0.05
Total Hardness	250 – 260	N/A
Total Alkalinity	175 – 185	N/A
pH	7.5 – 8.5	6.5 – 8.5
Total Dissolved Solids	520 – 530	500
Sulfates	235 – 245	250
Sodium	62 – 67	N/A
Chloride	15 – 20	250
Fluoride	0.45 – 0.55	2.0
TOC	2 – 3	N/A

3.4.2.2. Source Water Classification

Due to the proposed location of the well fields with respect to the Missouri River and the depth and type of wells, the possibility exists that some or all of the wells may be under the influence of the river. Classification of the raw water from the wells as groundwater or groundwater under the direct influence of surface water (GWUDI) will determine what regulations are applicable for the treatment plant and what extent of treatment is required.

Determination of a groundwater source as GWUDI can be made in a number of ways:

- Field evaluation of well construction characteristics, site geology, proximity of the well to surface water, and the depth of the well.
- Significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH that closely correlate to climatological or surface water conditions.
- Microscopic particulate analysis (MPA) indicating significant occurrence of surface water "bioindicators" such as insects, algae, diatoms, or large-diameter pathogens such as *Giardia*.

Based on discussions with South Dakota DENR personnel, the state relies heavily on MPA to determine whether a groundwater source is to be classified as GWUDI. Evaluation of each well and final classification of the groundwater source will be made after each well is constructed and put into operation. Since the determination cannot be made at this time and the possibility exists that the wells will be under the influence of Missouri River water, the water treatment plant design will be based on the assumption that the raw water is GWUDI as this classification entails more stringent treatment requirements.

3.4.2.3. In-Stream Water Quality Standards

Any wastewater generated by the water treatment processes must either be maintained on-site in complete retention ponds, discharged to a sanitary sewer or directly to a nearby receiving stream, either the Missouri or Vermillion Rivers. A National Pollution Discharge Elimination System (NPDES) permit will be required if wastewater is discharged to a receiving stream. In-stream water quality standards must not be exceeded. Table 3.4-3 summarizes the water quality standards for the Missouri and Vermillion Rivers.

Table 3.4-3.
In-Stream Water Quality Standards

Parameter	**Missouri River**	**Vermillion River**	**Special Conditions**
Total Alkalinity (as $CaCO_3$)	750	750	30-day average
	1,313	1,313	daily maximum
Total Dissolved Solids	1,000	2,500	30-day average
	1,750	4,375	daily maximum
Conductivity (at 25°C - micromhos/cm)	2,500	2,500	30-day average
	4,375	4,375	daily maximum
Nitrates (as N)	10	50	30-day average
	88	88	daily maximum
pH (standard units)	6.5-9.0	6.0-9.0	
Total Petroleum Hydrocarbon	10	10	
Oil and Grease	10	10	
Sodium Adsorption Ratio	10	10	
Total Coliform (/100 mL)	5,000		geometric mean of a minimum of 5 samples during separate 24-hour periods for a 30-day period and may not exceed this value in more than 20% of the samples examined in the same 30-day period
	20,000		in any one sample
Barium	1.0		
Chloride	250		30-day average
	438		daily maximum
Fluoride	4.0		
Sulfate	500		30-day average
	875		daily maximum
Un-ionized Ammonia Nitrogen (as N)	0.04	0.05	30-day average
Dissolved Oxygen	³5.0	³5.0	
Undisassociated Hydrogen Sulfide	0.002	0.002	
Total Suspended Solids	90	150	30-day average
	158	263	daily maximum
Temperature (°F)	80	90	
Fecal Coliform (/100 mL) (May 1- September 30)	200	1,000	geometric mean of a minimum of 5 samples during separate 24-hour periods for a 30-day period and may not exceed this value in more than 20% of the samples examined in the same 30-day period

3.4.2.4. Safe Drinking Water Act Rule

The SDWA regulations are very dynamic and several regulations have been recently promulgated. In addition, there are a number of proposed and anticipated future regulations. The design of the WTP will be based on compliance with existing, proposed, and anticipated future SDWA regulations. As discussed above, the classification of the source water as groundwater or GWUDI will impact the applicable regulations for the plant. Table 3.4-4 summarizes several specific SDWA regulations that are reviewed in the following sections and their applicability to the source water classification. Although the plant will be designed to comply with regulations required for systems treating GWUDI, the possibility exists that future classification of the source water as groundwater will reduce treatment requirements. Therefore, the regulations applicable to this classification will be reviewed as well.

Table 3.4-4.
Applicable Regulations

Regulation	Groundwater	GWUDI
Groundwater Rule	X	
Interim Enhanced Surface Water Treatment Rule		X
Stage 1 Disinfectant/Disinfection Byproduct Rule	X	X
Filter Backwash Rule	X(1)	X(1)
Arsenic Rule	X	X
Radionuclides Rule	X	X
Radon Rule	X	X
Long Term 2 Enhanced Surface Water Treatment Rule		X
Stage 2 Disinfectant/Disinfection Byproduct Rule	X	X

Note:
1. Applicable only if recycle employed.

3.4.2.4.1. Ground Water Rule

The Ground Water Rule (GWR) specifies appropriate use of disinfection for groundwater supplies to assure public health. This rule will require source water and distribution system disinfection and monitoring for all groundwater supplies. The rule was proposed in May 2000 and the final rule is expected in late 2001 or 2002. The following is a summary of the proposed rule:

? The State will be required to perform water system sanitary surveys to determine if significant deficiencies exist in the water systems of their state. Systems must provide the State, at their request, pertinent information that will allow them to perform the survey. This may include onsite review of the water source, identification of possible sources of contamination, facilities, equipment, operation, maintenance and monitoring compliance records.

- The state must conduct a one-time hydrogeologic sensitivity assessment of all systems that do not provide a 4-log virus inactivation/removal to identify those systems that are located in sensitive aquifers. The EPA considers sensitive aquifers to be located in karst, gravel or fractured bedrock.

- Monthly monitoring of source water for fecal indicators will be required for all groundwater systems that are considered sensitive and do not provide a 4-log inactivation of viruses. The sampling frequency may be reduced after twelve negative samples.

