PROCESS WATER REUSE FACILITY
Capital Facilities Plan/Engineering Report

Rev. #1 June 2019
Rev. #2 November 2019

City of Pasco Washington

VOLUME 1

PACE An Engineering Services Company

JACOBS®

CES

FCS GROUP

PROJECT CERTIFICATION

The technical material and data contained in this report was prepared by PACE Engineers, Inc., under the supervision of the below listed individuals. Those responsible staff members who are registered professional engineers are licensed in the State of Washington.

Robin D. Nelson, P.E.

PACE Engineers, Inc.
11255 Kirkland Way, Suite 300
Kirkland, Washington 98033-6715
Phone: 425.827.2014
www.paceengrs.com

THIS PAGE IS INTENTIONALLY LEFT BLANK.

EXECUTIVE SUMMARY

1.0 REPORT FORMAT

The Process Water Reuse Facility Capital Facilities Plan/Engineering Report is an assemblage of technical memorandums and engineering reports focused on the needs for the City of Pasco's agricultural waste collection and treatment utility. The report is segregated into five subsections:

- Section I – Land Treatment
- Section II – Pretreatment Design Basis
- Section III – Conveyance Design Basis
- Section IV – Financial Assessment

Section I includes a well-documented description of the Pasco Process Water Re-Use Facility (PWRF) utility including a site description, problem identification, description of type of wastewater, ownership, operational responsibilities, delineation of the service area, and demographics. This first section provides an introduction to the City's treatment of agricultural wastewater and the Land Treatment System permitted by the Department of Ecology defined in their State Waste Discharge Permit # ST0005369. This section also provides detailed assessments of the Land Treatment System and Hydrogeologic Report.

The Land Treatment Site Assessment chapter defines the agronomic capacity conclusions of the Land Treatment Assessment that the soils at the land treatment site are suitable for receiving the process water for land treatment purposes and the site performance indicates that nitrogen and hydraulic loadings have not typically exceeded the agronomic capacity. The agronomic capacity will vary from year to year depending upon the crop mix. The agronomic capacities within which the site must be managed by the City, will be established and reported each year in the Annual Farm Operations Report, as required by permit.

The design basis annual mass loading for the Land Treatment System are presented in Table 1-15.

The Hydrogeologic evaluation provided the following conclusions:

- Regional groundwater includes saturated material in unconsolidated coarse-grain material overlying the CRBG, and also flows within the CRBG.
- The unconsolidated material transmits groundwater more readily than the CRBG; the CRBG transmits groundwater less readily through joints and fractures, along flow contacts, and is further restricted across contacts.
- Surface soils drain at a moderate to moderately rapid rate of 1.1 to 6.3 inches per hour.

- Regional groundwater flow is from the north to south toward the Columbia River. Groundwater hydraulic conductivities range from 100 to 1,000 feet per day with a hydraulic gradient of 0.003 feet per foot and calculated flow velocity of 1.2 to 12 feet per day.
- The local site groundwater flow direction is from the northeast to southwest toward the Columbia River. Local groundwater flow characteristics are similar to regional flows, with hydraulic conductivities ranging from 90 to 900 feet per day with a hydraulic gradient of 0.002 feet per foot and calculated flow velocity of 0.7 to 7 feet per day.
- Locally, municipal wells are constructed at greater depth than the PWRF wells and are below the MCL for nitrate-N concentrations. Local Group A and Group B wells screened shallower than the municipal wells have had historical detections of nitrate-N greater than the MCL.
- The local unconsolidated material is 130 feet deep on the eastern portion of the site and increases to 245 feet on the western side. A perennial stream is located to the west and south of the site in Lower Smith Canyon that may act as a local groundwater recharge feature, like an unlined irrigation ditch.
- Local groundwater chemistry is different north and south of E. Foster Wells Road. Nitrate-N and TDS concentrations are generally higher to the north, and lower to the south.
- PWRF land application is controlled with application rates based on field rotation across the entire site without one specific area that would result in greater application than other areas.
- PWRF effluent concentrations were sampled during irrigation operations in 2016 with measured nitrite and nitrate-N significantly lower than groundwater concentrations and not likely a source of nitrate-N concentrations elevated in groundwater.

Section II includes an in-depth evaluation of the PWRF pretreatment system and future needs. The structure of Section II satisfies the required documentation for an engineering report. This section includes a detailed conditions assessment of the existing PWRF, establishes phased future flow and loading data for alternatives analysis, and provides an alternatives analysis including defined goals for the future operations, development of the preferred alternative, and sufficient preliminary design detail to serve as the basis for future design of the preferred alternative.

Section II details the future needs for the PWRF to accommodate growth within the defined service area. The City plans to Phase 1n new processors and additional treatment capacity at the PWRF. Each phase will incorporate new treatment capacity based on the flow and loading projections discussed in this document. It is anticipated that phasing will occur in the following order:

- Existing – Reser's, Freeze Pack, Pasco Processing, and Twin City Foods
- Phase 1 (2018) – Existing processors plus Simplot
- Phase 2 (2020) – Phase 1 processors plus Grimmway plus 30 percent growth at Reser's
- Phase 3 (2026) – Phase 2 processors plus Lamb Weston
- Phase 4 (2030) – Phase 3 processors plus one 2.5 mgd year-round new processor
- Phase 5 (2040) – Phase 4 processors plus one 2.5 mgd year-round new processor

Having developed the design criteria for the PWRF service area, Section II then documents the alternatives analysis performed to meet the design criteria for Phase 2 above. Phases 3, 4, and 5 will not be included in the engineering report and are briefly discussed as modular increases to the proposed Phase 2 capital needs.

This section also includes an evaluation of enhanced pretreatment of the wastewater to meet Industrial Reuse requirements. The additional enhanced treatment was found to be cost prohibitive and is not considered further in this report.

Section II presents the preferred capital recommendations required to meet existing and future conveyance needs and immediate pretreatment improvements required to meet Phase 2 customers' foreseeable needs, reduce nuisance odors, provide sufficient winter storage, and maintain use of the current 1,856 acres of agricultural land permitted for land treatment. The recommended alternative is to upgrade the pretreatment capacity at the PWRF immediately with the installation of a new screen; clarifier; pH adjustment; reduction of VFAs, BOD, and nitrogen; solids handling; and storage, sized for Phase 2 only. During the summer, the upgraded PWRF will treat process wastewater for BOD_5, TSS, and TN, and discharge the treated water to the existing land application site. During the winter, the same treatment will occur; however, the treated water will be stored onsite until it can be discharged to the spray fields in the spring. The selected secondary treatment will minimize odors and solids settling in the storage basins.

The recommended alternative consists of the following major elements:

- third identical rotary drum screen to be installed in the existing headworks building
- pH control downstream of the rotary drum screens to reduce odors in downstream processes and storage
- 90-foot-diameter circular primary clarifier
- Equalization and aeration using the existing 35 MG pond
- 183 MG additional winter storage across multiple basins
- solids handling for screened, primary, and secondary solids

The process flow diagram for the recommended system is presented in Figure 6.1. Other work elements include demolishing existing facilities, including the sedimentation basin, and constructing surface access to new facilities including driveways, pavement, and fencing. After the project is completed, the PWRF will operate within its permit limits using the same land application acreage. Foul odors will be minimized to ensure that the City is acting as a good neighbor to all industries and residents in the area. Sufficient preliminary design data is provided in Section II and appendices such that plans and specifications can be prepared for the Columbia East Regional pump station and forcemain, Irrigation Pump Station and forcemain, pretreatment capital needs, and the Land Treatment system.

Section III provides current conditions assessments for the collection systems for both the Foster Wells Service Area and Columbia East Service Area. This documentation defines needed capital improvements to maintain service to the existing customers including Pasco Processing, Reser's Fine Foods, Twin City Foods, Simplot RDO, and Freeze Pack. It also defines the need to transfer Grimmway Enterprise flow from the Municipal Treatment Plant to the Process Water Reuse Facility and the potential for future processors. Engineering reports are included in this section providing the basis for design of the proposed new Columbia East Pump Station and Forcemain and possible new customer, Lamb Weston.

Section IV presents a capital improvements plan for the recommended improvements discussed in Sections II and III. A prioritized list of capital improvements and cost estimates are segregated by conveyance needs, pretreatment needs, and land treatment system needs. The pretreatment needs are presented in a manner so as to define existing infrastructure rehabilitation; needed capacity for operational limitations of the existing pretreatment process, such as odor control, effective storage, and solids handling; and finally, for additional flow from Reser's Fine Foods and new flow from Grimmway Enterprises and possibly Lamb Weston.

Also included in this section are alternatives for cost allocation of capital and maintenance costs for the Phase 2 design criteria. The analysis described above concludes the cost allocation analysis for the City of Pasco Process Water Reuse Facility. Costs are forecast to increase as the facility undergoes $44.33 million in capital improvements over the next six years. These improvements are necessary to repair/replace existing infrastructure and upgrade/expand capacity for future customers. The costs shown in Chapter 14 represent the annual costs once all Phase 2 construction is completed. As mentioned previously, costs shown in this report are a snapshot in time; the City will need to perform annual updates to the forecast of costs to determine future year cost allocations for each customer. A year-end true-up will ensure equitable cost recovery and long-term PWRF operating and financial sustainability.

TABLE OF CONTENTS

CHAPTER 2 PWRF HYDROGEOLOGIC ASSESSMENT

SECTION II: PRETREATMENT DESIGN BASIS

CHAPTER 6 PRE-TREATMENT ALTERNATIVES

CHAPTER 11 FOSTER WELLS SERVICE AREA CONVEYANCE IMPROVEMENTS

CHAPTER 12 COLUMBIA EAST SERVICE AREA CONVEYANCE IMPROVEMENTS

SECTION IV FINANCIAL ASSESSMENT

CHAPTER 13 CAPITAL IMPROVEMENTS PLAN

CHAPTER 14 FINANCIAL ANALYSIS

APPENDICES

CHAPTER 1

CHAPTER 2

VOLUME 2: APPENDICES

LIST OF TABLES

LIST OF FIGURES

THIS PAGE IS INTENTIONALLY LEFT BLANK.

GLOSSARY AND TERMS

Activated Sludge Process	A biological wastewater treatment process whereby a mixture of wastewater and activated sludge is agitated and aerated. The activated sludge is subsequently separated from the treated wastewater (mixed liquor) by sedimentation, and wasted or returned to the process as needed.
Aeration	A process that mixes and/or infuses air into a liquid by one or more methods, such as spraying the liquid in the air, forcing air bubbles through the liquid, or agitating the liquid to promote surface absorption of the air.
Anaerobic	An environment devoid of oxygen.
Anoxic	An environment devoid of oxygen where nitrate acts as the electron acceptor.
Aquifer	A porous, water-bearing geologic formation. Generally restricted to materials capable of yielding an appreciable supply of water.
Average Annual Flow (AAF)	The average day flow for the entire year.
Average Dry Weather Flow (ADWF)	ADWF is the flow for an average day during the dry weather months (generally May through October), and represents the baseline of sewage flow for the service area. The ADWF includes sewage discharges plus the average amount of groundwater infiltration (base GWI) which occurs throughout the dry weather months. In the absence of actual data, 100 gallons per capita per day is often used to predict the ADWF for a new service area. Peaking factors for existing flows are derived on the basis of ADWF.
Average Wet Weather Flow (AWWF)	AWWF is the flow for an average day during the wet weather months of November through April. The AWWF includes sewage discharges, groundwater infiltration and stormwater inflow, which occurs throughout the wet weather months.
bgs	Below ground surface
Biochemical Oxygen Demand - Five Day (BOD5)	The quantity of oxygen required to support biological oxidation of the organic matter contained in wastewater. Usually referred to as BOD, this characteristic defines the strength of a wastewater and often determines the type and level of treatment which must be provided to produce a required effluent quality. BOD is commonly expressed as the amount of oxygen utilized in the oxidization of organic matter over a five-day period at 20 degrees C and is typically represented as (BOD5).

Ca	Calcium
Carbonaceous Biochemical Oxygen Demand (CBOD)	Similar to biochemical oxygen demand, except that nitrification is excluded from the oxygen demand calculation. CBOD is measured using nitrification inhibiting agents.
City	City of Pasco
Cl	Chloride
Combined Sewer	A sewer facility that receives both wastewater and storm or surface water through a direct connection (i.e. not incidental inflow).
Commercial Wastewater	Wastewater generated in predominantly business or commercial areas, including both sanitary wastes and wastes from the commercial activities. Typically, commercial wastewater includes, but is not limited to, wastes from restaurants, laundromats, and service stations.
CRBG	Columbia River Basalt Group
CRF	CRF Frozen Foods
Denitrification	Removal of nitrogen from wastewater by conversion of nitrate into nitrogen gas under anoxic conditions.
DOH	State of Washington Department of Health.
Domestic Wastewater	Wastewater principally derived from the sanitary conveniences of residences or produced by normal residential activities.
Dry Weather Flow	Wastewater flow during periods of little or no rainfall; in the Puget Sound area, this typically occurs during the months of May through October. Rates of flow exhibit hourly, daily, and seasonal variations. A certain amount of infiltration may also be present.
Dry Well	The dry compartment in a pump station, near or above the pumping level, where the pumps and/or motors and controls are located.
Ecology	Washington State Department of Ecology
EPA	The United States Environmental Protection Agency.
ERU	Equivalent Residential Unit. For the purpose of sewer system consists of a projected usage of 220 gallons per day of sewage flow, and 255 gallons per day of projected water usage. Where deemed appropriate, an alternative criteria for determining ERUs may be used and based on the organic loading into the system with consideration of Biological Oxygen Demand (BOD) and/or Suspended Solids (SS).
°F	Degree(s) Fahrenheit
Forcemain	A sewer pipeline that flows full under pressure, discharging from a pump station (as opposed to an inverted siphon)

ft^2	Square foot (feet)
GMA	State of Washington Growth Management Act
gpcd	Gallons per capita per day
gpd	Gallons per day
gpm	Gallons per minute
gpd/sf	Gallons per day per square foot
GWMA	Groundwater Management Area
HCO_3	Bicarbonate
Hydrogen Sulfide	A potentially toxic and lethal gas (chemical symbol H_2S) produced in sewers and digesters by anaerobic decomposition. Detectable in low (<0.0001 percent) concentrations by its characteristic "rotten egg" odor, it deadens the sense of smell in higher concentrations or after prolonged exposure.
Industrial Wastewater	Wastewater generated predominately from industrial area, including both sanitary wastes and waste from the industrial activity
Infiltration	Groundwater that leaks into the wastewater collection system from the surrounding soil. Common points of entry include cracked and/or defective pipes and manholes located below the groundwater table, and percolating rain or irrigation water. Infiltration is divided into two categories: Groundwater-Related Infiltration (GWI) which occurs throughout the year, and Rainfall-Dependent Infiltration (Rain GWI) which occurs during and shortly after storm events.
Inflow	Rainwater that enters the collection system through roof drain connections, catch basin connections (in Combined Sewer Overflow systems), and holes in the top of manhole covers. Inflow is generally distinguished from infiltration by the rapidity with which inflow begins and ends after a period of rainfall.
Interceptor	A sewer that receives flow from a number of main or trunk sewers, force mains, etc.
Inverted Siphon	Inverted Siphon is defined as a sewer that dips below the hydraulic grade line to avoid an obstruction such as a creek, ravine or other utility.
K	Potassium
Lateral	A sewer that has no other common sewers discharging into it.
Ma	Million years ago
Main	A sewer that receives flow from one or more submains. Also referred to as a "trunk."

MCL	Maximum Contaminant Level
meq	milliequivalent(s)
Mg	magnesium
mgd	Million gallons per day
mg/L	Milligrams per liter. See also "ppm."
mg N/L	Milligram(s) of nitrogen per liter
msl	Mean sea level
Nitrification	The process of converting organic and ammonia-nitrogen into nitrate nitrogen by nitrifying autotrophic bacteria.
N	Nitrogen
Na	Sodium
Nitrogen	An essential nutrient that is often present in wastewater as ammonia, nitrate, nitrite, and organic nitrogen. The concentrations of each form and the sum, total nitrogen, are expressed as mg/l elemental nitrogen. Also present in some ground water as nitrate and in some polluted ground water in other forms.
NO_2+NO_3-N	Nitrite and Nitrate as Nitrogen
NO_3-N	Nitrate as Nitrogen
NRCS	Natural Resources Conservation Service
Peak Day Flow (PDF)	The maximum flow received over a calendar day, usually occurring during wet weather months.
Peak Design Flow/ Peak Hour Flow (PHF)	The largest estimated flow sustained over a 60-minute period in the design year of the wastewater facility.
Peak Month Flow (PMF)	The largest estimated flow rate sustained over a calendar month.
pH	A measure of the hydrogen-ion concentration in a solution, expressed as the logarithm (base ten) of the reciprocal of the hydrogen-ion concentration in gram moles per liter. On the pH scale (0-14), a value of 7 at 25^{O}C represents a neutral condition. Decreasing values, below 7, indicate increasing acidity; increasing values, above 7, indicate increasing alkalinity.
Phosphorus	An essential chemical element and nutrient for all life forms. Occurs in orthophosphate, pyrophosphate, tripolyphosphate, and organic phosphate forms. Each of these forms is expressed as mg/l elemental phosphorus.
ppd	Pounds per day.
ppm	Parts per million.

PWRF	Process Water Reuse Facility
Revised Code of Washington (RCW)	Compilation of laws passed by the State legislature.
SEPA	State Environmental Policy Act.
SO_4	Sulfate
Suspended Solids (SS)	The suspended undiluted material transported in wastewater. The quantity of suspended material removed during treatment varies with the type and degree of treatment and has an important bearing on the size of many mechanical and process units. Also referred to as "Total Suspended Solids (TSS).
TDS	Total Dissolved Solids
Total Suspended Solids (TSS)	See "Suspended Solids."
Trunk	A sewer that receives flow from one or more sewer mains. See "Main".
Volatile Suspended Solids (VSS)	The organic portion of the total suspended solids which will oxidize and be driven off as a gas at 600°C. VSS typically represents 75 to 85 percent of the TSS for digested and undigested sludge.
USGS	U.S. Geological Survey
Washington Administrative Code (WAC)	Document which consists of regulations adopted by the State to carry out the RCW.
Wastewater	Water-carried wastes from residences, businesses, institutions, and industrial establishments, together with such ground and stormwater as may be present.
Wastewater Treatment Plant (WWTP)	A water pollution control facility engineered and constructed to remove pollutants from wastewater. Also referred to as a sewage treatment plant.
WDOH	State of Washington Department of Health.
Wet Weather Flow	Wastewater flow during or following periods of moderate to heavy rainfall; in the Puget Sound area, this typically occurs during the months November through April. Infiltration and inflow may increase the wet weather flow to a rate many times greater than the dry weather flow, and unless provided for in sewerage design, can produce hydraulic overloads resulting in wastewater overflows to streets or water courses, and/or reduced level of treatment and treatment efficiencies.
Wet Well	The compartment in a pump station where wastewater flow is collected and from which the pump intakes wastewater to be discharged into a force main.

THIS PAGE IS INTENTIONALLY LEFT BLANK.

SECTION I
LAND TREATMENT

Synergy of Water and Science™

Revised Land Treatment System Engineering Report

Permit Number ST0005369

City of Pasco, Washington
October 2018 (Revised November 2019)

12720 E Nora Avenue, Suite A
Spokane Valley, Washington 99216
Ph. (509) 921-0290
Fax (509) 921-1788
cascade-earth.com

Revised Land Treatment System Engineering Report
Permit Number ST0005369
City of Pasco, Washington

Prepared For:	Mr. Robin Nelson PACE Engineers, Inc. 11255 Kirkland Way, Suite 300 Kirkland, WA 98033
Prepared By:	Cascade Earth Sciences 12720 E Nora Avenue, Suite A Spokane Valley, Washington 99216 (509) 921-0290
Author(s):	David Sullivan, CCA-NW, Staff Soil Scientist Steven Venner, CCA-NW, Managing Scientist
Reviewed By:	Daniel J. Burgard, CPSS, Principal Soil Scientist
Report Date:	October 3, 2018 (Revised November 22, 2019)
Project Number:	2017230014
Submitted By:	Steven L. Venner, CCA-NW, Managing Scientist

Disclaimer: The contents of this document are confidential to the intended recipient at the location to which it is addressed. The contents may not be changed, edited, and/or deleted. The information contained in this document is only valid on the date indicated on the original project file report retained by CES. By accepting this document, you understand that neither CES nor its parent company, Valmont Industries, Inc. (Valmont) accepts any responsibility for liability resulting from unauthorized changes, edits, and/or deletions to the information in this document.

1.0 INTRODUCTION AND PURPOSE

The City of Pasco (City) treats and reuses process wastewater (process water) from a variety of vegetable processing facilities (Food Processors) by irrigation to agricultural crops in a City-owned land treatment system (Site). The Site is operated within the terms of State Waste Discharge Permit Number ST0005369 (Permit), effective July 1, 2015.

Permit Special Condition S9 requires the submittal of an approvable update to the 1990 Hickerson-Jacobs Engineering Report in accordance with Washington Administrative Code (WAC) Chapter 173-240. Permit Special Condition S9 includes specific items to address in addition to those required by WAC 173-240-130.

The specific items in Special Condition S9 include:

a. *The determination of the design limiting parameter for the sprayfield site.*
b. *All appropriate requirements as described in "Guidelines for Preparation of Engineering Reports for Industrial Wastewater Land Application Systems"* (Guidelines; (Ecology, 1993)).
    i. *Updated design criteria*
c. *The design treatment capacity of the site.*
d. *A water balance such that the leaching fraction is less than or equal to the leaching requirement.*
e. *The organic loading (soluble BOD; lbs/acre/day) that will not cause anaerobic or reducing conditions in the vadose zone.*
f. *An updated 1992 Land Management Plan*
g. *A "Salt Management Plan" that describes how the City will operate the system to comply with the groundwater enforcement limit for TDS; 631 mg/L.*
h. *The AKART that will be used to continuously comply with the pH enforcement limits.*

As defined by the Guidelines, "Land application means the use of irrigation methods for the distribution of material(s) upon the land surface for the purpose of pollutant removal, assimilation, and/or utilization. Land application systems utilize soil, microorganisms, and vegetation as an integral treatment component to remove potential pollutants from the applied wastewater."

The purpose of this Engineering Report Update is to provide Ecology with information on the proper design, operation, and performance of the treatment systems to maintain the highest quality of the state's groundwater and protect existing and future beneficial uses. This report describes the following elements:

- treatment systems and solids handling;
- considerations of water flow, quantity, quality, and constituent mass loadings;
- land treatment considerations of use, climate, soils, geology, and hydrogeology; and

- land treatment site management of the process water, cropping, constituent and hydraulic capacities, leaching requirement to control soil salinity, and irrigation system management.

2.0 FACILITY DESCRIPTION

This section summarizes the Food Processors that discharge their process water to the City Process Water Reuse Facility (PWRF), water source, process water treatment flow and storage, Permit limits, stormwater management, and solids handling. No domestic sanitary wastewater is discharged to the PWRF.

2.1 Food Processors

There currently are five Food Processors discharging process water to the PWRF (Figure 1). More could be added in the future dependent on availability of capacity at the PWRF. The Pasco Processing Center located north of the City and along U.S. Highway 395 has three Food Processors. The current Food Processors at the Pasco Processing Center are Reser's Fine Foods, Pasco Processing, and Twin City Foods. Freeze Pack and Simplot RDO (previously CRF Frozen Foods), located on the eastern boundary of the City along U.S. Highway 12 combine their process water to discharge through Simplot RDO to the PWRF.

The City anticipates the potential for several other processors to discharge process water to the PWRF in the near future including Grimmway Enterprises and potentially Lamb Weston. It plans to provide capacity for additional processors with year-round flow rates in the range of 3.2 million gallons per day (MGD). The City plans to phase in new Food Processors and additional treatment capacity at the PWRF.

2.2 Land Treatment Site

The Site consists of 1,856 acres of center-pivot irrigated agricultural crops (circles) located about five miles northeast of the City (Figures 1 and 3). Crops typically include alfalfa, potato, wheat, and grain corn in 14 fields (Circles 1 – 13 and 15). Little Circles 2 and Circle 7 (Figures 1-3) are part of Circles 2 and 7, respectively. Process water and/or freshwater flow to Little Circles 2 and 7 is possible only as part of the flow to Circles 2 and 7, respectively; flow monitoring to each of the large circles includes the flow to their respective little circle. All aspects of operation and management (e.g., irrigation, tillage, planting, harvesting, etc.) are identical on the respective circles. All reporting related to Circles 2 and 7 includes their respective Little Circle. During the irrigation period, March through November, the process water is land applied to the circles for final treatment. The process water is conveyed from the sedimentation basin and storage ponds into the Irrigation Pump Station (IPS) and pumped to the circles for crop irrigation.

2.3 Fresh Water

Supplemental fresh well water is provided from groundwater wells on the Site to meet the irrigation needs (crop water requirements) of the crops. Fresh water can be blended with process water at each circle or applied independently depending on the requirements of the irrigation operator.

2.4 Process Water

The process water is conveyed from the Food Processors to the PWRF via underground pipelines. The process water from Reser's Fine Foods, Twin City Foods, and Pasco Processing flows via gravity to a lift station from which it is then pumped approximately 2.5 miles to the PWRF (Figure 1). The process water from Simplot RDO and Freeze Pack is pumped approximately 5 miles to the PWRF.

2.4.1 Treatment and Storage

The process water flows are combined at the PWRF headworks, pretreated by two, internally fed rotary drum screens for liquid-solid separation and discharged into a sedimentation basin before being land applied or stored. Three lined storage ponds with a total capacity of 158 million gallons (MG) are used to store the process water during the non-irrigation period (December through February). A flow diagram for the existing process water system is presented in Figure 2.

2.4.2 Flow Measurement

Flow meters are used to monitor incoming and outgoing process water flow, process water load by circle, and supplemental fresh well water load by circle. The total incoming flow from the Food Processors is monitored before discharge into the screens, while the total outgoing flow to the circles is monitored at the discharge from the IPS. In addition, each circle is equipped with two flow meters to independently measure the process water and supplemental fresh well water loads to each circle. The circle-specific flows are used with process water and supplemental fresh well water constituent concentrations, respectively, to determine circle-specific constituent loads and water balances.

2.5 Permit Limits

The Permit limits the PWRF as follows:

- Apply process water to the Site via spray irrigation not to exceed the agronomic rates for nitrogen and water, and at rates for any other process water constituents to protect background water quality.
- Apply process water seasonally from March 1 through November 31.
- Total nitrogen and water applied to the Site must not exceed the crop requirements as determined by the annual Farm Operations Report.
- Do not exceed the facility loading specified in Special Condition S8 including:
    - Maximum month average flow of 10.6 MGD
    - Total annual flow of 1,003.4 MG
    - Maximum monthly five-day biochemical oxygen demand (BOD_5) load of 355,600 pounds (lb)
    - Total annual nitrogen load of 866,246 lb

2.6 Domestic Wastewater

Domestic wastewater produced at the PWRF is discharged to a septic system and leach field for final treatment and disposal.

2.7 Stormwater

Stormwater discharge from the PWRF infiltrates into the surrounding ground surface or is directed into the PWRF treatment system. A Stormwater Pollution Prevention Plan is located on file at the PWRF.

2.8 Solids Handling

There are two solids separation processes at the PWRF: the rotating drum screens and the sedimentation basin. The screened solids discharged from the internally-fed, rotating drum screens are continuously collected with an auger flight system that transfers the screened solids to a screw press for dewatering. These dewatered, screened solids are hauled offsite for livestock feed or taken to a landfill. The water from the screw press is directed back into the PWRF pretreatment or storage system.

The solids collected by the sedimentation basin are currently transferred to a 5 MG, lined holding pond for temporary storage while the City develops a solid waste management plan for approval by local and state agencies.

Domestic solid wastes from the PWRF office and other non-processing trash solids are disposed in solid waste containers and hauled to the local landfill.

3.0 SITE AND USE CONSIDERATIONS

The Site is located approximately five miles north of the City, one mile east of U.S. Highway 395, and north of East Foster Wells Road (Figures 1 and 2) and includes:

- Sections 3, 11, and 2 (N ½ and SW ¼), Township 9 North, Range 30 East of the Willamette Meridian
- Section 34 (S ½), Township 10 North, Range 30 East of the Willamette Meridian

All acreage is owned and operated by the City.

3.1 Historical Land Use, Land Ownership, and Neighboring Land Uses

The PWRF headworks is located a short distance west of the Site (Figure 1). U.S. Highway 395 is approximately 2 miles west and the City is approximately 2 miles to the southwest (Figure 2). Land use in the area ranges from irrigated agriculture to urban development approximately 2 miles away. The area immediately surrounding the Site is agricultural land and farm residences. A confined animal feeding operation (CAFO) is located approximately 0.3 miles from the northwestern corner (Circle 13) of the land treatment fields (Figure 3). The Snake River is approximately 3 miles south and the Columbia River is approximately 5 miles southwest.

3.2 Climate

Climate conditions including precipitation and crop evapotranspiration (ET) are important considerations of a land treatment system. Precipitation and ET rates are used in the circle-specific hydraulic budgets.

The Site is located in south central Washington State about 20 miles north of the Oregon border. The Pasco area is within the rain shadow of the Cascade Mountains. The climate consists of a relatively cool, moist fall and winter, with a relatively hot, dry spring and summer. The average monthly and annual precipitation is shown in Table 1 for the Washington State University AgWeatherNet CPC Pasco weather station, which is located about 5 miles west of the Site at an elevation of 404 feet above mean sea level (ft msl). The elevation of the Site is slightly higher at about 500 ft msl. The long-term (1997-2017) average precipitation is 5.8 inches. The 10-year return frequency high precipitation (highest precipitation expected every 10 years) is 8.3 inches, which is derived from the second highest precipitation year in the last 20 years of recorded data (Table 1, Appendix A).

3.3 Topography and Surface Hydrology

The Site is located in an area that is nearly level to gently sloping to the east. The elevation of the Site is in the range of 450 to 550 ft msl and generally slopes to the east and southeast. The majority of the topography of the Site can be characterized as nearly level. The northern and western parts of the Site would drain south and east toward the central and eastern circles. Drainage to the east is blocked by Piekaraski Road and Circle 1 would drain to the southeast toward Lower Smith Canyon.

3.4 Soil Characterization

The Site is included in the Soil Survey of Franklin County, Washington (USDA/SCS, 2006) and the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) Web Soil Survey (NRCS, 2018)[1]. The soils of the Site were also characterized by direct observation during a field evaluation in November 2017.

A CES soil scientist observed, described, and sampled the soils at the Site. The purpose of the soil characterization was to understand the extent of the soils and to quantify their properties, especially those relevant to the capacity of the Site for process water. Field work commenced with a reconnaissance across the Site to identify areas with soil that were expected to be the major soil types compared to the soil survey mapping. Soil pits were excavated in locations specifically selected to observe the soil profiles for comparison to the available soil survey information and to collect soil samples. The physical and chemical properties of the soil samples were determined through laboratory analysis. The field observations and laboratory analysis results generally confirm that the published soil survey information is accurate. Therefore, the soil survey information can be used to determine the extent of the soil types across each circle and calculate their estimated soil water capacity.

The soils predominantly consist of mixed eolian sands, with minor portions of underlying glaciofluvial deposits. Additional soils consisting of sandy alluvium and loess over layered

[1] https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

lacustrine deposits make up approximately 10% of the remaining soils. The soil textures across the Site are predominantly loamy fine sand or sandy loam surface soils underlain by fine sand or loamy fine sand. Table 2 and Figure 4 present the nine-soil map units identified across the Site and their extent/proportion on each circle. The Web Soil Survey results are presented in Appendix B.
The soil units and key characteristics are summarized here.

- **Soil Map Unit 29** - Hezel loamy fine sand, 0 to 15% slopes (approximately 6.3% of the irrigated area). Hezel soils consist of very deep, somewhat excessively drained, typically consisting of soils with a loamy find sand surface over fine sandy loam subsoil. Hezel soils occur on dissected terraces and terrace escarpments. This soil is limited to the central and northeast part of Circle 1, a portion of the north half of Little Circle 2, and is the predominant soil of Circle 12.
- **Soil Map Unit 89** - Quincy loamy fine sand, 0 to 15% slopes (approximately 60.9% of the irrigated area). Quincy soils consist of very deep, excessively drained soils formed in sands on dunes and terraces. Quincy soils occur on uplands, fan piedmonts and terraces, some having a ridged, hummocky, or dune micro-relief. This is the predominant soil of Circles 3, 4, 6, 8, 9, 10, 11, 13, and 15. Quincy soils are also located in the southeastern part of Circle 1, northeastern part of Circle 2, portions of Little Circle 2, southern part of Circle 5, western part of Circle 7, and northern part of Circle 12.
- **Soil Map Unit 92** - Quincy loamy fine sand, loamy substratum, 0 to 10% slopes (approximately 5.1% of the irrigated area). Quincy soils are excessively drained and occur on dunes and terraces. This soil consists of approximately 85% Quincy and similar soils with 15% contrasting inclusions of very fine sandy loam in the upper 52 inches and calcareous soils throughout the profile. These soils occur in the southeast half of Little Circle 2, the northwestern part of Circle 6, northeastern part of Circle 7 and all of Little Circle 7, western and southeastern parts of Circle 8, and northeast part of Circle 13.
- **Soil Map Unit 97** – Quincy-Hezel complex, 0 to 15% slopes (approximately 12.3% of the irrigated area). This complex consists of approximately 50% Quincy and similar soils, 25% Hezel and similar soils, and 25% contrasting inclusions. The Quincy-Hezel complex is somewhat excessively to excessively drained and occur on convex areas of dunes and terraces (Quincy soils) as well as concave areas of terraces (Hezel soils). The Quincy-Hezel complex occur in the central parts of Circle 11, northern and southern parts of Circle 15, eastern part of Circle 1, western part of Circle 2, northeastern and southern parts of Circle 4, and the majority of Circle 5.
- **Soil Map Unit 126** - Royal loamy fine sand, 0 to 10% slopes (approximately 0.1% of the irrigated area). This soil consists of approximately 85% Royal and similar soils with 15% contrasting inclusions of Sagehill soils. Royal soils are well drained and occur on terraces. This soil is located in the northeastern part of Circle 11.
- **Soil Map Unit 128** - Royal loamy fine sand, 0 to 2% slopes (approximately 4.3% of the irrigated area). Royal soils are well drained with a fine sandy loam surface over very fine sandy loam subsoil and occur on terraces. This soil is located in the western part of Circle 6, western and southern parts of Circle 8, northeastern part of Circle 10, and is the predominant soil of Circle 7.

- **Soil Map Unit 144** – Sagemoor very fine sandy loam, 0 to 2% slopes (approximately 6.5% of the irrigated area). Sagemoor soils are very deep, well-drained soils on gently sloping to steeply dissected terraces. This soil is located in the northwestern part of Circle 1, northeastern part of Circle 3, eastern part of Circle 12, central part of Circle 15, and is the predominate soil in Circle 2.
- **Soil Map Unit 145** - Sagemoor very fine sandy loam, 2 to 5% slopes (approximately 3.8% of the irrigated area). Sagemoor soils are very deep, well-drained soils occurring on gently sloping to steeply dissected terraces. These soils have a very fine sandy loam surface over silt loam subsoil. This soil is located in the southern part of Circle 1, northeastern part of Circle 2, northern and eastern parts of Circle 3, south and central part parts of Circle 5, northeastern part of Circle 12, and central part of Circle 15.
- **Soil Map Unit 146** - Sagemoor very fine sandy loam, 5 to 10% slopes (approximately 0.7% of the irrigated area). Sagemoor soils are very deep, well-drained soils occurring on gently sloping to steeply dissected terraces. These soils have a very fine sandy loam surface over silt loam subsoil. This soil is limited the southeastern part of Circle 12.

The majority of the Site (66.0%) is mapped in the Web Soil Survey as Quincy Loamy Fine Sand (soil map units 89 and 92, combined), followed by Quincy-Hezel complex (12.3%, soil map unit 97), and Sagemoor very fine sandy loam (11%, soil map units 144, 145, and 146). All soils at the Site are deep (> 60 inches), well drained, and suited to a wide variety of commercial crops, if irrigated, including, for example, grass (for seed, pasture, or hay), alfalfa, wheat, potatoes, and corn.

3.4.1 Water Holding Capacity

Total soil water holding capacity (field capacity) is the water content of the soil after the drainage of excess water, by gravity, has ceased. In other words, field capacity is the amount of water the soil can hold. Available soil water holding capacity is the amount of water available to plants between field capacity and the permanent wilting point. At permanent wilting point, remaining water in the soil is held too tightly to be available to most plants.

The field capacity of a 60-inch deep soil profile is shown for each soil map unit in Table 2. Field capacity ranges from 6.3 inches (soil map unit 89) to 15.1 inches soil (map units 144, 145, and 146). Available water content ranges from 4.9 inches (soil map unit 89) to 11.5 inches (soil map units 144, 145, and 146). These soil water holding capacity values will be used as the basis to compute circle-specific soil water hydraulic budgets. The acreage of each soil type within each circle, as measured using the Web Soil Survey, was used in conjunction with the soil water holding capacity values published in the web soil survey to estimate the average soil profile water capacity characteristics for each circle (Table 3).

Average field capacity ranges from 6.3 to 12.0 inches (Table 3). These values will be used in the soil water hydraulic budgets to help determine the hydraulic capacity of the Site for precipitation, process water, and supplemental fresh well water irrigation.

3.4.2 Expected Infiltration Rates and Permeability

The soil map units found at the Site are described as being well drained to excessively drained. The saturated hydraulic conductivity of the most limiting soil horizon for each soil map unit (surface) ranges from moderately high to very high (0.2 to 20 inches per hour), Soil Survey, (USDA/SCS, 2006), and is not a design limiting parameter. The risk of erosion by water is low.

3.4.3 Soil Fertility

Soil fertility is important in maintaining soil and crop growth conditions favorable for land treatment system use and uptake (treatment) of the process water hydraulic and nutrient loadings. The information presented is based on the soil conditions in 2016 and summarized from the discussion reported in the 2017 Farm Operations Report (CES, 2017). The soil analysis results for fall 2016 are presented in Table 4.

The Oregon State University Extension Service has published a Soil Test Interpretation Guide (Horneck, 2011) that provides a consistent reference for evaluating soil test results and guiding general fertility recommendations in Oregon and Washington. This document was used to evaluate the soil test results presented in the following paragraphs.

Soil pH is important to soil nutrient availability and crop growth. Soil pH during the fall of 2016 ranged from 7.1 to 7.8 in the surface one-foot of soil. Soils at the Site have pH values that are in an acceptable range. A pH of 8.5 or more would be considered strongly alkaline and likely reduce soil nutrient availability and crop growth. Soil pH should continue to be monitored at the Site to identify any significant trends in pH that indicate the need for operations adjustment.

The exchangeable sodium percentages (ESP) in the fall of 2016 ranged from 1.2 to 4.0%. When ESP values are greater than 15%, water infiltration in the soil is likely to decrease substantially, although this threshold value will vary for different soil types and is dependent on other soil properties such as saturation paste extract electrical conductivity (ECe) and soil texture (clay content). Since these values are below 15% and the soil clay content is low, soil ESP is not a limiting concern for water infiltration and drainage at the Site.

Soil organic matter (OM) is important in soil chemical reactions and soil-water relations. Maintaining or increasing soil OM is beneficial in sandy soils, such as those found at the Site. Soil OM in the surface one-foot of soil across the Site ranged from 0.9 to 1.7% and averaged 1.2% in the fall of 2016. The OM levels at the Site increased slightly compared to fall 2011, which ranged from 0.7 to 1.6% and averaged 1.1% (CES, 2012). This slight change over several years suggests that the soil OM levels are likely to remain relatively stable, being maintained by the inclusion of perennial and annual forage crops (alfalfa and grasses) within the overall crop rotation.

Test results indicate that some available soil nitrogen is present for crop growth on all circles. The available soil nitrogen (ammonium-nitrogen plus nitrate-nitrogen) ranged from 8.5 to 43.9 milligrams per kilogram (mg/kg) in the surface one-foot of soil. The other primary plant nutrients (phosphorus and potassium) appear to be at levels that do not require addition from commercial fertilizers. Of the secondary nutrients, magnesium concentrations are considered high, sulfate-sulfur concentrations are medium, and calcium concentrations are considered high.

Soluble salts (electrical conductivity, EC) in the surface one-foot of soil are within acceptable levels. The EC in the surface one-foot during the fall of 2016 ranged from 0.2 to 0.6 millimhos per centimeter (mmhos/cm) across the Site. The soil EC levels are not a limiting factor for process water irrigation at this Site, but should continue to be monitored.

3.4.4 Long Term Soil Constituent Trends

Charts 1 through 14 present historical trend plots for soil NO_3-N, EC, and ESP at each one foot of soil depth in each circle. Because Circles 11, 12, 13, and 15 were added in 2007, there is no data available prior to 2007. The EC data for Circles 1 through 10 prior to October 2003 is not available.

A review of the charts suggests that soil NO_3-N has fluctuated year to year as expected, and no increasing trend is present for any of the fields. The top foot of soil in field 1 has increased in the last three sampling events, but is non-problematic as it is immediately available for crop root zone uptake. The long term trends for EC and ESP were stable to decreasing in all fields with some year to year fluctuation as expected. ESP remains below 5% for all fields in the most recent sampling event.

3.4.5 Conclusions and Recommendations

According to this soil characterization analysis, the soils at the Site are suitable for receiving the process water for land treatment purposes. Irrigation management practices, including soil moisture monitoring and irrigation scheduling, are important considerations for these soils with relatively low water holding capacities across the Site. Irrigation amount (depth of water applied per pass or per set) should be managed to supply enough irrigation to meet the crop water use requirements, avoid runoff, and limit deep percolation to the estimated leaching requirement to maintain soluble salts at acceptable levels in the roots zone.

3.5 Site Performance and Potential Impact on Groundwater

A Hydrogeologic Assessment Report was prepared to support this Engineering Report for the land treatment system design and operations as it relates to protecting groundwater quality (CH2M, 2018). The Hydrogeologic Assessment Report addresses the site geology, hydrogeologic characterization, quality of groundwater flowing under the Site, and potential impacts on groundwater under the Site from areas outside of the Site. This section provides a brief summary of the land treatment system performance as it relates to potential impacts to groundwater under the Site and includes supporting information from the Hydrogeologic Assessment Report. The site geology and hydrogeologic characterization information required by the Guidelines (Ecology, 1993) is, therefore, not included in this Engineering Report, but is presented in the Hydrogeologic Assessment Report.

3.5.1 Land Treatment System Performance

The following nitrogen and hydraulic information is provided as an example of the land treatment system performance and its potential to negatively affect groundwater quality. Crop nitrogen uptake has historically been greater than the process water nitrogen applied. Specifically, in recent years (2012, 2013, 2014, 2015, and 2017), the acreage-weighted average nitrogen removal across the Site has averaged 104 pounds of nitrogen per acre (lb N/ac) greater than the amount of process water applied ((CES, 2013); (CES, 2014); (CES, 2015); (CES, 2016); and (CES, 2018)[2]).

The process water and supplemental fresh well water have been managed properly. The process water contains common inorganic ions (salts) that must be leached through the upper part of the soil profile as a standard agronomic practice to maintain crop productivity. The ratio of the amount of excess water draining through the soil (percolation) to gross water applied is called the leaching fraction. The leaching requirement is the calculated leaching fraction required to remove soluble salts from the root zone and maintain favorable soil salinity levels. For example, in recent years, the estimated leaching fraction was less than the leaching requirement on all circles except two (CES, 2018). For Circle 6 and Circle 12, their respective estimated leaching fractions (10.2% and 11.9%) exceeded their respective leaching requirements (8.3% and 7.6%). The leaching requirements at this Site typically range from about 8% to 12%.

This information suggests that the nitrogen and hydraulic loadings typically do not exceed the agronomic capacity of the soils and crops at the Site. It appears unlikely that present process water application and management would negatively affect groundwater quality beyond necessary salts leaching. This is supported by the findings in the Hydrogeologic Assessment Report, which suggests that groundwater nitrate and total dissolved solids (TDS) concentrations observed on the Site are more likely associated with groundwater flow into the Site area and not percolation due to widespread surface application across the Site.

4.0 LAND TREATMENT SYSTEM MANAGEMENT

Irrigation of agricultural land with process water conserves water and plant nutrients. The success of a process water land treatment system depends on the process water hydraulic and constituent loads, cropping, climate conditions, and management. Cropping, soils, and climate determine the nutrient and hydraulic capacities of the Site. The crop rotation tolerance to salinity influences the leaching requirement.

This section presents:

- historical loading and cropping information
- agronomic constituent and hydraulic capacities
- constituent management
- irrigation management of the Site

4.1 Historical Loads

This section discusses the historical water quality and loads of process water and supplemental fresh well water irrigation. Irrigation of process water and/or supplemental fresh well water is practiced during March through November. Irrigation is not practiced during December, January, or February.

[2] Nitrogen balance information for 2016 (CES, 2017) has been omitted because of flow meter malfunction during the 2016 irrigation season made loading calculations invalid.

4.1.1 Process Water Quantity

Process water hydraulic loads to the Site are presented in Table 5 for 2013, 2014, 2015, and 2017 ((CES, 2014); (CES, 2015); (CES, 2016); (CES, 2018)[3]). The annual irrigated volumes ranged from 622.0 MG in 2017 to 757.6 MG in 2015 and averaged 690.6 MG during the four operational years (Table 5). The operational year covers data from November of the previous year through October of the subsequent year. The monthly, irrigated process water flow will vary depending on Site-specific conditions and available process water flows. The average monthly irrigation values are important in consideration of the hydraulic loads for land treatment management projections. The average monthly process water irrigation ranged from 40.5 MG in November to 113.2 MG in September.

4.1.2 Process Water Quality

The process water is monitored for the following water quality parameters during each month when irrigation occurs:

- pH
- electrical conductivity (EC)
- total nitrogen (Total N) and total Kjeldahl nitrogen (TKN)
- BOD_5
- fixed dissolved solids (FDS)
- sodium, calcium, magnesium, potassium, sulfate, chloride, bicarbonate
- total phosphorous (Total P)
- sodium adsorption ratio (SAR)

Table 6 presents the results for each constituent across four irrigation seasons (March through November).

4.1.3 Sodium Adsorption Ratio

The SAR must be considered for land treatment. Too much sodium in a soil can cause the soil particles to disperse, sealing the surface of the soil, and limiting the ability of water to penetrate into the soil resulting in runoff and poor crop growth. The average SAR (computed from the calcium, magnesium, and sodium concentrations) was calculated to be 1.4, based on constituent concentrations presented in Table 6. If SAR is less than 6, there should be no problem with soil sealing (Canessa and Hermanson, 1994). This is especially true of the soil at the Site with very little clay. As such, the SAR of the process water should not limit process water application at the Site.

[3] The hydraulic loads for 2016 (CES, 2017) have been omitted from this report because of flow meter malfunction during the 2016 irrigation season made load calculations invalid.

4.1.4 pH

The process water pH must be considered for land treatment. A pH range of 3 to 11 has been applied successfully to land treatment systems (EPA, 2006). Irrigated process water quality at the Site has been at the low end of this range. Irrigated process water pH has ranged from 3.3 to 5.8 and averaged 4.3 (Table 6). The low pH of the process water is caused by the presence of organic acids. However, the supplemental fresh water has been blended at the circles, as needed, resulting in an assumed increase of irrigated water pH. In addition, the land treatment chemical reactions will have a neutralizing effect, as the organic acids are oxidized or degraded. If additional pH adjustment is required to maintain crop productivity, an alkaline solution may be used to further neutralize the process water pH.

4.1.5 Process Water Constituent Mass Loads

Table 7 presents the average annual process water mass loads based on the average quality results (Table 6) and an average annual total process water irrigation of 690.6 MG (Table 5).

4.1.6 Supplemental Fresh Well Water Quality

Supplemental fresh well water is provided to help meet the crop water requirements of crops at the Site. It is important to account for the supplemental fresh well water quality in land treatment system management. There are 11 supplemental fresh well water supply wells that supply fresh well water to specific circles (Table 8). Each year, more than 1,000 MG (not shown) of supplemental fresh well water is typically applied to the Site to meet the crop water demand not met by the process water. Supplemental fresh well water quality is as follows:

- TDS ranges from 317 mg/L (IW-1) to 678 mg/L (IW-12), with an average of 543 mg/L.
- Nitrate-nitrogen ranges from 10.1 mg/L (IW-5) to 31.6 mg/L (IW-7), with an average of 20.2 mg/L.
- EC averages 848 micromhos per centimeter (µmhos/cm) across all wells in 2017 (CES, 2018). EC was estimated using the following formula (US Salinity Lab Staff, 1954): EC (µmhos/cm) = TDS (mg/L) ÷ 0.64.

4.2 Cropping

Crop management plays a critical role in using process water on farmland. Beneficial use of process water nutrients is achieved by harvest and removal of plant material. Higher crop yields increase Site capacity for process water loads. The crops chosen for the Site must grow well in the local area and under the process water and soil conditions at the Site. Perennial crops such as alfalfa have been successfully grown at the Site. Perennial crops consume water and nutrients throughout the extent of the growing season, from early spring to late fall, which coincides with early and late season process water application as needed.

The perennial crops may be maintained in place for several years until productivity begins to decline. They are re-established after rotation to another crop for one or more crop growing seasons. Rotation to another crop before re-establishment is an agronomic best management practice. As a system best management practice, an established crop or cover crop should be maintained on all circles in the fall to take up nutrients and increase ET. Maintaining a crop or cover crop helps to remove nitrogen that may be available in the soil profile ahead of the winter precipitation period. This practice limits the potential for migration of nitrogen beyond the root zone during winter precipitation events. The established crops also provide soil protection against wind and water erosion during winter and early spring.

