Water System Master Plan Update

Adopted September 2019

Water System Master Plan Update

City of North Plains

Adopted September 2019

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Table of Contents

Executive Summary

Introduction ES-1
How This Plan Should Be Used ES-1
Authorization....................ES-2
Compliance....................ES-2
Planning Period ES-2
Study Area ES-2
Existing Water System....................ES-2
Supply *ES-2*
Water Rights....................*ES-3*
Storage *ES-3*
Pumping *ES-3*
Distribution System....................*ES-3*
Existing Water Demands ES-4
Water Demand Projections....................ES-4
Water Supply Source....................ES-5
Cost Estimating Data ES-5
Recommended Improvements....................ES-6
General....................*ES-6*
Study Recommendations ES-6
Summary ES-6

1. Introduction

1.1 Authorization.................... 1-1
1.2 Purpose 1-1
1.3 Compliance.................... 1-1
1.4 Scope.................... 1-2

2. Existing Water System

2.1 General ... 2-1

2.2 Background and Study Area ... 2-1

2.3 Supply Sources ... 2-3

2.3.1 Joint Water Commission Supply ... 2-3

2.3.2 Well No. 3 ... 2-3

2.3.3 Wells No. 1 and 2 ... 2-4

2.4 Water Rights Summary ... 2-4

2.5 System Pressure ... 2-4

2.6 Storage ... 2-5

2.7 Pump Station ... 2-5

2.8 System Operation Overview ... 2-6

2.9 Distribution System ... 2-7

2.10 Telemetry and Control System ... 2-7

2.11 Summary ... 2-7

3. Service Area, Land Use, and Water Requirements

3.1 General ... 3-1

3.2 Service Area ... 3-1

3.3 Planning Period ... 3-1

3.4 Land Use ... 3-2

3.5 Population Estimates ... 3-2

3.5.1 Historical Population ... 3-2

3.5.2 Population Forecast ... 3-3

3.6 Water Demand Estimates ... 3-4

3.6.1 Historical Water Use ... 3-4

3.6.2 Water Demand Projections ... 3-5

3.7 Summary ... 3-6

4. Planning and Analysis Criteria

4.1 General ... 4-1

4.2 Supply and Transmission Evaluation and Analysis Criteria ... 4-1

4.3 Distribution System ... 4-2
4.4 System Pressure Criteria ... 4-2
4.5 Storage Volume ... 4-3
4.5.1 Operational Storage ... 4-3
4.5.2 Emergency Storage ... 4-4
4.5.3 Fire Storage ... 4-4
4.6 Pumping Capacity ... 4-5
4.7 Water Quality ... 4-5
4.8 Total Coliform Rule ... 4-6
4.9 Lead and Copper and Corrosion Control ... 4-6
4.9.1 Stage 2 Disinfectants and Disinfection Byproducts Rule (D/DBPR) ... 4-7
4.10 Summary ... 4-7

5. Water System Analysis

5.1 General ... 5-1
5.2 Supply Source Analysis ... 5-1
5.3 Water Rights ... 5-2
5.4 Water System Pressure Analysis ... 5-2
5.5 Storage Capacity Analysis ... 5-3
5.6 Pumping Capacity Analysis ... 5-3
5.7 Distribution System Analysis ... 5-4
5.7.1 General ... 5-4
5.7.2 Hydraulic Model ... 5-5
5.7.3 Model Calibration ... 5-5
5.7.4 Modeling Conditions ... 5-5
5.7.5 Modeling Results ... 5-6
5.8 Water Conservation ... 5-6
5.8.1 Introduction ... 5-6
5.8.2 Public Education and Outreach ... 5-6
5.8.3 Technical and Financial Assistance Programs ... 5-7
5.8.4 Retrofit/Replacement of Inefficient Fixtures ... 5-7
5.8.5 Leak Detection Program ... 5-7

5.8.6 *Water Conservation Recommendations* *5-7*
5.9 Summary 5-8

6. Recommendations and Capital Improvement Plan

6.1 General 6-1
6.2 Cost Estimating Data 6-1
6.3 Recommended Improvements 6-2
6.3.1 *General* *6-2*
6.3.2 *Supply Source Agreement* *6-2*
6.3.3 *System Monitoring and Control* *6-2*
6.3.4 *Pumping Improvements* *6-3*
6.3.5 *Distribution System Improvements* *6-4*
6.3.6 *Storage Capacity Improvements* *6-6*
6.4 Additional Recommendations 6-6
6.4.1 *Financial Evaluation and Plan* *6-6*
6.4.2 *Source Alternatives Study* *6-6*
6.5 Summary 6-7

Figures

2-1 Water Service Area Map 2-2

Tables

ES-1 Distribution System Pipe Summary ES-4
ES-2 Population Forecasts and Estimated Water Demand Summary ES-5
2-1 Groundwater Well Pump, Depth, and Production Summary 2-4
2-2 Summary of Existing Pumps 2-6
2-3 Valve and Pump Station Operational Settings 2-6
2-4 Distribution System Pipe Summary 2-7
3-1 Land Use Summary 3-2
3-2 Historical and Current Estimated Population Summary 3-3
3-3 Population Forecast Summary 3-4
3-4 Historical Water Use Summary 3-5

3-5 Population Forecasts and Estimated Water Demand Summary 3-6
4-1 Storage Volume 4-3
4-2 Summary of Land Use and Recommended Fire Flows 4-5
4-3 Recommended Fire Flow Duration Summary 4-5
5-1 Population Forecasts and Estimated Water Demand Summary 5-2
5-2 Storage Volume Analysis Summary 5-3
5-3 Pumping Capacity Analysis 5-4
6-1 Capital Improvements Program 6-8

Appendix

Appendix A – Water System Master Plan Figure

Appendix B – Planning Level Cost Estimates

Appendix C – Water Storage Capacity Analysis

Appendix D – Water System Seismic Assessment and Mitigation Plan

Executive Summary

Executive Summary

Introduction

The purpose of this Water Master Plan (WMP) is to provide the City of North Plains a comprehensive planning document that provides basic information and guidance necessary for the sound stewardship of the municipal water system within its water service boundary. This plan is important because it:

- Compiles basic information relevant to the water system.
- Describes the basic functional parameters of the system.
- Highlights known system deficiencies.
- Describes and graphically illustrates recommended improvements.
- Presents basic cost information for general budgeting and the development of an adoptable 20-year capital improvements program (CIP).
- Provides a physical tool for informing individual citizens and other interested parties of the existing system and proposed improvements.
- Serves as an invaluable resource for gaining public support for needed improvements.
- Facilitates logical planning decisions relative to other City programs.

How This Plan Should Be Used

This Water Master Plan Update should be used in the following manner:

- This master plan should be viewed as a dynamic working document.
- The plan should be reviewed annually for the purpose of prioritizing and budgeting for needed improvements.
- Plan mapping should be updated to reflect current development and constructed system upgrades.
- Specific recommendations set forth in this plan should be considered as conceptual only. Additional details and potential alternatives should be investigated and analyzed in the preliminary engineering phase of final project designs.

- Cost estimates should be considered as planning level only and should be updated and refined with preliminary engineering and final project designs.
- This plan should be used as the guiding document for future water system improvements.

Authorization

In 2017, the firm of Murraysmith was authorized by the City of North Plains to prepare this Water System Master Plan Update.

Compliance

This plan complies with water system master planning requirements established under Oregon Administrative Rules (OAR) for Public Water Systems, Chapter 333, Division 61 and applicable elements of Division 86.

Planning Period

The planning period for this master plan is 20 years. Planning and facility sizing recommendations use estimated water demands at saturation development within the current urban growth boundary. Saturation development occurs when all existing developable land within the planning area has been developed. This planning document also assumes undefined expansion of the urban growth boundary will be required to accommodate planned growth through the 20 year planning horizon.

Study Area

The City of North Plains water service area currently serves a population of approximately 2,980 people and provides potable water to residential, commercial, and industrial services. The study area for this plan is the City's entire urban growth boundary (UGB), which is also the existing urban City limits. To accommodate projected population growth through the planning period the City will need to expand, likely by expanding the UGB into currently undesignated reserve areas as illustrated on Figure 2-1.

Existing Water System

Supply

In 2004 the City completed construction of a supply connection to the Joint Water Commission's (JWC) 72-inch diameter transmission main in Hillsboro. The JWC is a regional water supplier and a partnership of the Cities of Hillsboro, Forest Grove, Beaverton, Tigard and the Tualatin Valley Water District. The City of North Plains negotiated an agreement with the JWC to provide a maximum rate of flow not to exceed 875 gallons per minute (gpm) and a maximum volume of water not to exceed 1.05 million gallons per day (mgd). One of the City's existing groundwater wells, Well No. 3, is available as an emergency backup supply source, if needed.

Water Rights

The City of North Plains holds a groundwater use right with the Oregon Water Resources Department. This permit provides for groundwater production from Well Nos. 1, 2 and 3 up to the amount of 1.43 cubic feet per second (cfs) (642 gallons per minute (gpm) or 0.92 million gallons per day (mgd)). In February 2005, the City submitted a claim of beneficial use on this permit from Well No. 3. The amount claimed was 1.32 cfs (592 gpm or 0.85 mgd). The City has been issued Certificate number 82907, associated with Application number G-9398. No claims were made regarding Well Nos. 1 and 2. Well No. 2 is not currently operational, and Well No. 1 is a non-exempt use.

Storage

The City of North Plains' water system contains one storage reservoir, with a total storage capacity of approximately 1.0 million gallons (MG). This reservoir is located on the same site and adjacent to the City's booster pump station at the intersection of NW Commercial Street and NW 321st Avenue at an approximate ground elevation of 177 feet. The reservoir overflow elevation is approximately 208 feet. The reservoir is a 41-foot diameter bolted steel reservoir with a wall height of 33 feet. The reservoir is filled through a connection to the distribution system which is controlled by an altitude valve located inside the booster pump station.

Pumping

The City's existing booster pump station includes one 120 gallon per minute (gpm) pump, one 500 gpm pump, and one 3,600 gpm fire pump. Under typical operations the booster pump station serves only to help maintain water quality in the reservoir; however, during high demand periods or fire events the pump station serves to supplement the supply from the JWC connection.

Distribution System

The City's water distribution system is composed of various pipe types in sizes up to 16 inches in diameter. The total length of piping in the service area is approximately 97,996 feet, or approximately 18.6 miles. The pipe material types include cast iron, ductile iron, polyvinyl chloride (PVC), and galvanized iron. Most of the piping in the system is ductile iron and cast iron. The City Standard is for all new pipe to be ductile iron. Table ES-1 presents a summary of pipe lengths by diameter.

Table ES-1
Distribution System Pipe Summary

Pipe Diameter (inch)	Estimated Length (lf)
4	3,284
6	14,698
8	42,344
10	2,671
12	10,228
14	5,301
16	19,470
Total [1]	**97,996**

Existing Water Demands

Based on the City's most recent historical water use patterns and population, the water service area's average day per capita consumption has ranged from 115 to 128 gpcd since 2002. For the purposes of this plan, estimated average daily water usage per capita is assumed to remain constant at approximately 125 gpcd. As conservation plays an increasing role in water usage patterns, it is anticipated that the City's average daily per capita usage may ultimately be reduced over time.

Water Demand Projections

In recent years, the maximum day per capita usage has ranged between 2.0 and 2.4 times the average daily water usage per capita. For this study, a peaking factor of 2.2 is used to establish the future maximum day per capita usage at approximately 275 gpcd. Total estimated average and maximum day water demands for the City are then developed by multiplying the estimated per capita usage by the anticipated population for each year. To provide an estimate of peak hourly usage, a peak hour factor of 1.5 is applied to the estimated maximum day water demands. A 1.5 peak hour factor is consistent with water demand patterns of other communities in the region of similar size and type. Table ES-2 presents a summary of water demand forecasts in five-year increments to the year 2040, the end of the 20-year planning period.

Table ES-2
Population Forecasts and Estimated Water Demand Summary

Year	Population	Water Demand (mgd)		
		Average Day Demand [1] (ADD)	Maximum Day Demand [2] (MDD)	Peak Hour Demand [3]
2019	3,292	0.41	0.91	1.37
2024	4,221	0.53	1.16	1.74
2029	5,413	0.68	1.49	2.23
2034	6,942	0.87	1.91	2.86
2040—End of Planning Period	**8,902**	**1.11**	**2.45**	**3.67**

Notes:

1. Average Day Demand equals the Population multiplied by the estimated average daily per capita usage for the service area (125 gpcd).
2. Maximum Day Demand equals the Population multiplied by the estimated maximum daily per capita usage for the service area (275 gpcd).
3. Peak Hour Demand equals 1.5 times the Maximum Day Demand.

Water Supply Source

As previously described, the City's primary water supply is provided through a 16-inch diameter transmission main connected to the Joint Water Commission (JWC) supply system. With a maximum day supply allowance of 1.05 mgd, the JWC source is adequate to meet the City's maximum day demands now; however, the City recognizes it will soon exceed this available capacity, and is currently at risk of exceeding the requirement to maintain three times average day demand in storage volume. Thus, the City has initiated discussions with JWC to expand the supply amount, and other terms of the agreement. In addition, the City is moving forward with implementing an additional 1.0 to 2.0MG of storage. It should be noted that the existing 16-inch diameter pipeline has enough capacity to provide supply to the City well beyond the 20-year planning horizon.

Cost Estimating Data

An estimated project cost has been developed for each improvement project recommendation presented in this study. Itemized project cost estimate summaries are presented in Appendix B. This appendix also includes a cost data summary for recommended water main improvements developed on a unit cost basis. Project costs include construction costs and an allowance for administrative, engineering, contingencies and other project related costs.

The estimated costs included in this plan are planning level budget estimates presented in 2017 dollars. Since construction costs change periodically, an indexing method to adjust present estimates in the future is useful. The Engineering News Record (ENR) Construction Cost Index (CCI) is a commonly used index for this purpose. For purposes of future cost estimate updating, the April 2019 ENR CCI for Seattle, Washington of 12,015.45 is referenced.

Recommended Improvements

General

Presented below are recommended water system improvements for supply, storage, pumping, and distribution system piping. Project cost estimates are presented for all recommended improvements and annual budgets are presented for recommended capital improvement programming. The recommendations are presented by project type and discussed in order of need. A summary of all the recommended improvements is presented in Table 6-1. The table provides for prioritized project sequencing by illustrating fiscal year (FY) project needs for each facility and improvement category.

The proposed improvements listed are phased and sequenced for construction over the planning period of 20 years. While the funding needs for certain water system improvements may exceed this amount the proposed improvements listed in Table ES-3 are phased and sequenced so that the ultimate 20-year average annual capital requirement is approximately $710,000 per year in 2019 dollars.

Study Recommendations

It is recommended that the City take the following actions:

1. Formally adopt this study as the City of North Plains' Water System Master Plan.
2. Adopt the prioritized recommended system improvements described in Section 6 and specifically listed on Table 6-1 as the capital improvement plan (CIP) for the water system.
3. Develop and adopt a financing plan to implement the capital improvements recommended in this study.
4. Review and update this plan within five to seven years to accommodate changed or new conditions.

Summary

North Plains continues to experience steady population and water demand growth. A summary of all seismic mitigation and other recommended improvements is presented in **Table 6-1**. The combined Table 4 included in the Appendix D Seismic Assessment and Mitigation Plan includes all recommended improvements as well, for prioritized project sequencing by illustrating fiscal year (FY) project needs for each facility or improvement category. The total estimated project costs of the recommended improvements (adjusting the non-seismic improvements for inflation) are approximately $14.2 million over the 20-year planning horizon, based on today's dollars. It is recommended that the City's capital improvement program (CIP) be funded at approximately **$710,000** annually for seismic resilience, storage, pumping and distribution system piping. Financial planning work is recommended to identify funding options and alternatives.

Section 1

Section 1

Introduction

1.1 Authorization

In 2017, the firm of Murraysmith was authorized by the City of North Plains to prepare an update to the City's Water System Master Plan. In early 2016 the State of Oregon implemented a new law requiring cities to annex new territory without submitting the proposal to the electors of the city. This new law is resulting in rapid growth for the City of North Plains. Thus, it was determined that updating this plan, including the System Development Charges, was needed to properly integrate the new growth.

1.2 Purpose

The purpose of this Water Master Plan is to perform an updated comprehensive analysis of the City of North Plains water supply and distribution system and:

- Document existing water system service area, facilities and operation
- Estimate future water requirements including potential water system expansion areas
- Recommend improvements that correct deficiencies and provide for growth
- Update the City's capital improvement program (CIP)
- Provide the basis for updating system development charges (SDCs)

The City is currently experiencing significant service area and water demand growth, and is anticipating accelerated near term growth through two large service area expansions to the north and east of the City. In addition, expansion of the City into currently undesignated reserve areas is expected to be needed to provide sufficient growth for the 20-year planning period. This study will provide the City the guidance needed for the sound stewardship of the water system in anticipation of such near-term growth and for growth over the next 20 years.

1.3 Compliance

This plan complies with water system master planning requirements established under Oregon Administrative Rules (OAR) for Public Water Systems, Chapter 333, Division 61-0060 and applicable elements of Division 86.

1.4 Scope

The scope of work for this study includes the following work tasks:

- *Water System Description.* Prepare an inventory of existing water system facilities including supply, transmission and distribution piping, storage reservoirs, pumping stations, and control systems.
- *Water Requirements.* Review information related to service area, land use, population distribution, and historical water demands. Develop water demand forecasts for existing and undeveloped areas within the City's water service area.
- *System Analysis Criteria.* Develop system performance criteria for distribution and transmission systems and storage and pumping facilities. Develop analysis and planning criteria for pressure zone service pressure limits, for emergency fire suppression water needs, and for other system performance parameters.
- *Water System Analysis.* Perform a detailed analysis of the City's transmission and distribution system, storage and pumping capacity needs, and pressure zone limits.
- *Water Quality and Regulations.* Describe water quality and level of service goals for the water system, considering, existing and future regulatory requirements.
- *Prepare Capital Improvement Plan.* Develop estimated project costs for recommended improvements, recommend project sequencing and develop a Capital Improvement Program (CIP).
- *Financial Evaluation.* Existing System Development Charges (SDC's) will be updated based on the newly generated CIP. This work will be completed outside the scope of this Water Master Plan Update.
- *Prepare Updated Water Master Plan.* Prepare an Updated WMP that documents and describes the planning and analysis work efforts, including a color map identifying all existing and proposed water system facilities.

Section 2

Section 2

Existing Water System

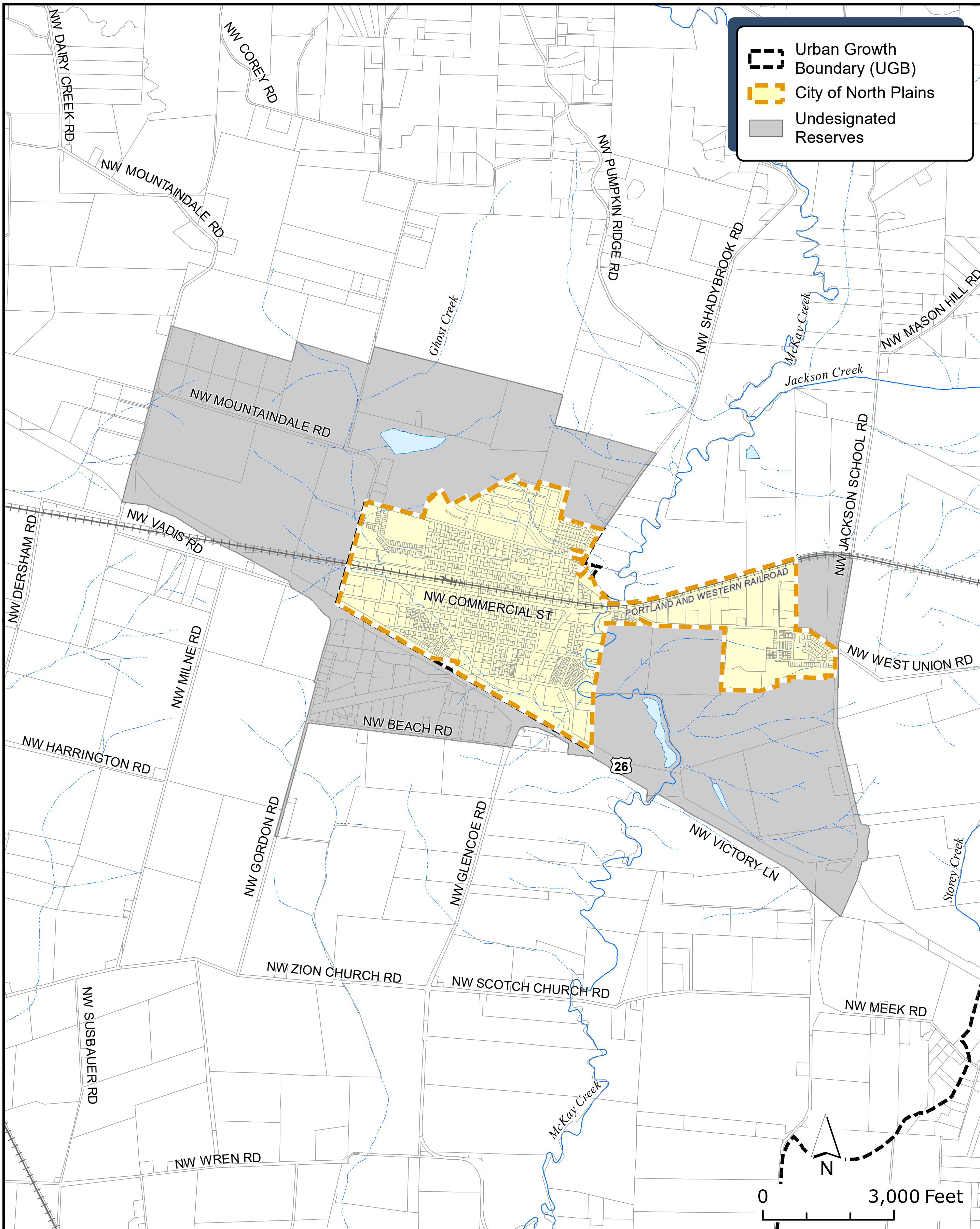
2.1 General

This section describes the City of North Plains water service area and existing water system facilities. Included in this section is a discussion of existing supply and transmission facilities, groundwater wells, system pressures, storage and pumping facilities, and distribution system piping.