- Corrective actions will be required for all PWS with a significant deficiency or source water contamination. Corrective actions may include eliminating the contamination source, providing an alternative source of water, or installing a treatment process that reliably achieves 4-log removal or inactivation of viruses. All systems that provide treatment must monitor their processes so that at least 4-log virus inactivation or removal is occurring.

- Compliance monitoring will be required for all groundwater systems that disinfect in order to avoid source water monitoring, or to systems that disinfect as a corrective action. Systems serving less than 3,300 people must monitor disinfection once daily, and systems serving 3,300 or more people must monitor their disinfection continuously.

The key to the proposed GWR is meeting a 4-log inactivation or removal of viruses if a system's water source is contaminated or determined to be sensitive to contamination. A 4-log inactivation/removal means that 99.99% of viruses must be removed and/or inactivated.

Effect on the Lewis & Clark WTP: The GWR will apply to the Lewis & Clark WTP only if the source water is determined to not be under the influence of surface water. In addition, the various Surface Water Treatment Rules will not apply with a groundwater classification. If this occurs, pathogen removal/inactivation will be limited to 4-log viral removal/inactivation. As a result, disinfectant requirements would be reduced.

3.4.2.4.2. Interim Enhanced Surface Water Treatment Rule

The Interim Enhanced Surface Water Treatment Rule (IESWTR) was promulgated on December 16, 1998 and became effective on February 16, 1999. This rule affects systems treating surface water or GWUDI serving 10,000 or more people. The IESWTR builds upon the treatment technique approach of the SWTR. Some key components of this rule are as follows:

- Combined filter water turbidity level limit of 0.3 NTU in at least 95% of monthly measurements.

- Turbidity levels shall not exceed 1.0 NTU at all times (maximum instantaneous).

- Individual filters shall have continuous monitoring.

- Produce a filter profile on individual filter within seven days if: 1) turbidities are greater than 1.0 NTU based on two consecutive measurements fifteen minutes apart, or 2) turbidity measurements are greater than 0.5 NTU after the initial four hours of filter operation.

- An exceptions report must be made and a self-assessment of a filter must be conducted if a particular individual filter produces water with turbidity greater than 1.0 NTU based on two consecutive measurements fifteen minutes apart at any time within three consecutive months.

- A Comprehensive Performance Evaluation (CPE) must be performed by the primacy agency or an approved third party if a particular individual filter produces water with a turbidity greater than 2.0 NTU based on 2 consecutive measurements fifteen minutes apart at any time in each of two consecutive months.

- When conditions trigger filter profiles, filter self-assessments, or CPEs exist, then the monthly report to the primacy agency must include this information.

- An MCLG of zero for *Cryptosporidium* was set to protect health. A minimum of 2-log removal of *Cryptosporidium* will be required.

- Disinfection profiling and benchmarking must be performed if one of the following occurs:
    - Significant changes to the disinfection process are made.
    - The total trihalomethanes (TTHM) annual average is greater than or equal to 0.064 mg/L.
    - The total of the five haloacetic acids (HAA5) annual average is greater than or equal to 0.048 mg/L.

Effect on the Lewis & Clark WTP: This rule will require that individual filters be continuously monitored for effluent turbidity to provide compliance with the rule. Filter self-assessments and/or CPEs must be performed if filter effluent turbidity levels exceed the levels set by the rule. The *Cryptosporidium* removal requirements will be met by the processes proposed for the plant.

3.4.2.4.3. Stage 1 Disinfectant/Disinfection Byproduct Rule

The Stage 1 Disinfectants/Disinfection Byproducts (D/DBP) Rule applies to all community water systems and non-transient non-community systems that use a disinfectant at any point of the treatment process. The rule was promulgated on December 16, 1998. The compliance date for systems serving 10,000 or more people is January 2002. The following are some of the key components of this rule.

- Maximum residual disinfectant levels (MRDLs) for three chemical disinfectants were set as follows:
    - Chlorine: 4.0 mg/L as Cl_2
    - Chloramine: 4.0 mg/L as Cl_2
    - Chlorine Dioxide: 0.8 mg/L as ClO_2

- DBPs in distribution systems must be reduced to the following MCLs:
    - Total Trihalomethanes (TTHMs): 0.080 mg/L (running annual average)
    - Five Haloacetic Acids (HAA5): 0.060 mg/L (running annual average)
    - Bromate Ion: 0.010 mg/L (running annual average)
    - Chlorite Ion: 1.0 mg/L (three-sample average)

- Systems must meet the required TOC removal by enhanced coagulation and/or enhanced softening as set forth in the following:

Table 3.4-5.
TOC Removal Requirements

Source Water TOC	**Source Water Alkalinity (mg/L as $CaCO_3$)**		
	< 60 mg/L	**≥ 60 mg/L - 120 mg/L**	**≥ 120 mg/L**
2.0 – 4.0 mg/L	35%	25%	15%
4.0 – 8.0 mg/L	45%	35%	25%
> 8.0 mg/L	50%	40%	30%

Note:
Systems practicing enhanced softening must meet TOC removal requirements of the last column on the right.

- Systems may meet one of the following alternative compliance criteria to be in compliance with the TOC removal requirements above:
  - Source or treated water TOC is less than 2.0 mg/L.
  - Source water TOC is less than 4.0 mg/L, source water alkalinity is greater than 60 mg/L (as $CaCO_3$), and the DBP levels for TTHM and HAA5 are less than 0.040 mg/L and 0.030 mg/L, respectively.
  - The system is using only chlorine as its disinfectant and the DBP levels for TTHM and HAA5 are less than 0.040 mg/L and 0.030 mg/L, respectively.
  - Source or treated water specific ultraviolet absorbance (SUVA) prior to any treatment is less than 2.0 L/mg-m.
  - System practices softening and removes at least 10 mg/L of magnesium hardness (as $CaCO_3$).
  - System practices softening and lowers treated water alkalinity to less than 60 mg/L (as $CaCO_3$).

Effect on the Lewis & Clark WTP: The Lewis & Clark project includes a large distribution system with long detention times, which will be conducive to the formation of DBPs. Chloramines, which form only low levels of DBPs, should be used as the disinfectant residual to reduce DBP formation and aid in compliance with the Stage 1 D/DBP Rule.