4.2.1 Crop Rotation

Table 9 presents the circles, acres, and crops grown at the Site during 2013 through 2017((CES, 2014); (CES, 2015); (CES, 2016); (CES, 2017); and (CES, 2018)), as well as the design basis limiting crop rotation used to calculate the Site hydraulic, nitrogen, and BOD capacities in section 4.3. The design basis rotation represents the minimum nitrogen capacity of any planned future crop mix at the Site.

The typical rotation has been to maintain alfalfa in a majority of the circles, grow potatoes in three circles, and double-crop three other circles. Double-cropping examples include triticale followed by corn or one cutting of alfalfa followed by corn. Lower nutrient removal rates may be expected during rotation periods compared to when a perennial crop is fully established and maintained. Keeping a majority of the fields in a perennial crop maintains nitrogen capacity. Established cover crops help maintain hydraulic capacity during late fall and winter months.

For example in 2015, the potato crop in Circle 2 was harvested in September and the circle was planted to alfalfa, which is shown as potato/alfalfa in Table 9. The potato crop consumed water and nutrients until September, while the alfalfa did so through the remainder of the season. The alfalfa has since been maintained. In 2013, the triticale in Circle 10 was harvested in May and the circle was planted to corn, which is shown as triticale/corn in Table 9. The triticale consumed water and nutrients through May, while the corn did so through late September when it was harvested. In this case, the circle remained in corn residue (stalks and leaves) after harvest and was planted to potato the following spring. The corn residues controlled wind erosion but the nitrogen capacity was limited the following spring because process water is not applied to potato.

4.2.2 Planting, Cultivation, Harvest, and Crop Nitrogen Capacity

Example planting and harvest months, yields, crop nitrogen removal, and crop nitrogen capacity by crop type are included in Table 10. The expected yields and crop nitrogen capacities are based on actual Site data from the operational years of 2013-2017.

Crops will be planted using accepted agronomic seeding rates and methods, and those circles with established crops (alfalfa, for example) will not require planting until they are rotated, as discussed above. Where two or more crops are listed for one circle, the second crop will be planted following harvest of the first crop and after any necessary cultivation for seedbed preparation.

Alfalfa will be harvested for hay (cut, cured, baled, or possibly green-chopped for haylage). Any other crops that may be grown at the Site will be harvested according to local and industry standard means. Harvest periods for each circle will be coordinated to improve crop removal management flexibility, but managed to allow process water application at all times in consideration of individual circle harvest schedules. The actual schedule will vary depending on weather and crop growth.

Crop nitrogen capacity shown in Table 10 is historical average crop nitrogen removal increased to account for volatilization and denitrification losses of nitrogen. Process water nitrogen availability has been estimated to be 86% based on recommendations in (Meisinger and Randall, 1991) using the average process water concentrations in Table 6.

Available Process Water Nitrogen = [((TKN - ammonia-nitrogen) + (ammonia-nitrogen x 0.80) + (nitrate-nitrogen)) * 0.96] ÷ (TKN + nitrate-nitrogen).

4.2.3 Fertilizer, Herbicide, and Pesticides Application

Commercial fertilizer will be applied, as needed, for the specific circle and crop to maintain healthy, viable land treatment system crops for maximum nutrient uptake under process water treatment conditions. The term viable may be defined as capable of living, developing, or germinating under maximum favorable conditions. Process water nitrogen availability will be considered in any decision to apply fertilizer. Fertilizer application will be according to soil test results, tissue test results, and recommended nutrient levels from state and local extension service and consultants. Nitrogen may be applied at recommended starter rates for legume crops (i.e., alfalfa). Once established, nitrogen fertilizer will not be required because legume crops are able to harness their own nitrogen in addition to utilizing the nitrogen supplied by the process water. Nitrogen may also be applied to non-legume crops (e.g., corn) if a deficiency is identified between the recommended amount and the amount that will be applied in the process water.

Pesticides, including herbicides, insecticides, and fungicides, will be used, as necessary, under the advice of a professional crop consultant. Herbicides for weed control are planned for use. Insecticides or fungicides will be used only if needed to treat specific problems. Herbicides are generally applied to alfalfa at the end of February and in mid-March. Actual herbicide use will vary depending on the weed problem, crop, time of year, and product availability from year to year. Aerial application or ground sprayer can apply pesticides with dependence on time, weather, soil wetness, price, suitability, and availability. All pesticides will be used and applied according to product labels.

4.3 Design Basis Capacity

The capacity of a land treatment site for nutrient and hydraulic loading is an important consideration for good management and design of a system that is protective of groundwater. Proper design and good management of process water application and nutrients encompasses the requirements of all known, available, and reasonable methods of prevention, control, and treatment (AKART) farming for land treatment. The term agronomic capacity is defined in the Implementation Guidance for the Ground Water Quality Standards (Ecology, 2005) as the “rate at which a viable crop can be maintained and there is minimal leaching of chemical downwards below the root zone. Crops should be managed for maximum nutrient uptake when used for wastewater treatment.” Therefore, agronomic rates can be used in combination with the design basis crop rotation to establish the design basis capacity of the land treatment site for both irrigation and nutrients.

The purpose of this section is to define the nutrient and hydraulic load capacities of the Site and evaluate the nutrient and hydraulic balances. This section also defines the capacities of other important parameters for land treatment design. The design basis for the land treatment capacity defined in this Engineering Report is the most limiting projected crop rotation presented in Table 9. The design basis crop rotation (Table 9) will be used to determine the minimum nutrient and hydraulic capacities of the Site. The design basis crop rotation has the minimum number of acres that would be in perennial and high yielding crops such as alfalfa, alfalfa/corn, and triticale/corn, and more acres of other crops (i.e., potato), which use the least amount of process water nitrogen. It will represent the lower limit of crop nitrogen removal from the Site in future operational years. As the perennial and high yield crop acreage changes, hydraulic and nutrient capacities also change at the Site and may be greater than the limiting rotation in some years.

The agronomic capacities, within which the Site must be managed by the City, will be established and reported each year in the annual Farm Operations Report, as required by the Permit. The Permit states that the total nitrogen and water applied to the Site must not exceed the crop requirements as determined by the Farm Operations Report. The design basis capacity defined in this Engineering Report can be considered the potential minimum agronomic capacity for the Site.

4.3.1 Hydraulic Capacity

The hydraulic capacity of the Site depends on the crop water needs (ET), precipitation, soil water holding capacity, leaching requirements, and nitrogen capacity. Soil hydraulic budgets were developed to determine the hydraulic capacity of the Site using these variables (Appendix C).

It is important to keep in mind that the capacity for process water and fresh water is dependent on the crop nitrogen capacity. The soil hydraulic budgets were constructed as examples using the design basis (limiting) crop rotation (Table 9) to demonstrate the minimum potential nitrogen capacity rotational year. Total process water and freshwater nitrogen loads to each circle cannot exceed the crop nitrogen capacity.

The budgets take into account the normalized 10-year return precipitation and ET (Table 1) and total water content at field capacity (Table 3). They were constructed with the initial soil water content of 90% of field capacity. Budgets were based on higher than expected (conservative) estimate of moisture stored in the soil and were prepared with example, maximum process water and supplemental fresh well water irrigation loads that result in estimated percolate loss (leaching fraction) at or less than the salts leaching requirement. The gross irrigation inputs into the soil hydraulic budgets illustrate an example of the potential hydraulic capacity of the Site, and thus, the agronomic capacity of the Site.

A leaching requirement was determined based on the average EC of the process water and supplemental fresh well water with the desired equilibrium soil salinity of 2 mmhos/cm. The process water has an EC of 1,099 µmhos/cm and the supplemental fresh well water has an EC that ranges from 584 to 878 µmhos/cm (Tables 6 and 8, respectively). The calculated leaching requirement for the combined process water and supplemental fresh well water averages 9.0% of the average hydraulic load to the Site (Table 11 and Appendix C). Additional supplemental fresh well water loading may be scheduled during the late fall or early months of the season to achieve a leaching fraction equivalent to the leaching requirement (Table 11 and Appendix C). The actual practice of irrigating extra supplemental fresh well water for leaching will depend on the need to decrease soil salts if indicated by the annual soil test results.

The leaching fractions shown in Table 11 are less than the leaching requirements for all circles. On circles where the leaching fraction is less than the leaching requirement, scheduling additional irrigation of either process water or fresh water to achieve the leaching requirement would result in the nitrogen load exceeding the nitrogen capacity. In other words, in this example, the maximum possible process water and fresh water have been scheduled across the circles without exceeding the nitrogen capacity.

The sum of the gross process water and supplemental fresh well water inputs represent the total irrigation capacity of the Site since they were balanced with the precipitation, ET, soil water holding capacity, leaching fractions, and nitrogen capacity. Monthly total process water loads were scheduled based on historical monthly loads and increased until the maximum capacity was achieved without excess leaching. Process water irrigation was not scheduled during the storage season of December, January, and February.

Table 11 presents a summary of the annual totals from the soil hydraulic budgets for each circle including precipitation, gross process water and supplemental fresh well water irrigation, ET, and leaching. Gross process water irrigation ranges from 6.1 to 41.8 inches, while gross supplemental fresh well water irrigation ranges from 12.0 to 34.4 inches. The estimated ET ranges from 32.8 to 50.8 inches.

In this example, the Site design basis capacity for gross process water irrigation ranges from 50 to 229 MG per month (Table 12). Supplemental fresh well water loads based on supplementing the process water to meet crop water requirements, range from 52 MG in April to 362 MG in July. The total irrigation capacity in this example is 2,373 MG per year during the irrigation season (i.e., November, and March through October).

The annual example hydraulic capacities in Table 12 were used with the process water quality (Table 6) and supplemental fresh well water quality (Table 8) to calculate constituent mass loads from the process water and supplemental fresh well water irrigation for comparison to the Site capacities discussed in the following section.

4.3.2 Nitrogen Capacity

There are two mechanisms of nitrogen treatment in a land treatment system. The first and largest is uptake by the crops growing and removal in the harvested portion of the crop. Table 13 shows the past performance of the crops grown at the Site to remove nitrogen applied in process water, supplemental fresh well water, and commercial fertilizer. The 2013 crop rotation example represents the maximum nitrogen removal from the Site during the previous five operational years. Potato crops receive only a small amount of process water nitrogen (typically around 58 pounds nitrogen per acre [lb/ac]). This is the average amount of process water nitrogen typically applied as a pre-plant source of nitrogen or after potato harvest to support the new seeding alfalfa that follows potatoes in the crop rotation. The “Crop Nitrogen Removal” category shown in Table 13 accounts for the full nitrogen removal of 195 lb/ac (Table 10) to account for the supplemental fresh well water and fertilizer nitrogen contributions.

As the crop mix acreage changes, nutrient capacities also change. The design basis crop rotation scenario (Table 10) was added to Table 13 to show the most limiting projected Site nitrogen capacity in comparison to historical Site removal and capacity.

Historically, nitrogen removal ranged from 541,600 pounds per year (lb/yr) (2017) to 689,700 lb/yr (2016). The design basis crop rotation nitrogen removal would be 656,800 lb/yr. The design basis crop rotation nitrogen removal and gross nitrogen capacity is greater than in operating years 2015 and 2017 as less acreage is dedicated to potatoes in the design basis rotation.

The second nitrogen treatment mechanism in land treatment systems is denitrification and volatilization (i.e., gaseous losses). The applied process water nitrogen is primarily in the organic and ammonia forms since there is no aerobic secondary treatment before it is land applied. Following irrigation, the organic nitrogen will be biologically mineralized to ammonia then nitrate and consumed by the crops. Denitrification of the nitrate is typically promoted by the dose and rest cycles of the irrigation systems in conjunction with a labile carbon content represented by the moderate BOD_5 load (EPA, 1981); (Smith, J.H., J.R. Peterson, 1982). The BOD_5 concentration of the process water is sufficient to drive this denitrification reaction so not all of the process water nitrate-nitrogen is considered available to the crops. Likewise, not all of the organic nitrogen is considered available because it has not been treated and will not easily mineralize following irrigation (Overcash and Pal, 1981).

The slightly to moderately alkaline pH of the soils and broadcast nature of sprinkler irrigation promotes a limited amount of volatilization of ammonia-nitrogen. The ammonia-nitrogen concentration is not tested in the process water. It is assumed to be approximately 55% of TKN. This value for ammonia-nitrogen is based on the quality of similar food process waters and biological conversion from organic nitrogen during residence time in the pipeline to the PWRF headworks and seasonal storage.

Denitrification and ammonia volatilization must be considered as part of the treatment and removal process for estimating nitrogen capacity. Based on the following equation, accounting for gaseous nitrogen losses, the available nitrogen load from process water is conservatively expected to be 86% of the total nitrogen applied (Meisinger and Randall, 1991):

Equation:

$$\text{Available Nitrogen \%} = [((\text{TKN} - \text{ammonia-nitrogen}) + (\text{ammonia-nitrogen} \times 0.80) + (\text{nitrate-nitrogen})) * 0.96] \div (\text{TKN} + \text{nitrate-nitrogen}) \times 100\%$$

Calculation:

$$\text{Available Nitrogen \%} = [((53\text{ mg/L} - 29\text{ mg/L}) + (29\text{ mg/L} \times 0.80) + (1.0\text{ mg/L})) * 0.96] \div (53\text{ mg/L} + 1.0\text{ mg/L}) \times 100\% = 86\%$$

Accounting for the 86% nitrogen availability, the Site gross nitrogen capacity is 16% greater than the crop nitrogen removal. Therefore, Site nitrogen capacity can be calculated by increasing the crop nitrogen removal rates by 16% to account for the gaseous losses expected with process water application. The historical Site nitrogen gross capacity ranges from 629,800 lb/yr (2017) to 802,000 lb/yr (2016) with the normal crop rotation.

Design Basis Nitrogen Load

Table 14 presents the Site nitrogen capacity and an example operational year nitrogen load scenario. The Site nitrogen capacity presented in Table 14 represents the field-by-field design basis crop nitrogen removal increased to account for net available process water nitrogen after volatilization and denitrification losses. The example operational load represents the gross nitrogen loads from process water and supplemental fresh well water for each circle based on the hydraulic capacity analysis above. The example operational nitrogen loads were calculated from the process water and supplemental fresh well water nitrogen concentrations (Tables 6 and 8, respectively) and the irrigation amounts from the soil hydraulic budgets discussed in the hydraulic capacity section. Nitrogen load from the supplemental fresh well water will be significant with limited gaseous losses. The available nitrogen load from the supplemental fresh well water is conservatively expected to be 96% of the total nitrate-nitrogen applied due to an assumed gaseous loss of 4% from denitrification.

The hydraulic capacity is linked to the nitrogen capacity. Nitrogen is the limiting constituent in this analysis that controls the process water hydraulic capacity. The hydraulic capacity for process water is dictated by the nitrogen load in the process water and supplemental fresh well water. In the hydraulic capacity analysis, the leaching requirements were not met due to nitrogen load limits within the nitrogen capacities. Therefore, nitrogen is the limiting parameter.

In the example operational load scenario presented in Table 14, the process water contributed a total of 561,871 lb, while supplemental fresh well water contributed a total of 157,112 lb. Table 14 also shows that the example operational circle-specific total nitrogen loads (process water plus supplemental fresh well water nitrogen) do not exceed their respective circle-specific nitrogen capacities. Total nitrogen application scheduled to the Site in the operational example using the design basis crop rotation is 718,983 lb. This is within the Site nitrogen capacity of 763,676 lb for the design basis crop rotation. The example total operational load is less than capacity due to crop-dependent agronomic irrigation management considerations such as storage capacity, crop dry-down and harvest periods.

4.3.3 Biochemical Oxygen Demand Capacity

The treatment capacity for BOD_5 depends on soil, temperature, and irrigation practices. The soil needs to allow sufficient oxygen transfer, the temperature affects the rate of microbial digestion of the organic components, and the irrigation practices provide sufficient water to maintain microbial function without extended soil saturation that would prevent sufficient oxygen. The BOD_5 capacity is most influenced by the soil texture and drainage rate because that affects the rate of oxygen diffusion into the soil. Sandier soils, such as those described for the Site, have larger soil pores with better oxygen diffusion potential, and thus, have a higher capacity for BOD_5 treatment than finer textured soils such as silt loams.

Crops also require an oxygenated soil. If the BOD_5 load is too great, the soil will become anaerobic and the crops will suffer stress that reduces performance, nutrient uptake, and yield. Table 15 presents a potential annual BOD_5 load of 8,520,000 lb based on a projected phase II BOD_5

concentration of 730 mg/L and process water flow of 1,399 MG. Based on 1,856 acres and 275 growing season days (November and March through October) and process water loads applied to meet nitrogen capacities, the maximum annual loading rate averages approximately 17 pounds per acre per day (lb/ac/day) BOD_5. This BOD_5 load is below the commonly referenced 45 to 450 lb/ac/day BOD_5 range given for land treatment of wastewater by the Environmental Protection Agency (EPA, 2006) and also below the existing permit limit of 100 lb/ac/day. The daily BOD_5 design load by field by month will range up to a maximum of 41 lb/ac/day; well below the 100 lb/ac/day Permit irrigation land application best management practice (Appendix D).

4.3.4 Mineral Salts and Salinity Management

The FDS are a measure of the mineral salts present in the process water and used to evaluate the salinity and mass of salts discharged to the Site. The FDS that make up the process water salinity include calcium, magnesium, sodium, potassium, sulfate, chloride, and bicarbonate ions. The annual process water FDS load of 8,240,000 pounds, calculated using the design basis flow, includes the FDS contribution from magnesium hydroxide ($Mg(OH)_2$) for pH adjustment of the process water for proper BOD_5 pretreatment (Table 15). The FDS load monitoring and management is important to manage accumulation of salts in the soil profile to prevent reductions in crop yields. The FDS load from process water, including the FDS contribution from the $Mg(OH)_2$, and supplemental fresh well water will determine the leaching requirements for each circle. The Site soil and crop FDS capacity is the calculated leaching requirement for each field (Table 11, Appendix C). The projected irrigation water FDS concentration, including the FDS contribution from the $Mg(OH)_2$, is presented in Appendix E. The EC of the water irrigated onto the Site is an indirect measure of the FDS (salinity) of the water. Therefore, irrigation water EC is used for computing the leaching requirement. Annual leaching fractions will not exceed calculated leaching requirements to limit the impact on groundwater quality. Soil salts will be monitored through annual soil sampling to determine effectiveness of scheduled leaching.

Leaching Requirement

The leaching requirement is the fraction of the total crop water supply from all sources that should percolate through the soil to control salt build-up in the soil profile. Leaching is required to prevent excessive amounts of salts from accumulating in the root zone. If not leached regularly, salts from both process water and supplemental fresh well water can build up in the soil profile to levels that could inhibit crop production. The salinity in the root zone should be maintained at or below the point of yield decline. A soil ECe of 2 mmhos/cm or less, which is suitable for most irrigated crops, was used to generate the leaching requirements. Given the limited precipitation in the region, it may be necessary to irrigate some supplemental fresh well water in the winter to meet the leaching requirement. At the same time, irrigation should minimize deep percolation losses so that FDS losses from the soil are managed to control impacts to groundwater. The deep percolation rate (leaching fraction) should be equal to or less than the leaching requirement.

The leaching requirement, presented as a percentage of total irrigation, depends on the average electrical conductivity of the total water supply to the crop for the year. A leaching requirement is as follows (Canessa and Hermanson, 1994):

$$LR = \frac{ECiw}{((5*ECe) - ECiw)}$$

Where:

LR = Fraction of the applied irrigation water that should become deep percolation

ECiw = EC of the irrigation water

ECe = Desired ECe of a soil saturated paste extract

Leaching requirements can be computed each year in the hydraulic budget calculations in the annual Farm Operations Report based on the actual water quality and hydraulic loads. The soil hydraulic budget calculations can also be used each year to compare the leaching requirement to the calculated leaching fraction as a check on agronomic irrigation management.

During the winter when leaching may occur from rainfall, there is low potential for nitrate to be leached if it has been adequately consumed by the crops. Cropping and loading rates can be managed to maintain a healthy crop to consume the available soil nitrate-nitrogen and maintain low nitrate concentrations in the soil before the time that winter leaching is more likely to occur.

4.3.5 Irrigation System Operation

Proper irrigation system operation is important for optimum process water treatment and agronomic capacity. The irrigation systems are operated to distribute the water across the circles for optimum control on irrigation depth and timing. Standard best management practices will include:

- visual observations of circles for runoff or ponding,
- routine soil profile moisture and nutrient monitoring,
- application rate monitoring, and
- leak and mechanical repair.

5.0 COMPLIANCE WITH STATE ENVIRONMENTAL POLICY ACT

A State Environmental Policy Act (SEPA) Checklist and a determination of non-significance are on file demonstrating compliance with the SEPA requirements. The information in this engineering report documents current conditions at the Site. No new SEPA process is required for compliance.

6.0 SUMMARY

The City treats and reuses process water from a variety of Food Processors by irrigation to agricultural crops on a City-owned land treatment site. There currently are five Food Processors discharging process water to the PWRF. More could be added in the future dependent on availability of capacity at the PWRF.

The purpose of this Engineering Report Update is to provide Ecology with information on the proper design, operation, performance, and agronomic capacity of the land treatment system to maintain the highest quality of the state's groundwater and protect existing and future beneficial uses. The soils at the Site are suitable for receiving the process water for land treatment purposes and Site performance indicates that the nitrogen and hydraulic loadings have not typically exceeded the agronomic capacity. The agronomic capacity will vary from year to year depending on the crop mix. The agronomic capacities, within which the Site must be managed by the City, will be established and reported each year in the annual Farm Operations Report, as required by the Permit.

REFERENCES

Canessa and Hermanson. (1994). *Irrigation Management Practices to Protect Ground Water and Surface Water Quality State of Washington. EM4885.* Washington State University Cooperative Extension Service and U.S. Department of Agriculture.

CES. (2012). *2012 Farm Operations Report for the City of Pasco, Washington.* Spokane: Cascade Earth Sciences.

CES. (2013). *2013 Farm Operations Report for the City of Pasco, Washington.* Spokane: Cascade Earth Sciences.

CES. (2014). *2014 Farm Operations Report for the City of Pasco, Washington.* Spokane: Cascade Earth Sciences.

CES. (2015). *2015 Farm Operations Report for the City of Pasco, Washington.* Spokane: Cascade Earth Sciences.

CES. (2016). *Farm Operations Report for the City of Pasco, Washington.* Spokane: Cascade Earth Sciences.

CES. (2017). *2017 Farm Operations Report for the City of Pasco, Washington.* Spokane Valley: Cascade Earth Sciences.

CES. (2018). *2018 Farm Operations Report for the City of Pasco, Washington.* Spokane Valley: Cascade Earth Sciences.

CH2M. (2018). *Hydrogeologic Assessment Report.* Seattle: CH2M.

Ecology. (1993). *Guidelines for the Preparation of Engineering Reports for Industrial Wastewater Land Treatment Systems.* Olympia: State of Washington Deparment of Ecology.

Ecology. (2005). *Implementation Guidance for the Ground Water Quality Standards Publication #96-02.* Olympia: State of Washington Department of Ecology.

EPA. (1981). *Process Design Manual for Land Treatment of Municipal Wastewater, EPA 625/1-81-013.* Washington: U.S. Environmental Protection Agency.

EPA. (2006). *Process Design Manual for Land Treatment of Municipal Wastewater Effluents EPA 625/R-06/016.* Cincinnati: U.S. Environmental Protection Agency.

Horneck, D. D. (2011). *Soil Test Interpretation Guide. EC 1478.* Corvallis: Oregon State University Extension Service.

Meisinger and Randall. (1991). *Managing Nitrogen for Groundwater Quality and Farm Profitability.* Madison: Soil Science Society of America, Inc.

NRCS. (2018, October). *Web Soil Survey*. Retrieved from http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

Overcash and Pal. (1981). *Design of Land Treatment Systems for Industrial Wastes - Theory and Practice.* Ann Arbor: Ann Arbor Science Publisher, Inc.

Smith, J.H., J.R. Peterson. (1982). Recycling of Nitrogen through Land Application of Agricultural Food Processing, and Municipal Wastes. In F. J. (ed), *Nitrogen in Agricultural Soils. Vol. 22* (pp. 791-831). Madison: American Society of Agonomy, Inc. Crop Science Society of America, Inc.

US Salinity Lab Staff. (1954). *Diagnosis and Improvement of Saline and Alkali Soils.* Washington: U.S. Govt Printing Office.

USDA/SCS. (2006). *Soil Survey of Franklin County, Washington.* Franklin County: U.S. Department of Agriculture.

TABLES

Table 1. Climate Summary

Month	Precipitation [1]		Potential Crops and Evapotranspiration [2]							
	Average	Normalized 10-Year Return	Alfalfa	Potato / Alfalfa	Alfalfa / Corn	Timothy / Corn	Corn	Potato	Triticale / Corn	Fallow
	inches									
Nov	0.6	0.9	1.2	0.5	1.2	1.0	0.5	0.5	1.0	0.5
Dec	0.9	1.3	0.7	0.2	0.7	0.6	0.2	0.2	0.6	0.2
Jan	0.8	1.2	0.7	0.3	0.7	0.7	0.3	0.3	0.7	0.3
Feb	0.5	0.7	1.4	0.5	1.4	1.2	0.5	0.5	1.2	0.5
Mar	0.5	0.7	3.1	0.5	3.1	2.6	0.5	0.5	2.6	0.5
Apr	0.4	0.5	5.0	1.4	5.0	4.1	1.0	1.4	4.1	0.3
May	0.5	0.8	7.1	4.5	7.1	5.7	3.9	4.5	5.7	0.4
Jun	0.5	0.7	8.8	9.0	6.4	5.4	8.1	9.0	5.4	0.5
Jul	0.1	0.2	10.1	10.3	7.8	7.8	10.4	10.3	7.8	0.3
Aug	0.2	0.2	8.2	4.9	7.4	7.4	7.4	4.9	7.4	0.3
Sep	0.3	0.4	4.8	2.4	0.8	0.8	0.8	0.2	0.8	0.2
Oct	0.5	0.7	2.6	2.6	0.8	0.8	0.8	0.2	0.8	0.2
Total	**5.8**	**8.3**	**53.5**	**37.0**	**42.3**	**38.0**	**34.3**	**32.3**	**38.0**	**3.8**

NOTES:
All data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington.
1 The average precipitation is based on actual monthly precipitation from 1997 through 2017.
The 2nd highest total annual precipitation out of 20 years (8.3 inches from 2015-2016) were normalized in relation to the long term average for each month to create the 10-year return precipitation data for design purposes.
2 Evapotranspiration is the average of actual monthly data from 1995-2017 for crops typically grown at the land treatment site.
Fallow evapotranspiration estimated using the chart on page 2-120, Soil Conservation Service National Engineering Handbook, Part 623, Chapter 2.
Fallow evapotranspiration is used when AgWeatherNet evapotranspiration is less than fallow evapotranspiration or when crops are not in place.

Table 2. Published Soil Type and Physical Properties

Soil Map Unit	Soil Unit Name	Soil Name	Proportion of Land Treatment Site	Texture	Depth	Bulk Density	Perm [1]	Average Available Soil Water Holding Capacity [2]			Water Content at Permanent Wilting Point [3]	Field Capacity [4]	Organic Matter
					in	g/cc	in/hr	in/in	Thickness (in)	in	in	in	%
89	Quincy loamy fine sand, 0 to 15 percent slopes	Quincy	60.9%	loamy fine sand	0-4	1.50-1.65	13.0	0.09-0.11	4	0.40	0.09	0.49	0.5-1.0
				loamy fine sand, fine sand	4-60	1.50-1.65	13.0	0.05-0.11	56	4.48	1.35	5.83	0.0-0.5
								Total	**60**	**4.88**	**1.44**	**6.32**	
97	Quincy-Hezel complex, 0 to 15 percent slopes	Quincy	12.3%	loamy fine sand	0-7	1.50-1.65	13.0	0.09-0.11	7	0.70	0.16	0.86	0.5-1.0
				loamy fine sand, fine sand	7-18	1.50-1.65	13.0	0.05-0.11	11	0.88	0.26	1.14	0.0-0.5
		Hezel		loamy fine sand	0-7	1.25-1.45	13.0	0.09-0.13	7	0.77	0.31	1.08	0.0-0.5
				loamy fine sand, loamy sand, fine sand	7-18	1.40-1.60	13.0	0.08-0.12	11	1.10	0.12	1.22	0.0-0.5
				fine sandy loam, very fine sandy loam, silt loam	18-27	1.30-1.50	1.3	0.13-0.21	9	1.53	0.35	1.88	0.0-0.5
				stratified fine sandy loam to silt loam	27-60	1.30-1.50	0.4	0.13-0.21	33	5.61	1.69	7.30	0.0-0.5
Quincy (7-18 inches) + Hezel (18-60 inches)								**Total**	**60**	**8.72**	**2.46**	**11.18**	
Hezel								**Total**	**60**	**9.01**	**2.89**	**13.48**	
144	Sagemoor very fine sandy loam, 0 to 2 percent slopes	Sagemoor	6.5%	very fine sandy loam	0-4	1.20-1.35	1.3	0.16-0.20	4	0.72	0.26	0.98	1.0-2.0
				silt loam	4-9	1.20-1.35	1.3	0.16-0.20	5	0.90	0.31	1.21	1.0-2.0
				silt loam, very fine sandy loam	9-18	1.30-1.40	1.3	0.18-0.20	9	1.71	0.53	2.24	0.0-0.5
				silt loam, very fine sandy loam	18-60	1.30-1.45	0.4	0.18-0.21	42	8.19	2.48	10.67	0.0-0.5
								Total	**60**	**11.52**	**3.59**	**15.11**	
29	Hezel loamy fine sand, 0 to 15 percent slopes	Hezel	6.3%	loamy fine sand	0-7	1.25-1.45	1.3	0.09-0.13	7	0.77	0.31	1.08	0.0-0.5
				loamy fine sand, loamy sand, fine sand	7-18	1.40-1.60	1.3	0.08-0.12	11	1.10	0.12	1.22	0.0-0.5
				fine sandy loam, very fine sandy loam, silt loam	18-27	1.30-1.50	1.3	0.13-0.21	9	1.53	0.35	1.88	0.0-0.5
				stratified fine sandy loam to silt loam	27-60	1.30-1.50	1.3	0.13-0.21	33	5.61	1.46	7.07	0.0-0.5
								Total	**60**	**9.01**	**2.24**	**11.25**	
92	Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes	Quincy	5.1%	loamy fine sand	0-3	1.25-1.45	13.0	0.08-0.11	3	0.29	0.10	0.39	1.0-2.0
				loamy fine sand	3-52	1.30-1.50	13.0	0.08-0.11	49	4.66	1.18	5.83	0.0-0.5
				silt loam, very fine sandy loam, fine sandy loam	52-60	1.50-1.70	1.3	0.16-0.18	8	1.36	0.41	1.77	0.0-0.5
								Total	**60**	**6.30**	**1.69**	**7.99**	
128	Royal fine sandy loam, 0 to 2 percent slopes	Royal	4.3%	fine sandy loam	0-5	1.30-1.40	4.0	0.13-0.15	5	0.70	0.27	0.97	0.5-1.0
				fine sandy loam, very fine sandy loam	5-15	1.30-1.50	4.0	0.13-0.17	10	1.50	0.51	2.01	0.0-0.5
				stratified fine sand to very fine sandy loam	15-60	1.40-1.60	4.0	0.10-0.14	45	5.40	2.30	7.70	0.0-0.5
								Total	**60**	**7.60**	**3.08**	**10.68**	

Table 2. Published Soil Type and Physical Properties

Soil Map Unit	Soil Unit Name	Soil Name	Proportion of Land Treatment Site	Texture	Depth	Bulk Density	Perm [1]	Average Available Soil Water Holding Capacity [2]			Water Content at Permanent Wilting Point [3]	Field Capacity [4]	Organic Matter
					in	g/cc	in/hr	in/in	Thickness (in)	in	in	in	%
145	Sagemoor very fine sandy loam, 2 to 5 percent slopes	Sagemoor	3.8%	very fine sandy loam	0-4	1.20-1.35	1.3	0.16-0.20	4	0.72	0.26	0.98	1.0-2.0
				silt loam	4-9	1.20-1.35	1.3	0.16-0.20	5	0.90	0.31	1.21	1.0-2.0
				silt loam, very fine sandy loam	9-18	1.30-1.40	1.3	0.18-0.20	9	1.71	0.53	2.24	0.0-0.5
				silt loam, very fine sandy loam	18-60	1.30-1.45	0.4	0.18-0.21	42	8.19	2.48	10.67	0.0-0.5
								Total	**60**	**11.52**	**3.59**	**15.11**	
146	Sagemoor very fine sandy loam, 5 to 10 percent slopes	Sagemoor	0.7%	very fine sandy loam	0-4	1.20-1.35	1.3	0.16-0.20	4	0.72	0.26	0.98	1.0-2.0
				silt loam	4-9	1.20-1.35	1.3	0.16-0.20	5	0.90	0.31	1.21	1.0-2.0
				silt loam, very fine sandy loam	9-18	1.30-1.40	1.3	0.18-0.20	9	1.71	0.53	2.24	0.0-0.5
				silt loam, very fine sandy loam	18-60	1.30-1.45	0.4	0.18-0.21	42	8.19	2.48	10.67	0.0-0.5
								Total	**60**	**11.52**	**3.59**	**15.11**	
126	Royal loamy fine sand, 0 to 10 percent slopes	Royal	0.1%	loamy fine sand	0-6	1.35-1.45	13.0	0.09-0.11	6	0.60	0.21	0.81	0.5-1.0
				fine sandy loam, very fine sandy loam	6-19	1.30-1.50	4.0	0.13-0.17	13	1.95	0.66	2.61	0.0-0.5
				stratified fine sand to very fine sandy loam	19-60	1.40-1.60	4.0	0.10-0.14	41	4.92	1.36	6.28	0.0-0.5
								Total	**60**	**7.47**	**2.24**	**9.71**	

NOTES:

Summary of Natural Resource Conservation Service Web Soil Survey of area of interest (http://websoilsurvey.nrcs.usda.gov/app/).

Abbreviations: % = percent, g/cc = grams per centimeter cubed, in = inch, in/hr = inches per hour, in/in = inches per inch, perm = permeability.

1 The permeability range values are from the Web Soil Survey for Franklin County. Permeability is the same as saturated hydraulic conductivity (Ksat), which is substantially lower than infiltration.

2 Available soil water holding capacity is the amount of water available to plants between field capacity and the permanent wilting point. The average available soil water holding capacity (inch) was calculated using the average of the range of the in/in values multiplied by the thickness of the horizon.

3 Estimated using estimates of sand, silt, organic matter, and gravel content to match the average soil available water holding capacity for each horizon using the Soil-Plant-Air-Water model (Saxton, K.E., W.J. Rawls, J.S. Ronberger, and R.I. Papenlick, 2009. Estimating Generalized Soil-Water Characteristics from Texture. Version 6.02.74. Soil Science Society of America Journal 50:1031-1036. 1986, revised 10/2009. http://hydrolab.arsusda.gov/soilwater/Index.htm.).

4 Field capacity is the water content of the soil after the drainage of excess water by gravity has ceased.

Table 3. Circle by Circle Soil Water Capacity

Soil Map Unit [1]		29	89	92	97	126	128	144	145	146	Average Field Capacity [6]	Average Available Capacity [6]
Depth	inches	60	60	60	60	60	60	60	60	60		
Field Capacity [2]	inches	11.2	6.3	8.0	13.5	9.7	10.7	15.1	15.1	15.1		
Available Capacity [3]	inches	9.0	4.9	6.3	9.0	7.5	7.6	11.5	11.5	11.5		
Wilting Point [4]	inches	2.2	1.4	1.7	2.9	2.2	3.1	3.6	3.6	3.6		
Circle [7]	acres	Percentage [5]									inches	
1	122	25.4	27.6	--	16.0	--	--	19.5	11.5	--	11.4	8.6
2	152	4.4	28.7	--	24.2	--	--	39.5	3.2	--	12.0	8.9
3	128	--	81.3	--	--	--	--	5.7	13.0	--	8.0	6.1
4	128	--	65.5	--	34.5	--	--	--	--	--	8.8	6.3
5	128	--	30.9	--	55.2	--	--	--	13.9	--	11.5	8.1
6	128	--	81.1	12.5	--	--	6.4	--	--	--	6.8	5.2
7	152	--	28.5	42.0	--	--	29.5	--	--	--	8.3	6.3
8	128	--	85.3	10.3	--	--	4.4	--	--	--	6.7	5.1
9	128	--	99.8	0.2	--	--	--	--	--	--	6.3	4.9
10	128	--	83.3	--	--	--	16.7	--	--	--	7.0	5.3
11	150	--	75.0	--	22.1	0.7	--	2.2	--	--	8.1	6.0
12	128	61.5	16.4	--	--	--	--	4.5	7.5	10.1	11.3	8.9
13	128	--	98.5	1.5	--	--	--	--	--	--	6.3	4.9
15	128	--	59.3	--	19.0	--	--	16.3	5.4	--	9.6	7.1

NOTES:

Summary of information from the Natural Resource Conservation Service Web Soil Survey of area of interest (http://websoilsurvey.nrcs.usda.gov/app/).

Abbreviation: -- = soil map unit not found.

1 The soil map unit is used to represent the soil unit on the soil survey map.

2 Field capacity is the maximum amount of water the soil can hold against gravitational forces.

3 Available water is the amount of water available to the crop. It is the difference between field capacity and the water content at the wilting point.

4 Wilting point is the water content remaining in the soil that is too difficult for the crop to uptake.

5 The percentage of each soil unit by circle is based on the Web Soil Survey mapping.

6 Average values are weighted by soil-type (soil map unit) percentages. Average field capacity = the sum of products of circle-specific field capacity and soil map unit percentages, divided by the sum of the soil map unit percentages (100). Average available capacity is calculated in the same way as field capacity, except using available capacity instead of field capacity.

7 Circle 2 is Circle 2 plus Little Circle 2. Circle 7 is Circle 7 plus Little Circle 7.

Table 4. Soil Analytical Results

Circle [1]	Depth	ESP	CEC	OM	TKN	NO_3-N	NH_4-N	Total P	EC	Na	Ca	Mg	K	SO_4-S	pH
	ft bgs	%	meq/100g	%	mg/kg				mmhos/cm	meq/100g			mg/kg		s.u.
1	1	2.3	8.7	1.12	622	9.2	8.5	943	0.30	0.26	6.8	3.15	399	14	7.5
	2	1.8	8.0	0.33	256	2.9	1.2	738	0.21	0.26	11.5	3.00	249	12	7.8
	3	1.6	10.5	0.38	249	4.4	2.4	728	0.25	0.35	16.4	3.80	192	9	7.9
	4	1.8	11.2	0.22	186	7.0	1.1	720	0.28	0.41	16.0	4.40	157	20	8.0
	5	2.0	10.2	0.28	198	9.3	1.3	743	0.28	0.41	14.3	4.73	213	15	8.0
	10	2.6	11.8	0.29	217	7.9	1.0	700	0.30	0.55	14.8	5.01	243	16	8.1
2	1	1.8	13.8	1.73	637	12.1	9.7	993	0.63	0.32	12.9	4.29	456	5	7.4
	2	2.8	11.9	0.66	259	1.5	1.3	768	0.34	0.54	14.2	3.95	172	7	7.7
	3	2.7	12.7	0.66	258	3.3	2.4	750	0.40	0.70	19.6	4.85	155	21	8.0
	4	2.6	12.0	0.31	145	1.0	1.0	700	0.31	0.67	18.3	5.56	143	32	8.1
	5	2.9	15.7	0.38	196	4.1	1.5	760	0.43	0.82	19.7	7.16	266	34	8.0
	10	4.0	16.5	0.33	134	11.9	1.1	838	0.35	1.02	18.0	5.88	314	15	8.2
3	1	3.5	12.9	1.70	834	19.0	5.6	1,125	0.59	0.56	11.0	4.23	478	41	7.5
	2	2.3	10.7	0.56	300	7.2	1.7	878	0.34	0.34	10.9	3.59	254	27	7.6
	3	2.0	12.9	0.51	182	11.0	2.1	773	0.33	0.41	16.6	3.71	186	18	7.8
	4	2.2	15.3	0.27	173	15.3	1.4	723	0.36	0.59	20.3	4.96	167	15	8.0
	5	2.3	13.7	0.44	247	16.1	2.0	815	0.40	0.55	19.0	4.22	222	22	7.9
	10	2.9	13.3	0.23	171	4.7	1.0	945	0.28	0.68	16.0	5.65	247	13	8.2
4	1	2.2	6.9	0.90	575	5.1	5.2	975	0.24	0.21	5.7	2.94	365	5	7.3
	2	1.5	6.0	0.17	176	1.5	1.0	758	0.18	0.25	13.6	2.55	179	5	8.0
	3	1.8	7.5	0.67	382	10.3	4.4	803	0.32	0.32	14.0	2.80	200	6	7.6
	4	2.2	7.3	0.13	141	1.3	1.0	728	0.20	0.40	14.0	2.54	86	13	8.2
	5	2.2	6.9	0.21	167	3.3	1.3	928	0.21	0.35	12.6	2.45	141	8	8.0
	10	2.5	7.4	0.16	149	4.5	1.2	743	0.23	0.39	11.7	3.07	149	14	8.2
5	1	2.2	9.3	1.06	660	10.7	5.5	1,075	0.25	0.27	8.6	3.15	355	8	7.3
	2	2.0	6.7	0.28	194	1.1	1.2	843	0.18	0.25	10.5	2.64	235	6	8.0
	3	2.1	7.7	0.51	371	5.4	2.9	905	0.21	0.25	9.4	2.53	257	7	7.8
	4	2.1	7.7	0.27	183	1.2	1.0	770	0.18	0.28	11.9	2.34	151	5	8.1
	5	2.4	10.6	0.39	220	3.7	1.5	813	0.24	0.45	15.4	3.32	195	9	8.1
	10	2.8	13.9	0.21	157	2.7	1.2	798	0.34	0.71	18.9	5.03	241	26	8.3

Table 4. Soil Analytical Results

Circle [1]	Depth	ESP	CEC	OM	TKN	NO_3-N	NH_4-N	Total P	EC	Na	Ca	Mg	K	SO_4-S	pH
	ft bgs	%	meq/100g	%	mg/kg				mmhos/cm	meq/100g			mg/kg		s.u.
6	1	1.5	9.6	1.04	680	4.1	9.3	1,153	0.32	0.19	8.8	3.45	543	3	7.3
	2	1.5	9.8	0.31	216	1.0	1.3	1,058	0.19	0.27	13.7	4.05	329	2	7.9
	3	1.6	11.0	0.52	341	4.1	3.2	1,095	0.25	0.35	17.0	3.80	252	4	8.0
	4	2.0	11.4	0.33	195	4.0	1.1	898	0.30	0.49	19.4	4.22	161	20	8.2
	5	2.1	11.8	0.49	308	6.9	3.7	1,055	0.34	0.51	18.3	4.43	269	19	8.1
	10	2.5	11.3	0.20	145	4.7	1.0	1,128	0.27	0.57	17.8	3.62	252	13	8.2
7	1	1.5	11.5	1.42	835	35.3	7.9	1,220	0.49	0.25	12.7	4.07	407	10	7.3
	2	2.4	10.7	0.49	299	5.7	1.3	958	0.28	0.40	14.1	4.50	204	9	7.8
	3	2.3	11.6	0.86	504	28.5	3.8	973	0.48	0.48	15.9	4.18	253	15	7.6
	4	3.0	12.0	0.27	183	2.5	1.0	838	0.36	0.73	19.0	4.38	134	25	8.1
	5	2.6	11.0	0.45	289	10.6	1.7	963	0.36	0.57	16.7	3.83	192	18	7.9
	10	2.9	11.4	0.37	225	7.4	1.2	898	0.37	0.67	16.7	4.66	186	21	8.1
8	1	1.7	8.4	1.05	576	9.6	4.3	1,048	0.25	0.18	7.1	3.02	289	6	7.4
	2	2.7	7.3	0.27	249	1.0	1.2	883	0.16	0.27	7.5	3.04	218	5	8.1
	3	2.9	8.8	0.41	258	5.7	2.2	875	0.21	0.33	8.5	3.21	232	7	7.9
	4	2.7	9.2	0.26	219	1.3	1.1	870	0.22	0.38	11.1	3.24	171	10	8.1
	5	2.4	9.4	0.35	223	4.3	1.8	923	0.24	0.36	12.7	3.08	220	9	8.2
	10	1.7	12.6	0.20	158	1.7	1.0	738	0.25	0.44	19.5	4.00	166	14	8.4
9	1	1.3	10.2	1.20	611	13.4	5.7	1,023	0.31	0.22	13.6	3.35	422	7	7.8
	2	1.6	8.7	0.26	192	4.6	1.0	810	0.21	0.25	14.1	3.63	208	9	8.2
	3	1.4	8.7	0.29	213	5.2	1.8	800	0.21	0.27	15.8	3.25	187	8	8.3
	4	1.6	9.1	0.17	140	2.7	1.0	740	0.20	0.31	15.8	3.26	138	10	8.4
	5	1.8	10.2	0.27	173	5.8	1.1	815	0.22	0.38	16.7	3.66	170	11	8.4
	10	2.4	10.2	0.16	137	6.7	1.2	960	0.22	0.43	14.8	3.12	161	7	8.5
10	1	1.2	10.0	1.11	651	8.5	8.0	1,290	0.27	0.17	12.9	3.08	375	5	7.5
	2	1.6	9.7	0.36	168	1.0	1.0	1,085	0.17	0.24	12.1	3.80	214	5	8.0
	3	1.2	10.5	0.56	413	9.7	5.4	1,115	0.27	0.27	17.2	3.63	191	7	7.9
	4	1.6	10.2	0.24	173	1.4	1.0	1,013	0.20	0.36	18.5	3.23	129	11	8.3
	5	2.0	11.8	0.40	243	4.7	1.9	950	0.26	0.48	19.5	3.35	162	13	8.1
	10	2.5	11.9	0.30	157	4.0	1.0	1,103	0.28	0.58	18.4	3.73	197	15	8.3

Table 4. Soil Analytical Results

Circle [1]	Depth	ESP	CEC	OM	TKN	NO_3-N	NH_4-N	Total P	EC	Na	Ca	Mg	K	SO_4-S	pH
	ft bgs	%	meq/100g	%	mg/kg				mmhos/cm	meq/100g			mg/kg		s.u.
11	1	1.5	10.1	1.09	621	6.1	4.1	1,190	0.21	0.19	8.3	3.85	270	5	7.4
	2	1.8	9.5	0.33	215	1.3	1.0	1,275	0.17	0.34	15.0	3.96	101	5	8.2
	3	1.7	10.1	0.41	244	2.6	1.4	1,170	0.21	0.37	17.2	3.67	134	7	8.2
	4	2.4	9.1	0.29	187	2.4	2.4	1,205	0.23	0.49	15.7	3.57	149	13	8.3
	5	2.6	10.7	0.36	258	6.6	2.3	1,198	0.28	0.56	17.5	3.74	153	15	8.3
	10	2.7	10.0	0.14	163	8.3	1.0	905	0.30	0.55	16.4	3.43	175	17	8.4
12	1	2.2	9.8	1.20	689	37.6	6.3	1,015	0.57	0.25	6.2	3.69	449	21	7.1
	2	1.9	12.3	0.55	314	15.3	3.5	770	0.41	0.40	16.9	4.29	139	28	7.8
	3	2.0	15.5	0.44	233	10.6	2.4	748	0.41	0.53	19.0	5.46	163	26	8.0
	4	2.8	17.2	0.39	177	10.5	1.7	713	0.40	0.87	23.5	5.87	153	22	8.2
	5	2.9	16.2	0.44	213	12.8	1.8	795	0.41	0.87	21.4	6.15	230	22	8.2
	10	2.7	14.7	0.32	205	12.9	1.4	823	0.49	0.74	19.3	5.76	283	31	8.2
13	1	2.4	7.8	1.11	575	4.5	4.0	905	0.24	0.23	5.6	2.98	331	7	7.4
	2	1.9	7.7	0.31	183	3.4	1.7	800	0.24	0.23	11.3	3.37	150	11	7.7
	3	1.7	9.2	0.40	236	22.2	1.5	820	0.44	0.31	15.9	3.49	136	26	7.9
	4	1.6	10.0	0.28	185	17.8	1.3	845	0.39	0.37	19.0	3.47	124	23	8.2
	5	1.9	10.2	0.26	177	6.7	1.2	778	0.26	0.44	19.3	2.94	143	14	8.3
	10	2.5	10.2	0.13	141	5.9	1.2	775	0.24	0.59	18.8	3.59	151	12	8.4
15	1	2.7	8.3	1.09	566	7.0	4.4	980	0.27	0.32	7.5	3.45	282	7	7.6
	2	2.2	7.3	0.41	181	3.1	1.2	835	0.23	0.32	13.1	3.10	125	15	7.9
	3	1.8	8.4	0.37	224	5.3	1.6	803	0.24	0.31	16.3	3.14	120	17	8.0
	4	2.0	7.8	0.26	163	5.4	1.3	828	0.23	0.32	15.1	3.11	111	16	8.1
	5	1.7	8.4	0.28	180	4.9	1.3	820	0.24	0.36	17.0	3.29	145	14	8.1
	10	2.6	9.7	0.20	149	2.2	1.0	1,090	0.21	0.51	15.6	3.72	169	11	8.3

NOTES:

Data represents the soil conditions at the end of the 2016 crop-growing season. Samples collected November 16, 2016.

