3.0 WATER SYSTEM CONCEPT DESIGN CRITERIA

Design parameters define the system capabilities by specifying the features and performance requirements of the system facilities and providing the necessary guidelines upon which to complete preliminary engineering evaluation efforts. The Final Engineering Report for the LCRWS prepared by Banner establishes the design criteria for the infrastructure required to serve the City of Sioux Falls under the LCRWS Alternative and subsequent expansion thereof as indicated in correspondence and documentation. The design parameters and criteria presented within this Section were used to develop the water system components (water supply, transmission, treatment, storage, and pumping facilities) required to accommodate the projected future growth and development of Sioux Falls under the remaining considered alternatives, whether supplementing the expanded capacity provided by the LCRWS or meeting the projected demands independently. The preliminary design criteria developed and presented in Chapter 3 of the Final Engineering Report for the LCRWS are similar to those established for the alternatives developed under this effort, which provides a consistent basis for comparing the Missouri River Pipeline Alternative (with or without consecutive users) to the LCRWS Alternative. In general, the design criteria follow parameters established in the Recommended Standards for Water Works (Ten States Standards) and by the American Water Works Association (AWWA), USEPA, and other recognized sources.

3.1 Water Supply Infrastructure

3.1.1 Assumptions and General Considerations

Due to the relatively large projected capacity requirements and the City’s current application for future use from the Missouri River, it was assumed that the City of Sioux Falls would consider the construction of a surface water intake at Gavin’s Point Dam on Lewis and Clark Lake near Yankton, South Dakota. The surface water intake at Gavin’s Point Dam would serve as the mechanism to provide raw water under the Missouri River Pipeline Alternative with or without consecutive users, as presented in the Water Supply Alternatives report completed in 1977. The surface water intake would also be considered to supplement the capacity provided by the LCRWS through the 50-year planning period (2062) under its respective alternative. It would seem beneficial to consider a surface water intake on the Missouri River downstream of Gavin’s Point Dam to minimize the distance and associated costs of conveying water to the City. However, the ability to obtain the approval could be rather difficult due to:

- Technicalities regarding the intended location and type of withdrawal indicated in City’s future water use permit on file with the South Dakota Department of Environment and Natural Resources (SDDENR);
- The presence of endangered species of fish downstream of Gavin’s Point Dam;
• Challenges posed by continuous river meandering and/or braiding; and
• Likely opposition from environmental interest groups wanting to preserve the designation of this portion of the Missouri River as a scenic water way by the National Park Service.

Surface water intakes are built for the purpose of capturing surface water from lakes, reservoirs, rivers, or other water bodies. Intake systems include those components necessary to divert and transport raw water from the supply source to subsequent pumping and/or treatment facilities. Components of a surface water intake at Gavin’s Point Dam would consist of the inlet screen assemblies, gravity transmission pipelines, and the raw water pumping facility.

Intake systems must be designed to function under an applicable set of site-specific conditions. An intake system must be able to reliably provide an adequate quantity of water over a wide array of conditions such as high water pool levels (flooding), low water pool levels (drought), and winter (ice-covered) conditions. Other challenges include water quality, silt deposition, zebra mussels, navigation, debris, ice, fish protection, flow velocity, orientation, wave action, storms, and bank instabilities (such as erosion). Ten States Standards (Great Lakes Upper Mississippi River Board of State Public Health & Environmental Managers) establishes minimum design standards for intake systems, which are summarized below:

• Provide multiple-level water withdrawal;
• Where frazil ice may be a problem, minimize the flow velocity into the intake structure;
• Include inspection manholes every 1,000 feet for pipe sizes large enough to permit visual inspection;
• Include provisions for occasional cleaning of the inlet conduit;
• Provide inlet conduit protection against rupture by dragging anchors and ice;
• Locate inlet ports above the bottom of the water body, but at sufficient depth to be kept submerged at low water levels;
• Provide screens capable of keeping large quantities of fish or debris from entering an intake structure;
• If necessary, provide control of zebra mussels or other aquatic nuisances; and
• Locate and design intake to reduce ice problems.