2.2 Background and Study Area

The City of North Plains water service area currently serves a population of approximately 3,292 people and provides potable water to residential, commercial, and industrial services. The study area for this plan is the City's entire area within the City limits, plus anticipated expansion areas required to provide 20-years of available lands inventory. Approximately 151 acres of land that had been outside of the City limits but within the urban growth boundary (UGB) had recently been annexed, partially as a result of the State of Oregon Senate Bill 1573. At the time of this writing, the City is expected, based on forecasted growth, to fall short of 20-years of available lands inventory. Thus, this plan assumes that areas currently identified as Undesignated Reserves will be made available to accommodate expected growth through the 20-year planning period. The study area, UGB, City limits, and Undesignated Reserves are illustrated on Figure 2-1.

The City maintains a connection to the Joint Water Commission's (JWC) 72-inch diameter transmission main in Hillsboro. The JWC is a regional water supplier and a partnership of the Cities of Hillsboro, Forest Grove, Beaverton, Tigard and the Tualatin Valley Water District. The connection to the JWC system serves as the City's primary water source with the City's groundwater supply well serving as an emergency backup source. The City also has a ground level reservoir and constant pressure pumping facility. The City's water distribution system has one pressure zone serving all customers with ground elevations ranging from approximately 160 feet to 220 feet above mean sea level (msl). Figure 1 of Appendix A illustrates the City of North Plains' water service area limits, supply system and distribution facilities. Figure 1 is also a digital representation of the computerized distribution system hydraulic model used for the system analysis.



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City of North Plains
Water Master Plan

Figure 2-1
Water Service Area Map

NORTH PLAINS
City to the Sunset

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2.3 **Supply Sources**

The City of North Plains supplies potable water to its customers through a connection to the JWC water supply system. The City negotiated an agreement with the JWC to provide a maximum rate of flow not to exceed 875 gallons per minute (gpm) and a maximum volume of water not to exceed 1.0 million gallons per day (mgd). The City's existing groundwater well, Well No. 3, is used as an emergency backup supply source. A more detailed description of each supply source is presented below.

2.3.1 Joint Water Commission Supply

In 2005 the City of North Plains connected to a new water supply source from the JWC. The JWC draws raw water from the Tualatin River and impoundments on the Trask River (Barney Reservoir) and Scoggins Creek (Henry Hagg Lake) in the Coast Mountain Range. Water is withdrawn from the Tualatin River via the Springhill River intake and raw water pump station and treated at the adjacent treatment plant. The JWC Water Treatment Plant currently has a treatment capacity of approximately 75 mgd. From the treatment plant water is pumped to the two 20 million-gallon (MG) Fernhill Reservoirs east of the treatment plant. From the Fernhill Reservoirs water flows by gravity through a 72-inch diameter transmission main to the City of Hillsboro and communities to the east.

The City of North Plains' water supply source connection to the JWC system is provided through the Glencoe Road 16-inch Water Transmission Line that extends approximately 3.5 miles from JWC facilities in Hillsboro to the City of North Plains. The project includes the following elements:

- A connection to the existing 72-inch diameter JWC transmission main at the intersection of NW Evergreen Road and NW Glencoe Road.
- A metering station consisting of a 10-inch diameter electromagnetic flow meter and meter bypass at the intersection of NW Evergreen Road and NW Glencoe Road.
- A backflow prevention station, consisting of a 10-inch diameter double check backflow prevention assembly and bypass, at the intersection of NW Evergreen Road and NW Glencoe Road.
- Approximately 19,000 feet of 16-inch diameter transmission main on NW Glencoe Road, NW Beach Road, NW 316th Place and NW 314th Avenue.
- A pressure and flow control station, including parallel 10-inch and 6-inch diameter control valves, and a connection to the City's distribution system on NW 314th Avenue near the City's southerly border, directly north of Highway 26.

2.3.2 Well No. 3

Well No. 3 serves as an emergency backup supply source and is housed within the City's booster pump station building located at the intersection of NW Commercial Street and NW 321st Avenue.

In an emergency the well may be controlled manually to pump water directly into the City's 1.0 MG ground-level reservoir. The well has a current production capacity of approximately 500 gpm (0.7 mgd). The well includes a 60-horsepower pump motor, a 12-inch diameter casing, and has a depth of approximately 485 feet below ground surface (bgs). Water from Well No. 3 is chlorinated at the wellhead just prior to being pumped into the reservoir.

The City could choose to upgrade Well No. 1 to a more robust status than equipment washing purposes. This well is significantly further from the contaminated site (2,150 feet from Well No. 1 as compared to 350 feet from Well No. 3). The work would include inspection and possible replacement of the well casing, replacing the two-inch diameter pump with a four-inch diameter submersible pump, upgrading the power supply, including a chlorination station, and making a piped connection to the distribution system. This work would cost approximately $250,000 and is not included in the CIP. The capacity of a four-inch submersible pump for this depth would only be around 100 gallons per minute.

It is suggested that two 10,000-gallon potable water pillow tanks at a total cost of $25,000 be purchased to store water from Well No. 1 in the case of an emergency. This would allow the City additional backup storage in the case that Well No. 3 became unusable.

Table 2-1 presents a current summary of the City's wells. If the City is concerned about potential future contamination of Well No. 3, then using Well No. 2 for emergency backup would likely have a similar risk of contamination due to the proximity to Well No. 3, and for this reason we would not recommend this change.

2.3.3 Wells No. 1 and 2

Well No. 1 is located approximately 50 feet southeasterly of City Hall near the public works operations building. The well is used to periodically wash vehicles and equipment. Well No. 1 has a 2-inch vertical turbine pump with the motor located above ground, and a 6-inch diameter casing and a depth of approximately 710 feet bgs. Well No. 2 is located within the City's pump station and is currently not operational. The motor has been refurbished but the pump is non-functional. Well No. 2 has a 6-inch diameter casing and a depth of approximately 440 feet bgs.

Table 2-1
Groundwater Well Pump, Depth, and Production Summary

Well No.	Horse-power (hp)	Total Well Depth (feet)	Casing Diameter (inches)	Approximate Existing Production Capacity (gpm)
1	N/A	710	6	N/A (Washing Only)
2	N/A	440	6	Not operational
3	60	485	12	500
		Total Supply Source Production Capacity [1]		**500 (0.7 mgd)**

Notes

1. Total supply source production capacity is the sum of the production capacities of all operational well pumps.

2.4 Water Rights Summary

The City of North Plains holds a groundwater use right with the Oregon Water Resources Department. This permit provides for groundwater production from Well Nos. 1, 2 and 3 up to the amount of 1.43 cubic feet per second (cfs) (642 gallons per minute (gpm) or 0.92 million gallons per day (mgd)). In February 2005, the City submitted a claim of beneficial use on this permit from Well No. 3. The amount claimed was 1.32 cfs (592 gpm or 0.85 mgd). The City has been issued Certificate number 82907, associated with Application number G-9398. No claims were made regarding Well Nos. 1 and 2. Well No. 2 is not currently operational, and Well No. 1 is a non-exempt use. Because of the permitted volume being 642 gpm, and the maximum anticipated yield of Well No. 3 being 500 gpm, it does not appear that additional water rights are required to withdraw less than 142 gpm from Well No. 1.

2.5 System Pressure

Pressure zones are typically defined by ground topography and designated by overflow elevations of water storage facilities or discharge hydraulic grades of pressure reducing facilities or booster pumping facilities serving the zone. The City of North Plains' water service area has one pressure zone operating at an approximate hydraulic grade line (HGL) of 365 feet, or approximately 82 psi at the connection point, which is the discharge pressure setting of the JWC supply source pressure reducing/flow control facility located at roughly 170 feet in elevation. Additionally, system pressures are maintained by the City's booster pump station during high demand periods.

2.6 Storage

The City of North Plains' water system contains one storage reservoir, with a total storage capacity of approximately 1.0 MG. This reservoir is located on the same site and adjacent to the City's booster pump station at the intersection of NW Commercial Street and NW 321st Avenue at an approximate ground elevation of 177 feet. The reservoir overflow elevation is approximately 208 feet. The reservoir is a 41-foot diameter bolted steel reservoir with a wall height of 33 feet. The reservoir is filled through a connection to the distribution system which is controlled by an altitude valve located inside the booster pump station.

2.7 Pump Station

Under typical operations the booster pump station serves only to help maintain water quality in the reservoir. The pump station typically operates on a daily timer to pump water from the reservoir into the distribution system. During the night, the altitude valve opens to fill the reservoir. This typical daily operation serves to provide turnover and circulation of the stored water in the reservoir to maintain proper disinfection residual levels in the tank. A low-level cutout switch turns off all booster pumps when the reservoir is down 31 feet below the overflow elevation.

During very high demand scenarios the booster pump station is designed to supplement the supply from the JWC system. The JWC source connection and the booster pump station operate in a coordinated fashion to provide a constant pressure water supply to the distribution system. A discussion of the coordinated operation of the two system components is presented below. The pump station includes four pumps. A summary of basic data on these pumps is shown in **Table 2-2**.

Table 2-2
Summary of Existing Pumps

Pump No. or Name	Nominal Capacity (gpm)	Motor Horsepower (HP)	Comments
1	120	10	Not in service
2	500	40	Lead pump, variable speed, maintains 82 psi discharge pressure
3	200	15	Lag pump, constant speed
Fire	3,600	--	Direct drive fire pump, 375 HP natural gas fueled engine

2.8 System Operation Overview

Under normal conditions, water is supplied from the JWC source to the distribution system through a 6-inch diameter flow control valve located in the pressure reducing/flow control facility at the northerly end of the Glencoe Road 16-inch Diameter Transmission Line on NW 314th Avenue. As water demands increase and system pressures drop, the City's booster pump station's two smaller pumps operate to maintain system pressures. If pressures further continue to decrease, the fire pump operates together with the smaller pumps to maintain system pressures. Under very high or emergency demand conditions, if water system pressures continue to decrease, the 10-inch diameter pressure reducing valve in the pressure reducing/flow control facility opens to allow unlimited supply from the JWC. As currently configured, the 6-inch diameter flow control valve discussed above has a 4-inch diameter internal orifice, which may be removed as overall system demands rise over time.

As demands decrease and the system pressures increase, the pumps and valves automatically respond in reverse order beginning with the closure of the JWC 10-inch diameter pressure reducing valve. As system pressures rise to 70 psi, the fire pump shuts down followed by the booster pumps at 75 psi. **Table 2-3** summarizes these operation settings.

Table 2-3
Valve and Pump Station Operational Settings

Facility	Pressure (psi)	Comments
JWC Supply - 6" Valve (Ground elevation = 175)	82 [1]	Maintains supply pressure of 82 psi at existing ground-level reservoir (ground elevation = 175) and flow up to 875 gpm.
Pump Station - Smaller Pumps	70 - 75 [2]	Both small pumps (Nos. 2 and 3) cycle on and off starting at 75 psi with both on at 70 psi. Pump No. 2 cycles on first, it runs up to full speed, then Pump No. 3 starts.
Pump Station - Fire Pump	65 - 70 [2]	Fire pump starts at 65 psi and turns off at 70 psi
JWC Supply - 10" Valve	60 [2]	Opens at 60 psi and maintains this pressure with no flow rate restriction

Notes
1. Valve discharge pressure setting
2. Station discharge pressure settings

2.9 Distribution System

The City's water distribution system is composed of various pipe types in sizes up to 16 inches in diameter. The total length of piping in the service area is approximately 79,176 feet, or approximately 15 miles. The pipe material types include cast iron, ductile iron, and polyvinyl chloride (PVC). The majority of the piping in the system is ductile iron and cast iron. **Table 2-4** presents a summary of pipe lengths and materials by diameter.

Table 2-4
Distribution System Pipe Summary

Diameter (inch)	Materials (linear feet)		
	Ductile or Cast Iron	PVC	Total Length (lf)
4	3,284	-	3,284
6	11,398	3,300	14,698
8	24,535	17,809	42,344
10	-	1,400	2,671
12	-	10,228	10,228
14	-	5,301	5,301
16	650		720
Total [1]	36,600	24,150	79,246

Note
1. The City's water system also includes approximately 18,750 linear feet of ductile iron transmission main supply piping, most of which lies outside of the study area (see Figure 1 in **Appendix A**).

2.10 Telemetry and Control System

The City of North Plains does not have a telemetry or supervisory control system; however, such a system may be recommended to help coordinate operations as a new reservoir is completed.

The pump station is operated by a control system within the pump station, but it will be important to coordinate filling and drawdown between the two reservoirs to maintain water quality.

2.11 **Summary**

This section presents a summary of the City of North Plains' existing water system, including the supply system, storage and pumping facilities, and distribution system piping. Also included is a discussion of existing groundwater wells and system pressures and operation. **Section 3** presents a summary of existing land uses within the water service area and develops estimates of the future population and water demand requirements.

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Section **3**

Section 3

Service Area, Land Use, and Water Requirements

3.1 General

This section develops and presents population projections and estimated water demand forecasts for the City of North Plains water service area. Population and water demand forecasts are developed from regional and City planning data, current land use designations, historical water demand records and previous City water supply planning work. Also included in this section is a discussion of the water service area limits and a summary of the current land use and zoning designations within the service area.

3.2 Service Area

The City's water system currently provides service to the area within the existing City limits boundary, which includes approximately 681 acres of residential, commercial, and industrial land. The anticipated future water service area for this plan includes areas currently outside the established City Limits. Currently, the UGB is consistent with the City Limits. Several areas outside the UGB have been identified as undesignated reserve areas; however, specific urban reserves have not been identified. Therefore, specific UGB expansions are not shown, nor proposed, and water system needs to meet projected development outside the current UGB are discussed in general terms only.

This plan makes certain assumptions regarding available buildable lands inventory for water system planning purposes only. There are two small proposed future development areas in the northeasterly portion of the City, within the UGB, that total approximately 2 acres of available buildable land. For the purposes of this study, these areas have been included in the long-term demand estimates and are illustrated as highlighted areas on Figure 1 in Appendix A. The Oregon Department of Land Conservation and Development prohibits City infrastructure from extending beyond the existing urban growth boundary.

3.3 Planning Period

In accordance with OAR Chapter 333, Division 61, Section 0060, Plan Submission and Review Requirements, Paragraph (5)(b), the planning period for this water system master plan is 20 years. Based on estimated probable infill densities and anticipated development rates, saturation development within the UGB/City Limits is anticipated to occur within the 20-year planning horizon. Therefore, this plan includes potential future development of undesignated reserve areas as shown in Figure 2-1. All planning and facility sizing recommendations are based on saturation development conditions within the UGB, plus unspecified development for growth through the 20-year planning period. Thus, recommendations reflect the ultimate size of facilities needed for the 20-year planning period.

3.4 Land Use

Land use and zoning classifications for North Plains' existing water service area within the City limits are established under the City's Comprehensive Plan. That plan is currently in the process of being updated, and most recent data related to the residential buildable lands inventory is presented in the City of North Plains Housing Needs Analysis, July 2019 Final Draft Report (ECONorthwest). Land use and zoning classifications will be established for expansion areas, once such areas have been identified. **Table 3-1** summarizes land use, zoning classifications, and associated acreage within the City limits and the UGB.

Table 3-1
Land Use Summary

Zone	Zone Description	Area within North Plains UGB (gross acres)
R7.5	Single-Family Residential	66
R5	Single-Family Residential	62
R2.5	Multi-Family Residential	90
C1	General Commercial	7
C2	Highway Commercial	45
M1	Light Industrial	21
M2	General Industrial	138
NC [1]	Neighborhood Community	63
FD10	Future Dev. within UGB (10 Ac min.)	75
	Total	**681**

Note:
1. Land use and zoning classifications have not yet been designated by City planning. See Figure 1 in **Appendix A** for locations within UGB.

3.5 Population Estimates

3.5.1 Historical Population

Historical population data was obtained through the City of North Plains, the U.S. Census Bureau, and Portland State University Population Research Center. **Table 3-2** presents a summary of this historical population data from 1980 through 2019. The average annual growth rate over this period, as measured for the time intervals shown in **Table 3-2**, varied between 0.78 and 21.61

percent and the overall annual growth rate for this 37-year period averaged approximately 3.93 percent. The City estimates the current population at 3,292.

Table 3-2
Historical and Current Estimated Population Summary

Year	Population	Average Annual Growth Rate
1980	715	-
1990	972	3.12%
2000	1,605	5.14%
2010*	1,953	1.98%
2015**	2,015	0.78%
2019**	3,292	13.06%

* 2010 Estimate from United States Census Bureau

** Estimates from Portland State University Population Research Center

3.5.2 Population Forecast

From the Portland State University, Population Research Center, the City of North Plains population has been determined to be 3,292 in the year 2019. The City recently completed the City of North Plains Housing Needs Analysis, July 2017 Final Draft Report (ECONorthwest), that projected an average future growth rate of 5.1% through the year 2040. The City desires to implement this 5.1% average annual growth rate for this study as well.

3.5.2.1 Infill Development

Two annexations totaling 151 acres were recently completed, and partially influenced by Oregon Senate Bill 1573. The City anticipates continued rapid development of these areas, as well as continued infill development in remaining portions of the City.

3.5.2.2 Expansion Area Development

At the time of this writing there are several undesignated reserve areas outside of the current City limits and potentially available for future City expansion (See Figure 2-1). However, since these areas are currently identified as undesignated reserve areas, water system impacts associated with City expansion are addressed in general terms only, in this document, with the intent of having system expansion being fully paid for by developments in these undesignated reserve areas.

A potential 1.5-acre annexation area at the northwesterly corner of the intersection of NW North Avenue and NW Shadybrook Road is currently occupied by a Portland General Electric (PGE) power sub-station. It is not anticipated that any residential development will occur on this site after annexation. A 1.6-acre area zoned FD-10 just easterly of the intersection of NW Glencoe Road and NW North Avenue is a proposed annexation area with the capacity for approximately 15 residents.

According to the City of North Plains Housing Needs Analysis, July 2017, ECONorthwest, depending on development density assumptions, the City will need between 82 and 118 acres of additional land outside of the current UGB to accommodate the total anticipated population by the year 2040.

Table 3-3 presents a summary of population forecast, based on the above referenced average annual population growth rate of 5.1 percent. As discussed above, the historical annual growth rate over the period from 1980 to 2019 averaged approximately 3.93 percent. However, the growth rate over the past two years has been roughly 16.8 percent. **Table 3-3** illustrates beginning of fiscal year population estimates in 5-year increments through saturation development.

Table 3-3
Population Forecast Summary

Year	Population
2019	3,292
2022	3,821
2027	4,901
2032	6,284
2040	9,356

For water system planning purposes, it is generally considered most prudent to plan facility improvements for saturation development capacity requirements. By assuming full occupancy at saturation development, this methodology helps avoid the construction of new facilities that will need to be upsized in future years for increased capacity needs. The planning period for this master plan is 20 years and saturation development is anticipated to occur within that time frame. Recommendations presented in this plan are intended to maximize efficiency and avoid undesirable facility upsizing in future years where practical.

3.6 Water Demand Estimates

The term "water demand" refers to all the water requirements of the system including domestic, commercial, municipal, institutional and industrial as well as unaccounted-for water. Water demand estimates were developed from a review of historical water consumption records provided by the City, and population forecasts generated as part of this planning work. Demands are discussed in terms of gallons per unit of time such as gallons per day (gpd), million gallons per day (mgd), or gallons per minute (gpm). Demands are also related to per capita use as gallons per capita per day (gpcd).

3.6.1 Historical Water Use

The City of North Plains maintains records of historical monthly water usage by customer, which was used to calculate historical total annual consumption. The average day demand (ADD), often referred to as the average annual daily demand, is determined by dividing the total annual consumption by 365 days. The historical maximum day demand (MDD) is identified from historical consumption patterns. The peaking factor is calculated by dividing the historical MDD by the historical ADD and has been determined to be 2.2. **Table 3-4** summarizes this data for the years 2007 through 2015.

Table 3-4
Historical Water Use Summary

Year	Water Service Area Population	Water Demand (mgd)		
		Average Day Demand (ADD)	Maximum Day Demand (MDD)	Calculated Peaking Factor
2007	1,795	0.26	0.57	2.2
2011	1,958	0.19	0.42	2.2
2015	2,015	0.23	0.51	2.2

3.6.2 Water Demand Projections

Based on historical water consumption patterns, the water service area's average day demand (ADD) has been approximately 230,000 gallons per day. Based on the City's most recent historical water use patterns and population, the water service area's average day per capita consumption has ranged from 94 to 146 gpcd since 2006. For the purposes of this plan, estimated average daily water usage per capita is assumed to remain constant at approximately 125 gpcd. As conservation plays an increasing role in water usage patterns, it is anticipated that North Plains' average daily per capita usage may ultimately be reduced over time.

Future water demand estimates were developed by projecting historical consumption forward, using the previously presented population forecasts. As growth continues, both residential infill development within the current City limits/UGB area and development in anticipated future expansion areas are expected to result in significantly increased overall water demands.

As referenced above, a peaking factor of 2.2 is used to establish the future maximum day per capita usage at approximately 275 gpcd. Total estimated average and maximum day water demands for the City are then developed by multiplying the estimated per capita usage by the anticipated population for each year. To provide an estimate of peak hourly usage, a peak hour factor of 1.5 is applied to the estimated maximum day water demands. A 1.5 peak hour factor is consistent with water demand patterns of other communities in the region of similar size and type. **Table 3-5** presents a summary of water demand forecasts in five-year increments to the year 2040, the year completing the planning period development, including average day, maximum day and peak hour estimates.