Abbreviations: % = percent, Ca = calcium, CEC = cation exchange capacity, EC = electrical conductivity, ESP = exchangeable sodium percentage, ft bgs = feet below ground surface, K = potassium, meq/100g = milliequivalents per 100 grams of soil, Mg = magnesium, mg/kg = milligrams per kilogram, mmhos/cm = millimhos per centimeter, Na = sodium, NH_4-N = ammonia-nitrogen, NO_3-N = nitrate-nitrogen, OM = organic matter, P = phosphorus, s.u. = standard units, SO_4-S = sulfate-sulfur, TKN = total Kjeldahl nitrogen.

1 Circle 2 is Circle 2 plus Little Circle 2. Circle 7 is Circle 7 plus Little Circle 7.

Table 5. Monthly Hydraulic Loads

Year [1]	2013			2014			2015			2017			Average		
Discharge	Process	Fresh	Total	Process	Fresh	Total	Process	Fresh	Total	Process	Fresh	Total	Process	Fresh	Total
Month	million gallons														
Nov	33.4	8.4	41.8	34.2	13.7	47.9	44.6	0.0	44.6	49.7	2.1	51.8	40.5	6.1	46.5
Mar	57.0	10.1	67.1	47.6	19.1	66.7	96.4	10.2	106.6	0.0	0.0	0.0	50.2	9.9	60.1
Apr	39.6	154.1	193.7	58.8	127.8	186.6	62.2	147.1	209.3	96.1	38.4	134.5	64.2	116.8	181.0
May	17.4	183.4	200.8	48.4	228.4	276.8	43.7	237.1	280.8	87.2	169.0	256.2	49.2	204.5	253.6
Jun	56.2	318.7	374.9	86.1	302.9	389.0	83.1	277.7	360.8	69.0	308.4	377.4	73.6	301.9	375.5
Jul	84.8	288.0	372.8	91.7	277.3	369.0	99.4	267.5	366.9	77.7	316.1	393.8	88.4	287.2	375.6
Aug	118.3	193.8	312.1	131.6	266.5	398.1	110.6	254.1	364.7	86.8	328.2	415.0	111.8	260.6	372.5
Sep	120.8	87.3	208.1	144.7	56.8	201.5	103.6	89.1	192.7	83.9	161.7	245.6	113.2	98.7	212.0
Oct	103.9	42.1	145.9	108.3	10.6	118.9	114.0	26.3	140.3	71.6	23.2	94.8	99.4	25.5	125.0
Total	**631.3**	**1,286.0**	**1,917.2**	**751.4**	**1,303.1**	**2,054.5**	**757.6**	**1,309.1**	**2,066.7**	**622.0**	**1,347.1**	**1,969.1**	**690.6**	**1,311.3**	**2,001.9**

NOTES:
Process and fresh water irrigation volumes discharged for land treatment from the City of Pasco facility as reported in the Annual Farm Operations Reports.
Winter (no flow) months are not shown. Flow values from the 2016 operational year are not included due to flow meter malfunction.
1 The operational year runs from November through October which corresponds with the approximate beginning of the winter period through the completion of crop harvest.
Land treatment irrigation occurs from March though November.

Sources:
CES, 2014. 2014 Farm Operations Report. City of Pasco – Pasco, Washington. Cascade Earth Sciences. Spokane, Washington. April 23, 2014.
CES, 2015. 2015 Farm Operations Report. City of Pasco – Pasco, Washington. Cascade Earth Sciences. Spokane, Washington. April 24, 2015.
CES, 2016. 2016 Farm Operations Report. City of Pasco – Pasco, Washington. Cascade Earth Sciences. Spokane, Washington. April 22, 2016.
CES, 2017. 2017 Farm Operations Report. City of Pasco – Pasco, Washington. Cascade Earth Sciences. Spokane Valley, Washington. April 25, 2017.
CES, 2018. 2018 Farm Operations Report. City of Pasco – Pasco, Washington. Cascade Earth Sciences. Spokane Valley, Washington. April 24, 2018.

Table 6. Monthly Process Water Quality

Month	pH	EC [1]	Total N	TKN	BOD_5	FDS	Na	Ca	Mg	K	SO_4	Cl	HCO_3	Total P	SAR
	s.u.	µmhos/cm	mg/L												
13-Nov	4.2	1,316	78.0	76.1	4,980	674	--	--	--	--	--	--	--	--	--
14-Mar	4.3	1,371	69.3	69.2	1,324	702	--	--	--	--	--	--	--	--	--
14-Apr	5.6	1,320	66.0	65.9	1,105	676	--	--	--	--	--	--	--	--	--
14-May	5.6	1,375	62.2	62.1	1,328	704	55.0	36.2	17.3	219.0	40.5	62.0	5.0	35.6	1.9
14-Jun	4.9	1,365	62.9	62.8	2,321	699	--	--	--	--	--	--	--	--	--
14-Jul	5.1	1,322	64.2	64.1	3,486	677	--	--	--	--	--	--	--	--	--
14-Aug	4.4	1,334	67.9	67.2	5,550	683	--	--	--	--	--	--	--	--	--
14-Sep	4.6	1,307	76.8	76.2	5,086	669	37.0	31.3	27.3	174.0	38.2	58.0	5.0	28.0	1.2
14-Oct	4.5	1,377	77.2	76.6	3,899	705	--	--	--	--	--	--	--	--	--
14-Nov	4.8	1,268	67.3	67.0	2,223	649	--	--	--	--	--	--	--	--	--
15-Mar	4.9	1,270	62.9	62.4	1,544	650	--	--	--	--	--	--	--	--	--
15-Apr	5.8	1,348	64.8	64.2	1,376	690	89.0	151.6	52.5	195.0	46.8	62.0	141.6	53.5	1.6
15-May	4.3	1,434	71.5	71.0	12,076	734	--	--	--	--	--	--	--	--	--
15-Jun	4.3	1,445	41.4	41.1	3,426	740	--	--	--	--	--	--	--	--	--
15-Jul	4.4	1,023	27.4	27.3	3,984	524	--	--	--	--	--	--	--	--	--
15-Aug	4.2	1,133	54.7	54.7	4,993	580	--	--	--	--	--	--	--	--	--
15-Sep	4.6	953	50.7	50.7	4,002	488	35.0	26.2	26.3	--	30.1	46.0	--	17.7	1.2
15-Oct	4.6	895	50.9	50.9	5,320	458	--	--	--	--	--	--	--	--	--
15-Nov	4.1	963	44.5	44.5	4,026	493	--	--	--	--	--	--	--	--	--
16-Mar	3.8	791	40.4	40.1	2,034	405	--	--	--	--	--	--	--	--	--
16-Apr	4.5	779	35.9	35.5	2,001	399	--	--	--	--	--	--	--	--	--
16-May	5.1	832	41.0	40.5	1,333	426	54.0	62.5	24.7	--	36.7	44.0	11.7	5.2	1.5
16-Jun	4.4	961	37.4	37.1	1,526	492	--	--	--	--	--	--	--	--	--
16-Jul	3.7	873	34.9	34.7	978	447	--	--	--	--	--	--	--	--	--
16-Aug	3.3	1,301	50.0	49.6	1,016	666	--	--	--	--	--	--	--	--	--
16-Sep	3.4	916	37.4	37.1	934	469	42.0	65.2	27.1	--	36.7	39.0	--	4.2	1.1
16-Oct	3.6	924	41.9	41.5	1,072	473	--	--	--	--	--	--	--	--	--

Table 6. Monthly Process Water Quality

Month	pH	EC [1]	Total N	TKN	BOD_5	FDS	Na	Ca	Mg	K	SO_4	Cl	HCO_3	Total P	SAR
	s.u.	µmhos/cm	mg/L												
16-Nov	3.7	873	48.7	41.0	2,770	447	--	--	--	--	--	--	--	--	--
17-Apr	3.7	957	41.8	41.2	2,171	490	--	--	--	--	--	--	--	--	--
17-May	3.8	943	39.6	39.0	2,287	483	63.0	62.4	20.5	--	33.8	45.0	12.3	3.9	1.8
17-Jun	3.6	916	38.1	37.5	1,887	469	--	--	--	--	--	--	--	--	--
17-Jul	3.3	887	36.0	35.4	2,710	454	--	--	--	--	--	--	--	--	--
17-Aug	3.3	943	60.2	59.6	7,317	483	--	--	--	--	--	--	--	--	--
17-Sep	3.4	881	68.8	68.2	8,306	451	33.0	28.1	20.7	--	51.3	17.0	5.0	42.8	1.2
17-Oct	3.7	871	69.0	68.4	8,264	446	--	--	--	--	--	--	--	--	--
Summary of Average Values															
Average	**4.3**	**1,099**	**54**	**53**	**3,390**	**563**	**51.0**	**57.9**	**27.1**	**196.0**	**39.3**	**46.6**	**30.1**	**23.9**	**1.4**
Maximum	**5.8**	**1,445**	**78**	**77**	**12,076**	**740**	**89.0**	**151.6**	**52.5**	**219.0**	**51.3**	**62.0**	**141.6**	**53.5**	**1.9**

NOTES:

Analytical data for process water discharged for land treatment from the City of Pasco facility as reported in the Annual Farm Operations Reports. Months with no flow are not shown.

Abbreviations: -- = not tested, BOD_5 = five-day biochemical oxygen demand, Ca = calcium, Cl = chloride, EC = electrical conductivity, FDS = fixed dissolved solids, HCO_3 = bicarbonate, K = potassium, Mg = magnesium, mg/L = milligrams per liter, Na = sodium, P = phosphorus, s.u. = standard units, SAR = sodium adsorption ratio, SO_4 = sulfate, TKN = total Kjeldahl nitrogen, Total N = total nitrogen (TKN + nitrite-nitrogen + nitrate-nitrogen), µmhos/cm = micromhos per centimeter.

1 EC is estimated as follows: EC = FDS x 1.25 ÷ 0.64 assuming FDS is 80% of total dissolved solids and the standard relationship of EC = total dissolved solids ÷ 0.64. (US Salinity Lab Staff, 1954. Diagnosis and Improvement of Saline and Alkali Soils. U.S. Govt Printing Office, Wash. D.C.).

Sources:

CES, 2014. 2014 Farm Operations Report. City of Pasco – Pasco, Washington. Cascade Earth Sciences. Spokane, Washington. April 23, 2014.
CES, 2015. 2015 Farm Operations Report. City of Pasco – Pasco, Washington. Cascade Earth Sciences. Spokane, Washington. April 24, 2015.
CES, 2016. 2016 Farm Operations Report. City of Pasco – Pasco, Washington. Cascade Earth Sciences. Spokane, Washington. April 22, 2016.
CES, 2017. 2017 Farm Operations Report. City of Pasco – Pasco, Washington. Cascade Earth Sciences. Spokane Valley, Washington. April 25, 2017.
CES, 2018. 2018 Farm Operations Report. City of Pasco – Pasco, Washington. Cascade Earth Sciences. Spokane Valley, Washington. April 24, 2018.

Table 7. Average Annual Process Water Mass Loads

Flow	Total N	TKN	BOD_5	FDS
million gallons	pounds			
690.6	309,600	306,100	19,525,000	3,240,900

NOTES:
Mass loadings calculated using the annual average total irrigated flow and the average constituent concentrations during the previous five operational years 2014-2017. Flow values from the 2016 operational year are not included due to flow meter malfunction.
Calculation: flow (million gallons) x concentration (milligrams per liter) x 8.34 million pounds per million gallons.
Abbreviations: BOD_5 = five-day biochemical oxygen demand, FDS = fixed dissolved solids, TKN = total Kjeldahl nitrogen, Total N = total nitrogen (TKN + nitrite-nitrogen + nitrate-nitrogen).

Table 8. Irrigation Fresh Water Quality

Well	Circle [1]	TDS	NO_3-N	EC [2]
		mg/L		µmhos/cm
IW-1	1	374	11.7	584
IW-2	2	446	12.2	697
IW-3	3	397	13.5	620
IW-4	4	386	12.1	603
IW-5	5	426	11.0	666
IW-6,9	6 - 15	562	23.2	878
IW-7	6 - 15	562	23.2	878
IW-8,10	6 - 15	562	23.2	878
IW-11,13	6 - 15	562	23.2	878
IW-12	6 - 15	562	23.2	878
IW-15	6 - 15	562	23.2	878
Flow Weighted Average		**502**	**18.9**	**784**

NOTES:

Supplemental irrigation water (fresh water) was sampled on August 17, 2018 from the individual City of Pasco wells.

Abbreviations: EC = electrical conductivity, mg/L = milligrams per liter, NO_3-N = nitrate-nitrogen, TDS = total dissolved solids, µmhos/cm = micromhos per centimeter.

1 Circles served from corresponding wells. Well quality for IW-6 through IW-15 is not tracked separately. Average constituent values are presented for IW-6 through IW-15 for the for the purpose of this report.

2 EC = calculated assuming the relationship of EC = TDS ÷ 0.64 (US Salinity Lab Staff, 1954. Diagnosis and Improvement of Saline and Alkali Soils. U.S. Govt Printing Office, Wash. D.C.).

Table 9. Crop Rotations

Circle [1]	Acres	2013	2014	2015	2016	2017	Design Basis Crop Rotation [2]
1	122	Alfalfa	Alfalfa	Alfalfa	Triticale / Corn	Potato / Alfalfa	Alfalfa
2	152	Alfalfa	Alfalfa / Corn	Potato / Alfalfa	Alfalfa	Alfalfa	Potato / Alfalfa
3	128	Alfalfa	Alfalfa	Alfalfa / Corn	Potato / Alfalfa	Alfalfa	Alfalfa / Corn
4	128	Alfalfa	Potato / Alfalfa	Alfalfa	Alfalfa	Wheat / Buckwheat	Alfalfa
5	128	Potato / Alfalfa	Alfalfa	Alfalfa	Alfalfa	Alfalfa / Corn	Alfalfa
6	128	Potato / Alfalfa	Alfalfa	Alfalfa	Alfalfa	Potato / Alfalfa	Alfalfa
7	152	Alfalfa / Corn	Potato / Alfalfa	Alfalfa	Alfalfa	Alfalfa / Corn	Potato / Alfalfa
8	128	Triticale / Corn	Corn	Potato / Alfalfa	Alfalfa	Alfalfa	Alfalfa / Corn
9	128	Potato / Alfalfa	Alfalfa	Alfalfa	Alfalfa / Corn	Potato / Alfalfa	Alfalfa
10	128	Triticale / Corn	Potato / Alfalfa	Alfalfa	Alfalfa	Alfalfa / Corn	Alfalfa
11	150	Alfalfa	Alfalfa / Corn	Potato / Alfalfa	Alfalfa	Alfalfa	Triticale / Corn
12	128	Alfalfa	Alfalfa	Alfalfa	Alfalfa / Corn	Potato / Alfalfa	Alfalfa / Corn
13	128	Alfalfa	Alfalfa	Alfalfa	Potato / Alfalfa	Alfalfa	Alfalfa
15	128	Alfalfa	Alfalfa	Timothy / Corn	Potato / Alfalfa	Alfalfa	Alfalfa
Total	**1,856**						
Summary by Crop (acres)							
Alfalfa		1,064	1,018	1,170	1,094	814	1,018
Alfalfa / Corn		152	302	128	256	408	384
Triticale / Corn		256	0	0	122	0	150
Potato / Alfalfa		384	408	430	384	506	304
Other		0	128	128	0	128	0

NOTES:

Cropping information obtained from the Annual Farm Operations Reports. Where two crops are listed together, the first crop is grown and harvested followed by planting and harvest of the second crop, except for the crop after potatoes, which is planted but not harvested until the following growing season.

1 Circle 2 is Circle 2 plus Little Circle 2. Circle 7 is Circle 7 plus Little Circle 7.

2 Design basis crop rotation is the most limiting projected crop mixture used to calculate the limiting design basis capacity for the land treatment site.

Sources:

CES, 2014. 2014 Farm Operations Report. City of Pasco – Pasco, Washington. Cascade Earth Sciences. Spokane, Washington. April 23, 2014.

CES, 2015. 2015 Farm Operations Report. City of Pasco – Pasco, Washington. Cascade Earth Sciences. Spokane, Washington. April 24, 2015.

CES, 2016. 2016 Farm Operations Report. City of Pasco – Pasco, Washington. Cascade Earth Sciences. Spokane, Washington. April 22, 2016.

CES, 2017. 2017 Farm Operations Report. City of Pasco – Pasco, Washington. Cascade Earth Sciences. Spokane Valley, Washington. April 25, 2017.

CES, 2018. 2018 Farm Operations Report. City of Pasco – Pasco, Washington. Cascade Earth Sciences. Spokane Valley, Washington. April 24, 2018.

Table 10. Crop Planting, Harvest, and Nitrogen Management

Crop	Planting Month	Number of Harvest(s) - Harvest Month(s)	Expected Yield	Crop Nitrogen	
				Removal [1]	Capacity [2]
			tons/ac/yr	lb/ac/yr	
Alfalfa	September to Early October	3 to 4 harvests - May, June/July, July/August, September	7.5	437	510
Alfalfa/Corn	Established/May	May/October	14	295	340
Corn	March or April	October	8.6	216	250
Potato	April	September	30.1	195	230
Triticale/Silage Corn	September/May	May/October	22.6	261	300
Wheat	March	August	4.0	176	200

NOTES:

Planting and harvest months, expected yield, and crop nitrogen are based on City of Pasco records.

Abbreviations: % = percentage, lb/ac/yr = pounds per acre per year, mg/L = milligrams per liter, TKN = total Kjeldahl nitrogen, tons/ac/yr = tons per acre per year.

1 Crop nitrogen removal represents the average removal rate expected.

2 Nitrogen capacity is the crop nitrogen need increased to account for net available process water nitrogen after volatilization and denitrification losses.
Nitrogen need = crop nitrogen removal ÷ 0.86. Available nitrogen of 86% is calculated using rates based on recommendations in Meisinger and Randall (1991).
Formula: [((TKN - ammonia-nitrogen) + (ammonia-nitrogen x 0.80) + (nitrate-nitrogen)) * 0.96] ÷ (TKN + nitrate-nitrogen)
Calculation: [((54 mg/L - 27 mg/L) + (27 mg/L x 0.80) + (1.0 mg/L)) * 0.96] ÷ (54 mg/L + 1.0 mg/L)

Source:

Meisinger, J.J. and G.W. Randall, 1991. Estimating Nitrogen Budgets for Soil-Crop Systems, Ch 5. p. 85-124. In: R. F. Follett, D. R. Keeney, and R. M. Cruse, Editors. Managing Nitrogen for Groundwater Quality and Farm Profitability. Soil Science Society of America. Madison, Wisconsin.

Table 11. Summary of Circle-Specific Monthly Soil Hydraulic Budgets - Annual Totals

Circle [1]	Acres	Crop [2]	Gross Precip [3]	Gross Irrigation [4]			Net Irrigation [5]	Evapotranspiration [6]		Leaching	
				Process	Fresh	Total		Potential	Estimated	LF [7]	LR [8]
			inches			MG	inches			percent	
1	122	Alfalfa	8.3	40.5	17.5	192	52.3	53.5	50.8	1.6	11.1
2	152	Potato / Alfalfa	8.3	6.1	34.4	167	37.6	37.0	36.0	3.6	7.1
3	128	Alfalfa / Corn	8.3	28.0	12.8	142	39.0	42.3	38.0	2.3	10.5
4	128	Alfalfa	8.3	41.2	12.0	185	48.9	53.5	47.6	1.7	11.6
5	128	Alfalfa	8.3	41.8	13.0	191	50.1	53.5	49.1	1.6	11.7
6	128	Alfalfa	8.3	31.8	26.5	203	51.8	53.5	50.8	1.6	11.2
7	152	Potato / Alfalfa	8.3	6.3	27.1	138	32.6	37.0	32.8	5.0	8.4
8	128	Alfalfa / Corn	8.3	17.3	25.0	147	39.8	42.3	38.8	2.1	10.0
9	128	Alfalfa	8.3	34.6	22.0	197	51.5	53.5	50.4	1.7	11.5
10	128	Alfalfa	8.3	35.2	20.0	192	51.8	53.5	50.8	1.8	11.6
11	150	Triticale / Corn	8.3	18.6	16.5	143	34.6	38.0	33.5	2.9	10.2
12	128	Alfalfa / Corn	8.3	22.5	17.0	137	38.1	42.3	37.2	2.2	10.6
13	128	Alfalfa	8.3	36.8	17.0	187	48.8	53.5	47.6	1.8	11.8
15	128	Alfalfa	8.3	38.3	14.0	182	47.6	53.5	46.8	1.7	12.0
Average			**8.3**	**28.5**	**19.6**	**171.5**	**44.6**	**47.7**	**43.6**	**2.3**	**10.6**
Total (MG)			**416**	**1,399**	**1,002**	**2,402**	**2,228**	**2,381**	**2,177**		

NOTES:

Abbreviations: LF = leaching fraction, LR = leaching requirement, MG = million gallons, Precip = precipitation.

1 Circle 2 is Circle 2 plus Little Circle 2. Circle 7 is Circle 7 plus Little Circle 7.

2 Design basis crop rotation.

3 The gross precipitation is based on monthly precipitation from the years with sufficient data from 1995-2016 from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington. The 2nd highest total annual precipitation out of 20 years (8.25 inches from 2015-2016) were normalized in relation to the long term average for each month to create the 10-year return precipitation data for design purposes.

4 Gross irrigation = inches of process and fresh water delivered at the irrigation system discharge point (i.e., sprinkler heads). Total MG = acres x (process + fresh inches) x 27,154 gallons per acre-inch / 1,000,000.

5 Net irrigation = gross irrigation * irrigation efficiency (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

6 Potential evapotranspiration is from the average of available data from 1995-2016 for crops that are grown at the land treatment site from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington. Estimated evapotranspiration calculated from potential evapotranspiration and soil moisture content.

7 Leaching Fraction = percent of gross input estimated to percolate beyond the root zone (total percolate loss / [precipitation + gross irrigation]).

8 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Table 12. Design Basis Hydraulic Capacity

Month	Process Water [1]	Fresh Water	Total
	million gallons		
Nov	50	0	50
Dec	0	0	0
Jan	0	0	0
Feb	0	0	0
Mar	53	0	53
Apr	180	52	232
May	225	129	354
Jun	150	310	460
Jul	201	362	563
Aug	229	121	349
Sep	223	0	223
Oct	89	0	89
Total	**1,399**	**973**	**2,373**

NOTES:

Million gallons calculated from the inches of process and fresh water scheduled to all fields within the monthly soil hydraulic budgets based on the design basis crop rotation.

Hydraulic capacity was developed considering crop irrigation and nitrogen requirements.

1 Potato fields historically have received low amounts of process water nitrogen (~58 lb/ac on average). Therefore, the loads shown above assume potato field loads equivalent to 58 lb/ac to reflect a conservative process water load scenario.

Table 13. Crop Nitrogen Removal and Capacity

Year	2013	2014	2015	2016	2017	Design Basis Crop Rotation [1]
	pounds per year					
Crop Nitrogen Removal [2]						
Crop Removal	673,900	658,800	651,700	689,700	541,600	656,800
Site Gross Nitrogen Capacity [3]						
Gross Capacity	783,600	766,000	757,800	802,000	629,800	763,700

NOTES:

All values rounded to the nearest hundred.

Abbreviations: lb/ac = pounds per acre, mg/L = milligrams per liter, TKN = total Kjeldahl nitrogen.

1 Design basis crop rotation is the most limiting projected crop mixture resulting in the limiting design basis capacity for the land treatment site.

2 Crop nitrogen removal calculated from crop yield and crop tissue nitrogen concentration data from the City of Pasco records.

3 Site gross nitrogen capacity is crop nitrogen removal increased to account for net available process water nitrogen after volatilization and denitrification losses.
Site gross nitrogen capacity = crop nitrogen removal ÷ 0.86. Available nitrogen of 86% is calculated using rates based on recommendations in Meisinger and Randall (1991).
Formula: [((TKN - ammonia-nitrogen) + (ammonia-nitrogen x 0.80) + (nitrate-nitrogen)) * 0.96] ÷ (TKN + nitrate-nitrogen)
Calculation: [((53 mg/L - 29 mg/L) + (29 mg/L * 0.80) + (1.0 mg/L)) * 0.96] ÷ (53 mg/L + 1.0 mg/L)
Ammonia-nitrogen assumed at approximately 55 percent of TKN based on similar food process wastewater and limited conversion of TKN to ammonia-nitrogen.

Source:

Meisinger, J.J. and G.W. Randall, 1991. Estimating Nitrogen Budgets for Soil-Crop Systems, Ch 5. p. 85-124. In: R. F. Follett, D. R. Keeney, and R. M. Cruse, Editors. Managing Nitrogen for Groundwater Quality and Farm Profitability. Soil Science Society of America. Madison, Wisconsin.

Table 14. Design Basis Nitrogen Capacity and Operational Analysis

Circle [1]	Process Water [2]	Fresh Water [3]	Total Load [4]	Capacity [5]
	pounds nitrogen			
1	54,304	5,444	59,747	61,998
2	9,837	13,901	23,738	34,421
3	38,783	4,820	43,603	43,970
4	57,657	4,050	61,707	65,047
5	58,602	3,989	62,591	65,047
6	44,806	17,149	61,955	65,047
7	10,173	20,826	30,998	34,421
8	24,780	16,178	40,958	43,970
9	48,164	14,237	62,401	65,047
10	49,323	12,943	62,266	65,047
11	29,723	12,513	42,236	45,599
12	30,771	11,001	41,772	43,970
13	51,306	11,001	62,307	65,047
15	53,643	9,060	62,703	65,047
Total	**561,871**	**157,112**	**718,983**	**763,676**

NOTES:

Pounds of nitrogen calculated from the inches of process and fresh water scheduled to each field within monthly soil hydraulic budgets based on the projected "Phase II" nitrogen concentration of the process water and the average historical concentration of supplemental fresh irrigation water water, respectively.

Abbreviations: % = percent, lb/ac = pounds per acre, mg/L = milligrams per liter, TKN = total Kjeldahl nitrogen.

1 Circle 2 is Circle 2 plus Little Circle 2. Circle 7 is Circle 7 plus Little Circle 7.

2 Potato fields historically have received small amounts of process water nitrogen (~58 lb/ac on average). Therefore, the loading of potato fields was assumed equivalent to 58 lb/ac to reflect a realistic loading scenario for process water load.

3 Fresh water nitrogen load accounts for an assumed gaseous losses of 4% due to denitrification.

4 Example total operational load is less than capacity due to crop-dependent agronomic irrigation management considerations such as crop dry-down and harvest periods.

5 Capacity is the field by field design basis crop nitrogen removal increased to account for net available process water nitrogen after volatilization and denitrification losses.
Nitrogen need = crop nitrogen removal ÷ 0.86. Available nitrogen of 86% is calculated using rates based on recommendations in Meisinger and Randall (1991).
Formula: [((TKN - ammonia-nitrogen) + (ammonia-nitrogen x 0.80) + (nitrate-nitrogen)) * 0.96] ÷ (TKN + nitrate-nitrogen)
Calculation: [((54 mg/L - 27 mg/L) + (27 mg/L x 0.80) + (1.0 mg/L)) * 0.96] ÷ (54 mg/L + 1.0 mg/L)

Source:

Meisinger, J.J. and G.W. Randall, 1991. Estimating Nitrogen Budgets for Soil-Crop Systems, Ch 5. p. 85-124. In: R. F. Follett, D. R. Keeney, and R. M. Cruse, Editors. Managing Nitrogen for Groundwater Quality and Farm Profitability. Soil Science Society of America. Madison, Wisconsin.

Table 15. Design Basis Annual Mass Loads

Source	Flow	Total N	BOD_5	FDS
	million gallons	pounds		
Process Water [1]	1,399	561,871	8,520,000	8,240,000
Fresh Water [2]	973	157,112	--	3,260,000
Total	2,373	718,983	8,520,000	11,500,000

NOTES:
BOD_5 and FDS rounded to the nearest 10,000 pounds.
Abbreviations: "--" = not calculated, BOD_5 = five-day biochemical oxygen demand,
FDS = fixed dissolved solids, Total N = total nitrogen (TKN + nitrite-nitrogen + nitrate-nitrogen).

1 Process water mass loads calculated using the projected Phase II proccess water constitutent concentrations for Total N (43.4 mg/L), BOD_5 (730 mg/L) , and flow scheduled to each field within the monthly soil hydraulic budgets. The process water FDS mass load was calculated using the average concentration from operational years of 2014-2017 and includes the estimated FDS contribution associated with $Mg(OH)_2$ treatment for process water pH reduction.

2 Fresh water mass loads calculated using the 2018 constituent concentrations for Total N and FDS. No BOD_5 fresh water data is available.

FIGURES

Figure 1. Area Map

0 3500'
1" = 3500'
(SCALE AND LOCATIONS ARE APPROXIMATE)

(SOURCE: Google Earth Pro Image June 2017, ©2017 Google)

PROJECT NUMBER: 2017230014	Land Treatment System Engineering Report PACE Engineers, Inc.
DATE: 8/28/2018	
DWG NO: 2017230014 F1.DWG	City of Pasco Pasco, Washington
DWG BY: 6DJR PROJECT MANAGER: 6SLV	
REVISED:	CES CASCADE EARTH SCIENCES

S:\[Working Drafting]\2017230014 PACE\DWG\Land Treatment System Eng. Report\2017230014 F1.dwg August 28, 2018 DR702784

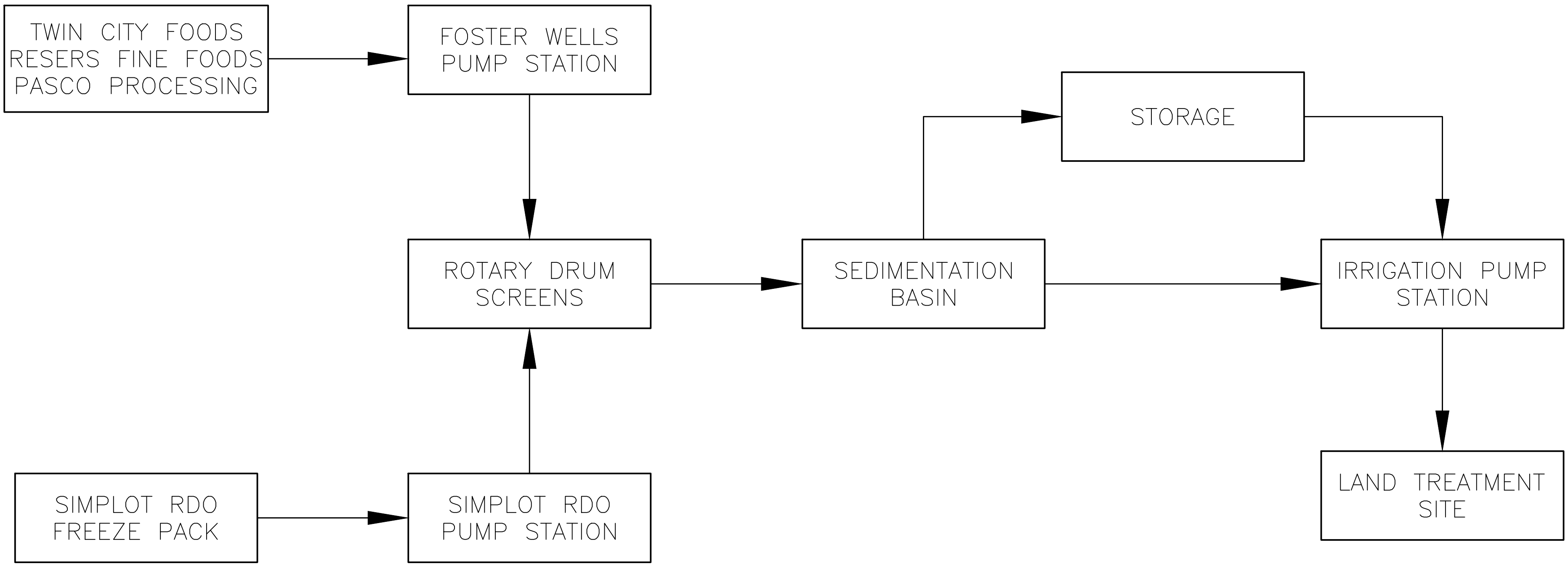


Figure 2. Process Flow Diagram

PROJECT NUMBER: 2017230014 DATE: 8/28/2018	Land Treatment System Engineering Report PACE Engineers, Inc.
DWG NO: 2017230014 F1.DWG DWG BY: 6DJR — PROJECT MANAGER: 6SLV	City of Pasco Pasco, Washinton
REVISED:	CES CASCADE EARTH SCIENCES

2017230014 F1.dwg August 28, 2018 DR702784

EXPLANATION

C01 Land Treatment Circle

Figure 3. Land Treatment Site Map

PROJECT NUMBER: 2017230014	Land Treatment System Engineering Report PACE Engineers, Inc.
DATE: 8/28/2018	
DWG NO: 2017230014 F1.DWG	City of Pasco Pasco, Washington
DWG BY: 6DJR / PROJECT MANAGER: 6SLV	
REVISED:	CES CASCADE EARTH SCIENCES

(SOURCE: Google Earth Pro Image June 2017, ©2017 Google)

S:\[Working Drafting]\2017230014 PACE\DWG\Land Treatment System Eng. Report\2017230014 F1.dwg August 28, 2018 DR702784

EXPLANATION

89 SOIL MAP UNITS AND BOUNDARIES

0 2000'
1" = 2000'
(SCALE AND LOCATIONS ARE APPROXIMATE)

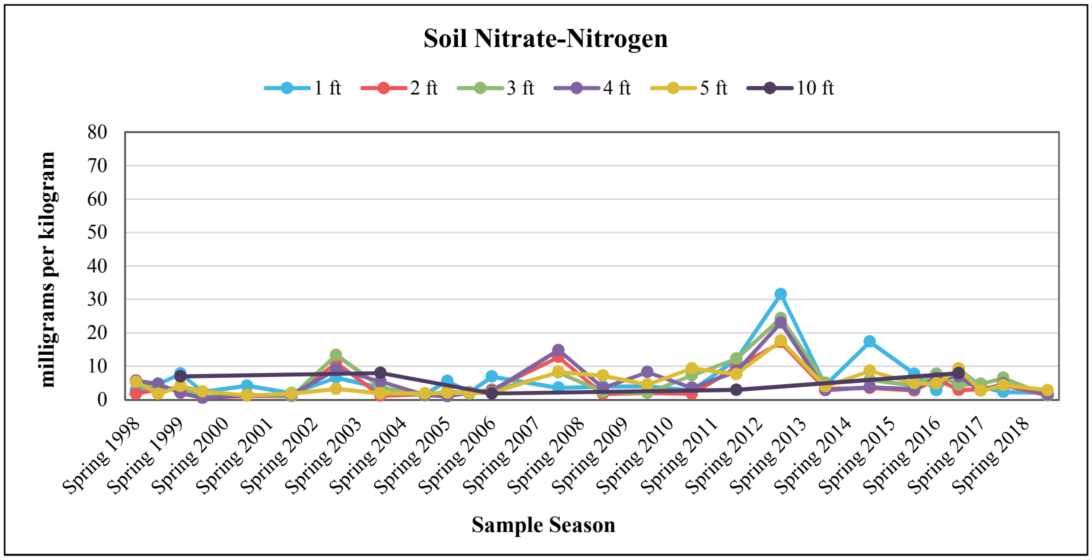
Figure 4. Soil Map

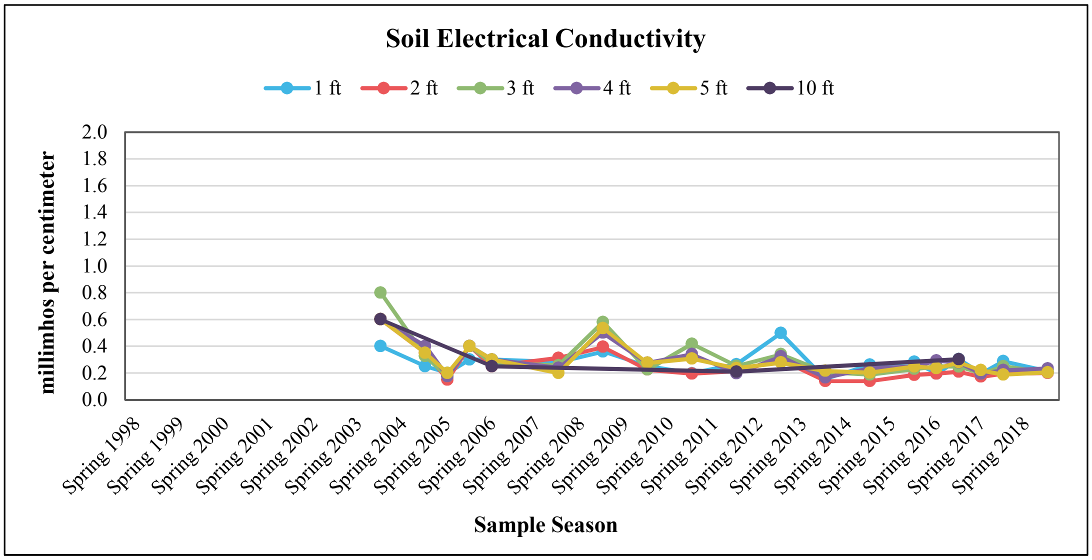
PROJECT NUMBER: 2017230014	Land Treatment System Engineering Report PACE Engineers, Inc.
DATE: 8/28/2018	
DWG NO: 2017230014 F4.DWG	City of Pasco Pasco, Washington
DWG BY: 6DJR / PROJECT MANAGER: 6SLV	
REVISED:	CES CASCADE EARTH SCIENCES

S:\[Working Drafting]\2017230014 PACE\DWG\Land Treatment System Eng. Report\2017230014 F4.dwg August 29, 2018 DR702784

CHARTS

Chart 1. Soil Concentrations - Circle 1





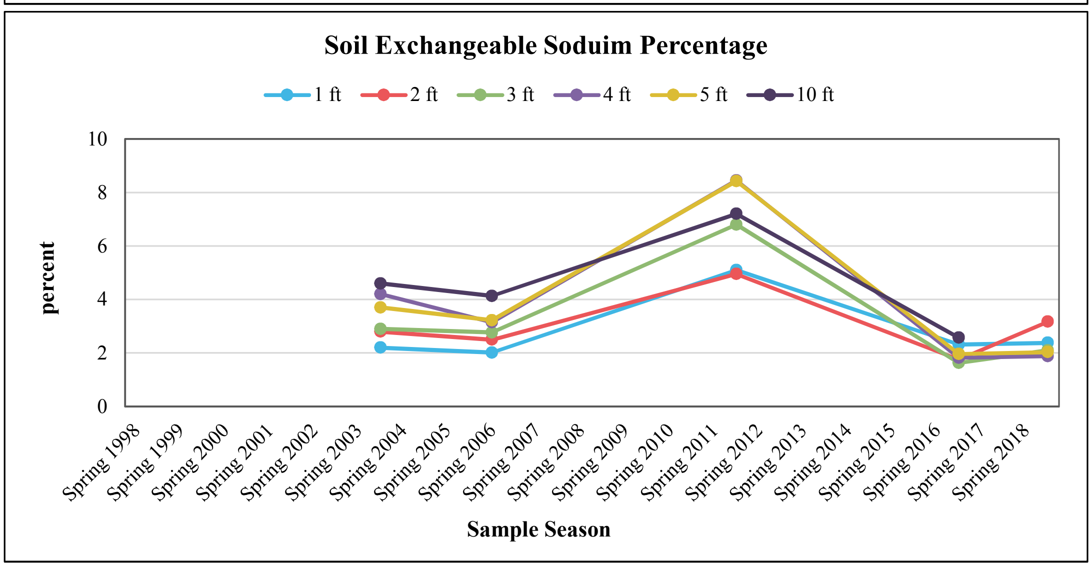
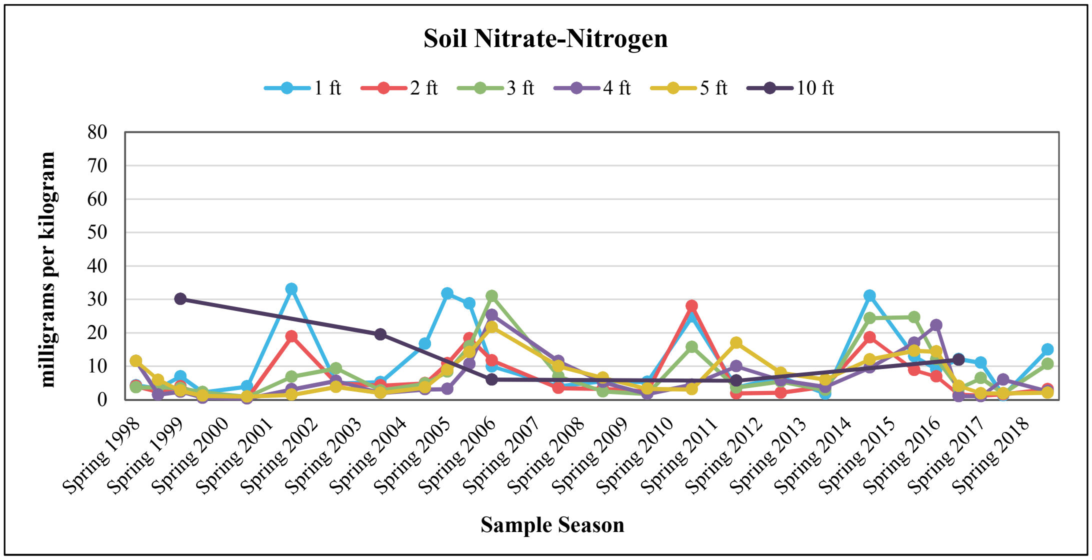
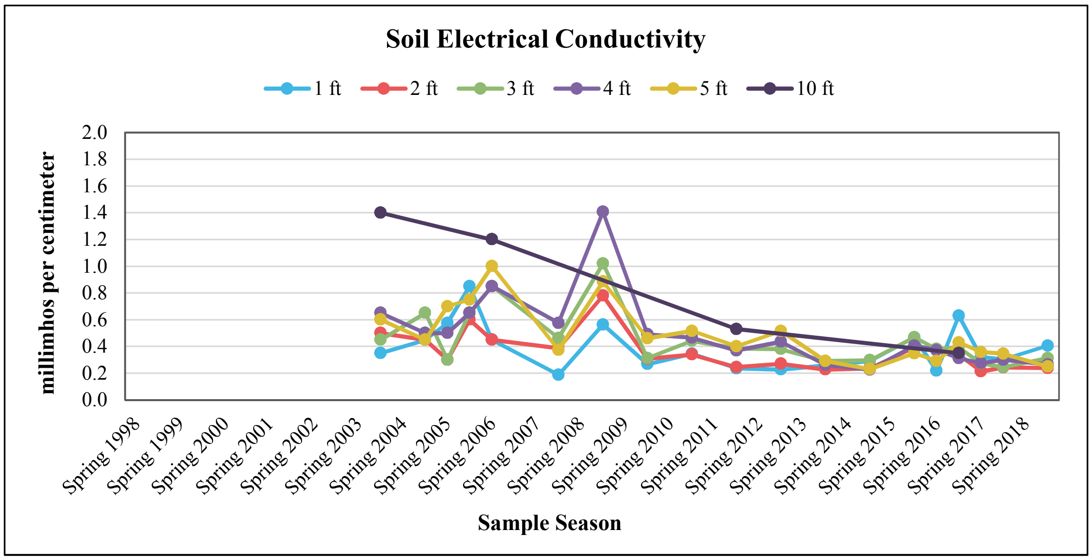


Chart 2. Soil Concentrations - Circle 2





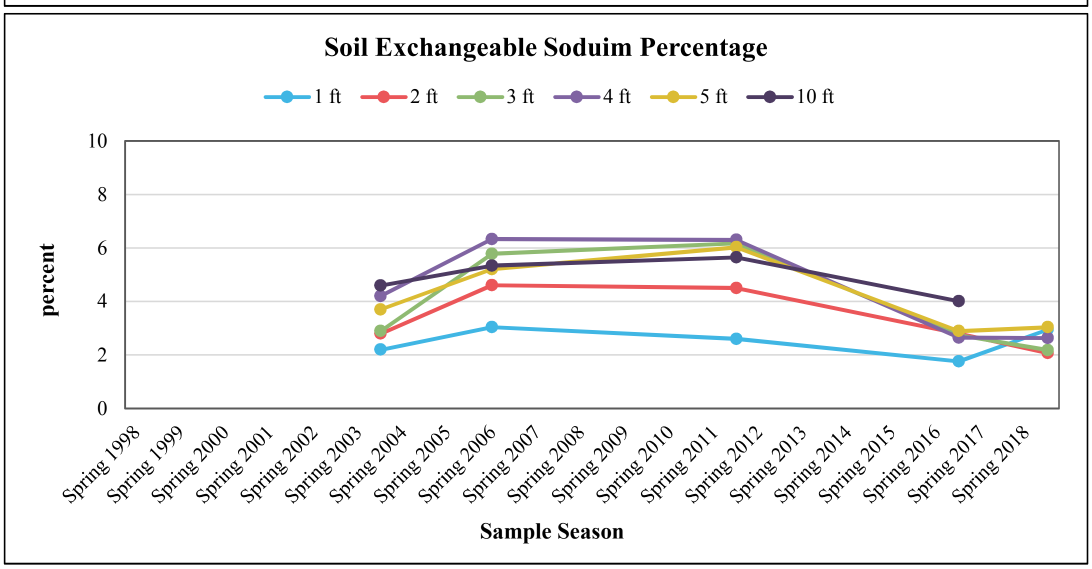
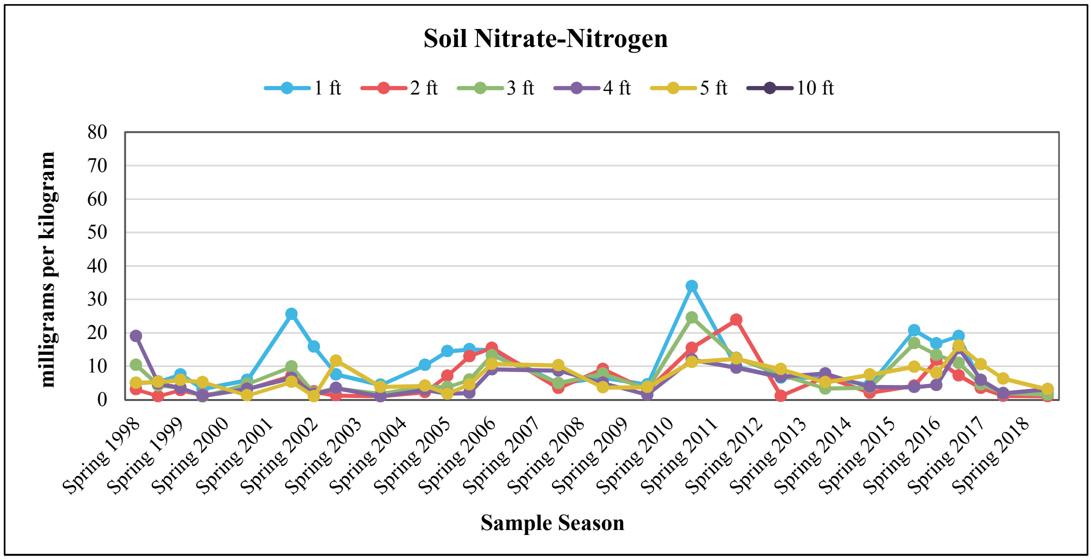
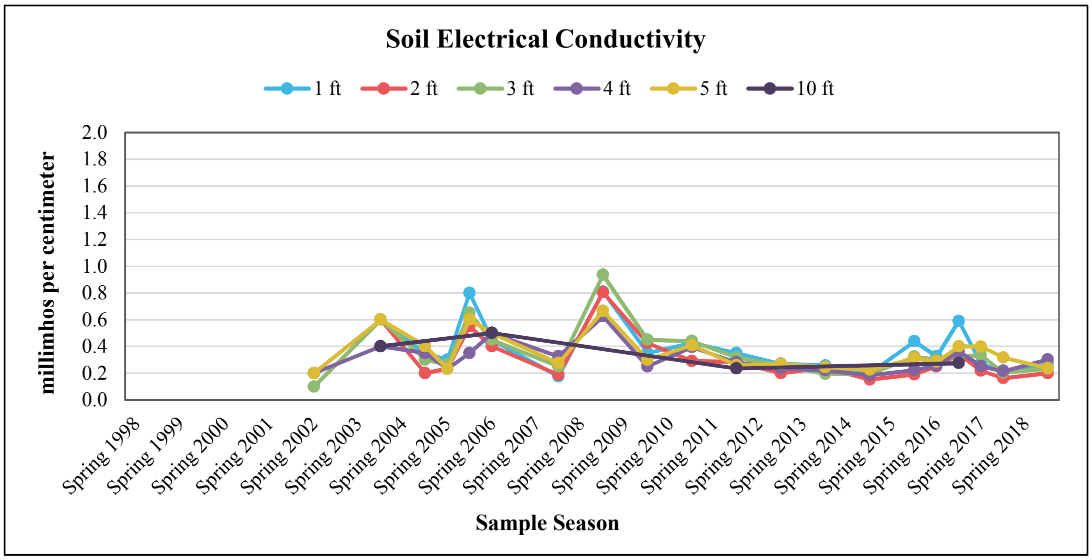