The surface water intake concept at Gavin’s Point Dam considered for the City of Sioux Falls would include features to address the minimum requirements established by Ten States Standards. The following discussion presents the assumed features of a potential surface water intake concept, which complies with the suggestions of Ten States Standards and addresses operational redundancy, capacity, maintenance, and security issues.
3.1.2 Intake Capacity

The initial construction and future expansion of surface water intake systems can be very difficult. For this reason, intake facilities are typically designed based on a projection of long-term water demands, whereby the construction of near-term infrastructure facilitates future expansion. For the purposes of this report, it was assumed that the initial intake capacity and future expansion thereof would be based on the water demand projections defined under the drought conditions scenario presented in Section 2.

3.1.3 Intake Screen Assemblies

Intake (inlet) screen assemblies are commonly used on surface water intake systems to prevent large objects and fish from entering the water supply system. Specific preliminary design considerations with respect to inlet screens are discussed below.

Configuration, Redundancy, and Location

Multiple inlet screen assemblies were assumed in order to reduce the individual inlet screen size and increase the overall depth of submergence. In addition, multiple inlet screen assemblies provide system redundancy, which allows continued service should one of the assemblies need maintenance, sustain damage, or require replacement. A minimum of three intake screen assemblies would be a prudent consideration, with two of the intake screen assemblies being capable of meeting the rated design capacity. The relatively stable water surface elevation maintained in Lewis and Clark Lake per the operating plan coupled with the relatively good water quality eliminate the need for a multiple-level withdrawal feature. The intake screen assemblies would be situated on an intake crib, which would collect the water and connect the screens to the transmission pipelines. The crib and intake screen assemblies would most likely be located directly to the south of a marina near the dam structure. Photos taken from the north and northeast on September 1, 2004 of this location are provided in Figure 3.1 and Figure 3.2, respectively. The approximate assumed location of the intake crib and screens is identified in the red circle imposed on the photos.

Submergence and Protection

Intake capacity is directly related to the submergence depth of the intake screen. It was assumed that adequate submergence of a series of inlet screens could be achieved to provide the projected water demands at the minimum water level of Lewis and Clark Lake. Depending on the type of inlet screen, a minimum submergence depth is generally required to assure the inlet assembly is not damaged by floating debris, boating activities, or ice flows. For the purposes of this report, it was assumed that the inlet screens would
be submerged at least 15 feet below the minimum water surface elevation in Lewis and Clark Lake. The intake system could be protected via the use of a buoy and netting system to prevent boating and fishing activities in the vicinity of the intake screens.

**Inlet Screen Velocities**

Inlet velocities through the screen openings are generally designed for a maximum of 0.5 feet per second (fps). The relatively low velocity helps to prevent suspended matter from accumulating on and impeding water flow through the screen assembly, minimizes headloss through the intake screen, and minimizes the potential for the formation of frazil ice, as discussed below.

**Frazil Ice**

Ice starts to form when water temperature is reduced to 32 degrees Fahrenheit (°F) and water continues to lose heat to the atmosphere. Frazil ice forms when water turbulence occurs in conjunction with freezing temperatures.
When water loses heat to the atmosphere and a condition of turbulence exists, uniform cooling of a large fraction of the water body occurs. As freezing occurs, small, disk-shaped frazil ice crystals form and are distributed throughout the turbulent mass. Active frazil ice will readily adhere to underwater objects such as inlet screens. When this occurs, inlet flow capacities can be reduced significantly. Frazil ice remains active for only a short period of time. As an ice sheet forms across the surface of the water body, the water temperature below the ice sheet stabilizes near 32°F and frazil ice becomes inactive and eventually dissipates. Provisions for frazil ice control are addressed for the preliminary design criteria by assuming that inlet velocities would be maintained below 0.5 fps. In addition, the extent of submergence minimizes the impacts of wave action (turbulence) at the depth of the intake screen.

Cleaning Provisions

Cleaning provisions to address particulate and frazil ice accumulation are also typically incorporated into an inlet screen design. A method of backwashing the inlet to clear...
away accumulated matter from the screen surface is a prudent consideration, as clogging of the screen surface can occur even with proper inlet velocities and screen placement. Air is sometimes incorporated into the system to supplement and improve the effectiveness of the backwash system. Chemical addition should be considered in applications where zebra mussels could present a problem with the inlet. A means of chemical addition could be provided either near the river inlet or within the pumping facility to assist in removing zebra mussels should they adhere to the inlet assemblies and impede water flow. If the SDDENR prohibits the intermittent use of chemicals, a zebra mussel resistant protective coating could be applied to the inlet screens. To minimize the potential for environmental implications, it was assumed that the screens would include the protective coating if zebra mussels represent a valid concern.