The groundwater source for Lewis & Clark will most likely have low levels of TOC, and the system may have problems meeting the TOC removal requirements of this rule. The system may be able to meet one of the following alternative criteria:

- TOC levels less than 2 mg/L.
- TOC levels less than 4 mg/L and TTHM and HAA5 levels less than 0.040 mg/L and 0.030 mg/L, respectively.
- Softening alternative of providing at least 10 mg/L of magnesium hardness removal.

3.4.2.4.4. Filter Backwash Rule

The Filter Backwash Rule (FBR) was promulgated on June 8, 2001. This rule will require all water systems using rapid sand filters with surface water or GWUDI supplies to return filter backwash, thickener supernatants, and liquids from dewatering processes to a location such that the recycle stream will be treated by all processes of a plant's conventional or direct filtration system including coagulation, flocculation, sedimentation (conventional filtration only), and filtration. Alternative recycle locations may be approved by the State, however, it must be demonstrated that the alternative location is required to provide optimal finished water quality, the plant needs the recycle flow as an intrinsic component of the process, or that the plant has unique treatment requirements or processes. Under the FBR, backwash water equalization or treatment is not mandatory before it is recycled.

Specific requirements of the rule include:

- Systems that recycle backwash water must notify the state and provide flow details, filter details, and a plant schematic by November 2003.
- Systems must comply with the recycle return location requirements by June 2004 or by June 2006 if capital improvements are required

Effect on the Lewis & Clark WTP: This rule will require that any recycle streams employed at the Lewis & Clark WTP be returned to the head of the plant, prior to any coagulant or lime addition. No treatment of the recycle stream will be required prior to its addition to the raw water; however, treatment of the recycle water may be desirable to prevent possible deleterious effects on downstream processes resulting from the return of the recycle stream.

3.4.2.4.5. Arsenic Rule

The Arsenic Rule published in the Federal Register on January 22, 2001 lowered the existing MCL for Arsenic from 50 µg/L to 10 µg/L. EPA announced on May 22, 2001 that it will delay the effective date for the rule until February 22, 2002. The delay will allow EPA to perform a reassessment of the Arsenic standard so that it is based on sound science and accurate cost estimates.

The lowered standard set under the Arsenic Rule aims at further protecting public health by reducing the risk of chronic effects of long-term exposure to arsenic in drinking water. The long-term consumption of water with low concentrations of arsenic can lead to various forms of cancer including bladder, skin, and lung. Other non-cancer adverse health effects include cardiovascular disease, diabetes, developmental and neurological effects.

In September 2001, the National Academy of Science (NAS) released a report which estimates the risk of bladder and lung cancer from ingested arsenic is more than EPA's original estimates. In November, the EPA announced that the arsenic limit would be lowered to 10 µg/l.

Effect on the Lewis & Clark WTP: The treatment processes being considered for the Lewis & Clark WTP are effective at removing arsenic or can be slightly modified to enhance arsenic removal if it is determined that significant arsenic removal is necessary to comply with this rule.

3.4.2.4.6. Radionuclides Rule

The Radionuclides Rule was promulgated on December 7, 2000 and will become effective on December 8, 2003. The rule applies to all community water systems. The purpose of the rule is to reduce the risk associated with exposure to radionuclides (excluding radon) in drinking water including combined radium-226/-228, (adjusted) gross alpha, beta particles and photon radioactivity and uranium. Health effects from exposure to radioactive compounds includes the ionization process that can damage chromosomes or other parts of cells, potentially leading to cell death or unnatural cell reproduction leading to cancer. Certain elements can accumulate in specific organs, such as iodine in the thyroid and radium in the bones. In addition, exposure to uranium can cause damage to kidneys, potentially leading to kidney failure. The rule will set the following MCLs:

- Combined Radium-226 and Radium-228: 5 picoCuries per liter
- Gross Alpha (excluding radium and uranium): 15 picoCuries per liter
- Beta Particles and Photon Reactivity: 4 millirem per year
- Uranium: 30 µg/L

Effect on the Lewis & Clark WTP: The source water for Lewis & Clark will most likely not have significant levels of radionuclides. If high levels are detected, the processes being evaluated for use at the WTP can be optimized to provide some removal of radionuclides.

3.4.2.4.7. Radon Rule

Radon is a naturally occurring radioactive gas that has been shown to be a major contributor to lung cancer. According to a 1999 report by the National Academy of Science, the inhalation of radon from indoor air contributes to approximately 20,000 lung cancer deaths in the United States each year. The release of radon from drinking water contributes an estimated one to two percent of the total radon of indoor air, increasing the risk of lung cancer. In addition, the consumption of drinking water with radon poses a small risk of stomach cancer.

Based upon the cancer risks associated with radon in drinking water, the Radon Rule was proposed in the Federal Register on November 2, 1999 and is expected to be finalized in the second half of 2001. The rule will require the following:

- An MCL of 300 picoCuries per liter for radon in drinking water.

- An alternate MCL of 4,000 picoCuries per liter for radon in drinking water if the state implements a Multimedia Mitigation (MMM) program.

The MMM program is aimed at a cost-effective method of radon reduction by addressing the soil source of radon in indoor air, while also addressing high levels of radon in drinking water. The goal of an MMM program is to reduce the public health risk from radon by an amount comparable to that achieved by treating drinking water to the 300 picoCuries per liter MCL.

Effect on the Lewis & Clark WTP: High concentrations of radon are not anticipated to be present in the Lewis & Clark source water. In addition, the State of South Dakota will most likely implement an MMM program, which would result in the higher MCL of 4,000 picoCuries per liter for radon. As a result, the Lewis & Clark WTP is anticipated to be in compliance with the requirements of this rule.

3.4.2.4.8. Long Term 2 Enhanced Surface Water Treatment Rule and Stage 2 Disinfectants/Disinfection Byproducts Rule

A negotiative rulemaking process for the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) and the Stage 2 D/DBP Rule came to a conclusion in the form of a Federal Advisory Committee Act (FACA) committee agreement approved September 29, 2000. The agreement in principle resulting from this negotiative process served as the basis for the Environmental Protection Agency to formally propose the Stage 2 D/DBP rule and LT2ESWTR in late 2001 and issue a final rule in 2002.

