NORTH GROUP

# *DRAFT* PRELIMINARY ENGINEERING REPORT

Central Lake County Joint Action Water Agency

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CDM Smith

Applied Technologies
Engineers - Architects

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## List of Abbreviations

| | |
|---|---|
| ATI | Applied Technologies, Inc. |
| AWWA | American Water Works Association |
| bgs | Below Ground Surface |
| CLCJAWA | Central Lake County Joint Action Water Agency (Agency) |
| DIP | Ductile iron pipe |
| EcoCAT | Ecological Compliance Assessment Tool |
| EIA | Environmental Impact Assessment |
| EPA | Environmental Protection Agency |
| gpm | gallons per minute |
| HAARGIS | Historic Architectural/Archaeological Resources Geographic Information System |
| HDD | Horizontal directional drilling |
| HDPE | High Density Polyethylene |
| HMI | Hazardous Material Inventory |
| IDNR | Illinois Department of Natural Resources |
| IDOT | Illinois Department of Transportation |
| IEPA | Illinois Environmental Protection Agency |
| IHPA | Illinois Historic Preservation Agency |
| IDNR/OWR | Illinois Department of Natural Resources Office of Water Resources |
| INAI | Illinois Natural Area Inventory |
| IWLC | Isolated Waters of Lake County |
| LCDOT | Lake County Department of Transportation |
| LCSMC | Lake County Stormwater Management Commission |
| NE | Northeast Route |
| NW | Northwest Route |
| NWI | National Wetlands Inventory |
| PER | Preliminary Engineering Report |
| PVC | Polyvinyl chloride |
| ppd | pounds per day |
| ppm | parts per million |
| psi | pounds per square inch |
| ROW | right-of-way |
| SRF | State Revolving Fund |
| USEPA | United States Environmental Protection Agency |
| USACE | United States Army Corps of Engineers |
| UST | Underground Storage Tank |
| WOUS | Waters of the United States |

# Section 1
# Introduction and Background

## 1.1 Project Background and Overview

The Central Lake County Joint Action Water Agency (Agency) has been providing its nine members, serving 12 communities, with potable Lake Michigan water with a high degree of quality and reliability for over twenty years. Over the past several years, a number of Lake County communities approached the Agency for membership to access Lake Michigan as their water supply source.

Four communities (Lake Villa, Lindenhurst, Grandwood Park, and Fox Lake Hills) formed one of the prospective member groups designated by the Agency as the North Group. The North Group began discussions to obtain Lake Michigan water from the Agency, and a water supply agreement was reached in 2013. In accordance with the agreement, the Agency will supply Lake Michigan water to the North Group, and the North Group will fund the expansion of the Agency's finished water transmission main system, and other associated improvements. Two of the North Group members, Fox Lake Hills and Grandwood Park, are unincorporated communities with public water systems that are owned and operated by the Lake County Department of Public Works. Lake County is a current member of the Agency. The agreement includes provisions for expanding the Lake County water service area to include these two communities. The other two North Group members, Lake Villa and Lindenhurst, are incorporated villages. Each of these villages has a public water system. The agreement includes adding Lake Villa and Lindenhurst to the Agency as new members.

A North Group Membership Expansion Technical Committee was formed to review and present recommendations to the Agency's Board of Directors during the design and construction of finished water transmission main system improvements. The new committee consists of representation from the North Group, Agency staff, and an existing Executive Committee member.

## 1.2 Project Description

The Agency's expansion project for the North Group involves extending the Agency's transmission pipeline system with approximately 13 miles of 10-inch to 20-inch piping and a delivery structure for each community. The project is divided into the Northeast (NE) and Northwest (NW) pipelines. The NE pipeline will serve the communities of Grandwood Park and Lindenhurst. The NW pipeline will serve the communities of Lake Villa and Fox Lake Hills. Section 2 provides additional information on the existing and new system along with a map showing the pipeline extension to the new communities.

In 2013, the North Group Technical Committee commissioned a Route Study to identify and evaluate pipeline routes to serve the new communities. The Route Study recommended a route for the

In 2014, the North Group Technical Committee commissioned the development of a preliminary engineering report (PER) and 30% design drawings for the transmission pipeline. This phase of the project also includes all following field investigations:

- Topographic utility survey of the pipeline routes;
- Geotechnical investigations for the pipeline routes;
- Wetland delineation and tree survey; and
- Corrosion evaluation.

In addition to field investigations, the following evaluations were completed as part of the PER Phase:

- Hydraulic analysis;
- Development of design criteria for the pipeline and delivery structures;
- Development of pipeline appurtenances design details; and
- Review of required permits and initiation with permit applications with critical agencies, such as the Lake County Stormwater Management Commission (LCSMC).

## 1.3 Report Organization

This report is divided into the following sections:

- Section 1 (Introduction and Background) – Provides background on the project and report organization.
- Section 2 (Description of Existing and Proposed System) – Provides a description of the existing Agency system and the proposed improvements along with a map of the expansion.
- Section 3 (Selected Pipeline Alignment) – Provides a description of the proposed routes along with required permits and considerations for the next phases of the project.
- Section 4 (Hydraulic and Surge Analysis) – Provides a summary of the hydraulic and surge analysis results for the final pipeline routes.
- Section 5 (Geotechnical Evaluation) – Provides a summary of the Phase I geotechnical program results.
- Section 6 (Corrosion Control and Protection) – Provides a summary of the corrosion evaluation findings and recommendations for corrosion control and protection.
- Section 7 (Wetland Delineation) – Provides a summary of the wetland delineation report.
- Section 8 (Environmental Impact Assessment) – Provides a summary of the environmental investigations, including the hazardous materials assessment.

- Section 9 (Basis of Design) – Provides a summary of the basis of design of the pipeline along with the conceptual design of the delivery structures.
- Section 10 (Opinion of Probable Construction Cost) – Provides the OPCC for the 30% design along with assumptions.
- Section 11 (Implementation Plan) – Provides an implementation plan for the project thru startup.

# Section 2
# Description of Existing and Proposed Systems

This section provides an overview of the existing Central Lake County Joint Action Water Agency (Agency) finished water transmission system and expansion to serve the North Group members.

## 2.1 Description of Existing System

The existing Agency system services its nine members, representing 12 communities located within Lake County, Illinois. Refer to **Figure 2-1** for an overview the Agency's existing finished water transmission system and existing member communities served. The finished water transmission system consists of the following components:

- Finished water pump station;
- Finished water transmission main piping;
- Booster pump station and standpipes;
- Elevated storage tank;
- Delivery structures;
- Hydropneumatic surge arrestors; and
- Sodium hypochlorite system.

The Agency is not responsible for meeting peak hour flows or fire flow demands of a member community. Member communities shall receive their allocation percentage of total flow available for distribution.

### 2.1.1 Finished Water Pump Station

The finished water pump station, located at the water treatment plant (WTP), includes six vertical turbine pumps. These pumps take water from the wetwell and pump it into the 48-inch diameter water transmission main. Three of the six pumps were replaced with larger pumps as part of the Phase 2 plant expansion project. Assuming five pumps running with the largest pump out of service at a C-factor of 130, the firm capacity of the finished water pump station is 48 MGD.

### 2.1.2 Finished Water Transmission Main Piping

The finished water transmission main is a branch system. The existing system consists of approximately XX miles of pipe, ranging in size from 48-inch diameter near the WTP to 12-inch diameter at the perimeter of the system. The existing transmission main has a capacity of 56 MGD. The pipe material is predominately pre-stressed concrete cylinder pipe (PCCP) with some shorter segments of PVC (1.3 miles total) and ductile iron pipe (2.55 miles total).

### 2.1.3 Booster Pump Station

The booster pump station (BPS) includes three vertical turbine variable speed pumps. Space has been provided for the installation of a fourth pump. The firm capacity of the BPS, with two pumps in operation and one pump as backup, is approximately 34 MGD. The BPS also includes an emergency power generator system to power the station when utility electrical service is interrupted.

### 2.1.4 System Storage

The Agency maintains storage both at the WTP and in the transmission system. At the WTP, two clearwells provide a total of 5MG of storage. The clearwell storage volume provides finished water storage for the three primary functions:

- *One-hour chlorine contact time* - Illinois Rules and Regulations require a one-hour chlorine contact time prior to the water reaching the first user.
- *Filter backwash supply* - The volume required for two successive backwashes is stored for the filter backwash supply.
- *Emergency storage* - The remaining volume in the clearwells is for emergency use.

The transmission system storage provides operational storage of 10.5 MG to allow for variable demand and pumpage in the system as well as emergency storage. This storage includes:

- *Three standpipes* - Located at the booster pump station, their total capacity is 9MG.
- *One elevated tank* - Located in Grayslake, its capacity is 1.5 MG.

### 2.1.5 Miscellaneous Finished Water Distribution Components

This section describes the delivery structures, hydropneumatic surge arrestors, and sodium hypochlorite system.

- *Delivery Structures* - Located where individual communities receive water from the Agency, each delivery structure includes a venturi meter for flow measurement, a control valve, and isolation valves. The Agency provides a minimum allowable residual pressure of 25 psi at all delivery structures.
- *Hydropneumatic Surge Arrestors* – This system protects the facility equipment from damage during a surge event. The hydropneumatic surge arrestors consists of large tanks filled partially with water and partially with air. During a surge event, which can occur after a sudden shutoff of pumps, the tanks will be able to absorb the surge wave by compressing the air inside of the tanks.
- *Sodium Hypochlorite System* - A sodium hypochlorite chemical feed system composed of on-site storage and pumping is located at the booster pump station to provide additional chlorine residual to the system.

## 2.2 Description of Proposed System

The addition of the North Group involves the following improvements to the Agency's finished water transmission system.

- Finished water transmission main piping extension; and
- Delivery structure for each new member community.

No other improvements are required as part of the Agency's expansion project for the North Group.

The new member communities will receive their allocation percentage of total flow available for distribution just as the existing member communities receive their allocated percentages. The new member communities are to provide equipment and other infrastructure required to meet peak hour flows or fire flow demands.

## 2.2.1 Proposed Finished Water Transmission Main Piping

The expansion of the finished water transmission main piping to the North Group consists of two pipelines. The first pipeline extends from an existing Agency transmission main to the Village of Lake Villa and to the Fox Lake Hills service area of Lake County Public Works (LCPW), which will be referred to as the Northwest (NW) Pipeline. The second pipeline extends from an existing Agency transmission main to the Village of Lindenhurst and to the Grandwood Park service area of the LCPW, which will be referred to as the Northeast (NE) Pipeline.

The route summaries are described below. **Section 3** provides a review of the selection process of the pipeline alignments.

The expansion will consist of 10-inch, 16-inch and 20-inch diameter pipe. The pipeline material will be either ductile iron for the 16-inch and 20-inch diameter pipe. Smaller than 16-inch diameter will be bid both as ductile iron and PVC. The design criteria for the finished water transmission main piping and appurtenances are detailed further in **Section 9**.

### 2.2.1.1 NW Pipeline Route Summary

The NW pipeline is shown in **Figure 2-2**. The pipeline route is described as a series of legs. The selected route begins at the existing Agency water main at the south end of Wood Street. Leg 1 of the route proceeds north from the beginning point to the intersection of Wood Street and Rollins Road, and then proceeds east along Rollins Road to the intersection of Rollins Road and Hook Drive. Leg 2 proceeds west along Hook drive from the end of Leg 1 to the intersection of Hook Drive and Illinois Route 83. Leg 3 proceeds north along Illinois Route 83 from the end of Leg 2 to the intersection of Illinois Route 83 and Monaville Road.

Leg 4 of the Northwest water main route begins at the end of Leg 3 and proceeds west along Monaville Road to the intersection of Monaville Road and Cedar Lake Road. Leg 5 proceeds west along Monaville Road from the end of Leg 4 to the intersection of Monaville Road and Avon Drive, then proceeds north along Avon Drive, and then east along Lincoln Drive to the terminus of the water main at the connection to the Fox Lake Hills water system.

Leg 6 of the Northwest water main begins at the end of Leg 4 at the intersection of Monaville Road and Cedar Lake Road, proceeds north along Cedar Lake Road to an easement, and proceeds east through the easement to the terminus of the water main at the connection to the Lake Villa water system.

### 2.2.1.2 NE Pipeline Route Summary

The NE pipeline is shown in **Figure 2-3**. The pipeline route is described as a series of legs. The selected route begins at the existing Agency water main in the intersection of Washington Street and Hunt Club Road. Leg 1 of the route proceeds east from the beginning point to the intersection of Washington Street and Almond Road. The route includes an alternative beginning point at the intersection of Almond Road and Illinois Route 120. The alternative Leg 1A proceeds north from its beginning point to the intersection of Almond Road and Washington Street.

Leg 2 of the Northeast route proceeds north along Almond Road from Washington Street to Illinois Route 132. Leg 3 proceeds north along Hutchins Road from the end of Leg 2 to the intersection of Hutchins Road and Woodland Terrace. Leg 4 proceeds north along Hutchins Road from the end of Leg 3 to the intersection of Hutchins Road and Stearns School Road. Leg 5 proceeds northwest along Stearns School Road from the end of Leg 4 to the intersection of Stearns School Road and U.S. Highway 45. Leg 6 proceeds south along U.S. Highway 45 from the end of Leg 5 to the intersection of U.S. Highway 45 and Falling Waters Boulevard. Leg 7 proceeds west along Falling Waters Boulevard from the end of Leg 6 to the terminus of the water main at the connection point to the Lindenhurst water system.