3.1.4 Gravity Transmission Pipelines

Pipeline Size

The size of the gravity transmission pipelines is ultimately determined by the required flow capacity and maximum flow velocity. For redundancy, two pipelines would extend from the intake crib to the raw water pumping facility. The total design capacity of the pipelines would be equivalent to build-out capacity of the system to avoid the need for future construction activities near the dam. The flow through the gravity transmission pipelines would need to provide adequate scour velocity (greater that 2.0 fps) to remove sediment without incurring excessive friction loss that limits capacity. In most instances, locating the pumping facility within reasonable proximity to the intake screens minimizes friction loss concerns, which would probably be the case at Gavin’s Point Dam. Therefore, the gravity transmission pipelines would be sized such that the flow velocity is at least 2.0 fps at the initial (25-year) intake design capacity with one transmission pipeline in operation, which would essentially allow the system capacity to be quadrupled while limiting the maximum flow velocity to a reasonable range of 4.0 to 5.0 fps in the future (50-year planning period and beyond).

Pipe Material

As noted above, two gravity transmission pipelines would convey water from the intake crib to the raw water pumping facility. The gravity transmission pipelines from the inlet screens to the pumping facility would likely need to be constructed via horizontal directional drilling (HDD) or microtunneling technology due to the submergence depth of the screens and the proximity to Gavin’s Point Dam and a nearby marina. Steel pipe was assumed for this application over other pipe materials, such as polyvinyl chloride (PVC), high-density polyethylene (HDPE), ductile iron, and pre-stressed concrete. Factors contributing to the preliminary selection of steel pipe include:

- The wide range of pipe diameter sizes available;
• The ability to withstand deformation or failure caused by excessive soil burden;
• The presence of welded joints versus mechanically sealed joints; and
• The conformance with HDD installation methods.

The primary disadvantage associated with steel pipe is its susceptibility to corrosion in submerged and underground environments. Therefore, cathodic protection and an appropriate corrosion resistant interior and exterior coating system would be required to preserve the integrity of the pipeline system over a prolonged period of time.

3.1.5 Raw Water Pumping Facility

Conceptually, a site north of the dam and marina appears to be the most appropriate location for the pumping facility. A photo of the site taken from the south on September 1, 2004 is presented in Figure 3.3. The gravity transmission pipelines could be located under a gravel access road that runs parallel to the toe of the dam along the edge adjacent to the marina. As shown in Figure 3.3, the assumed site contained various stockpiles of rock and fill material, which suggests that the site is owned by the United States Army Corps of Engineers (COE), highway department, or a contractor. A potential location for the facility is identified in the red box imposed on the photo.

Figure 3.3 Conceptual Raw Water Pumping Facility Location
Substructure

A reinforced concrete caisson (cylindrical shape) would serve as the substructure for the pumping facility. When considering the overall depth of the substructure, a caisson provides structural advantages when compared to a rectangular substructure. In addition, a circular structure is better suited than a rectangular structure for alternative methods of construction, such as “sinking.” Once the caisson is sunk to the appropriate elevation, the reinforced concrete floor slab is poured in place to make the caisson watertight.

Depending on the preference, the substructure would serve as a dry well or a wet well for the pumping facility. To minimize system maintenance by eliminating the need to periodically clean and maintain a wet-well, it was assumed that the City of Sioux Falls would most likely consider a dry well configuration. The significant amount of displaced soil material would probably require a complex geotechnical design to address buoyancy and base slab upheaval issues. Therefore, a comprehensive subsurface soil exploration effort would be necessary to properly design the foundation system, which would most likely consist of a pile system.

Superstructure

The pump house superstructure would be constructed directly above the substructure and contain the necessary equipment and facilities to operate and maintain the pumping system. Under the dry well configuration, vertical turbine pumps would extend from the operating floor of the pump station into a water column encased by large diameter pipes connected to the gravity pipelines by a manifold system for increased operational flexibility. An enclosed stair tower would provide access to the manifold piping system and associated equipment located in the substructure.