Chart 3. Soil Concentrations - Circle 3





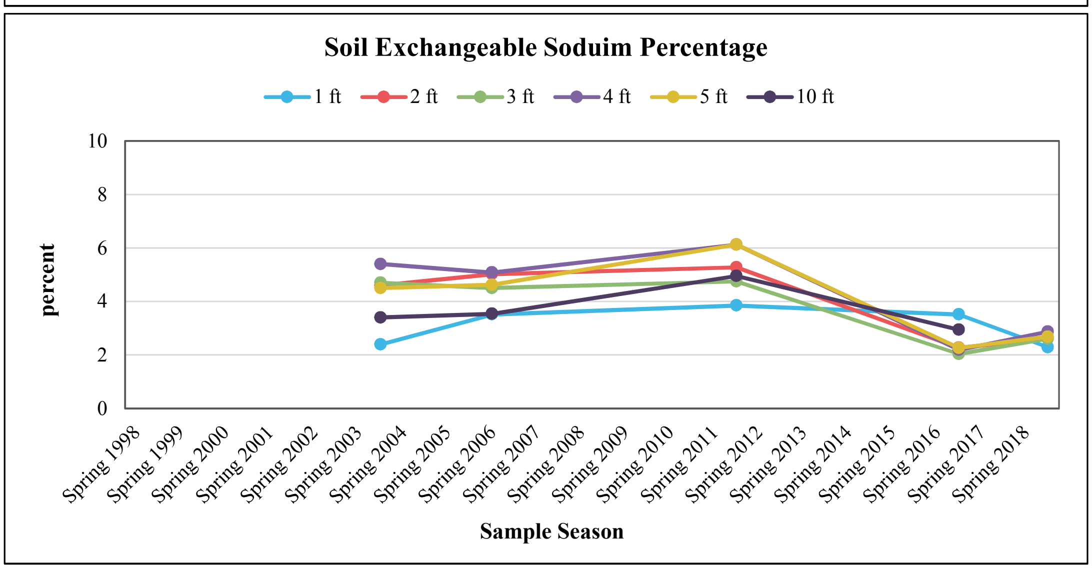
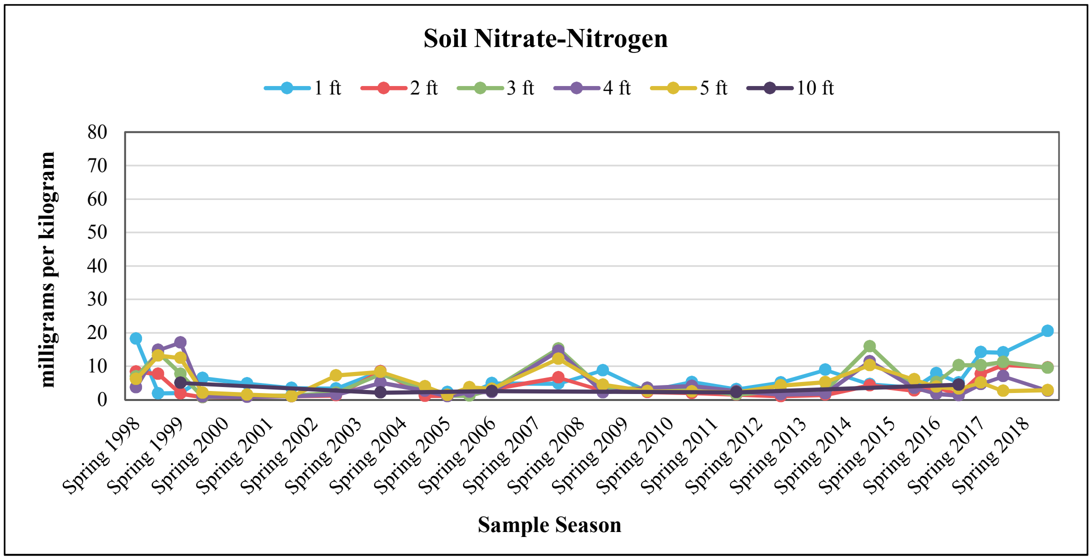
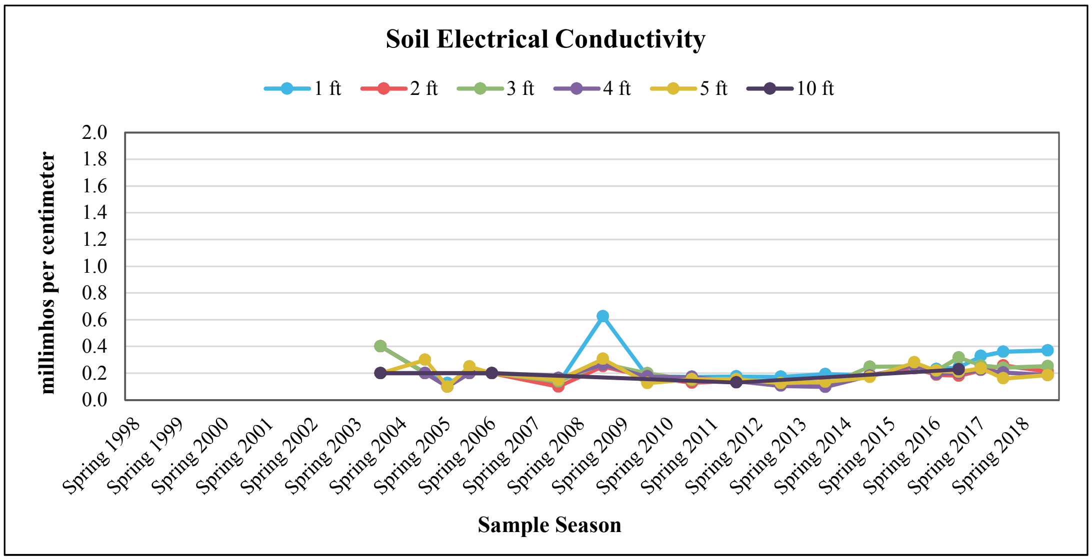


Chart 4. Soil Concentrations - Circle 4





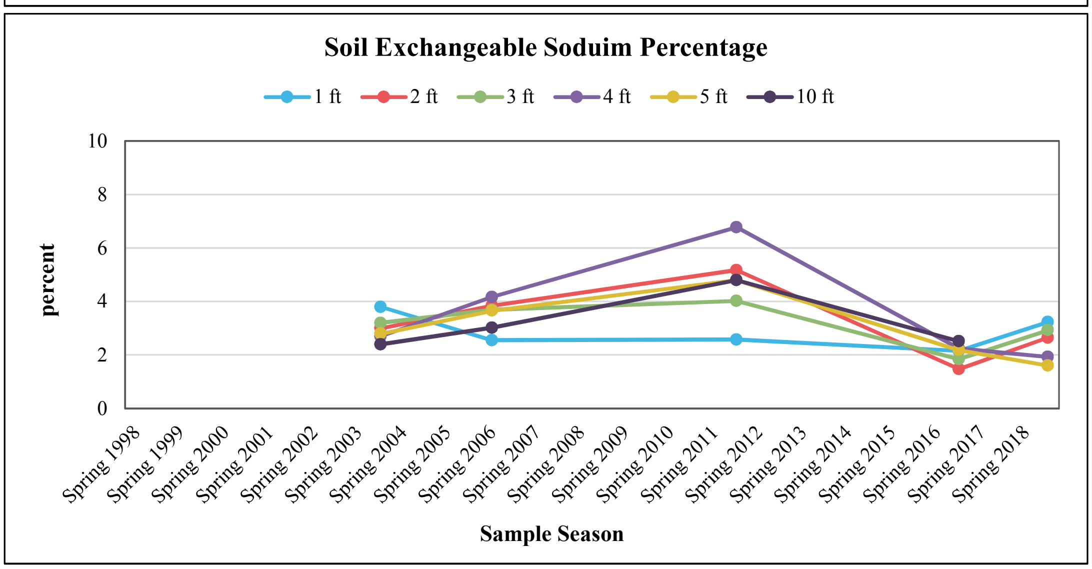
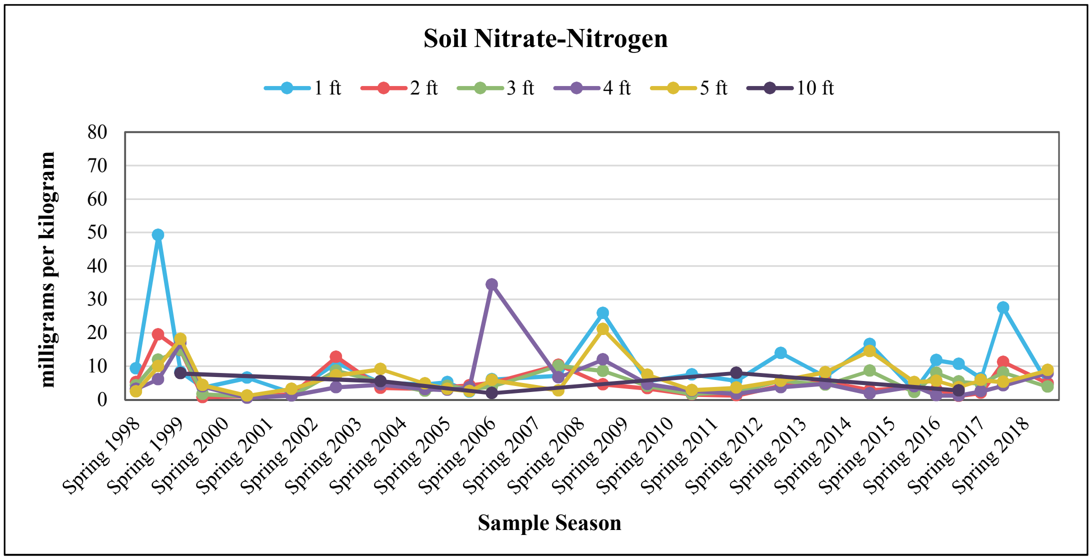
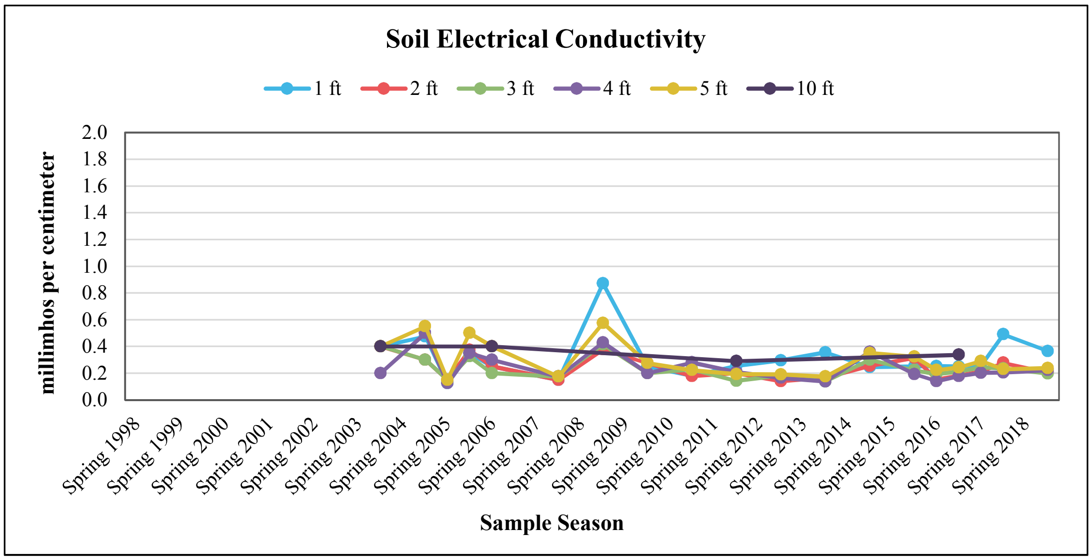


Chart 5. Soil Concentrations - Circle 5





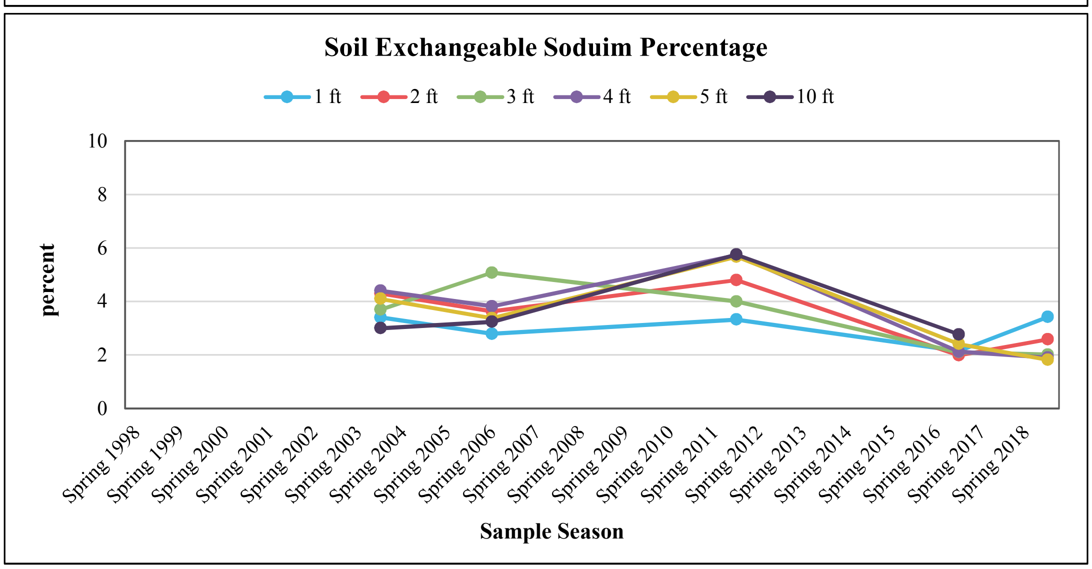
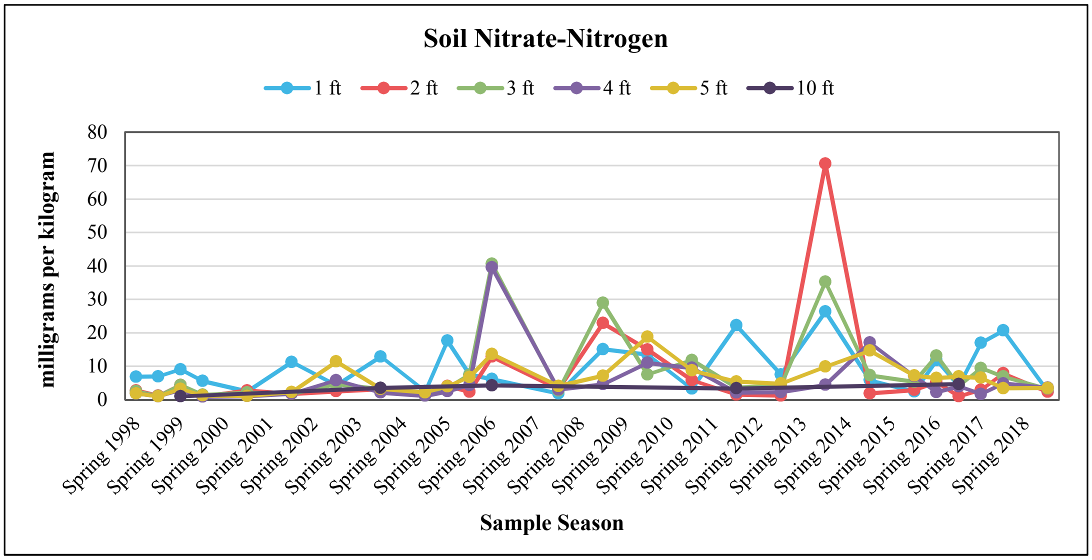
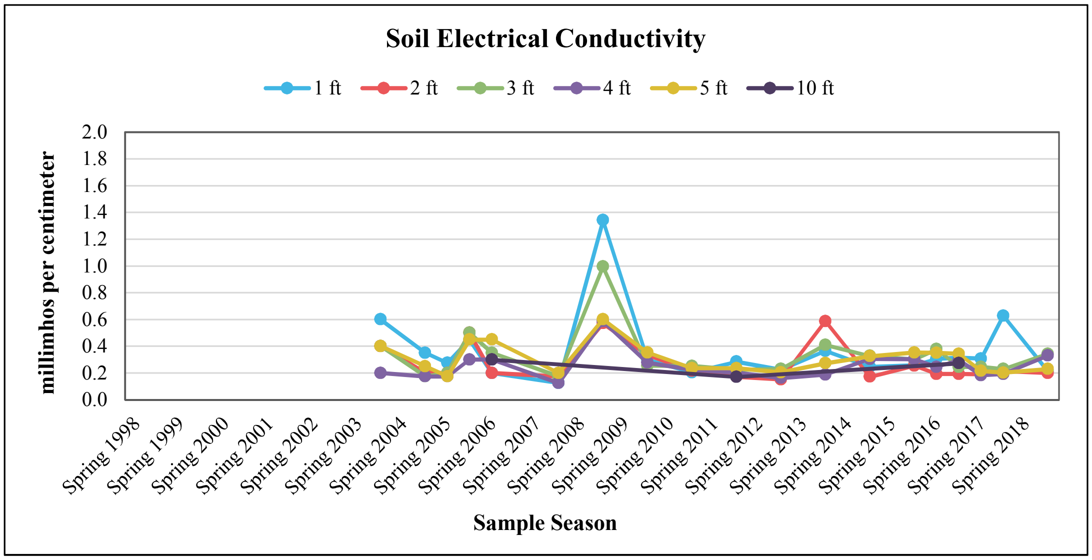


Chart 6. Soil Concentrations - Circle 6





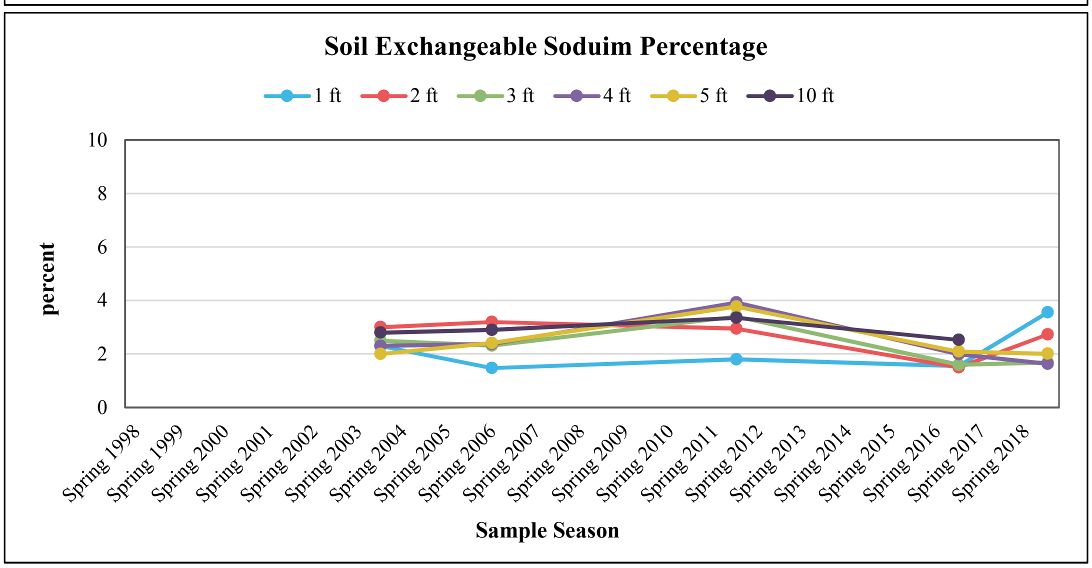
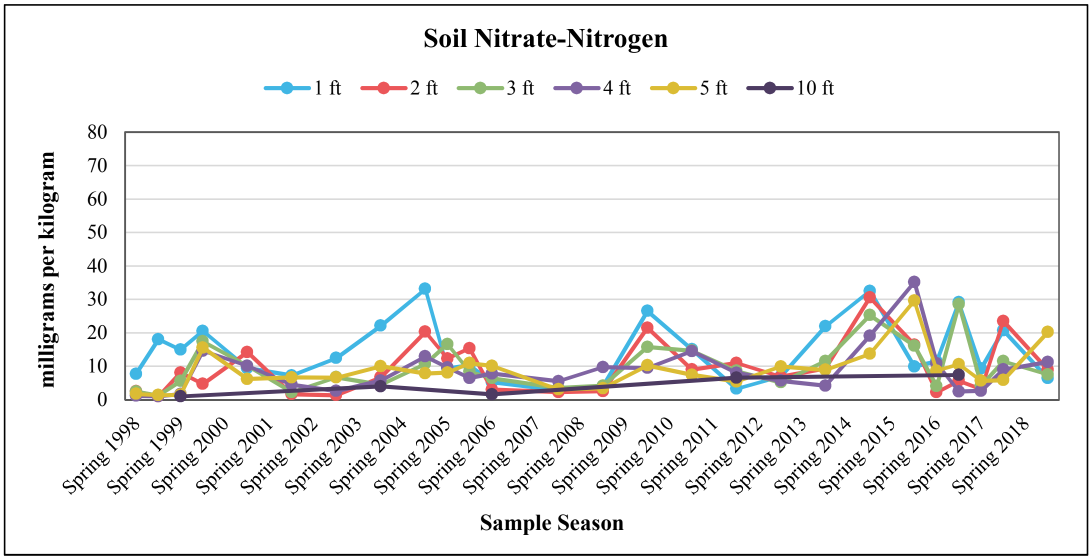
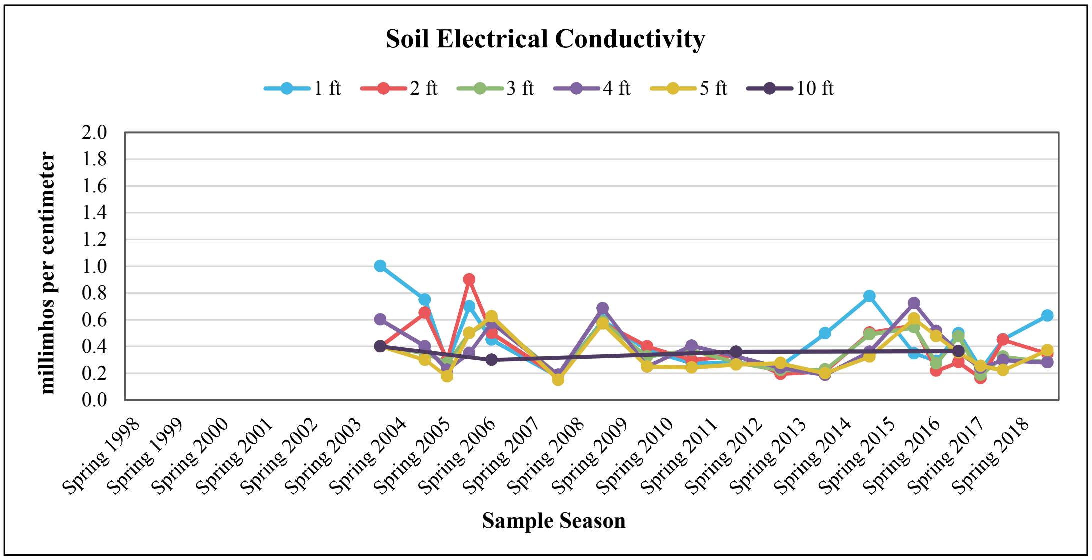


Chart 7. Soil Concentrations - Circle 7





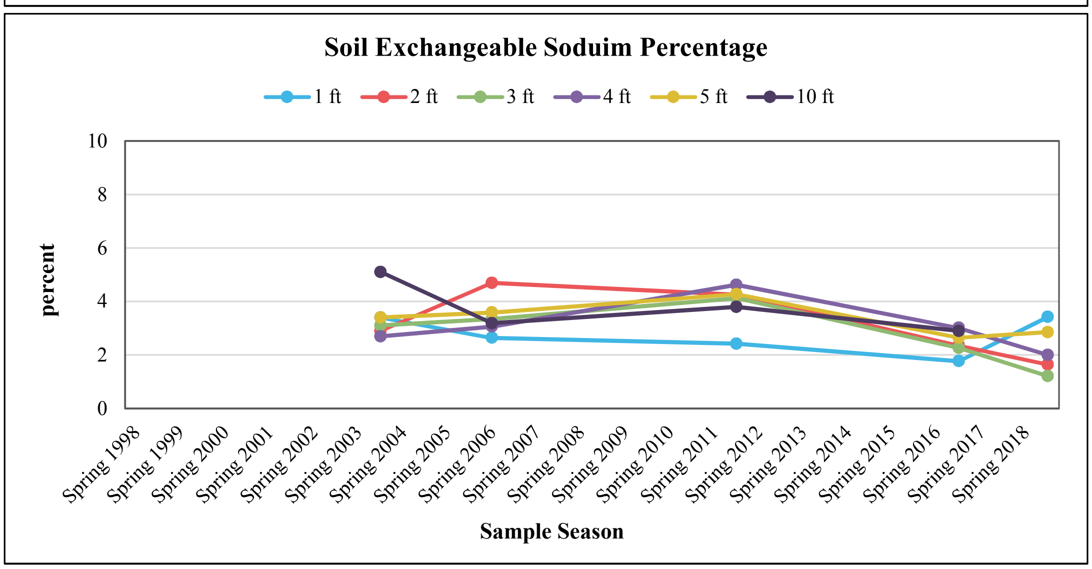
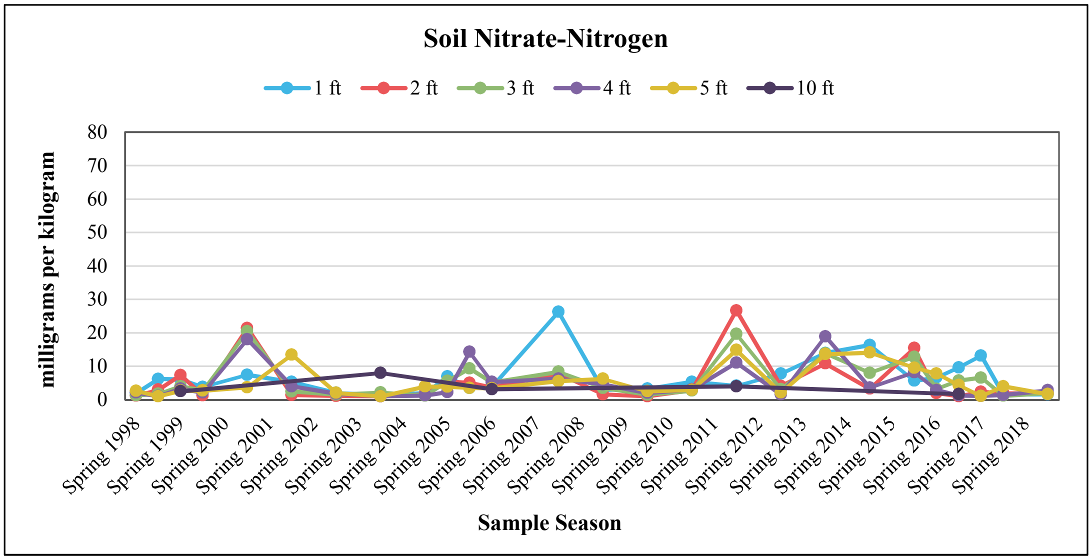
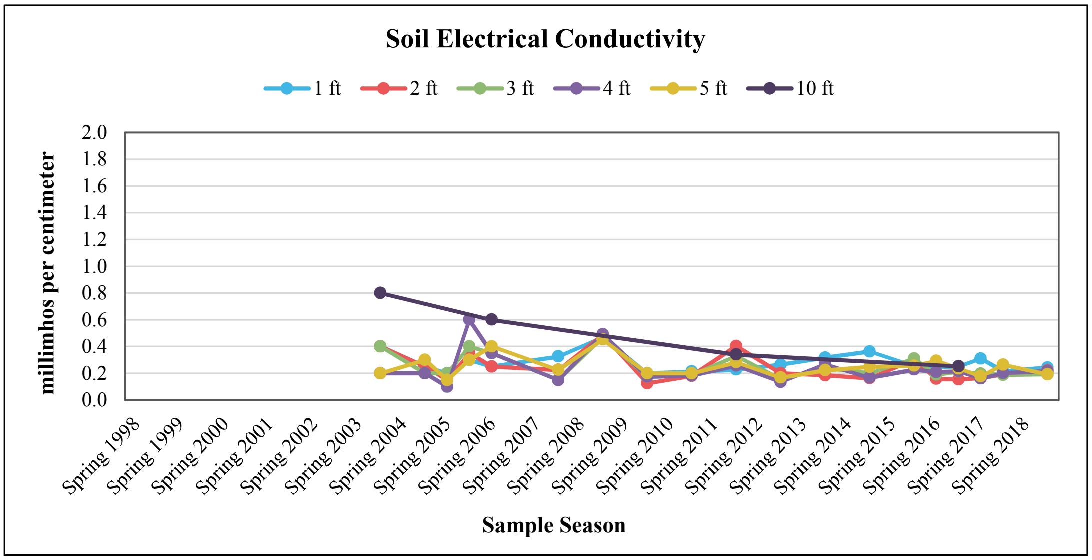


Chart 8. Soil Concentrations - Circle 8





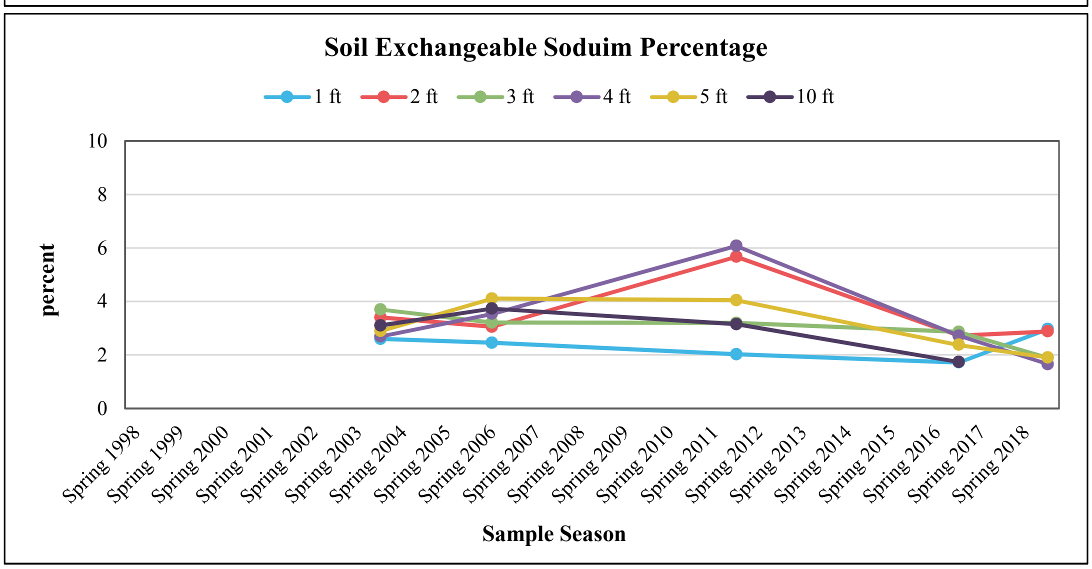
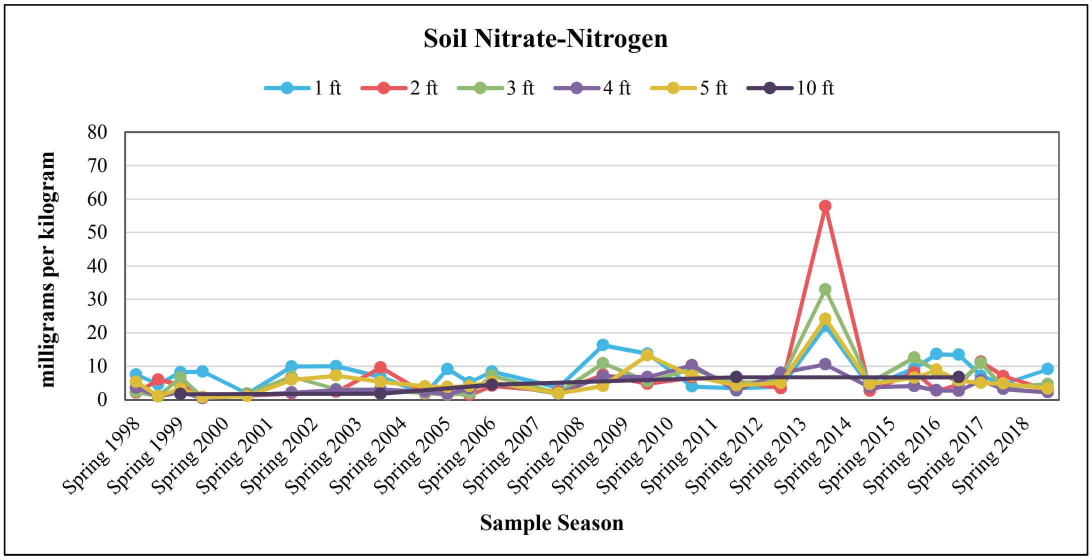
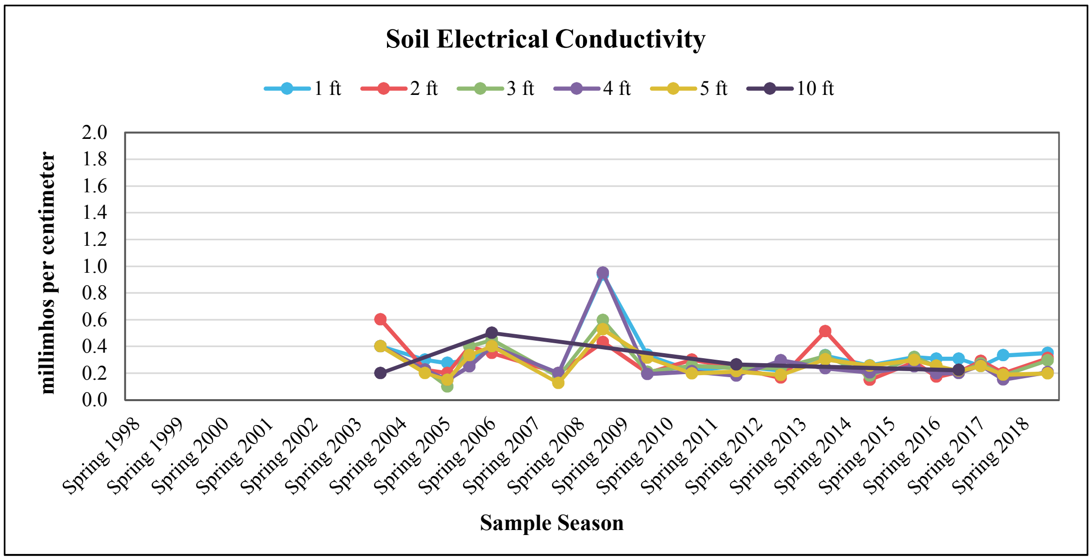


Chart 9. Soil Concentrations - Circle 9





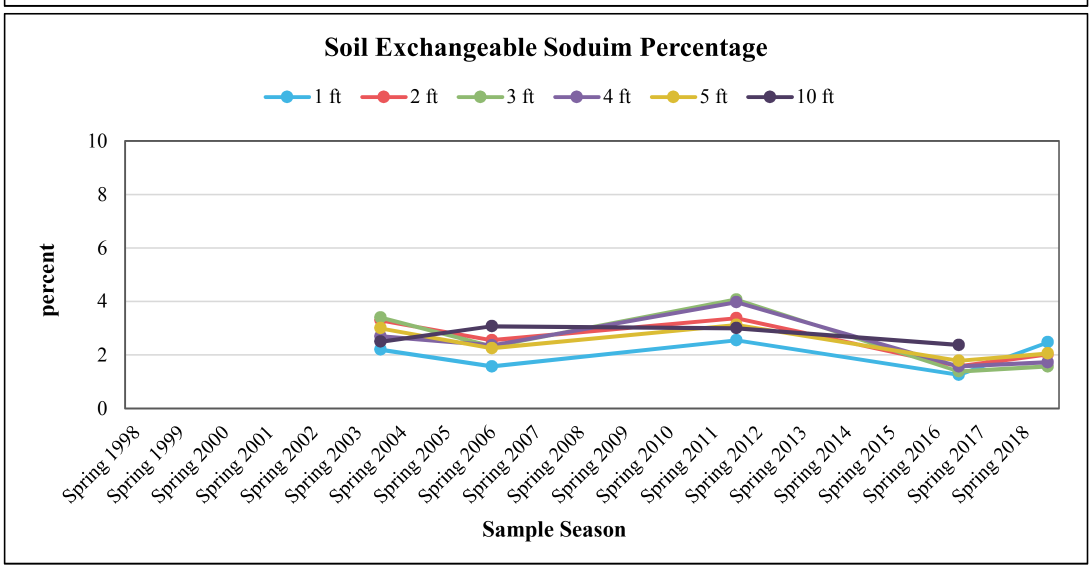
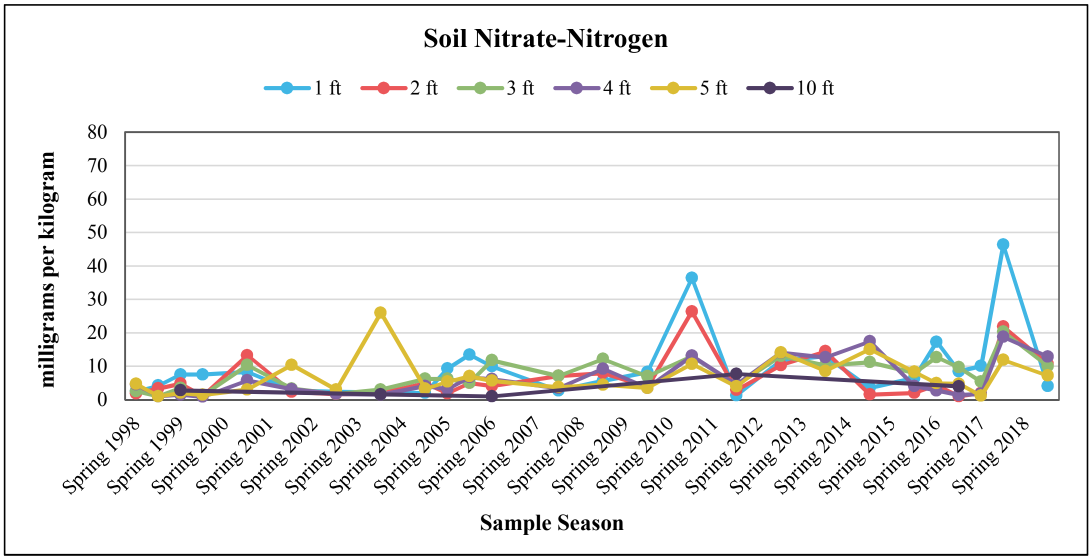
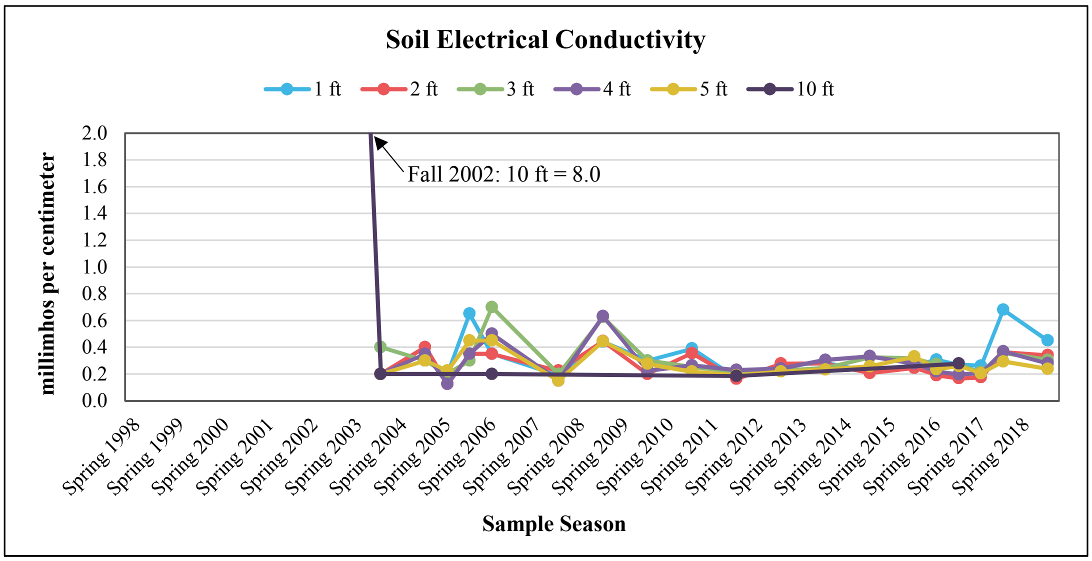


Chart 10. Soil Concentrations - Circle 10





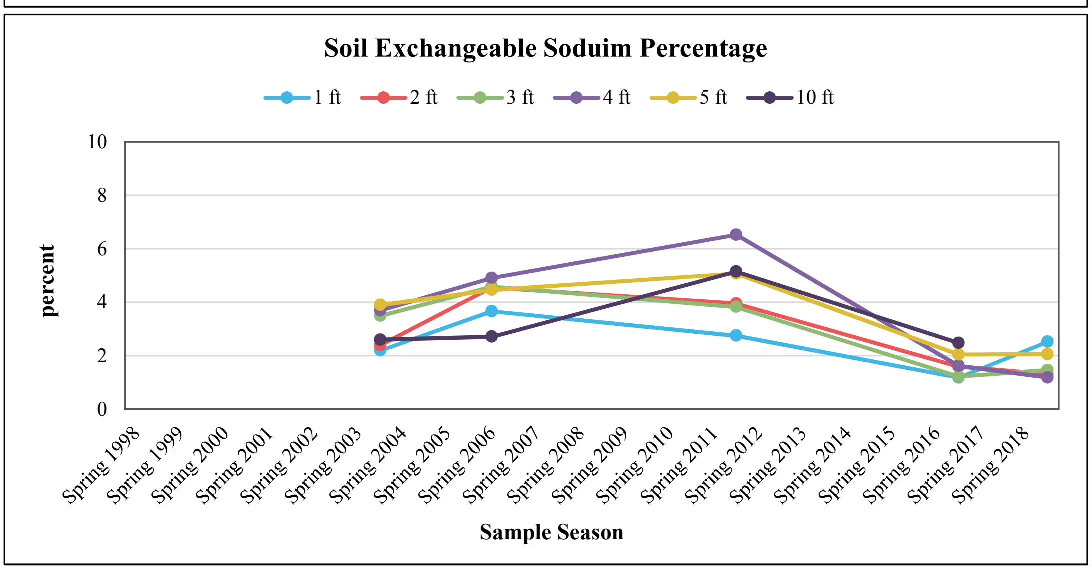
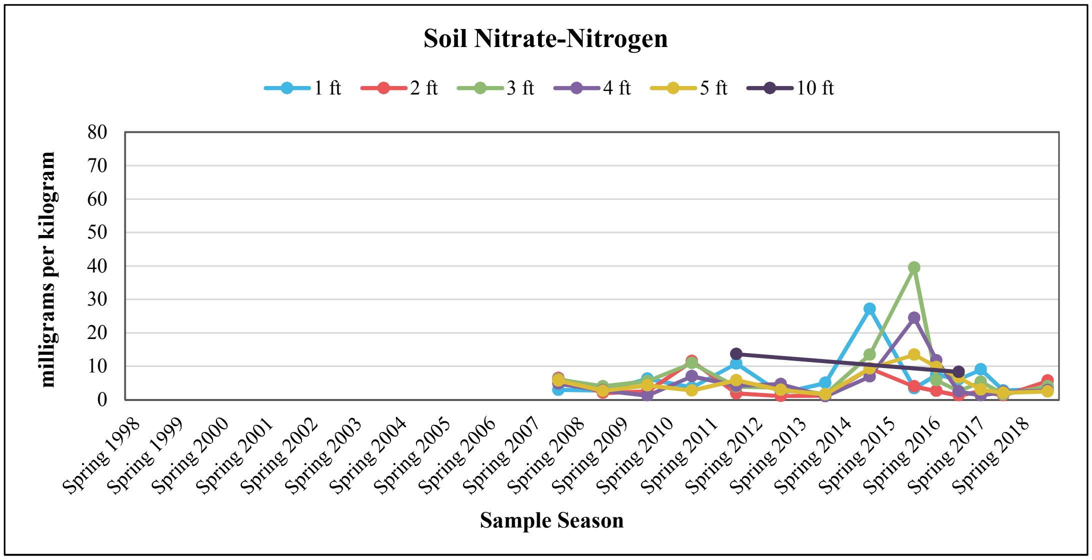
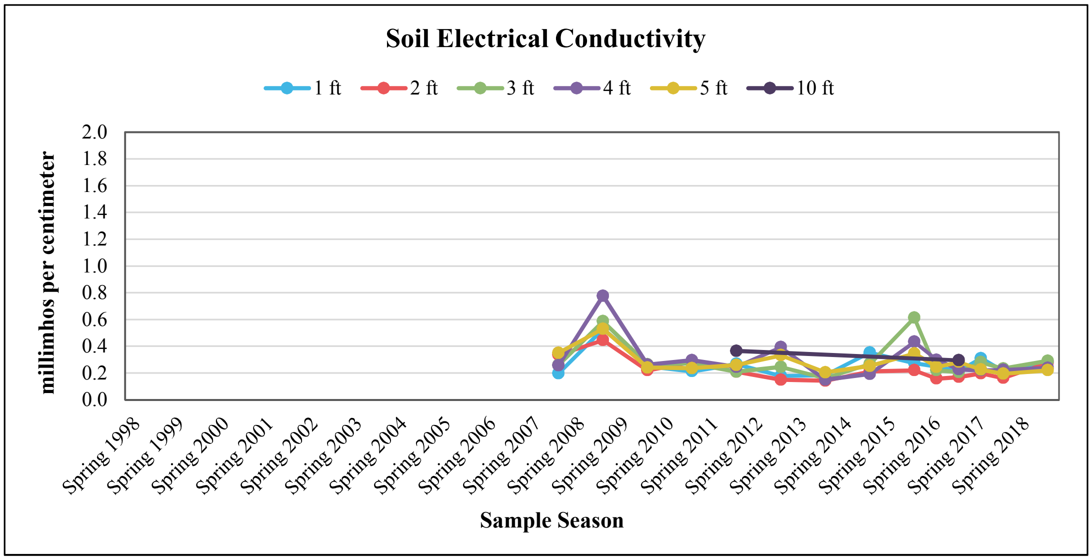


Chart 11. Soil Concentrations - Circle 11





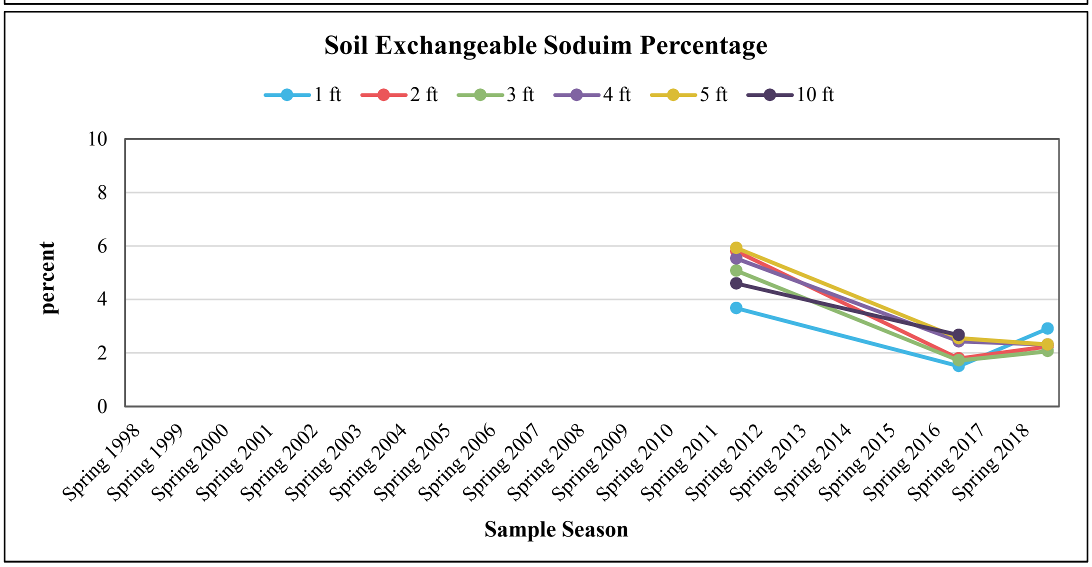
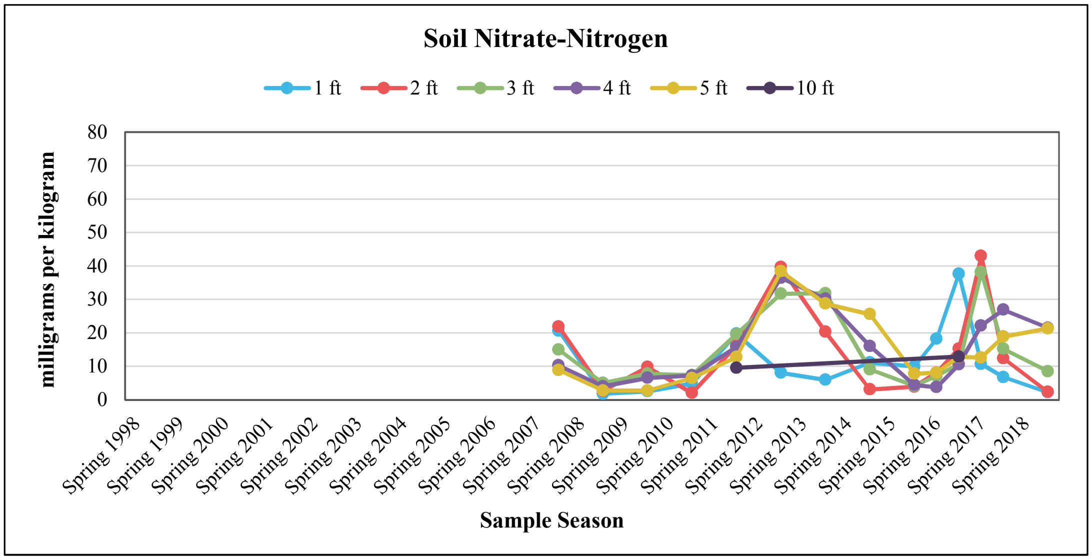
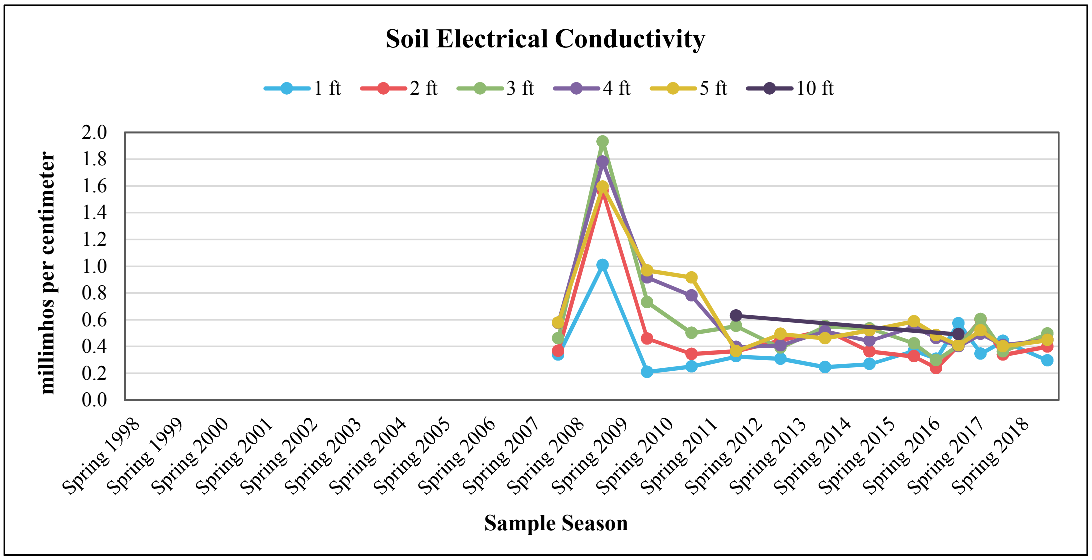