The Stage 2 D/DBP rule and LT2ESWTR will contain the principle of simultaneous compliance. This means that water systems will address the Stage 2 D/DBP rule and LT2ESWTR requirements concurrently in order to protect public health by ensuring a proper balance between microbial and DBP risks while optimizing technology choice decisions.

Long Term 2 Enhanced Surface Water Treatment Rule

The requirements of the LT2ESWTR will apply to all public water systems that use surface water or GWUDI. The LT2ESWTR will be proposed to provide further protection from *Cryptosporidium* contamination of drinking water. Based upon the recommendations of the FACA committee agreement, the following are the anticipated requirements of the LT2ESWTR:

- The total *Cryptosporidium* removal requirement for a system will be based upon the source water quality.

- Conventional treatment plants in compliance with the IESWTR will be given a 3-log removal credit for *Cryptosporidium*.

- Source water monitoring for *Cryptosporidium* will be required to determine the "bin" classification of the system. Monitoring will be conducted using EPA Method 1622/23 and no less than 10L samples. Bins are categories of additional treatment (beyond conventional treatment) required based upon source water *Cryptosporidium* concentrations. *Cryptosporidium*, E. coli and turbidity source water sampling will be carried out on a predetermined schedule for 24 months with one of two choices: 1) bin classification based on highest 12 month running average if monthly samples, or 2) optional bin classification based on two year mean if facility conducts twice per month monitoring for 24 months (i.e. 48 samples). Anticipated bin classifications are provided in Table 3.4-6.

Table 3.4-6.
Bin Classifications

Bin Number	**Average *Cryptosporidium* Concentration**	**Additional treatment requirements for systems with conventional treatment that are in full compliance with IESWTR**
1	*Cryptosporidium* < 0.075/L	No action.
2	0.075/L ≤ *Cryptosporidium* < 1.0/L	1-log treatment (systems may use any technology or combination of technologies from toolbox as long as total credit is at least 1-log).
3	1.0/L ≤ *Cryptosporidium* < 3.0/L	2.0-log treatment (systems must achieve at least 1-log of the required 2-log treatment using ozone, chlorine dioxide, UV, membranes, bag/cartridge filters, or in-bank filtration).
4	*Cryptosporidium* ≥ 3.0/L	2.5-log treatment (systems must achieve at least 1-log of the required 2.5-log treatment using ozone, chlorine dioxide, UV, membranes, bag/cartridge filters, or in-bank filtration).

- Systems have three years following initial bin classification to meet the treatment requirements associated with the bin (see Table 3.4-6). The primacy agency may grant systems a two-year extension to comply when capital investments are necessary.
- System currently using ozone, chlorine dioxide, UV, or membranes in addition to conventional treatment may receive credit for those technologies towards bin requirements.

- The total *Cryptosporidium* removal requirement depending upon bin classification will be 3, 4, 5, or 5.5-log removal.
- Treatment options acceptable to meet the additional removal requirements are listed in Table 3.4-7.

Effect on the Lewis & Clark WTP: Lewis & Clark will be required to monitor their source water for *Cryptosporidium*. Although the source water may be under the influence of surface water, it is very unlikely that high concentrations of *Cryptosporidium* will be detected. Therefore, no improved treatment or disinfection should be necessary to meet the requirements of this rule.

Stage 2 Disinfectants/Disinfection Byproducts Rule

To further protect the public from the adverse health effects of disinfection byproducts, the Stage 2 D/DBP Rule will build upon the requirements of the Stage 1 D/DBP Rule. The following summarizes the anticipated requirements of the rule based upon the September 29, 2000 FACA committee agreement.

- Compliance monitoring will be proceeded by an initial distribution system monitoring (IDSE)/study to select site-specific optimal sample points for capturing peaks. All systems conducting IDSE monitoring must monitor during the peak historical month for DBP levels or water temperature. TTHM and HAA5 samples will be taken at each site.

- MCLs for TTHMs, HAA5, bromate, and chlorite will not be reduced from the Stage 1 levels. The bromate level will be reviewed as part of the 6-year review process to determine whether a reduction to 0.005 mg/L or lower concentration is required.

Table 3.4-7.
Microbial Toolbox

APPROACH	**Potential Log Credit**			
	0.5	**1**	**2**	**>2.5**
Watershed Control				
Watershed Control Program (1)	◆			
Reduction in oocyst concentration (3)	As measured			
Reduction in viable oocyst concentration (3)	As measured			
Alternative Source				
Intake Relocation (3)	As measured			
Change to Alternative Source of Supply (3)	As measured			
Management of Intake to Reduce Capture of Oocysts in Source Water (3)	As measured			
Managing Timing of Withdrawal (3)	As measured			
Managing Level of Withdrawal in Water Column (3)	As measured			
Pretreatment				
Off-Stream Raw Water Storage w/Detention ~ X days (1)	◆			
Off-Stream Raw Water Storage w/Detention ~ Y weeks (1)		◆		
Pre-Settling Basin w/Coagulant	◆	→		
Lime Softening (1)	→	→		
In-Bank Filtration (1)		◆	→	→
Improved Treatment				
Lower Finished Water Turbidity (0.15 NTU 95% tile CFE)	◆			
Slow Sand Filters (1)				X
Roughing Filter (1)	◆			
Membranes (MF, UF, NF, RO) (1)				X
Bag Filters (1)		◆	→	→
Cartridge Filters (1)			◆	
Improved Disinfection				
Chlorine Dioxide (2)	◆	◆		
Ozone (2)	◆	◆	◆	
UV (2)				◆
Peer Review/Other Demonstration/Validation or System Performance				
Peer Review Program (ex. Partnership Phase IV)		◆		
Performance studies demonstrating reliabile specific log removals for technologies not listed above. This prpovision does not supercede other inactivation requirements.	As demonstrated			

Notes:

1. Criteria to be specified in guidance to determine allowed credit.
2. Inactivation dependent on dose and source water characteristics.
3. Additional monitoring for *Cryptosporidium* after this action would determine new bin classification and whether additional treatment is required.