The pump motors, electrical gear, controls, mechanical systems, and other equipment would be located on the main floor of the superstructure whenever possible, or at least above the maximum water level of Lewis and Clark Lake. To facilitate this design parameter, the top of the caisson should be constructed three feet above the 100-year flood elevation. Regarding redundancy provisions, the pumping system would provide firm capacity (the ability to achieve the rated design capacity with the largest pump out of service), and the facility would be equipped with an emergency power generator on site. To minimize staff hours and associated labor costs, the system would be fully operational from the Sioux Falls WPP via a compatible Supervisory Control and Data Acquisition System (SCADA). Intrusion alarms could be incorporated into the SCADA system for security purposes.

The site layout would need to include the facility, parking for operational staff, and access and egress for service vehicles. A square or rectangular (not to exceed a length to width ratio of 3:2) parcel of property containing approximately two acres of land would
accommodate the facility as conceptualized. Due to the remote location of the facility, a perimeter fence would be a prudent security consideration.

It is anticipated that the appearance of the superstructure could be an issue due to the presence of recreation and permanent upscale residences in the Gavin’s Point Dam area. Therefore, a simple precast concrete or concrete masonry unit structure would probably receive negative feedback from area residents. As a result, the City of Sioux Falls would likely need to consider an architecturally enhanced design with a limited amount of decorative brick and/or stone to augment the appearance of the facility. Site landscaping and the type of security fence could also be used to improve the appearance of the facility without adding exorbitant costs.

3.1.6 Well Systems

Well systems are utilized to withdraw groundwater from porous sand and gravel formations. Types of wells include vertical wells, angle wells, and horizontal (radial) collector wells. The LCRWS project is scheduled to consist of a combination of these types of wells. Due to their configuration, horizontal collector wells provide increased production rates over vertical and angle wells and provide the ability to withdraw water underneath a river system. Since the Missouri River is suitable for horizontal collector well applications in some areas and the projected water supply capacity by the City of Sioux Falls is relatively large, the City could consider the development of a horizontal collector well system in lieu of a surface water intake. Due to the reduced capacity provided by vertical wells and angle wells, the corresponding number of wells required when compared to horizontal collectors wells, and associated maintenance costs, it was assumed that the City of Sioux Falls would forego the consideration of a series of vertical and/or angle wells.

In consideration of a horizontal collector well near the Missouri River, the City of Sioux Falls could pursue appropriations in the vicinity of Vermillion, South Dakota to reduce the transmission pipeline distance. It is anticipated that the environmental and endangered species issues identified with the construction of a surface water intake along this segment of the Missouri River would no longer apply under the concept of a horizontal collector well. However, the pursuit of appropriations from this area would require the City to address various stipulations of its future use permit for the Missouri River, including the designation (surface water versus groundwater) and location of withdrawal. Preliminary discussions with SDDENR representatives do not suggest that either of these issues would prevent the City of Sioux Falls from developing a horizontal collector well system near Vermillion, South Dakota. Although the Missouri River Pipeline Alternative is based on a surface water intake, a general description of a conceptual horizontal collector well is provided.
Horizontal collector wells typically consist of a large diameter reinforced concrete caisson installed adjacent to a water body with a series of lateral well screens that are projected out horizontally (radially) from the caisson into the base of the aquifer formation (under the river) at one or more elevations in a variety of patterns and lengths. The length of the lateral screens are set to limit entrance velocities, reduce headloss, and maximize the length of time between lateral maintenance events. The geological characteristics at the site should consist of unconsolidated, saturated, predominantly alluvial outwash material.

The caisson for a horizontal collector well would be similar to that discussed for the surface water intake but serve as a wet-well due to the natural filtration process limiting the propensity for solids accumulation. As with the suggested configuration of the surface water intake system, the pumping facility would be constructed on top of the caisson. The operational components and features of the pumping facility would again be similar to that described of the surface water intake at Gavin’s Point Dam; however, the appearance of the facility would probably not be as much of an issue.