Chart 12. Soil Concentrations - Circle 12





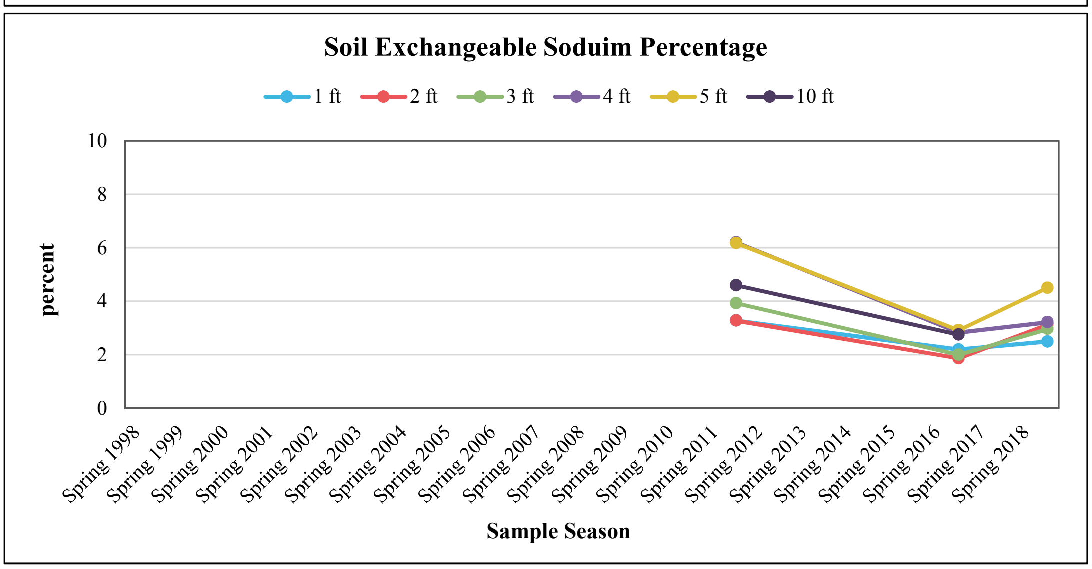
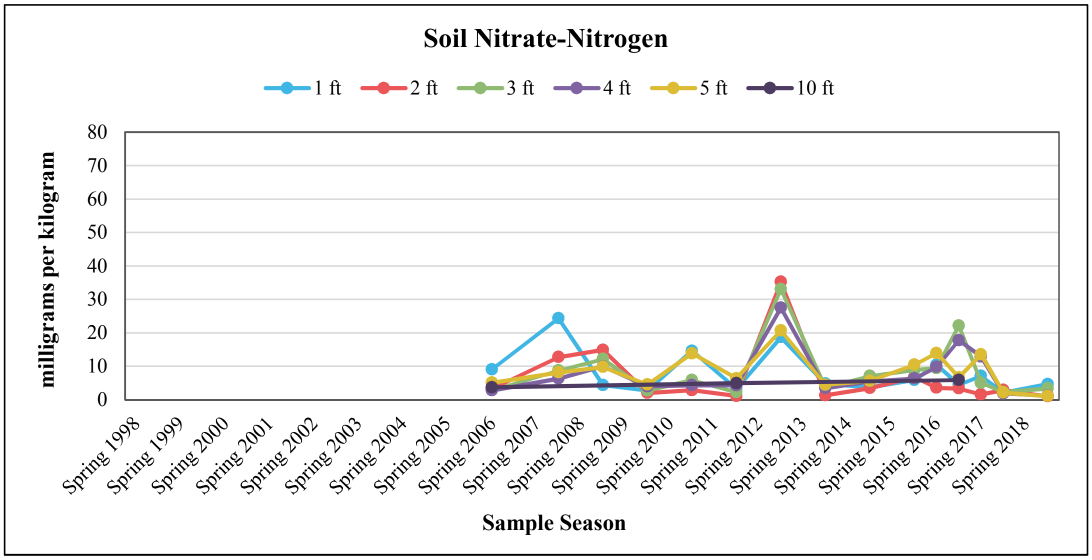
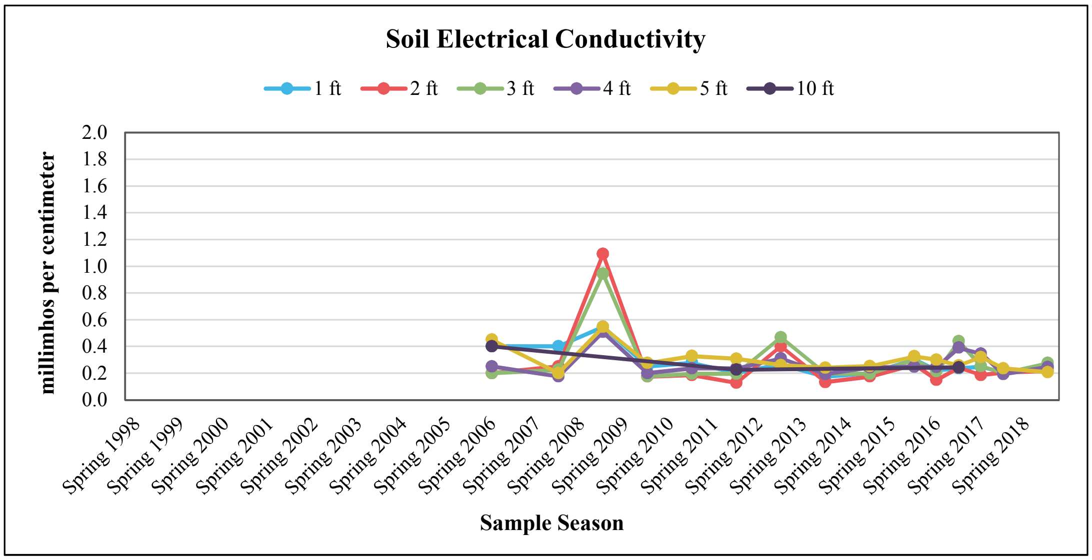


Chart 13. Soil Concentrations - Circle 13





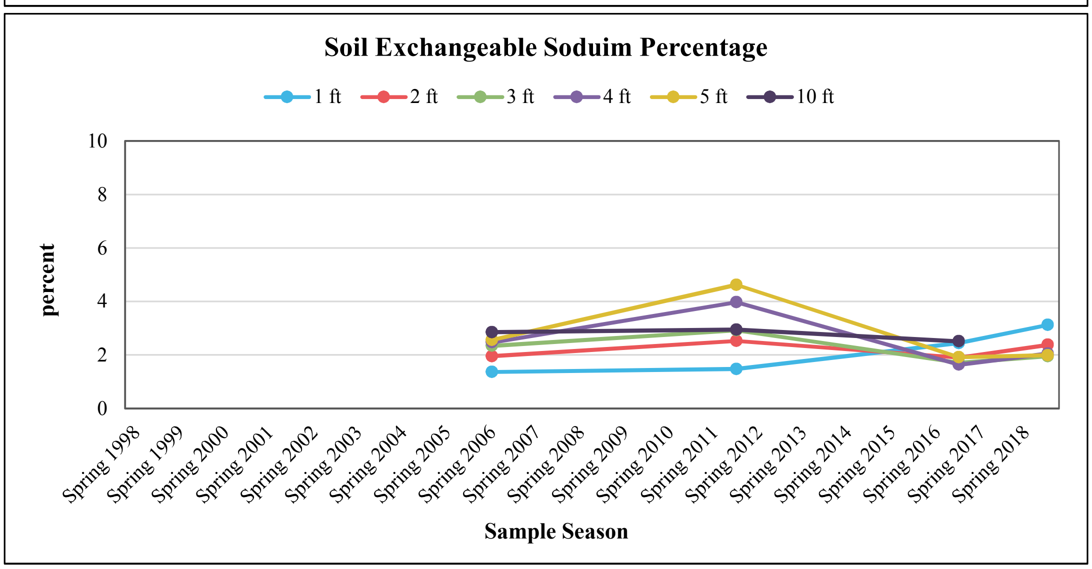
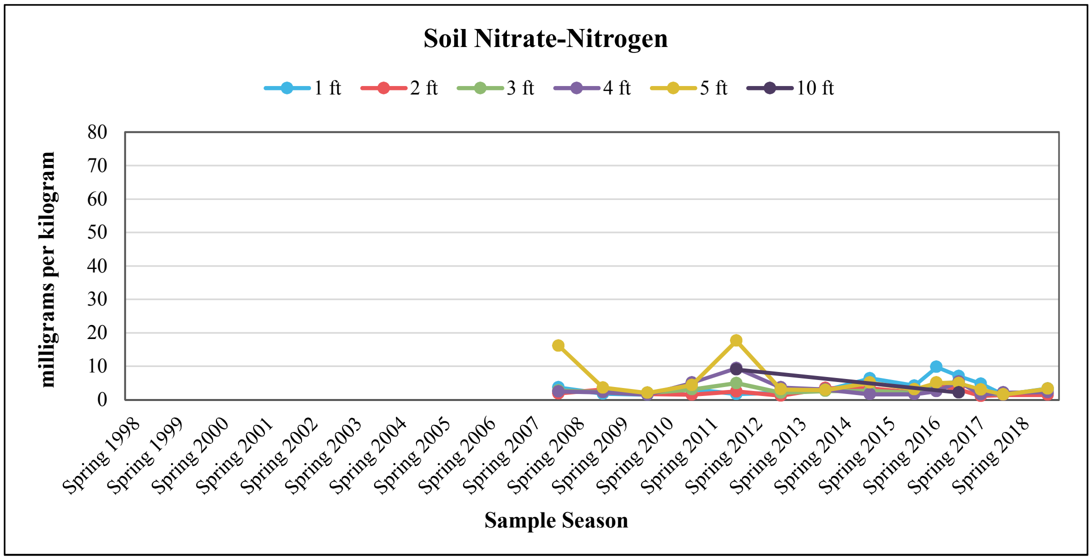
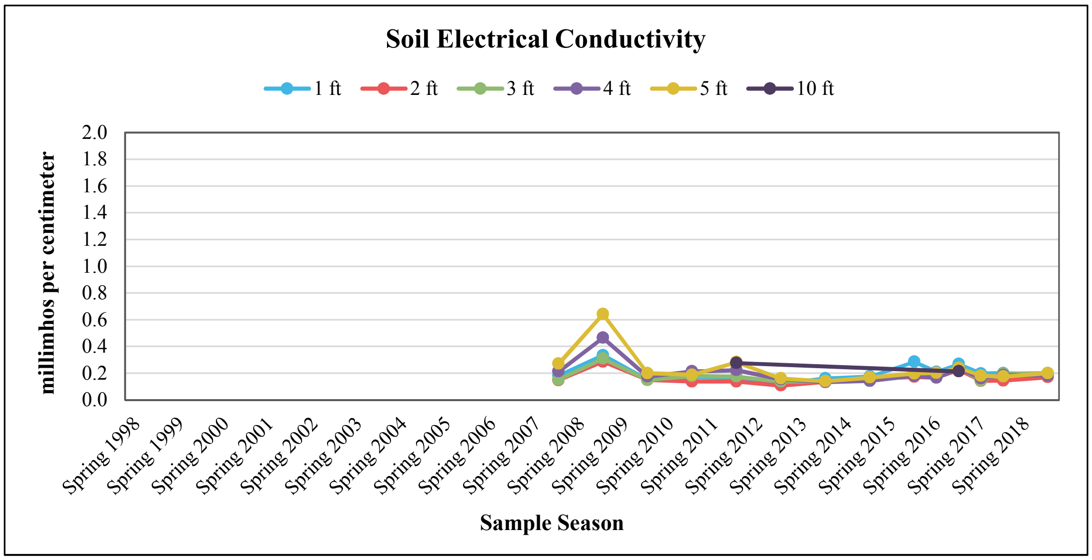
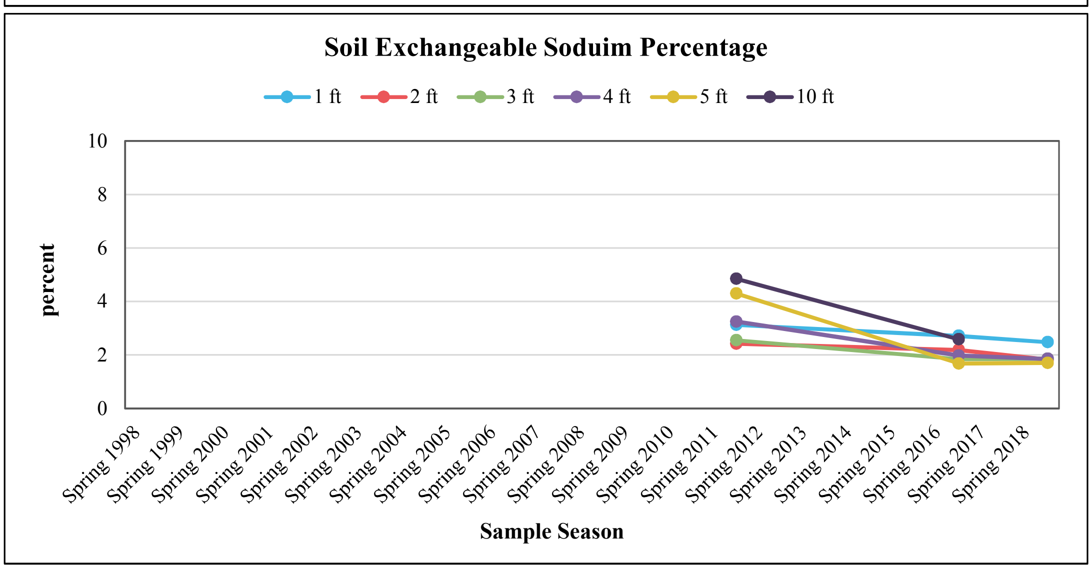


Chart 14. Soil Concentrations - Circle 15







APPENDICES

Appendix A1.

Historical and Design Precipitation – 1997 through 2017

Appendix A1. Historical and Design Precipitation – 1997 through 2017

Month	Average [1]	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	Normalized [2] Factor	Normalized [2] Return Precipitation (Design)
	inches																						inches
Nov	0.61	0.96	0.99	0.29	0.93	1.08	0.29	0.14	0.54	0.91	1.00	1.13	0.76	0.36	0.54	0.14	0.71	0.30	0.37	0.46	0.37	10%	0.87
Dec	0.91	0.35	0.25	0.21	0.57	0.59	2.16	1.34	0.71	1.77	1.51	0.69	0.64	0.74	2.21	0.07	0.80	0.28	1.18	1.66	0.40	16%	1.29
Jan	0.84	1.17	0.13	1.02	0.54	0.26	1.85	1.36	0.63	1.38	0.29	0.99	1.08	1.47	0.64	0.47	0.24	0.47	0.94	1.36	0.42	14%	1.19
Feb	0.51	0.95	0.56	0.99	0.23	0.74	0.84	0.64	0.05	0.24	0.35	0.41	0.68	0.41	0.35	0.32	0.03	0.48	0.55	0.27	1.20	9%	0.72
Mar	0.51	0.46	0.11	0.67	0.88	0.31	0.21	0.15	0.11	0.30	0.70	0.42	1.27	0.30	1.11	0.68	0.12	0.42	0.30	0.79	0.98	9%	0.72
Apr	0.36	0.11	0.15	0.09	0.79	0.23	0.77	0.16	0.18	0.86	0.24	0.12	0.27	0.63	0.41	0.77	0.33	0.21	0.14	0.21	0.60	6%	0.51
May	0.54	0.69	0.37	0.55	0.12	0.18	0.52	0.80	0.00	0.62	0.60	0.31	0.06	1.19	1.32	0.16	0.36	0.19	1.35	1.18	0.16	9%	0.77
Jun	0.49	0.50	0.00	0.50	0.30	0.91	0.00	1.15	0.00	1.25	0.60	0.48	0.05	1.14	0.17	1.12	0.78	0.12	0.00	0.31	0.36	8%	0.70
Jul	0.14	0.32	0.17	0.00	0.13	0.29	0.00	0.00	0.25	0.00	0.60	0.00	0.01	0.28	0.00	0.55	0.00	0.00	0.00	0.22	0.00	2%	0.20
Aug	0.17	0.00	0.07	0.00	0.25	0.20	0.00	0.47	0.05	0.00	0.48	0.80	0.04	0.25	0.01	0.15	0.19	0.46	0.00	0.02	0.03	3%	0.24
Sep	0.25	0.19	0.00	0.71	0.00	0.00	0.23	0.13	0.56	0.24	0.79	0.02	0.11	1.17	0.00	0.00	0.50	0.04	0.02	0.17	0.11	4%	0.35
Oct	0.48	0.14	0.43	0.95	0.49	0.14	0.07	0.00	0.45	0.39	0.30	0.03	1.01	1.28	0.47	0.75	0.01	0.63	0.02	1.60	0.42	8%	0.68
Winter [3]	2.26	2.47	0.94	2.22	1.34	1.59	4.85	3.34	1.39	3.39	2.15	2.09	2.40	2.62	3.20	0.86	1.07	1.23	2.67	3.29	2.02		3.21
Annual [4]	**5.81**	**5.84**	**3.23**	**5.98**	**5.23**	**4.93**	**6.94**	**6.34**	**3.53**	**7.96**	**7.46**	**5.40**	**5.98**	**9.22**	**7.23**	**5.18**	**4.07**	**3.60**	**4.87**	**8.25**	**5.05**	100%	8.25
Statistics [2]																							
Rank (m)		10	20	8	12	15	6	7	19	3	4	11	9	1	5	13	17	18	16	2	14		
Exceedance Probability (p)		48%	95%	38%	57%	71%	29%	33%	90%	14%	19%	52%	43%	5%	24%	62%	81%	86%	76%	10%	67%		
Recurrance Interval (T)		2.1	1.1	2.6	1.8	1.4	3.5	3.0	1.1	7.0	5.3	1.9	2.3	21.0	4.2	1.6	1.2	1.2	1.3	10.5	1.5		

NOTES:

All data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington.

1 The average precipitation is based on actual monthly precipitation from 1997 through 2017.

2 The 2nd highest total annual precipitation out of 20 years (8.25 inches from 2015-16 [shaded]) were normalized in relation to the long term average for each month to create the 10-year return precipitation data for design purposes.

3 Winter period is December through February.

4 Annual precipitation is based on the land treatment operating year November through October.

5 Rank (m) = rank of annual precipitation, where 1 is given to the highest precipitation and 20 is given to the lowest precipitation.

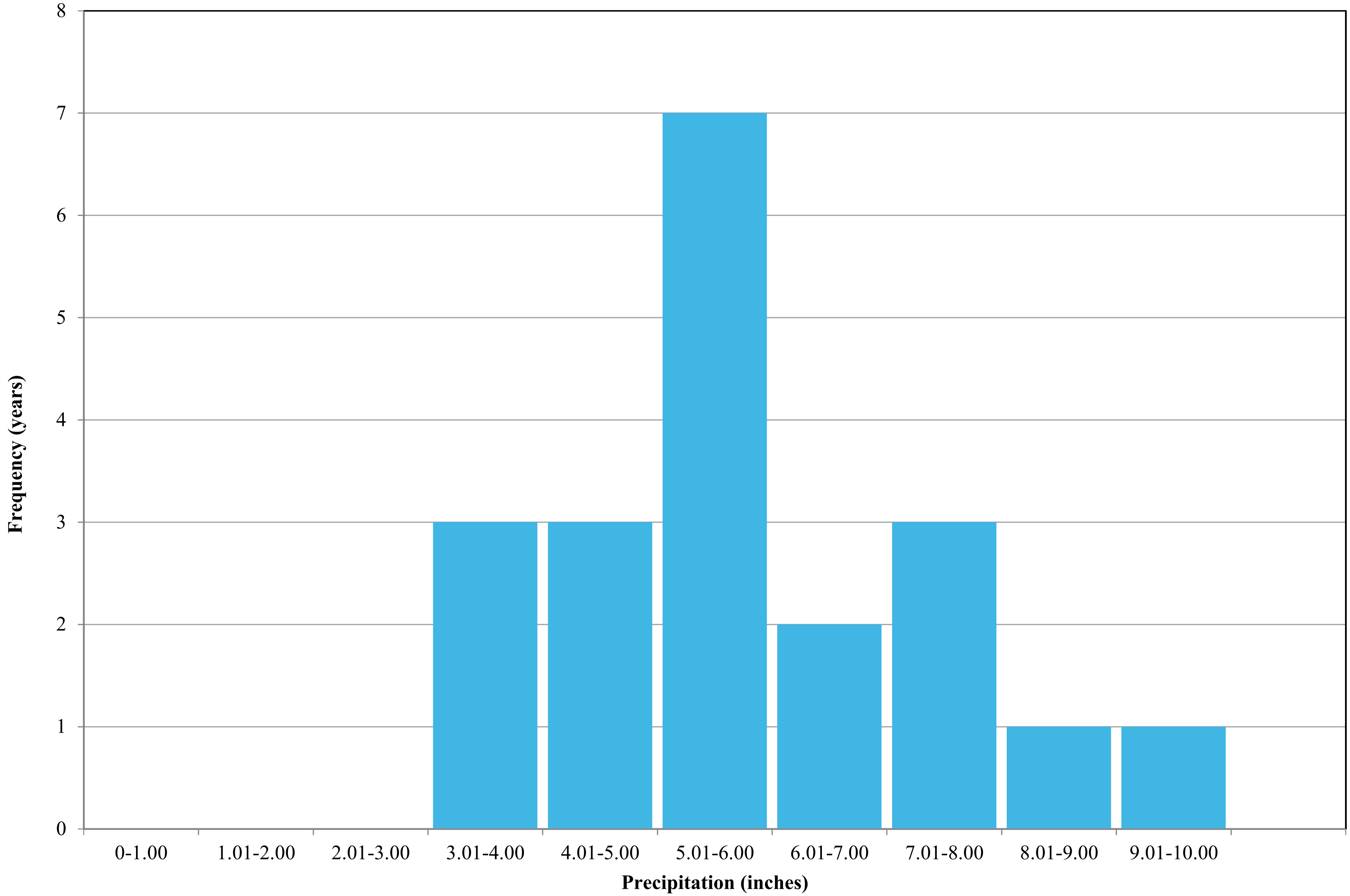
Exceedance Probability (p) = probability of precipitation equal to or higher in any given year. Calculated as p = m ÷ (n + 1), where n = number of years in data set.

Recurrance Interval (T) = average number of years between precipitation events equal to or higher than any given year. Calculated as T = 1 ÷ p = (n + 1) ÷ m, where n = number of years in data set.

Appendix A2.

20-Year Precipitation Histogram

Appendix A2. 20-Year Precipitation Histogram



Appendix B.

Web Soil Survey Results

United States Department of Agriculture

NRCS

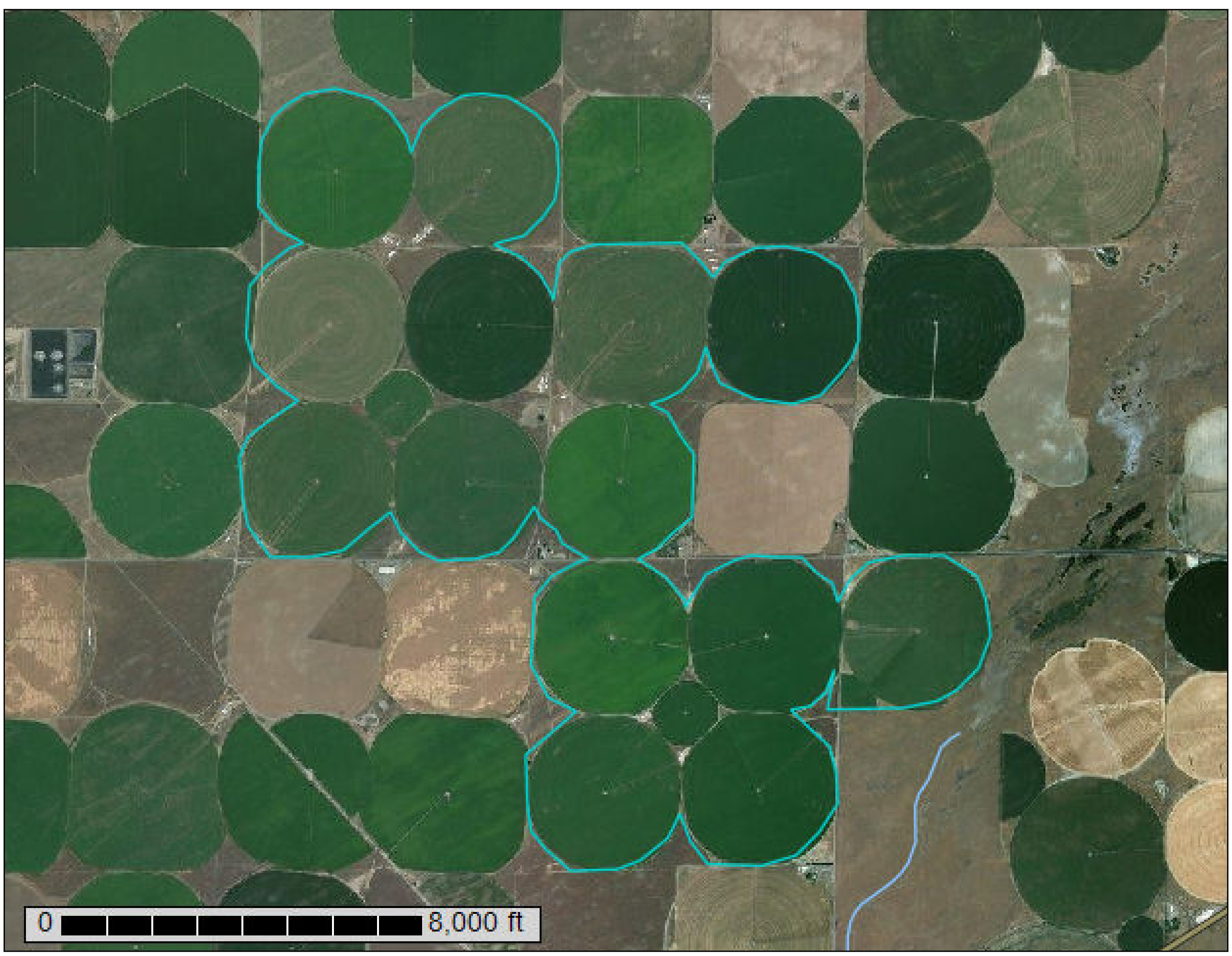
Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Franklin County, Washington

City of Pasco Land Application Site



October 16, 2017

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

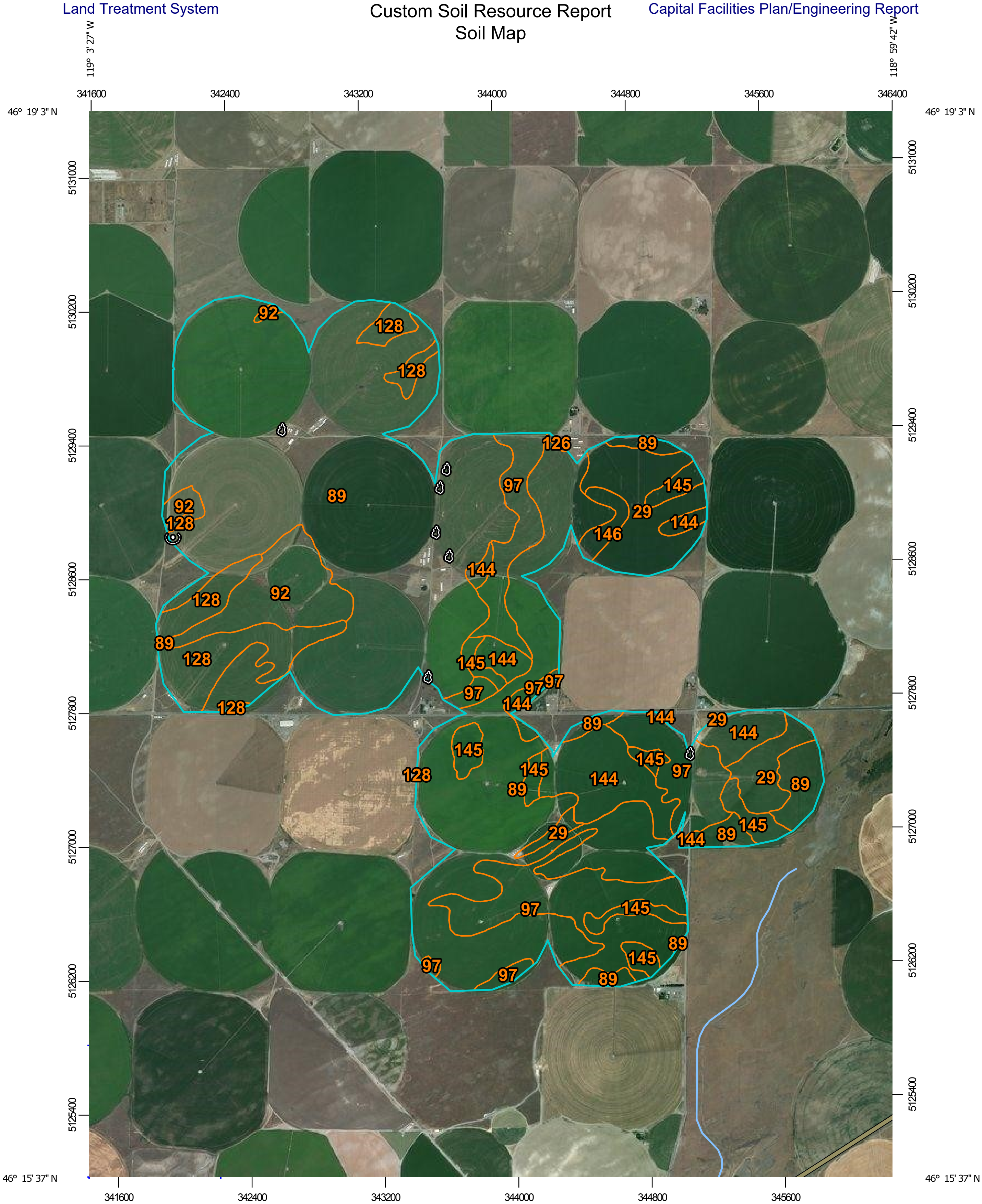
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map



Map Scale: 1:31,000 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 450, 900, 1800, 2700

Feet: 0, 1500, 3000, 6000, 9000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 11N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Franklin County, Washington
Survey Area Data: Version 14, Sep 8, 2016

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 28, 2014—Sep 11, 2016

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
29	Hezel loamy fine sand, 0 to 15 percent slopes	125.2	6.1%
89	Quincy loamy fine sand, 0 to 15 percent slopes	1,255.1	60.7%
92	Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes	92.7	4.5%
97	Quincy-Hezel complex, 0 to 15 percent slopes	255.4	12.4%
126	Royal loamy fine sand, 0 to 10 percent slopes	1.0	0.0%
128	Royal fine sandy loam, 0 to 2 percent slopes	111.8	5.4%
144	Sagemoor very fine sandy loam, 0 to 2 percent slopes	135.9	6.6%
145	Sagemoor very fine sandy loam, 2 to 5 percent slopes	74.3	3.6%
146	Sagemoor very fine sandy loam, 5 to 10 percent slopes	14.7	0.7%
Totals for Area of Interest		**2,066.1**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Franklin County, Washington

29—Hezel loamy fine sand, 0 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2dm1
Elevation: 400 to 2,500 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 150 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Hezel and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hezel

Setting

Landform: Terraces
Parent material: Glaciofluvial deposits with a mantle of eolian sands

Typical profile

H1 - 0 to 7 inches: loamy fine sand
H2 - 7 to 18 inches: loamy sand
H3 - 18 to 27 inches: fine sandy loam
H4 - 27 to 60 inches: stratified fine sandy loam to silt loam

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 9.0 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: SANDS 6-10 PZ (R007XY502WA)
Hydric soil rating: No

Minor Components

Quincy

Percent of map unit: 10 percent
Landform: Terraces
Hydric soil rating: No

Sagehill

Percent of map unit: 5 percent
Landform: Terraces
Hydric soil rating: No

89—Quincy loamy fine sand, 0 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2dtt
Elevation: 350 to 1,200 feet
Mean annual precipitation: 6 to 12 inches
Mean annual air temperature: 48 to 54 degrees F
Frost-free period: 150 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Quincy and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Quincy

Setting

Landform: Terraces
Parent material: Mixed eolian sands

Typical profile

H1 - 0 to 4 inches: loamy fine sand
H2 - 4 to 60 inches: fine sand

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 3 percent
Available water storage in profile: Low (about 4.9 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: SANDS 6-10 PZ (R007XY502WA)
Hydric soil rating: No

Minor Components

Sagehill

Percent of map unit: 15 percent
Landform: Dunes, terraces
Hydric soil rating: No

92—Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2dv6
Elevation: 350 to 1,000 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Quincy and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Quincy

Setting

Landform: Terraces
Parent material: Mixed eolian sands

Typical profile

H1 - 0 to 3 inches: loamy fine sand
H2 - 3 to 52 inches: loamy fine sand
H3 - 52 to 60 inches: silt loam

Properties and qualities

Slope: 0 to 10 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 5.0
Available water storage in profile: Moderate (about 6.5 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 7e

Hydrologic Soil Group: A
Ecological site: SANDS 6-10 PZ (R007XY502WA)
Hydric soil rating: No

97—Quincy-Hezel complex, 0 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2dvt
Elevation: 350 to 2,500 feet
Mean annual precipitation: 6 to 12 inches
Mean annual air temperature: 48 to 54 degrees F
Frost-free period: 150 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Quincy and similar soils: 50 percent
Hezel and similar soils: 25 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Quincy

Setting

Landform: Terraces
Parent material: Mixed eolian sands

Typical profile

H1 - 0 to 4 inches: loamy fine sand
H2 - 4 to 60 inches: fine sand

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 3 percent
Available water storage in profile: Low (about 4.9 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: SANDS 6-10 PZ (R007XY502WA)
Hydric soil rating: No

Description of Hezel

Setting

Landform: Terraces

Parent material: Glaciofluvial deposits with a mantle of eolian sands

Typical profile

H1 - 0 to 7 inches: loamy fine sand
H2 - 7 to 18 inches: loamy sand
H3 - 18 to 27 inches: fine sandy loam
H4 - 27 to 60 inches: stratified fine sandy loam to silt loam

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 9.0 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: SANDS 6-10 PZ (R007XY502WA)
Hydric soil rating: No

Minor Components

Sagehill

Percent of map unit: 5 percent
Landform: Dunes, terraces
Hydric soil rating: No

Kennewick

Percent of map unit: 5 percent
Landform: Terraces
Hydric soil rating: No

Warden

Percent of map unit: 5 percent
Landform: Terraces, dunes
Hydric soil rating: No

126—Royal loamy fine sand, 0 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2df7
Elevation: 400 to 1,400 feet

Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Royal and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Royal

Setting

Landform: Terraces
Parent material: Sandy alluvium

Typical profile

H1 - 0 to 6 inches: loamy fine sand
H2 - 6 to 19 inches: fine sandy loam
H3 - 19 to 60 inches: stratified fine sand to very fine sandy loam

Properties and qualities

Slope: 0 to 10 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 7.5 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: A
Ecological site: SANDS 6-10 PZ (R007XY502WA)
Hydric soil rating: No

Minor Components

Sagehill

Percent of map unit: 15 percent
Landform: Terraces
Hydric soil rating: No

128—Royal fine sandy loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 2dfc
Elevation: 400 to 1,400 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Royal and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Royal

Setting

Landform: Terraces
Parent material: Sandy alluvium

Typical profile

H1 - 0 to 5 inches: fine sandy loam
H2 - 5 to 15 inches: fine sandy loam
H3 - 15 to 60 inches: stratified fine sand to very fine sandy loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): 1
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: A
Ecological site: SANDY 6-10 PZ (R007XY501WA)
Hydric soil rating: No

Minor Components

Sagehill

Percent of map unit: 15 percent
Landform: Terraces
Hydric soil rating: No

144—Sagemoor very fine sandy loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 2dgj
Elevation: 400 to 1,000 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Sagemoor and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Sagemoor

Setting

Landform: Terraces
Parent material: Loess over layered lacustrine deposits

Typical profile

H1 - 0 to 4 inches: very fine sandy loam
H2 - 4 to 9 inches: silt loam
H3 - 9 to 18 inches: silt loam
H4 - 18 to 60 inches: silt loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: High (about 11.7 inches)

Interpretive groups

Land capability classification (irrigated): 1

Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: C
Ecological site: LOAMY 6-10 PZ (R007XY102WA)
Hydric soil rating: No

Minor Components

Kennewick

Percent of map unit: 10 percent
Landform: Terraces
Hydric soil rating: No

145—Sagemoor very fine sandy loam, 2 to 5 percent slopes

Map Unit Setting

National map unit symbol: 2dgl
Elevation: 400 to 1,000 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Sagemoor and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Sagemoor

Setting

Landform: Terraces
Parent material: Loess over layered lacustrine deposits

Typical profile

H1 - 0 to 4 inches: very fine sandy loam
H2 - 4 to 9 inches: silt loam
H3 - 9 to 18 inches: silt loam
H4 - 18 to 60 inches: silt loam

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

Available water storage in profile: High (about 11.7 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: LOAMY 6-10 PZ (R007XY102WA)
Hydric soil rating: No

Minor Components

Kennewick

Percent of map unit: 10 percent
Landform: Terraces
Hydric soil rating: No

146—Sagemoor very fine sandy loam, 5 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2dgn
Elevation: 400 to 1,000 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Sagemoor and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Sagemoor

Setting

Landform: Terraces
Parent material: Loess over layered lacustrine deposits

Typical profile

H1 - 0 to 4 inches: very fine sandy loam
H2 - 4 to 9 inches: silt loam
H3 - 9 to 18 inches: silt loam
H4 - 18 to 60 inches: silt loam

Properties and qualities

Slope: 5 to 10 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None

Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: High (about 11.7 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: LOAMY 6-10 PZ (R007XY102WA)
Hydric soil rating: No

Minor Components

Kennewick

Percent of map unit: 10 percent
Landform: Terraces
Hydric soil rating: No

References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf

Appendix C.

Circle-Specific Monthly Soil Hydraulic Budgets

Appendix C1. Circle-Specific Monthly Soil Hydraulic Budget

Circle: 1 **Acres:** 122 **Soil Water Content at Field Capacity [7]:** 11.4

Crop: Alfalfa **Rooting Depth [3] (approx):** 60 **Initial Soil Water Content [8]:** 10.3

Month	Precip [1]	Gross Irrigation [2]		Net Irrigation [4]		Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Fresh	Process	Fresh		Potential	Estimate		
		inches								
Nov	0.9	1.6	0.0	1.4	0.0	2.3	1.2	1.1	11.4	0.0
Dec	1.3	0.0	0.0	0.0	0.0	1.3	0.7	0.7	11.4	0.6
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.7	0.7	11.4	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.7	1.4	1.4	10.8	0.0
Mar	0.7	1.3	0.0	1.2	0.0	1.9	3.1	3.0	9.7	0.0
Apr	0.5	5.0	2.0	4.0	1.6	6.1	5.0	4.6	11.3	0.0
May	0.8	5.0	3.0	4.0	2.4	7.2	7.1	7.1	11.3	0.0
Jun	0.7	5.0	6.0	3.5	4.2	8.4	8.8	8.7	11.0	0.0
Jul	0.2	5.0	6.5	3.5	4.6	8.2	10.1	9.9	9.4	0.0
Aug	0.2	7.5	0.0	5.3	0.0	5.5	8.2	7.4	7.5	0.0
Sep	0.4	7.3	0.0	5.9	0.0	6.2	4.8	3.9	9.8	0.0
Oct	0.7	2.8	0.0	2.5	0.0	3.2	2.6	2.4	10.7	0.0
Total	8.3	40.5	17.5	31.3	12.8	52.3	53.5	50.8		1.1

Leaching Fraction [11]	1.6%
Leaching Requirement [12]	11.1%

NOTES:

Abbreviation: Precip = precipitation.

1 Precipitation is the normalized 10-year return values from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington.

2 Gross Irrigation = inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation * irrigation efficiency (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

6 Potential evapotranspiration is the average of available data from 1995-2016 at the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington.
Estimated evapotranspiration = potential evapotranspiration x (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K.E., W.J. Rawls, J.S. Ronberger, and R.I. Papenlick, 2009. Estimating Generalized Soil-Water Characteristics from Texture. Version 6.02.74. Soil Sci. Soc. Am. J. 50:1031-1036. 1986, revised 10/2009. http://hydrolab.arsusda.gov/soilwater/Index.htm).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix C2. Circle-Specific Monthly Soil Hydraulic Budget

Circle: 2 | **Acres:** 152 | **Soil Water Content at Field Capacity [7]:** 12.0

Crop: Potato / Alfalfa | **Rooting Depth [3] (approx):** 48 | **Initial Soil Water Content [8]:** 10.8

Month	Precip [1]	Gross Irrigation [2]		Net Irrigation [4]		Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Fresh	Process	Fresh		Potential	Estimate		
	inches									
Nov	0.9	0.0	0.0	0.0	0.0	0.9	0.5	0.5	11.2	0.0
Dec	1.3	0.0	0.0	0.0	0.0	1.3	0.2	0.2	12.0	0.3
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.3	0.3	12.0	0.9
Feb	0.7	0.0	0.0	0.0	0.0	0.7	0.5	0.5	12.0	0.2
Mar	0.7	0.0	0.0	0.0	0.0	0.7	0.5	0.5	12.0	0.3
Apr	0.5	1.1	0.0	0.8	0.0	1.4	1.4	1.4	12.0	0.0
May	0.8	4.0	0.0	3.2	0.0	4.0	4.5	4.5	11.5	0.0
Jun	0.7	1.0	10.0	0.7	7.0	8.4	9.0	8.8	11.0	0.0
Jul	0.2	0.0	14.0	0.0	9.8	10.0	10.3	9.9	11.2	0.0
Aug	0.2	0.0	7.0	0.0	4.9	5.1	4.9	4.7	11.6	0.0
Sep	0.4	0.0	2.0	0.0	1.6	2.0	2.4	2.3	11.2	0.0
Oct	0.7	0.0	1.4	0.0	1.3	1.9	2.6	2.5	10.7	0.0
Total	8.3	6.1	34.4	4.7	24.6	37.6	37.0	36.0		1.7

Leaching Fraction [11]	3.6%
Leaching Requirement [12]	7.1%

NOTES:

Circle 2 includes circle 2 plus little circle 2.

Abbreviation: Precip = precipitation.

1 Precipitation is the normalized 10-year return values from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington.

2 Gross Irrigation = inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation * irrigation efficiency (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

6 Potential evapotranspiration is the average of available data from 1995-2016 at the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington. Estimated evapotranspiration = potential evapotranspiration x (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K.E., W.J. Rawls, J.S. Ronberger, and R.I. Papenlick, 2009. Estimating Generalized Soil-Water Characteristics from Texture. Version 6.02.74. Soil Sci. Soc. Am. J. 50:1031-1036. 1986, revised 10/2009. http://hydrolab.arsusda.gov/soilwater/Index.htm).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone. Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix C3. Circle-Specific Monthly Soil Hydraulic Budget

Circle: 3 **Acres:** 128 **Soil Water Content at Field Capacity [7]:** 8.0

Crop: Alfalfa / Corn **Rooting Depth [3] (approx):** 60 **Initial Soil Water Content [8]:** 7.2

Month	Precip [1]	Gross Irrigation [2]		Net Irrigation [4]		Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Fresh	Process	Fresh		Potential	Estimate		
		inches								
Nov	0.9	1.2	0.0	1.1	0.0	1.9	1.2	1.1	8.0	0.0
Dec	1.3	0.0	0.0	0.0	0.0	1.3	0.7	0.7	8.0	0.6
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.7	0.7	8.0	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.7	1.4	1.4	7.3	0.0
Mar	0.7	1.3	0.0	1.2	0.0	1.9	3.1	3.0	6.3	0.0
Apr	0.5	4.0	1.0	3.2	0.8	4.5	5.0	4.4	6.4	0.0
May	0.8	5.0	2.0	4.0	1.6	6.4	7.1	6.4	6.3	0.0
Jun	0.7	4.0	3.0	2.8	2.1	5.6	6.4	5.7	6.2	0.0
Jul	0.2	3.5	5.8	2.5	4.1	6.7	7.8	6.9	6.0	0.0
Aug	0.2	5.0	1.0	3.5	0.7	4.4	7.4	6.5	4.0	0.0
Sep	0.4	3.0	0.0	2.4	0.0	2.7	0.8	0.5	6.2	0.0
Oct	0.7	1.0	0.0	0.9	0.0	1.6	0.8	0.7	7.1	0.0
Total	8.3	28.0	12.8	21.5	9.3	39.0	42.3	38.0		1.1

Leaching Fraction [11]	2.3%
Leaching Requirement [12]	10.5%

NOTES:

Abbreviation: Precip = precipitation.

1 Precipitation is the normalized 10-year return values from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington.

2 Gross Irrigation = inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation * irrigation efficiency (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

6 Potential evapotranspiration is the average of available data from 1995-2016 at the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington. Estimated evapotranspiration = potential evapotranspiration x (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K.E., W.J. Rawls, J.S. Ronberger, and R.I. Papenlick, 2009. Estimating Generalized Soil-Water Characteristics from Texture. Version 6.02.74. Soil Sci. Soc. Am. J. 50:1031-1036. 1986, revised 10/2009. http://hydrolab.arsusda.gov/soilwater/Index.htm).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone. Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix C4. Circle-Specific Monthly Soil Hydraulic Budget

Circle: 4 **Acres:** 128 **Soil Water Content at Field Capacity [7]:** 8.8

Crop: Alfalfa **Rooting Depth [3] (approx):** 60 **Initial Soil Water Content [8]:** 7.9

Month	Precip [1]	Gross Irrigation [2]		Net Irrigation [4]		Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Fresh	Process	Fresh		Potential	Estimate		
		inches								
Nov	0.9	1.2	0.0	1.1	0.0	1.9	1.2	1.1	8.8	0.0
Dec	1.3	0.0	0.0	0.0	0.0	1.3	0.7	0.7	8.8	0.6
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.7	0.7	8.8	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.7	1.4	1.4	8.2	0.0
Mar	0.7	1.3	0.0	1.2	0.0	1.9	3.1	3.0	7.1	0.0
Apr	0.5	5.0	2.0	4.0	1.6	6.1	5.0	4.5	8.7	0.0
May	0.8	6.0	2.0	4.8	1.6	7.2	7.1	7.1	8.8	0.0
Jun	0.7	3.0	8.0	2.1	5.6	8.4	8.8	8.8	8.4	0.0
Jul	0.2	7.0	0.0	4.9	0.0	5.1	10.1	9.9	3.6	0.0
Aug	0.2	7.0	0.0	4.9	0.0	5.1	8.2	5.3	3.5	0.0
Sep	0.4	7.5	0.0	6.0	0.0	6.4	4.8	3.0	6.8	0.0
Oct	0.7	3.2	0.0	2.9	0.0	3.6	2.6	2.3	8.2	0.0
Total	8.3	41.2	12.0	31.8	8.8	48.9	53.5	47.6		1.0

Leaching Fraction [11]	1.7%
Leaching Requirement [12]	11.6%

NOTES:

Abbreviation: Precip = precipitation.