Table 3-5
Population Forecasts and Estimated Water Demand Summary

Year	Population	Water Demand (mgd)		
		Average Day Demand [1] (ADD)	Maximum Day Demand [2] (MDD)	Peak Hour Demand [3]
2019	3,292	0.37	0.82	1.23
2022	3,821	0.48	1.05	1.58
2027	4,901	0.61	1.35	2.02
2032	6,284	0.79	1.73	2.59
2040—End of Planning Period	**9,356**	**1.01**	**2.22**	**3.32**

Notes:

1. Average Day Demand equals the Population multiplied by the estimated average daily per capita usage for the service area (125 gpcd).
2. Maximum Day Demand equals the Population multiplied by the estimated maximum daily per capita usage for the service area (275 gpcd).
3. Peak Hour Demand equals 1.5 times the Maximum Day Demand.

3.7 Summary

This section presents estimates of the current and future population, and forecasts of future water demands. **Section 4** outlines the planning criteria that, in conjunction with the water demand estimates developed in this section, are used in the system analysis presented in **Section 5**.

Section **4**

Section 4

Planning and Analysis Criteria

4.1 General

This section develops and presents the planning and analysis criteria used for the water system analysis. Criteria and planning assumptions are presented for the City of North Plains' supply and transmission system, distribution system piping, pressure zone, and storage and pumping facilities. Recommendations of water needs for emergency fire suppression are also presented. The water demand forecasts developed in **Section 3** are used with these criteria in **Section 5** for the analysis of North Plains' water system.

Seismic vulnerability and mitigation criteria are covered in Appendix D – Seismic Vulnerability and Mitigation Plan.

4.2 Supply and Transmission Evaluation and Analysis Criteria

The City's supply and transmission systems must be capable of providing estimated maximum day demands for the 20-year planning horizon. The capacity of each element of the supply and transmission system are evaluated in this plan to determine if adequate capacity exists to meet the water system needs through the planning period. If it is determined that additional supply and transmission system capacity is required to meet water system needs, analysis of improvement options will be completed, and recommendations will be included in this plan.

As described in **Section 2**, the City's primary water supply is provided through a connection to the JWC Supply System with a 16-inch diameter transmission main. The City also maintains a groundwater well, that could be used for emergency supply backup purposes. The JWC source water is supplied directly to the distribution system through a pressure reducing/flow control facility. This supply connection also serves to fill the City's 1.0 MG reservoir through the distribution system. The agreement with JWC restricts the maximum continuous rate of flow to 875 gpm (1.26 mgd) and the maximum volume of water to 1.05 mgd. However, in the event of a fire, the supply is designed to provide full capacity flow for the duration of the event. This interest is discussed further in the pumping capacity criteria, below. It is understood that the City is currently renegotiating its agreement with JWC to increase the terms related to supply flow rate and volume. The physical characteristics of the supply system can accommodate the City's needs well beyond the 20-year planning horizon.

The emergency supply groundwater well (Well No. 3) is available to pump water directly into the City's 1.0 MG reservoir, should the need arise. Water is pumped from the reservoir into the distribution system by the City's booster pump station. Further analysis of the supply, treatment and transmission systems is contained in Section 5, and recommendations for supply, treatment and transmission system improvements are presented in Section 6.

4.3 Distribution System

The water distribution system should be capable of operating within certain system performance limits, or guidelines, under varying demand and operational conditions. The recommendations of this plan are based on the following performance guidelines, which have been developed through a review of State requirements, American Water Works Association (AWWA) acceptable practice guidelines, operational practices of similar water providers, and discussions with City water system operations staff. The analysis criteria are as follows:

1. The water system should be capable of supplying the peak hourly demand while maintaining minimum service pressures of not less than approximately 75 percent of normal system pressures.

2. During a fire flow event or emergency, the minimum service pressure is 20 psi as required by Oregon Health Authority, Drinking Water Services (OHA) and OAR 333-061-0025(7). The system shall be capable of providing fire flow capacity while simultaneously delivering MDD and maintaining 20 psi throughout the distribution system. The system shall meet this criterion with operational storage in the City's reservoirs depleted.

3. The distribution system shall be looped as much as practical to provide optimal water circulation, water quality, fire flow capacity, and system reliability and redundancy.

Proposed or new water mains should be at least 8 inches in diameter to supply minimum fire flows. In special cases, 6-inch or 4-inch diameter mains are acceptable if no fire hydrant connection is required, there are limited services on the main, the main is dead-ended and looping or future extension of the main is not anticipated.

4.4 System Pressure Criteria

As discussed in Section 2, the City has one pressure zone. For planning and analysis purposes, and for the purposes of performing the distribution system hydraulic analysis, it is assumed that the hydraulic grade line of the water system is approximately 365 feet. The hydraulic grade line is based on the pressure settings of the pressure reducing facility at the City's connection to the JWC, as well as control settings at the booster pump station.

Pressure zones are usually defined by ground topography and designated by overflow elevations of water storage facilities or outlet settings of pressure reducing facilities or discharge pressures of booster pump stations serving the zone. Typically, water from a reservoir will serve customers by gravity within a specified range of ground elevations to maintain acceptable minimum and maximum water pressures at individual service connections. When it is not feasible or practical to site a reservoir such that the water surface elevation is at the hydraulic grade of a given pressure zone then pumping facilities or pressure reducing facilities are used to adjust the reservoir pressure for serving the pressure zone.

Generally, 80 psi is considered the desirable maximum upper pressure limit within a water distribution system and 40 psi the lower limit. The JWC supply and the pump station are set to maintain a supply pressure of approximately 82 psi, which is the desired service pressure setting for the City. Whenever feasible, it is desirable to achieve no less than 40 psi at the point of the highest fixture within a given building being served. Conformance to this pressure range may not always be possible or practical due to topographical relief, existing system configurations and economic considerations. **Table 4-1** summarizes the service pressure criteria used in the analysis of the City's water system.

Table 4-1
Recommended Service Pressure Criteria

Condition	Pressure (psi)
Minimum Service Pressure Under Fire Flow Conditions	20
Minimum Normal Service Pressure	40
Maximum Service Pressure	82*

* The typical recommended range is 40-80 psi. However, the City has set the supply PRV at 82 psi without any over pressurization problems to date. While the *Oregon Plumbing Specialty Code* (OPSC) 608.2, recommends individual PRV's where supply pressures exceed 80 psi, it is expected that this pressure is only exceeded by perhaps 1-2 psi for a very small number of services in the City. Thus, this report recommends keeping the supply PRV set at 82 psi until conditions warrant a change.

4.5 Storage Volume

There are two independent criteria for analyzing storage volume needs in North Plains. One is based on standards of water industry practice and the other is based on the City's agreement with the JWC. In accordance with AWWA standards and other regional water system design guidelines, water storage facilities are typically intended for three purposes: Operational storage, fire storage, and emergency storage. Thus, the recommended storage volume must be equal to or greater than the sum of these three components, or the JWC required storage amount, whichever is greater. A brief discussion of each storage volume component is provided below. The City's agreement for purchasing water from the JWC requires a storage volume or supplemental water supply, equal to three times the average day demand.

4.5.1 Operational Storage

Operational storage is required to meet water system demands in excess of delivery capacity from the supply source. Operational storage volume should be sufficient to supply demand fluctuations throughout the day resulting from typical customer water use patterns and is generally considered as the difference between peak hour demand and MDD on a 24-hour duration basis. This planning methodology is intended to provide sufficient Operational storage daily when high demand conditions occur repeatedly over the course of several days. For this system Operational storage volume in the amount of 25 percent of maximum day demand is considered appropriate.

4.5.2 Emergency Storage

Emergency storage is often provided to accommodate certain emergencies such as pipeline failures, equipment failures, power outages or natural disasters. The amount of emergency storage provided can be highly variable depending upon an assessment of risk and the desired degree of system reliability. Provisions for emergency storage in other systems vary from none to a volume that would supply a maximum day's flow or higher. Considering that the City of North Plain's distribution system is supplied from a connection to the historically reliable JWC system, and the City maintains an emergency backup supply well, it is recommended that North Plains provide a minimum emergency storage volume to supply approximately 25 percent of maximum day demand. This amount of storage volume for emergency purposes is consistent with accepted water industry practices and guidelines. It should be noted that the JWC agreement requires total water storage, rather than "emergency storage" for the City to be three times average day demand.

4.5.3 Fire Storage

Fire storage should be provided to meet the single most severe fire flow demand within each zone. The fire storage volume is determined by multiplying the recommended fire flow rate by the expected duration of that flow. Specific fire flow quantity and duration recommendations are discussed below.

4.5.3.1 Fire Flow Recommendations

While the water distribution system provides water for domestic uses, it is also expected to provide water for fire suppression. The amount of water recommended for fire suppression purposes is typically associated with the local building type or land use of a specific location within the distribution system. Fire flow recommendations are typically much greater in magnitude than the normal maximum day demand present in any local area. Adequate hydraulic capacity must be provided for these large occasional fire flow demands.

A summary of fire flow recommendations by land use designation is presented in **Table 4-2**. The recommended fire flows presented in **Table 4-2** were developed through a review of fire flow criteria adopted by similar communities, fire flow guidelines as developed by the AWWA, the Insurance Services Office (ISO), recommendations of the Oregon Fire Code, and discussions with Tualatin Valley Fire & Rescue.

Table 4-2
Summary of Land Use and Recommended Fire Flows

City of North Plains Zoning Classification		Recommended Fire Flow (gpm)
R7.5	Single-Family Residential	1,500
R5	Single-Family Residential	1,500
R2.5	Multi-Family Residential	1,500
C1	General Commercial	3,500
C2	Highway Commercial	3,500
M1	Light Industrial	3,500
M2	General Industrial	3,500

Water stored for fire suppression is typically provided to meet the single most severe fire flow demand within each zone. The recommended fire storage volume is determined by multiplying the fire flow rate by the duration of that flow. **Table 4-3** summarizes recommended fire flow durations. Therefore, the maximum fire flow storage required is 3,500 gpm X 3 hours = 0.63 MG.

Table 4-3
Recommended Fire Flow Duration Summary

Recommended Fire Flow (gpm)	Duration (hours)
Up to 3,000	2
3,000 to 4,000	3

4.6 Pumping Capacity

The City's water system is supplied by a connection to the JWC system and includes an emergency backup well and storage reservoir. With this arrangement, the City's water system is classified as an "open system", with primary flow and system pressure provided by an outside water supply source. Minimum pumping capacity requirements for an open system is required to meet MDD conditions with all pumps in service and meet ADD conditions with the largest pump out of service (firm capacity). The agreement with JWC restricts the maximum continuous rate of flow to 875 gpm (1.26 mgd) and the maximum daily volume of water to 1.05 mgd. However, in the event of a fire, the supply is designed to provide full capacity flow for the duration of the event; therefore, the above criteria appear reasonable. To date, the highly reliable JWC supply has never failed to provide needed water supply volumes and pressures to North Plains.

4.7 Water Quality

In Oregon, drinking water quality standards for 95 primary and 12 secondary contaminants are established under the Oregon Drinking Water Quality Act (OAR 333-061) which includes implementation of national drinking water quality standards. To maintain public health, each contaminant has either an established maximum contaminant level (MCL) or a recommended treatment technique.

There are three drinking water quality standards and potential contaminants that may be exasperated or originate in the distribution system. Specifically, microbial contaminants (Total Coliform Rule), lead and copper (Lead and Copper Rule) and disinfection byproducts (Disinfectants and Disinfection Byproducts Rule).

Beyond the current testing being done by the City, plans are in place to periodically test Well No. 3 for contaminants.

4.8 Total Coliform Rule

There are a variety of bacteria, parasites, and viruses which can cause health problems when ingested. Testing water for each of these germs would be difficult and expensive. Instead, total coliform levels are measured. The presence of any coliforms in the drinking water suggests that there may be disease-causing agents in the water also. A positive coliform sample may indicate that the water treatment system isn't working properly or that there is a problem in the distribution system. Although many types of coliform bacteria are harmless, some can cause gastroenteritis including diarrhea, cramps, nausea and vomiting. This is not usually serious for a healthy person, but it can lead to more serious health problems for people with weakened immune systems.

The Total Coliform Rule applies to all public water systems. Total coliforms include both fecal coliforms and E. coli. Compliance with the MCL is based initially on the presence or absence of total coliforms in a sample, then a focus on the presence or absence of E. coli. For North Plains, the MCL is exceeded if more than five percent of the 3 required monthly samples have total coliforms present. A water system must collect a set of repeat samples for each positive total coliform result and have it analyzed for total coliforms and E. coli.

4.9 Lead and Copper and Corrosion Control

Lead and copper enter drinking water primarily through corrosion of plumbing materials most commonly caused by a chemical reaction with the water which may be due to dissolved oxygen, low pH or low mineral content. Exposure to lead and copper may cause health problems ranging from gastroenteritis to brain damage. In 1991, the national Lead and Copper Rule (LCR) established action levels for lead and copper concentrations in drinking water. Under the Oregon Drinking Water Quality Act, water utilities are required to implement optimal corrosion control treatment that minimizes the lead and copper concentrations at customers' taps, while ensuring that the treatment efforts do not cause the water system to violate other existing water regulations. It should be noted that an update to the LCR is currently being considered, though implications to the City's water system are anticipated to be minimal.

Utilities are required to conduct monitoring for lead and copper from taps in customers' homes. Samples are currently required to be taken every three years at 12 sampling sites. The action level for either compound is exceeded when more than 10 percent of the samples are greater than the action level in a given monitoring period.

4.9.1 Stage 2 Disinfectants and Disinfection Byproducts Rule (D/DBPR)

Disinfectants are used in public water systems to control microbial pathogens in source water which may cause gastrointestinal illness. These disinfectants can react with naturally-occurring material in the water to form by-products which have been found to increase health risks when consumed in larger concentrations over many years. The D/DBPR is focused on two groups of disinfection by-products, total trihalomethanes (TTHMs) and haloacetic acids (HAA5). Under Stage 2 of the D/DBPR, water providers are required to monitor running locational average concentrations of these by-products at sampling sites in the distribution system previously identified under Stage 1 monitoring. These sampling sites represent the worst-case DBP water quality for the water system.

The City is currently conducting compliance monitoring under the Stage 2 D/DBPR which requires samples to be taken yearly at each of two sampling sites. The locational running average at each site may not exceed the MCL for either TTHMs or HAA5s in order to remain in compliance.

4.10 Summary

The criteria developed in this section are used in **Section 5** to assess the system's ability to provide adequate water service under existing conditions and to guide improvements needed to provide service for future water needs. A similar analysis and recommendation of improvements to the water supply system is offered in **Section 6**. Cost estimates and a recommended capital improvement plan are developed and presented in **Section 6**.

Recommended planning criteria for the City's source, pumping stations, distribution system, pressure zones, and storage facilities are summarized as follows:

- *Source Capacity:* Should deliver MDD through the planning horizon.
- *Pumping Station Capacity:* MDD conditions plus fire flow demands with the largest pump out of service.
- *Distribution System Criteria:* The distribution system should be capable of supplying the peak hourly demand while maintaining minimum service pressures of not less than approximately 75 percent of normal system pressures.
- *Fire Flow Criteria:* The distribution system should be capable of supplying the recommended fire flows while maintaining minimum residual pressures everywhere in the system of not less than 20 psi.

- *Service Pressure Criteria:* Minimum static system service pressures within each pressure zone should be at least 40 psi at the highest fixture in any building being served. Maximum static service pressure should not exceed approximately 82 psi.

- *Storage Volume Criteria:* Total storage volume should be the sum of the operational, fire and emergency storage volume components, or three times average day demand per the JWC agreement, whichever is greater.

Section **5**

Section 5

Water System Analysis

5.1 General

This section presents an analysis of North Plains' water distribution system based on the water demand forecasts presented in **Section 3** and the analysis criteria developed in **Section 4**. This section analyses the City's supply sources, evaluates the system's existing service pressures and storage and pumping capacity requirements, and presents the findings of a computerized hydraulic network analysis of the water distribution system. Through evaluation and analysis, system deficiencies were identified, and improvement options were developed. **Section 6** presents a recommended capital improvement program that includes prioritized recommended improvements to correct system deficiencies and provide for system expansion.

Water demand estimates for the study area were developed in 5-year increments through the 20-year planning period to FY 2040, as shown on **Table 5-1**. These water demand estimates along with the planning criteria established in **Section 4** are the basis for the analysis of the existing system and the development of recommended system improvements. All improvements to storage and pumping facilities and distribution piping are based on estimated maximum day demands for projected populations through the 20-year planning period.

Seismic vulnerability and mitigation analysis is presented in Appendix D – Seismic Vulnerability and Mitigation Plan.

5.2 Supply Source Analysis

The City's primary water supply is provided through a 16-inch diameter transmission main connected to the Joint Water Commission (JWC) supply system. The City has negotiated an agreement with the JWC that provides an instantaneous rate of flow not to exceed 875 gpm and a maximum volume of water per day not to exceed 1.05 million gallons. It is understood that once the new Willamette Water Supply Pipeline is in place in 2024, the JWC will be in a position of increasing supply to North Plains.

In addition, the City's existing well, Well No. 3, is available as an emergency backup supply with a production capacity of approximately 0.7 mgd. The City's supply capacity is adequate to meet the current maximum day demands of approximately 0.76 mgd. The water demand analysis in **Section 3** projects an estimated maximum day demand of approximately 2.22 mgd through the 20-year planning period.

With a maximum day supply allowance of 1.05 mgd, the JWC source will soon be inadequate to meet the City's maximum day demands. Thus, it is recommended that the City begin discussions with the Joint Water Commission to renegotiate their supply agreement. When the agreement was originally drafted in 2003, the City's maximum day demand was 0.45 MG. The methodology that was used with the original agreement established a maximum volume per day that was roughly twice the maximum day demand (MDD), and the instantaneous rate of flow was 1.2 times that calculated maximum volume. Applying this methodology today for the planning period through 2040 would result in the maximum volume of water use increased to 4.1 MG, and the instantaneous flow rate would be increased to 3,400 gpm. **Table 3-8** summarizes the water demands relating to population forecast, which is repeated and presented as **Table 5-1** for convenience.

Table 5-1
Population Forecasts and Estimated Water Demand Summary

Year	Population	Water Demand (mgd)		
		Average Day Demand 1 (ADD)	Maximum Day Demand [2] (MDD)	Peak Hour Demand [3]
2019	3,292	0.37	0.82	1.23
2022	3,821	0.48	1.05	1.58
2027	4,901	0.61	1.35	2.02
2032	6,284	0.79	1.73	2.59
2040—End of Planning Period	**9,356**	**1.01**	**2.22**	**3.67**

Notes:
1. Average Day Demand equals the Population multiplied by the estimated average daily per capita usage for the service area (125 gpcd).
2. Maximum Day Demand equals the Population multiplied by the estimated maximum daily per capita usage for the service area (275 gpcd).
3. Peak Hour Demand equals 1.5 times the Maximum Day Demand.

5.3 Water Rights

The City of North Plains holds a groundwater use permit with the Oregon Water Resources Department. This permit provides for groundwater extraction from Well Nos. 1, 2 and 3 up to the amount of 1.43 cubic feet per second (cfs) (642 gpm or 0.92 mgd)). In February 2005, the City submitted a claim of beneficial use on this permit from Well No. 3. The amount claimed was 1.32 cfs (592 gpm or 0.85 mgd). No claims were made regarding Well Nos. 1 and 2. Well No. 2 is currently not operational, and Well No. 1 is considered to be a non-exempt use and it was not included in the claim. Assuming the claim is approved, the City will in due course be issued a water right certificate for the amount claimed from Well No. 3.

5.4 Water System Pressure Analysis

As discussed in **Section 2**, North Plains' distribution system currently has one single pressure zone. The planning criteria developed in **Section 4** established acceptable service pressure limits for the water system. Under normal operating conditions, water will be supplied to the service area primarily through the supply line from JWC. Analysis of system pressures under average day, maximum day, peak hour, and fire flow conditions indicate that the City's distribution system will require some improvements over the planning horizon. These improvements are discussed in **Section 6**.

5.5 Storage Capacity Analysis

The storage capacity analysis evaluates the City's existing storage capacity and determines the recommended storage volume needs for the water service area. Reservoir capacity requirements are developed based on the planning criteria presented in **Sections 3** and **4**. Estimated reservoir storage volume requirements are typically based on the sum of operational, fire suppression and emergency storage volume needs. However, because of the City's agreement with the Joint Water Commission that stipulates that North Plains must maintain storage capacity or supplemental water supply equal or greater than three times the average day demand, this is the criteria that controls the need and is thus reflected in **Table 5-2**.

It should be noted that the City does have in place Well No. 3, which is capable of providing roughly twice the current average day demand. However, this well is intended as an emergency backup supply only, and this report recommends implementing additional storage in the near term.

Table 5-2
Storage Volume Analysis Summary

Storage Requirement (MG) [1]		Existing Storage Capacity (MG)	Storage Deficit (MG)	
2019 (Existing)	2040 (Planning Horizon)		2019 (Existing)	2040 (Planning Horizon)
1.00	3.51	1.00	0.23	2.51

Notes:

1. Storage capacity requirements equal the greater of the two storage capacity criteria stated in **Section 4**. See **Table C-1** in **Appendix C** for required capacity under each criterion.

Based on the above described assumption that Well No. 3 is to serve on an emergency basis only, this analysis indicates that the City's storage requirements have just begun to exceed existing storage capacity. An additional 2.34 MG will be required through the planning period. Based on the above analysis, it is recommended that additional storage capacity be provided in the near term. Specific recommendations regarding future reservoir sizing and locations are presented in **Section 6**. It appears that the storage criteria based on the current JWC agreement governs; therefore, it is suggested that a review of the agreement and renegotiation be considered to confirm sizing requirements as the City considers building additional storage capacity. Storage capacity requirements for each criterion through the year 2040 are presented in **Table C-1** in **Appendix C**.

5.6 Pumping Capacity Analysis

As presented in **Section 2**, under typical operations the booster pump station serves only to help maintain water quality in the reservoir. Typically, each day the pump station operates on a timer to pump water from the reservoir into the distribution system. During the night an altitude valve opens to fill the reservoir from the distribution system. Occasionally, during very high demand conditions, the booster pump station serves to supplement the supply from the JWC system by pumping water from the reservoir into the distribution system. The pump station also operates to provide fire suppression capability when fire demands lower system pressures enough to trigger such pumping.