### 3.2 Water Transmission Infrastructure

Guidelines for the design of transmission pipelines often vary based on local and state requirements and operational preferences expressed by the owner. AWWA and other organizations provide general guidelines on design parameters such as pipe velocity and head loss. The following sections discuss the design parameters established for the development of the transmission pipeline infrastructure. These parameters apply regardless of whether or not the pipeline conveys raw or treated water.

#### 3.2.1 Transmission Pipeline Materials

Common transmission pipeline materials include PVC, ductile iron, steel, and pre-stressed concrete. Since the anticipated range of pipe sizes for the alternatives includes relatively large diameters (greater than 48 inches), ductile iron and steel were considered as viable pipeline materials in lieu of PVC and pre-stressed concrete. At the present time, the applicability of PVC pipe in large diameter is limited due to the required operating pressure range. Pre-stressed concrete cylinder pipe (PCCP) is available and feasible in the required size and operating pressure range; however, Banner excluded the consideration of PCCP per discussion in the Final Engineering Report for the LCRWS. Therefore, PCCP pipe was not considered for the purposes of this study to provide consistency with the LCRWS Alternative as proposed. As an alternative consideration in the future, the City of Sioux Falls could request that PCCP pipe be considered during subsequent preliminary or final design efforts. With the use of ductile iron and steel pipelines, appropriate measures should be taken to limit corrosion in order to prolong the integrity of the pipeline.
3.2.2 Transmission Pipeline Sizing

The maximum flow (conveyance capacity) for a given pipe diameter directly corresponds to the maximum permissible velocity within the pipe. Pipelines are sized to meet maximum flow conditions and should be designed to convey water without incurring excessive pressure (head) loss. Pipeline velocities have a direct effect on hydraulic surges and water hammer created in pipelines. In general, increased design velocities will result in greater operating pressures and increase the risk associated with water hammer. Establishing a maximum permissible velocity in a given pipeline system must include the simultaneous consideration of these factors. Therefore, the estimated headloss and risk for catastrophic water hammer, in direct relation with the water velocity, are the controlling factors regarding pipe size and pressure rating requirements. For pipelines intended to convey raw water, consideration should be given to maintain a minimum pipeline scour velocity of approximately 2 fps to suspend and remove settled material.

The following general preliminary design criteria were established as guidelines for the development of transmission pipeline systems:

- Headloss due to friction was limited to two feet per 1,000 feet of pipe;
- A C-factor of 130 was assumed for the calculation of headloss due to friction;
- Pipeline velocities were limited to approximately 4 fps at initial design capacity, with the potential to increase to a maximum velocity of approximately 6 fps via expansion of the transmission pipeline system; and
- The maximum operating pressures were limited to 250 pounds per square inch (psi).

Together, these criteria represent a relatively conservative basis of preliminary design. It should be noted that these design criteria are similar to those established for the LCRWS project. Using these guidelines in conjunction with a computer model allows the pipeline systems to be sized, evaluated, and optimized at a conceptual level over identified routes and associated terrain from the Missouri River to the City of Sioux Falls.

3.2.3 Transmission Pipeline Installation

Open cut trench excavation with appropriate bedding, backfilling, and surface restoration would be the most economical method of pipeline installation. The pipeline would need to be located in easements or permits in public right-of-way authorizing operation and maintenance activities, as necessary. For large diameter pipelines, permanent easements should be no less than 75 feet in width to allow parallel pipeline installation in the future, and temporary construction easements should provide another 100 feet of width or more to adequately accommodate construction activities.
Ideally, the pipeline would be located adjacent to section lines or roadways to promote ease of access, while avoiding excessively wet areas and difficult terrain. To minimize the extent of private easements required and potential associated costs, the use of public right-of-way adjacent to roadways could be considered. To maximize the amount of available public right-of-way, the pipeline could be installed parallel to state or interstate highways; however, the number of interferences, which incur costs, could increase due to the potential for increased development along such routes. On the other hand, the limited amount of right-of-way adjacent to county or township roads would provide a relatively small amount of the required easement width. Since a majority of the transmission pipeline for the LCRWS project extending from the water treatment facility to the City of Sioux Falls is proposed along township and county, it was assumed that the City of Sioux Falls would consider a similar route with an effort to utilize a portion of the available public right-of-way, if possible.