### 2.2.2 Proposed Delivery Structures

Each new member community is entitled to one delivery structures as part of the finished water transmission system expansion. The new delivery structures will be located based on the preference of the individual community. Each delivery structure will be consistent with those of the existing members and include a flow meter for flow measurement, a control valve, and isolation valves. Conceptual drawings for the design of the delivery structures are included in **Section 9** of the Report. The Agency will provide a minimum residual pressure of 25 psi at the delivery structures.

# Section 3
# Selected Pipeline Alignments

## 3.1 Route Study

In April 2014, the Route Study Report was submitted and approved by the Agency's Technical Committee. The Route Study Report presented two alignments: Northwest and Northeast. **Section 2** includes a summary of each of these alignments as determined in the route study phase of the project. This section identifies changes made to those alignments.

The Northwest alignment consists of seven legs. This alignment was proposed in the route study to include an alternate (referred to as Leg 7A) for the connection to Fox Lake Hills. A slight modification of Leg 7A was subsequently selected. Leg 7 was eliminated as it was located on a State Route, and would add additional pipeline installation costs with no additional benefit.

The Northeast alignment consists of eight legs. Two alternates were proposed for this pipeline alignment in the route study. During the preliminary engineering phase of the project Leg 1 and alternate Leg 1A are continued to be evaluated, and neither has been selected. Alternate Leg 7A was selected for the Lindenhurst connection. This leg will require easements from Principal Lindenhurst LLC and Northern Plains, LLC who are the underlying property owners. It is anticipated that if discussions with either company cannot result in a mutual understanding, that Leg 7 will be selected and field work will commence for this leg.

## 3.2 Agencies and Required Permits

Various Federal, State, County, local, and a railroad require permits and associated fees for the field investigation required to prepare the PER report as well as for the ultimate construction of the watermain. The agencies with the greatest potential cost impact and regulating authority are discussed below. **Appendix A** summarizes all of the anticipated project permits known at this time.

### 3.2.1 Lake County Stormwater Management Commission (LCSMC)

LCSMC's mission is to coordinate the stormwater activities of local jurisdictions to improve water quality, reduce flood damage, and restore and enhance the natural drainage system. The permits that are required by the LCSMC in accordance with the Watershed Development Ordinance (WDO) are as follows:

- Preliminary Jurisdictional Determination (PJD)
- Boundary Verification (BV)

During the course of the preliminary engineering report, the Agency has completed and paid for the PJD and BV for both the Northwest and Northeast alignments. Future fees required by the WDO will include inspection fees required to compensate the designated erosion control inspector.

The LCSMC has indicated that the length of trenchless crossings utilizing horizontal directional drilling (HDD) will be limited to a maximum length of 500-feet or less due to the potential for hydrofracture and inadvertent fluid returns. Hydrofracture is a major concern to regulatory bodies because of the perceived threats to the ecosystem as it is caused by excessive drilling fluid pressures. Hydrofractures can be caused by a number of variables such as the following:

- Loose fill or rubble above the borehole

- Desiccation cracks in highly plastic clay that extend near the depth of the bore
- Pile foundations that extend to the depth of the bore
- Bridge piers, granular material around existing utilities, tree roots, etc.
- Shallow earth cover
- Collapse of the borehole
- Excessive reaming and pullback rates
- Thin drilling fluid

Because of these risks, the LCSMC may identify additional requirements for crossing Waters of the United States (WOUS) which are regulated by the United States Army Corps of Engineers (USACE) under Section 404 of the Clean Water Act, or Isolated Waters of Lake County (IWLC) which are regulated by the LCSMC under the Lake County Watershed Development Ordinance (WDO). Both WOUS and IWLC waters are located within the limits of both of the alignments.

In addition, during review of the project's Stormwater Pollution Prevention Plan (SWPPP), The LCSMC is expected to require any dewatering water to be treated for sediment removal prior to discharge.

### 3.2.2 Lake County Forest Preserve

The Lake County Forest Preserve District agreed to the installation of the pipeline within or near their lands for specific sections of the route study phase of the project where there was no alternative. However, if an alternate is available, the District did not want the pipeline installed on or near their property which can, in some cases, extend to the centerline of the right-of-way. However, for the portion of Leg 5 of the Northwest alignment they stated that they will accept the pipeline to be located on their lands even though there is an alternate route on the south side of the street. The alternate route on the south side of the street contains a few high quality trees that they do not want to see disturbed while the north side of the street contains low quality vegetation. Field work had already been conducted on the originally agreed upon (south) side of the street. Switching to the north side of the street will require additional field work and coordination activities. It is anticipated that there will be additional as of yet unknown fees imposed on the Agency by the FPDCC for installing the pipeline on their lands.

Lake County Forest Preserve lands are located in the vicinity of both pipeline alignments, but Forest Preserve their lands will be directly impacted by the Northwest alignment. When direct impact is required, an easement will be required with a fee which includes the market value of the property, tree compensation, and additional considerations.

### 3.2.3 Illinois Department of Transportation (IDOT)

The Illinois Department of Transportation is the permitting authority for the Illinois Route 45, Illinois 83 The portion of Illinois Route 45 adjacent to Northeast leg 6 is anticipated to be widened in the near term with IDOT currently purchasing lands to expand their right-of-way in this area. This is reflected in the 30% design drawings.

The anticipated permits for IDOT include the Utility Construction Permit which will be completed by the Contractor who will also be required to obtain a Utility Bond. The Northeast and Northwest pipeline alignments both contain legs located within the IDOT ROW.

### 3.2.4 Lake County Department of Transportation

The Lake County Department of Transportation (LCDOT) is the permitting authority for the following right-of-ways located along the Northeast alignment which include the following:

- Almond Road from Route 120 north to Washington (the portion of Almond Road between Washington Street and Grand Avenue is under the jurisdiction of the Village of Gurnee)
- Washington Street
- Hutchins Road
- Sterns School Road

The following right-of-ways along the Northwest Alignment are regulated by LCDOT:

- Rollins Road
- Monaville Road, and
- Cedar Lake Road

For each roadway right-of-way under the jurisdiction of LCDOT, a Watermain Construction Permit will be required as well as a performance guarantee and insurance will be required to be obtained by the Contractor.

In discussions between LCDOT and ATI, LCDOT stated that they require the pipeline to be installed a minimum of 36-feet offset from the centerline of the right-of-way.

## 3.3 Topographical and Utility Survey

A topographical and utility survey for each of the alignments was performed. The topographical survey included survey control and benchmarks, locating geotechnical borings, locating tagged tree locations, and wetland flagging limits.

The topographical survey was performed using total station technology. The horizontal datum used is NAD 1983, Vertical datum is NAVD 1988 with conversion to NGVD 29. All horizontal and vertical control conforms to Class I Third Order Accuracy, and tied to the Illinois East State Plane Coordinate System.

Location of the wetlands flagging were performed utilizing Global Positioning System (GPS) which does not meet the accuracy requirements of the topographic survey.

A full right-of-way topographical survey was performed for the following legs of each alignment:

- Northwest: Leg1, Leg 2, Leg 3, and Leg 7A
- Northeast: Leg 6, Leg 7A, and Leg 8

A half right-of-way survey was performed for all of the remaining legs for both of the alignments.

A utility survey was performed in conjunction with the topographic survey. The following levels of utility data (in accordance with the American Society of Civil Engineering Standard Guideline 38-02) were gathered to complete the utility survey:

- Subsurface Utility Engineering (SUE) D which involves information derived from existing records or oral recollections.
- SUE C which illustrates information obtained by surveying and plotting visible above-ground utility features, and by using professional judgment in correlating this information to quality level SUE D.
- SUE B which includes obtaining information through the application of appropriate surface geophysical methods to determine the existing and approximate horizontal position of subsurface utilities. It should be noted that SUE D was only known to have been performed by the subsurface locating sub-consultant (Baker Peterson), to try to identify a pipe potentially located along Almond Road in Northeast alignment Leg 1A.

SUE quality level A (actual exposure of a utility through intrusive excavation) was not performed as part of this project.

## 3.4 Permanent and Temporary Easements

### 3.4.1 General

Permanent easements were conceptually evaluated prior to the production of 30% design drawings. The quantity of both is expected to vary throughout each stage of design as stakeholders and the public provide continual input. The quantities listed below are therefore estimates.

CLCJAWA has indicated that the location of the pipeline within easements is preferred over locating the pipeline within the existing right-of-way. Therefore, the preparation of the permanent easement locations was evaluated with an emphasis of placing the pipeline within easements wherever possible.

### 3.4.2 Permanent Easements

It was estimated that approximately 160 permanent easements may be required for this project. The locations of the proposed permanent easements are shown in **Appendix B**.

### 3.4.3 Temporary Easements

An equal number of temporary easements as permanent easements are assumed for this project. Temporary easements are required where the construction activities extend beyond the right-of-way onto adjacent privately owned lands.

## 3.5 Challenges

### 3.5.1 Permitting

Permitting will require the approval of an assortment of agencies, and not a single entity. As such, it is recommended that the stakeholders requiring permits along each of the alignments be engaged early in the process to obtain their opinions. It is suggested that engagement occur following the development of the 30 % complete design documents. These documents would be used as the basis of discussion. Currently permitting agencies have voiced their requirements as follows:

- Village of Gurnee requires horizontal directional drilling (HDD) for the crossing of their roadways.
- The Village of Lake Villa and unincorporated Warrenville Township both requires the pipeline be installed utilizing jack and bore techniques for the crossings of all roadways within their jurisdiction.

- LCDOT and IDOT also require the pipeline to be installed utilizing jack and bore techniques for the crossing of all roadways in their jurisdiction.
- LCDOT also requires the pipeline to be installed a minimum of 36-feet offset from the centerline of the right-of-way and will not allow the pipeline to be installed under pavement.
- The Village of Gurnee has stated that they will not allow for the removal of select trees along Leg 1A.
- LCSMC requires horizontal directional drilling under all wetlands.
- The railroad crossing located on Leg 4 of the Northwest alignment (Canadian National Railroad [Metra]) is required to be installed utilizing jack and bore techniques.

### 3.5.2 Constructability

One form of construction is preferred to maximize efficiency and cost. Open cut installation is the preferred method of installation of the pipeline to allow for greater local participation of contractors, shallower burial depths, and potentially lower overall costs for installation. Open cut installation is very disruptive to the right of way, and can result in the loss of vegetation, damage to existing utilities, and damage to surface features. Trenchless installation by horizontal directional drilling is normally preferred for the installation of pipe around major obstacles where the pipeline cannot be installed utilizing open cut. Various local authorities have requested the installation of the pipeline across local roads utilizing trenchless methods including horizontal directional drilling or jack and bore technologies.

Horizontal directional drilling for larger pipelines can also result in disturbances to the surface. For example, in accordance with the American Society of Civil Engineering (ASCE) Manual of Practice, the rig side area is estimated as requiring an area of approximately 15,000 square feet to be cleared and stabilized to allow for the drilling equipment, mud pump, bentonite storage, power unit, drill pipe, fluid system and tank, and associated ancillary equipment. The exit or pipe layout side is where the pipeline is fabricated to be pulled through the borehole. The workspace varies for the type of pipe being installed. For ductile iron pipe it is assumed an excavation is made for the pipe to be installed by the cartridge method. Additional workspace would include stockpiled pipe and an area for equipment to lower pipe into the excavated area. PVC pipe would require additional surface area to butt fuse the pipes together and string them out on roller stands.

Horinzontal directional drilling for larger pipeline also becomes more technically challenging the as the pipe diameter increases and the corresponding rig sizes increase. For this project, assuming a coefficient of friction between the pipe and the ground face of the bore hole, it is assumed, for a 20-inch diameter ductile iron pipe, that a force of greater than approximately 60,000lbs would be required to pull up to 1,000 feet of pipe (assuming no capstan forces as the cartridge method is assumed). However, the rig would be sized to exclude the buoyancy effect of a borehole, and would be sized to have a capacity of at least 155,000lb. This size rig capacity which would have over 100,000lbs of pullback force would be either a medi- or maxi- rig for such a long pull distance and pipe diameter. However, the maximum pullback force would be limited by the pipe joints which for DIP would be approximately 150,000lbs. Therefore, as longer drill paths are approximated there is the potential for the pipe to fail in tension at the joints as the rigs can have the capacity to pull at the yield point of the pipe. In addition, assuming a depth of 15-feet deep and the ability to drill in a medium to stiff clay (with an assumed friction angle of 17), this same pipe has the potential to settle up to approximately 3.5-inches over the centerline of the pipe at these relatively shallow depths. The settlement area can span up to 13-feet either side of the centerline of the borehole with gradually decreasing approximate settlements the farther away from the centerline of the borehole. If the pipe is able to remain in a continuous medium to stiff clay, this would require fairly low pumping pressures of the

bentonite. However, sand or gravel seams (such as existing trenches, etc) can result in frac outs as the slurry pumps compensate for the higher permeability and loss of fluids.

Jack and bore is also requested for street crossing by various municipalities. This method of trenchless installation can be used under a variety of soil conditions, and can reduce pavement damage, traffic disruptions. It is also used where open-cut construction is too disruptive, not cost effective, or not feasible either due to physical conditions or regulatory requirements. The jacking and receiving pits are required to perform this method of construction. Jacking pits are installed on one side of the road and receiving pits on the other. These pits are excavated, and typically filled with a crushed stone or gravel to provide a firm surface to support the boring machine e tracks, machine and casing pipe. The receiving pit is a much smaller pit. This form of installation also becomes more technically challenging the larger the diameter of the casing pipe, and the longer the length of the bore.