Pumping capacity requirements were evaluated using criteria established in **Section 4**. This report recommends requiring firm pumping capacity meet ADD, and total pumping capacity to meet MDD. Firm pumping capacity is defined as the pumping capacity when the largest pump is out of service. For the pumping capacity analysis, water demand estimates have been converted to gallons per minute (gpm). **Table 5-3** presents a summary of pumping requirements, existing pumping capacity, and the surplus or deficit of capacity over the planning horizon in 5-year increments.

It should be noted that the City is currently implementing a new storage reservoir and pumping station. The new reservoir will be a ground level tank requiring pumping to increase pressures for use in the distribution system. For efficiency, it is recommended that the new pump station be designed to allow for incremental pumping capacity increases over time as needed. Specific recommendations regarding pumping improvements are presented in **Section 6**.

Table 5-3
Pumping Capacity Analysis

Year	Pumping Capacity (gpm)					
	Requirement		Existing		Surplus (+) / Deficit (-)	
	Firm (ADD)	Total (MDD)	Firm	Total	Firm	Total
2019	286	629	700	4300	414	3671
2022	306	673	700	4300	394	3627
2027	393	864	700	4300	307	3436
2032	503	1108	700	4300	197	3192
2040	812	1787	700	4300	(112)	2513

5.7 Distribution System Analysis

5.7.1 General

A hydraulic network analysis computer program was used to evaluate the performance of the existing distribution system and to aid in the development of proposed system improvements. The network analysis program determined pressure and flow relationships throughout the distribution system for a variety of critical hydraulic conditions. System performance and adequacy was then evaluated on the basis of water demand estimates developed in **Section 3** and planning criteria presented in **Section 4**.

5.7.2 Hydraulic Model

For modeling purposes, the water distribution system facilities data was brought into ArcGIS and imported into InfoWater, a fully GIS integrated water distribution system modeling software. The model was then used to perform the system analysis and to develop recommended improvements. Final recommendations are presented as the “Proposed Water System Plan Map” Figure 1 in **Appendix A**.

All pipes on the map are shown as “links” between “nodes” which represent pipeline junctions or changes in pipe size. Within the program, pipes and nodes are numbered to allow for easy system updating and revision. These numbers have been assigned to frozen drawing layers and have not been shown for drawing clarity. Also within the program, diameter, material type and length are specified for each pipe, and an approximate ground elevation is specified for each node. Hydraulic elements such as closed valves, pressure reducing valves, pumps and reservoirs are also illustrated and incorporated into the model database.

5.7.3 Model Calibration

The hydraulic model simulates the City’s existing water distribution system by approximating the length, diameter and friction loss characteristics of all distribution system piping. In addition, the modeling conditions assume that the City’s water supply is provided through the connection to the JWC system, as discussed in **Section 2**. It is anticipated that the City’s pump station will operate as presented in **Section 2** and is reflected in fire flow capacity estimates. Existing pump station performance and system pressure data was not sufficient to calibrate the hydraulic model with actual flow test data. As such, pipe friction loss coefficients and pump performance are estimated based on industry standards and local experience with water systems of similar size, age, pipe material and usage.

5.7.4 Modeling Conditions

To simulate system operation under maximum usage conditions, it is necessary to determine the water usage anticipated for the highest water use day of the year. For this purpose, the maximum day demands at saturation development, previously presented as part of **Table 5-1**, were distributed throughout the system.

To use the computerized hydraulic model of the water system to assess system adequacy, several conditions were examined. The adequacy of the major transmission piping and the system's ability to provide recommended fire flows throughout the system were analyzed.

All fire flow modeling was performed assuming that the connection to the JWC system was supplying water and the fire pump was operating in accordance with the system operational settings as identified in **Table 2-3**. In addition, it was assumed that the system must can provide the recommended fire flows while maintaining a minimum system pressure of approximately 20 psi to all services.

5.7.5 Modeling Results

5.7.5.1 Distribution System

Certain distribution system improvements are required to adequately supply the water system during maximum day demand conditions and to meet fire flow requirements over the 20-year planning horizon. Improvement sequencing, pipe size recommendations, and detailed project cost estimates are presented in **Section 6**.

5.7.5.2 Fire Flow

Modeling results under maximum day demand conditions at saturation development indicate that improvements are required to provide recommended fire flows while maintaining minimum service pressures. Fire flows were simulated throughout the study area based on the estimated fire flow recommendations for representative land uses as presented in **Section 4**. The needed improvements are limited to upsizing existing distribution mains. The locations of improvements are indicated on Figure 1 in **Appendix A**. Improvement sequencing and pipe sizing recommendations are presented in **Section 6** in addition to detailed project cost estimates.

5.7.5.3 System Expansion

As discussed in **Section 3**, the City of North Plains' UGB currently encompasses approximately 709 acres. The future water service area includes the UGB, but is undefined outside of that. For the purposes of this study, it's assumed that water system improvements needed to serve new areas outside of the current UGB will need to be paid for by the new developments.

5.8 Water Conservation

5.8.1 Introduction

The City of North Plains is a wholesale customer of the Joint Water Commission (JWC). As the City is not an active municipal water rights holder for its regular supply, it is not required to develop a formal Water Management and Conservation Plan, but may consider establishing a formal program to implement the following conservation measures to reduce water usage, particularly peak water usage. The following are examples of water conservation efforts that water utilities are required to consider under the Oregon Administration Rules Chapter 690, Division 86, Water Management and Conservation Plans.

5.8.2 Public Education and Outreach

Water conservation can be promoted through a variety of programs and activities in the public-school system, higher education system, community events and regional partnerships. Conservation information could be provided with billing statements and/or at the City's front lobby. In addition, specific conservation messages could be included with the billing statements to provide tips to use water wisely. These tips, in conjunction with the other elements of the City's public education program, provide a clear link between water conservation and financial savings for the individual customer.

5.8.3 Technical and Financial Assistance Programs

There are existing State of Oregon and federal water conservation programs that the City can promote through awareness. Examples include the Oregon Energy Trust and federal rebate programs. The City can also take an active role in promoting conservation through technical and financial assistance programs. For example, the City of North Plains could distribute residential kits to homeowners upon request to help them detect leaks and reduce water usage.

5.8.4 Retrofit/Replacement of Inefficient Fixtures

The City can offer commercial and residential rebates for replacement of high-water use appliances and fixtures and, as described above, provide kits to help identify leaks and other potential reasons for high water bills, such as inefficient fixtures. These programs can be effective where a water system service area contains a high number of older homes that likely still contain aging, inefficient fixtures.

5.8.5 Leak Detection Program

Water loss prevention and leak detection programs are typically economical when annual water losses regularly exceed 10 percent. Given that the estimated percentage of unaccounted-for water is below this level, the City does a more than sufficient job by conducting leak detection work every other year.

The City is actively implementing a water main replacement program that is systematically replacing aging mains to reduce water loss and excessive main breaks. The continuation of this program as a key element of the City’s water system capital budget and is recommended to maintain current low levels of water loss.

5.8.6 Water Conservation Recommendations

It is recommended that the City consider implementing the above programs. No further investment in City-specific water conservation measures is recommended at this time; however, as the City continues to grow and develop, future efforts to encourage and support water conservation efforts may help to delay the need to make substantial capital improvements to meet increased water demands. The City should continue to evaluate potential conservation-encouraging programs with future Water Master Plan updates.

5.9 Summary

This section developed and presented an analysis of the North Plains’ water system. The analysis found that additional water supply capacity, storage volume, pumping capacity and piping improvements are needed to adequately meet near term needs and to provide for system expansion in the future. Water conservation was also addressed. **Section 6** presents specific recommendations and a capital improvement plan that includes proposed project sequencing, phasing requirements and project cost estimates.

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Section 6

Section 6

Recommendations and Capital Improvement Plan

6.1 General

This section presents recommended water system improvements based on the analysis and findings presented in **Section 5**. These improvements include proposed additional water supply capacity, storage volume, pumping capacity and piping improvements. The analysis found that certain improvements are needed to adequately meet near term needs and to provide for system expansion in the future. All proposed system improvements are illustrated on **Figure 1** in **Appendix A**. Also presented is a capital improvement program (CIP) schedule for all recommended improvements.

For purposes of future cost estimate updating, the April 2019 ENR CCI for Seattle, Washington of 12,015.45 is referenced. Composite tables of CIP projects are included in Section 6 and Appendix D.

6.2 Cost Estimating Data

An estimated project cost has been developed for each improvement project recommendation presented in this section. Itemized project cost estimate summaries are presented in **Appendix B**. **Appendix B** also includes a Piping Improvement Project Cost Estimate Summary developed on a unit cost basis for recommended water main improvements.

The cost estimates are based upon recent experience with construction costs for similar work in the region and assume improvements will be accomplished by private contractors. Cost estimates represent opinions of costs only, acknowledging that final costs of individual projects will vary depending on actual labor and material costs, market conditions for construction, regulatory factors, final project scope, project schedule and other factors.

Estimated costs include planning level contingencies of 30% for the proposed reservoir and pump station, and 40% for all other recommended system improvements. The contingencies include engineering, administration and other project-related costs. Since construction costs change periodically, an indexing method to adjust present estimates in the future is useful. The Engineering News-Record (ENR) Construction Cost Index (CCI) is a commonly used index for this purpose. ENR provides monthly index estimates for 20 major U.S. metropolitan areas. The closest regional CCI provided by ENR is for Seattle, Washington. For purposes of future cost estimate updating, the April 2019 ENR CCI for Seattle, Washington of 12,015.45 is referenced.

6.3 Recommended Improvements

6.3.1 General

Presented below are recommended water system improvements for supply, storage, pumping, and distribution system piping. Project cost estimates are presented for all recommended improvements and annual budgets are presented for recommended capital improvement programming. The recommendations are presented by project type and discussed in order of need. A summary of all the recommended improvements is presented in Table 6-1. The table provides for prioritized project sequencing by illustrating fiscal year (FY) project needs for each facility and improvement category. The proposed improvements listed are phased and sequenced for construction over the planning period of 20 years.

6.3.2 Supply Source Agreement

In 2005 the City of North Plains implemented a water supply source from the Joint Water Commission (JWC) that provides a peak flow of approximately 875 gpm and a maximum supply per day of 1.05 million gallons, as per the City/JWC supply agreement. As discussed in Section 5, system demands are beginning to exceed the currently agreed supply limits. Although the City maintains an emergency backup water supply well, it is desirable to limit future reliance on the well due to potential for contamination from the nearby superfund site. It is estimated that an additional 1.17 million gallons of maximum day supply capacity is needed at the end of the 20-year planning period. It is understood that the City has contacted JWC, with the response being that additional supply will become available following implementation of the Willamette Water Supply Pipeline. Alternatively, the City could seek other supply sources.

It should be noted that Oregon Administrative Rules now mandate the preparation of a Water Management and Conservation Plan (WMCP) in accordance with Division 86 guidelines for all municipal water suppliers. As per the JWC/North Plains agreement, the City of North Plains effectively adopts the JWC Water Management and Conservation Plan, thereby satisfying the OAR requirements in this regard.

6.3.3 System Monitoring and Control

Considering the need for additional storage and proper coordination between reservoirs and the supply connection, it is recommended that the City implement monitoring and control system improvements. There are several key reasons for implementing monitoring and control system improvements, including greater control of supply flows, and better water quality management associated with the addition of a second water storage reservoir. The monitoring and control improvements would help the City stay within the instantaneous flow limit, and better manage the daily volume allowance established by the City/JWC agreement. By better controlling demand peaking the City may defer, as long as practical, the need to renegotiate the City/JWC agreement again in the future, or develop other water sources and additional storage as needed. Also, by exhibiting a consistent pattern of mitigated demands on the JWC source, North Plains may be better positioned for possible future agreement renegotiation.

Recommended improvements include a flow meter and additional valve control components installed within or near the existing supply pressure/flow control station on NW 314th Avenue. Additional elements include supervisory control and data acquisition (SCADA) and telemetry system components installed and programmed at the station and both the City's pump station and at the Public Works offices, as well as at the new pump station planned for the new storage reservoir. This work could all be combined with the new reservoir/pump station project, or be implemented separately. The estimated project cost of these system monitoring, and control improvements is $155,000. For project budgeting purposes, the costs for components required at the new pump station are included in the proposed pump station costs.

6.3.4 Pumping Improvements

The City's existing pump station currently houses one 40 hp booster pump, one 15 hp booster pump, one non-operational booster pump, and one 3,600 gpm fire pump. The existing 3,600 gpm natural gas fueled fire pump is not considered as a booster pump for this analysis, and the City may continue to maintain it over the long term for emergency (fire) purposes, or replace it as may be desired.

As discussed in **Section 4**, with the City's water system being supplied by a connection to the JWC, the system is classified as an "open system", with primary flow and system pressure provided by an outside water supply source. Minimum pumping capacity for an open system is required to meet MDD conditions with all pumps in service, and meet ADD conditions with the largest pump out of service (firm capacity). The City's current pump station fails to meet these criteria currently, with the fire pump not included in the current capacity calculation. It is recommended that the existing pump station, plus the new pump station required for the proposed reservoir, meet MDD conditions with all pumps in service, and meet ADD conditions with the largest pump out of service (firm capacity).

It is recommended that the new pump station be implemented with approximately 1,200 gpm total capacity, and four pump cans. This could be accomplished with perhaps one 200 gpm pump and two 500 gpm pumps. This will provide pumping redundancy in the event of a pump failure at the existing pump station, and will provide needed pumping capacity when the existing pump station is shut down for recommended upgrades.

As per the 2005 Water System Master Plan, it is also recommended that the existing booster pumps be replaced by two new pumps, each with a capacity of approximately 600 gpm. To rely on the existing pump station to contribute to accommodating the 20-year ADD with firm capacity, and the 20-year MDD with total capacity, it is recommended that emergency backup power generation facilities be implemented at the existing pump station as well.

It is also recommended that the existing motor control center (MCC) be replaced or modified to include provisions for providing variable speed control to all booster pumps, except for the fire pump. Variable speed control of the pumps is recommended to optimize efficiency and performance of the pumps and limit operating costs.

6.3.5 Distribution System Improvements

The analysis found that distribution system water line improvements are needed to improve fire flow capacities within the distribution system and provide improved hydraulic transmission capacity and accommodate system expansion needs. A detailed list of system piping improvements is in **Appendix B**. The total non-developer funded costs for distribution piping improvements through the 20-year planning period are approximately $5,111,000.

Table 6-1 presents recommended distribution system water line improvements, included in the CIP, for each fiscal year. Each improvement is identified by category and includes an estimated project cost. For the purpose of this section recommended distribution system improvements are grouped in the following general categories:

1. Distribution and Fire Flow Capacity Improvements
2. Developer contributions
3. Water main replacement program

Below are summary descriptions of recommended water line improvements by category.

6.3.5.1 Distribution and Fire Flow Capacity Improvements

It is recommended that distribution system water line improvements be completed to improve fire flow capacities and to provide for system expansion needs. Approximately 4,100 linear feet of 12-inch and 10-inch diameter mains are recommended for construction. These improvements are required to meet existing and future fire flow needs and will also facilitate meeting system capacity requirements at saturation development.

6.3.5.2 Developer Contributions

On **Figure 1** in **Appendix A** there are approximately 39,500 linear feet of 8-inch to 12-inch diameter piping shown serving certain undeveloped areas within the UGB. Such improvements are shown as dashed lines on **Figure 1**. The improvement alignments shown are rough approximations of piping required to serve these areas. It is assumed that all developer installed piping will be a minimum of 8-inches in diameter. Since development details have yet to be established, the full extent of distribution piping required to adequately serve these areas is not known.

The total estimated construction cost for the developer contribution improvements shown on **Figure 1** is approximately $10,260,000. It is anticipated that the funding and construction of these and certain other improvements required by development will be provided by private interests as these areas are developed. Consequently, construction costs for this work are not reflected in the CIP presented in this study, and thus not shown on **Figure 6-1**. Following the completion of these improvements it is expected that these facilities will become City-owned and operated. Brief descriptions of the more significant developer contribution improvements shown on **Figure 1** are provided below.

12-inch diameter main serving northern expansion area – A minimum 12-inch diameter water main will be required to serve the proposed 70-acre residential expansion area on the City's northerly border. Construction costs for this waterline are estimated at approximately $400,000. This water main will provide service and fire flows within the northern expansion area.

12-inch diameter main serving eastern expansion area – A minimum 12-inch diameter water main will be required to serve the proposed 70-acre residential expansion area on the easterly end of the City. Construction costs for this waterline are estimated at approximately $670,000. This waterline will provide service and fire flows within the eastern expansion area.

Currently the easterly portion of the City is served by a single 14-inch diameter water main. While the existing 14-inch diameter main has adequate hydraulic capacity to serve the eastern expansion area, in addition to the easterly portion of the City which it currently serves, annexation and subsequent development of the eastern expansion area would warrant the need to provide redundant water supply to this area.

A second water main, extending from NW Commercial Street or NW Pacific Street, could serve the easterly portion of the City and would allow for looping of the pipeline system thereby improving water circulation, water quality, improved fire flow capacity, and greatly improved system reliability. This new water main extension should be implemented with development easterly of McKay Creek and south of NW West Union Road. It is recommended that this line be constructed and paid for by such development.

In the near term, the City will be providing redundant supply to the easterly portion of the City by locating the new water storage reservoir along NW West Union Road easterly of McKay Creek. This reservoir will help provide similar benefits regarding water circulation, water quality, improved fire flow capacity and redundancy as a second main. As discussed in this report, an additional reservoir is needed in the near future due to overall population and water demand growth. The reservoir located in the easterly portion of the City is shown on **Figure 1**, the Proposed Water System Plan Map.

Pipeline mains serving northwestern industrial and residential area – Water mains will be required to provide service and fire flows to future industrial and residential development in the northwesterly portion of the City. City supported water mains are included in the CIP, whereas developer implemented water mains are not.

6.3.5.3 Water Main Replacement Program

It is recommended that the City's current water main replacement program continue. This program provides for the routine replacement of leaking, damaged and older water mains throughout the water system. The minimum recommended replacement size is 8 inches in diameter. It is recommended that $195,000 be budgeted annually for this program. This funding amount assumes an average service of approximately 100 years for water system piping.

6.3.6 Storage Capacity Improvements

Results of the storage capacity analysis indicate that the City will have a total storage capacity deficit of approximately 2.02 MG at the end of the planning period based on demand estimates developed in **Section 3** and storage criteria developed in **Section 4**. The City's storage requirements are now beginning to exceed existing storage capacity. As such, it is recommended that the City construct a minimum 2.0 MG reservoir as soon as practical. A 2.0 MG reservoir should be implemented at a total project cost of $6,768,000.

It is understood that the City has acquired land for the reservoir. The costs of which are included in the total project costs presented above. As discussed previously, potential reservoir siting outside of the City that would allow for operation by gravity without pumping has been considered and was found to result in higher life cycle costs than locating the reservoir within the City with pumping.

6.3.6.1 Unaccounted-for Water Evaluation

The analysis in **Section 5** indicated that the City's water loss is within acceptable levels. It is recommended that the City continue monitoring water loss. The completion of recommended telemetry and control system improvements will allow the City to more closely and accurately monitor its water demand and consumption data.

6.4 Additional Recommendations

6.4.1 Financial Evaluation and Plan

A long-term financial planning evaluation and strategy is recommended to support the proposed capital improvement plan. The financial evaluation should include an evaluation of system revenue requirements, and development of a rate increase strategy that balances system investment needs with rate impacts. Adequate SDC's should be established to collect funds from new customers to pay for improvements that expand the capacity of the system and require reimbursement for buy in to existing capacity. It is recommended that approximately $11,000 be budgeted to develop the financial plan.

6.4.2 Source Alternatives Study

As previously discussed, and based on estimates of future water demands presented in this study, the existing source capacity should be expanded within the planning horizon. Previously considered source alternative studies should be updated relative to this master plan's analysis, and an evaluation should be made of the need to pursue other alternatives as an option to the existing JWC supply. It is understood that the City is currently renegotiating its agreement with

JWC to expand supply volumes. It should also be noted that the existing supply facilities, including the approximately three-mile-long supply line, are capable of providing significantly more supply to the City than is needed through the end of the 20-year planning period. Thus, continued increased supply from JWC remains an option for the foreseeable future.

6.5 Summary

A summary of all the recommended improvements is presented in Table 6-1. The table provides for prioritized project sequencing by illustrating fiscal year (FY) project needs for each facility or improvement category. The total estimated project costs of the recommended improvements are approximately $14.2 million over the 20-year planning horizon, based on today's dollars. It is recommended that the City's capital improvement program (CIP) be funded at approximately $720,000 annually for storage, pumping, distribution system piping and seismic resilience improvements. Financial planning work is recommended to identify funding options and alternatives.