- Compliance with TTHM and HAA5 will be determined based on Locational Running Annual Average (LRAA) as opposed to averaging across the distribution system that is required under the Stage 1 D/DBP Rule. Compliance will be in two phases. Phase 1 will require that all systems must comply with 120/100 (TTHM/HAA5) LRAA based on Stage 1 monitoring sites and also continue to comply with Stage 1 80/60 running averages within three years after promulgation. Phase 2 requires that large and medium systems must comply with an 80/60 LRAA based on new sampling sites identified under IDSE within six years after promulgation.

- Sampling points to determine compliance with the rule will be identified by an initial distribution system evaluation (IDSE). Monitoring will be required every other month (approximately 60 days) for one year at eight distribution sites that are different from sites monitored under the Stage 1 requirements.

- Based upon the IDSE, compliance monitoring will be required at four locations:
  - One for the representative average from the Stage 1 locations.
  - One at the high HAA5 site location as identified by the IDSE.
  - Two at the highest TTHM site locations as identified by the IDSE.

- Compliance sample frequency will remain quarterly.

<u>Effect on the Lewis & Clark WTP</u>: The Stage 2 D/DBP Rule will place stricter requirements for DBP levels on systems. As discussed under the Stage 1 D/DBP Rule, the size of the Lewis & Clark distribution system will be conducive to DBP formation, and chloramines should be used as the secondary disinfectant to reduce DBP formation to the extent possible. If the system has problems complying with this rule, use of UV disinfection as a primary disinfectant may be justified, as this technology produces no known DBPs.

3.4.2.5. Chemical Differences

The finished water at the Lewis & Clark plant should be slightly scale forming. The principal scale-forming substance in water is calcium carbonate. Water is considered stable when it will neither dissolve nor deposit calcium carbonate. This is referred to as the calcium carbonate stability, or equilibrium, point. Thus, the reactions and behavior of calcium carbonate and calcium bicarbonate are important in water supplies. The actual amount of calcium carbonate that will remain in solution in water depends on five basic factors:

1. calcium content
2. alkalinity
3. pH
4. temperature, and
5. total dissolved solids

Several methods can be used to determine the calcium stability of water. A popular method is the Langelier Saturation Index (LI, also referred to as the Langelier Index). The index is equal to measured pH (of the water) minus pH_s (saturation). The pH_s is the theoretical pH at which calcium carbonate will neither be dissolved into or precipitate from water. At the pH_s water is stable. Therefore, if $pH - pH_s = 0$, the water is in equilibrium and will neither dissolve nor deposit calcium carbonate on the pipes. If $pH - pH_s > 0$ (positive value), the water is not in equilibrium and will deposit calcium carbonate on the pipes. If $pH - pH_s < 0$, (negative value), the water is not in equilibrium and will dissolve the calcium carbonate it contacts. No coating will be deposited on the distribution pipes. However, if pipes are not protected, they may corrode.

The calcium carbonate stability of water is maintained in the distribution system by adjusting the saturation index of the water to a slightly positive value.

If the temperature, total dissolved solids, calcium content, and alkalinity are known, pH_s can be calculated. The following expression may be used:

$$\mathrm{pHs} = A + B - \log(\mathrm{Ca}^{+2}) - \log(\mathrm{alkalinity})$$

In the equation, *A* and *B* are constants, and calcium and alkalinity values are expressed in terms of mg/L as calcium carbonate equivalents.

Table 3.4-8.
Constants A and B

Constant A as Function of Water Temperature		**Constant B as Function of Total Dissolved Solids**	
mg/L	**A**	**mg/L**	***B***
0	2.60	0	9.70
4	2.50	100	9.77
8	2.40	200	9.83
12	2.30	400	9.86
16	2.20	800	9.89
20	2.10	1,000	9.90
24	2.00		

{Source: AWWA, Volume 4, Introduction to Water Quality Analysis – Principles and Practices of Water Supply Operations, 1982.}

Table 3.4-9.
Estimated Langelier Stability Index for Lewis & Clark Finished Water

Description	**pH SU**	**Temp Deg. C**	**TDS mg/L**	**Ca mg/L**	**T. Alk mg/L**	**pHs**	**LI**
Conventional – Average	8.6	10	400	60	70	8.6	0.0
Membrane – Average	7.8	10	225	60	90	8.4	-0.6

The pH_s for the Lewis & Clark finished water is estimated to be approximately 8.3 to 8.6 for conventional treatment and 8.3 to 8.5 for membrane filtration. The Lewis & Clark finished water should be delivered at pH 8.6 to 8.9 for the transmission mains. Once the Lewis & Clark water reaches the member system connection, pH and/or alkalinity adjustment may be required to minimize instability problems in the member distribution system.

Table 3.4-10.
Estimated Langelier Stability Index for Lewis & Clark Members

LCWRS Member	pH SU	Temp (^{o}C)	TDS (mg/L)	Ca (as $CaCO_3$) (mg/L)	T. Alk (as $CaCO_3$) (mg/L)	pHs	LSI
Beresford, SD	9.3	13	502	130	31	8.5	0.7
Boyden, IA	7.2	13	529	109	301	7.6	-0.4
Centerville, SD	7.5	13	728	320	276	7.2	0.3
Clay Regional RWS, IA	7.4	13	442	190	240	7.5	-0.1
Harrisburg, SD	7.6	13	904	420	289	7.1	0.5
Hull, IA	7.7	13	593	376	1,200	6.5	1.2
Lennox, SD	7.9	13	517	117	266	7.7	0.2
Lincoln Co. RWS, SD	7.3	13	868	433	367	7.0	0.3
Lincoln-Pipestone RWS, MN	7.4	13	378	160	168	7.7	-0.3
Luverne, MN Filter # 1	7.8	13	499	242	314	7.3	0.5
Luverne, MN Filter # 2	7.6	13	592	270	324	7.2	0.4
Madison, SD	7.6	15	1,191	288	10	8.7	-1.0
MCWC, SD	8.7	13	376	79	29	8.8	-0.1
Parker, SD	7.3	13	895	338	279	7.2	0.1
Rock County RWS, MN	7.0	13	500	313	245	7.3	-0.3
Rock Rapids, IA	7.7	13	657	250	280	7.3	0.4
Rural Water #1, IA	7.5	13	947	320	310	7.2	0.3
Sheldon, IA	7.5	13	510	222	310	7.3	0.2
Sibley, IA	7.6	13	570	320	230	7.3	0.4
Sioux Center, IA	7.2	13	808	170	312	7.4	-0.2
Sioux Falls, SD	7.9	15	491	178	31	8.4	-0.4
South Lincoln RWS, SD	7.6	13	612	82	299	7.7	-0.1
Tea, SD	7.1	13	1,982	733	376	6.7	0.4
Worthington, MN	7.0	13	570	210	250	7.4	-0.4
AVERAGE	**7.6**	**13**	**695**	**257**	**283**	**7.5**	**0.1**
MAXIMUM	**9.3**	**15**	**1,982**	**733**	**1,200**	**8.8**	**1.2**
MINIMUM	**7.0**	**13**	**376**	**79**	**10**	**6.5**	**-1.0**