### 3.5.3 Traffic and Public Impacts

The traveling public, residences and businesses will be impacted by the work activities resulting in social costs. The social costs of construction include the inconvenience to the general public, damage to the environment, loss of business, and potential damage to existing structures. The social costs can be generally categorized as including:

- Vehicular traffic disruption
- Road and pavement damage
- Damage to adjacent utilities
- Noise and vibration
- Pedestrian and biker safety
- Site and public safety
- Business and trade loss
- Citizen complaints
- Environmental impacts

The social costs can be mitigated utilizing trenchless techniques instead of open cut, however this can result in higher overall project costs, and deeper pipe that is more difficult and expensive to maintain with the potential for existing utilities, trees, or structures located above., .

### 3.5.4 Tree Impacts

There are many trees that will be impacted by the pipeline installation. It is assumed that the primary installation method will be open cut which will have tree impact. Trenchless installation will also result in tree impacts due to the area required for work zones, however they will be less than open cut. The impact of tree loss can be minimized by relocating trees, planting trees that have restricted growth heights (and conversely restricted root depths), or other mitigating methods.

### 3.5.5 Changes to the Agreed Upon Route

As mentioned earlier in this Section, the FPDCC has verbally committed to allowing the pipeline to be installed on the north side of Monaville Road. Since field work has already been performed on the other half

of Monaville Road along this leg, this change could impact the project schedule as could other agencies requiring a shift of the alignment as the design drawings are reviewed by stakeholders having jurisdiction along either of the alignments.

### 3.5.6 Additional Requests During Design

Three villages have requested trenchless installation for the crossing of their roads as follows:

- The Village of Lake Villa requires HDD across all of their roadways.
- The Village of Gurnee requires HDD across all of their roadways.
- Unincorporated Warrenville Township requires jack and bore across all of their roadways.

# Section 4
# Hydraulic and Surge Analysis

The objectives of the hydraulic analysis are to:

- Confirm pipeline sizing for the proposed pipelines serving the new communities while maintaining the Agency's system operating criteria;
- Provide residual pressure results to the existing and new members at current and future flow conditions; and
- Provide water age and chlorine residual information to the current and new members at current low flow conditions.

## 4.1 Basis of Modeling and Assumptions

The Agency's existing calibrated hydraulic model was used as the base for the new model development. This existing model was created in WaterGEMS V8i (SELECT series 4) software Version 8.11. The existing model included the Agency's water transmission system and facilities (elevated tank, standpipes, reservoir, high service and booster pumps) and also delivery structures for Lake Bluff, Vernon Hills, Libertyville, Mundelein, Libertyville, Round Lake Park, Grayslake, Round Lake, Gurnee, and Round Lake Beach. The new model development included addition of new transmission mains and delivery structures for Fox Lake Hills, Grandwood Park, Lake Villa, Lindenhurst, Volo, and Wauconda. Although the communities of Wauconda and Volo are not included in this phase of the project, it is important to simulate their water demands and assess that impact on overall system operation. All modeling simulations and results presented below include the water demands of Wauconda and Volo.

Transmission pipes and delivery structures of the new communities were added to the existing hydraulic model from the GIS database. **Figure 2-1** shows the locations of the new community delivery structures and Agency transmission pipelines to those delivery structures. Proposed pipe sizes for the new transmission pipelines are also shown. The pipe sizes are consistent with the 2012 Capacity Expansion Assessment.

The following inputs were developed for the model development:

- New Delivery Structure Elevations - Elevations for the delivery structures were extracted from the Lake County Digital Terrain Model (DTM).
- New Transmission Pipe Lengths Size – The transmission pipeline lengths were extracted from the Route Study and latest revisions using GIS mapping. The initial pipeline sizing was based on the 2012 CDM Smith Study (Capacity Expansion Assessment dated August 14, 2012).
- Pipe Friction Factors (C-value) - The Hazen-Williams C-value is a relative measure of the hydraulic capacity of a water main. The C-value for the new transmission mains was assumed to be 110. This is consistent with the 2012 analysis. Although previous model calibration efforts confirmed a C-value of 130, it is important to account for C-value degradation over the life of the pipeline and this why the 110 C-value was used in the analysis.
- Demand Data and Allocations - The 2040 average day demands for the existing and new communities were taken from the 2012 Water Demand Projection Assessment. Current water

demands for the new members were as provided in 2012 Capacity Expansion Assessment. Current water demands for the existing members were estimated from recent water demands provided by the Agency. Current and 2040 Maximum Day Demands were developed using a peaking factor of 1.65 times the average day demands. **Table 4-1** provides a summary of water demands for the new members used in the hydraulic analysis.

**Table 4-1. Current and 2040 Water Demands for the North Group**

| Community | Current Average Demand (MGD) | Current Maximum Demand (MGD) | 2040 Average Demand (MGD) | 2040 Maximum Demand (MGD) |
|---|---|---|---|---|
| Fox Lake Hills | 0.18 | 0.30 | 0.20 | 0.33 |
| Grandwood Park | 0.44 | 0.73 | 0.46 | 0.76 |
| Lake Villa | 0.68 | 1.12 | 1.26 | 2.08 |
| Lindenhurst | 1.02 | 1.68 | 1.37 | 2.26 |

- Demand Patterns – Demand patterns for the Extended Period Simulations (EPS) were assumed to be consistent over the 24-hour period during average and maximum day demand conditions. This is consistent with the Agency's historical desired operation of maintaining constant flow over the course of the day since the Agency is not responsible for diurnal flow changes (such as peak hour flows) as well as fire flows.

The proposed transmission main sizes were evaluated for the current and 2040 demand conditions. The evaluation was based on the following established criteria:

- Velocities not to exceed 7 feet per second (fps) and ideally less than 5 fps for the new pipelines;
- Head losses not to exceed 6 feet/1,000 feet;
- Pressures not to exceed 135 psi in the system; and
- Minimum pressure of 25 psi at each delivery structure.

The model results assume Alternative B is selected for the Northeast connection point to the Agency's existing system. The hydraulic comparison between the two alternatives is later discussed in this memorandum.

**Table 4-2** summarizes the basis of hydraulic and water quality analysis, as well as the design criteria for the system.

**Table 4-2. Summary Basis of Analysis and Design Criteria**

| Parameter | Value | Notes/Comments |
|---|---|---|
| Number of Delivery Structures Per Community | One | - |
| Minimum Delivery Pressure | 25 psi | Pressure will vary depending on water demands and system conditions/operation |
| Design Flows | Maximum Day Demand Only (per CMAP 2040 flows at 1.65 peaking factor) | Fire flows and peak hour flows are the responsibility of the communities via adequate existing or new storage |
| CLCJAWA Demand Responsibility | Allocated Percentage of Plant Production Capacity | - |
| Minimum Delivery Chlorine Residual | 0.2 ppm | Each community will be responsible for booster chlorination beyond the delivery point |
| Corrosion Control and Flushing | Agency will provide non-corrosive water with an ortho-phosphate | Each community is responsible for flushing of existing distribution system to address hydraulic and water quality changes in the system during the transition to Lake Michigan water |
| Pipeline C-Value | 110 | C-value is a measure of the roughness of the pipe and is a critical parameter in sizing transmission main piping. |
| Maximum Allowable System Pressure | 135 psi | - |
| Maximum Design Velocity | <7 feet per second | |

(1) Members cannot assume 100% continuous water service from the Agency 100% of the time.
(2) An emergency response plan for existing and new members is being developed by the individual member communities.

## 4.2 Hydraulic Model Results

The hydraulic model results are broken into the following:

- Current average day and maximum day residual pressure results
- Future (2040) average day and maximum day residual pressure results
- Water age and chlorine residual results simulated during a current low flow condition (worse case water age condition).

For the residual pressure results where the hydraulic model was simulated under current and future average and maximum demand conditions, it is important to understand the limitations and assumptions:

- WTP (Water Treatment Plant) high service pumps are operational using a combination of pumps maintaining the desired flow condition and maintaining discharge pressure of less than 135 psi.
- The new intermediate booster pump station is assumed to be operational when simulating the 2040 maximum day flow conditions. This pump station is on the finished water transmission main, located along Route 176 near the east border of Libertyville.

- The analysis assumes that the existing and new members' water demands are consistent and peak (at the peaking factor of 1.65) simultaneously.
- The existing elevated tank continues to float on the system at all times to provide the surge protection needed (continued to operate below the overflow elevation of 1000-feet and above the minimum level of approximately 960-feet). Given the hydraulic impact of the elevated tank on the system, the model was simulated with and without the elevated tank in service. The model assumed an initial elevated tank level of 974-feet.
- The standpipes water level will vary to provide the Agency with the flexibility to operate the system efficiently and stay below the standpipe overflow elevation of approximately 896-feet.
- The existing standpipes and booster pumping station are operational using a combination of pumps required to maintain the hydraulic grade line to float the elevated tank on the system. A future fourth booster pump will be required for the 2040 maximum flow conditions.
- The available pressures provided in this memorandum are estimated based on normal operational scenarios and should not be used by the communities for designing their internal distribution system improvements. The North Group should design all internal improvements assuming a delivery pressure of 25 psi and chlorine residual of 0.2 ppm.

### 4.2.1 Current Average Day Demand Results

The water model was simulated for the current average day demand conditions. The total demand in the system for this scenario is 25.3 MGD. The available residual pressures for the current average day demand conditions are summarized in **Table 4-3**. Please note that these pressures are estimated based on normal operational scenarios. The Agency will optimize its system operation to delivery 25 psi at the control point, which can change depending on the flow conditions.

**Table 4-3. Residual Pressure for Current Average Day Demand Conditions**

| Community | Residual Pressure (PSI) with Elevated Tank in Service (1) |
|---|---|
| Fox Lake Hills | 25 – 83 (+/- 5%) |
| Grandwood Park | 25 – 83 (+/- 5%) |
| Lake Villa | 25 – 71 (+/- 5%) |
| Lindenhurst | 25 – 78 (+/- 5%) |

(1) The residual pressure when the tank is out of service depends on the number of booster pumps in operation and the water demands for the existing members. The estimate pressure ranges between 25 and 40 psi for the new communities.

### 4.2.2 Current Maximum Day Demand Results

The water model was simulated for the current maximum day demand conditions. A peaking factor of 1.65 was applied to the average day demands. The total demand in the system for this scenario is 41.8 MGD. The available residual pressures for the current maximum day demand conditions are summarized in **Table 4-4**.

**Table 4-4. Residual Pressure for Current Maximum Day Demand Conditions**

| Community | Pressures (PSI) with Elevated Tank in Service | Pressures (PSI) with Elevated Tank Out of Service |
|---|---|---|
| Fox Lake Hills | 25 – 75 (+/- 5%) | 25 – 37 (+/- 5%) |
| Grandwood Park | 25 – 75 (+/- 5%) | 25 – 37 (+/- 5%) |
| Lake Villa | 25 – 63 (+/- 5%) | 25 (+/- 5%) |
| Lindenhurst | 25 – 66 (+/- 5%) | 25 – 28 (+/- 5%) |

**Appendix C** includes a summary of flows and residual pressures for the current and future communities under current water demand conditions.

### 4.2.3 2040 Average Day Demand Results

The water model was simulated for the 2040 average day demand conditions. The total demand in the system for this scenario is 30.9 MGD. The available residual pressures for the 2040 average day demand conditions are summarized in **Table 4-5**.

**Table 4-5. Residual Pressure for 2040 Average Day Demand Conditions**

| Community | Pressures (PSI) with Elevated Tank in Service (1) |
|---|---|
| Fox Lake Hills | 25 - 79 (+/- 5%) |
| Grandwood Park | 25 - 81 (+/- 5%) |
| Lake Villa | 25 - 65 (+/- 5%) |
| Lindenhurst | 25 - 74 (+/- 5%) |

(1) The residual pressure when the tank is out of service depends on the number of booster pumps in operation and the water demands for the existing members. The estimate pressure ranges between 25 and 40 psi for the new communities.

### 4.2.4 2040 Maximum Day Demand Results

The water model was simulated for the 2040 maximum day demand conditions. A peaking factor of 1.65 was applied to the average day demand. The total demand in the system for this scenario is 51.0 MGD. The available residual pressures for the 2040 maximum day demand conditions are summarized in **Table 4-6**.

**Table 4-6. Residual Pressures for 2040 Maximum Day Demand Conditions**

| Community | Pressures (PSI) with Elevated Tank in Service | Pressures (PSI) with Elevated Tank Out of Service |
|---|---|---|
| Fox Lake Hills | 25 – 64 (+/- 5%) | 25 – 47 (+/- 5%) |
| Grandwood Park | 25 - 70 (+/- 5%) | 25 - 53 (+/- 5%) |
| Lake Villa | 25 - 50 (+/- 5%) | 25 - 33 (+/- 5%) |
| Lindenhurst | 25 - 57 (+/- 5%) | 25 - 40 (+/- 5%) |

This scenario assumes the operation of the new intermediate booster pumping station, WTP improvements to provide the 51 MGD flow, and the addition of a fourth pump at the existing Booster Pumping Station. The new intermediate booster pumping station is needed when flows from the WTP approach 46 MGD. This is based on a C-value in the pipe of 110. **Figure 4-1** provides a hydraulic profile at the 2040 maximum day demand conditions (design condition). **Appendix C** includes the full hydraulic analysis results.