Table 6-1 City of North Plains Water System Master Plan

Category	Project Description	Fiscal Year 2019 2020	Fiscal Year 2020 2021	Fiscal Year 2021 2022	Fiscal Year 2022 2023	Fiscal Year 2023 2024	Fiscal Year 2024 2025	Fiscal Year 2025 2026	Fiscal Year 2026 2027	Fiscal Year 2027 2028	Fiscal Year 2028 2029	Fiscal Year 2029 2030	Fiscal Year 2030 2031	Fiscal Year 2031 2032	Fiscal Year 2032 2033	Fiscal Year 2033 2034	Fiscal Year 2034 2035	Fiscal Year 2035 2036	Fiscal Year 2036 2037	Fiscal Year 2037 2038	Fiscal Year 2038 2039	Fiscal Year 2039 2040	Fiscal Year 2041 2042	Fiscal Year 2050 2051	Fiscal Year 2060 2061	Estimated Total Project Costs
Table 6-1																										
Telemetry & Control	New Telemetry and Control (SCADA) System		Telemetry and Control System $162,750																							
	Sub-Total	$ -	$162,750	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 162,750				$ -
Pumping Facilities	Pump Station Upgrades			P.S. Upgrades $246,750																						
	Booster Pump Station	P.S. No. 2 $840,000																								
	Sub-Total	$ 840,000	$ -	$ 246,750	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,086,750				$ -
Distribution System Piping	Fire Flow and Distribution Improvements				Gordon Crossing 12" Waterline $462,536		UE2A - 968 lf - 10 " Waterline $274,428		UE2B - 910 lf - 12 " Waterline $277,095		UE1 - 420 lf - 12 " Waterline $127,890		UE3 - 260 lf - 10 " Waterline $73,710													
	Main Replacement and Standard Upsizing Program			$194,777		$389,554		$389,554		$389,554		$389,554	$194,777	$389,554	$389,554	$389,554	$194,777	$194,777	$194,777	$194,777	$194,777					
	Sub-Total	$ -	$ -	$ 194,777	$ 462,536	$ 389,554	$ 274,428	$ 389,554	$ 277,095	$ 389,554	$ 127,890	$ 389,554	$ 268,487	$ 389,554	$ 389,554	$ 389,554	$ 194,777	$ 194,777	$ 194,777	$ 194,777	$ 194,777	$ 5,111,195				$ -
Storage Facilities	New Reservoir and Pump Station	Res. & P.S. Eng. $735,000	2.0 MG Reservoir $6,001,650																							
	Sub-Total	$735,000	$6,001,650	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 7,471,650				$ -
Seismic Resilience	Critical Facilities Seismic Improvements & Aquifer Storage and Recovery			Two 10,000 gallon potable water pillow tanks	Aquifer Storage and Recovery Feasibility Study								JWC Supply Pipeline Joint Strengthening										314th Avenue PRV Vault Strengthening	JWC Connection Vault Strengthening	Aquifer Storage and Recovery Well	
	Sub-Total			$ 25,000	$ 100,000								$ 1,000,000									$ 1,125,000	$ 340,000	$ 90,000	$ 6,000,000	$ 6,430,000
	Total	**$ 1,600,000**	**$6,264,400**	**$ 466,527**	**$ 562,536**	**$ 389,554**	**$ 274,428**	**$ 389,554**	**$ 277,095**	**$ 389,554**	**$ 127,890**	**$ 389,554**	**$ 1,268,487**	**$ 389,554**	**$ 389,554**	**$ 389,554**	**$ 194,777**	**$ 194,777**	**$ 194,777**	**$ 194,777**	**$ 194,777**	**$ 15,082,345**	**$ 340,000**	**$ 90,000**	**$ 6,000,000**	**$ 6,430,000**
																					20-Year Subtotal	**$ 15,082,345**			**Fiscal Year 2040 - 2061**	**$ 6,430,000**

* All costs are in 2019 DOLLARS

** Ground improvements assumed not to be required for JWC connection vault. City priorities could change pending the results of Project #1.

Appendix

APPENDIX A

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APPENDIX B

Appendix B

Table B–1
Piping Improvement Project Cost Estimate Summary[1]

Distribution and Fire Flow Capacity Improvements				
Location	Size (inches)	Length (feet)	Unit Cost ($/lf)	Estimated Project Cost[1]
Gordon Crossing	12	1,519	$305	$462,536
NW Gordon Rd/Wasco Extension (EU1)	12	420	$305	$127,890
NW Hillcrest west of NW 319th Ave (EU2B)	12	910	$305	$277,095
NW 319th Avenue (EU3)	10	260	$284	$73,710
NW Hillcrest 319th to Main St. (EU2A)	10	968	$284	$274,428
Standard Upgrade to 8-inch Diameter	8	15,143	$257	$3,895,537
			Total	**$5,111,195**

[1] The cost estimates presented are opinions of cost based on the assumptions stated and developed from information available at the time of the estimate. Final costs for all projects will depend on actual field conditions, on actual material and labor costs, final project scope, project implementation and other variables.

Table B-2
Telemetry and Control System
Project Cost Estimate Summary

Pump station project cost estimates are based on the following assumptions:

- No rock excavation included.
- No property acquisition costs included.
- No backup power supply.
- Construction by private contractors.
- An ENR construction cost index of 8,409 for Seattle, Washington (October 2005).

Item No.	Description	Estimated Project Cost[2]
1.	Mobilization	$9,450
2.	Flow Control Station Controls and Telemetry	$18,900
3.	Flow Meter (Installed within Supply Flow Control Station)	$18,900
4.	Pump Station Control System Modifications	$26,250
5.	Public Works Telemetry and Control	$21,000
6.	System Programming	$21,000
	Total Construction Cost	$115,500
	40% Contingency, Administration & Engineering	$46,200
	Total Project Cost	$161,700
	USE	**$162,750**

[2] The cost estimates presented are opinions of cost based on the assumptions stated and developed from information available at the time of the estimate. Final costs for all projects will depend on actual field conditions, on actual material and labor costs, final project scope, project implementation and other variables.

Table B-3
Pump Station Upgrades
Project Cost Estimate Summary

Pump station project cost estimates are based on the following assumptions:

- No rock excavation included.
- No property acquisition costs included.
- No backup power supply.
- Construction by private contractors.
- An ENR construction cost index of 8,409 for Seattle, Washington (October 2005).

Item No.	Description		Estimated Project Cost[3]
1.	Mobilization		$15,750
2.	Mechanical		$68,250
7.	Controls		$26,250
8.	Electrical		$73,500
		Total Construction Cost	$173,250
		40% Contingency, Administration & Engineering	$69,300
		Total Project Cost	$242,550
		USE	**$246,750**

[3] The cost estimates presented are opinions of cost based on the assumptions stated and developed from information available at the time of the estimate. Final costs for all projects will depend on actual field conditions, on actual material and labor costs, final project scope, project implementation and other variables.

Table B-4
City of North Plains
Proposed 2.0 MG Reservoir & Pump Station
Engineer's Construction Cost Estimate Summary
Ground Level Prestressed Concrete Reservoir with Pump Station Option

Item	Description	Cost
1.	Mobilization, Bonds and Insurance (at 5% of Construction Costs)	$206,850
2.	Construction Surveying and Staking	$4,200
3.	Site Preparation, Excavation, Backfill and Grading & Erosion Control	$54,600
4.	2.0 MG Ground Level Prestressed Conc Reservoir (AWWA D110, Type I), Complete w/ Mixing System, Foundation, and Accessories	$1,858,500
5.	1,500 GPM Firm Capacity Concrete Masonry Unit (CMU) Pump Station, Complete w/ Electrical and Instrumentation & Controls	$651,000
6.	Waterline Piping & Accessories, Including Reservoir Flow Control Vault	$147,000
7.	Stormwater & Tank Overflow Management	$63,000
8.	City Shop & Offices	$1,281,000
9.	AC Pavement Driveway and Site Parking	$31,500
10.	Fencing, Finish Grading & Landscaping	$31,500
11.	Testing, Disinfection, Start-up and Clean-up	$10,500
12.	Site Subsurface Ground Stabilization Improvements	$1,200,000
	Subtotal Estimated Construction Cost (1)	$4,133,000
	Contingency	$462, 000
	Total	**$6,001,650**

Note:
1. This preliminary construction cost estimate is an opinion of cost based on information available at the time of the estimate. Final costs will depend on actual field conditions, actual material and labor costs, market conditions for construction, regulatory factors, final project scope, method of implementation, schedule and other variables. For purposes of future cost estimate updating, the April 2019 ENR CCI for Seattle, Washington of 12,015.45 is referenced.

APPENDIX C

Appendix C

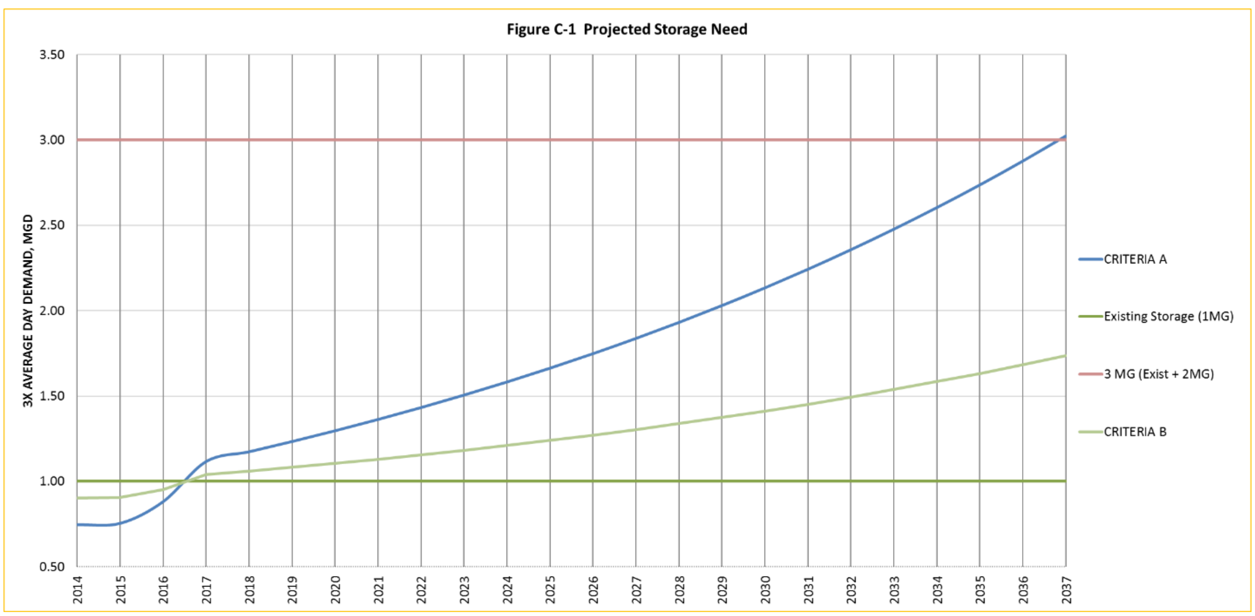
Water Storage Capacity Analysis

Figure C-1 presents an analysis of water system storage capacity requirements based on the two separate criteria presented in **Section 4**. This table summarizes the required storage capacity for each criterion over the planning horizon. As shown, Criteria A governs until approximately 2016 at which time Criteria B storage requirements exceed Criteria A requirements.

C.1 Reservoir Storage Requirement Criteria

Criteria A - Regional Water Supply Design Criteria
Required Storage Volume = [Operational Storage] + [Fire Storage] + [Emergency Storage]
= [0.25 x MDD] + [3500gpm x 60min x 3hours] + [0.25 x MDD]
= 0.5 x MDD + 0.63 MG

Criteria B – Joint Water Commission Supply Agreement
Required Storage Volume = 3 x ADD



APPENDIX D

Stantec

Water System Seismic Assessment and Mitigation Plan - Addendum to 2018 Water Master Plan Update

Technical Memorandum

April 29, 2019

Prepared for:

City of North Plains, Oregon

Prepared by:

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Table of Contents

1.0 INTRODUCTION 1.1
1.1 REGULATORY REQUIREMENTS 1.2

2.0 CRITICAL FACILITIES AND RISK ASSESSMENT 2.4
2.1 CRITICAL FACILITIES IDENTIFICATION 2.4
2.2 PERFORMANCE CRITERIA 2.4
2.3 GEOLOGIC CONDITIONS 2.5
2.3.1 Local Geology 2.5
2.3.2 Regional Seismicity and Local Faults 2.6
2.3.3 Ground Water Level 2.7
2.3.4 Geologic Hazards 2.8
2.4 EVALUATION OF CRITICAL FACILITIES 2.9
2.4.1 JWC Connection Vault 2.9
2.4.2 JWC Supply Pipeline 2.9
2.4.3 314th Avenue Vault 2.11
2.4.4 Well #3 at Water Station No. 1 .... 2.12
2.4.5 Trunk Distribution Pipes 2.12

3.0 MITIGATION PLAN 3.14
3.1 JWC VAULT 3.14
3.2 JWC SUPPLY PIPELINE 3.14
3.3 314TH AVENUE VAULT 3.14
3.4 WELL #3 AT WATER STATION NO. 1 .... 3.15
3.5 TRUNK DISTRIBUTION PIPES 3.15
3.6 PRIORITY PROJECTS 3.16
3.7 CAPITAL IMPROVEMENT PLAN TO IMPROVE SEISMIC RESILIENCY 3.16

4.0 CONCLUSION AND RECOMMENDATIONS 4.1

5.0 REFERENCES 5.1

LIST OF TABLES

Table 1: Performance Criteria 2.5
Table 2: JWC Supply Pipeline break summary 2.10
Table 3: Summary of Expected Pipe Breaks in North Plains 2.13
Table 4: North Plains Capital Improvement Plan with seismic resiliency recommendations 3.1

LIST OF FIGURES

Figure 1: North Plains distribution system, facilities and JWC Supply Pipeline 1.1
Figure 2: Earthquake Damage Potential and Legend for North Plains and Vicinity 1.3
Figure 3. Local Helvetia Fault 2.7

LIST OF APPENDICES

APPENDIX A REFERENCES & FIGURES A.1
APPENDIX B EQUIPMENT A.2

April 29, 2019

1.0 INTRODUCTION

This Technical Memorandum is an addendum to the City of North Plains (City) 2018 Water Master Plan Update (Murraysmith 2018). It was developed to identify seismic risks and mitigation strategies for the City's water system and to meet regulatory requirements summarized below.

North Plains receives its drinking water from the Joint Water Commission (JWC) in Hillsboro via an 18,470 foot-long, 16-inch ductile iron pipe (JWC Supply Pipeline) which extends to the 314th Avenue Vault within North Plains and connects to the City's distribution system (Figure 1). The distribution system of North Plains serves local residents and businesses, and Water Station No. 1, where a 1.0-million-gallon reservoir and pump station provide additional storage and pressurization to the system. The city also has a well (Well #3), located inside the pump house at Water Station No. 1 which provides a secondary source of water, however it is not normally used. Additional information about the City's water supply and distribution system is available in the most recent water master plan (Murraysmith, 2018).

Figure 1: North Plains distribution system, facilities and JWC Supply Pipeline

To meet the requirements for master planning of the water system, the City is required to assess the risk, consequences and develop mitigation measures for drinking water facilities deemed critical. Oregon Administrative Rule (OAR) 333-061-0060(5)(J) requires communities with more than 300 drinking water connections to conduct a seismic risk assessment and mitigation plan as part of their water master planning effort. The City has more than 300 connections and is located within a moderate seismic hazard zone (Zone VII) as described in the following section and therefore requires this seismic risk assessment and mitigation plan.

1.1 REGULATORY REQUIREMENTS

One purpose of this technical memo is to meet the requirements of Oregon Administrative Rule (OAR) 333-061-006(5)(J). This requirement is also shown under Item 10 in the Oregon Health Authority, Drinking Water Services *Plan Review Requirements for Master Plans at Existing or New Public Water Systems.* The OAR states:

> *(J) A seismic risk assessment and mitigation plan for water systems fully or partially located in areas identified as VII to X, inclusive, for moderate to very heavy damage potential using the Map of Earthquake and Tsunami Damage Potential for a Simulated Magnitude 9 Cascadia Earthquake, Open File Report 0-13-06, Plate 7 published by the State of Oregon, Department of Geology and Mineral Industries.*
>
> *(i) The seismic risk assessment must identify critical facilities capable of supplying key community needs, including fire suppression, health and emergency response and community drinking water supply points.*
>
> *(ii) The seismic risk assessment must identify and evaluate the likelihood and consequences of seismic failures for each critical facility.*
>
> *(iii) The mitigation plan may encompass a 50-year planning horizon and include recommendations to minimize water loss from each critical facility, capital improvements or recommendations for further study or analysis.*

Figure 2 below shows an adaptation of the Open File Report 0-13-06, Plate 7 as described above, which includes the intensity scale and damage potential for the Northwest region of Oregon, including North Plains. Based on the figure, the intensity for North Plains is expected to be in zone VII, classified as Moderate. For the purpose of this report, a major seismic event is defined as a Cascadia Subduction Zone earthquake of magnitude 9.0.

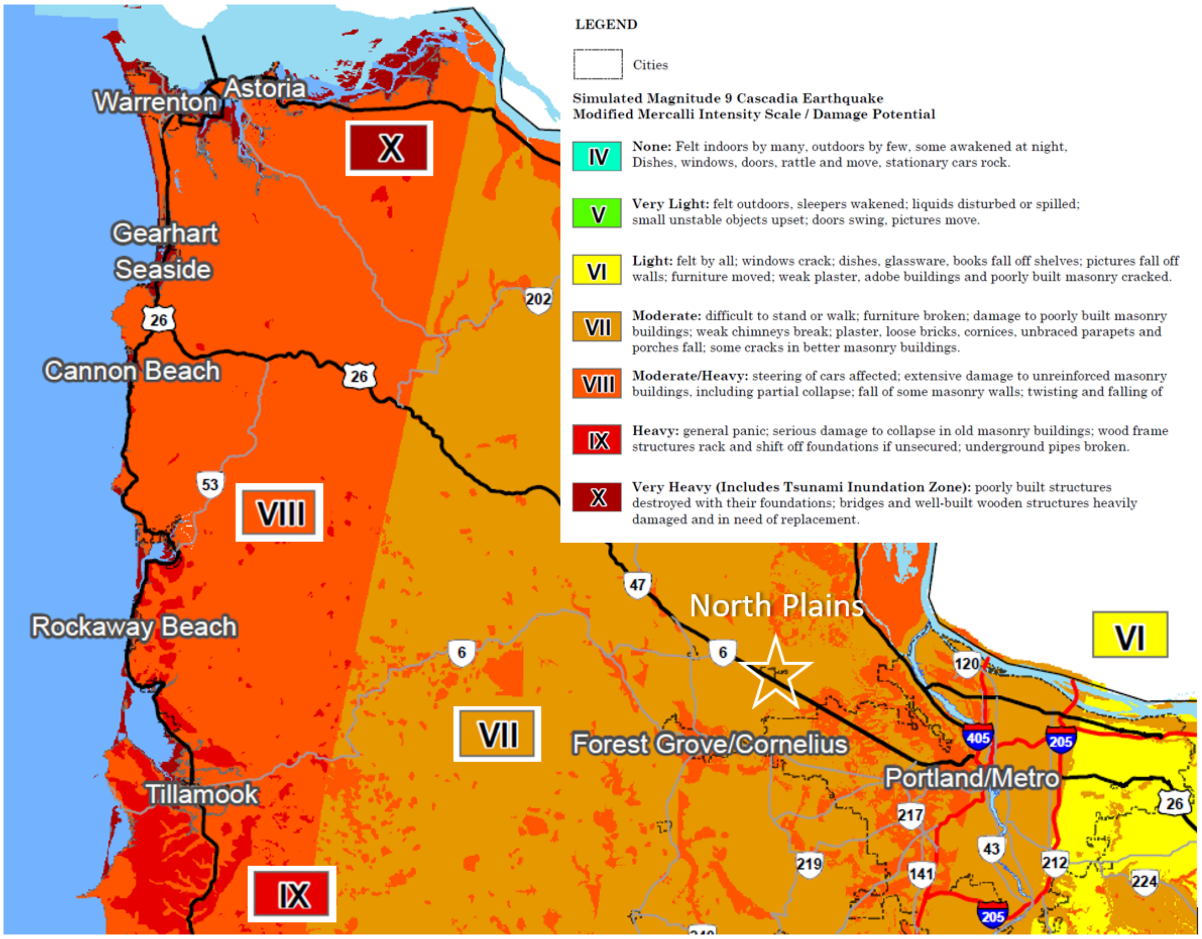


Figure 2: Earthquake Damage Potential and Legend for North Plains and Vicinity (adapted from DOGAMI, 2013a)

2.0 CRITICAL FACILITIES AND RISK ASSESSMENT

This section identifies critical facilities to be included in the risk assessment and sets performance criteria for evaluation within the local geological setting. High-level summaries for the critical facilities are provided.

2.1 CRITICAL FACILITIES IDENTIFICATION

A workshop with City staff and consultant staff was held on March 4th, 2019. The following facilities were identified as critical with respect to their importance for supply the City with water under normal operations and also fire flow:

- Joint Water Commission (JWC) Vault (owned by the City of Hillsboro). This is the critical point of connection to the City's primary water supply.
- 16-inch JWC Supply Pipeline from Hillsboro to North Plains (approximately 18,470' length). This pipeline conveys the City's water supply from the point of purchase from JWC in Hillsboro, to the City of North Plains.
- 314th Avenue PRV Vault. This vault contains valves that control the flow of water into the City's distribution system under normal and fire flow conditions.
- Well #3 at Water Station No. 1. This well is the City's only backup water supply.
- Trunk distribution pipes within the City's distribution system 12-inch in diameter or larger. These pipelines are critical to maintaining pressure and flow in the City's water distribution system.

Additional facilities in the City were not identified as critical to maintenance of supply during and after a significant seismic event. These include the Water Station No. 1 reservoir tank / booster pump station, and distribution pipelines smaller than 12-inch in diameter. A proposed Water Station No. 2 reservoir and booster pump station is currently in design phase will be built on the east side of the City. Water Station No. 2 is not included in this evaluation because it is not existing infrastructure and it is being designed with seismic resiliency as critical infrastructure.

Seismic risk and mitigation measures for the above listed critical facilities will be discussed in the following report sections.

2.2 PERFORMANCE CRITERIA

Facilities have been evaluated and rated as Excellent, Good, or Poor in categories of structural and nonstructural based on the descriptions below. The facilities are separated into two separate categories, structural, and nonstructural. The structural category is related to the structural building systems, the structural walls, the foundation, and similar elements. The nonstructural category relates to architectural, mechanical, and electrical systems. Table 1 below defines the rating for structural and non-structural criteria.

Table 1: Performance Criteria

Structural Performance	Excellent	Indicates the facility is expected to have only minor damage and retain original strength, occupancy is unaffected.
	Good	Indicates the facility is expected to generally retain its original shape, and original strength, light damage is anticipated which could include concrete cracking, small permanent displacements.
	Poor	Indicates a potential for significant damage including loss of a significant portion of original strength, and significant permanent displacements, doors could be inoperable due to damages. Continued occupancy is not expected and building repairs are not likely to be economical.
Non-Structural Performance	Excellent	Indicates negligible damage is expected to occur, all systems remain secured in place and functional.
	Good	Indicates equipment, lights, piping, and other utilities are expected to be secured in place, operations may resume when utilities are restored, and minor repairs completed.
	Poor	Indicates systems are expected to be damaged or fail and require replacement.