In northern climates, the depth of bury typically needs to exceed six to seven feet depending on location to prevent freezing. To avoid the entrapment of air, the pipeline would need to be installed according to a design grade, whereby any air that does become entrapped could be expelled at high locations along the pipeline route.

3.2.4 Transmission Pipeline Appurtenances

The transmission pipeline would include valves, fittings, meters, and other appurtenances and considerations as appropriate to facilitate proper operation and maintenance of the system. The following provides a general description of the anticipated pipeline appurtenances that would be required.

Isolation Valves

The function of the isolation valves is to serve as a means to isolate portions of the transmission pipeline that require maintenance. For estimating purposes, it was assumed that isolation valves would consist of gate, plug, or butterfly valves and be required every four to five miles along the pipeline route. If desired, the isolation valves could be installed in an underground concrete vault. Regarding the Missouri River Pipeline Alternative, isolation valve spacing would be strategically located at connection points to possible subsequent consecutive user infrastructure. For the purposes of this evaluation, it was assumed that consecutive users would be responsible for subsequent pumping, storage, and transmission infrastructure.

Combination Air Release/Air Vacuum Valves

Combination air release/air vacuum valves would be required to dispel entrapped air and allow the entrance of air to avoid negative pressures due to large leaks or other abnormal operating conditions. Air release/air vacuum valves are installed at high points or at
transitions of positive grade to negative grade of the pipeline system. The location of the air release/air vacuum valve should be slightly downstream of the high points in the direction of flow because air in the pipeline is typically dragged along the top of pipe by the flow of water. The air release/air vacuum valves could be located in an underground concrete vault structure or in an above grade enclosure. To minimize costs associated with large diameter fittings and heating an above grade building, it was assumed that the valves would be installed below grade in concrete vaults.

Above Grade Discharge Points

The transmission pipeline system should include above grade discharge points at strategic locations along the pipeline route. Such locations include low elevations that readily offer drainage of the water to be discharged. The discharge points allow the pipeline to be flushed for purposes of sediment removal and drained for ease of pipeline repairs and miscellaneous maintenance. A valve would be provided on the discharge pipeline to regulate the rate of discharge flow.

Surge Pressure Suppression

Surge pressures within pipelines can occur during the startup and shutdown of pumping systems, valve operations, or power outages that result in abrupt pump system failure or valve closure. Pipeline surge pressures are directly related to the water velocity, working pressure, length, and material of the pipeline system. If appropriate measures are not taken into consideration to minimize the potential for excessive surge pressures (water hammer), significant damage to the system can occur. In addition to designing the pipeline system for appropriate velocities and working pressures, methods of minimizing the propensity for excessive surge pressures consist of providing “soft start” motors on pumps, actuators that open and close valves at allowable rates, surge/pressure relief valves, and backup power systems.

Corrosion Control

Steel and ductile iron pipelines and other metallic appurtenances are at risk of corrosion when buried underground. The extent of corrosion protection is primarily dependent upon the pipeline material and soil properties. Common methods for minimizing corrosion include cathodic protection systems, protective coatings bonded to the pipe, polyethylene encasement, insulation, and joint bonding. In addition to heeding established guidelines and manufacturer recommendations, soil testing along the proposed pipeline route should be completed to ascertain the corrosivity of the types of soils encountered and determine the level of corrosion protection required. Based on design efforts completed to date by Banner for the LCRWS regarding the relatively corrosive nature of the soils found along the proposed pipeline route, it is anticipated that
a combination of the above referenced methods would be required to protect the pipeline from corrosion, regardless of whether steel or ductile iron pipe is used.

Pipeline Route Interferences

To convey water from the Missouri River to the City of Sioux Falls, the transmission pipeline would encounter numerous obstacles including: dirt and gravel roads; paved county, state, and interstate highways; railroads; various underground power, communication, and gas utilities; overhead power lines; rivers and streams; and wetlands. In some cases, special permits are required. The pipeline route should attempt to minimize the impacts associated with interferences due to the incurred costs associated with alignment changes, elevation adjustments, alternate methods of pipeline installation, and permit requirements. Input from utilities, transportation officials, and government agency representatives are often very helpful when evaluating potential pipeline routes during the preliminary stages of final design.