### 4.2.5 Water Quality Analysis – Water Age and Chlorine Residual

Water age is a measure of the water turnover in the distribution system (i.e. how long has the water been in the distribution system since its original source at the water treatment plant). Long water age (distribution system residence time) may lead to loss of chlorine residual in the system, potential formation of disinfection-by-products, and formation of biofilm.

An extended period simulation (EPS) of the model was performed for ten days under a current minimum day demand of 13 MGD to determine if the system has water age problems. Minimum day demand was estimated using a peaking factor of 0.5 over the current average day demand. Water age is a function primarily of water demand, system operation, and system design. Generally, water age decreases as the demand in the system increases, operation of booster pumps or smaller pipe sizes. The water age under the low demand flow condition for the new communities is summarized in **Table 4-7**.

**Table 4-7. Water Age During Minimum Day Demand Conditions (13 MGD)**

| Community | Water Age (hours) |
|---|---|
| Fox Lake Hills | 66 (+/- 10%) |
| Grandwood Park | 42 (+/- 10%) |
| Lake Villa | 58 (+/- 10%) |
| Lindenhurst | 50 (+/- 10%) |

Analysis for residual chlorine is dependent on the following parameters. These parameters were based from the 2002 Water Quality Modeling Study where the reaction rates were simulated based on actual field conditions for the Agency's system.

- Bulk reaction rate of 0.22/day – The bulk reaction rate or decay factor was developed based on August 2002 chlorine residual testing where the water temperature ranged between 20 and 23 degrees Celsius. This will produce more conservative results since most low flow conditions occur in the winter where chlorine decay is lower.
- Wall reaction rate of 0.080 feet/day.
- Diffusivity (of chlorine in water) is 1.208 x $10^{-9}$ $ft^2$/sec.

For this scenario a chlorine residual of 0.7 mg/L was simulated leaving the water treatment plant and a residual of 0.8 mg/L at the existing booster pumping station. An extended period simulation (EPS) of the model was performed for ten days under a current minimum day demand of 13 MGD to identify the available chlorine residual in the system. Minimum chlorine residual at the delivery structure of the newer communities are summarized in **Table 4-8**.

**Table 4-8. Chlorine Residual Results During Minimum Day Demand Conditions (13 MGD)**

| Community | Chlorine Residual (ppm) |
|---|---|
| Fox Lake Hills | 0.2 - 0.4 (+/- 0.1) |
| Grandwood Park | 0.2 – 0.6 (+/- 0.1) |
| Lake Villa | 0.2 – 0.5 (+/- 0.1) |
| Lindenhurst | 0.2 – 0.5 (+/- 0.1) |

**Figure 4-2** provides a chlorine decay curve from the WTP to Fox Lake Hills. **Appendix C** includes a summary of flows, water age, and chlorine residual for the current and future communities.

### 4.2.6 Northeast Route – Alternative A Route vs Alternative B Route

As shown in the attached map, for the Northeast pipeline serving the communities of Grandwood Park and Lindenhurst, two alternatives are currently being evaluated to where the proposed pipeline will tie into the existing Agency's transmission system. Alternative A is a proposed 20-inch along Washington Street running in parallel to an existing 12-inch pipeline. The proposed 20-inch ties to the existing 30-inch along Hunt Club Road. Alternative B is a proposed 20-inch along Almond Road. Both alternatives are currently being included in the Preliminary Engineering Report and will be surveyed.

The hydraulic model was simulated to determine the hydraulic impact for both alternatives under the 2040 maximum day demand conditions. **Table 4-9** summarizes the comparison between the two alternative routes. Based on the hydraulic results and the additional headloss through the existing 30-inch pipeline on Hunt Club Road, Alternative B along Almond Road is recommended.

**Table 4-9. Comparison of Hydraulic Results for Northeast Connection Point to Agency's System**

| Parameter | Alternative A | Alternative B |
|---|---|---|
| Pressure (PSI) at Grandwood Park Delivery Point | 59 (+/- 5%) | 67 (+/- 5%) |
| Pressure (PSI) at Gurnee Delivery Point | 74 (+/- 5%) | 78 (+/- 5%) |
| Pressure (PSI) at Lindenhurst Delivery Point | 45 (+/- 5%) | 54 (+/- 5%) |

### 4.2.7 Conclusions and Recommendations

The following conclusions and recommendations were developed based on the above hydraulic and water quality modeling results:

- The pipeline sizes previously developed to serve the new communities are confirmed.
- The new intermediate booster pump station is needed when the discharge pressure out of the WTP high service pumps approaches 135 psi, which equates to a total system demand of 46 MGD.
- The Agency's water system and proposed improvements will allow the Agency to meet the new members current and future water demands while maintaining a minimum delivery pressure of 25 psi. Higher residual pressure at the delivery points depends on the operation/level of the elevated tank, distribution of demands in the system, and the optimization of pumping operation at the WTP and booster pumping stations.
- The expansion of the Agency's system will result in higher water age to the new members. The higher water age will reduce chlorine residual in the system to the new members. Based upon the results, all four new communities should plan on booster chlorination.
- In comparing Alternative A versus Alternative B for connecting to the Agency's existing transmission system, Alternative B (Almond Road) is recommended due to the decrease in headloss and the improved reliability of the system.

## 4.3 Surge Analysis

To be completed following completion of 30% design drawings to capture pipe profile.

# Section 5
# Geotechnical Evaluation

## 5.1 Overview

A preliminary geotechnical evaluation, including a subsurface site investigation and laboratory testing program, was conducted as part of the preliminary design for this project.

The proposed water main will typically be constructed using the open cut method. However, due to various physical limitations (for example railroad track), permitting, and other project constraints, a number of trenchless crossings were proposed. Preliminary evaluation on the subsurface conditions for trench excavation, pipe support and considerations for trenchless crossing construction is provided below.

## 5.2 Subsurface Exploration Programs

To assist with design of the proposed pipeline, a two-phase geotechnical exploration program was planned to evaluate the subsurface conditions along the pipeline alignment.

### 5.2.1 Phase I Subsurface Exploration Program

The Phase I geotechnical exploration consisting of 74 test borings along the northeast and northwest alignments was conducted by Wang Engineering, Inc. of Lombard, Illinois between August and November 2014. The test borings are typically spaced approximately 1000 feet to 1200 feet along the alignment and extended to depth ranging from 12 to 36 feet. All test borings were drilled and logged by Wang Engineering, Inc. Ten groundwater level piezometers were installed at select trenchless boring locations along the alignment as part of this exploration program.

Laboratory testing consisting of moisture content, grain size analysis, Atterburg Limits and organic content was conducted on selected soil samples.

Details of the Phase I subsurface investigation program, including boring logs, and laboratory testing data are included in the Draft Geotechnical Data Report prepared by Wang Engineering in **Appendix D**.

### 5.2.2 Phase II Subsurface Exploration Program

Phase II subsurface investigation program will be conducted as part of the final design of the project. The Phase II investigation program will include approximately 70 to 75 additional test borings along the final pipe alignment to provide additional subsurface information, and will focus particularly on areas that require further investigation as identified in the Phase I exploration program. Associated Phase II laboratory testing program will also be conducted to assist in the evaluation of engineering properties of the soils encountered.

## 5.3 Subsurface Conditions and Preliminary Geotechnical Evaluation

Based on the Phase I subsurface investigation data and the approximate depth of the proposed pipeline, the subsurface condition along the pipe alignment generally consists of medium stiff to very stiff clay and silt with occasional layers of loose to medium dense silty sand, which are generally suitable for supporting the proposed pipeline with the below noted exception.

At test boring location 4NW-11, which is along Cedar Lake Road, soft silty clay was encountered over approximately 11 feet of soft, compressible, highly organic fibrous peat to a depth of about 18 feet below ground surface. These materials are not suitable for pipeline support due to potential for significant settlement of the pipeline as well as other constructability issues. Method of mitigation includes over-excavation and replacement with suitable materials. Additional test borings in this area should be conducted during the detailed design phase of the project to further delineate both lateral and vertical extent of this organic layer. Further evaluation on mitigation measures as well as potential limits of over-excavation will be conducted during the detailed design phase.

Along most of the trenchless crossing areas, medium stiff to very stiff clay and silt with various amount of sand were encountered to the depth where the test borings terminated. A sand and gravel layer was encountered at depth along part of Almond Road in the area of Northeast alignment Leg 2, which will be further evaluated in the selection of the trenchless method and vertical alignment of the crossing.

Considering the size of the carrier pipe (10 to 20-inch diameter), the subsurface conditions and other project limitations, trenchless methods including pipe jacking, horizontal direction drilling (HDD), and jack and bore are considered technically feasible and will be further evaluated in the final design.

Rock was not encountered at any of test boring locations and very limited thickness of fill were noted in the test borings. Therefore, it is anticipated that most of the excavation could be conducted without requiring utilization of a rock excavation technique.

Due to the large variation of the site grade along the two alignments (NE and NW), which ranges from approximately elevation 720 to elevation 820, groundwater elevation is anticipated to vary. Groundwater was not encountered in most of the shallow borings that extended to about 12 feet below ground surface. However, groundwater levels readings ranging from about 5 to 36 feet below ground surface were recorded at selected test boring location at time of drilling. Due to the low permeability nature of the majority of the soils encountered, the water level measured at the end of drilling may not be representative of the steady-state groundwater level. Additional groundwater level measurements from the installed piezometers will be recorded during the Phase II Geotechnical Program.

# Section 6
# Corrosion Control and Protection

## 6.1 Overview

A corrosion assessment was performed for both the Northwest and Northeast proposed pipeline alignments. The assessment consisted of collecting and analyzing soil samples collected during the Phase I geotechnical investigation program for specific parameters that influence corrosion, and performing a field and record search for existing pipelines or other appurtenances that could impact the rate of corrosion. This section summarizes the results of the Corrosion Evaluation Report provided in **Appendix E**.

## 6.2 Conclusions

Soil samples collected and analyzed along the Northwest and Northeast alignments indicate the soils are corrosive due to their poorly draining clayey soil indicated by resistivity measurements less than 2,000 ohm-cm, and moisture contents of less than 25%. Additional soil parameters were also evaluated including chloride ion concentrations, sulfate ion concentrations, soil pH, and oxidation/reduction measurements. However, these additional parameters did not indicate they impacted the corrosion of metallic structures.

Therefore, based on the results collected, the soil conditions exhibit properties where sustained corrosion can occur, and metallic pipelines and appurtenances would be expected to exhibit normal corrosion of buried metallic materials.

In addition to the evaluation of the soil properties, a DC interference study was performed. It was determined that the following pipeline operators operate and maintain foreign pipelines located in the vicinity of the transmission main and protected by a rectified anode cathodic protection system:

- Kinder Morgan/NGPL
- West Shore Pipeline
- AGL/Nicor Gas Company

Based on the results of the corrosion protection investigation, all ferrous materials should be protected from soil corrosion. All ductile iron pipe shall be wrapped in polyethylene sheathing (poly wrap), and supplemented with sacrificial anodes installed with the pipe.

At the locations of pipelines containing rectified anode systems that cross the proposed transmission main, foreign test stations should be installed to allow the draining of any DC interference current from the transmission main back to the foreign pipeline. It is further recommended that a minimum distance of 12-inches (preferably 24-inches) be maintained between the proposed water transmission main and any foreign pipeline.

The PVC pipe does not require any special corrosion protection except at those locations where metallic material is installed such as at valves or fittings. Those metallic materials should be coated with fusion bonded epoxy and supplemented with sacrificial anodes.

# Section 7
# Wetland Delineation

## 7.1 Overview

A wetland delineation of the Northwest and Northeast alignments was conducted in the Summer and Fall of 2014 by Hey and Associates, Inc. This section summarizes the results of the wetlands delineation and report. The reports for the Northwest and Northeast alignments are located in Appendices F and G, respectively.

## 7.2 Wetlands Delineation Summary

The Northeast alignment contains thirteen wetlands and two waters of the United States. Lake County Stormwater Management Commission (LCSMC) provided a written preliminary jurisdictional determination letter dated November 18, 2014 which concluded that "the WOUS include Wetlands 4, 6, 7, 8, 9, 11, and 12, and Waters WOUS 1 and WOUS 2", "the IWLC include Wetlands 1, 2 (western portion only), 5, and 13 (including Farmed Wetland FW 13)" and that the eastern portion of Wetland 2, Wetlands 3 and 10 are "excluded from regulatory status".

The Northwest alignment contains sixteen wetlands. Lake County Stormwater Management Commission (LCSMC) provided a written preliminary jurisdictional determination letter dated October 17, 2014. The letter stated that "the WOUS include Wetlands 6, 7, 8, 9, 10, 12, 13, 14 and 15", "and the IWLC include Wetlands 1, 2, 4, 11 and 16" and that Wetlands 3 and 5 are "excluded from regulatory status".

Wetlands cannot be filled or otherwise impacted without permit authorization. Generally, permanent impacts under 0.10-acre and temporary impacts for jurisdictional and isolated wetlands do not require mitigation of wetland losses. Any permanent impacts over this acreage threshold will require mitigation at a minimum of 1.5:1. Jurisdictional wetland/water impacts would be permitted by the Corps under a Regional Permit 8 (Utility Line Projects) unless the permanent impacts are greater than 1.00-acre. Then an Individual Permit would be required from the Corps as well as a 401 water quality certification from the Illinois Environmental Protection Agency. Isolated wetland impacts would be permitted through LCSMC.