2.3 GEOLOGIC CONDITIONS

The latest available State of Oregon Department of Geology and Mineral Services (DOGAMI) seismic hazard maps, existing available geotechnical investigation reports, geologic maps, and historical well reports conducted within the limits or within close proximity to the critical water system facilities, were utilized in support of the seismic risk assessment for the critical water system facilities. The North Plains Water Station 2 Geotechnical Design Report (Stantec, 2019) provides site-specific geotechnical information to support the seismic risk assessment.

The potential for liquefaction, settlement, lateral spreading, fault rupture zones, and slope stability issues that may occur during a seismic event have been summarized for the critical water system facilities. It should be noted that the information presented is a summary of potential geologic hazards and seismic risks which may exist at critical facilities for the City and is based upon limited geologic and geotechnical information. Work done for Water Station 2 represents a localized geotechnical view for that site, so additional site-specific geotechnical information and evaluations may be warranted and recommended to decrease the uncertainty of the geologic and seismic risks at the identified critical facilities.

2.3.1 Local Geology

The City is situated in the Tualatin Valley and the northern portion of the Willamette Valley in Northwest Oregon. The site is located in the Willamette-Cowlitz-Puget Lowland of the Pacific Border physiographic province (Fenneman, 1931). The Tualatin Valley covers approximately 300 square miles and is characterized by wide, flat lowlands and upland features which trend in a northern-northwestern direction. The valley is bounded to the south by the Chehalem Mountains, to the north and east by the Tualatin Mountains, and to the west by the Coast Range. The upland topographic features are controlled by folding and faulting of the underlying bedrock. The lowland areas are thickly filled with sediments and are drained by streams flowing into the Willamette river.

The majority of the valley is covered by sediment deposits from the Pleistocene age Missoula Floods. The Willamette Silt geologic unit resulted from the successive dam-burst flood deposits (Burns and Coe, 2012) and is up to 120-feet thick. The Willamette Silt compromises nearly all of the lowlands within the Tualatin Valley and the City. The Willamette Silt is composed of unconsolidated beds and lenses of fine sand, silt and clay. The stratification is on the order of 4- to 6-inch beds and 3- to 4-foot beds which are locally present. However, in many areas, the Willamette Silt is massive with indistinct stratification. Lenses of pebbly, fine to medium sand with scattered cobbles of granite and quartzite occur in some of the outcrops. The silt is usually light brown to buff in color, and occasionally light gray where granular soils predominate. The Willamette Silt is correlative with widespread lacustrine deposits of similar composition.

Young alluvium deposits are located in the channels and flood plains of main streams and small tributaries (Burns and Coe, 2012). Small tributaries and creeks which pass through the City are McKay Creek and a smaller tributary of McKay Creek which runs through the downtown area of the City. The smaller tributaries also generally contain wetland areas as shown in the City Local Wetlands Inventory (North Plains, 2002). The young alluvium unit is predominantly silty clay, clayey silt, find sand and in some areas, peat and organic clay. Young alluvium deposits are located near the site along McKay Creek according to the Geology and Surficial Deposits of the Tualatin Valley Region Map (Hart and Newcomb, 1965). The geology and surficial deposits of the Tualatin Valley are shown in Figure 4 -Geology Map in the Appendix with the site location on the map (Deacon and Schliker, 1967; Stantec, 2019).

Underlying the Willamette Silt unit is the Hillsboro Formation, a fine-grained sequence of fluvial and lacustrine sediments (Wilson, 1998) up to 940-feet below ground surface (bgs). The Hillsboro Formation is generally poorly sorted and ranges in classification from silty sand to clay. The sediments of the Hillsboro Formation are primarily derived from the highlands surrounding the Tualatin Valley. The Hillsboro Formation primarily formed in the Pleistocene to the Miocene.

2.3.2 Regional Seismicity and Local Faults

The site is located in a seismically active region. There are three sources for earthquakes that can affect the site. “Interface” earthquakes which occur between the subducting oceanic plates and the North American plate, “intraplate” earthquakes which occur within subducting oceanic plates, and “crustal” earthquakes within the North American Plate. “Interface” earthquakes which occur on the Cascadia Subduction Zone and can have magnitudes up to 9.0 or 9.2. “Intraplate” earthquakes occurring on the subducting oceanic plate have magnitudes up to about 7.5. “Crustal” earthquakes occur on faults which have been mapped as active or potentially active or occur on faults which are unknown and have not yet been mapped.

Mapped fault locations and descriptions for nearby faults can be found on the USGS Quaternary Fault and Fold Database (USGS, 2014) and Stantec's Geotechnical Design Report (Stantec, 2019). The Helvetia Fault is located to the east of the City. The trace of the fault has been mapped crossing NW West Union Road and Highway 26 as shown in Figure 3 and is 7 km long. The fault is classified as a Quaternary fault. Special care should be taken to any facilities or pipes near the fault. Fault rupture of the Helvetia Fault may cause surface displacement, or high peak ground accelerations and velocities. Neither the City distribution system, nor the JWC Supply Pipeline cross this fault. However, site-specific seismic evaluations of critical facilities or pipelines near the Helvetia Fault are recommended. Other nearby faults within 10 miles of the City are the Oatfield Fault, Beaverton Fault, Portland Hills Fault, Gales Creek Fault and East Bank Fault (USGS, 2014).

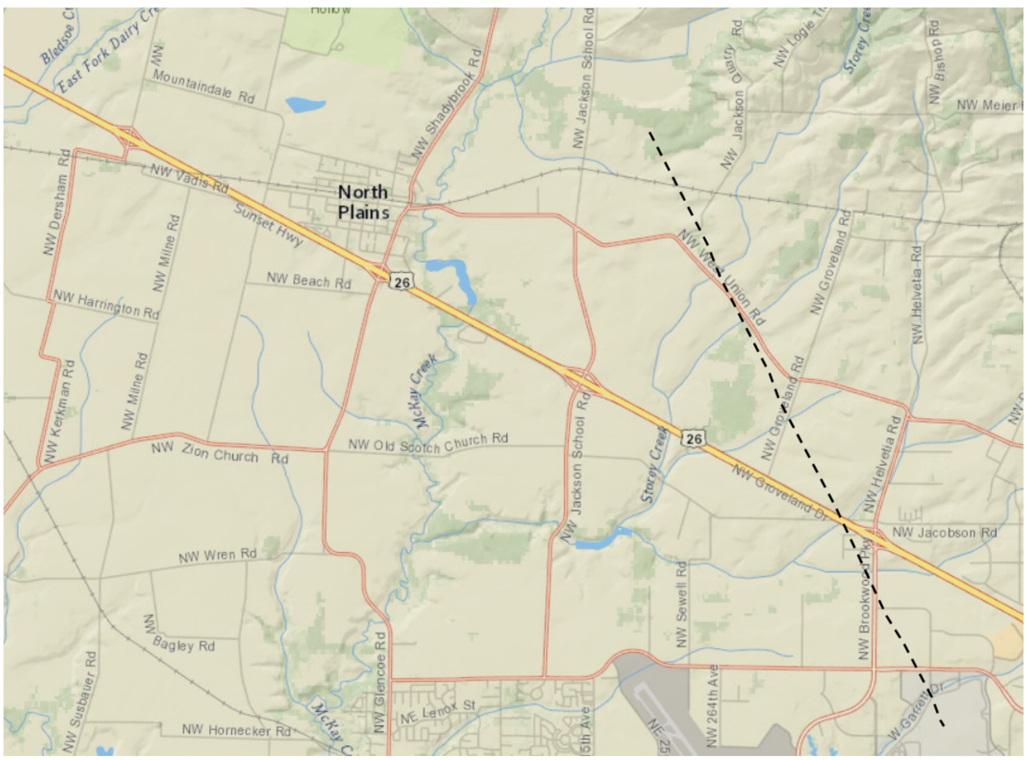


Figure 3. Local Helvetia Fault

2.3.3 Ground Water Level

The Oregon Water Resources Department retains public information regarding the ground water levels and well information from previously drilled boreholes or wells. Well logs completed between 2002 to 2018 from the township and range where the critical facilities are located within (Township: 1.00N, Range: 2.00W) indicate the static ground water level ranges from 1 ft bgs to 60 ft bgs. The ground water level measured at the Water Station 2 site by Stantec on August 2, 2018 in BH-2 was 12.5 ft bgs. See Appendix A for the North Plains Local Wetlands Inventory Map – Figure 4 (North Plains, 2002). As a result, it is expected that the ground water levels are generally high throughout the entire City.

2.3.4 Geologic Hazards

Assessment of the following geologic hazards associated with seismic activity include: liquefaction settlement, lateral spreading, slope stability hazards. The potential for fault rupture is summarized in Section 2.3.2.

The City has been characterized as an area which has a “high” probability of liquefaction by the DOGAMI hazard maps (Madin and Burns, 2013) in the event of a magnitude (M 9.0) Cascadia Subduction Zone Earthquake as shown as Plate 3 in the Appendix (DOGAMI, 2013b). In addition to the probability of liquefaction, the DOGAMI hazard maps, Plate 4 have characterized the peak ground deformation (PGD) associated with lateral spreading from liquefied soils which is likely in the event of a M 9.0 Cascadia Subduction Zone Earthquake (DOGAMI, 2013c). The City has a “high” PGD of 39 to 173 inches (Madin and Burns, 2013) as shown as Plate 4 in the Appendix. In the vicinity of Water Station 2, the amount of liquefaction settlement was evaluated to be approximately 14 inches. It should be noted that the liquefaction hazard maps are created for a region, and that site-specific geotechnical information and analysis is required to quantify the settlement and reduce uncertainty at specific facilities. However, these maps and the Water Station 2 liquefaction settlement evaluation indicate that liquefaction, liquefaction settlement, and lateral displacement pose a risk in the City, and that facilities should account for these risks and displacements.

The City generally lies within the Tualatin Valley. The city is generally flat, with some slopes, and with creeks passing through the City. It is likely that slopes in the City are composed of Young Alluvium deposits or Willamette Silt deposits, which are generally unconsolidated and soft, and likely to lose strength and fail in seismic activity. The DOGAMI hazard maps have evaluated that the area has a “medium” probability of earthquake-induced landslides. Slope stability failure and lateral displacement as evaluated by DOGAMI are likely to occur in any areas in the City where a slope and high groundwater is present. This is especially the case near creeks and wetlands. These areas are shown as Plate 5 in the Appendix (DOGAMI, 2013D)

In any areas in which a pipe or critical facility is near a slope or crossing a slope, or near a creek, it is likely that lateral displacement issues will be present. Site-specific studies may be required to quantify the amount of lateral displacement likely to occur, however DOGAMI has evaluated the lateral displacement movement to be up to 173 inches. Movement, tilt, and vertical or horizontal displacement are likely to occur at structures or pipelines in these areas associated with slope failure and lateral displacement.

2.4 EVALUATION OF CRITICAL FACILITIES

The following evaluation of critical facilities shows the likelihood and consequences of risks as well as structural and geotechnical performance estimates for critical facilities.

2.4.1 JWC Connection Vault

The JWC Vault is a concrete structure approximately 10 feet deep and near the point where the 16-inch diameter JWC Supply Pipeline connects to the North Transmission line. The vaults include one for backflow prevention and one for flow metering and isolation.

2.4.1.1 Assessment

- **Structural Performance Level: Good**
  - Potential for liquefaction or settlement of the vault, liquefaction may lead to differential settlement.
  - Lateral spreading may occur due to sloping ground to the north east.
- **Nonstructural Performance Level: Poor**
  - Interface between vault and where the pipes enter is a hard connection, if the vault settles during a seismic event the pipe will be forced to displace, the pipe does not have any expansion joints to accommodate this displacement.
  - Pipe supports provide vertical support only, no horizontal restraint provided.

2.4.1.2 Consequences of Failure

The consequences of a seismic failure at this facility would be significant, this vault is along the only pipeline which provides drinking water to the City. Repair of the vault and associated piping could take weeks.

2.4.2 JWC Supply Pipeline

Approximately 18,470 feet of 16-inch diameter ductile iron pipe connects the City's water distribution system to the Joint Water Commission (JWC) system in Hillsboro. As stated prior, JWC is the primary supplier of drinking water to the City.

2.4.2.1 Geotechnical Evaluation

In any areas where the pipeline is near a slope or crossing a slope, or near a creek, it is likely that lateral displacement issues will be present. The JWC Pipeline crosses McKay Creek between NW Wren Road and NE Evergreen Road. In addition, the JWC Pipeline is near the McKay Creek tributary and wetland near the 314 Avenue Vault. It is expected that this area will also have increased liquefaction potential and lateral displacement issues due to the high ground water table, slopes, and soft soils. The DOGAMI Statewide Geohazards viewer shows the potential for landslide risk in the areas described above (DOGAMI, 2019).

2.4.2.2 Pipe Break Analysis

An analysis was performed to estimate the amount of breakages that may occur in the JWC Supply Pipeline during a major seismic event. The analysis is based on the American Lifelines Alliance, *Seismic Fragility Formulations for Water Systems, Part 1 – Guideline*, April 2001 (ALA, 2001), which has modeled pipe breakages from past earthquakes. For this analysis, the permanent ground deformation model was used.

The ground deformation model:

$$RR = K_2 * 1.06 * PGD^{0.319}$$

Where:

RR = repairs per 1000 feet of pipe
K_2 = modification factor. (0.5 for DI, 0.8 for PVC)
PDG = permanent ground deformation (inches), estimated at 39 inches for North Plains (DOGAMI, 2013)

The City could expect at least 34 breaks along the JWC Supply Pipeline during a major seismic event as shown in Table 2.

Table 2: JWC Supply Pipeline break summary

Pipe Type	Length (feet)	Repair rate (RR) per 1000 feet	Estimated number of breaks after magnitude 9.0 earthquake
JWC Supply Pipeline (DI)	18,470	2.73	34

2.4.2.3 Pipe Structural Evaluation

From the record drawings, the pipeline includes 18,470-feet of 16-inch ductile iron pipe from the JWC Connection in Hillsboro north to the 314th Avenue Pressure Reducing Valve (PRV) Vault in North Plains. The review found that the pipeline was constructed using both restrained joints and unrestrained joints as follows:

- 12,715 linear feet (in multiple segments) are indicated to be “slip-on joint pipe” interpreted to mean unrestrained joints
- 5,755 linear feet (in multiple segments) are indicated to be “restrained joint pipe”

Designing this pipeline with unrestrained joints was relatively common practice at the time of its construction. However, since publication of the Oregon Resilience Plan for Cascadia Subduction Zone Earthquakes, new information has become available along with new practices for pipeline design for seismic resiliency. The pipeline is now known to be constructed in a region with documented potential for permanent land deformation. Current seismic design considerations (Ballantyne, 2010) call for exclusive use of restrained joint pipe where potential for permanent land deformation exists. The segment of pipe under McKay Creek, identified above as an area of significant liquefaction or lateral displacement has been built with restrained pipe joints. However, the unrestrained joints present a significant risk of failure during a seismic event.

2.4.2.4 Assessment

The overall rating for the JWC Supply Pipeline is poor due to the significant length of pipeline constructed with unrestrained joints.

2.4.2.5 Consequences of Failure

The consequences of a seismic failure of the JWC Supply Pipeline are significant. Severing of the transmission main pipeline could leave the City without water for a month or more, depending on the number of breaches.

Note: See Section 2.4.5 for an estimation of the expected pipe breaks in the City's distribution network.

2.4.3 314th Avenue Vault

The 314th Avenue Vault contains pressure reducing valves that control flow to the City's distribution system from the JWC Supply Pipeline under normal and emergency conditions. The PRVs also control the pressure in the City's distribution system.

2.4.3.1 Assessment

- **Structural Performance Level: Poor**
  - The 314th Avenue Vault is located near a McKay Creek Tributary and Wetland, indicating a high ground water table. Evidence of water infiltration into the vault confirms the high ground water table.
  - Liquefaction could cause significant soil pressures on the walls and uplift forces on the bottom of the vault. No evidence has been found that the vault design considered liquefaction.
  - Soft soils susceptible to liquefaction are expected in this area due to the high ground water table and wetland. It is likely that liquefaction settlement and lateral displacements towards the creek at the vault will occur. The vault may move horizontally and vertically and undergo differential settlements associated with the liquefaction in this area.
- **Nonstructural Performance Level: Poor**
  - The connection between the 314th Avenue Vault and the JWC Pipeline are at risk of differential settlement and horizontal displacement due to liquefaction and lateral displacement issues in this area.

2.4.3.2 Consequences of Failure

The consequences of a seismic failure at this facility would be significant, this vault is along the only pipeline that supplies drinking water to the City. Repair of the vault and associated piping could take weeks depending on the extent of damage and the availability of materials and labor.

2.4.4 Well #3 at Water Station No. 1

Well #3 is located inside the Water Station No. 1 pump station building, adjacent to Reservoir 1. The well depth is 485-feet with a 12-inch diameter casing.

2.4.4.1 Assessment

There appears to be little documentation regarding the well construction details. The location of the well is near a known shallow contamination plume of pentachlorophenol and naphthalene from a closed Superfund site. Although its capacity is listed as 500 gallons per minute (gpm) in the Water Master Plan, the City's operators indicate there is interference or cavitation that may limit the actual production to a lower rate such as 350 gpm. Another vulnerability is that the well and its electrical and control gear are located within the Water Station No. 1 booster pump building that is assumed not to be seismically resilient.

Well #3 may be susceptible to damage if the seismic lateral loads and seismic velocities on the Well are too large for Well #3 to accommodate. The McKay Creek Tributary known as Ghost Creek is within 50 feet of Well #3, indicating that there is high ground water likely in this area and sloping ground. Lateral displacements due to liquefaction in this area are likely. Due to the lack of information on the construction of Well #3, the uncertainty for if the Well will accommodate the seismic loads and deformations are high. As a result, the well is rated as poor for both structural and non-structural performance, as defined in Table 1.

2.4.4.2 Consequences of Failure

Failure of Well #3 would result in the loss of a backup water supply for the City for periods on the order of months. If the JWC connection is maintained, this is not expected to have a significant impact on water supply to the City.

2.4.5 Trunk Distribution Pipes

The City's distribution system has approximately 14,260 feet of PVC pipe and 6,070 feet of ductile iron (DI) respectively within the city limits 12-inch in diameter or greater. An additional 18,470 feet of 16-inch diameter ductile iron pipe connects the City's distribution system to the JWC system in Hillsboro, as described above in Section 2.4.2.

2.4.5.1 Pipe Break Analysis

Using the ground deformation model (ALA, 2001) as described in Section 2.4.2 above, 39 PVC pipe and 11 ductile iron pipes are estimated to break during a major seismic event. Table 3 below summarized the ground deformation model results and pipe break estimates for ductile iron and PVC pipe segments 12-inch or greater in diameter.

Table 3: Summary of Expected Pipe Breaks in North Plains

Pipe Type	Length (feet)	Repair rate (RR) per 1000 feet	Estimated number of breaks after magnitude 9 earthquake
North Plains PVC	14,260	2.73	39
North Plains Ductile Iron	6,070	1.71	11

2.4.5.2 Assessment

- In any areas where the pipeline is near a slope or crossing a slope, or near a creek, it is likely that lateral displacement issues will be present.
- The extent of unrestrained piping joints is unknown
- Looping of distribution piping with redundancy is an important mitigation strategy for pipeline breaks. There are currently some non-looped transmission mains such as the 14-inch diameter PVC pipeline extending to the east.

The overall rating for the City's distribution system is good. Use of ductile iron pipe with restrained joints for future construction along with completing looping within the distribution system will continue to improve seismic resiliency.

2.4.5.3 Consequences of Failure

The consequences of these breakages could be significant as loss of large diameter trunk lines could cause service outages for large portions of the city, especially in areas without looped piping. Pipe breaks in major trunks lines may also limit water distribution to and from Reservoir and Pump Station No. 2, even though that facility is to be built with seismic resiliency.

3.0 MITIGATION PLAN

The following mitigation options for each of the critical facilities have been identified.

3.1 JWC VAULT

Mitigation of seismic vulnerabilities at the JWC vault could include specific geotechnical evaluation ($20,000), bracing of piping and equipment within the vault ($20,000), and / or installation of flexible piping connections immediately outside of the vault limits ($50,000). If ground improvement is determined to be necessary, costs could be in the range of ($250,000).

The risks associated with liquefaction and settlements are based on regional soils information and are general to the Hillsboro and North Plains area. Site-specific geotechnical investigations and geotechnical analysis is recommended to better understand the risks associated with liquefaction and settlement and to quantify potential movements and loads on the vaults.

Once the risks associated with liquefaction and settlement are better understood the vaults and the internal piping systems can be evaluated, and the risks more clearly defined.

3.2 JWC SUPPLY PIPELINE

The JWC Pipeline crosses McKay Creek between NW Wren Road and NE Evergreen Road and the alignment is adjacent to the McKay Creek tributary and wetland near the 314 St Vault. It is expected that this area will also have increased liquefaction potential and lateral displacement issues due to the high ground water table, slopes, and soft soils. It is likely that increased pipeline displacements will occur in these areas, increasing the likelihood of breakage. It is recommended that site-specific lateral displacements be evaluated in these areas to ensure the JWC pipeline can accommodate the displacements expected.

The JWC water transmission main has unrestrained pipe joints that could pull apart during an earthquake, particularly if permanent ground deformation occurs. A mitigation project to improve seismic resiliency could involve retrofit installation of split harnesses to restrain the currently unrestrained joints (see information in Appendix B). A rough estimate of the number of joints to be strengthened is 688. The rough order of magnitude opinion of cost for this work is $1,000,000 and it is anticipated to take one crew about 10 months to complete.