1 Precipitation is the normalized 10-year return values from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington.

2 Gross Irrigation = inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation * irrigation efficiency (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

6 Potential evapotranspiration is the average of available data from 1995-2016 at the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington. Estimated evapotranspiration = potential evapotranspiration x (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K.E., W.J. Rawls, J.S. Ronberger, and R.I. Papenlick, 2009. Estimating Generalized Soil-Water Characteristics from Texture. Version 6.02.74. Soil Sci. Soc. Am. J. 50:1031-1036. 1986, revised 10/2009. http://hydrolab.arsusda.gov/soilwater/Index.htm).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix C5. Circle-Specific Monthly Soil Hydraulic Budget

Circle: 5 | **Acres:** 128 | **Soil Water Content at Field Capacity [7]:** 11.5

Crop: Alfalfa | **Rooting Depth [3] (approx):** 60 | **Initial Soil Water Content [8]:** 10.3

Month	Precip [1]	Gross Irrigation [2]		Net Irrigation [4]		Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Fresh	Process	Fresh		Potential	Estimate		
		inches								
Nov	0.9	1.5	0.0	1.4	0.0	2.2	1.2	1.1	11.5	0.0
Dec	1.3	0.0	0.0	0.0	0.0	1.3	0.7	0.7	11.5	0.6
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.7	0.7	11.5	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.7	1.4	1.4	10.9	0.0
Mar	0.7	1.3	0.0	1.2	0.0	1.9	3.1	3.0	9.8	0.0
Apr	0.5	5.0	2.0	4.0	1.6	6.1	5.0	4.6	11.3	0.0
May	0.8	6.0	2.0	4.8	1.6	7.2	7.1	7.1	11.4	0.0
Jun	0.7	3.0	8.0	2.1	5.6	8.4	8.8	8.7	11.0	0.0
Jul	0.2	7.0	1.0	4.9	0.7	5.8	10.1	9.9	7.0	0.0
Aug	0.2	7.0	0.0	4.9	0.0	5.1	8.2	6.4	5.7	0.0
Sep	0.4	7.5	0.0	6.0	0.0	6.4	4.8	3.4	8.7	0.0
Oct	0.7	3.5	0.0	3.2	0.0	3.8	2.6	2.2	10.3	0.0
Total	8.3	41.8	13.0	32.4	9.5	50.1	53.5	49.1		1.0

Leaching Fraction [11]	1.6%
Leaching Requirement [12]	11.7%

NOTES:

Abbreviation: Precip = precipitation.

1 Precipitation is the normalized 10-year return values from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington.

2 Gross Irrigation = inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation * irrigation efficiency (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

6 Potential evapotranspiration is the average of available data from 1995-2016 at the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington. Estimated evapotranspiration = potential evapotranspiration x (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K.E., W.J. Rawls, J.S. Ronberger, and R.I. Papenlick, 2009. Estimating Generalized Soil-Water Characteristics from Texture. Version 6.02.74. Soil Sci. Soc. Am. J. 50:1031-1036. 1986, revised 10/2009. http://hydrolab.arsusda.gov/soilwater/Index.htm).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone. Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix C6. Circle-Specific Monthly Soil Hydraulic Budget

Circle: 6 | **Acres:** 128 | **Soil Water Content at Field Capacity [7]:** 6.8

Crop: Alfalfa | **Rooting Depth [3] (approx):** 60 | **Initial Soil Water Content [8]:** 6.1

Month	Precip [1]	Gross Irrigation [2]		Net Irrigation [4]		Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Fresh	Process	Fresh		Potential	Estimate		
		inches								
Nov	0.9	1.0	0.0	0.9	0.0	1.8	1.2	1.1	6.8	0.0
Dec	1.3	0.0	0.0	0.0	0.0	1.3	0.7	0.7	6.8	0.6
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.7	0.7	6.8	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.7	1.4	1.4	6.2	0.0
Mar	0.7	1.3	0.0	1.2	0.0	1.9	3.1	2.9	5.1	0.0
Apr	0.5	4.5	2.0	3.6	1.6	5.7	5.0	4.3	6.5	0.0
May	0.8	4.5	3.0	3.6	2.4	6.8	7.1	7.0	6.3	0.0
Jun	0.7	3.0	8.0	2.1	5.6	8.4	8.8	8.5	6.2	0.0
Jul	0.2	4.0	9.0	2.8	6.3	9.3	10.1	9.7	5.9	0.0
Aug	0.2	6.5	4.5	4.6	3.2	7.9	8.2	7.6	6.2	0.0
Sep	0.4	5.0	0.0	4.0	0.0	4.4	4.8	4.6	6.0	0.0
Oct	0.7	2.0	0.0	1.8	0.0	2.5	2.6	2.4	6.1	0.0
Total	8.3	31.8	26.5	24.5	19.1	51.8	53.5	50.8		1.1

Leaching Fraction [11]	1.6%
Leaching Requirement [12]	11.2%

NOTES:

Abbreviation: Precip = precipitation.

1 Precipitation is the normalized 10-year return values from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington.

2 Gross Irrigation = inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation * irrigation efficiency (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

6 Potential evapotranspiration is the average of available data from 1995-2016 at the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington. Estimated evapotranspiration = potential evapotranspiration x (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K.E., W.J. Rawls, J.S. Ronberger, and R.I. Papenlick, 2009. Estimating Generalized Soil-Water Characteristics from Texture. Version 6.02.74. Soil Sci. Soc. Am. J. 50:1031-1036. 1986, revised 10/2009. http://hydrolab.arsusda.gov/soilwater/Index.htm).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone. Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix C7. Circle-Specific Monthly Soil Hydraulic Budget

Circle: 7 **Acres:** 152 **Soil Water Content at Field Capacity [7]:** 8.3

Crop: Potato / Alfalfa **Rooting Depth [3] (approx):** 48 **Initial Soil Water Content [8]:** 7.5

Month	Precip [1]	Gross Irrigation [2]		Net Irrigation [4]		Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Fresh	Process	Fresh		Potential	Estimate		
		inches								
Nov	0.9	0.0	0.0	0.0	0.0	0.9	0.5	0.5	7.9	0.0
Dec	1.3	0.0	0.0	0.0	0.0	1.3	0.2	0.2	8.3	0.7
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.3	0.3	8.3	0.9
Feb	0.7	0.0	0.0	0.0	0.0	0.7	0.5	0.5	8.3	0.2
Mar	0.7	0.0	0.0	0.0	0.0	0.7	0.5	0.5	8.3	0.3
Apr	0.5	1.1	0.0	0.8	0.0	1.4	1.4	1.4	8.3	0.0
May	0.8	4.2	0.0	3.4	0.0	4.1	4.5	4.5	7.9	0.0
Jun	0.7	1.0	7.5	0.7	5.3	6.6	9.0	8.8	5.7	0.0
Jul	0.2	0.0	11.0	0.0	7.7	7.9	10.3	8.6	5.1	0.0
Aug	0.2	0.0	5.0	0.0	3.5	3.7	4.9	3.8	5.0	0.0
Sep	0.4	0.0	2.0	0.0	1.6	2.0	2.4	1.8	5.1	0.0
Oct	0.7	0.0	1.6	0.0	1.4	2.1	2.6	2.0	5.2	0.0
Total	8.3	6.3	27.1	4.9	19.5	32.6	37.0	32.8		2.1

Leaching Fraction [11]	5.0%
Leaching Requirement [12]	8.4%

NOTES:

Circle 7 is circle 7 plus little circle 7.

Abbreviation: Precip = precipitation.

1 Precipitation is the normalized 10-year return values from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington.

2 Gross Irrigation = inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation * irrigation efficiency (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

6 Potential evapotranspiration is the average of available data from 1995-2016 at the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington.
Estimated evapotranspiration = potential evapotranspiration x (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K.E., W.J. Rawls, J.S. Ronberger, and R.I. Papenlick, 2009. Estimating Generalized Soil-Water Characteristics from Texture. Version 6.02.74. Soil Sci. Soc. Am. J. 50:1031-1036. 1986, revised 10/2009. http://hydrolab.arsusda.gov/soilwater/Index.htm).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix C8. Circle-Specific Monthly Soil Hydraulic Budget

Circle: 8 **Acres:** 128 **Soil Water Content at Field Capacity [7]:** 6.7

Crop: Alfalfa / Corn **Rooting Depth [3] (approx):** 60 **Initial Soil Water Content [8]:** 6.0

Month	Precip [1]	Gross Irrigation [2]		Net Irrigation [4]		Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Fresh	Process	Fresh		Potential	Estimate		
		inches								
Nov	0.9	1.0	0.0	0.9	0.0	1.8	1.2	1.1	6.7	0.0
Dec	1.3	0.0	0.0	0.0	0.0	1.3	0.7	0.7	6.7	0.6
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.7	0.7	6.7	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.7	1.4	1.4	6.0	0.0
Mar	0.7	1.3	0.0	1.2	0.0	1.9	3.1	2.9	5.0	0.0
Apr	0.5	1.5	5.0	1.2	4.0	5.7	5.0	4.3	6.4	0.0
May	0.8	0.0	8.0	0.0	6.4	7.2	7.1	7.0	6.6	0.0
Jun	0.7	0.0	5.0	0.0	3.5	4.2	6.4	6.4	4.4	0.0
Jul	0.2	3.5	7.0	2.5	4.9	7.5	7.8	6.4	5.6	0.0
Aug	0.2	5.0	0.0	3.5	0.0	3.7	7.4	6.8	2.5	0.0
Sep	0.4	4.0	0.0	3.2	0.0	3.6	0.8	0.5	5.6	0.0
Oct	0.7	1.0	0.0	0.3	0.0	1.0	0.8	0.7	5.9	0.0
Total	8.3	17.3	25.0	12.7	18.8	39.8	42.3	38.8		1.1

Leaching Fraction [11]	2.1%
Leaching Requirement [12]	10.0%

NOTES:

Abbreviation: Precip = precipitation.

1 Precipitation is the normalized 10-year return values from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington.

2 Gross Irrigation = inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation * irrigation efficiency (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

6 Potential evapotranspiration is the average of available data from 1995-2016 at the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington. Estimated evapotranspiration = potential evapotranspiration x (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K.E., W.J. Rawls, J.S. Ronberger, and R.I. Papenlick, 2009. Estimating Generalized Soil-Water Characteristics from Texture. Version 6.02.74. Soil Sci. Soc. Am. J. 50:1031-1036. 1986, revised 10/2009. http://hydrolab.arsusda.gov/soilwater/Index.htm).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix C9. Circle-Specific Monthly Soil Hydraulic Budget

Circle: 9 **Acres:** 128 **Soil Water Content at Field Capacity [7]:** 6.3

Crop: Alfalfa **Rooting Depth [3] (approx):** 60 **Initial Soil Water Content [8]:** 5.7

Month	Precip [1]	Gross Irrigation [2]		Net Irrigation [4]		Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Fresh	Process	Fresh		Potential	Estimate		
		inches								
Nov	0.9	1.0	0.0	0.9	0.0	1.8	1.2	1.1	6.3	0.0
Dec	1.3	0.0	0.0	0.0	0.0	1.3	0.7	0.7	6.3	0.6
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.7	0.7	6.3	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.7	1.4	1.4	5.7	0.0
Mar	0.7	1.3	0.0	1.2	0.0	1.9	3.1	2.9	4.7	0.0
Apr	0.5	5.0	0.0	4.0	0.0	4.5	5.0	4.3	4.9	0.0
May	0.8	5.0	3.5	4.0	2.8	7.6	7.1	6.3	6.2	0.0
Jun	0.7	4.0	7.5	2.8	5.3	8.7	8.8	8.7	6.2	0.0
Jul	0.2	5.0	9.0	3.5	6.3	10.0	10.1	10.0	6.2	0.0
Aug	0.2	6.0	2.0	4.2	1.4	5.8	8.2	8.1	3.9	0.0
Sep	0.4	5.0	0.0	5.0	0.0	5.4	4.8	3.8	5.5	0.0
Oct	0.7	2.3	0.0	1.9	0.0	2.6	2.6	2.4	5.7	0.0
Total	8.3	34.6	22.0	27.5	15.8	51.5	53.5	50.4		1.1

Leaching Fraction [11]	1.7%
Leaching Requirement [12]	11.5%

NOTES:

Abbreviation: Precip = precipitation.

1 Precipitation is the normalized 10-year return values from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington.

2 Gross Irrigation = inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation * irrigation efficiency (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

6 Potential evapotranspiration is the average of available data from 1995-2016 at the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington. Estimated evapotranspiration = potential evapotranspiration x (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K.E., W.J. Rawls, J.S. Ronberger, and R.I. Papenlick, 2009. Estimating Generalized Soil-Water Characteristics from Texture. Version 6.02.74. Soil Sci. Soc. Am. J. 50:1031-1036. 1986, revised 10/2009. http://hydrolab.arsusda.gov/soilwater/Index.htm).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone. Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix C10. Circle-Specific Monthly Soil Hydraulic Budget

Circle: 10 | **Acres:** 128 | **Soil Water Content at Field Capacity [7]:** 7.0

Crop: Alfalfa | **Rooting Depth [3] (approx):** 60 | **Initial Soil Water Content [8]:** 6.3

Month	Precip [1]	Gross Irrigation [2]		Net Irrigation [4]		Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Fresh	Process	Fresh		Potential	Estimate		
		inches								
Nov	0.9	1.1	0.0	1.0	0.0	1.9	1.2	1.1	7.0	0.0
Dec	1.3	0.0	0.0	0.0	0.0	1.3	0.7	0.7	7.0	0.6
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.7	0.7	7.0	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.7	1.4	1.4	6.4	0.0
Mar	0.7	1.3	0.0	1.2	0.0	1.9	3.1	2.9	5.4	0.0
Apr	0.5	5.0	1.0	4.0	0.8	5.3	5.0	4.3	6.4	0.0
May	0.8	5.0	3.0	4.0	2.4	7.2	7.1	6.8	6.7	0.0
Jun	0.7	4.0	6.0	4.0	4.2	8.9	8.8	8.6	7.0	0.0
Jul	0.2	4.5	9.0	3.0	6.3	9.5	10.1	10.1	6.5	0.0
Aug	0.2	6.5	1.0	5.0	0.7	5.9	8.2	7.8	4.6	0.0
Sep	0.4	5.5	0.0	5.5	0.0	5.9	4.8	3.8	6.6	0.0
Oct	0.7	2.3	0.0	1.5	0.0	2.2	2.6	2.5	6.3	0.0
Total	8.3	35.2	20.0	29.2	14.4	51.8	53.5	50.8		1.1

Leaching Fraction [11]	1.8%
Leaching Requirement [12]	11.6%

NOTES:

Abbreviation: Precip = precipitation.

1 Precipitation is the normalized 10-year return values from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington.

2 Gross Irrigation = inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation * irrigation efficiency (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

6 Potential evapotranspiration is the average of available data from 1995-2016 at the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington. Estimated evapotranspiration = potential evapotranspiration x (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K.E., W.J. Rawls, J.S. Ronberger, and R.I. Papenlick, 2009. Estimating Generalized Soil-Water Characteristics from Texture. Version 6.02.74. Soil Sci. Soc. Am. J. 50:1031-1036. 1986, revised 10/2009. http://hydrolab.arsusda.gov/soilwater/Index.htm).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone. Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix C11. Circle-Specific Monthly Soil Hydraulic Budget

Circle: 11 **Acres:** 150 **Soil Water Content at Field Capacity** [7]**:** 8.1

Crop: Triticale / Corn **Rooting Depth** [3] **(approx):** 60 **Initial Soil Water Content** [8]**:** 7.3

Month	Precip [1]	Gross Irrigation [2]		Net Irrigation [4]		Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Fresh	Process	Fresh		Potential	Estimate		
		inches								
Nov	0.9	1.0	0.0	0.9	0.0	1.8	1.0	0.9	8.1	0.0
Dec	1.3	0.0	0.0	0.0	0.0	1.3	0.6	0.6	8.1	0.7
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.7	0.7	8.1	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.7	1.2	1.2	7.7	0.0
Mar	0.7	1.3	0.0	1.2	0.0	1.9	2.6	2.6	7.0	0.0
Apr	0.5	0.0	0.0	0.0	0.0	0.5	4.1	3.8	3.7	0.0
May	0.8	4.0	4.0	3.2	3.2	7.2	5.7	3.9	7.0	0.0
Jun	0.7	0.0	4.0	0.0	2.8	3.5	5.4	5.1	5.5	0.0
Jul	0.2	6.0	6.0	4.2	4.2	8.6	7.8	6.4	7.6	0.0
Aug	0.2	2.2	2.5	1.5	1.8	3.5	7.4	7.2	4.0	0.0
Sep	0.4	3.1	0.0	2.5	0.0	2.8	0.8	0.5	6.3	0.0
Oct	0.7	1.0	0.0	0.9	0.0	1.6	0.8	0.7	7.2	0.0
Total	8.3	18.6	16.5	14.4	12.0	34.6	38.0	33.5		1.3

Leaching Fraction [11]	2.9%
Leaching Requirement [12]	10.2%

NOTES:

Abbreviation: Precip = precipitation.

1 Precipitation is the normalized 10-year return values from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington.

2 Gross Irrigation = inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation * irrigation efficiency (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

6 Potential evapotranspiration is the average of available data from 1995-2016 at the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington.
Estimated evapotranspiration = potential evapotranspiration x (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K.E., W.J. Rawls, J.S. Ronberger, and R.I. Papenlick, 2009. Estimating Generalized Soil-Water Characteristics from Texture. Version 6.02.74. Soil Sci. Soc. Am. J. 50:1031-1036. 1986, revised 10/2009. http://hydrolab.arsusda.gov/soilwater/Index.htm).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix C12. Circle-Specific Monthly Soil Hydraulic Budget

Circle: 12 **Acres:** 128 **Soil Water Content at Field Capacity [7]:** 11.3

Crop: Alfalfa / Corn **Rooting Depth [3] (approx):** 60 **Initial Soil Water Content [8]:** 10.2

Month	Precip [1]	Gross Irrigation [2]		Net Irrigation [4]		Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Fresh	Process	Fresh		Potential	Estimate		
		inches								
Nov	0.9	1.5	0.0	1.4	0.0	2.2	1.2	1.1	11.3	0.0
Dec	1.3	0.0	0.0	0.0	0.0	1.3	0.7	0.7	11.3	0.6
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.7	0.7	11.3	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.7	1.4	1.4	10.7	0.0
Mar	0.7	1.0	0.0	0.9	0.0	1.6	3.1	3.0	9.3	0.0
Apr	0.5	4.5	0.0	3.6	0.0	4.1	5.0	4.5	8.9	0.0
May	0.8	4.0	2.0	3.2	1.6	5.6	7.1	6.3	8.1	0.0
Jun	0.7	3.0	2.0	2.1	1.4	4.2	6.4	5.4	6.9	0.0
Jul	0.2	3.5	8.0	2.5	5.6	8.2	7.8	6.1	9.0	0.0
Aug	0.2	0.0	5.0	0.0	3.5	3.7	7.4	6.7	6.1	0.0
Sep	0.4	4.0	0.0	3.2	0.0	3.6	0.8	0.6	9.1	0.0
Oct	0.7	1.0	0.0	0.9	0.0	1.6	0.8	0.7	10.0	0.0
Total	8.3	22.5	17.0	17.7	12.1	38.1	42.3	37.2		1.1

Leaching Fraction [11]	2.2%
Leaching Requirement [12]	10.6%

NOTES:

Abbreviation: Precip = precipitation.

1 Precipitation is the normalized 10-year return values from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington.

2 Gross Irrigation = inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation * irrigation efficiency (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

6 Potential evapotranspiration is the average of available data from 1995-2016 at the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington. Estimated evapotranspiration = potential evapotranspiration x (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K.E., W.J. Rawls, J.S. Ronberger, and R.I. Papenlick, 2009. Estimating Generalized Soil-Water Characteristics from Texture. Version 6.02.74. Soil Sci. Soc. Am. J. 50:1031-1036. 1986, revised 10/2009. http://hydrolab.arsusda.gov/soilwater/Index.htm).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix C13. Circle-Specific Monthly Soil Hydraulic Budget

Circle: 13 **Acres:** 128 **Soil Water Content at Field Capacity [7]:** 6.3

Crop: Alfalfa **Rooting Depth [3] (approx):** 60 **Initial Soil Water Content [8]:** 5.7

Month	Precip [1]	Gross Irrigation [2]		Net Irrigation [4]		Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Fresh	Process	Fresh		Potential	Estimate		
		inches								
Nov	0.9	1.0	0.0	0.9	0.0	1.8	1.2	1.1	6.3	0.0
Dec	1.3	0.0	0.0	0.0	0.0	1.3	0.7	0.7	6.3	0.6
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.7	0.7	6.3	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.7	1.4	1.4	5.7	0.0
Mar	0.7	1.1	0.0	1.0	0.0	1.7	3.1	2.9	4.5	0.0
Apr	0.5	5.0	0.0	4.0	0.0	4.5	5.0	4.2	4.8	0.0
May	0.8	5.0	3.0	4.0	2.4	7.2	7.1	6.2	5.8	0.0
Jun	0.7	6.0	5.5	4.2	3.9	8.7	8.8	8.4	6.1	0.0
Jul	0.2	4.0	7.0	2.8	4.9	7.9	10.1	9.9	4.1	0.0
Aug	0.2	6.0	1.5	4.2	1.1	5.5	8.2	6.6	3.0	0.0
Sep	0.4	6.0	0.0	4.8	0.0	5.2	4.8	3.3	4.9	0.0
Oct	0.7	2.7	0.0	2.4	0.0	3.1	2.6	2.2	5.7	0.0
Total	8.3	36.8	17.0	28.3	12.2	48.8	53.5	47.6		1.1

Leaching Fraction [11]	1.8%
Leaching Requirement [12]	11.8%

NOTES:

Abbreviation: Precip = precipitation.

1 Precipitation is the normalized 10-year return values from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington.

2 Gross Irrigation = inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation * irrigation efficiency (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

6 Potential evapotranspiration is the average of available data from 1995-2016 at the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington. Estimated evapotranspiration = potential evapotranspiration x (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K.E., W.J. Rawls, J.S. Ronberger, and R.I. Papenlick, 2009. Estimating Generalized Soil-Water Characteristics from Texture. Version 6.02.74. Soil Sci. Soc. Am. J. 50:1031-1036. 1986, revised 10/2009. http://hydrolab.arsusda.gov/soilwater/Index.htm).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone. Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix C14. Circle-Specific Monthly Soil Hydraulic Budget

Circle: 15 **Acres:** 128 **Soil Water Content at Field Capacity [7]:** 9.6

Crop: Alfalfa **Rooting Depth [3] (approx):** 60 **Initial Soil Water Content [8]:** 8.6

Month	Precip [1]	Gross Irrigation [2]		Net Irrigation [4]		Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Fresh	Process	Fresh		Potential	Estimate		
		inches								
Nov	0.9	1.3	0.0	1.2	0.0	2.0	1.2	1.1	9.6	0.0
Dec	1.3	0.0	0.0	0.0	0.0	1.3	0.7	0.7	9.6	0.6
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.7	0.7	9.6	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.7	1.4	1.4	9.0	0.0
Mar	0.7	1.3	0.0	1.2	0.0	1.9	3.1	3.0	7.9	0.0
Apr	0.5	5.0	0.0	4.0	0.0	4.5	5.0	4.5	7.9	0.0
May	0.8	5.0	1.0	4.0	0.8	5.6	7.1	6.5	7.0	0.0
Jun	0.7	6.0	5.0	4.2	3.5	8.4	8.8	7.5	7.9	0.0
Jul	0.2	4.0	5.5	2.8	3.9	6.8	10.1	9.1	5.6	0.0
Aug	0.2	7.0	2.5	4.9	1.8	6.9	8.2	6.3	6.2	0.0
Sep	0.4	6.0	0.0	4.8	0.0	5.2	4.8	3.8	7.5	0.0
Oct	0.7	2.7	0.0	2.4	0.0	3.1	2.6	2.3	8.4	0.0
Total	8.3	38.3	14.0	29.5	9.9	47.6	53.5	46.8		1.0

Leaching Fraction [11]	1.7%
Leaching Requirement [12]	12.0%

NOTES:

Abbreviation: Precip = precipitation.

1 Precipitation is the normalized 10-year return values from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington.

2 Gross Irrigation = inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation * irrigation efficiency (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% Nov-Mar, 80% Apr-May, 70% Jun-Aug, 80% Sep, 90% Oct).

6 Potential evapotranspiration is the average of available data from 1995-2016 at the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington. Estimated evapotranspiration = potential evapotranspiration x (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K.E., W.J. Rawls, J.S. Ronberger, and R.I. Papenlick, 2009. Estimating Generalized Soil-Water Characteristics from Texture. Version 6.02.74. Soil Sci. Soc. Am. J. 50:1031-1036. 1986, revised 10/2009. http://hydrolab.arsusda.gov/soilwater/Index.htm).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone. Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix D.

Projected Five-Day Biochemical Oxygen Demand Loadings

Appendix D. Projected Five-Day Biochemical Oxygen Demand Loadings

Circle [1]	Month											
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
	pounds BOD_5 per acre per day											
1	9	0	0	0	7	28	27	28	27	40	40	15
2	0	0	0	0	0	6	21	6	0	0	0	0
3	7	0	0	0	7	22	27	22	19	27	16	5
4	7	0	0	0	7	28	32	17	37	37	41	17
5	8	0	0	0	7	28	32	17	37	37	41	19
6	6	0	0	0	7	25	24	17	21	35	28	11
7	0	0	0	0	0	6	22	6	0	0	0	0
8	6	0	0	0	7	8	0	0	19	27	22	5
9	6	0	0	0	7	28	27	22	27	32	28	12
10	6	0	0	0	7	28	27	22	24	35	30	12
11	6	0	0	0	7	0	21	0	32	12	17	5
12	8	0	0	0	5	25	21	17	19	0	22	5
13	6	0	0	0	6	28	27	33	21	32	33	14
15	7	0	0	0	7	28	27	33	21	37	33	14

NOTES

Projected BOD_5 loadings based on monthly process water design flow and an estimated BOD_5 concentration of 730 milligrams per liter as follows:

Million gallons x 8.34 x 730 / acres / days per month.

Abbeviation: BOD_5 = five-day biochemical oxygen demand.

1 Circle 2 is Circle 2 plus Little Circle 2. Circle 7 is Circle 7 plus Little Circle 7.

Appendix E.

Design Fixed Dissolved Solids Concentrations

Appendix E. Design Fixed Dissolved Solids Concentrations

Source	Milligrams per Liter
PW [1]	563
FW [2]	502
PW + FW [3]	538
PW + FW + $Mg(OH)_2$ [4]	622

NOTES

Abbreviations: FW = fresh water, H = hydrogen, Mg = magnesium, O = oxygen, PW = process water.

1 PW is the average concentration from operating years 2014-17.

2 FW is the average concentration from individual city of Pasco wells, based on samples analyzed in August, 2018.

3 PW + FW is the combined PW and FW flow weighted concentration based on the design hydraulic loads

4 PW + FW + $MG(OH)_2$ is the combined PW and FW flow weighted concentration and includes an increase in FDS concentration from the total annual MG(OH)2 load used for PW pH adjustment.

Sources:

CES, 2014. 2014 Farm Operations Report. City of Pasco – Pasco, Washington. Cascade Earth Sciences. Spokane, Washington. April 23, 2014.

CES, 2015. 2015 Farm Operations Report. City of Pasco – Pasco, Washington. Cascade Earth Sciences. Spokane, Washington. April 24, 2015.

CES, 2016. 2016 Farm Operations Report. City of Pasco – Pasco, Washington. Cascade Earth Sciences. Spokane, Washington. April 22, 2016.

CES, 2017. 2017 Farm Operations Report. City of Pasco – Pasco, Washington. Cascade Earth Sciences. Spokane Valley, Washington. April 25, 2017.

CES, 2018. 2018 Farm Operations Report. City of Pasco – Pasco, Washington. Cascade Earth Sciences.Spokane Valley, Washington. April 24, 2018.

FINAL

Hydrogeologic Assessment Report
City of Pasco
Process Wastewater Reuse Facility

Prepared for

PACE Engineers, Inc.

June 2018; revised December 2019

CH2M HILL Engineers, Inc.
1100 112th Ave NE
Suite 500
Bellevue, WA 98004

Contents

Acronyms and Abbreviations

°F	degree(s) Fahrenheit
bgs	below ground surface
Ca	calcium
City	City of Pasco
Cl	chloride
CRBG	Columbia River Basalt Group
CRF	CRF Frozen Foods
Ecology	Washington State Department of Ecology
ft^2	square foot (feet)
gpd	gallon(s) per day
GWMA	groundwater management area
HCO_3	bicarbonate
K	potassium
Ma	Million years ago
MCL	maximum contaminant level
meq	milli-equivalent(s)
Mg	magnesium
mg N/L	milligram(s) of nitrogen per liter
mg/L	milligram(s) per liter
mgd	million gallons per day
msl	mean sea level
N	nitrogen
Na	sodium
NO_2+NO_3-N	nitrite and nitrate as nitrogen
NO_3-N	nitrate as nitrogen
NRCS	Natural Resources Conservation Service
PWRF	Process Wastewater Reuse Facility
SO_4	sulfate
TDS	total dissolved solids
USGS	U.S. Geological Survey

SECTION 1

Introduction

This Hydrogeologic Assessment Report has been prepared to identify the quality of groundwater flowing under the City of Pasco Process Wastewater Reuse Facility (PWRF) and to identify potential impacts from the adjacent land treatment site on the groundwater. The study is not designed to identify sources of groundwater contamination contributing to the groundwater prior to entering the land treatment site but quantifies the quality of the water entering the site. This report was developed by evaluating existing reports, well logs, and available groundwater quality data, and describes the surface and subsurface geology, groundwater, and water quality conditions at the site.

The City of Pasco (City) has owned and operated the PWRF since 1995. The PWRF and the associated farm properties used for land treatment are located in an area of irrigated agriculture production fields on approximately 1,856 acres north of Pasco and east of Highway 395 in Franklin County (Figure 1). The PWRF has a State Waste Discharge Permit (No. ST0005369) from the Washington State Department of Ecology (Ecology) and discharges its treated water via center-pivot irrigators onto land leased by agricultural operators (Figure 2).

The City designed the PWRF to manage process wastewater from a variety of potential vegetable processing facilities. It currently receives process wastewater from four food processors; no sanitary wastewater is discharged into the industrial system. Three processors (Reser’s Fine Foods, Pasco Processing, and Twin City Foods) combine their process wastewater at the Pasco Processing Center that is located north of the city and along State Highway 395. Freeze Pack is connected to CRF Frozen Foods, which is located on the eastern boundary of the city along State Highway 12. CRF discharged to the PWRF until January 2016, when the facility was shut down. Freeze Pack flows continue to discharge through CRF to the PWRF.

Reser’s, Freeze Pack, Pasco Processing, and Twin City Foods will continue to discharge process wastewater to the PWRF. The City anticipates that several other processors will discharge process wastewater to the PWRF in the future. It plans to provide capacity for additional processors with year-round flow rates in the range of 2.5 million gallons per day. The City plans to phase in new processors and additional treatment capacity at the PWRF.

SECTION 2

Background

Site-specific hydrogeologic evaluations have previously been conducted at the PWRF site, prior to construction, and again during operation of the PWRF. Two of the studies are discussed below.

Prior to construction of the PWRF, Shannon and Wilson (1992) conducted a hydrogeologic evaluation of the site proposed for irrigation disposal of food processing wastewater. The study used existing information to describe the geologic and hydrogeologic conditions at the site, describe the water quality conditions, and develop a conceptual hydrogeologic model that described the subsurface geology, groundwater, and water quality conditions. The report concluded that the uppermost aquifer beneath the site is unconfined and exists within alluvial sediments overlying basalt bedrock, and that groundwater is recharged primarily from water infiltration from the Smith Canyon and Esquatzel Coulee north of the site, with groundwater flow direction in a south to south-southwest direction beneath the site, ultimately discharging to the Snake or Columbia rivers (Shannon and Wilson, 1992). As part of the evaluation, wells on or near the site completed within the unconfined aquifer were tested for major cations and anions in November 1990 and August 1991. Total dissolved solids (TDS) ranged from 330 milligrams/liter (mg/L) to 520 mg/L, and averaged 420 mg/L; nitrate (as nitrogen) concentrations ranged from 0.2 to 45 mg/L (Shannon and Wilson, 1992).

In 2003, Landau Associates completed an amended hydrogeologic study for the active PWRF site. The purpose of the study was to install a new groundwater monitoring well at the site (MW-9) in addition to the existing eight groundwater monitoring wells, to compile background groundwater quality data from MW-9, and to conduct a statistical comparison of background data and downgradient data at the site to recommend changes to the groundwater monitoring plan for the site (Landau, 2003). A previous study conducted by Landau in 2000 concluded that two different water-bearing zones were being monitored at the PWRF site (Landau, 2003). One water-bearing zone was located within a shallow silt unit and was being monitored by MW-1; the second water-bearing zone was deeper and being monitored by wells MW-2 through MW-8, and was composed of a sand and gravel unit (Landau, 2003). Because MW-1 was intended for monitoring groundwater conditions hydraulically upgradient of the site, but had been installed in a different water bearing zone than the remainder of the site monitoring wells, the purpose of MW-9 was to replace MW-1 as an upgradient monitoring well within the sand and gravel unit. The study concluded that, based on groundwater elevations and lithology in all site monitoring wells, MW-9 had been installed hydraulically upgradient of the site. Groundwater flow direction in the sand and gravel aquifer was from MW-9 toward the southwest. The study also concluded that a perched aquifer is present above a discontinuous silt layer in the northern half of the PWRF site, near MW-1. Groundwater quality sampling results indicated that concentrations of some constituents were highest in the northern wells MW-7, MW-8, and MW-9, and to a lesser degree MW-2, and the lowest values were present in MW-4, MW-5, and MW-6, and to a lesser degree MW-3 (Landau, 2003).

SECTION 3

Regional Setting

The following section is a summary of the regional geology, hydrology, and hydrogeology of the PWRF and land treatment site. This summary provides the background to support understanding the setting and evaluation of local groundwater conditions.

3.1 Regional Topography and Climate

The Pasco site resides in the Pasco Basin part of the Columbia Plateau Province in Washington. Elevations in the region range from 340 feet above mean sea level (msl) along the Columbia River near Pasco to 2,700 feet in the Saddle Mountains, with an average elevation of about 900 feet. The climate is arid to semi-arid, with mean annual precipitation ranging from 7 to 10 inches and occurring primarily during the winter. Average temperatures range from the upper 20s (degrees Fahrenheit [°F]) in December and January to more than 90°F in July and August (Heywood et al., 2016). In general, precipitation ranges from 6 to 15 inches a year for areas 350 to 2,000 feet elevation, with vegetation principally sage and grasslands (Bauer and Hansen, 2000).

The three most common types of land cover in the basin as reported in 2006 were planted/cultivated crops (51 percent), followed by shrubland (38 percent) and developed (5 percent). Use of groundwater resources in the Pasco Basin began in the late 1800s, when groundwater was withdrawn for agriculture, stock watering, and domestic use. In the 1950s, the Columbia Basin Project began to deliver water diverted from the Columbia River at Grand Coulee Dam for large-scale agricultural development. Subsequently, groundwater levels generally have risen in the shallow basin-fill sediments.

Although groundwater withdrawals have increased since the 1950s, surface-water irrigation systems supply most of the agricultural water demand in the study area. Water obtained from the Columbia River is distributed through a system of canals and pipes, or buried drains, and excess irrigation water that is not recycled through drains and wasteways recharges the groundwater system.

3.2 Regional Surface Water

The region surrounding the site is completely within the Columbia River drainage (Figure 3). The major surface water features include Potholes Reservoir to the north, Snake River to the east and southeast, and the Columbia River to the west and southwest. Numerous dams have been constructed throughout the lengths of the Columbia and Snake rivers, and only a few short reaches of these rivers are not impounded. While the impoundments have influence over the groundwater in this area as areas of groundwater discharge, a more profound effect on the groundwater system is from the delivery of irrigation water from the impounded river water to large areas (Bauer and Hansen, 2000). Review of pool level measurements above McNary Dam indicate that river pool levels rise in the spring and then quickly decreases inlto July (USGS Station 12514500 Columbian River on Clover Island at Kennewick, WA , October 2016 through Jan 2019).

3.3 Regional Geology

The PWRF site lies in the eastern half of the Pasco Basin, which is a structural and topographic low area in south-central Washington. Most locally significant groundwater occurs in three major stratigraphic units that underlie the eastern Pasco Basin. In ascending order, these units are (1) the Columbia River Basalt Group (CRBG), (2) the Ringold Formation, and (3) the sediments deposited by catastrophic flooding (Drost et al., 1997). A map of the surface geology of the area (Figure 4) was simplified from the digital geologic map database of Washington.

The geologic setting of the area is summarized here as described by Drost and others, (1997). During the Tertiary period, basalts from volcanic fissure eruptions intermittently flooded into the Pasco Basin, creating a basalt-layer sequence more than 15,000 feet thick. Between eruptions, particularly those producing the younger flows, minor amounts of sediment (Ellensburg Formation) were interbedded with the basalts. Northwest- to west-trending folds were formed during late stages of the flood basalt volcanism.

Regional folding and subsidence of the basalts in the Late Miocene resulted in the deposition of fluvial sediments in the Pasco Basin by ancestral rivers flowing into and through the basin. These sediments formed the Ringold Formation of Miocene to Pliocene age, which consists of four textural sub-units referred to as the basal, lower, middle, and upper Ringold Formation.

The basal Ringold Formation, which is a coarse gravel conglomerate, typically is less than 20 meters (66 feet) thick and resulted from the deposition of channel bedload on braided plains. This deposition is limited to the farthest lateral extent of the shallow, shifting channels. There also were occasional silt overbank deposits near the channel from individual flood events.

As structural deformation began to obstruct the river systems, a shallow lake formed in the new basin. The gradual formation of Ringold Lake slowly changed the depositional setting. Silt and clay were deposited above the basal Ringold Formation and the basalt bedrock (outside the former channel boundaries) throughout the basin. As a new channel began to form and provide an outlet for the basin, Ringold Lake slowly drained. The river once again rechannelized into a shifting braided system. Frequent flood events continued to produce fine-grained silt and clay overbank deposits throughout the basin, similar in texture and composition to those in the lower Ringold Formation. Conglomerate in the middle Ringold Formation formed in river channels and continued to thicken as the basin subsided (6.5–5.5 Ma). Although the quantity of gravel deposited generally decreases with distance from a channel swath, channel migration and repeated floods of various sizes resulted in conglomerate, well-sorted sands, and overbank deposits that routinely interfinger, pinch out, or form lenses.

About 5.5 Ma, the basin began to fill again, forming a shallow lake. Sands, silts, and clays filled the basin with 30 to more than 230 meters (100 to 755 feet) of fine-grained laminated sediments in the upper Ringold Formation. These fine-grained sediments are similar in composition and hydraulic characteristics to those in the lower Ringold Formation. After Ringold Lake drained, a calcium-carbonate precipitate formed that cemented the fine-grained sedimentary surface with a thick caliche layer. Subsequent to the formation of the caliche layer, severe dust storms left thick eolian deposits in low-lying areas.

The Pasco gravels that overlie the Ringold Formation are unconsolidated sandy gravels deposited during the Missoula floods. The contact between the Ringold Formation and the Pasco gravels is an irregular disconformity, caused by high-energy erosion during the initial stages of flooding. A temporary lake again filled the basin due to a downstream restriction in the Columbia River Gorge. The Missoula flood deposits consist of very poorly sorted sediments ranging from silts to boulders. The coarsest material was deposited near the river channel. Sedimentation farther from the channel consists of fine-grained slack-water deposits. The size of the lake was directly related to the volume of floodwater. The varying size of flood pulses created interfingering between the coarse- and fine-grained deposits.

Holocene post-Missoula-flood deposits consist of eolian loess, slope wash, eolian dune sand, alluvium, talus, landslide/debris flow, and volcanic ash. Both the fine-grained, well-sorted wind deposits and the poorly sorted, massive landslide and debris-flow deposits typically are unweathered and unconsolidated. These silts, sands, and gravels generally are less than 5 meters (16 feet) thick.

Geologic hazards are limited in the area and specific to the PWRF area. The ground surface is relatively flat, located above the impoundment-controlled rivers and outside flood zones. Seismically, the area is relatively stable with approximately a 0.3-g acceleration ground motion response as estimated by the U.S. Geological Survey (USGS) in collaboration with the Federal Emergency Management Agency (IBC, 2012). The closest mapped faults are south of the PWRF area, approximately 12 miles south and on the south side of the Columbia River, the closest being the Wallula fault zone.

3.4 Regional and Local Soil Conditions

Figure 5 shows a map of soil conditions as mapped by the Natural Resources Conservation Service (NRCS, 2017). Soils in the area are generally fine sandy loam to a loamy fine sand. Soils at the PWRF area are characterized as Quincy loamy fine sand with 0 to 15 percent slopes and 15 to 30 percent slopes, and consist of the following four soil types:

- Fine sandy loam with loamy fine sand; deep, well-drained soil and somewhat excessively drained
- Loamy fine sand with sand to coarse sand; excessively drained soil
- Loamy fine sand; well-drained soil
- Loamy fine sand; excessively drained

These soils have a low-to-moderate available water-holding capacity (7.22 to 11.12 inches) and drain at a moderate-to-moderately-rapid rate (1.1 to 6.3 inches per hour). The average bulk density of the soil is approximately 1.51 grams per cubic centimeter for the site (Ecology, 2015).

3.5 Regional Hydrogeology

3.5.1 Groundwater Flow

As described previously, the groundwater recharge is influenced significantly by various surface water activities including river impoundments, irrigation supplies, and groundwater withdrawals from pumping wells. The following section discusses the hydrogeologic features that influence groundwater flow and interpretation of a predevelopment groundwater flow to better understand the regional hydrogeologic setting. Section 4.3 describes the specific hydrogeologic conditions observed at the site.

The Columbia Plateau is underlain by a series of layered basalt flows that collectively are known as the CRBG. Generally, the rubbly, vesicular tops of flows readily transmit groundwater. The mass central portion of a basalt flow contains some joints and fractures, but transmits groundwater much less readily and impedes the vertical movement of water between the flow tops (Bauer and Hansen, 2000).

The sedimentary materials overlying the CRBG transmit groundwater more readily than the basalts and compose an upper groundwater hydrostratigraphic unit. These upper groundwater hydrostratigraphic units are generally coarse-grained and highly permeable in their upper sections and fine-grained and less permeable at depth. However, in the site area, extensive coarse-grained layers exist deeper in the section.

Water levels measured during 1939 to 1945 in wells screened in both overburden sediments and underlying basalt aquifers (Figure 6) may be considered representative of the predevelopment conditions that were present before the construction of surface-water delivery infrastructure or substantial groundwater withdrawals. During that period, the horizontal directions of groundwater flow were generally perpendicular to water-level elevation contours shown in Figure 6, but generally from the north to south toward the Columbia River. Groundwater flowed southwestward from high-elevation areas in the northeastern part of the study area toward the Columbia and Snake rivers. Because water-level gradients could differ between the overburden and basalt aquifers, the directions of predevelopment groundwater flow in both overburden and basalt aquifers might not be perpendicular to the contours for all areas. Water levels in the basalt and overburden aquifers began to rise substantially following the development of surface-water delivery infrastructure and associated agricultural irrigation in the early 1950s (Heywood, et al., 2016).

Groundwater hydraulic conductivities were calculated for the unconsolidated upper hydrostratigraphic unit and ranged from approximately 100 to 1,000 feet per day, with an approximate value of 400 feet per day used as representative at the regional scale (Bauer and Hansen, 2000). Using a regional groundwater flow in the Pasco area, groundwater elevations decrease from approximately 550 to 350 feet over 18 miles, for a hydraulic gradient of 0.003 foot per foot. The groundwater flow velocity, based on a literature value of 0.25 effective porosity, is calculated to range from 1.2 to 12 feet per day, with an approximate velocity of 5 feet per day.

3.5.2 Groundwater Quality

A hydrogeologic assessment was conducted in 2015 that included a review of regional groundwater quality, including nitrate concentrations in the shallow groundwater in the unconsolidated material above the CRBG (Ecology, 2015). The following summarizes the groundwater quality conditions observed in that study. Site-specific groundwater quality is discussed in Section 4.3.2.

In 1998, a groundwater management area (GWMA) was established for the Columbia Basin at the request of Adams, Franklin, Grant, and Lincoln counties. The GWMA is governed by local citizens, stakeholders, industries, and leaders as a nonregulatory, proactive means to protect groundwater and address issues relating to the aquifer for the Columbia Basin. The GWMA covers over 7.5 million acres.

The GWMA was originally established to assess the extent and magnitude of nitrate contamination in groundwater and to identify the population at risk. An interagency study found that approximately 20 percent (127 wells) of the wells sampled (631 wells) exceeded (did not meet) the Washington state drinking water standard of 10 milligrams of nitrogen per liter (mg N/L). Localized areas of nitrate contamination were identified, but the health effects were not quantified.

The USGS evaluated anthropogenic and natural influences to assess the sources of elevated nitrate concentrations in the Columbia Basin GWMA (Frans, 2000). This study evaluated well construction and location information, recharge rates, proximity to canals, fertilizer application rates, soils, surficial geology, and land use. The strongest correlations with nitrate concentrations above 3 mg N/L (which indicates anthropogenic impacts) were fertilizer applications and well depth. The strongest correlations with nitrate concentrations above 10 mg N/L (the drinking water standard) were fertilizer application, well depth, and soil infiltration rate. These observations were used to develop a model that predicts the probability of groundwater exceeding the concentration thresholds of 3 mg N/L and 10 mg N/L. Maps were developed to illustrate the predicted nitrate concentrations at different depths below land surface. Based on these evaluations, irrigated agricultural areas were considered at the highest risk of having elevated groundwater nitrate concentrations.

The USGS evaluated groundwater nitrate concentrations from approximately 500 wells in the GWMA. Based on an aggregate evaluation of data from these wells, USGS determined that there were no statistically significant trends in nitrate concentrations from 1998 to 2002. However, when only nitrate data exceeding the drinking water standard were evaluated for the entire GWMA, a statistically significant declining trend of -0.4 mg N/L per year was observed during this timeframe. In Franklin County, the wells with nitrate levels higher than the drinking water standard had a declining nitrate trend of -0.46 mg N/L for this timeframe.

When evaluating nitrate trends in Franklin County from a smaller data set of 51 wells over a longer time period, USGS found a statistically significant increase in nitrate concentrations of 0.1 mg N/L per year between 1986 and 1991, but observed no statistically significant trends between 1998 and 2003. This suggests that while nitrate concentrations in the Columbia Basin are locally elevated, they are stable and in some places are declining.

In 2008, additional research was conducted analyzing nitrate groundwater data within the Columbia Basin GWMA. Within the Pasco Basin of the Columbia Basin GWMA, 70 wells were analyzed by GWMA researchers within the uppermost aquifer system (unconsolidated coarse-grained material overlying the CRBG). The mean nitrate concentration was 12.3 mg N/L, with concentrations ranging from nondetect (0.01 mg N/L) to 70.4 mg N/L. These researchers noted that elevated average nitrate concentrations (higher than the drinking water standard) tend to be located in areas where the groundwater gradient is relatively flat, in the southeastern area of the basin. This phenomenon is the result of slower groundwater flow rates, less dilution, mixing, and flushing of nitrate loading to the land surface. Additionally, a positive correlation was observed between nitrate concentration and well depth. These researchers noted that the highest concentrations are located within the uppermost 40 feet of the aquifer system. A statistical analysis of the data indicates a decreasing nitrate trend with increasing depth in the aquifer.

Additionally, it was noted that a dilution effect occurs when wells were located within one-half mile of an unlined irrigation canal. Leaking canals provide added groundwater recharge during the irrigation season of approximately April through September. The researchers concluded that the majority of wells with nitrate concentrations less than 10 mg N/L are located within one-half mile of a canal. These researchers also noted that manmade subsurface drains, used for collecting irrigation return flows, typically leak and could also contribute additional recharge and dilution; however, this source was not evaluated.

These researchers also noted that there are no consistent seasonal variations across the Pasco Basin, but within individual wells, seasonal variations of nitrate levels are related to variations in the elevation of the water table. This dilution effect is characterized by decreasing nitrate concentrations as the water table rises. However, a decreasing nitrate concentration with a lowering of the water table was noted with the wells that are in close proximity to canals. This phenomenon is related to the dilution effects of the canals.

SECTION 4

Local Setting

The following section describes local and site-specific geology, hydrology, subsurface, and hydrogeology conditions, and areas potentially impacted by high nitrogen and TDS levels in groundwater. The summary provided in the previous regional section was used to better interpret site hydrogeologic conditions. Some features, such as geologic hazards and surface soil conditions, were addressed at the regional level in Section 3.

4.1 Local Topography, Surface Water, and Climate

The PWRF site is located in a relatively flat agricultural area as shown in Figures 2 and 3. There are no surface water bodies or wetlands mapped within the site boundaries, with the exception of the PWRF water storage basins. To the southeast of the site, just outside the eastern site boundary, there is an intermittent stream that flows toward the southwest in Lower Smith Canyon.

The topography within 2 miles of Pasco contains only modest variations in elevation, with a maximum elevation change of 148 feet and an average elevation of 391 feet msl. The area within 2 miles of Pasco is mostly covered by artificial surfaces (75 percent), within 10 miles by cropland (49 percent) and artificial surfaces (22 percent), and within 50 miles by cropland (43 percent) and shrubs (42 percent).