Hey and Associates recommends avoiding wetland impacts. For the Northeast alignment, it is recommended to especially avoid Wetland 7 which is a wet meadow/forested woodland. This wetland is located along a Mill Creek tributary located on the east side of Hutchins Road.. This wetland has been identified to have high functional value for water quality. For the Northwest alignment it is recommended to especially avoid Wetland 10 which is an emergent marsh. This wetland is located on the north and south side of Monaville Road at the intersection with Old Monaville Road. This wetland has moderate functional value for water quality and wildlife habitat, but is of high vegetative quality. Both wetlands should be avoided as best as practicable by going around or under each wetlands.

# Section 8
# Environmental Impact Assessment

## 8.1 Description

CDM Smith completed an environmental assessment for two pipeline routes, a northwest route and a northeast route. The approximately 13 miles of pipeline is assumed to be 20-inches in diameter or less and buried a minimum of 6-feet using a combination of open cut and trenchless installation. The pipelines would be predominantly installed in the right-of-ways, but it is assumed that a portion may be installed within easements.

The purpose of this environmental assessment is to identify historically significant sites, wetlands, endangered species, and natural areas that could exist within the project areas and that could impact project construction. This Section also provides an assessment of the hazardous materials impact.

**Appendix H** contains the environmental approvals and correspondence received to date.

## 8.2 Northwest Route

The northwest route extends north along Illinois Route 83 and then west along Monaville Road. The following is a summary of the environmental assessment in relation to this route.

### 8.2.1 Illinois State Historic Preservation Agency

CDM Smith consulted with the Illinois Historic Preservation Agency (IHPA) State Historic Preservation Officer (SHPO) to request a federal Section 106 sign-off for this pipeline route. CDM Smith used the Historic and Architectural Resources Geographic Information System (HARGIS) to determine if there are potential historic sites along the proposed route. There are no historic sites in the vicinity of the proposed route. A letter from the IHPA SHPO stated that no historic properties are affected by this undertaking.

### 8.2.2 Wetlands

CDM Smith coordinated with the Illinois Department of Natural Resources (IDNR) to identify potential wetlands along this pipeline route. CDM Smith submitted a request through the Ecological Compliance Assessment Tool (EcoCAT). The National Wetlands Inventory (NWI) shows wetlands within 250 feet of the proposed route and further IDNR review was required. A letter from the IDNR Division of Ecosystems and Environment stated that the proposed action is generally considered a minimal wetland impact. Impacts are minimal if the affected wetland is located within a maintained road right-of-way or the area is zoned and utilized in its entirety for residential, commercial, industrial, or other developed categories, and each of the following construction conditions exist:

- The trench width is less than 10 feet.
- Erosion control measures meet either the specifications in the “Green” book for erosion control in construction sites or the requirements of the NPDES Construction Site Activities permit.
- Any wetland tree removal is less than 4-inch diameter at breast height (dbh).
- Soil stockpiles and construction equipment are stored outside of the wetland.

If wetlands will be disturbed, the following 1:1 mitigation requirements must be incorporated into project plans:

1. Grade and contour the disturbed area to its original conditions within 30 days of project completion.
2. Reseed the area within seven days of completing step 1.
3. Restore any other pre-existing wetland condition.

If wetlands will be impacted and the minimal impact criteria will not be met, or if the 1:1 mitigation requirements cannot be incorporated into the construction plans, IDNR must be notified and the consultation will be re-opened. If wetlands will not be disturbed, no action is necessary.

### 8.2.3 Endangered Species and Natural Areas

CDM Smith coordinated with the IDNR to identify potential endangered species and natural areas along this pipeline route. CDM Smith submitted a request through the EcoCAT. The Illinois Natural Heritage Database shows that the following protected resources may be in the vicinity of the proposed route: Cedar Lake Illinois Natural Area Inventory (INAI) site, Deep Lake INAI site, Fourth Lake-Rollins Road Savanna INAI site, Gavin Bog and Prairie INAI site, Windance Acres Marsh INAI site, Cedar Lake Bog Nature Preserve, Gavin Bog and Prairie Nature Preserve, Branded Killfish (*Fundulus diaphanus*), Black Tern (*Chlidonias niger*), Black-Crowned Night-Heron (*Nycticorax nycticorax*), Blackchin Shiner (*Notropis heterodon*), Blacknose Shiner (*Notropis heterolepis*), Blanding's Turtle (*Emydoidea blandingii*), Common Moorhen (*Gallinula chloropus*), Forster's Tern (*Sterna forsteri*), Iowa Darter (*Etheostoma exile*), Least Bittern (*Ixobrychus exilis*), Small Sundrops (*Oenothera perennis*), Wilson's Phalarope (*Phalaropus tricolor*), and Yellow-Headed Blackbird (*Xanthocephalus xanthocephalus*).

A letter from the IDNR Division of Ecosystems and Environment stated that the state-endangered Blanding's Turtle (*Emydoidea blandingii*) has been recorded in the vicinity of the proposed route. To minimize potential adverse effects during construction, the following protective measures must be observed:

1. Educate personnel working on site about Blanding's Turtle. Post photos of juvenile and adult Blanding's at a central location.
2. Install exclusionary fencing (making sure it is dug into the ground) to prevent turtles from entering construction areas.
3. Conduct daily inspections for transiting turtles. If a Blanding's Turtle is encountered, crews must stop work and allow the turtle to move out of the way or call IDNR.
4. Routinely inspect trenches and excavations before starting work each day to assure no turtles have become trapped within them. Make sure trenches and excavated areas are covered each evening to avoid trapping any amphibians or reptiles.

## 8.3 Northeast Route

The northeast route extends north along Almond Road and Hutchins Road. The following is a summary of the environmental assessment in relation to this route.

### 8.3.1 Illinois State Historic Preservation Agency

CDM Smith consulted with the IHPA SHPO to request a federal Section 106 sign-off for this pipeline route. CDM Smith used HARGIS to determine if there are potential historic sites along the proposed route. There are no historic sites in the vicinity of the proposed route. A letter from the IHPA SHPO stated that no historic properties are affected by this undertaking.

### 8.3.2 Wetlands

CDM Smith coordinated with the IDNR to identify potential wetlands along this pipeline route. CDM Smith submitted a request through the EcoCAT. The NWI shows wetlands within 250 feet of the proposed route and further IDNR review was required. A letter from the IDNR Division of Ecosystems and Environment stated that if wetlands will be disturbed, the project must meet certain construction conditions and incorporate 1:1 mitigation requirements into the project plans. Impacts are minimal if the affected wetland is located within a maintained road right-of-way or the area is zoned and utilized in its entirety for residential, commercial, industrial, or other developed categories, and each of the following construction conditions exist:

- The trench width is less than 10 feet.
- Erosion control measures meet either the specifications in the "Green" book for erosion control in construction sites or the requirements of the NPDES Construction Site Activities permit.
- Any wetland tree removal is less than 4-inch dbh.
- Soil stockpiles and construction equipment are stored outside of the wetland.

If wetlands will be disturbed, the following 1:1 mitigation requirements must be incorporated into project plans:

1. Grade and contour the disturbed area to its original conditions within 30 days of project completion.
2. Reseed the area within seven days of completing step 1.
3. Restore any other pre-existing wetland condition.

If wetlands will be impacted and the minimal impact criteria will not be met, or if the 1:1 mitigation requirements cannot be incorporated into the construction plans, IDNR must be notified and the consultation will be re-opened. If wetlands will not be disturbed, no action is necessary.

### 8.3.3 Endangered Species and Natural Areas

CDM Smith coordinated with the IDNR to identify potential endangered species and natural areas along this pipeline route. CDM Smith submitted a request through the EcoCAT. The Illinois Natural Heritage Database shows that the following protected resources may be in the vicinity of the proposed route: Almond Marsh Illinois Natural Area Inventory (INAI) site, Fourth Lake-Rollins Road Savanna INAI site, Mcdonald Woods Marsh INAI site, Almond Marsh Nature Preserve, Fourth Lake Fen Nature Preserve, Oak Openings Nature Preserve, Rollins Savanna Nature Preserve, Black-Crowned Night-Heron (*Nycticorax nycticorax*), Blanding's Turtle (*Emydoidea blandingii*), Common Moorhen (*Gallinula chloropus*), Forster's Tern (*Sterna forsteri*), Least Bittern (*Ixobrychus exilis*), Wilson's Phalarope (*Phalaropus tricolor*), and Yellow-Headed Blackbird (*Xanthocephalus xanthocephalus*).

A letter from the IDNR Division of Ecosystems and Environment stated that adverse effects are unlikely to the above listed resources and consultation is terminated.

## 8.4 Potential Hazardous Materials Sites

CDM Smith completed a limited Hazardous Materials Impact (HMI) Summary for the Agency's North Group Water System Expansion Project. The HMI was performed along the two proposed water transmission routes (Northeast and Northwest).

The purpose of the HMI is to identify properties within the Project area with the potential for hazardous materials to be present in environmental media. Additionally, a list of sites requiring additional investigation was identified based on the construction requirements proposed for the Project. These sites have been identified to be the most likely to cause a hazardous materials impact to the proposed construction.

This assessment is critical to optimizing soil disposal during the project to reduce environmental risks and minimize unnecessary costs.

### 8.4.1 Basis of Environmental Assessment and Analysis

The scope included a review of state and federal databases in order to identify the sites/parcels with the most potential for hazardous materials concerns.

The following is a summary of the databases included as part of the review.

- Review of state and federal databases: CDM Smith retained GeoSearch to conduct a search of state and federal databases to identify any environmental sites located within 500 feet of the study area. The following databases were reviewed:
  - Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS)
  - USEPA National Priority List (NPL)
  - Facility Index System (FINDS)
  - CERCLIS-No Further Remedial Action Planned (NFRAP)
  - Resource Conservation and Recovery Information System-Treatment, Storage, and Disposal (RCRIS-TSD)
  - Resource Conservation and Recovery (RCRA) Corrective Action Activity (CORRACTS)
  - RCRIS-Large Quantity Generators (LQG)
  - RCRIS-Small Large Quantity Generators (SQG)
  - US Brownfields List
  - Toxic Release Inventory System (TRIS)
  - Emergency Response Notification System (ERNS)
  - Department of Defense (DOD) sites
  - Office of the Illinois State Fire Marshal (OSFM) Underground Storage Tank (UST) Database
  - Illinois Environmental Protection Agency (IEPA) Site Remediation Program (SRP) Sites
  - IEPA List of Sites with Controls
  - IEPA List of State Response Action Sites
  - IEPA List of Construction Debris Landfills
  - IEPA List of Active Landfills

- IEPA Listing of Spills
- IEPA List of Leaking Underground Storage Tanks (LUST)
- IEPA List of National Pollutant Discharge Elimination System Database

### 8.4.2 Environmental Risk Assessment

Sites may be listed in one or more databases. In general, a site listed under the Facility Registry System (FRSIL), National Pollutant Discharge Elimination System (NPDES), and/or as a Resource Conservation Recovery Act Generator (RCRAGR05) was considered a **low risk**. Sites with single listings that included dry cleaners (CLEANERS), underground storage tanks (UST), permit compliance system (PCS), No Further Response Action Planned (NFRAP), or spills along the roadway (SPILLS) were considered a **moderate risk**. Sites with multiple listings including RCRAGR05, Hazardous Materials Incident Reporting System (HMIRSR05), Site with Controls (SC), Leaking UST (LUST) incidents, SPILLS with a UST present, or Site Remediation Program (SRP) were given a **high risk**.

**Table 8-1** provides the numbers of sites for each risk category.

**Table 8-1. Potential Hazardous Materials Sites**

| Route | Sites with Potential Hazardous Materials Concerns | | |
|---|---|---|---|
| | High Risk | Medium Risk | Low Risk |
| Northeast Route | 0 | 5 | 6 |
| Northwest Route | 3 | 0 | 12 |

### 8.4.3 Environmental Sampling

The environmental sampling program was performed to investigate the level of contamination in soils that may be excavated during the construction of the Pipeline. The samples proposed for testing were determined by CDM Smith based on the review of the database and the general area of the boring (farmland, residential, industrial).

Each sample selected for environmental testing was analyzed for all or part of the following parameters:

- Volatile organic compounds (VOCs)
- Semi-volatile organic compounds (SVOCs)
- Polynuclear aromatic hydrocarbons (PNAs)
- Target Analyte List (TAL) metals
- Resource Conservation and Recovery Act (RCRA) metals
- Pesticides and herbicides
- Polychlorinated biphenyls (PCBs)
- pH

In general, sample analysis was determined based on the following:

- All samples selected for environmental testing were analyzed for pH.
- Samples in areas near sites identified as a potential high risk in the environmental database review were also analyzed for VOCs, SVOCs, and TAL or RCRA metals.
- Samples not in areas near sites as a potential risk in the environmental database review were analyzed for VOCs only if elevated PID (photoionization detector) readings occur in the field, as well as PNAs and RCRA metals.
- Select samples in farmland areas were analyzed for herbicides and pesticides.
- Select samples in industrial areas were analyzed for PCBs.

### 8.4.4 Subsurface Soil Investigation

An environmental sampling program was performed by Wang to investigate the extent of contamination in soils that may be excavated during the construction of the Pipeline. The Phase I environmental sampling was conducted in the same boreholes as the geotechnical investigation. Phase II sampling will be completed upon a review of both the geotechnical and environmental findings. At this time additional samples may be collected in order to delineated the known impacts and reduce the overall disposal costs.