3.3 314TH AVENUE VAULT

This vault is a similar vintage to the JWC Vault described above and has similar mitigation strategies. However, the location of the vault close to McKay Creek tributary increases the potential for ground movement and the associated seismic problems. Mitigation of seismic vulnerabilities at the 314th Avenue PRV Vault could include specific geotechnical evaluation ($20,000), bracing of piping and equipment within the vault ($20,000), and / or installation of flexible piping connections immediately outside of the vault limits ($50,000). If ground improvement is determined to be necessary, costs could be in the range of ($250,000).

The risks associated with liquefaction and settlements are based on regional soils information and are general to the Hillsboro and North Plains region. Site-specific geotechnical investigations and geotechnical analysis is recommended to better understand the risks associated with liquefaction and settlement and to quantify potential movements and loads on the vaults.

Once the risks associated with liquefaction and settlement are better understood the vaults and the internal piping systems can be evaluated and the risks more clearly defined.

3.4 WELL #3 AT WATER STATION NO. 1

Given the seismic risk and production / water quality challenges described above for Well No. 3, it is recommended that the City consider replacing the well's capacity with a new well located in a different location. The new well could be equipped with aquifer storage and recovery (ASR) capability. With ASR, the City could inject and store potable water underground during the winter when demands are low, and then recover the stored water in the summer to serve customers when demands peak. The ASR well would likely need to penetrate basalt rock to perform with ASR functionality. Typical values for an ASR well include storage of approximately 200 million gallons per season with recovery rates in the range of 2 million gallons per day. Construction of an ASR well with these characteristics is anticipated to be $6,000,000. Hydrogeologic and engineering services would also be required to determine the potential for this to work in the North Plains area, to select a site, and for well design. Nearby agencies with ASR wells include Tualatin Valley Water District, City of Beaverton, City of Tualatin, and City of Cornelius. Given the City's single source of supply and the vulnerabilities of the long JWC transmission main from Hillsboro, an advantage of a new ASR well would be development of an alternate (redundant) source that does not depend on maintaining continuous integrity of the JWC Supply Pipeline connection.

3.5 TRUNK DISTRIBUTION PIPES

In any areas where the distribution pipes are near a slope, crossing a slope, or near a creek, it is likely that lateral displacement issues will be present and breaks in the pipeline will occur.

The distribution pipelines are near the Helvetia Fault as shown above in Figure 3. Site-specific evaluations are recommended, especially for the easternmost segments of the distribution system, or for future pipeline extensions closer to the fault. Fault rupture of the Helvetia Fault may cause surface displacement, or high peak ground accelerations and velocities. Site-specific evaluations of fault rupture and seismic loads are recommended to ensure that the pipelines can accommodate the displacements and seismic loads predicted.

Ductile iron has a lower breakage rate during seismic events due to the reduced modification factor (K_2) of 0.5 for ductile iron pipes versus 0.8 for PVC (ALA, 2001). It is recommended that the City replace PVC pipe at the end of its service life with ductile iron segments, with focus on system branches where only one pipe provides water to many customers. Any new ductile iron pipe design should consider the use of proprietary mechanical joint restraint to provide additional seismic resiliency. Also, as the City expands its distribution system, it should continue to install 'loops' (redundant piping) to provide multiple water flow pathways to each customer.

3.6 PRIORITY PROJECTS

The key seismic vulnerability for the City is the loss of supply from the JWC water supply transmission main. This could result in the City being without water for weeks or months, depending on the degree of damage and the availability of repair materials and labor. There are two basic choices to mitigate this vulnerability. The City could 1) harden the JWC supply infrastructure or 2) implement an Aquifer Storage and Recovery (ASR) facility that could store water and supply the City with seasonal independence from the JWC supply pipeline.

To help make this decision, it is recommended that the City evaluate the feasibility and costs of implementing an ASR program. It would also be useful for the City to have discussion with the JWC regarding the JWC's seismic vulnerabilities, service expectations for the City under post-earthquake conditions, and how that may change with time as the new Willamette Water Supply Program is brought on-line around 2026. With this information, the City can make an informed choice between its two primary options.

Should the City prefer the path of strengthening the JWC Supply Pipeline connection, projects related to the JWC Vault, the JWC transmission main, and the 314th Avenue Vault would be prioritized. If the City prefers to mitigate its water supply vulnerabilities using ASR, then that implementation would be prioritized. The Capital Improvement Plan summarized in Section 3.7 assumes the City chooses to strengthen its JWC connection.

3.7 CAPITAL IMPROVEMENT PLAN TO IMPROVE SEISMIC RESILIENCY

A proposed capital improvement plan is outlined below to improve the seismic vulnerability of the City' water system. The timing of an earthquake is not known. For this reason, the identified projects should be completed as soon as possible to limit risk. However, affordability limits what the City can accomplish considering its other needs. Therefore, the projects are shown to be phased, thinking that it may be desirable to limit overlapping debt service and the associated impact on water rates. The City's capital improvement plan is shown in Table 4 below, as adapted from the 2018 Water System Master Plan (Murraysmith, 2018).

Table 4: North Plains Capital Improvement Plan with seismic resiliency recommendations, adapted from Murraysmith 2018

Category	Project Description	Fiscal Year 2017 2018	Fiscal Year 2018 2019	Fiscal Year 2019 2020	Fiscal Year 2020 2021	Fiscal Year 2021 2022	Fiscal Year 2022 2023	Fiscal Year 2023 2024	Fiscal Year 2024 2025	Fiscal Year 2025 2026	Fiscal Year 2026 2027	Fiscal Year 2027 2028	Fiscal Year 2028 2029	Fiscal Year 2029 2030	Fiscal Year 2030 2031	Fiscal Year 2031 2032	Fiscal Year 2032 2033	Fiscal Year 2033 2034	Fiscal Year 2034 2035	Fiscal Year 2035 2036	Fiscal Year 2036 2037	Fiscal Year 2040 2041	Fiscal Year 2050 2051	Fiscal Year 2060 2061	Estimated Total Project
Telemetry & Control	New Telemetry and Control (SCADA) System			Telemetry and Control System $155,000																					
	Sub-Total	$0	$0	$155,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$155,000
Pumping Facilities	Pump Station Upgrades				P.S. Upgrades $235,000																				
	Booster Pump Station		P.S. No. 2 $800,000																						
	Sub-Total	$0	$800,000	$0	$235,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1,035,000
Distribution System Piping	Fire Flow and Distribution Improvements					Gordon Crossing 12" Waterline $440,510		UE2A - 968 lf - 10" Waterline $261,360		UE2B - 910 lf - 12" Waterline $263,900		UE1 - 420 lf - 12" Waterline $121,800		UE3 - 260 lf - 10" Waterline $70,200											
	Main Replacement and Standard Upsizing Program				$185,502		$371,004		$371,004		$371,004		$371,004	$185,502	$371,004	$371,004	$371,004	$185,502	$185,502	$185,502	$185,502				
	Sub-Total	$0	$0	$0	$185,502	$440,510	$371,004	$261,360	$371,004	$263,900	$371,004	$121,800	$371,004	$255,702	$371,004	$371,004	$371,004	$185,502	$185,502	$185,502	$185,502	$0	$0	$0	$4,867,810
Storage Facilities	New Reservoir and Pump Station	Res. & P.S. Land $695,000																							
		Res. & P.S. Eng. $700,000	2.0 MG Reservoir $4,573,000																						
	Sub-Total	$1,395,000	$4,573,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$5,968,000
Seismic Resilience	Critical Facilities Seismic Improvements & Aquifer Storage and Recovery				Aquifer Storage and Recovery Feasibility Study										JWC Supply Pipeline Joint Strengthening							314th Avenue PRV Vault Strengthening	JWC Connection Vault Strengthening	Aquifer Storage and Recovery Well	
	Sub-Total				$100,000										$1,000,000							$340,000	$90,000	$6,000,000	$7,530,000
	Total	$1,395,000	$5,373,000	$155,000	$520,502	$440,510	$371,004	$261,360	$371,004	$263,900	$371,004	$121,800	$371,004	$255,702	$1,371,004	$371,004	$371,004	$185,502	$185,502	$185,502	$185,502	$340,000	$90,000	$6,000,000	$19,555,810

Notes: Ground improvements assumed not to be required for JWC connection vault. City priorities could change pending the results of Project #1.

4.0 CONCLUSION AND RECOMMENDATIONS

The primary seismic vulnerability of the City's water system is maintaining continuity with the JWC supply, it's single source of water. Disruption of this supply could interrupt water services for weeks or months.

The City has two primary options to reduce seismic vulnerabilities. The City could 1) harden the JWC supply infrastructure or 2) implement an Aquifer Storage and Recovery (ASR) facility that could store water and supply the City with seasonal independence from the JWC supply pipeline.

The recommendation of this evaluation is to complete a feasibility study for Aquifer Storage and Recovery. Depending on its results, the City could either move toward implementation of an ASR facility or move to harden its JWC supply infrastructure.

5.0 REFERENCES

American Lifelines Alliance (ALA). 2001. Seismic Fragility Formulations for Water Systems Part 1 – Guideline, https://www.americanlifelinesalliance.com/pdf/Part_1_Guideline.pdf.

Ballantyne, Donald. 2010. Seismic Vulnerability Assessment and Design of Pipelines, Journal American Water Works Association, May, Denver.

Burns, William J, and Daniel E Coe. 2012. "Missoula Floods - Inundation Extent and Primary Flood Features in the Portland Metropolitan Area." Oregon Department of Geology and Mineral Industries, 2012, www.oregongeology.org/pubs/ims/IMS-036_print.pdf.

Fenneman, N.M., 1931. Physiography of western United States: New York, McGraw – Hill Book Co., Inc.

Hart, D. H. and R.C. Newcomb. 1965. Geology and ground water of the Tualatin Valley, Oregon. USGS Numbered Series. (Vol. 172, Ser. 1697, Rep.). U.S.G.P.O. doi:10.3133/wsp1697 p. :ill., maps ;24 cm.

Madin, Ian P., and William J. Burns. 2013. Ground Motion, Ground Deformation, Tsunami Inundation, Coseismic Subsidence, and Damage Potential Maps for the 2012 Oregon Resilience Plan for Cascadia Subduction Zone Earthquakes. Rep. no. O-13-06. Oregon Department of Geology and Mineral Industries, 2013.

Murraysmith. 2018. Water System Master Plan Update: City of North Plains

North Plains, City of. 2002. North Plains Local Wetlands Inventory, Figure 4. Provided by Pacific Habitat Services, Inc., Wilsonville, OR.

State of Oregon Department of Geology and Mineral Services (DOGAMI). 2019. Oregon HazVu: Statewide Geohazards Viewer
https://gis.dogami.oregon.gov/maps/hazvu/

State of Oregon Department of Geology and Mineral Services (DOGAMI). 2013.A – Map of Earthquake and Tsunami Damage Potential for a Simulated Magnitude 9 Cascadia Earthquake. Open File Report O-13-06, Plate 7

State of Oregon Department of Geology and Mineral Services (DOGAMI). 2013.B. Map of Probability of Liquefaction for a Simulated Magnitude 9 Cascadia Earthquake. Open File Report 0-13-06, Plate 3

State of Oregon Department of Geology and Mineral Services (DOGAMI). 2013.C. Map of Permanent Ground Deformation Due to Liquefaction Lateral Spreading for a Simulated Magnitude 9 Cascadia Earthquake. Open File Report 0-13-06, Plate 4

State of Oregon Department of Geology and Mineral Services (DOGAMI). 2013.D. Map of Probability of Earthquake-Induced Landslides from a Simulated Magnitude 9 Cascadia Earthquake. Open File Report 0-13-06, Plate 5

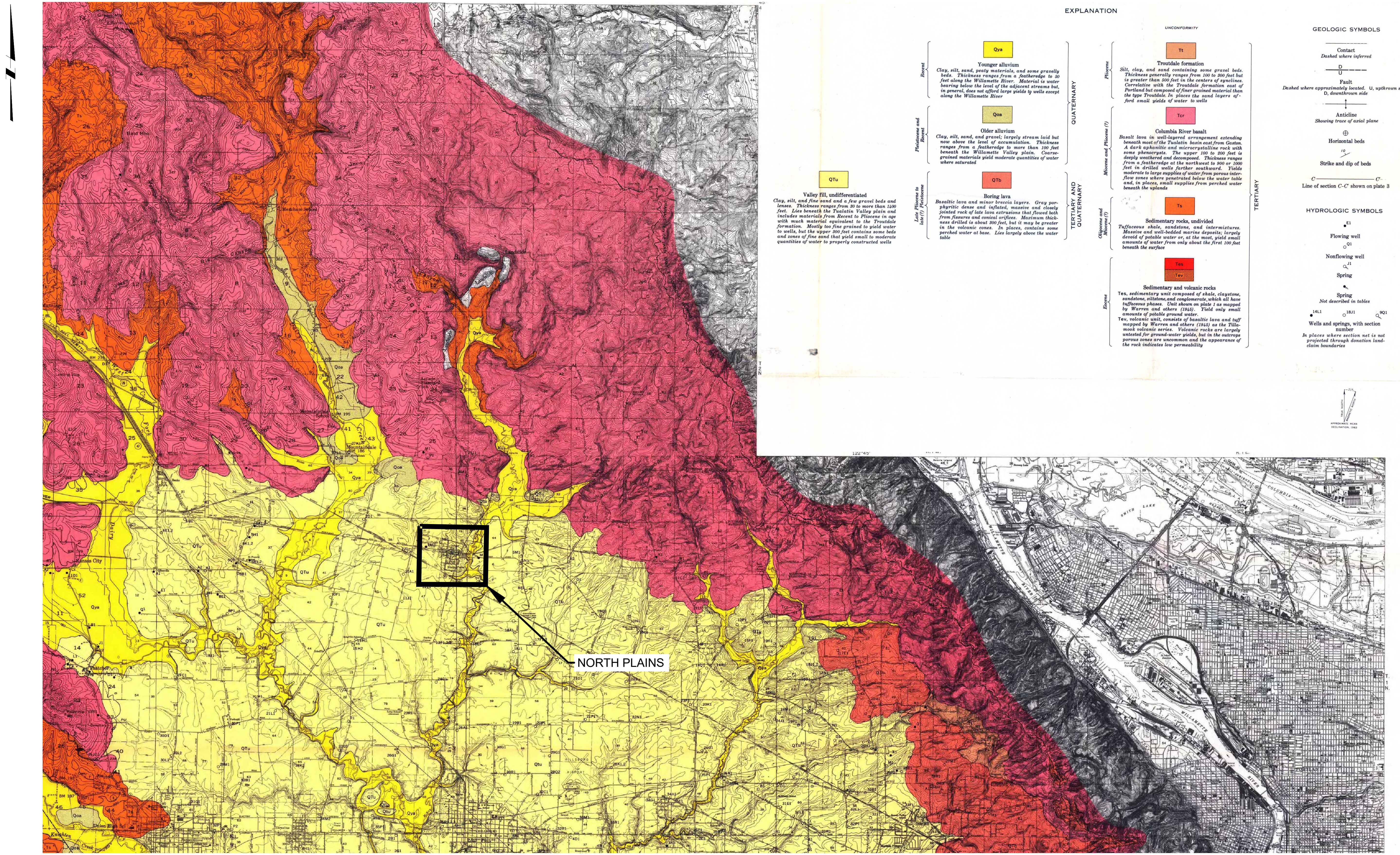
Schliker, H. G., and R. J. Deacon. 1967. “Geology and Surficial Deposits of the Tualatin Valley Region, Oregon.” DOGAMI Bulletin 60, Engineering Geology of the Tualatin Valley Region, Oregon, Oregon Department of Geology and Mineral Industries. http://digital.osl.state.or.us/islandora/object/osl%3A803/datastream/OBJ/view.

Stantec. 2019. Geotechnical Design Report: Proposed North Plains Reservoir and Pump Station

USGS. 2014. 2014 National Seismic Hazard Maps - Source Parameters. U.S. Geological Survey, http://earthquake.usgs.gov/cfusion/hazfaults_2014_search/query_results.cfm.

Wilson, Doyle C. 1998. Post-middle Miocene geologic evolution of the Tualatin basin, Oregon. Oregon Geology, 60 (5), 99-116.

Appendix A REFERENCES & FIGURES



REV	DATE	BY	DESCRIPTION

SCALE: NO SCALE

WARNING: 0 ½ 1 — IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED: A HERPERGER
DRAWN: T BAILEY
CHECKED: B BLACK

CONSTRUCTION DOCUMENT PHASE - FEBRUARY 2019

NOT FOR CONSTRUCTION

This document is an interim document and not suitable for construction. As an interim document, it may contain data that is potentially inaccurate or incomplete and is not to be relied upon without the express written consent of the preparer.

Stantec

NORTH PLAINS
City to the Sunset

CITY OF NORTH PLAINS

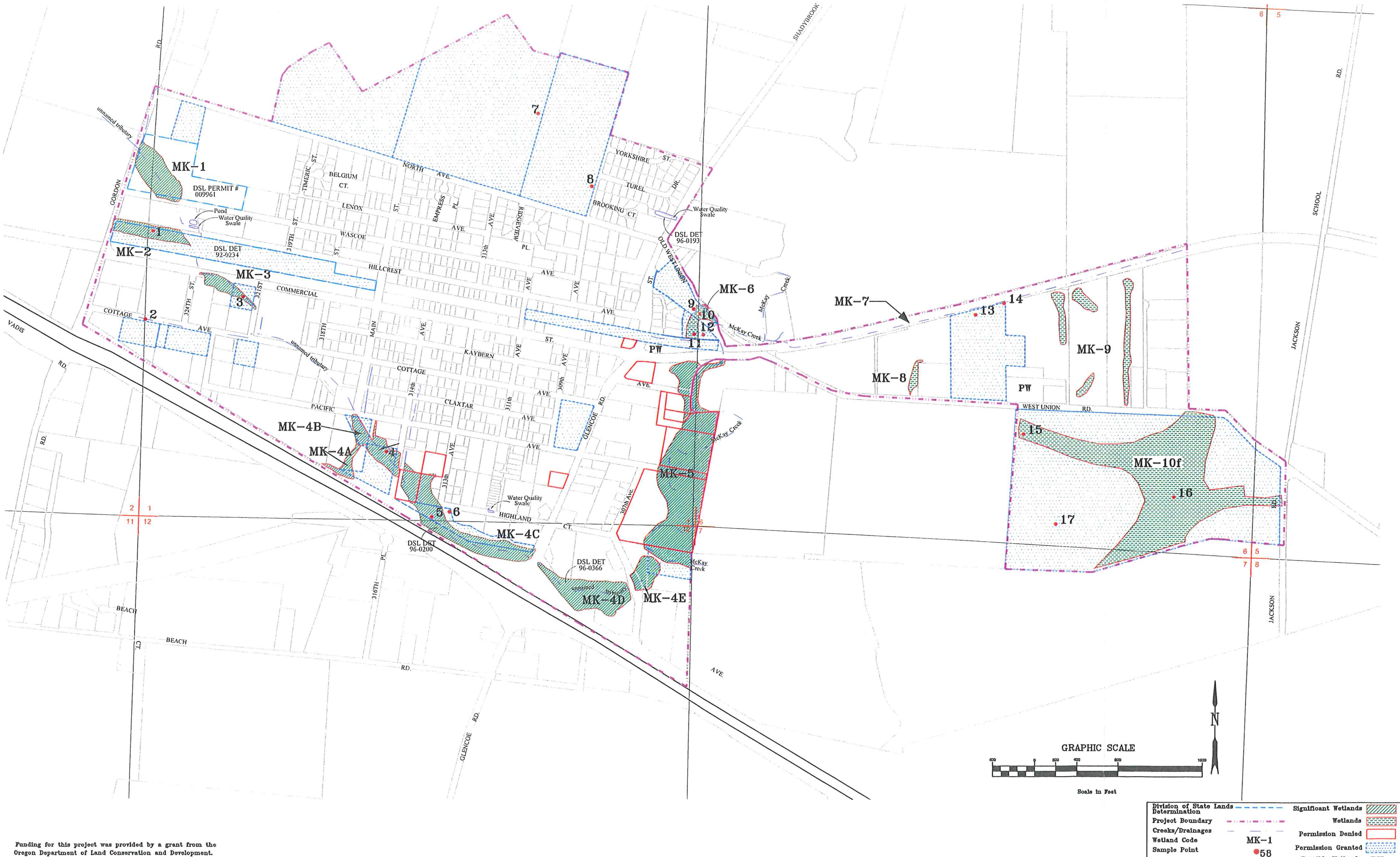
RESERVOIR AND PUMP STATION NO 2

FIGURE 4
GEOLOGY MAP

SHEET
F-4

2002300044

Tuesday, February 5, 2019 5:54:21 PM C:\PWWORKDIR\D0485963\GEOTECH FIGURES.DWG BAILEY, THOMAS



Funding for this project was provided by a grant from the Oregon Department of Land Conservation and Development.