At locations where the pipeline encounters roadways, installation via boring or jacking would probably be most appropriate to minimize transportation impacts. The pipeline could be installed by open-cut methods through less traveled roadways as a cost savings measure; however, disadvantages would include the costs of surface restoration and the potential for future settlement and associated maintenance. Steel casing pipe is typically required to obtain state highway, interstate highway, and railroad crossing permits.

It is anticipated that most underground utilities could be avoided or crossed without significant modifications to the pipeline alignment or depth of bury. As an exception, the pipeline would likely encounter existing regional water system pipelines. In lieu of making rather costly alignment or elevation adjustments to the relatively large diameter pipeline associated with providing water service to the City of Sioux Falls, approval should be sought from the regional water systems to modify the location or elevation of existing pipelines of smaller diameters to an alignment or depth to obtain proper horizontal and vertical clearances between the pipes. Alternative methods of construction should be used if suggested by utility representatives. In most instances, equipment operators should be capable of avoiding overhead utilities. If necessary, the power company may be asked to provide temporary support of power poles.

Because of the anticipated size of the pipeline, streams and rivers would most likely be crossed using temporary channel diversions to facilitate open cut construction methods, which requires a 404 Permit from the COE. Installation of the pipeline through streams and rivers should be accomplished during periods of reduced channel flow and in accordance with potential fish and wildlife limitations and requirements.
3.3 Intermediate Pumping and Storage Facilities

Due to the length of the transmission pipeline and terrain from the Missouri River to the City of Sioux Falls, one or more intermediate pumping facilities would be necessary to limit system working pressures within the transmission pipeline system. As water demands increase, additional intermediate pumping facilities could be placed at strategic locations as a relatively economical means of increasing the capacity of the water transmission pipeline system. The following provides a description of the pumping facilities considered as part of this study effort.

3.3.1 Pumping Facilities

The pumping facilities could be designed as in-line booster stations without storage located on site, which would require operational synchronization with upstream and downstream facilities. Synchronized booster station operation would not be impossible, but it would be very complex with respect to instrumentation and controls because of the size of the system, the anticipated distance between facilities, and the potential for varied flows during operation.

Locating a concrete storage facility adjacent to the pumping station greatly simplifies operations. Storage would also provide several other benefits, such as equalization between influent and discharge flow rates, operational and reserve system storage, and additional protection from surge pressures. The primary disadvantages of a storage facility are increased capital and maintenance costs. The transmission pipeline under the Missouri River Alternative without consecutive users would convey raw water to the City of Sioux Falls; therefore, there would be increased potential for sediment accumulation in the storage reservoir. Since Lewis and Clark Lake essentially serves as a large sedimentation basin, it is anticipated that the amount of sediment deposited in the storage reservoir would require semi-annual or annual maintenance activities, which is a typical frequency for inspections and maintenance of raw water basins. For the purposes of this report, the concepts included pumping facilities with on-site storage reservoirs.

The pumping facilities would be designed to meet the maximum flow with the largest pump out of service (firm capacity). Depending on the preferred configuration, the pump station could be equipped with vertical turbine or horizontal split case centrifugal pumps. To provide increased operational flexibility and allow a range of discharge rates, the pumps would be controlled with variable frequency drives (VFDs). The system would be equipped with valves, meters, and associated appurtenances to measure flow, pressure, and other parameters. The information would be made available to the operating staff at the Sioux Falls WPP via radio telemetry SCADA system.
To minimize maintenance, below grade construction would be comprised of poured in place concrete. Concrete masonry units and brick or precast concrete, or a combination thereof, would be used for the construction of the building. The size of the building would include space for: the proposed pump system; future pumps, valves, meters, and process piping; a control room; a lavatory; an area for maintenance activities, spare parts, and tools; an electrical room and motor control center; a mechanical room; and an emergency power generator. A chemical feed room, storage, and associated equipment would also be necessary if the system is designed to convey treated water. The facility should be equipped with an overhead crane or roof hatch system that provides the ability to hoist and remove the pumps, motors, and other large equipment.