The subsurface soil investigation was conducted at the Site from August 11 through October 8, 2014. As part of the subsurface investigation, a total of 72 soil borings were advanced to assess soil quality beneath the Site at the locations shown on **Figure 8-1** and **Figure 8-2**. The soil borings were completed using a hollow-stem auger drill rig (HSA). Soil was collected continuously in approximately 4-foot intervals to depths of 12 feet below ground surface (bgs). Subsurface soils were collected by driving a stainless steel barrel into the subsurface. Upon sample retrieval, soils were examined for visual indications (i.e., staining, discoloration, oily sheens, etc.) and olfactory indications (i.e., solvent odors, petroleum odors, etc.) of potential contamination. In addition, a photoionization detector (PID) was used to qualitatively screen the soil. The visual, olfactory, and PID information was used to indicate potential contamination. One sample was collected from each boring (73 total) based on the field screening results. A field scientist classified soils according to the Unified Soil Classification System (USCS) and recorded soil boring details on a field form.

The soil samples were logged, properly labeled, placed in iced coolers and delivered to STAT Analysis (STAT) using standard chain-of-custody procedures. STAT performed the analyses in accordance with the Quality Assurance/Quality Control (QA/QC) procedures set forth for each analytical method in USEPA SW-846 (USEPA 1996) as well as their own established QA/QC procedures.

### 8.4.5 Analytical Soil Results

A total of 72 soil samples were analyzed by the environmental testing laboratory. The results were compared to the Summary of Maximum Allowable Concentrations (MAC) of Chemical Constituents in Uncontaminated Soil Used as Fill Materials from 35 IAC 1100.Subpart F. The MAC standards outline objectives for soil to be used as clean fill based on risks to human health. A summary of soil analytical results compared to the MAC standards is shown on **Figure 8-1** and **Figure 8-2**, and the results are summarized in **Table 8-2**.

- There were no exceedances of VOCs, SVOCs, PNAs, PCBs, herbicides, pesticides, or pH.

- Metals (Arsenic, Chromium, Iron, and Manganese) exceeding the MAC table were detected at twelve (12) soil boring locations.

**Table 8-2. Analytical Results**

| Route | Chemical | No. Borings | Range | MAC | Background |
|---|---|---|---|---|---|
| Northeast Route | Chromium (Cr) | 2 | 23-26 | 21-24 | 16.2 |
| | Iron (Fe) | 5 | 16,000-43,000 | 15,900 | 15,900 |
| | Manganese (Mg) | 2 | 710-720 | 636 | 636 |
| Northwest Route | Arsenic (Ar) | 1 | 22 | 13.0 | 13.0 |
| | Chromium (Cr) | 2 | 34-37 | 21-36 | 16.2 |
| | Iron (Fe) | 2 | 24,000-29,000 | 15,900 | 15,900 |
| | Manganese | 1 | 650 | 636 | 636 |

## 8.4.6 Conclusions and Next Steps

Based upon the site investigations and results, additional investigation is recommended required during Phase II in order to delineate the contaminants found in soil along the pipeline. Currently, approximately 17% of the material will require disposal as nonhazardous waste at a Subtitle D landfill. Typical disposal costs at a Clean Construction and Demolition Debris (CCDD) facility is $100 per load (~$5 per ton). Typical disposal costs at a Subtitle D landfill is $400 per load (~$20 per ton). There would also be transportation costs that will vary depending on the location of the chosen disposal facility.

Further sampling will allow us to delineate the impacted area along the pipeline and hopefully reduce the amount of soil that will be required to be disposed at a Subtitle D landfill as opposed to a CCDD facility, thus potentially reducing project costs. **Table 8-3** summarizes the preliminary percentages of boring locations that exceeded the MAC standards and the subsequent disposal options.

**Table 8-3. Soil Disposal**

| Route | Disposal at CCDD Facility | Disposal at Subtitle D Landfill |
|---|---|---|
| Northeast Corridor | 82% of Borings | 18% of Borings |
| Northwest Corridor | 85% of Borings | 15% of Borings |

# Section 9
# Basis of Design

The purpose of this section is to:

- Summarize the design criteria or basis of design for the pipeline;
- Compare pipe materials and summarize design information for each material;
- Provide basis of design for the delivery structures; and
- Provide conceptual level design detail for pipeline appurtenances and valves.

## 9.1 Pipeline System Design Criteria

**Table 9-1** summarizes the design criteria for the overall pipeline system.

**Table 9-1. Summary Basis of Analysis and Design Criteria**

| *Parameter* | *Value* | *Notes/Comments* |
|---|---|---|
| ***Overall Basis of Design*** | | |
| *Service* | *Potable Water with Chlorine* | |
| *Water Temperature* | *32 to 77 degrees Fahrenheit* | |
| ***Pipeline Basis of Design*** | | |
| *Service Life* | *50 years or higher* | |
| *Maximum Pipeline Design Operating Pressure* | *150 psi* | - |
| *Minimum Delivery Pressure Under Normal Operation* | *25 psi* | *Pressure will vary depending on water demands and system conditions/operation* |
| *Maximum Surge Pressure* | *225 psi* | |
| *Minimum Surge Pressure* | *-6 psi* | *Air release and air vacuum valves will be located to minimize negative pressures to the extent feasible.* |
| *Maximum Design Velocity* | *<7 feet per second* | |
| *Burial Depth Preference* | *<15 feet for accessibility with minimum cover of 6-feet to top of pipe* | *This is a general preference only* |
| ***Location and Soil Conditions*** | | |
| *Soil Conditions* | Predominantly clay soil with sand and gravel seams (potential for peat in few areas) | |
| *Water Table* | Based on preliminary draft Phase I soil boring logs, groundwater appears to be 20-feet or deeper with areas of perched groundwater at 6 -feet or deeper | |

| Parameter | Value | Notes/Comments |
|---|---|---|
| *Pipeline Location* | Mostly in ROW (predominantly outside of pavement) | |
| *Modulus of Soil Reaction* | 400 psi | Value used in conditions where backfill is lightly consolidated on top of pipe. Primary driver for this value is the HDD due to potential for gaps in the annulus around the pipe. |
| *Soil Density* | 120lb/ft^3 | |

The following project objectives were developed during discussions with Agency staff and should be added to the basis of design for the project:

- The Agency prefers to have common pipeline material for the bid packages to avoid having multiple pipeline materials for maintenance.
- The pipeline will not be pre-purchased or pre-procured by the Agency and will be procured by the Contractor as part of the construction. This was discussed and agreed based upon the pipeline sizes for this project and also the challenges with direct pre-purchase and ownership of the pipeline during project duration.

This project is funded by the IEPA SRF Loan Program and thus will comply with American Steel and Iron Requirements and also multiple material and valve vendors.

## 9.2 Delivery Structures

Each community will have a dedicated delivery structure. **Figure 9-1** and **Figure 9-2** provide a plan/section view of the delivery structure along with a process flow diagram for the delivery structure. In addition, each delivery structure will have the following features:

- Dedicated ComEd service with ComEd meter;
- Flow metering capability with either magnetic or venturi technology;
- Isolation valves upstream and downstream of each delivery structure;
- Flow control valve;
- Check valve;
- Pressure gauges to maintain pressure control and optimize system operation;
- Bypass piping in the event the delivery structure has to be taken out of service;
- Pressure relief valve;
- Dehumidifier;
- Heater;
- Ventilation fan;
- Chlorine monitor;

- Sump/pump;
- PLC with discrete and analog data points and communication back to the main WTP SCADA system; and
- Radio equipment. A radio or cell-based system will be evaluated as part of the detailed design phase.

## 9.3 Pipeline Materials

A preliminary evaluation of the following pipe materials commonly used in the potable water industry was investigated for the North Group Pipeline. These materials included:

- Carbon steel pipe
- Ductile iron pipe
- Prestressed concrete cylinder pipe
- Bar wrapped concrete cylinder pipe
- Polyvinyl chloride (PVC) pipe
- Molecular oriented PVC pipe
- High density polyethylene pipe
- Fiberglass Reinforced Concrete Polymer Pipe

Large diameter (12-inch diameter and greater) pressure pipelines are usually constructed from four types of pipe: ductile iron pipe (DIP), coated and lined welded steel pipe, reinforced concrete cylinder pipe (RCCP), and bar-wrapped CCP. Polyvinyl Chloride (PVC), High Density Polyethylene (HDPE) and Glass-Fiber Reinforced Polymer (FRP) pipe have also been used for water mains, although not as prevalently.

Each type of pipe has its own unique requirements for field assembly, trenching, and installation as well as differing systems for external coating, pipe section joint assembly, joint restraint, and internal lining. The ultimate construction cost for each of these unique pipe systems is dependent on the features selected by the designer, local availability of pipe, and the cost of construction based on local conditions and contractor experience. A discussion of each of these materials follows.

For the North Group's Northwest and Northeast pipeline alignments, HDPE, DIP, and PVC pipe materials were selected for further evaluation based on the range of diameters considered for this project (10-inch to 20-inch).

Three pipeline materials commonly used in the region for the diameters being considered (10" to 20") were selected for further evaluation. Each of these pipe materials is used in pressure applications, and has an associated American Water Works Association (AWWA) standard.

### 9.3.1 Ductile Iron Pipe (AWWA C150/151-04; 3" to 64"; 350psi max)

Ductile iron pipe (DIP) is a relative of cast iron pipe, which has been used in North American water systems for over 150 years. Numerous cities have functioning cast iron water mains over 100 years old. DIP pipe and fittings were first manufactured in 1948 and have been used successfully in water systems since that time. Ductile iron pipe is manufactured by the addition of magnesium to low sulfur molten iron. At this time, DIP is supplied in sizes from 3 inches to 64 inches in diameter.

#### 9.3.1.1 Design

DIP has high tensile strength and high impact resistance and is manufactured in accordance with the American Water Works Association "Standard for Ductile-Iron Pipe, Centrifugally Cast, for Water or Other Liquids" (AWWA C151-02). The standard includes five pressure classes, from 150 psi to 350 psi in 50 psi increments, each of which corresponds to a specific wall thickness for each diameter. The pressure class corresponds to the related internal working pressure. Additional thickness classes are available if thicker wall pipe is required due to loading or other structural considerations.

There are a number of local suppliers in the Midwest region, including U.S. Pipe, Griffin Pipe, and American Cast Iron Pipe Company. DIP tends to be the material of choice for pipelines of less than 36-inches. In larger sizes, DIP sometimes loses its cost competitive edge to steel and concrete, thus requiring a more detailed evaluation of discriminating project factors. However, many other factors can influence the choice of pipe material. For example, highly corrosive soils may require protective design, which could favor other pipe materials.

For this project it is recommended that Class 350 be used for the 20-inch diameter pipe.

#### 9.3.1.2 Pipe Joint Systems

Pipe joints are of the gasketed bell and spigot design or mechanical joints, with the bell end integrally cast with the barrel of the pipe.

#### 9.3.1.3 Thrust Restraint

Thrust restraint can be provided by concrete thrust blocks or by restrained joints. Restrained joints would be "locked-type" and would involve a manufacturer's proprietary modification of a standard gasketed push-on bell design; a circumferential bead or ring on the spigot end; and locking segments which are inserted into the bell after the spigot is pushed into the bell. Restrained joints are usually not required along the entire pipeline and their use at all fittings would add significantly to the pipeline material cost. During the final design of the pipeline, the length and number of restrained joints will be determined based on maximum operating, test, and/or surge pressures. On straight runs of pipe, much of the pipeline would likely be equipped with non-restrained push-on joints.

Concrete thrust blocks can be placed at bends to absorb unbalanced forces. Thrust blocks are simple to design and construct. However, for large-diameter pipe, thrust blocks are relatively large to resist thrust forces and their size can be impractical. The installation of large thrust blocks may also cause more extensive conflicts in city streets with many existing utilities and consume underground space that could be more effectively used for future utilities. Thus, concrete thrust blocks are typically not used for large diameter pipelines and are not recommended for this project.

#### 9.3.1.4 Standard Lengths and Fittings

The nominal pipe length for DIP is 20-feet. Short lengths and spigot-by-spigot pieces are customarily cut from standard pipe lengths in the field. Because DIP is available in short lengths, it is a practical material of choice for installation in heavily populated areas, where streets are laden with utilities. Many contractors have significant experience in laying DIP and their equipment and trench boxes are suited to accommodate this material. For restrained joint pipe, which employs a bead on the spigot end, special short lengths and spigot-by-spigot pieces can be made to order in the foundry.

Unless specifically fabricated, DIP fittings are available as 11-1/4, 22-1/2, 45 and 90 degree. Standard pipe joints are also capable of being deflected several degrees to allow for gradual changes in pipe alignment without the need for fittings. Fittings would meet the requirements of AWWA C110 or AWWA C153 as applicable and would have the same pressure rating, as a minimum, of the connecting pipe.

#### 9.3.1.5 Lining and Coating Systems

The recommended internal lining for the water supply main and all fittings would be a double thickness cement mortar lining in accordance with AWWA C104. A cement mortar lining provides high hydraulic flow capacity without the build-up of tubercles. The cement provides a high pH environment in conjunction with a low oxygen supply, and self-healing characteristics. A seal coat can also be applied, but is not always required.