DATE: January, 2002
BASE MAP INFO: Supplied by Metro
JOB NO.: 2453

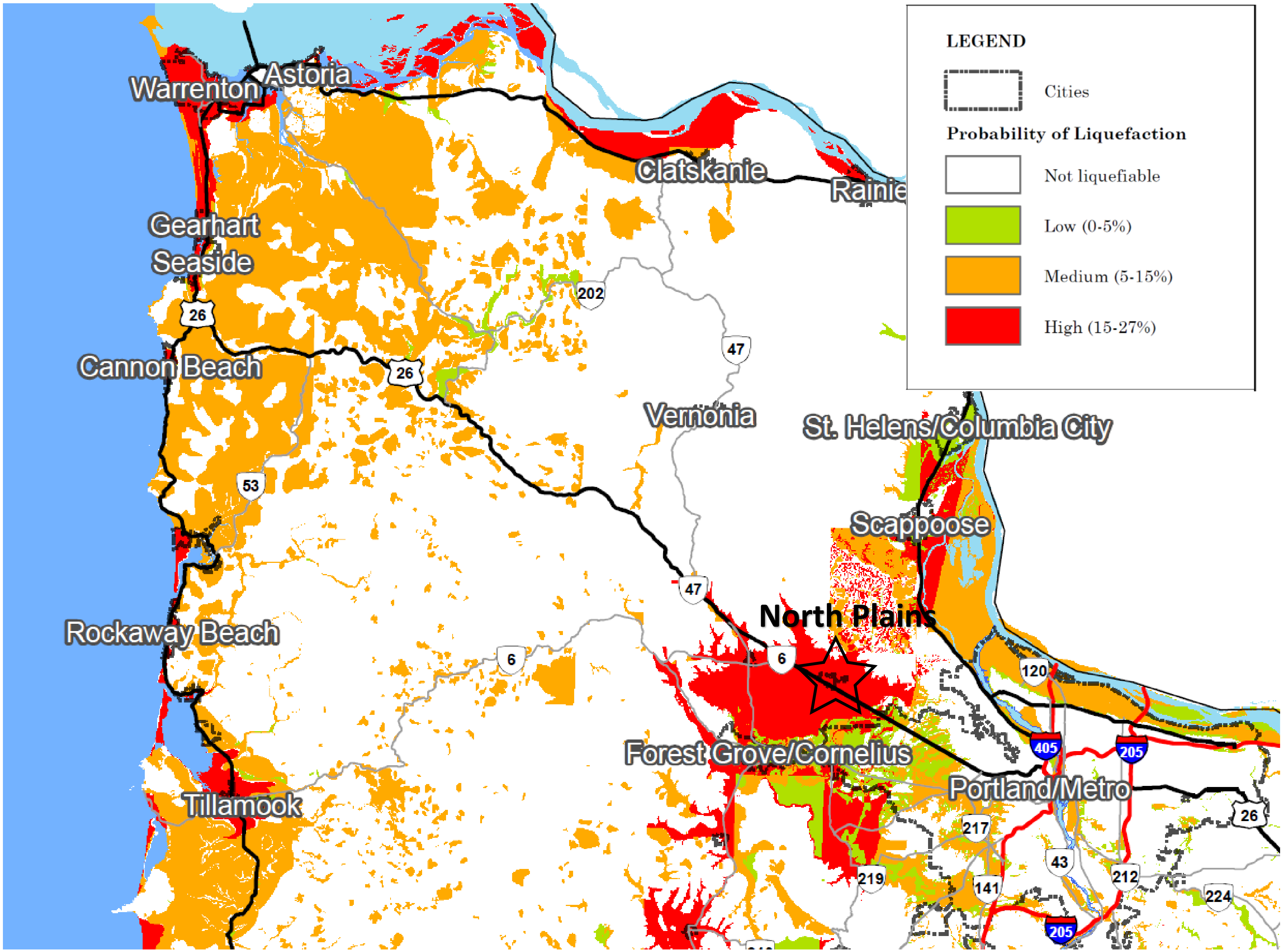
North Plains
Local Wetlands Inventory

Pacific Habitat Services, Inc.
9450 SW Commerce Circle, Suite 180
Wilsonville, Oregon 97070
Phone: (503) 570-0800
PHS

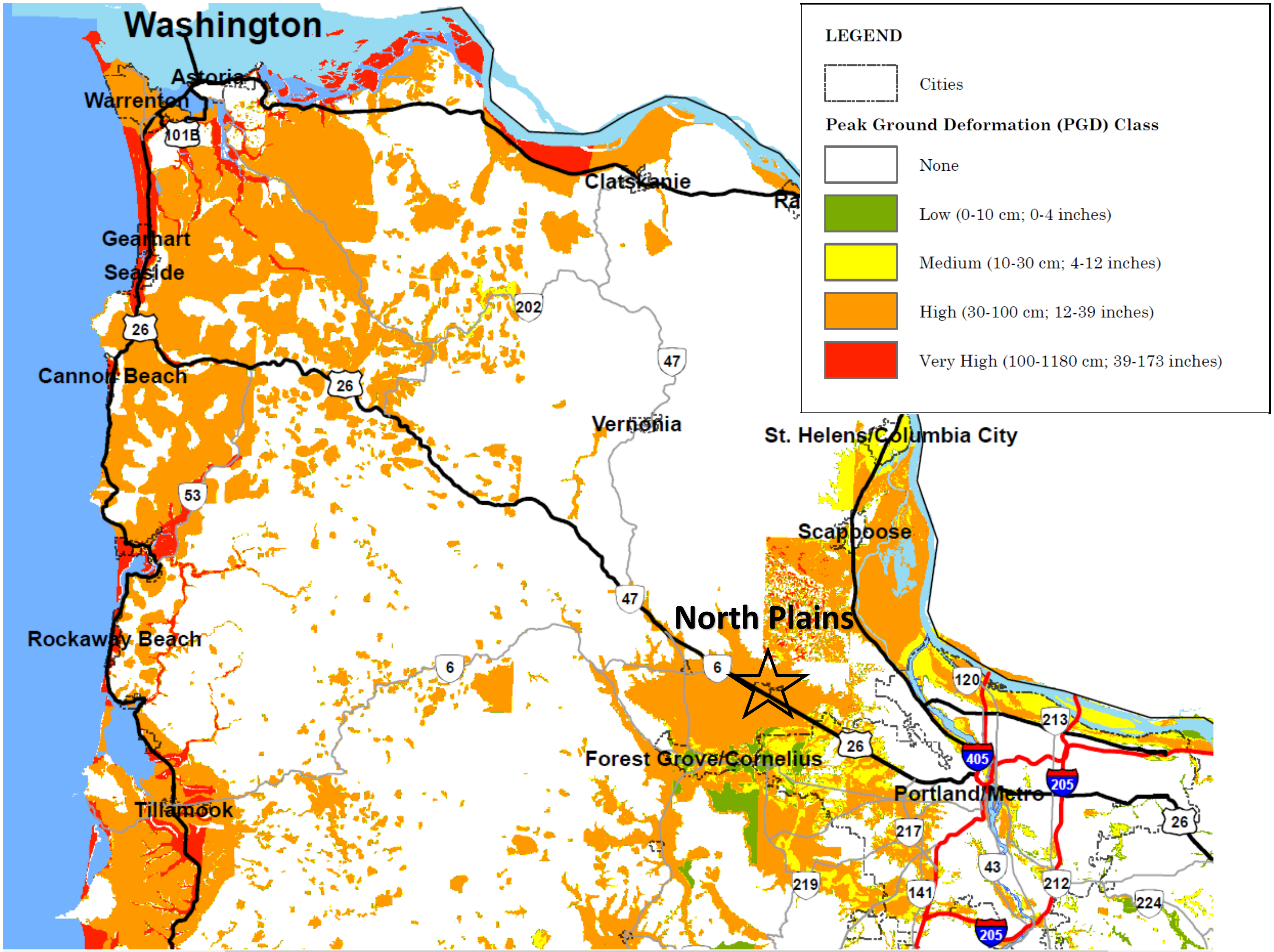
THIS MAP IS FOR PLANNING PURPOSES ONLY
WETLAND BOUNDARIES ARE APPROXIMATE
AND SUBJECT TO CHANGE

Information shown on this map is for planning purposes only and wetland information is subject to change. There may be unmapped wetlands subject to regulation and all wetland boundary mapping is approximate. In all cases, actual field conditions determine wetland boundaries. You are advised to contact the Oregon Division of State Lands and the U.S. Army Corps of Engineers with any regulatory questions.

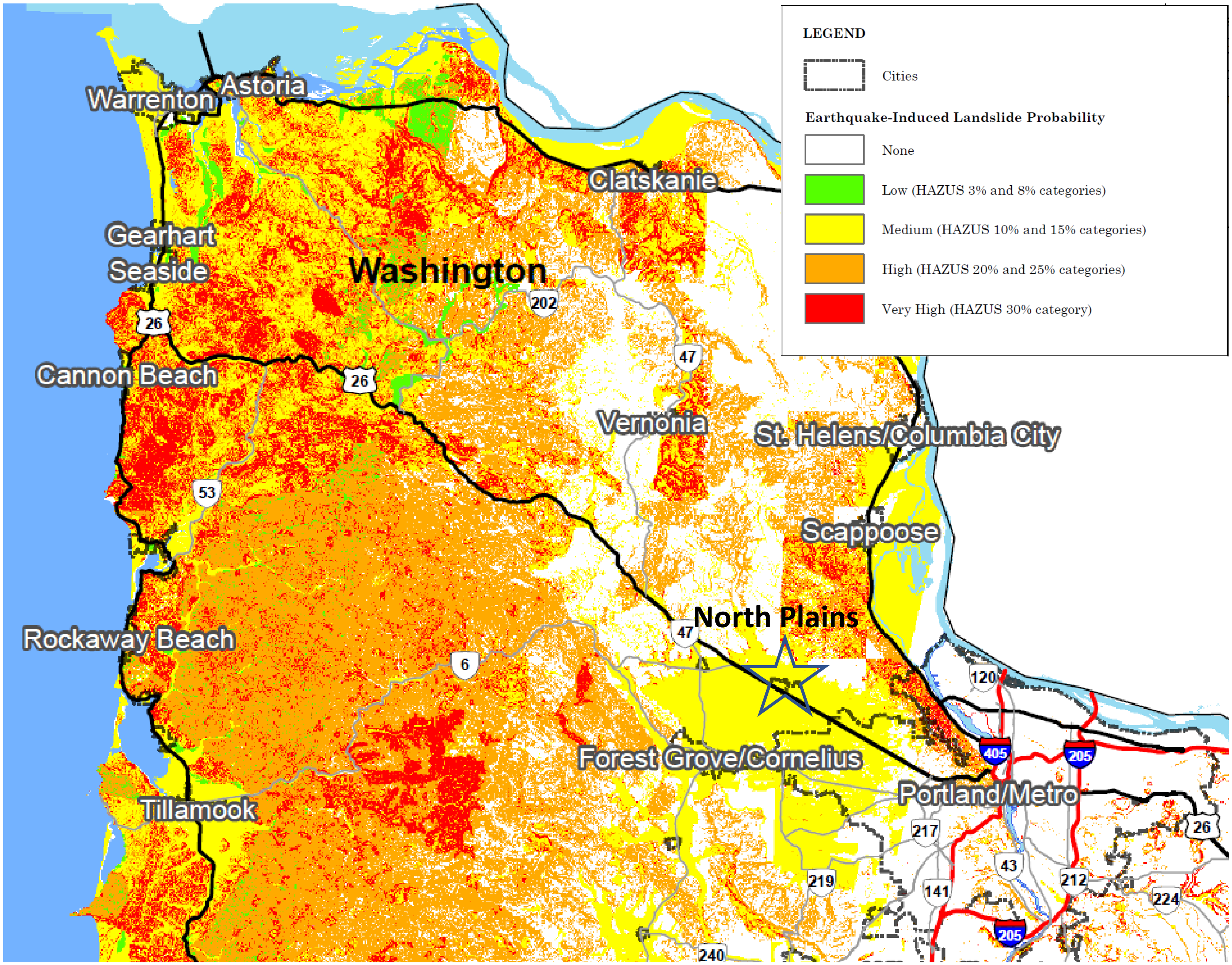
FIGURE 4



(DOGAMI, 2013b) Map of Probability of Liquefaction for a Simulated Magnitude 9 Cascadia Earthquake. Open-File Report O-13-06, Plate 3



(DOGAMI, 2013c) Map of Permanent Ground Deformation Due to Liquefaction Later Spreading for a Simulated Magnitude Simulated Magnitude 9 Cascadia Earthquake. Open-File Report O-13-06, Plate 4



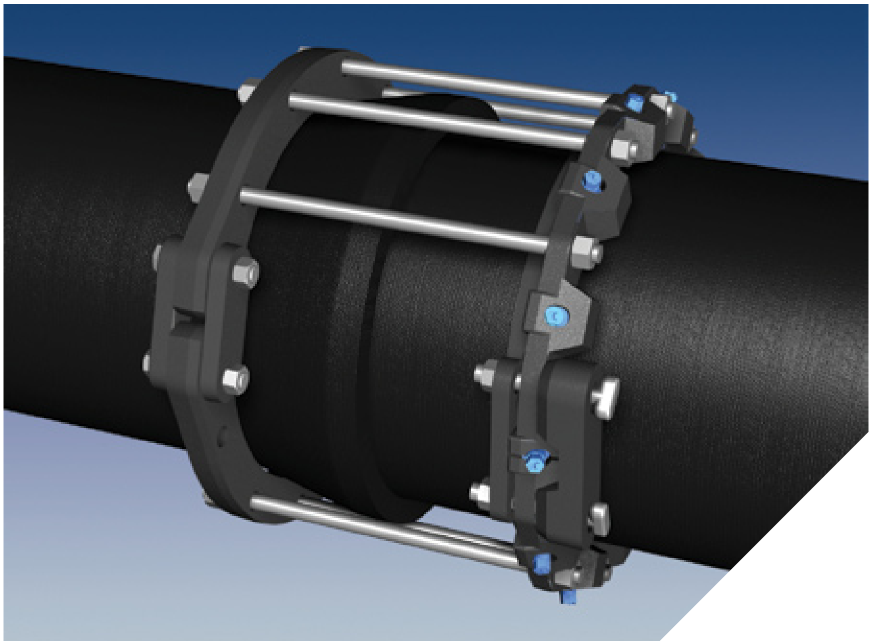
(DOGAMI, 2013d) Map of Probability of Earthquake-Induced Landslides from a Simulated Magnitude 9 Cascadia Earthquake. Open-File Report O-13-06, Plate 5

Appendix B EQUIPMENT

Series 1100HD

Split MEGALUG® Bell Restraint Harness for Existing Ductile Iron Pipe

Your Connection to the Future™



Series 1116HD on 16 inch Ductile Iron Pipe.

Features and Applications:

- For use on Existing Ductile Iron Pipe at Pipe to Pipe Push On Joints
- MEGA-BOND® Restraint Coating System
- Minimum 2 to 1 Safety Factor
- Split Design for Ease of Installation
- Constructed of ASTM A536 Ductile Iron

For use on water or wastewater pipelines subject to hydrostatic pressure and tested in accordance with either AWWA C600 or ASTM D2774.

			Pressure Ratings Table	
Nominal Pipe Size	Series Number	Approximate Shipping Weight	Thrust Rods (Quantity - Size)	Pressure Rating (PSI)
3	1103HD	9.50	4 - ⅝ x 12	350
4	1104HD	23.50	4 - ¾ x 13	350
6	1106HD	33.00	4 - ¾ x 13	350
8	1108HD	41.00	4 - ¾ x 13	350
10	1110HD	63.16	4 - ¾ x 18	300
12	1112HD	77.06	4 - ¾ x 18	300
14	1114HD	136.15	6 - ¾ x 18	300
16	1116HD	143.92	8 - ¾ x 18	300
18	1118HD	160.41	8 - ¾ x 18	200
20	1120HD	187.08	10 - ¾ x 18	200
24	1124HD	252.89	12 - ¾ x 18	200
30	1130HD	492.20	16 - 1 x 18	200
36	1136HD	546.30	20 - 1 x 18	200
42	1142HD	964.30	24 - 1¼ x 28	175
48	1148HD	1270.90	28 - 1¼ x 28	175

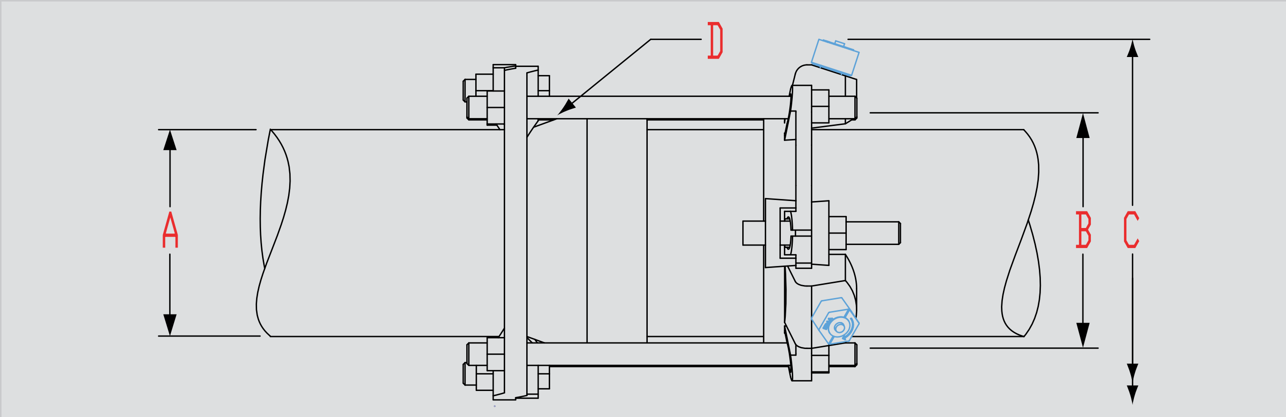
NOTE: For applications or pressures other than those shown, please contact EBAA for assistance.

Sample Specification

Restraint for existing bell joints found on ductile iron pipes shall consist of the following: The restraints shall be manufactured of ductile iron conforming to ASTM A536. The split restraint rings, incorporating a plurality of individually-actuating gripping surfaces, shall be used to grip the pipe on either side of the bell, and a sufficient number of rods shall be used to connect each restraint to one another. The restraint devices shall be coated using MEGA-BOND. (For complete specifications on MEGA-BOND visit www.ebaa.com.) The combination shall have a minimum working pressure rating as shown in the adjacent table. The restraint shall be the Series 1100HD, as manufactured by EBAA Iron, Inc., or approved equal.

Submittal Reference Drawing

EBAA IRON



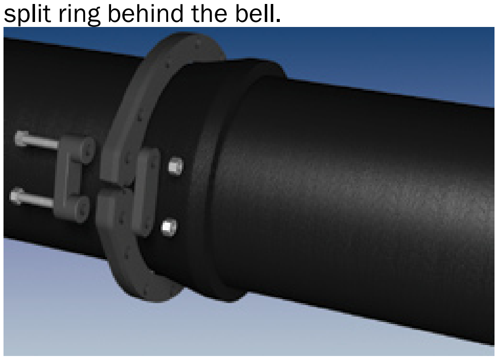
MADE IN USA

Nominal Pipe Size	Series Number	A Pipe O.D.	B Maximum Bell O.D. Cleared	C Casing Clearance (w/Nuts Off)	D Thrust Rods (Quantity - Size)
3	1103HD	3.95	5.40	9.06	4 - ⅝ x 12
4	1104HD	4.81	6.60	9.90	4 - ¾ x 13
6	1106HD	6.90	8.60	12.00	4 - ¾ x 13
8	1108HD	9.05	10.90	14.15	4 - ¾ x 13
10	1110HD	11.10	13.10	16.20	4 - ¾ x 18
12	1112HD	13.20	15.40	18.30	4 - ¾ x 18
14	1114HD	15.30	17.90	21.88	6 - ¾ x 18
16	1116HD	17.40	20.10	24.13	8 - ¾ x 18
18	1118HD	19.50	22.40	26.50	8 - ¾ x 18
20	1120HD	21.60	24.60	28.50	10 - ¾ x 18
24	1124HD	25.80	29.10	33.38	12 - ¾ x 18
30	1130HD	32.00	35.80	40.25	16 - 1 x 18
36	1136HD	38.30	42.60	46.75	20 - 1 x 18
42	1142HD	44.50	49.20	55.57	24 - 1¼ x 28
48	1148HD	50.80	56.00	61.87	28 - 1¼ x 28

NOTE: Dimensions are in inches and are subject to change without notice.

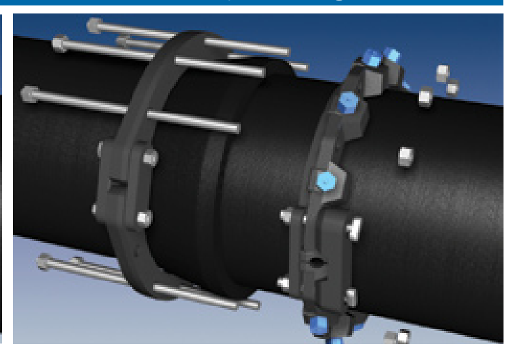
Installation Instructions

The Series 1100HD is designed for restraining existing ductile iron pipe, conforming to ANSI/AWWA C151/A21.51 (all thickness classes), push on pipe bells. It has a split restraint ring on the spigot and a split ring behind the bell.



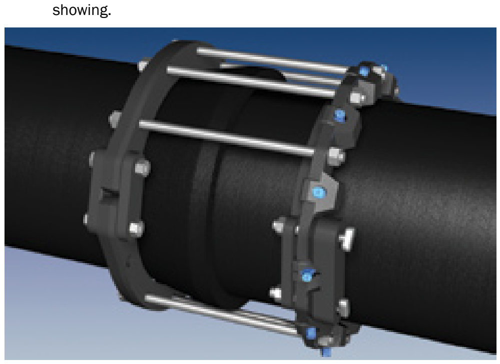
1. Install the split ring behind the bell in the direction indicated on the casting. Tighten the clamp bolts to 90 ft-lbs.

2. Disassemble the split restraint ring then reassemble restraint on the spigot such that the bolt holes are in alignment and the distance between the rings is suitable for the tie bolt length with the lip of the restraint facing toward the bell. Allow enough room on the tie bolt to fully engage the nut with several threads showing.



3. Install the tie bolts in each available bolt hole for maximum distribution of operating forces. Place nuts on the end of the tie bolts. Allow enough room on the tie bolt to fully engage the nut with several threads showing.

   Pull the restraint ring away from the joint until the slack is removed from the tie bolts.



4. Tighten the torque limiting twist off nuts in a clockwise direction (direction indicated by arrow on top of nut) until all wedges are in firm contact with the pipe surface.

Continued from Step 4
Continue tightening in an alternate manner until all of the nuts have been twisted off.

Tighten the tie bolt nuts until the ring behind the bell is in firm contact with the back of the bell.

5. If removal is necessary; use the ⅝" hex heads provided. If reassembly is required, assemble the product in the same manner as indicated in the previous steps and tighten the wedge bolts to 90 ft-lbs.

EBAA IRON Sales, Inc.
P.O. Box 857, Eastland, TX 76448
Tel: (254) 629-1731
Fax: (254) 629-8931
(800) 433-1716 within US and Canada
contact@ebaa.com
www.ebaa.com

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