3.4.3. General Water Quality Requirements as Delivered (Mixing)

Member systems that will blend Lewis & Clark water with their water may experience stability problems for a period of time related to existing scale deposition and tuberculation in the distribution pipes. This problem may be exacerbated by the continual change in blending ratio between Lewis & Clark and member systems' water. There may be a need to adjust pH and alkalinity at the system connection point, as the Lewis & Clark water enters the member's water distribution system so that initially the water has a Langelier Stability Index (LSI) similar to the water supplied before Lewis & Clark water. Changes could be made to water chemical characteristics over a period of time, in order to minimize problems of stability.

3.4.4. Design Unit Flow Capacity

The total reserved capacity of Lewis & Clark members is 27.19 million gallons per day (mgd). The treatment process units will be sized to provide a nominal finished water flow of 27.2 mgd on a continuous basis. As a result, the in-plant usage of water (i.e., filter cleaning, sludge withdrawal, etc.) and system losses must be accounted for in the overall facility sizing. In order to produce 27.2 mgd of flow, the system raw water supply and treatment units must be sized greater than 27.2 mgd. Typically, water treatment facilities utilize from 2 to 10 percent of the water supplied to the plant for in-plant uses. Therefore, this additional water requirement will need to be added to the 27.2 mgd production capacity. This percentage will vary depending upon the treatment processes selected for implementation.

Lewis & Clark is a wholesale water system and the piping includes transmission mains only. Water loss from this type of system should be substantially less than a system that serves individual customers. Normal loss in a municipal system can be 5 to 6 percent or more, however, this is an entirely new system and the transmission losses are estimated to be insignificant (2%, or less). A 5% loss figure has been included in the transmissions pipeline system to account for system losses.

The number and capacity of the treatment process units will be determined using criteria from Ten States Standards and manufacturers' recommendations for their equipment systems. If design criteria are not available in Ten States Standards for the proposed process units, the proposed sizing will be based on criteria from other water treatment plant texts and manuals. Also manufacturers input will be evaluated. Final sizing of evolving technologies such as membranes would require pilot testing to confirm the design parameters.

3.4.5. Telemetry and Controls

Normal operation of medium and large water treatment plants is performed from a central location – typically, at the treatment plant itself, although it can be located elsewhere. The control system implemented for the Lewis & Clark facilities will consist of microprocessor based controllers (Programmable Logic Controllers and/or Remote Terminal Units), a computer based HMIs (Human Machine Interface), radios and local instruments.

Instruments will be utilized to measure process variables such as levels, flow rates, pressures, chemical feed dosages, pump speeds, vibration levels, motor temperatures, etc. The measured values will be transmitted to PLCs (programmable logic controllers) and/or intelligent RTUs (Remote Terminal Units). PLCs or RTUs located remotely from the treatment plant's control room will communicate via radio with the master PLC/RTU located at the Water Treatment Plant.

Redundant computer-based HMIs located in the Water Treatment Plant's control room will provide operators an interface with the capability to both monitor and control the entire system. Measured variables can be viewed, trended and saved via the computer. Compact disks or tapes will be utilized to automatically save data from the computer's hard-drive for historical data archiving.

Information that must be collected and managed by the Lewis & Clark instrumentation system is particularly important. This information can generally be placed into one or more of four broad categories:

? Treatment process data, to maintain the plant operation within established parameters and notify plant personnel of out-of-limit conditions.

? Technical information to provide operating cost and efficiency information and produce routine reports.

? Historical data, to identify long-term trends in water quality and plant performance that can be used for evaluating optimization or upgrade of plant facilities.

? Pressure, flow, levels, and water quality information in the transmission, storage and distribution system.

The computer-based HMIs provide indication of equipment status and centralized alarm management. Alarms are displayed, prioritized, time stamped, acknowledged, and reset via the HMIs. Printouts are generated to provide a written listing of all alarms and their time of occurrence.

In addition to the monitoring functions noted above, operators will have the ability to change valve openings, adjust pump speeds, start and stop equipment, and make other process and equipment adjustments from the HMIs located in the central control room.

Also, it is often desirable to integrate maintenance monitoring and dispatch functions, inventory control for chemicals, and laboratory analysis functions into the system. These off-line functions require the capability to combine operational data with operator entered data to produce necessary reports.

A computer-based instrumentation and control is recommended. This type of system provides significant operational advantages over the discreet system, particularly in plant automation and data retrieval. With the use of computer-based systems, there are several system architecture options. The two principal system architecture types are distributed and non-distributed control systems.

Non-distributed systems rely on a single central computer, interlinked to all the system devices. A standby computer is often needed to assure system reliability, significantly increasing the cost of the system. System intelligence is centralized, with the remote devices simply serving for data gathering and command implementation.

Distributed control systems utilize several different computers or processors to perform the control functions. The processors are interconnected, with each processor dedicated to a separate function to minimize the impact on the overall facility operation in the event a processor fails. The processors can be arranged into one of three different schemes: data acquisitioning systems, networked programmable logic controllers and distributed control systems. A distributed control system will be necessary for the wells and transmission pipeline system. It is recommended the distributed control system be considered for the water treatment plant as well.