The exterior of ductile iron pipe is typically factory coated with a 1 mil thick asphaltic coating in accordance with AWWA C151 the pipe and in accordance with AWWA C110 and C153 for fittings. The primary purpose of the asphaltic coating is to minimize atmospheric oxidation for aesthetic reasons prior to burial. If soils are deemed to be moderately corrosive to ductile iron pipe when tested, it is recommended that polyethylene encasement be used in accordance with AWWA C105. Polyethylene encasement is manufactured of virgin polyethylene material conforming to the requirements of ANSI/ASTM D1248. The polyethylene material would be a minimum of 8-mils thick. The polyethylene wrap is not very expensive and therefore it is becoming increasingly common to see it installed with DIP systems, even when corrosive soils are not a concern. Highly corrosive soils may require more significant measures such as bonded coating systems, electrically continuous joints, and sacrificial or impressed current systems. Because of DIP industry resistance to most bonded coating systems, DIP may not be cost competitive or available when these types of protective systems are called for.

Corrosion evaluation and recommendations is presented in **Section 6** of the Report.

#### 9.3.1.6 Field Installation

DIP can be installed using open cut or trenchless operations, and can be cut into shorter lengths in the field to allow for ease of installation. In horizontal directional drilling (HDD) operations, HDD can be installed using the cartridge method when space is restricted, and the pipe cannot be strung out due to space limitations.

### 9.3.2 High Density Polyethylene Pipe (AWWA C906-07; 4” to 63”; Availability Limited to 54”)

High density polyethylene (HDPE) pipe has been used in potable water applications since the 1960’s, and has been gaining approval and growth in municipalities ever since. HDPE Pipe is designed and manufactured in accordance with AWWA C901, AWWA C906, and AWWA M55. This pipe is a high strength polymer conduit, which depends on the surrounding soils to support internal and external loading and to maintain roundness. Although the use of HDPE is not common for large water mains, it has some advantages over other materials. Like PVC, it is an inert material and impervious to most forms of corrosion. There is generally no cost penalty to restraining systems since they are inherent in the joint design. Also, HDPE has good characteristics for limiting surge pressure rise and is, therefore, a common material used in force main applications. HDPE pipe is manufactured up to diameters of 63-inches and is typically furnished in lengths of 40-feet.

#### 9.3.2.1 Design

HDPE pipe and fittings are manufactured in accordance with AWWA C906-07 – Standard for Polyethylene (PE) Pressure Pipe & Fittings, 4-in through 63-in, for Water Distribution & Transmission. The thickness of HDPE pipe wall increases substantially as internal and external loading requirements are increased. The pipe is outside diameter controlled, meaning that the internal diameter is reduced when the pipe wall thickness is increased. This can result in an actual internal diameter that is significantly smaller than the nominal diameter. Outside diameters are consistent with iron, ductile iron, and ISO sizing systems. Although the frictional resistance of HDPE is less than that of ductile iron, steel or CCP, the smaller internal

diameter will result in higher fluid flow velocities and head losses. Another factor with HDPE is that it has a high-degree of expansion, which must be accounted for. HDPE pipe can accommodate operating pressures up to 254 psi depending on the dimension ratio available from the manufacturer. However, the larger diameter HDPE pipe has difficulty meeting the higher operating pressures due to the increased wall thickness.

The pressure capacity of HDPE pipe is negatively impacted by operating temperatures greater than 73.4°F. Temperature derating factors for the pipe material begin at operating temperatures of 81°F and greater. Derating factors increase with increasing operating temperatures.

#### 9.3.2.2 Pipe Joint and Thrust Restraint System

Polyethylene piping may be joined by thermal butt fusion, socket fusion, electrofusion, flange assemblies, or mechanical methods. HDPE is self-restraining, and generally thrust blocks or additional means of restraint are not required. HDPE pipe can be bent to a radius 25 times the nominal pipe diameter, which can eliminate many fittings required for directional changes in the piping system.

It should be noted the HDPE pipe weighs less than water, so if HDPE pipe is installed in high groundwater conditions, the construction costs to restrain the pipe against buoyant forces can become very expensive.

#### 9.3.2.3 Standard Lengths and Fittings

HDPE fittings are constructed similar to welded steel pipe fittings through fabrication from cut and mitered pieces of HDPE, which are fused together to form the desired bend. Bends are not limited to standard angles as with ductile iron, but can be made to any desired angle. Fittings are typically joined to straight pipe in the field by fusing.

#### 9.3.2.4 Lining & Coating Systems

HDPE pipe is generally one-hundred percent corrosion resistant and therefore typically requires no corrosion protection other than what is already provided in the manufacturing process. Valves will be of ductile or cast iron design. Corrosion protection for valves is usually achieved with coating systems and sacrificial anodes.

The smooth interior walls of HDPE pipe offers higher flow capacities leading to savings from reduced pumping costs over the life of the system. Since HDPE pipe is petroleum based, it can however absorb petroleum products. In addition, the interior pipe wall of HDPE pipe has been documented as reacting with chemical oxidants present in potable water system resulting in longitudinal cracking.

#### 9.3.2.5 Field Installation

HDPE pipe can be installed in open cut trenches, but is more commonly used in horizontal directional drilling (HDD) applications, pipe bursting, and lining existing pipelines. HDPE pipe can be cut into shorter lengths in the field to allow for ease of installation. In HDD applications, HDPE pipe is typically strung at the ground surface requiring a large work zone.

### 9.3.3 Polyvinyl Chloride (PVC) Pressure Pipe (AWWA C900/C905; 4” to 48” Diameters; 305psi max through 18” 235psi max 20” through 30” 200psi max for 36”, 165 psi max 42” through 48”)

PVC pipe has been manufactured and used for infrastructure applications in North America for over 25 years. This pipe is a type of flexible conduit, which depends on the surrounding soils in order to support internal and external loading and to maintain roundness. PVC pressure pipe absorbs the underground shear and flexure stresses from soil movement that can place traditional rigid pipe at risk. Similar to HDPE,

PVC pipe is outside diameter controlled, resulting in an internal diameter which is less than the nominal diameter.

#### 9.3.3.1 Design

PVC pressure pipe is manufactured in accordance with AWWA C900 or C905, and designed in accordance with Manual M23 PVC Pipe – Design and Installation. The AWWA C905 PVC pressure pipe standard was approved in 1988 for diameters of 14" through 36". In 1997, 42" and 48" diameters were added. PVC pipe can accommodate operating pressures up to 305 psi, or a dimension ratio (DR) of 14. However the larger diameter PVC pipe cannot meet the higher end of the pressure range.

The pressure capacity of PVC pipe is negatively impacted by operating temperatures greater than 73.4°F. Temperature derating factors for the pipe material begin at operating temperatures of 80°F and greater. Derating factors increase with increasing operating temperature.

For this project the following parameters were assumed for PVC pipe:

- Deflection lag factor of 1.5 (as recommended by the PVC Pipe Association).
- Bedding constant of 0.110.
- Trench width of 18" on either side of the pipe.
- Maximum burial depth of 15-feet.
- Approximate internal diameter of 19.4-inches.
- Thermal derating factor of 0.88% based on a maximum operating temperature of 80°F. A higher operating temperature could result in a lower DR pipe material selection.

For the 20" pipe, DR21 pipe was selected which has a calculated deflection of 3.3% which is less than the maximum allowable deflection of 7.5% allowed by the PVC Pipe Association. This pipe could maintain a maximum internal pressure (working + surge) of approximately 247psi while still maintaining a safety factor for surges of approximately 2.6.

The 20-inch diameter pipe would also have the following properties during construction:

During construction, a maximum temperature of 100°F was assumed which minimizes the allowable bending stress that can be placed on the pipe such as:

- Minimum bending radius of 581-feet
- Offset for a 20-foot length of pipe of approximately 4"

#### 9.3.3.2 Pipe Joint System

Standard bell and spigot joints are typically used for PVC pipe. Each PVC pipe manufacturer has its own approach to joint systems. Ipex, for example, has a lock-ring gasket design proven to withstand many times the pressure class of the pipe, while providing for fast, easy installation. Flanged joints are also available for tapping and service connections. Pipe joints meet ASTM D3139 requirements.

There are various options for restrained joint PVC pipe. Two that would be required to meet thrust restrain criteria, or for horizontal directional drilling. There are two common joints used for directional drilling applications; a mechanical joint and fused joint. Both joints require a specially fabricated pipe.

An example of a mechanical joint is CertainTeed's Certa-Lok C900/RJ and C905/RJ PVC pipe. PVC pipe that is connected using the Certa-Lok system is a non-metallic mechanically restrained joint that meets the performance requirements of AWWA C900 and AWWA C905, respectively. This joint can be disassembled and reused if necessary, and can be used for pipeline restraint required for horizontal directional drilling applications and open cut installation. Certa-Lok's system are limited to pipe diameters up to and including 12" (SDR14 and SDR18), 16" (SDR 18, SDR 21 and SDR 25); 18" and 24" (SDR 18 and SDR 25). These mechanical joint systems are fairly easy to install.

An example of a fusible joint is Underground Solution's Fusible PVC is a second option for PVC pipe restraint. This pipe is also a non-metallic restrained joint, however the two segments of pipe are butt fused to effectively form a continuous gasket free fully restrained pipe system that is virtually leak free. Fusible PVC meets the requirements of AWWA C900 and AWWA C905, and is most commonly used for horizontal directional drilling applications. Fusible PVC pipe is available up to 36-inches in diameter. The joint requires a qualified technician to correctly fuse the joint, and generally has a higher maximum safe pulling force than the mechanical joint.

#### 9.3.3.3 Thrust Restraint System

PVC pressure pipe is compatible with auxiliary equipment such as cast-iron restraints, tapping saddles, stops, megalug-type mechanical-joint and slip-joint fittings. Thrust restraint can also be provided by thrust blocks, joint restraint, and pipe bells can be restrained with bell harnesses. Thrust blocks are generally not practical for large diameter pipes, and are not recommended for this project.

#### 9.3.3.4 Standard Lengths and Fittings

The pipe is normally furnished in 20-foot lengths. Custom fabricated fittings are available for PVC in sizes and pressure ratings to match the pipe. Fittings are made from segments of AWWA C905 PVC pipe, butt-fused or bonded together, and overwrapped with fiberglass-reinforced polyester, to meet the requirements of AWWA C905. PVC has the same outside diameter as ductile iron pipe and thus, ductile iron fittings can also be used with a PVC pipe system.

#### 9.3.3.5 Lining & Coating Systems

PVC pipe is generally one-hundred percent corrosion resistant and therefore typically requires no corrosion protection other than what is already provided in the manufacturing process. It is usually appropriate to use DIP standard fittings at bends and valves will be of ductile or cast iron design. Corrosion protection for valves and fittings is usually achieved with coating systems and sacrificial anodes.

The smooth interior walls of PVC pipe offer higher flow capacities leading to savings from reduced pumping costs over the life of the system.

#### 9.3.3.6 Field Installation

PVC pipe can be installed using open cut or trenchless technologies. The pipe can also be cut into shorter lengths in the field to allow for ease of installation. In HDD applications, HDPE pipe is typically strung at the ground surface requiring a large work zone.

### 9.3.4 Comparison of the Selected Pipeline Materials

Each of the pipeline materials has advantages and disadvantages. **Table 9-2** compares the three pipeline materials.

**Table 9-2. Pipe Material Comparison**

| Pipe Material | Advantages | Disadvantages |
|---|---|---|
| Ductile Iron Pipe | ▪ Less stringent bedding requirements<br>▪ Easy to install and adapt to field conditions<br>▪ Rapid contractor production rates due to familiarity.<br>▪ Excellent long term performance history of standard pipe materials.<br>▪ Each piece of pipe pressure tested to 500psi at the factory<br>▪ Strong material with a good ability to handle surge pressures, high load bearing strength, impact strength, beam strength and ability to bend or deform when external loads applied.<br>▪ Cement mortar lining prevents tuberculation and enhances hydraulic capability. Can be field repaired if impacted during construction | ▪ Pipe can leak at joints<br>▪ Unprotected pipe is susceptible to corrosion and may require corrosion protection system<br>▪ Not all corrosion protection methods used over the decades have been effective in all environments.<br>▪ Standard SBR gaskets are subject to chemical attack and permeation over the small exposed area of the joints.<br>▪ Standard 20’ lay lengths. |
| High Density Polyethylene Pipe | ▪ Inert material and resistant to most forms of internal and external corrosion.<br>▪ Typically does not require any special corrosion protection.<br>▪ Butt fused connections essentially create a leak free restrained joint.<br>▪ High ductility and flexibility.<br>▪ Good characteristics for limiting surge pressure rise.<br>▪ Low internal friction<br>▪ Resists shatter-type or rapid crack propagation failure<br>▪ Can be field cut to accommodate changes in field conditions.<br>▪ Typically furnished in 40’ lay lengths.<br>▪ Fittings not limited to standard angles.<br>▪ Can be field bent. | ▪ May be subject to stress cracking. Ongoing studies currently being undertaken to evaluate.<br>▪ PE 4710 which is now commonly used, is not yet approved by an AWWA standard for potable water systems.<br>▪ Skilled labor and special equipment required for butt fusion to join pieces of pipe together.<br>▪ Very sensitive to temperature differentials when compared to other common pipe materials.<br>▪ Cannot be located unless buried with metallic wire or tape.<br>▪ More permeable to certain chemical contaminants than other thermoplastic pipes.<br>▪ Lower hydrostatic design basis (HDB) than other thermoplastic materials requiring thicker walls resulting in a smaller diameter flow area.<br>▪ Sensitive to operating temperature. Must be de-rated in case of long term exposure to temperatures that are generally higher than room temperature |

| Pipe Material | Advantages | Disadvantages |
|---|---|---|
| Polyvinyl Chloride Pipe | ▪ Inert material and resistant to most forms of internal and external corrosion.<br>▪ Fusible type PVC pipe essentially creates a leak free restrained joint.<br>▪ Low internal frictional resistance<br>▪ Expansion significantly lower than HDPE pipe.<br>▪ At least 2.5 times stronger than HDPE.<br>▪ Light material that is easy to handle | ▪ Susceptible to impact damage in cold temperatures resulting in rapid crack propagation.<br>▪ Gasket joints can fail in the long term if spigot is over-inserted into bell.<br>▪ Susceptible to chemical permeation in cases of gross contamination.<br>▪ Sensitive to backfill design and installation when used in open cut.<br>▪ Normally furnished in 20' laying lengths.<br>▪ Sensitive to operating temperature. Must be de-rated in case of long term exposure to temperatures that are generally higher than room temperature |

On September 29, 2014 CDM Smith facilitated a pipe material selection workshop with Agency staff. The workshop presented and discussed each of the following three pipe materials: DIP, HDPE, and PVC. A Material Selection Evaluation Matrix was developed to evaluate each pipeline material against specific criteria. **Appendix I** shows the pipeline material selection workshop results. Each of the criterion were weighted based on their relative importance to the Agency. DIP scored the best with PVC scoring second, followed by HDPE.