In addition to the active agricultural areas surrounding the PWRF site, several concentrated animal feeding operations (CAFO) are located adjacent to, and to the northeast of the site. Figure 2 shows an active CAFO adjacent to the Norwest corner of the PWRF boundaries. There are irrigation areas south of the CAFO and within the quarter mile boundary to the PWRF that are owned by, and apparently operated by the same individuals that own the CAFO parcel. Another CAFO identified as Five D Farms is located off the figure, is located northeast approximately 4 miles of the PWRF and includes ponds and irrigations areas apparently associated with operations.

Table 4-1 presents the local normal precipitation and temperature for the site. While precipitation is higher in the November through January period, the overall precipitation is relatively low. The semi-arid conditions result in an evapotranspiration (pan) equal to approximately 41 inches per year, versus an annual precipitation equal to approximately 7.5 inches (Pritchett, 2011). The growing season is the period of time when temperature and moisture conditions are suitable for crop growth. The rest of the year comprises the nongrowing season. This is when there is intermittent freezing of the surface soils, reportedly for this area from approximately November to March 15 (Pritchett, 2011). Figure 2 shows the PWRF and the land treatment boundaries. The area is irrigated in irrigation circles as shown on the map.

Irrigation operations were reviewed with PWRF site operators and a site visit attended by Jacobs and Ecology representatives on with City staff on February 12, 2019. The site visit included meeting with the operators at the City offices, followed by a site visit of the PWRF facilities and discussing the operations and controls on land application, superficially looking if some areas would be operated in a way that could represent greater loading that other areas. Based on these conversations, fields are irrigated based on rotations, with planting rotated throughout the PWRF area. These operations result in controlled irrigation and applications based on the application plan and plant specific, with operations homogenous in the entire PWRF area. That is, the same plants, irrigation, and rates have been applied consistently throughout the extent of the site.

Table 4-1. Monthly Climate Normals (for the period 1981 to 2010)

Month	Total Precipitation Normal (inches)	Mean Maximum Temperature Normal (°F)	Mean Minimum Temperature Normal (°F)	Mean Average Temperature Normal (°F)
January	1.22	41.8	27.9	34.9
February	0.86	49.0	28.7	38.9
March	0.79	59.1	33.6	46.3
April	0.65	67.4	38.5	52.9
May	0.73	75.6	45.8	60.7
June	0.68	82.9	52.2	67.5
July	0.28	91.3	55.7	73.5
August	0.27	90.0	55.5	72.8
September	0.40	80.3	46.6	63.4
October	0.65	65.8	38.0	51.9
November	1.09	50.2	32.4	41.3
December	1.21	39.9	26.4	33.1

Source: National Climatic Data Center, Pasco Tri-Cities Airport, Washington, USW00024163.
https://www.ncdc.noaa.gov/cdo-web/datatools/normals

4.2 Local Geology

Within the Pasco Basin, and below the PWRF, the basalt flows are overlain with sedimentary units of the Ringold Formation, which consists of silt, sand, clay, and gravel. Aeolian deposits of wind-blown silt and fine sand overlie the Ringold Formation, and in some areas are covered by gravels deposited during the Pleistocene-epoch floods from glacial Lake Missoula (Landau, 2003). These site observations are consistent with the regional geology as described in Section 3 and Figure 4.

The subsurface conditions beneath the PWRF are based on interpretation of available drillers' well logs for wells located within the project site boundaries, and on interpretations provided in previous hydrogeologic reports for the PWRF. Figure 2 shows the locations of monitoring wells, irrigation wells, and private wells located within the PWRF and within a quarter mile of the PWRF site boundaries. Figure 7 shows the nearest water supply wells located outside of the PWRF boundaries. The drillers' logs for the locations shown on Figure 2 are provided in Appendix A.

Two subsurface profiles (located on Figure 2) were modified from Shannon & Wilson (1992) and are presented as Figure 8 and Figure 9. These profile sections show the hydrogeologic interpretation of the subsurface beneath the site. Generally, the subsurface consists of brown silt approximately 25 to 50 feet thick, underlain by a sequence of silty sand and gravel that ranges between 60 and 100 feet thick above a discontinuous silt/clay unit. Based on drilling information from monitoring wells MW-2 through MW-8, this discontinuous silt/clay unit is 5 to 10 feet thick and is present at elevations between 398 and 366 feet msl, approximately 100 to 140 feet below ground surface (bgs) (Landau, 2003). The discontinuous silt/clay unit is present in the vicinity of wells MW-2, MW-3, MW-6, and MW-8 and was not encountered in wells MW-4, MW-5, MW-7, or MW-9. The silt/clay unit is also absent to the northwest of the site as well as to the west and south of circles IV and V (Figure 2). This silt unit appears to dip from north to south and from east to west, but may also slope east in the central portion of the site near monitoring well MW-8 (Landau, 2003). Beneath the discontinuous silt/clay unit are well-graded sands and gravels that are up to 95 feet thick. Underlying the sands and gravels is basalt of the CRBG at approximately 130 feet bgs in the eastern portion of the site, which dips toward the western portion of the site to a maximum depth of 245 feet bgs (Shannon & Wilson, 1992). In the northwest portion of the site, upgradient toward MW-1, the lithology is different and consists of approximately 50 feet of fine sands and silt, underlain by a unit of brown silt which is over 60 feet thick. The silt layer is at an elevation of approximately 510 feet msl, which is over 100 feet higher than the silt unit encountered in downgradient wells MW-2 through MW-8. Beneath this silt is well-graded sand. Below the sand, basalt is typically present at depths of 150 to 225 feet bgs (Landau, 2003).

4.3 Local Hydrogeology

The upper most groundwater beneath the site occurs within an unconfined aquifer comprised of alluvial sediments overlying basalt bedrock. Groundwater monitoring wells MW-2 through MW-9 are screened within a sand and gravel aquifer beneath the site. Monitoring well MW-1 is installed in the northern portion of the site, screened across a perched zone of saturation located above the discontinuous silt/clay layer located on the northern half of the site. Saturation above the discontinuous silt/clay layer can result in temporary and localized perched conditions (Landau, 2003). The perched zones are anticipated to have vertical gradients and result in recharge to groundwater in the sand and gravel near irrigation circles VI and VII (Figure 2) where the silt becomes discontinuous, or to the east, west, and south of the irrigation circles, where the silt/clay unit is absent (Landau, 2003). While not located within the saturated zone underlying site to the south, this saturated zone likely represents contributions from upgradient and outside the influence of the site operations and contributes as recharge to the underlying laterally continuous groundwater.

Previous studies using well yield data to determine transmissivity values for the site are presented in a report by Shannon & Wilson (1992). Transmissivity values determined from well yield data obtained from driller's logs ranged from 500,000 gallons per day (gpd) per foot near irrigation circles VI – IX, to 50,000 gpd per foot near irrigation circles II – V. Using the transmissivity values presented above, and an average aquifer thickness of 70 feet, calculated hydraulic conductivity estimates for the site range from 700 gpd per square foot (ft^2) near irrigation circles II – V to 7,000 gpd/ft^2 near irrigation circles VI – IX (Shannon & Wilson, 1992). This converts to approximately 90 to 900 feet per day, which is comparable to the range for the regional unconsolidated hydrostratigraphic unit of 100 to 1,000 feet per day.

4.3.1 Groundwater Flow

Monthly groundwater elevation measurements for 2017 are shown as a hydrograph in Figure 10**,** and groundwater elevation data are provided in Appendix B. The groundwater elevations across the site were generally consistent with each other throughout 2017.

Considering the generally consistent groundwater elevations in each well throughout 2017, a representative round of data was selected to interpret groundwater flow at the site. Groundwater elevations from May 2017 were chosen for the groundwater potentiometric surface shown in Figure 11. Groundwater elevations from wells MW-2 through MW-9 were used to construct the potentiometric surface and interpret groundwater flow across the PWRF site. These water levels represent groundwater conditions for wells screened in the sand and gravel aquifer. The potentiometric surface shows groundwater flow generally to the south and southwest. This flow direction is consistent with the results of previous site hydrogeological evaluations (Shannon & Wilson, 1992; Landau, 2003). Based on the local groundwater potentiometric surface, the groundwater elevations decrease approximately 12 feet over 1 mile for a hydraulic gradient of approximately 0.002 foot per foot, lower than the 0.003 foot per foot calculated for the regional flow in this area. Correspondingly, this results in a lower groundwater flow velocity of approximately 0.7 to 7 feet per day, but still relatively consistent with the calculated regional flow velocity of 1.2 to 12 feet per day.

4.3.2 Groundwater Quality

To facilitate the comparison of general groundwater chemistry between wells, and over time within each well, the major cations (sodium [Na], potassium [K], calcium [Ca], and magnesium [Mg]) and major anions (chloride [Cl], bicarbonate [HCO_3], carbonate [CO_3], and sulfate [SO_4]) in PWRF site monitoring wells were graphically evaluated. To do this, the constituent concentrations shown in Appendix B, Monitoring and Irrigation Well Analytical Data, (measured in mg/L) were converted to milliequivalents (meq)/L and plotted as “Stiff” diagrams for the rounds of available general chemistry results collected at the PWRF site. A Stiff diagram is a six-sided polygon. Each point on the polygon represents the milliequivalent concentration of each constituent, with cations on the left and anions on the right. The further a point is from the center of the polygon, the greater the concentration. In Stiff diagrams, sodium and potassium are combined on the cation side, and bicarbonate and carbonate are combined on the anion side. The overall size of a Stiff diagram indicates the relative TDS concentration of the sample.

Stiff diagrams for each well and for each round of monitoring where general chemistry data were available are shown in Figure 12 and Figure 13 for historical monitoring conducted 11/1/2009, 5/1/2010, 11/7/2012, 5/15/2014, and 5/14/2015. The change in the size and shape of a given well’s Stiff diagram indicates the extent to which the general water chemistry has changed at that location. A review of these diagrams reveals relatively little change in the size and shape of the Stiff diagrams for each well, indicating consistent general groundwater chemistry through time at each monitoring location.

Considering the relatively consistent general groundwater chemistry over time within each well, a representative round of data was selected to compare the general groundwater chemistry between wells in 2014, the largest well dataset. Three general Stiff diagram shape-types are apparent across the site: a diamond-like shape, a “left turn signal” shape, and a “right turn signal” shape. The diamond-like shape reflects more calcium-carbonate groundwater conditions (wells MW-2, MW-3, and MW-9), the left turn signal shape reflects more magnesium-sulfate (wells MW-1, MW-7, and MW-8), and the right turn signal shape reflects more carbonate (wells MW-4, MW-5, and MW-6). The groundwater along the southwest portion of the site appears to be more carbonate in chemical signature (south of the flowline in Figure 11).

A review of publicly available groundwater analytical data on the Washington Department of Health, Office of Drinking Water website (2018) for water supply wells located in the area surrounding the PWRF site boundaries was conducted and available data were compared to groundwater analytical data from the monitoring wells on the PWRF site. These wells are shown on Figure 7.1. This evaluation was conducted to determine background conditions upgradient and outside of the PWRF land treatment boundaries. The dates for available groundwater quality data in the vicinity of the PWRF site ranged from 1985 to 2004 for smaller-volume Group B water supply wells, and 2017 for larger-volume Group A water supply wells. There are three Group B wells located 1 to 2 miles to the north and northwest of the site boundaries. These wells are installed to depths of approximately 200 feet (for wells with available depth information), and are deeper than the PWRF site wells, which range in depth from approximately 115 to 197 feet, with an average depth of 147 feet. Nitrate-nitrogen sample results for these offsite wells were below the maximum contaminant level (MCL) of 10.0 mg/L. To the east of the PWRF site boundaries, at approximately 2 miles, there is one Group B well installed to 599 feet with no detections of nitrate-nitrogen. To the west of the site boundaries, at approximately 2 to 3 miles, are four water supply wells with nitrate-nitrogen concentrations detected in excess of the MCL. A nitrate-nitrogen concentration of 16.5 mg/L was detected in 2002 from a 225-foot-deep Group B well, a concentration of 24.1 mg/L from a 119-foot-deep Group B well was detected in June 2000, and quarterly samples collected from two Group A wells (installed to 83 feet and 98 feet deep) in 2017 ranged from 19 to 25 mg/L. Within the site boundaries, there is one Group B well, located approximately one-half mile to the northeast of MW-3, installed to 154 feet, with a nitrate-nitrogen concentration of 17.9 mg/L in 1991.

TDS concentration information for wells located outside of the PWRF site boundaries was not as available as nitrate-nitrogen information. Results were available for five wells and show that TDS exceed the MCL in two shallow (83 feet and 98 feet deep) Group A wells to the west of the site boundaries at 530 and 560 mg/L in August 2016 samples. The remaining three wells had detections below the MCL.

Additional groundwater quality data was available from Washington Department of Ecology EIM database. Ecology's EIM system contains historical data that has been collected under a wide variety of regimes, but was used to provide additional information regarding nitrates in groundwater in the PWRF site area for consideration. Three studies were identified that had data for nitrates in groundwater in the PWRF site and are shown in Figure 7.2. The Columbia Basin Crop and Water Quality Monitoring Study and Irrigated AG Technical Assistance Study provided information for the FCD well locations. The Central Columbia Basin GWMA – Nitrate Characterization study provided information for the GO well locations. The location, groundwater nitrate concentrations, and well depths (if available) are included for comparison on Figure 7.2.

The nitrate results generally show higher elevations in shallower wells in similar locations, such as at locations GO540 (170 ft depth, 20.9 mg/L) and GO594 (366 ft depth, 0.409 mg/L). These studies groundwater nitrate concentrations also increased from the southwest side of the PWRF to higher nitrate concentrations to the north (with the highest concentration in GO603 of 67 mg/L at a depth of 370 ft).

Downgradient of the PWRF site, wells GO637, GO591, and GO629, are located north, southwest and southeast of the PWRF pond area. Nitrate concentration in groundwater is highest in GO637 located the farthest north (30.3 mg/L), while concentrations decrease in GO591 (25.5 mg/L) and GO629 (19.8 mg/L). The groundwater flow as shown in Figure 11 would suggest that well GO637 is located almost cross gradient from the PWRF application areas, however would be within the influence of the CAFO irrigation areas. As CAFOs are potential sources of nitrate in groundwater, these results provide consideration sources of these elevated nitrate concentrations other than the PWRF application.

Elevated nitrate-nitrogen concentrations and TDS concentrations in exceedance of the MCL drinking water standard of 10.0 mg/L for nitrate-nitrogen and 500 mg/L for TDS are present in groundwater sample results from upgradient and downgradient monitoring wells on the PWRF site. Figures 14 through 17 show the nitrate-nitrogen and TDS concentrations in PWRF site monitoring wells and irrigation wells that are regularly sampled. Nitrate-nitrogen concentrations in monitoring wells MW-1, MW-2, MW-3, MW-7, MW-8, and MW-9 have consistently been detected at levels above the MCL. Nitrate-nitrogen concentrations in the remaining monitoring wells, MW-4, MW-5, and MW-6, at the southern end of the site, have been detected at levels near but predominantly below the MCL, with concentrations in MW-5 consistently detected just above the MCL from August through December 2017 (Figure 11 and Figure 14).

In the irrigation wells, nitrate-nitrogen concentrations were consistently detected above the MCL in wells IW-6-9, IW-7, IW-8-10, IW-11-13, and IW-12. Concentrations in the remaining irrigation wells, IW-1, IW-2, IW-3, IW-4, IW-5, and IW-15, have consistently hovered just above or just below the MCL since August 2012 (Figure 15).

Similar to the distribution of nitrate-nitrogen concentrations, TDS concentrations consistently exceed the MCL in monitoring wells MW-1, MW-2, MW-3, MW-7, MW-8, and MW-9 and are mostly detected below the MCL in wells MW-4, MW-5, and MW-6 (Figure 16).

Irrigation wells IW-7, IW-8-10, IW-11-13, and IW-12 consistently have concentrations of TDS detected above the MCL, while wells IW-1, IW-2, IW-3, IW-4, IW-5, IW-6-9, and IW-15 have TDS concentrations primarily below the MCL except for concentrations in IW-2, IW-3, IW-5, and IW-6-9 in 2017 (Figure 17). Groundwater analytical data for the irrigation wells and monitoring wells are provided in Appendix B.

The general groundwater chemistry, nitrate concentrations, and TDS concentrations display differences between the groundwater in the southwest area of the site.

4.4 Potentially Impacted Areas

Historically, nitrate-nitrogen and TDS concentrations have been detected above the MCLs in groundwater monitoring wells on the PWRF site. Analytical results for wells located offsite, to the west of the PWRF, also show elevated levels of nitrate-nitrogen and TDS in groundwater, indicating regionally elevated levels are present.

Within the PWRF site boundaries, the elevated concentrations of nitrate-nitrogen and TDS primarily occur in the central to northern portion of the site, north of E. Foster Wells Road. Based on the groundwater flow at the PWRF site toward the south and southwest in monitoring wells MW-2 through MW-9, the area north of E. Foster Wells Road has higher concentrations of nitrate and TDS. The general groundwater chemistry shows a consistent difference in the groundwater quality north of the road.

Previous conducted groundwater monitoring in well MW-1 as indicated higher concentrations of nitrates in perched upgradient groundwater likely contributing to groundwater recharge in the northern section of the PWRF site. The MW-1 saturated zone is perched on a discontinuous silt layer that has been interpreted sloping to the south and west, with discontinuous sections to the south.

Based on the groundwater flow direction to the southwest and PWRF application areas to the central and southeast areas, impacts to groundwater in these areas are not indicated from land application, which is consistently applied throughout the site. The groundwater concentrations for wells monitoring downgradient of groundwater from the north and northeast are likely from these upgradient groundwater sources, as have been historically indicated in well MW-1.

The PWRF effluent concentrations for the nitrite and nitrate as nitrogen (NO_2+NO_3-N) and TDS are summarized in Table 4-2. The city collected samples of the effluent from June 9, 2016, to October 20, 2016, during land application operations. Land application operations normally extend from March 1 to November 30 of each year. The samples were collected approximately weekly and provide a good representation of the effluent water chemistry applied to the irrigation site. The effluent concentrations for nitrate-N (which would be a portion of the combined nitrate and nitrate) are significantly lower than those observed in groundwater at the site, and lower than the groundwater concentrations reported in wells outside the area and as reported regionally. The effluent TDS concentrations are higher than observed in groundwater. However, the groundwater distribution across the site and general chemistry, nitrate-N, and TDS concentrations suggest that the impacts of nitrates and TDS observed on the site are more associated with groundwater flow in the northwest and not percolation due to widespread surface application across both the north and south sections of the area.

Table 4-2. PWRF 2016 Sampling Summary

Date	Flow (mgd)	NO2+NO3-N (mg/L)	TDS (mg/L)
6/9/2016	1.776	0.26	754
6/16/2016	1.707	0.34	818
6/23/2016	2.045	0.29	975
6/30/2016	2.421	0.16	852
7/7/2016	2.351	0.2	806
7/21/2016	2.735	0.32	771
7/28/2016	5.663	0.32	771
8/4/2016	5.606	0.23	988
8/18/2016	2.675	0.47	1,005
8/25/2016	4.072	0.41	974
9/1/2016	4.986	0.41	794

9/8/2016	3.428	0.33	771
9/15/2016	3.043	0.38	639
9/22/2016	3.446	0.22	773
9/29/2016	3.546	0.34	755
10/6/2016	3.440	0.55	756
10/13/2016	4.245	0.56	805
10/20/2016	3.079	0.56	805
10/27/2017	1.292	0.92	472
Average	3.348	0.35	823
Median	3.254	0.34	800
Maximum	5.663	0.56	1,005
Minimum	1.707	0.16	639

Note: Sampling conducted approximately weekly from 6/9/2016 to 10/20/2016.

SECTION 5

Conclusions

The hydrogeologic evaluation described above provided the following conclusions:

- Regional groundwater includes saturated material in unconsolidated coarse-grain material overlying the CRBG, and also flows within the CRBG.
- The unconsolidated material transmits groundwater more readily than the CRBG; the CRBG transmits groundwater less readily through joints and fractures, along flow contacts, and is further restricted across contacts.
- Surface soils drain at a moderate to moderately rapid rate of 1.1 to 6.3 inches per hour.
- Regional groundwater flow is from the north to south toward the Columbia River. Groundwater hydraulic conductivities range from 100 to 1,000 feet per day with a hydraulic gradient of 0.003 foot per foot and calculated flow velocity of 1.2 to 12 feet per day.
- The local site groundwater flow direction is from the northeast to southwest toward the Columbia River. Local groundwater flow characteristics are similar to regional flows, with hydraulic conductivities ranging from 90 to 900 feet per day with a hydraulic gradient of 0.002 foot per foot and calculated flow velocity of 0.7 to 7 feet per day.
- Locally, municipal wells are constructed at greater depth than the PWRF wells and are below the MCL for nitrate-N concentrations. Local Group A and Group B wells screened shallower than the municipal wells have had historical detections of nitrate-N greater than the MCL.
- The local unconsolidated material is 130 feet deep on the eastern portion of the site and increases to 245 feet on the western side. A perennial stream is located to the west and south of the site in Lower Smith Canyon that may act as a local groundwater recharge feature, like an unlined irrigation ditch.
- Local groundwater chemistry is different north and south of E. Foster Wells Road. Nitrate-N and TDS concentrations are generally higher to the north, and lower to the south.
- Historical perched groundwater measurements in well MW-1 indicated higher nitrate concentrations in this area likely recharging the lower laterally continuous groundwater.
- PWRF land application are controlled with application rates based on field rotation across the entire site without one specific area that would result in greater application than other areas.
- PWRF effluent concentrations were sampled during irrigation operations in 2016 with measured nitrite and nitrate-N significantly lower than groundwater concentrations and not likely a source of nitrate-N concentrations elevated in groundwater.
- While existing monitoring results do not indicate PWRF effluent and irrigation operations are the source of elevated nitrate-N concentration in groundwater, information regarding flow direction and upgradient groundwater is limited for the northern section of the application area and for comparison to downgradient monitoring wells MW-2, MW-7, and MW-8.

SECTION 6

References

Bauer, H.H., and A.J. Hansen. 2000. *Hydrology of the Columbia Plateau Regional Aquifer System, Washington, Oregon, and Idaho*. U.S. Geological Survey Water Resources Investigations Report 96-4106.

Drost, B.W., Cox, S.E., and Schurr, K.M.. 1997. *Changes in ground-water levels and ground-water budgets, from predevelopment to 1986, in parts of the Pasco Basin, Washington.* U.S. Geological Survey Water-Resources Investigations Report 96–4086, 172 p.

IBC. 2012. *International Building Code*. International code Council, Inc.

Heywood, C.E., S.C. Kahle, T.D. Olsen, J.D. Patterson, and E. Burns. 2016. *Simulation of Groundwater Storage Changes in the Eastern Pasco Basin, Washington*. U.S. Geological Survey Scientific Investigations Report 2016–5026.

Frans, L.M.. 2000. *Estimating the probability of Elevated Nitrate (NO2+NO3-N) Concentrations in Ground Water in the Columbia Basin Ground Water Management Area, Washington.* U.S. Geologic Survey Water-Resources Investigations report 00-410, 24 pgs.

Landau Associates. 2003. *Report, Amended Hydrogeologic Study, Industrial Waste Water Treatment Facility, Pasco, Washington*. October 6.

National Climatic Data Center, Pasco Tri-Cities Airport, Washington, USW00024163. https://www.ncdc.noaa.gov/cdo-web/datatools/normals

National Weather Service Forecast Office. Monthly Climate Normals (1981 – 2010), Tri-Cities Area, Washington. http://w2.weather.gov/climate/xmacis.php?wfo=pdt. Accessed March 2018.

Natural Resources Conservation Service (NRCS). 2017. United State Department of Agriculture, Natural Resources Conservation Service, Web Soil Survey. https://websoilsurvey.nrcs.usda.gov/app/. Accessed March 2018.

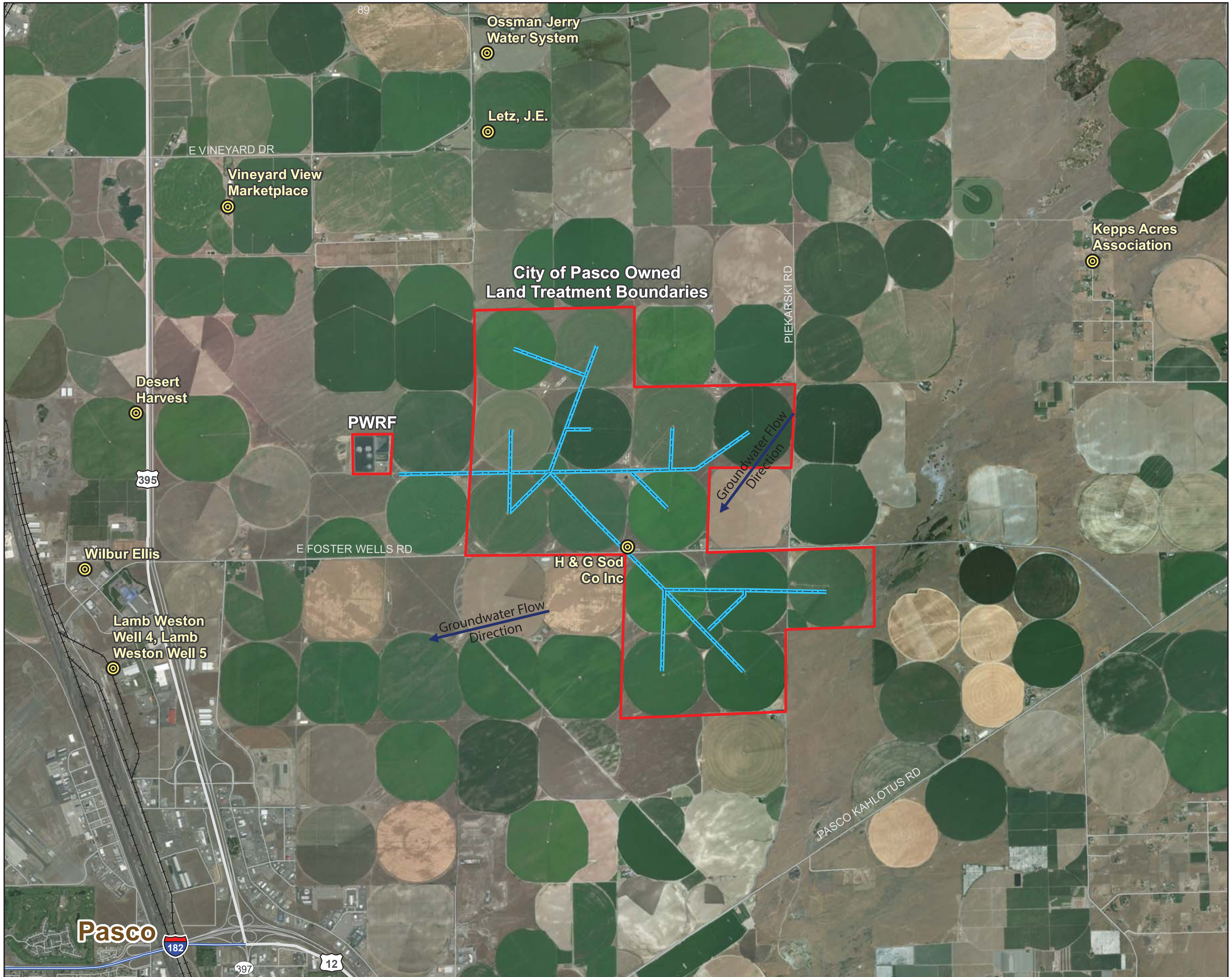
Pritchett, K.. 2011. *2011 Cropping and Irrigation Schedule ConAgra Foods Lamb Weston Pasco, Washington.* Cascade Earth Sciences, Spokane, WA, 15 pgs+ tables and figures

Shannon and Wilson, Inc. 1992. *Hydrogeology Evaluation, Pasco Industrial Wastewater Treatment Plant Site, Pasco, Washington.* April.

Washington State Department of Ecology (Ecology). 2015. *ConAgra Foods Lamb Weston Inc., Pasco, Washington, Hydrogeologic Assessment*. Prepared by Melanie B. Redding, Licensed Hydrogeologist. Publication No. 15-03-023. July.

Washington State Department of Health. 2018. Division of Environmental Health, Office of Drinking Water, Sentry Internet. https://fortress.wa.gov/doh/eh/portal/odw/si/Intro.aspx. Accessed February.

Figures



VICINITY MAP

LEGEND

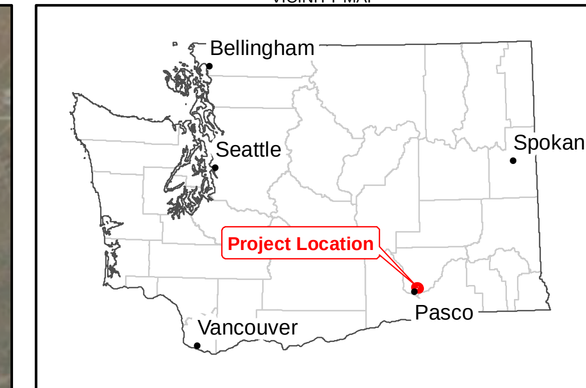
- Water Supply Well
- Irrigation Mains
- Roads
- Project Boundary
- Flow

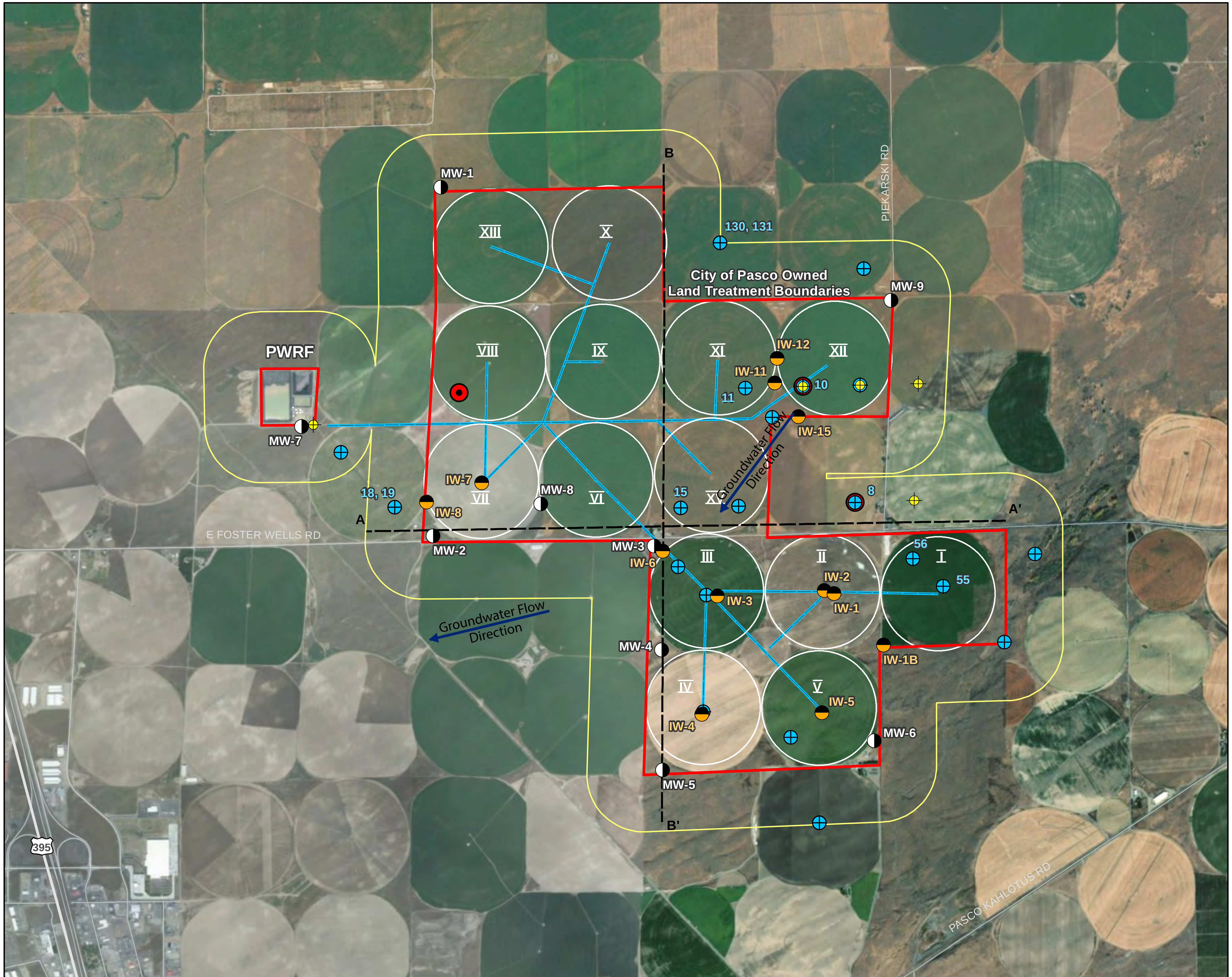
Notes:
1. City of Pasco - Roads centerline
2. ESRI Basemap Imagery

N

0 0.75 1.5
Miles

FIGURE 1
Vicinity Map
City of Pasco
Process Water Reuse Facility
Hydrogeologic Assessment





LEGEND

- Irrigation Well
- Monitoring Well
- Resource Protection Wells
- Water Wells
- Decommissioned Wells
- Flow
- Project Boundary
- Quarter Mile Buffer
- Irrigation Mains
- Roads
- A — A' Subsurface Profile
- 18 Well Designations Used for Subsurface Profile
- XII Irrigation Circle Identification

Notes:
1. City of Pasco - Roads centerline, monitoring wells
2. Washington State Department of Ecology - Well Log Database https://fortress.wa.gov/ecy/waterresources/map/WCLSWebMap/default.aspx
3. Wells 2017 PWRF Survey (CAD) - monitoring/irrigation wells
4. ESRI Basemap Imagery
5. Location of resource protection wells, water wells, and decommissioned wells obtained from WA Department of Ecology Well Log Database. Obtained locations shown on this figure may differ from the well's actual location.

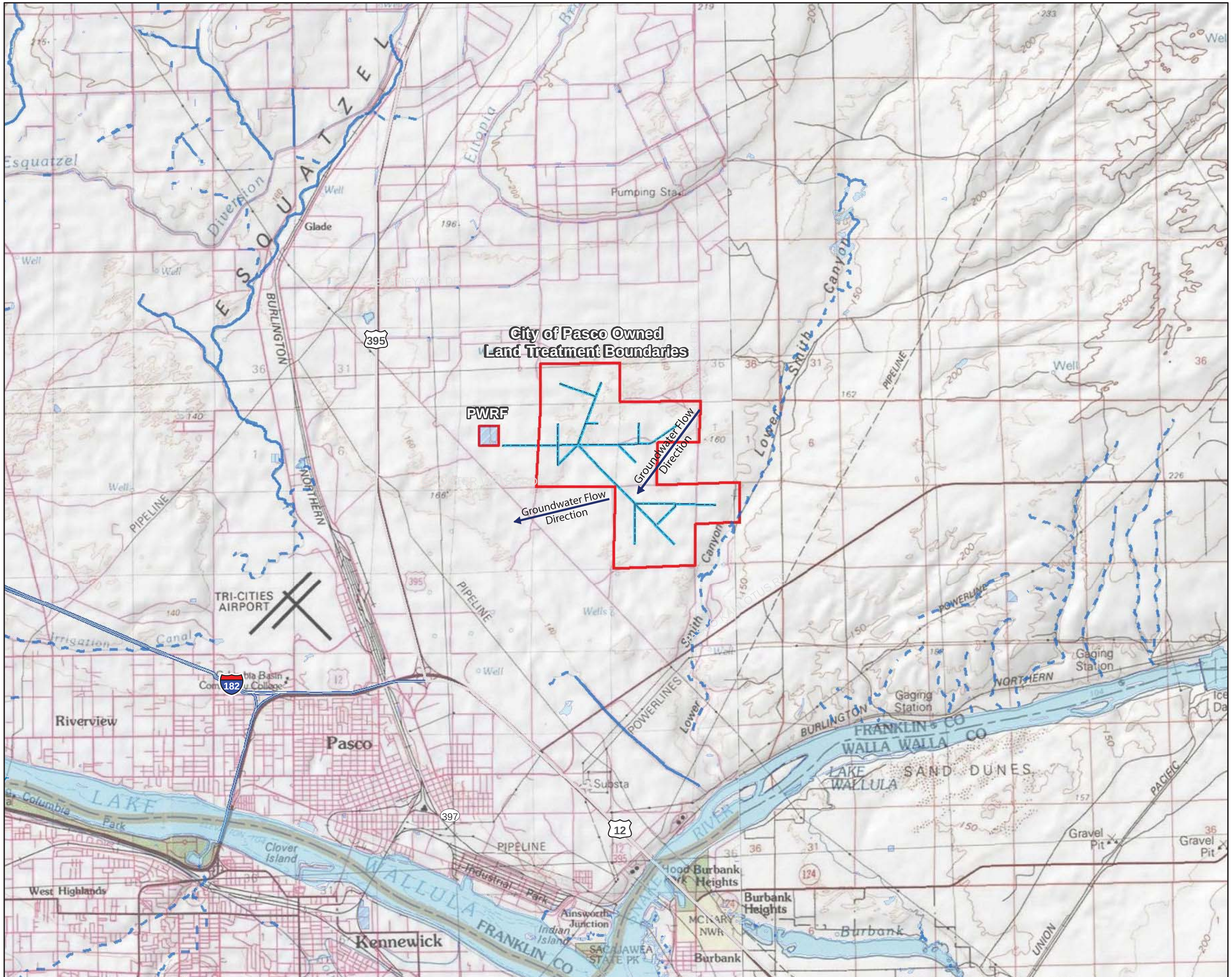
N

0 0.5 1
Miles

FIGURE 2
Site Map
City of Pasco
Process Water Reuse Facility
Hydrogeologic Assessment

UNK \\SEAFPP01\PROJ\CITYOFPASCO\697159\GIS\MAPFILES\REPORT\FIGURE_WELLLOCATIONS.MXD SB058815 3/29/2018 9:06:15 AM

ch2m:



VICINITY MAP

LEGEND

- Stream/River
- Intermittent Stream/River
- Perennial Stream/River
- Irrigation Mains
- LakePond
- Reservoir
- Project Boundary
- Flow

Notes:
1. City of Pasco - Roads centerline
2. Washington State Department of Ecology - National Hydrography Dataset - Rivers/Lakes
3. ESRI Topographic Basemap

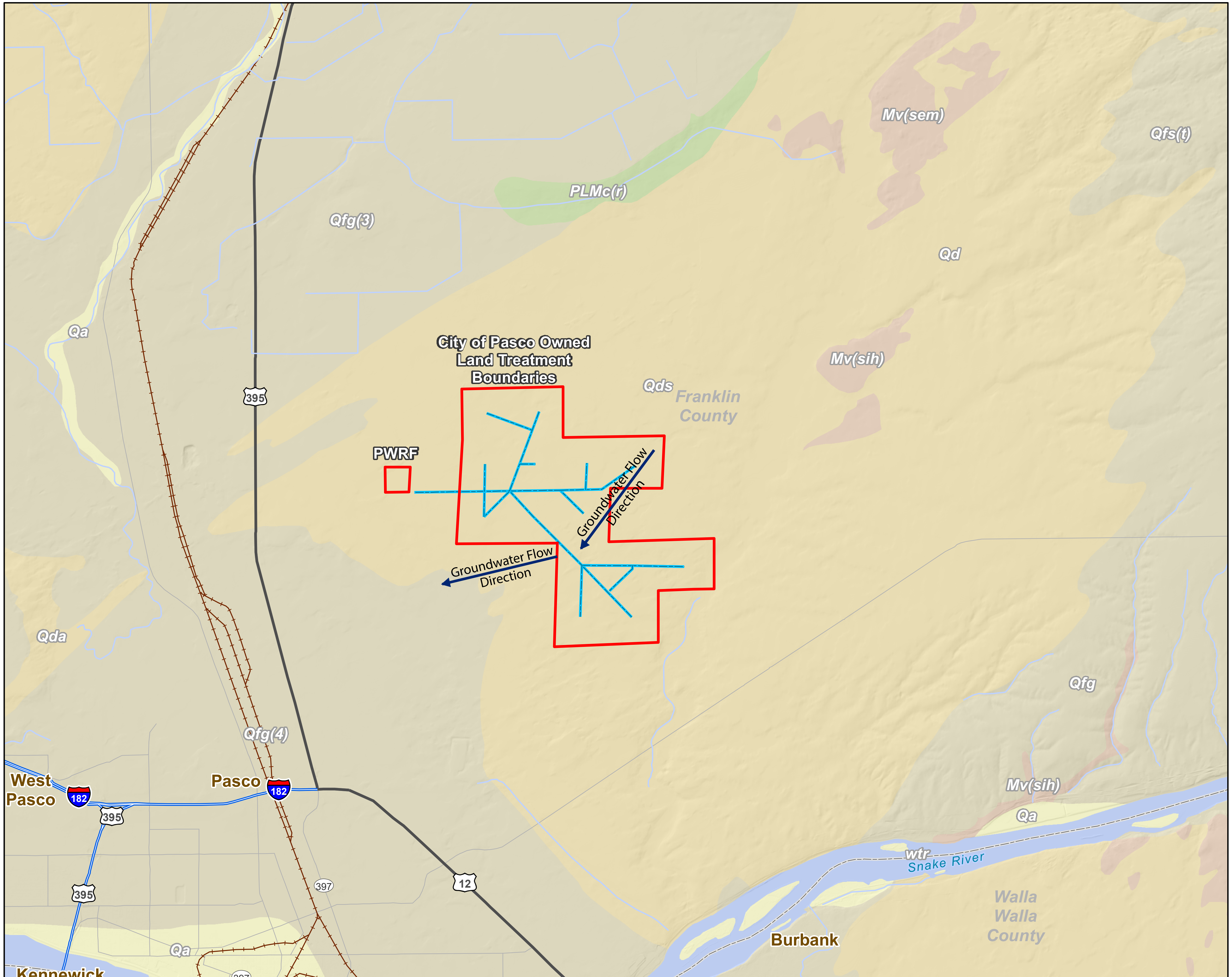
N

0 1.5 3
Miles

FIGURE 3
Topography and Surface Features
City of Pasco
Process Water Reuse Facility
Hydrogeologic Assessment

ch2m:

VICINITY MAP



LEGEND

- Rivers
- Irrigation Mains
- Project Boundary
- County Boundary

Surface Geology (100K)

Quaternary Rocks and

- Qa: Quaternary alluvium
- Qd/Qda/Qds: Quaternary dune
- Qfg/Qfg(3)/Qfg(4)/Qfs(t): Pleistocene outburst flood deposits

Tertiary Rocks

- PLMc(r): Tertiary sedimentary rocks and deposits
- MV(sem)/(sih): Miocene Columbia River Basalt Group, Saddle Mountains Basalt

Water

- wtr: Water
- Flow

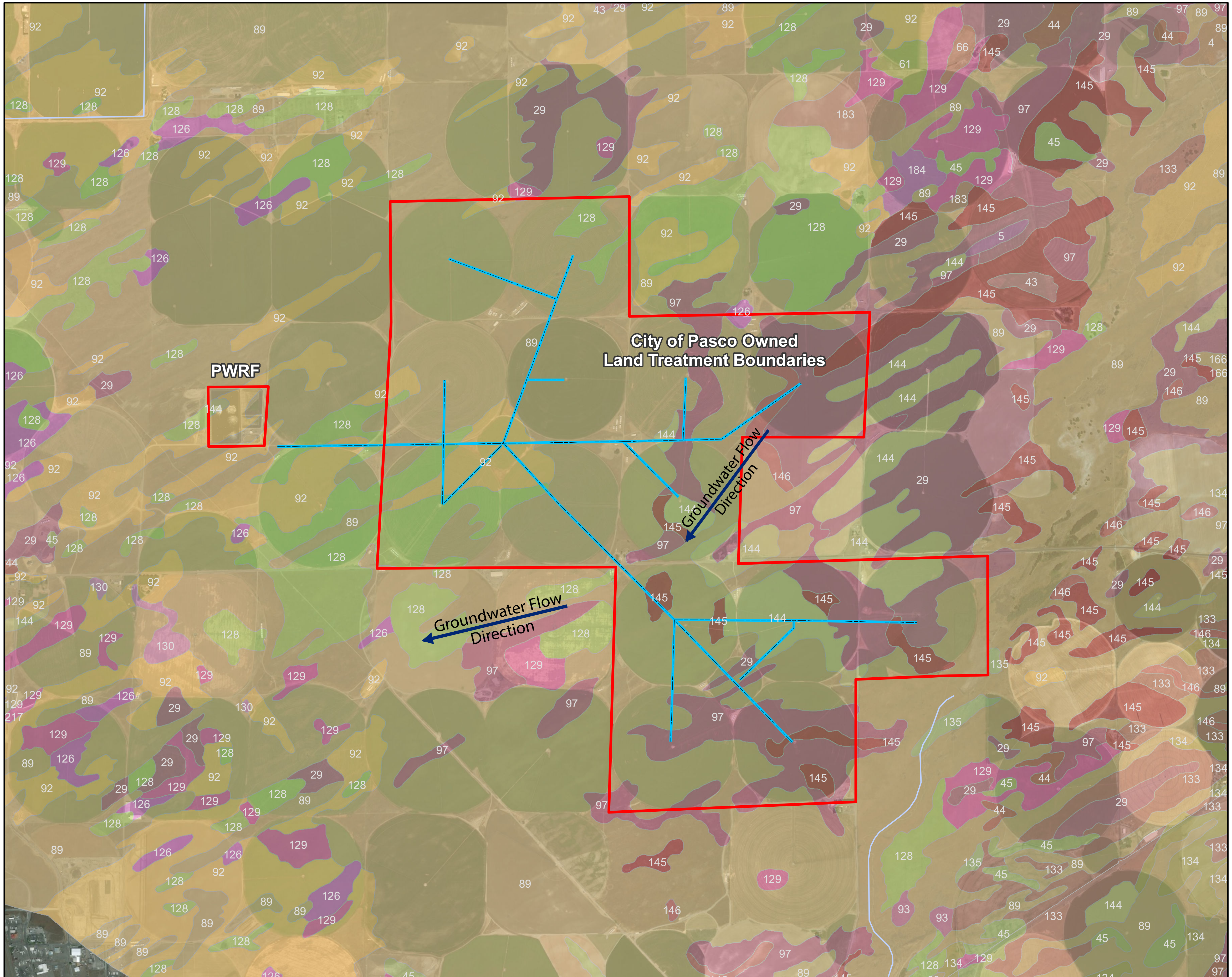
Notes:
1. USGS Surface Geology 1:100,000 scale. Washington Division of Geology and Earth Resources (2016)

N

0 1 2
Miles

FIGURE 4
Surface Geology
City of Pasco
Process Water Reuse Facility
Hydrogeologic Assessment

ch2m:



VICINITY MAP

LEGEND

- Flow
- Rivers
- Irrigation Mains
- Project Boundary

Soils

- 126: Royal loamy fine sand, 0 to 10 percent slopes
- 128: Royal fine sandy loam, 0 to 2 percent slopes
- 129: Royal fine sandy loam, 2 to 5 percent slopes
- 130: Royal fine sandy loam, 5 to 10 percent slopes
- 133: Sagehill very fine sandy loam, 0 to 2 percent
- 134: Sagehill very fine sandy loam, 2 to 5 percent
- 135: Sagehill very fine sandy loam, 5 to 10 percent
- 144: Sagemoor very fine sandy loam, 0 to 2 percent
- 145: Sagemoor very fine sandy loam, 2 to 5 percent
- 146: Sagemoor very fine sandy loam, 5 to 10 percent
- 166: Starbuck silt loam, 0 to 15 percent slopes
- 183: Timmerman fine sandy loam, 0 to 2 percent
- 184: Timmerman fine sandy loam, 2 to 5 percent
- 217: Winchester loamy coarse sand, 2 to 5 percent
- 29: Hezel loamy fine sand, 0 to 15 percent slopes
- 43: Kennewick silt loam, 0 to 2 percent slopes
- 44: Kennewick silt loam, 2 to 5 percent slopes
- 45: Kennewick silt loam, 5 to 10 percent slopes
- 4: Burbank loamy fine sand, 0 to 5 percent slopes
- 5: Burbank loamy fine sand, 5 to 10 percent slopes
- 61: Neppel very fine sandy loam, 2 to 5 percent
- 66: Novark silt loam, 2 to 5 percent slopes
- 89: Quincy loamy fine sand, 0 to 15 percent slopes
- 92: Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes
- 93: Quincy loamy fine sand, loamy substratum, 10 to 15 percent slopes
- 97: Quincy-Hezel complex, 0 to 15 percent slopes

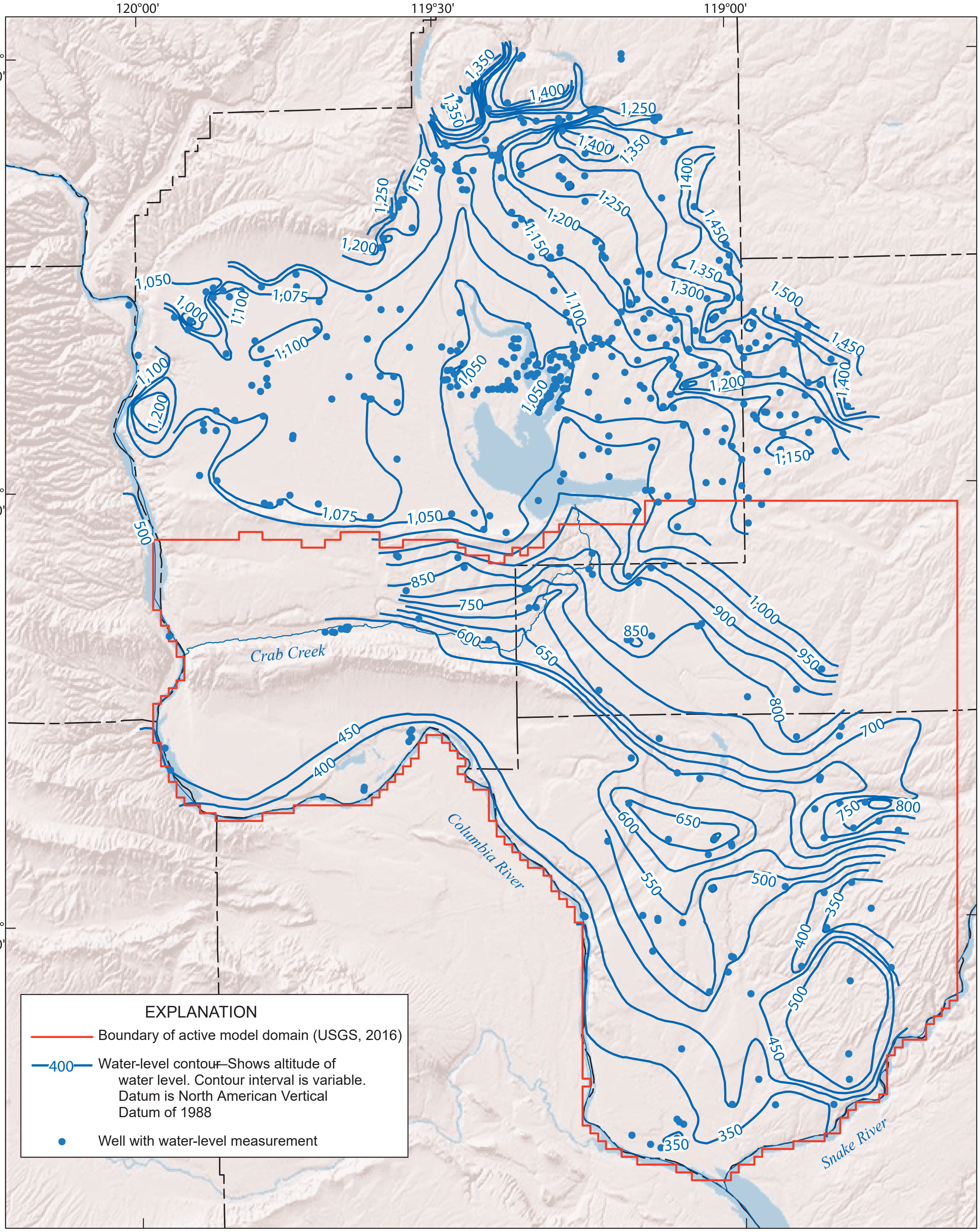
Notes:
1. SSURGO Soils database - Natural Resource Conservation Services (NRCS). January 2017

N

0 0.5 1
Miles

FIGURE 5
Surface Soils
City of Pasco
Process Water Reuse Facility
Hydrogeologic Assessment

ch2m.