3.4.6. Emergency Power

The reliability of the Lewis & Clark system is critical since many of the system customers are dependent on the system as their primary or sole source of water. If utility power is not available, standby power must be capable of allowing operation of the facilities. Not all electrical loads are critical, but the system must be capable of pumping and processing water for the following key functions:

- Raw Water Supply
- Water Treatment Facilities
- Distribution System Repump Station

Ten States Standards requires adequate standby power to meet average day demands. The design capacity of the facilities is 28.6 mgd and the estimated average day demand is 22 to 23 mgd. The various pumping and treatment facilities will have the minimum standby power generators to operate the required equipment at the average day demand. The proximity of various standby power locations will require emergency generators at each of the key locations. A second power source to provide the required reliability will be evaluated on the major electrical loads.

3.4.7. Piping and Valves

3.4.7.1. Pipe Materials

The pipe materials selected for use in the process piping at the Lewis & Clark WTP will be based on experience gained from their use at other water treatment facilities and technical considerations. Materials used for buried and exposed process piping within plants usually consist of ductile iron or steel. Chemical systems will use material that is chemical resistant such as PVC or fiberglass. A pipe schedule listing the various process piping and chemical systems with recommended pipe materials is shown in Table 3.4-11.

Table 3.4-11.
Pipe Schedule

Service	Size Range (in)	Type	Comments
Yard Piping	4-72	Ductile Iron	AWWA C151
		Steel	AWWA C200
In-Plant Process Piping	4-72	Ductile Iron	AWWA C151
		Steel	AWWA C200
Potable and Nonpotable Water	To 2	Rigid Copper	ASTM B88, Type L or K
	2½-3½	Steel	ASTM A53, Schedule 40
	4 and larger	Ductile Iron	AWWA C151, Class 53
In-plant Sludge	All	Ductile Iron	AWWA C151, Class 53 w/ grooved joints
Buried Sludge	All	Ductile Iron	AWWA C151, Class 50 w/ cleanouts
Plant Compressed Air	All	Stainless Steel	ASTM A269
Buried Sanitary Sewer	All	PVC	ASTM D3034, SDR 35
		Ductile Iron	AWWA C151, Class 50
Dry Chemical Unloading System	All	Steel	ASTM A53, Schedule 40 w/ coupling joints
Lime Solution	All	Fiberglass	Molded trough with open top
		Stainless Steel	
Chemical Solution Lines	All	PVC	ASTM D1785, Schedule 80
Pressurized Gas or Liquid Chlorine, Ammonia, and Carbon Dioxide	All	Steel	ASTM A53, Schedule 80

Internal operating pressures and external loading conditions for the piping systems will be taken into consideration during the final design. Process piping in the plant will be flowing under gravity conditions so the maximum pressures will usually be less than 10 psi. For the buried pipelines, special consideration will have to be given for the bury depth and increased live loadings in areas such as road crossings. Yard piping will be buried with a minimum of 5.5 feet of cover. This will prevent freezing of the lines and minimize the impact of live loads. Ductile iron pipelines will be placed on granular bedding similar to Type 4 per AWWA C600 for support.

The bedding will be provided at a minimum depth of 1/8 the pipe diameter, and selected compacted backfill will be used to the top of the pipe. Similar granular support bedding to a minimum depth of 1/2 the pipe diameter will be used for steel piping.

The chemical feed systems will be designed to minimize or eliminate any buried chemical lines wherever possible. This is desirable to minimize the risk of any leaks of chemical directly into the ground surrounding the pipe. If buried chemical pipes become necessary, a double containment piping system will be used.

3.4.7.2. Pipe Joints

In general, all exposed ductile iron piping systems will have flanged joints unless otherwise noted in Table 3.4-11. One exception noted will be the sludge piping, which is recommended to use grooved couplings. This will allow for easy removal of the sludge piping for cleaning. Large diameter exposed steel piping will be welded with flanges provided at valves and selected joints to allow for removal. Couplings with tie rods will also be allowed for joints. Exposed copper piping systems will utilize soldered joints. Exposed PVC piping systems will use solvent welded socket joints. All large diameter interior piping systems will be evaluated for expansion and contraction and will have couplings provided where needed to allow for this flexibility. The coupling will be harnessed with tie rods to prevent separation of the pipe. Couplings will also be placed near valves, if required, to allow for removal. Joints on the exterior piping systems will be bell and spigot type design. As required at valves, tees, and bends, the pipe will have restrained joints several lengths from the fittings or provided with thrust blocks to prevent separation of the pipe.

3.4.7.3. Linings and Coatings

Linings and coatings will be specified on piping systems as required to protect the pipe from corrosion. See Table 3.3-3 for additional discussion concerning corrosion control. All ductile iron and steel process piping will be cement mortar lined in accordance with AWWA C104 and C205, respectively. Ductile iron pipe used for sewer service will have a polyethylene lining. All other piping systems will be unlined since the piping materials used are compatible with the type of service.

An exterior coating or method of corrosion protection will be provided on all exposed and buried piping. For exposed piping, it will be painted in accordance with the Ten States

Standards guidelines for color identification with a high quality epoxy paint system. Buried ductile iron and steel pipe materials will be evaluated for corrosion protection during final design. There are three basic methods that will be evaluated to control corrosion on these pipelines as follows:

- Isolate and electrically insulate the pipe from the surrounding soil with a protective coating. For steel, this will be a protective tape wrap or polyurethane coating with heat shrink sleeves at the joints. For ductile iron, this will be a polyethylene membrane encasement.

- Provide bonded joints with sacrificial galvanic anodes.

- Provide electric currents to the piping system to counteract the galvanic currents associated with corrosion. This is usually done by bonding the joints with impressed current and having energized sacrificial anodes.

3.4.7.4. Pipe Support Systems

Several methods can be used to support exposed large diameter piping. Pipes located near the finished floor (1 to 4 feet) will be supported from the floor. These supports would consist of concrete saddles or steel framework. All other piping will be supported with hangers from above, from the wall, or a combination of both.

Support hangers from above can be provided by either the upper concrete floor/roof system or from a steel support beam. The steel support beam has been popular with contractors on some projects because it allows for easier installation of the piping. A steel support system allows the top of a pipe gallery area to remain open before placement of the floor or roof above, thus allowing the gallery piping to be placed by crane. This eliminates having to install the piping without the aid of a crane as would be required if the floor or roof above is placed first to provide connection locations for hangers. Placing the concrete floor or roof above first usually results in a more difficult and expensive method of installation. In addition, the upper floor/roof supported system, conceals the hanger connections, which makes them inaccessible for inspection. Because of these reasons, it is recommended that the structural steel beam support system be used for the final design.