If possible, the pumping facility should be located near existing power supply infrastructure. The site layout would need to include the facility, parking for operational staff, and access and egress for service vehicles. The amount of land required would be largely dependent upon the size of the storage reservoir. Due to the remote location of the facility, intrusion alarms connected to the SCADA system and a perimeter fence would be prudent security considerations.

3.3.2 Storage Facilities

Storage facilities adjacent to the pump stations would be concrete ground storage reservoirs poured in place or constructed as a series of precast panels. Although initially more costly, concrete storage structures were considered instead of steel tank structures based on future maintenance costs. The size of the storage facilities would be based on the capacity of the pumping facility and the desired amount of reserve storage, which was assumed to be equivalent to a third of the maximum pumping capacity on a daily basis. As noted above, the size of the storage reservoir ultimately dictates the required parcel size. Recognizing the potential need to add storage in the future, the pumping and storage facilities would probably require a 10-acre parcel of land.

3.4 Water Treatment Infrastructure

3.4.1 Treatment Processes

Water treatment facilities are designed based on the nature and quality of the source water(s), applicable regulations, water quality objectives, and technology preferences. For the purposes of this study effort, it was assumed that the facilities to provide treatment of surface water from the Missouri River would include the primary treatment processes of lime softening, conventional filtration, and chlorine/chloramine disinfection. These processes are consistent with the current processes utilized by the City of the Sioux Falls at the WPP, which minimizes training requirements and provides equipment familiarity for operational staff. It was assumed that expansion of the existing WPP and facilities proposed to supplement the LCRWS or meet future demands would not require...
Actiflo® clarification for turbidity removal because of the natural sedimentation process provided by Lewis and Clark Lake. Based on conversations with Banner and per review of the Final Engineering Report, the LCRWS plans to utilize similar treatment processes on the groundwater withdrawn from wells in the proximity of the Missouri River due to groundwater under the influence of surface water concerns. Therefore, the City of Sioux Falls could consider the application of the proposed treatment facilities if the City chooses to pursue groundwater near Vermillion, South Dakota in lieu of a surface water intake at Gavin’s Point Dam.

Since the City of Sioux Falls is familiar with surface water regulations and proposed treatment processes, a comprehensive discussion of drinking water regulations and an explanation of the treatment process units was deemed unnecessary for inclusion in this report document. The Missouri River is generally characterized as good water quality. As such, when treated via lime softening, conventional filtration, and chlorine/chloramine disinfection, the finished water quality would be equivalent overall to that produced by the Sioux Falls WPP and potentially of greater quality with respect to hardness. From a preliminary design perspective, the parameters defining the size and configuration of individual process units to expand the existing Sioux Falls WPP or construct a new water treatment facility are based on information provided in the Update to the Water Treatment Plant Master Plan completed by HDR Engineering, Inc. Regarding the construction of a new facility, it was assumed that the City of Sioux Falls would require similar support systems and levels of redundancy present or recommended for implementation at the existing WPP.

According to the Update to the Water Treatment Plant Master Plan, the existing WPP could be expanded to approximately 72 mgd. Based on water demand projections presented in Section 2, the City of Sioux Falls will surpass the capacity of the existing WPP in the future. It is assumed that future treatment capacity beyond 72 mgd would be provided by LCRWS or the construction of a new facility by the City of Sioux Falls.

If treatment is provided by LCRWS, the City has directed LCRWS to deliver water to the existing WPP location, with the potential identification of emergency connection points at 85th Street and Minnesota Avenue and Tea/Ellis Road and 26th Street. This decision was documented in a Blending Evaluation technical memorandum completed by HDR Engineering, Inc. per a workshop with representatives from the City of Sioux Falls, LCRWS, and Banner. The document identified various technical and public perception issues associated with receiving treated water from LCRWS at various points of the distribution system. The decision to receive water at the WPP is expected to address distribution operational concerns and minimize impacts associated with blending the water qualities.

If the City of Sioux Falls implements the Missouri River Pipeline Alternative and constructs a new facility, a similar blending issue would arise. Therefore, it is anticipated
that the City would handle blending the water quality in a similar fashion as discussed above. Under the alternatives presented in this report document, the existing pumping and storage facilities at the WPP would serve as the primary entry point of water into the distribution system through the year 2062.