Based on the evaluation and subsequent discussions with the Technical Committee, the pipeline materials will be as follows:

- For pipelines 12-inches and larger, ductile iron pipe will be used as the bid with PVC as an alternate;
- For pipelines smaller than 12-inches ductile iron and PVC pipe will be bid against each other; and
- For locations and where ductile iron pipe is not feasible due to construction method, PVC will be used.

## 9.4 Valves and Pipeline Appurtenances

Pipeline valves, blow-offs, air release/vacuum valves, and other miscellaneous appurtenances were discussed with Agency staff during the September 29, 2014 workshop. It is the goal of the Agency to limit the number of valves and other appurtenances on the transmission main system in an effort to minimize points of failure in a branch system.

### 9.4.1 Blow-offs

Blow-off hydrants are located at pipeline low points between isolation valves and at intermediate pipeline low points to allow for pipeline drainage for maintenance. The typical arrangement for a blow-off is illustrated on CD-1 of the 30% Design Drawings. The auxiliary valve shall be located as close to the blow-off as site conditions allow. This is a preference expressed by the Agency transmission main staff and will increase the efficiency of the anode bag to protect both the auxiliary valve and hydrant from corrosion.

Cathodic protection for blow-off hydrants will be designed to meet site specific conditions during detailed design.

The existing transmission main system is comprised typically of two blow-off hydrants:

- Super Centurion 250 Fire Hydrant manufactured by Mueller Company
- Model WB67-250 manufactured by Waterous

The Agency's preference is to continue with one of these two blow-off hydrants for the installation of the new transmission main and is consistent with recent projects executed.

The auxiliary valve used by the Agency is a resilient seated gate valve, specifically the Mueller Company's Series 2360 resilient wedge gate valve and American Flow Control's Series 500 NRS gate valve. American Flow Control's Trench Adapter or equivalent will be utilized.

### 9.4.2 Isolation Valves

A high level evaluation of gate versus butterfly valves was performed. Here is a summary of the findings:

- Butterfly valves are more common for transmission systems (valves larger than 12-inches) mainly due to cost.
- Gate valves do have an advantage when it comes to pressure rating and sealing, and also allow for the pipeline to be pigged should the need arise. Also, gate valves, if designed to address the service conditions, can potentially last longer than butterfly. There are also advantages to gate valves in raw water or wastewater applications from a solids handling/damage control perspective over butterfly valves (due to damage/clogging at the disc), but those are not applicable on this project.
- Butterfly valves on the other hand do weigh less (can be easier to install/handle) and are generally easier to operate.
- The below table (**Table 9-3**) provides a cost comparison of gate versus butterfly valves for the different valve sizes:

**Table 9-3. Butterfly-Gate Valve Cost Comparison**

| Size (inches) | Butterfly | Gate |
|---|---|---|
| 10 | $1,700 | $2,700 |
| 16 | $3,000 | $10,000 |
| 20 | $4,000 | $18,000 |

Based on the above, it is recommended to proceed with butterfly valves since the Agency has butterfly valves and there is generally no "special" need to require the more expensive gate valve. The original cost estimate was based on butterfly valves. The Agency currently utilizes butterfly valves for isolation within the transmission main system. Triton rubber seated butterfly valves manufactured by Henry Pratt Company have been standard for the Agency on any new installations in recent years. This is a butterfly valve similar to what was previous installed throughout the existing transmission main system.

For 24-inch diameter or smaller, valve and actuator will be located in a vault. The butterfly valves are side actuated which creates a tight maintenance space in a standard 6-foot diameter vault. The vaults will be

increased to 8-foot diameter where site conditions permit. The valve vault detail shown on CD-1 of the 30% Design Drawings.

Isolation valves are located at intervals specific to the pipe diameter for isolation, pipeline branches and at highway, railroad and stream crossings. When locating isolation valves based on pipe diameter, the criteria is based on the Agency's ability to drain a pipe in two hours at 450 gpm. The length of pipe derived represents the maximum spacing permitted between isolation valves. **Table 9-4** provides the maximum valve spacing for different diameter pipes.

**Table 9-4. Isolation Valve Maximum Spacing**

| Pipe Diameter (inches) | Valve Spacing (feet) |
|---|---|
| 10 | 13,500 |
| 16 | 5,200 |
| 20 | 3,300 |

### 9.4.3 Pipeline Encasement

Sheet CD-1 of the 30% Design Drawings provides a detail for pipeline encasement where required for the Pipeline Project. Insulated spacers shall be used to provide corrosion protection for the ductile iron pipe.

### 9.4.4 Air Release/Vacuum Valves

Air release/vacuum valves are located at pipeline high points between isolation valves and at intermediate high points to allow release of air accumulated during operation and allow air to enter during pipeline drainage. The typical arrange currently found in the Agency's transmission main system is illustrated on Sheet CD-1 of the 30% Design Drawings.

The air release/vacuum valves are located in a standard 6-foot diameter vault. The Agency has expressed no issues with access for maintenance. The current arrangement is to have separate units for the air release and air vacuum assemblies. The Agency prefers this to the alternative of a combination air valve assembly.

The current air release/vacuum valves continue to be a maintenance issue throughout the existing transmission main system. The Agency has been experiencing issues with material compatibility as well as poor performance of appurtenances related to the air release/vacuum valve arrangement. During detailed design, the air release/vacuum valve detail and specification will be further revised to address issues experienced by the Agency transmission main staff.

## 9.5 Miscellaneous Appurtenances

### 9.5.1 Locating

Tracer wire will be required for locating the pipeline in the future regardless of pipe material selected. Tracer wire will be NEPTCO TRACE SAFE or equal. Critical transmission main components will be locatable utilizing the 3M Electronic Marker System RFID tagging markers.

### 9.5.2 Vaults

Vaults housing Agency appurtenances shall be watertight. Brick and mortar will not be an acceptable method of sealing penetrations. Link seals or rubber boots are the preferred method of sealing penetrations into vaults by the Agency.

The Agency has requested an alternative to the standard Neenah manhole covers. A traffic rated product such as FiberShield by McGard and equivalent products will be evaluated during specification development. The benefit is a lightweight manhole cover that is easier for transmission main staff to handle.

# Section 10
# Opinion of Probable Construction Cost

## 10.1 Cost Estimating Criteria

This section provides the opinion of probable construction cost estimate for NE and NW pipeline routes. This section details the cost estimation justification and criteria in addition to presenting the cost estimate table.

### 10.1.1 Estimating Costs

Several types of cost estimations can be made and updated at different stages of a project. The type of cost estimate made depends on the state of development of the project, the definition of scope, and the level of design detail. The three main categories of cost estimates as defined by the American Association of Cost Engineers are:

- **Order-of-Magnitude Estimate:** An approximate estimate, this type of cost estimate is made without detailed engineering data. Examples include cost capacity curves, scale-up or scale-down factors, and approximate ratios. Order of magnitude estimates are provided with accuracy within 50% above or 30% below the actual construction cost. This is the cost estimate developed by CDM Smith in the August 2012 Report.

- **Budget Estimate:** This type of estimate is used to help establish the owner's project budget and is prepared from flow diagrams, layout drawings, and equipment details. Accuracy is expected within 30% above or 15% below the actual construction cost.

- **Definitive Estimate:** This estimate is prepared from engineering data. Plot plans and elevations, piping and instrument diagrams, structural sketches, soil data, sketches of major foundations and buildings, one-line electrical diagrams, equipment data sheets and quotations, and a complete set of specifications are the minimum requirements for a definitive estimate. "Approved for Construction" drawings and specifications give a maximum definitive estimate. Accuracy is expected within 15% above or 5% below the actual construction cost.

The estimates provided in this report shall be considered the first level of a Definitive Estimate based upon the criteria set forth by the American Association of Cost Engineers.

### 10.1.2 Cost Escalation

Methods commonly used for projecting costs are: (1) escalation based on an assumed rate of inflation; or, (2) a published cost index. The Engineering News-Record Construction Cost Index (ENRCCI), published in the magazine ENR (a McGraw-Hill publication), is one of the commonly used indexes in the water engineering field. The cost estimate will be developed in December 2014 dollars and escalated to the mid-point of construction.

### 10.1.3 Contingency

Contingency, added to the construction cost estimate, attempts to account for construction costs not identified or that may be required due to incomplete information. The more detailed the design, the less the contingency will be required. The AWWA textbook recommends a contingency between 25% and 35% for an order-of-magnitude estimate, between 15% and 25% for a budgetary estimate, and between 5% and 15% for a definitive (or final design) estimate.

A contingency of 20% is used for the cost estimate.

### 10.1.4 Source of Cost Estimate Information

In order to prepare the cost estimates presented in this report, several different sources of information were considered, including:

- Vendor Quotes: Recent vendor quotes were obtained and utilized to estimate material and installation costs for some individual process components.
- CDM Smith Experience: All costs were compared to recent bid costs for CDM Smith projects of similar size and scope across that nation to confirm that the cost curves and vendor quotes used were applicable.
- Quantity take-offs were based on the 30% design drawings.

## 10.2 Opinion of Probable Construction Costs

The cost estimate is broken in four bid packages (in accordance with the 30% Design Drawings).

OPCC will be completed following preparation of quantity take-offs based upon the 30% Design Drawings.

# Section 11
# Implementation Plan

This section provides an overview of the schedule through the end of construction for the Central Lake County Joint Action Water Agency (Agency) finished water transmission system expansion to serve the North Group members.

## 11.1 Implementation Plan

The remainder of the project consists of five phases:

- Detailed Design
- Permitting & IEPA State Revolving Fund
- Bidding
- Construction
- Startup & Testing

Each of these phases s discussed briefly to address critical assumptions that would impact the overall schedule. A draft project schedule through construction is shown in **Figure 11-1**.

### 11.1.1 Detailed Design

Upon submission of the final PER documents, CDM Smith will proceed into the detail design phase of the project. The detail design phase of the project is anticipated to take between 8 to 10 months to complete. 30% design specifications are listed in **Appendix J**.

### 11.1.2 Permitting & IEPA State Revolving Fund

Prior to commencing the construction phase, required permits for the project will be procured. This will occur in parallel of bidding. The required permits are discussed elsewhere in the PER.

### 11.1.3 Bidding

The bid packages will be advertised as detailed design is completed. The bid packages will be advertised for two months. Bids will be received by the Agency and publically opened and announced. CDM Smith will review the bids for compliance with the contract documents, along with contractor references and experience on similar projects. CDM Smith will make a recommendation to award the contracts to the lowest responsive and responsible bidders, subject to review by the Agency's legal counsel. The overall bidding phase is anticipated to take approximately three months.

It is assumed that bid packages will be advertised for bidding as soon as the documents are completed and permits are received or in review.

### 11.1.4 Construction

The general contract for construction is expected to take approximately 20 months for the entirety of the project. Mobilization by the contractor is anticipated for the spring of 2016. The critical milestone for the project is delivering water to the new member communities by June 2017. Site restoration and project close-out is anticipated to be completed in the fall of 2017.

### 11.1.5 Startup & Testing

The startup and testing the transmission main piping will consist of the following:

- Pressure tests;
- Disinfection; and
- Sampling.

Pressure tests will be completed as stretches, valve to valve, of pipe are installed by the contractor. At the completion of a bid package, the contractor will execute their previously approved disinfection plan. The Agency will sample and test the water quality for final approval.

## 11.2 Critical Assumptions

### 11.2.1 Route Modifications

The schedule assumes the alignments based on the previously completed route study will remain relatively set and no deviation from the alignments presented in the PER will be required. Any modifications to the alignment requiring additional field investigation or revisiting of previously completed tasks could potential delay a bid package advertisement. Circumstances that could result in route modifications include, but is not limited to, the following:

- Failure to procure all temporary and permanent easements by bidding.
- Electing to pursue an alignment not previously approved by Technical Committee.
- Regulatory agency (or agencies) delaying approval or input on the project or not granting a construction permit

### 11.2.2 Installation Method

Trenchless methods of installation, both bore and jack and horizontal directional drilling (HDD), is assumed to require a minimum of four weeks per installation. Based on the conditions documented in the route study, it is assumed that a given trenchless setup would yield up to

- 400 linear feet of pipe installed per bore and jack setup; and
- 2,000 linear feet of pipe installed per HDD setup.

Using the same information from the route study, it is assumed that open cut would yield approximately 200 linear feet of pipe installed per day. The trenchless installation becomes the critical path for any of the bid packages if used as the primary method of installation.