3.4.7.5. Valves

There are many sizes and types of valves that will be required for the Lewis & Clark WTP. Valves will be needed for isolation, on-off, throttling, and pump check operations. Many of these valves will also require automatic actuators. Specialty valves, such as air/vacuum and air release will have to be provided at high points in pipelines. Surge relief valves may have to be provided in the high service discharge to protect against high-pressure surges. The requirements for specialty valves will be evaluated during the final design.

3.4.7.6. Valve Operators

Each valve provided at the Lewis & Clark WTP will have either a manual or automatic actuated valve operator. A manual operator, either lever or hand wheel, will be provided on all valves that do not require remote or automatic operation and are only used for isolation. The valves that will have automatic actuators will be determined during the final design. All automatic valves will be provided with a manual override in case the automatic operator fails. In addition, careful consideration will be given to the failure mode of all automatic valves during final design so that over pressurization of piping systems does not occur.

3.4.7.6.1. Manual Operators

Manual operators to be used for all valves will either be lever, hand wheel, or operating nut. Lever operators will be provided for all plug valves, butterfly valves, and ball valves smaller than 4 inches. Gear operators with hand wheels will be provided for all plug valves, butterfly valves, and ball valves 4 inches and larger. Chain operators will be furnished where necessary for all valves 6 feet or higher from the floor. Buried valves will have 2-inch operating nuts to be used with a standard valve wrench.

3.4.7.6.2. Automatic Operators

There are three types of automatic valve operators that have commonly been used in water plants, which are:

- Hydraulic
- Pneumatic
- Electric

Hydraulic operators use water or oil as the driving force. The water hydraulic operators have decreased in popularity due to the leakage and maintenance problems associated with them. Hydraulic valves using oil are still used but involve some negative aspects. These actuators are potential maintenance problems due to oil leaks from the pressurized lines that run throughout treatment facilities. These leaks could also cause a potential water contamination risk. There is also a higher safety risk involved due to the high hydraulic operating pressures. Because of these reasons, it is recommended that hydraulic valve operators not be considered for use at the Lewis & Clark WTP.

The remaining two types, pneumatic and electric, are the more common categories of actuators used in water plants today. These are recommended for use at the Lewis & Clark WTP due to the general accepted use of them at other water treatment facilities. The final decision on the type of actuator will be determined by cost during final design. In general, economics will most likely favor electric valve operators for remotely located and small valves and air actuators for air actuators for areas that have a high concentration of larger valves. All actuators will be provided in accordance with AWWA C540. In addition, all automatic actuators will be provided with a manually operated hand wheel for emergency operation.

3.4.8. Site Improvements and Land Requirements

The purpose of this section is to present the criteria to be used for selecting the water treatment plant site. The criteria include non-monetary and site-specific cost factors. The categories are floodway/floodplain issues, access, utilities (power, telephone, gas), site development costs, land cost/availability, zoning/public acceptance, Corps of Engineers 404 Permit, connecting pipeline costs (process and drain), environmental issues, and location for system growth.

Floodplain/Floodway Issues

The first category, Floodplain/Floodway, determines whether the site is in the floodplain or floodway or out of both the floodway and floodplain. If a site is in the floodway, mitigation requirements will lead to increased costs and increased permitting requirements. A water treatment plant site in the floodplain region can result in increased construction costs to keep the treatment system above flood levels, increased probability of poor soils and also represents a potential accessibility risk, which is unacceptable.

Access

This category rates transportation routes to the sites. The distance to paved roads, gravel roads, and the City of Vermillion are considerations. Obviously sites with good quality all-weather roads have more reliable access than sites with lower quality roads. Sites with low quality roads will require upgrading, which will increase costs. Sites closer to Vermillion will involve less travel time for treatment plant personnel.

Utilities (power, gas and telephone)

Sites with power and gas utilities nearby will have lower utility development costs as compared to sites with utilities a relatively longer distance away.

Site Development Cost

Site Development Cost category involves rating the sites based on the anticipated preparation of the site needed for facility construction. Factors in this category include site grading, degree of earthwork required, whether or not a special foundation system (such as piling) is required due to poor soils, and whether site dewatering is expected. All of these factors impact costs.

Land Cost/Availability

Land cost and availability are based on what is perceived to be the relative value of land depending on location and willingness of landowner to sell the property. Land adjacent to existing development is generally considered more expensive than general agriculture land. Land out of the floodplain is considered more expensive than land in the floodplain. Another consideration is whether the required property can be purchased without leaving the property owner a small, inefficient piece of land to farm. Land is much easier to obtain from a landowner willing to sell property than from a non-willing landowner.

Zoning/Public Acceptance

Zoning/Public Acceptance category will be evaluated based upon the anticipated difficulty in obtaining zoning and construction permits for the treatment facility. Sites in rural areas are perceived as having little difficulty in receiving permits as compared to those sites closer to developed property. Sites with dwellings will require people to be relocated, which is not desirable.

Corps of Engineers 404 Permit

The Corps of Engineers 404 Permit category was inserted to evaluate the sensitivity of the sites to wetlands, wetlands mitigation or the filling of water bodies. Generally, if wetlands vegetation or water bodies are identified on a site, it will be considered as having wetland areas and some type of mitigation is required which impacts costs.

Connecting Pipeline Costs

The Connecting Pipeline Costs category is a subjective comparison of the various sites regarding additional pipeline costs due to location. These pipelines are defined as the connecting pipeline to the water treatment plant from planned transmission lines from the well field and to the distribution system. The connecting pipelines will be large diameter, with line costs likely to be several hundred thousand dollars per mile.

Environmental Issues

Construction problems due to noise, dust, loss of vegetation, and a general disruption of the area will be evaluated under Environmental Issues. Cultural resource issues, if known, will be considered. Also, aesthetics and visual effects such as visibility and prominence from key locations will be evaluated.

Location for System Growth

The last category, Location for System Growth, rates each site based on how advantageous it is to provide high service pumping into the expanding distribution system.