Elevation data from the National Elevation Dataset.
Washington State Plane South, FIPS zone 4602, units in feet. Horizontal datum is North American Datum of 1983.

Water-level altitudes in wells, 1939–45
Modified from: Simulation of Groundwater Storage Changes in the Eastern Pasco Basin, Washington, USGS Scientific Investigations Report 2016-5026, 2016.

FIGURE 6
Regional Hydrogeology
City of Pasco
Process Water Reuse Facility
Hydrogeologic Assessment

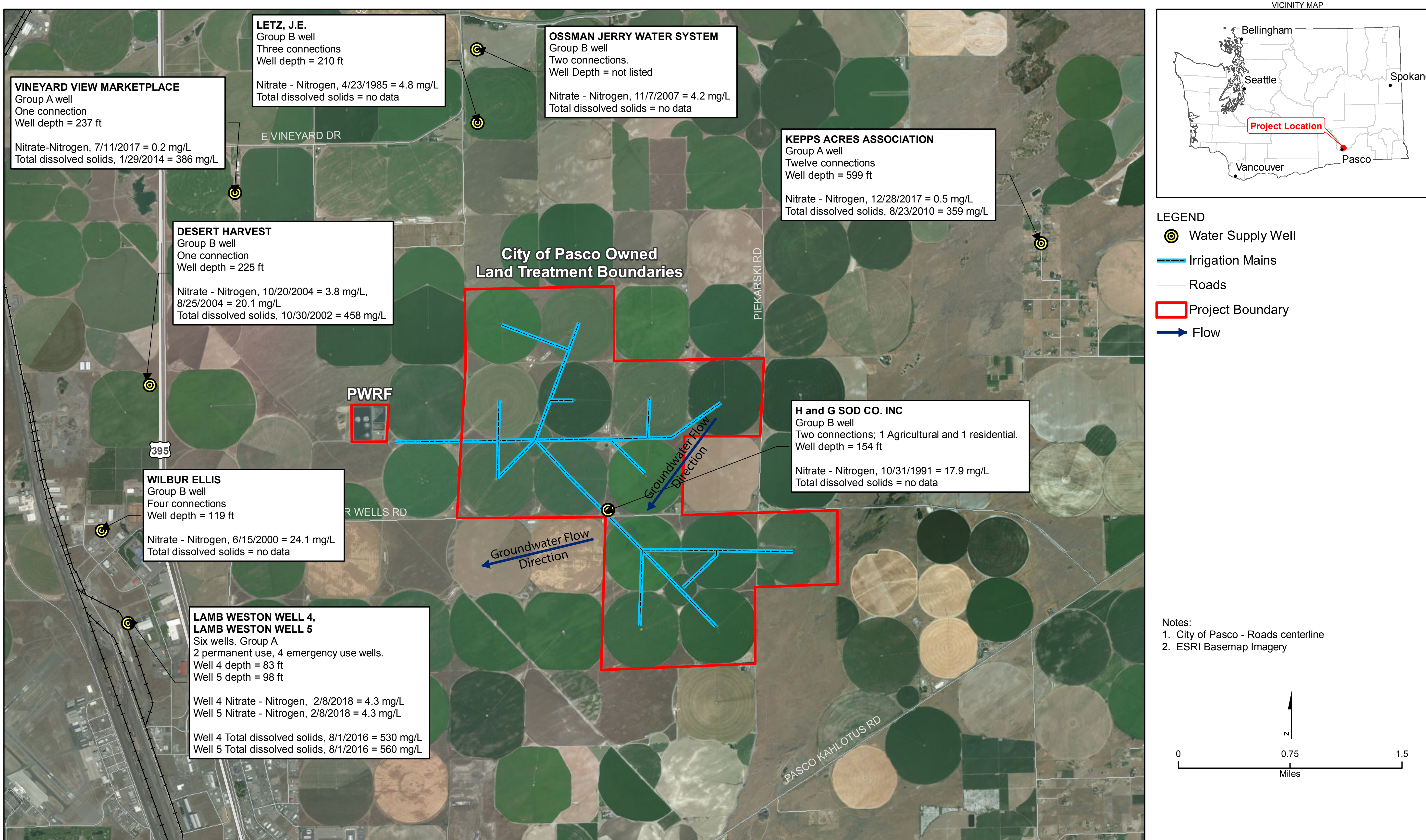
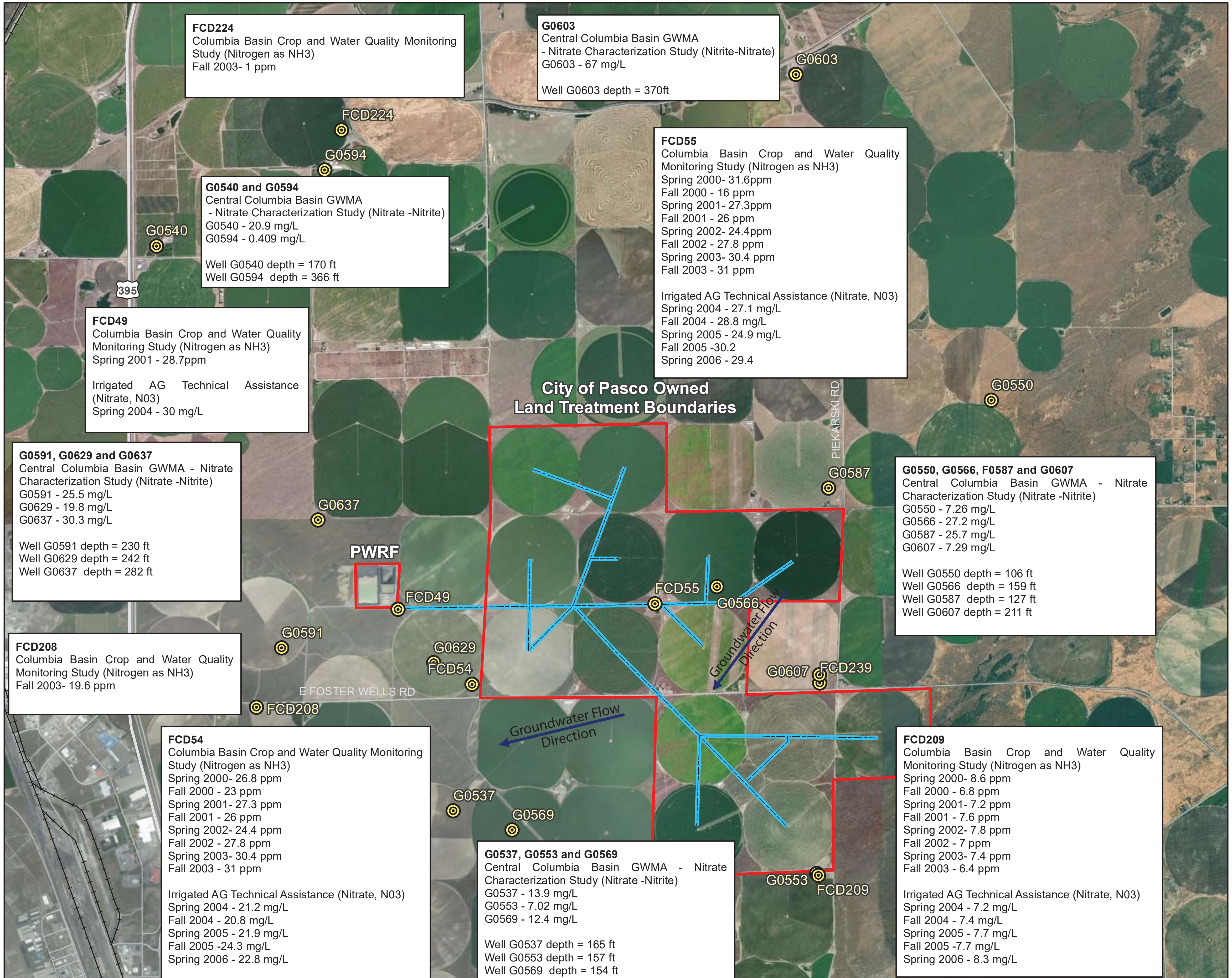


FIGURE 7.1
Water Supply Wells
City of Pasco
Process Water Reuse Facility
Hydrogeologic Assessment

ch2m



LEGEND

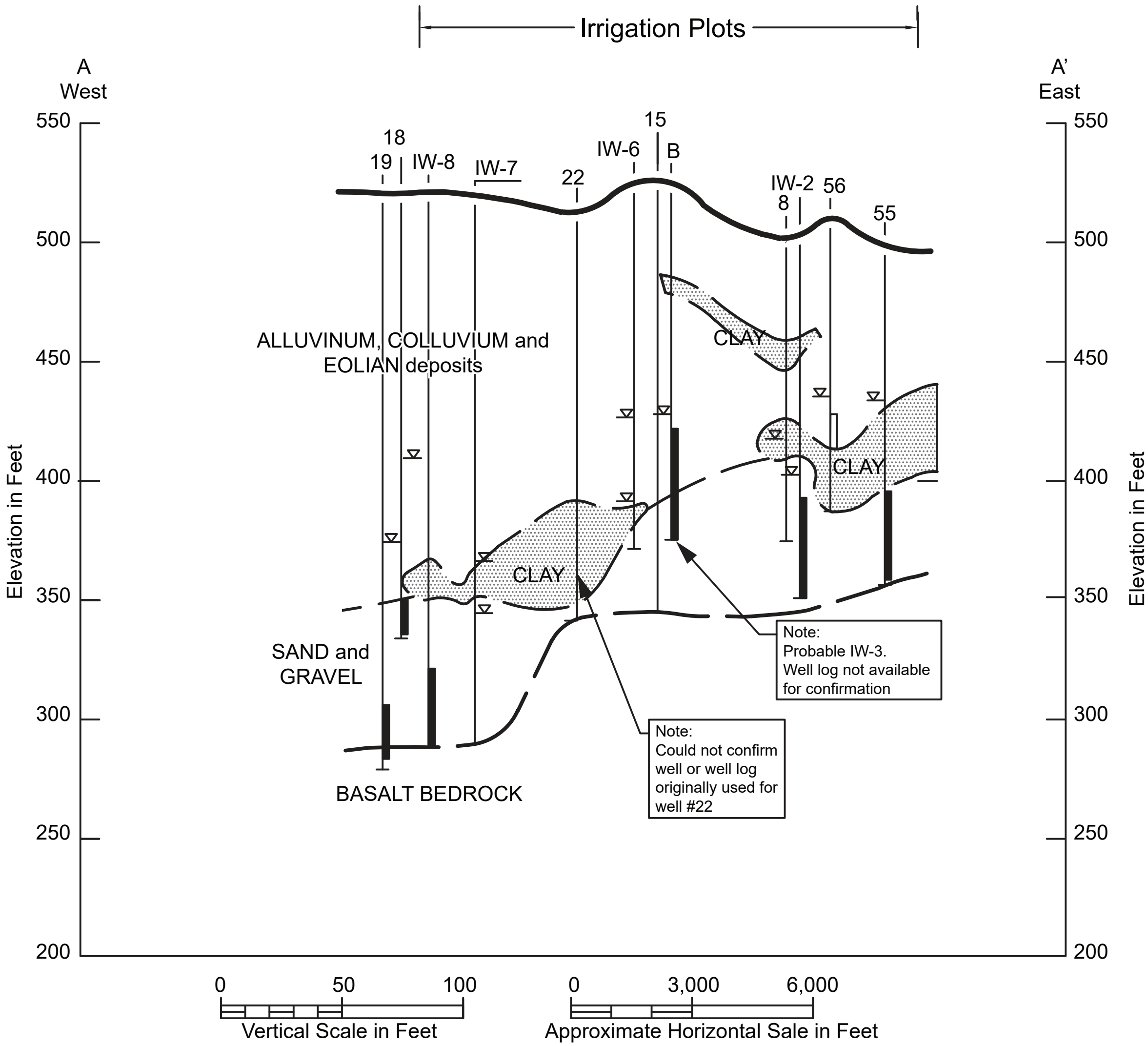
- Monitoring Well
- Irrigation Mains
- Roads
- Project Boundary
- Flow

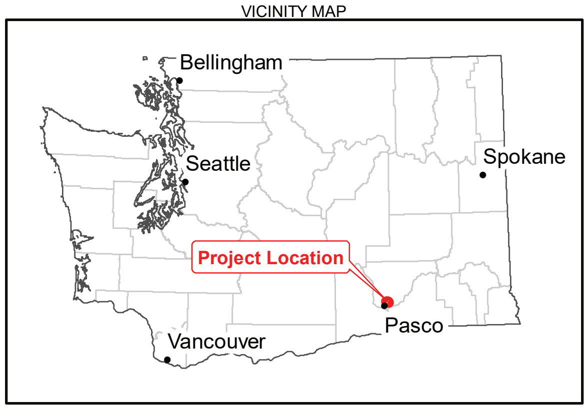
Notes:
1. City of Pasco - Roads centerline
2. ESRI Basemap Imagery

0 0.5 1
Miles

FIGURE 7.2
Nitrate in Groundwater
Ecology EIM Database
City of Pasco
Process Water Reuse Facility
Hydrogeologic Assessment

ch2m.





LEGEND

121 Well Locaiton and Designation

Contact Between Soil Types

Groundwater Level (reported by Driller)

Contact Between Major Geologic Units

Well Screen

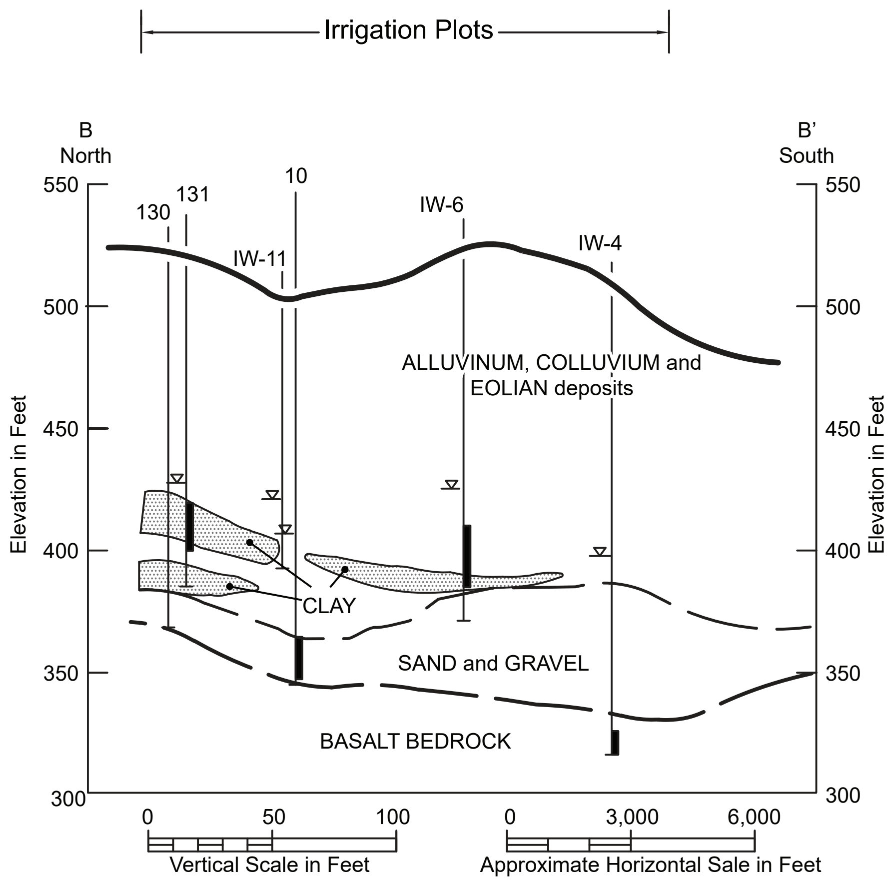
Bottom of Boring

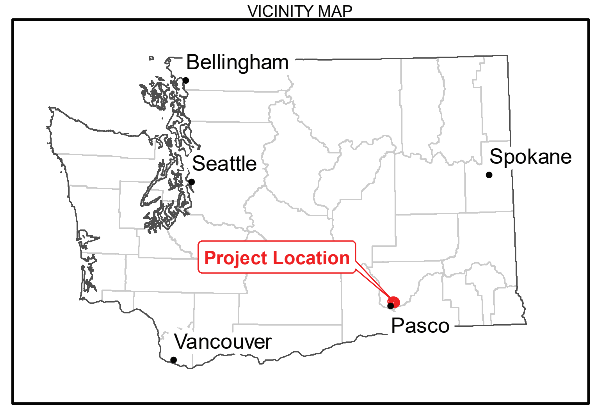
Notes:
1. Contacts between soil units were intrepreted from driller's well logs and are approximate.
Variations between the profile and actual conditions may exist.
2. Subsurface profile modified from Shannon & Wilson, Inc. 1992

Modified from:
Hydrogeology Evaluation, Pasco Industrial Wastewater Treatment Plant Site, Pasco, Washington, Shannon and Wilson, Inc. April 1992

FIGURE 8
Generalized Subsurface Profile A-A'
City of Pasco
Process Water Reuse Facility
Hydrogeologic Assessment

ch2m





LEGEND

121 Well Locaiton and Designation

Contact Between Soil Types

Groundwater Level (reported by Driller)

Contact Between Major Geologic Units

Well Screen

Bottom of Boring

Notes:
1. Contacts between soil units were intrepreted from driller’s well logs and are approximate.
Variations between the profile and actual conditions may exist.
2. Subsurface profile modified from
Shannon & Wilson, Inc. 1992

Modified from:
Hydrogeology Evaluation, Pasco Industrial Wastewater Treatment Plant Site, Pasco, Washington, Shannon and Wilson, Inc. April 1992

FIGURE 9
Generalized Subsurface Profile B-B’
City of Pasco
Process Water Reuse Facility
Hydrogeologic Assessment

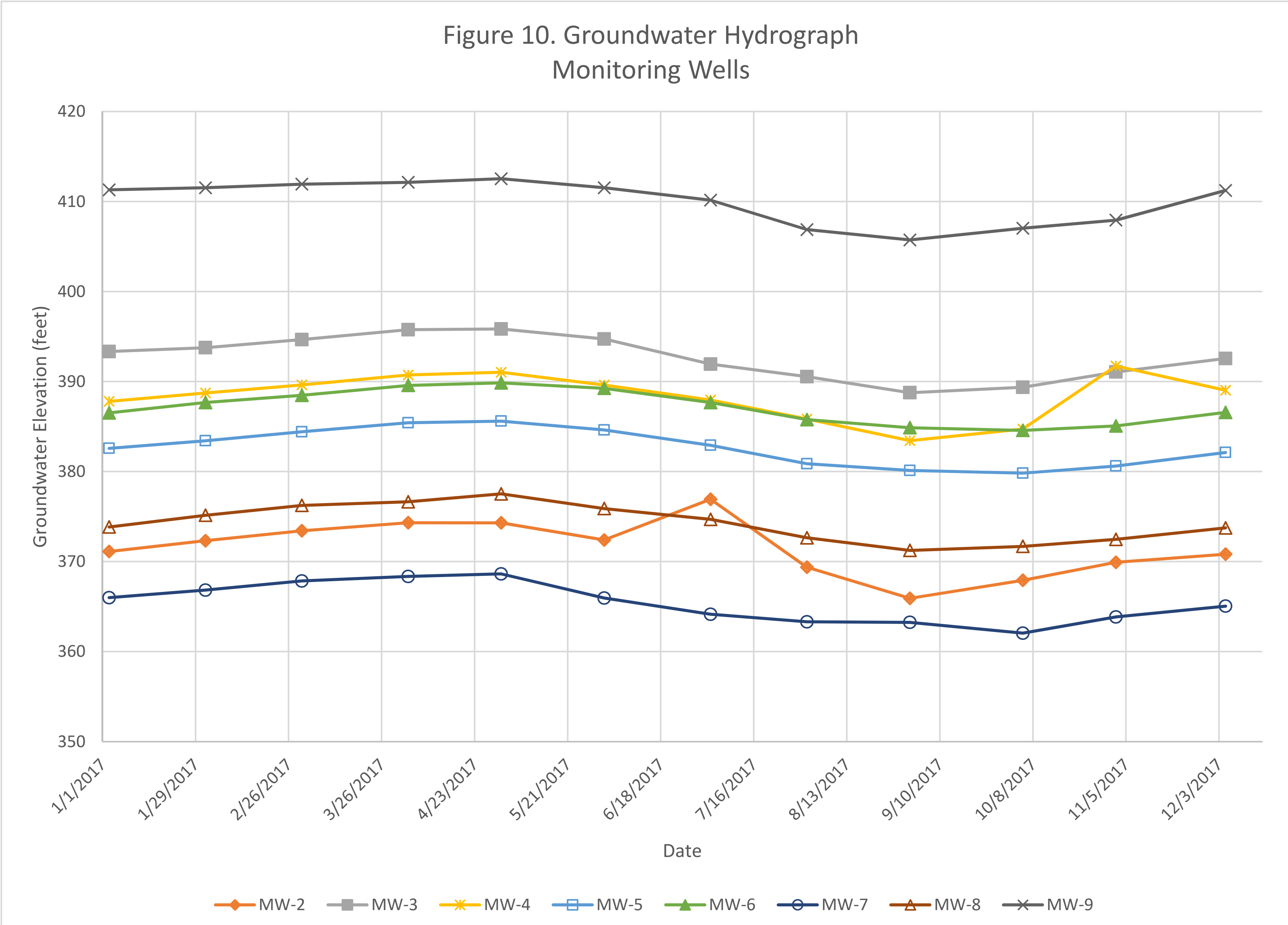
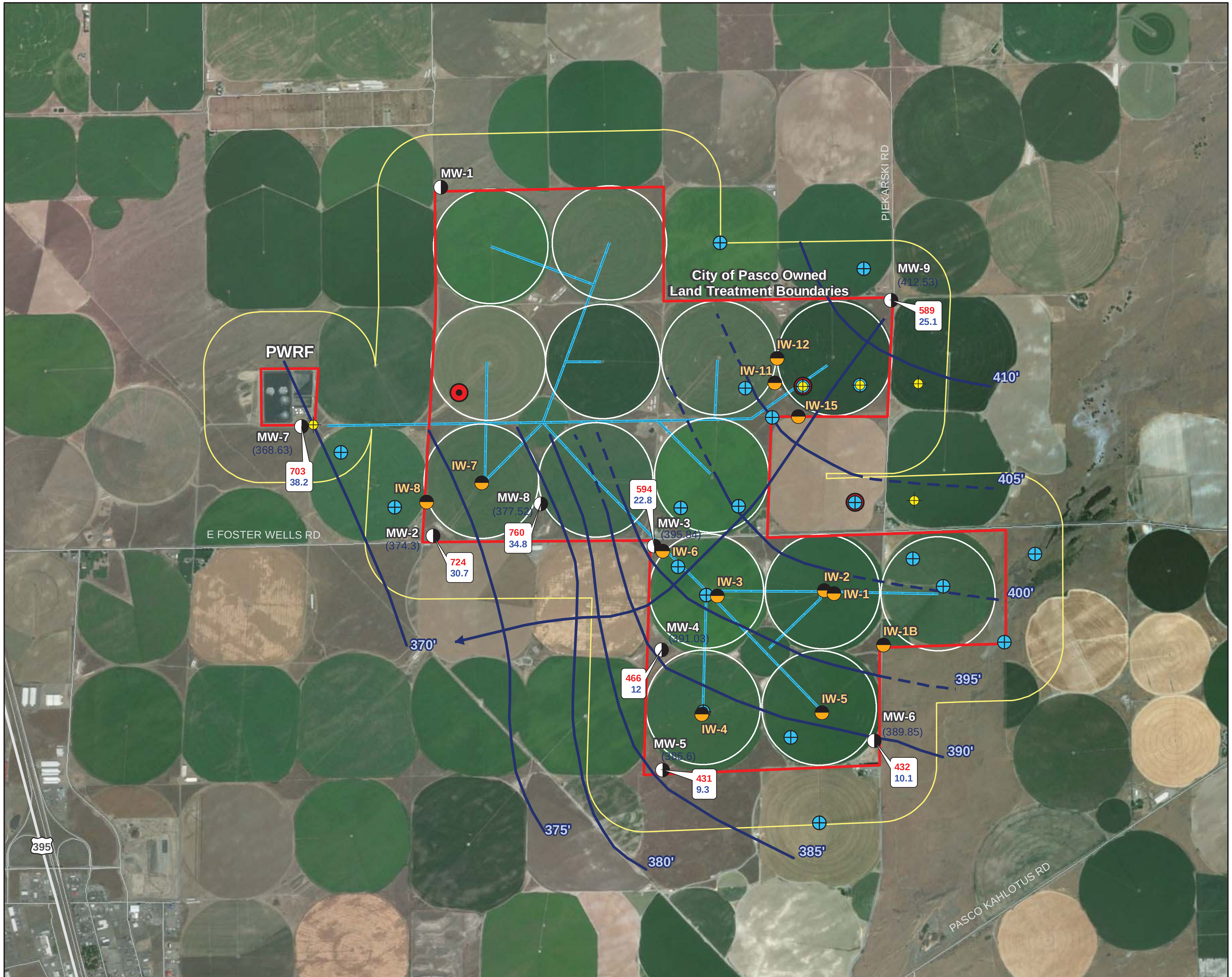


Figure 10. Groundwater Hydrograph
Monitoring Wells
Groundwater Elevation (feet)
420
410
400
390
380
370
360
350
1/1/2017
1/29/2017
2/26/2017
3/26/2017
4/23/2017
5/21/2017
6/18/2017
7/16/2017
8/13/2017
9/10/2017
10/8/2017
11/5/2017
12/3/2017
Date
MW-2
MW-3
MW-4
MW-5
MW-6
MW-7
MW-8
MW-9



VICINITY MAP

LEGEND

- Irrigation Well
- Monitoring Well
- Resource Protection Wells
- Water Wells
- Decommissioned Wells
- 400' Groundwater Elevation Contour (feet)
- (400') Groundwater Elevation (feet)
- Direction of Groundwater Flow
- Irrigation Mains
- Roads
- Quarter Mile Buffer
- Project Boundary
- 400 -- TDS- concentration (mg/L)
- 10 -- Nitrate-nitrogen concentration (mg/L)

Notes:
1. City of Pasco - Roads centerline, monitoring wells
2. Washington State Department of Ecology - Well Log Database https://fortress.wa.gov/ecy/waterresources/map/WCLSWebMap/default.aspx
3. Wells 2017 PWRF Survey (CAD) - monitoring/irrigation wells
4. ESRI Basemap Imagery
5. Location of resource protection wells, water wells, and decommissioned wells obtained from WA Department of Ecology Well Log Database. Obtained locations shown on this figure may differ from the well's actual location.

N

0 0.5 1
Miles

FIGURE 11
Groundwater Potentiometric Surface, May 1, 2017
City of Pasco
Process Water Reuse Facility
Hydrogeologic Assessment

ch2m.

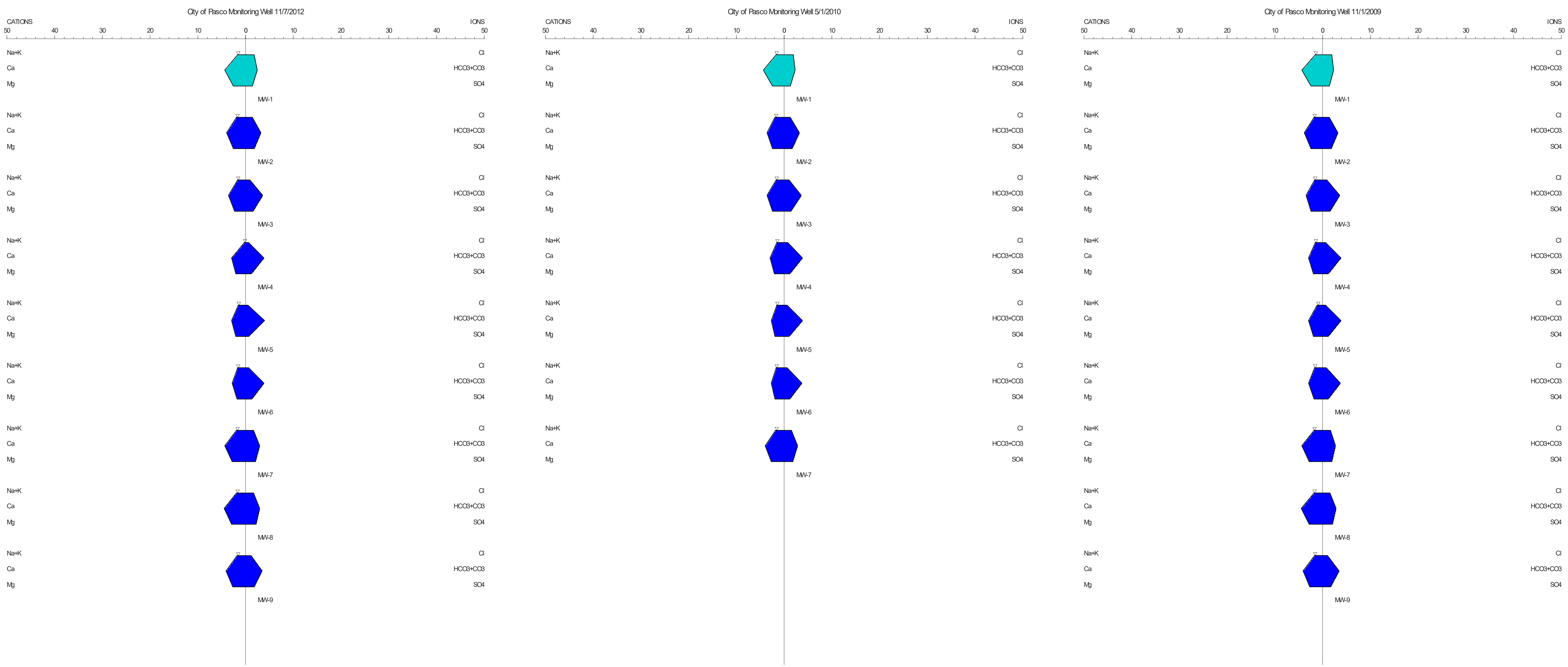
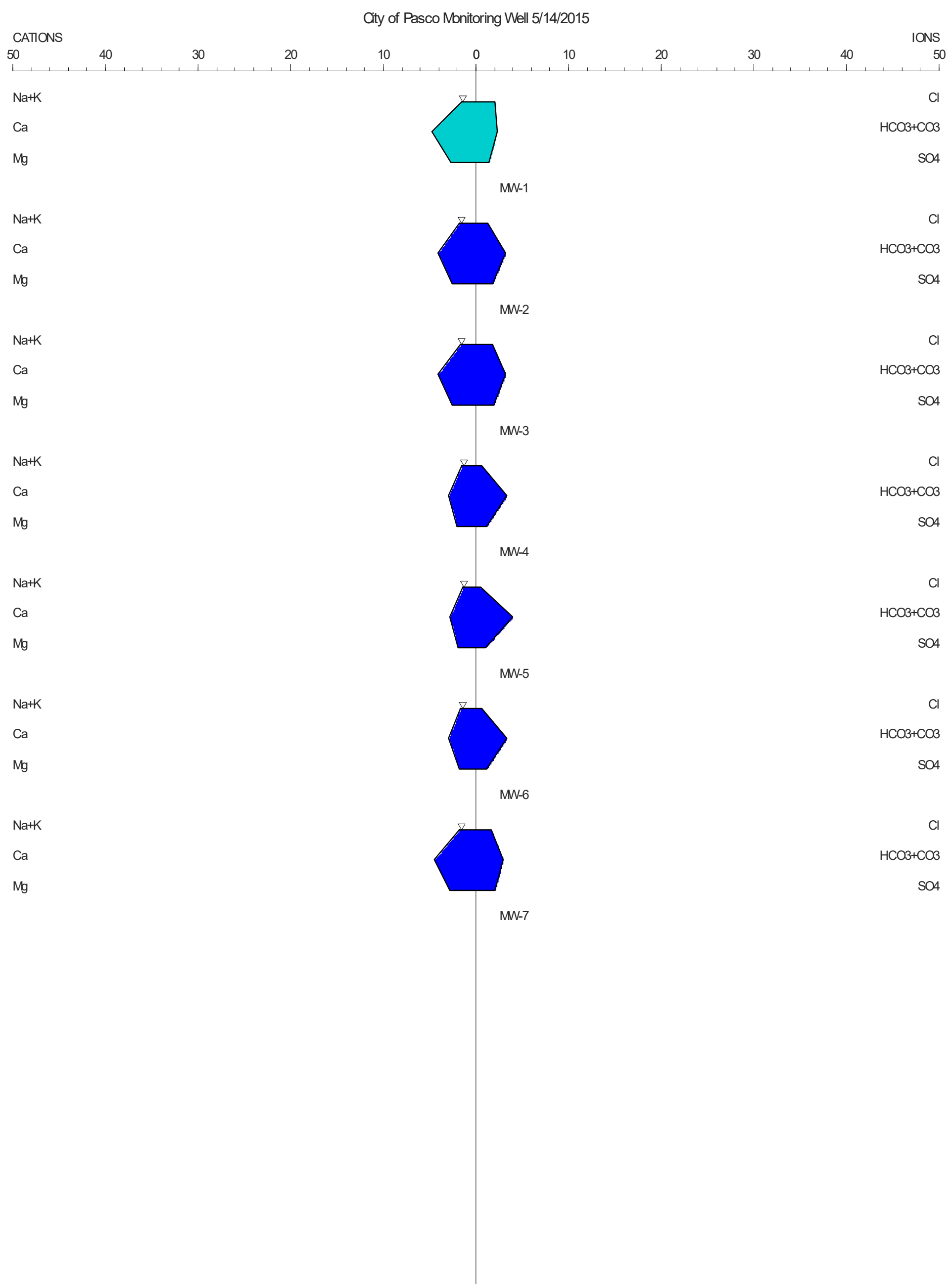


Figure 12
Groundwater General Chemistry STIFF Plots 2009 – 2012
City of Pasco
Process Water Reuse Facility
Hydrogeologic Assessment



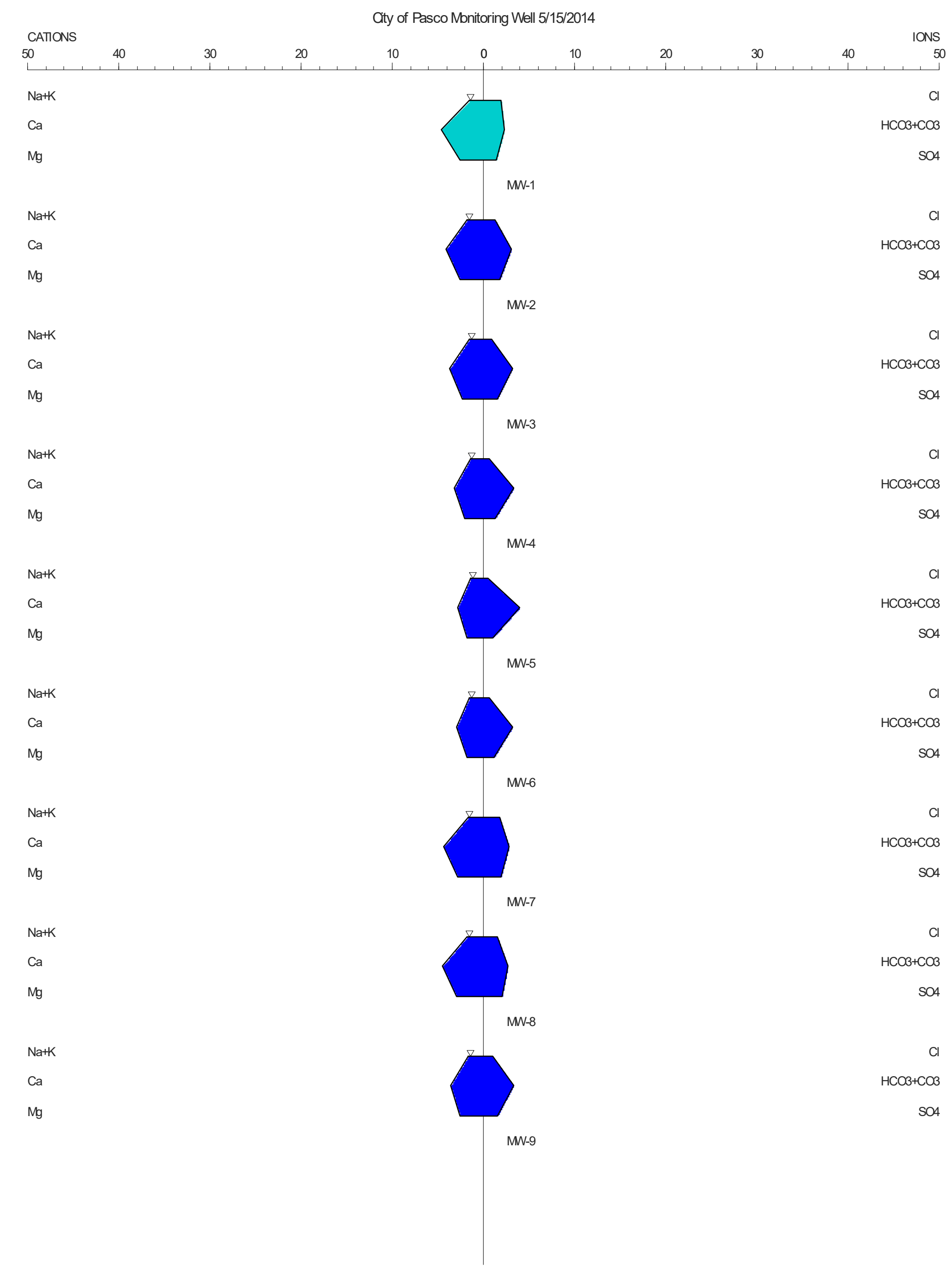


Figure 13
Groundwater General Chemistry STIFF Plots 2014 - 2015
City of Pasco
Process Water Reuse Facility
Hydrogeologic Assessment

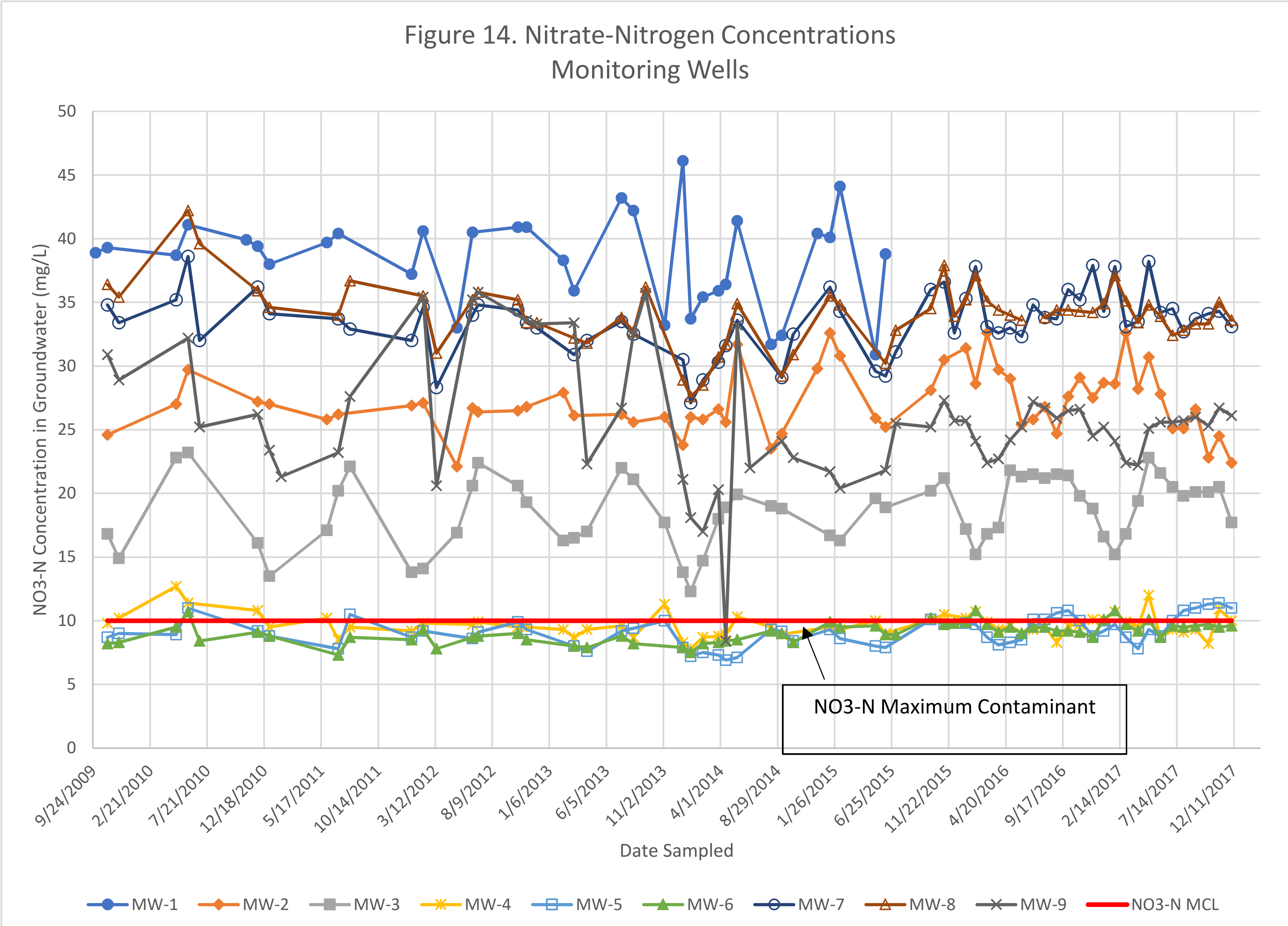


Figure 14. Nitrate-Nitrogen Concentrations
Monitoring Wells
NO3-N Concentration in Groundwater (mg/L)
50
45
40
35
30
25
20
15
10
5
0
9/24/2009
2/21/2010
7/21/2010
12/18/2010
5/17/2011
10/14/2011
3/12/2012
8/9/2012
1/6/2013
6/5/2013
11/2/2013
4/1/2014
8/29/2014
1/26/2015
6/25/2015
11/22/2015
4/20/2016
9/17/2016
2/14/2017
7/14/2017
12/11/2017
Date Sampled
NO3-N Maximum Contaminant
MW-1
MW-2
MW-3
MW-4
MW-5
MW-6
MW-7
MW-8
MW-9
NO3-N MCL

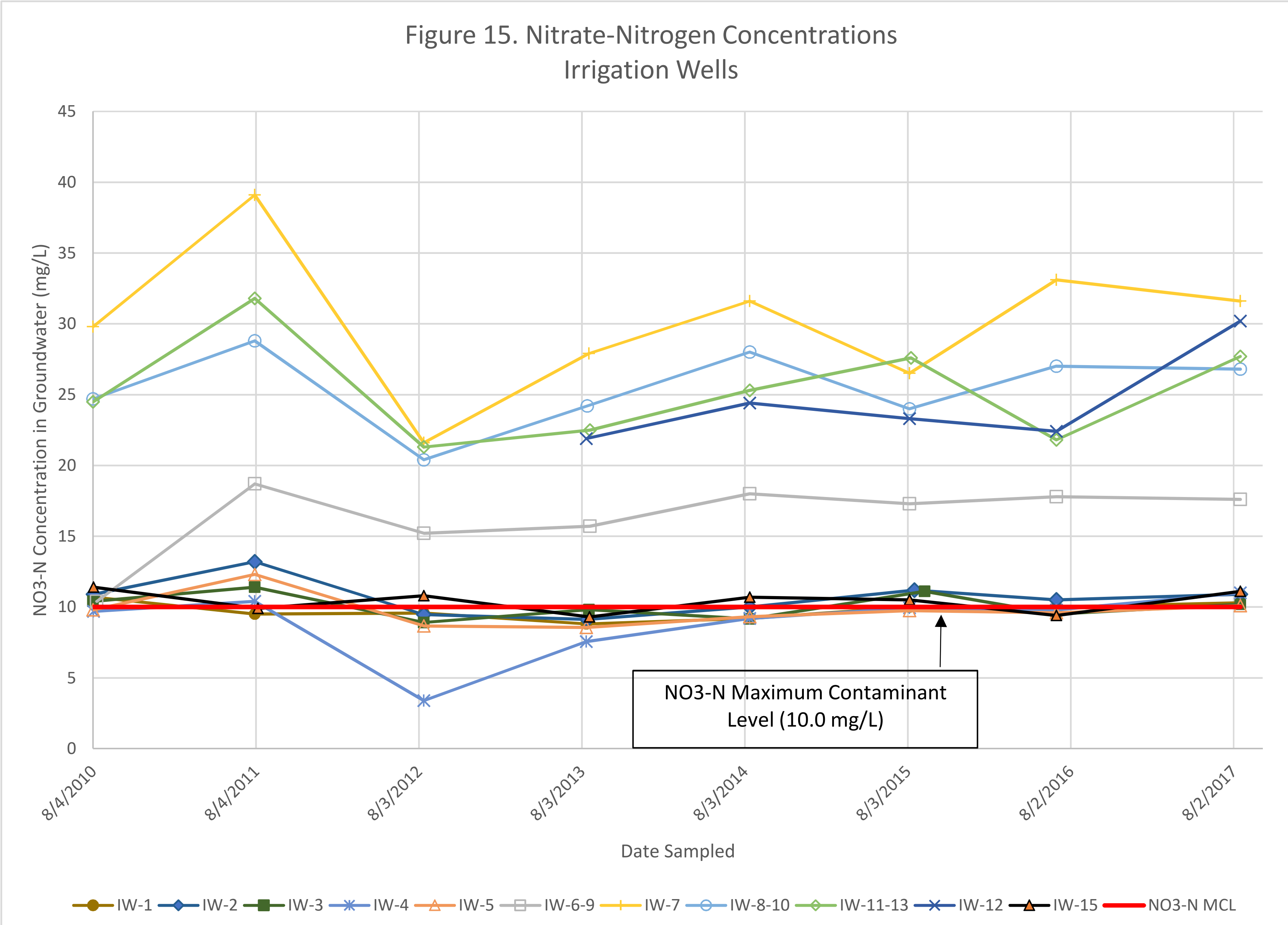


Figure 15. Nitrate-Nitrogen Concentrations
Irrigation Wells
NO3-N Concentration in Groundwater (mg/L)
45
40
35
30
25
20
15
10
5
0
8/4/2010
8/4/2011
8/3/2012
8/3/2013
8/3/2014
8/3/2015
8/2/2016
8/2/2017
Date Sampled
NO3-N Maximum Contaminant Level (10.0 mg/L)
IW-1
IW-2
IW-3
IW-4
IW-5
IW-6-9
IW-7
IW-8-10
IW-11-13
IW-12
IW-15
NO3-N MCL

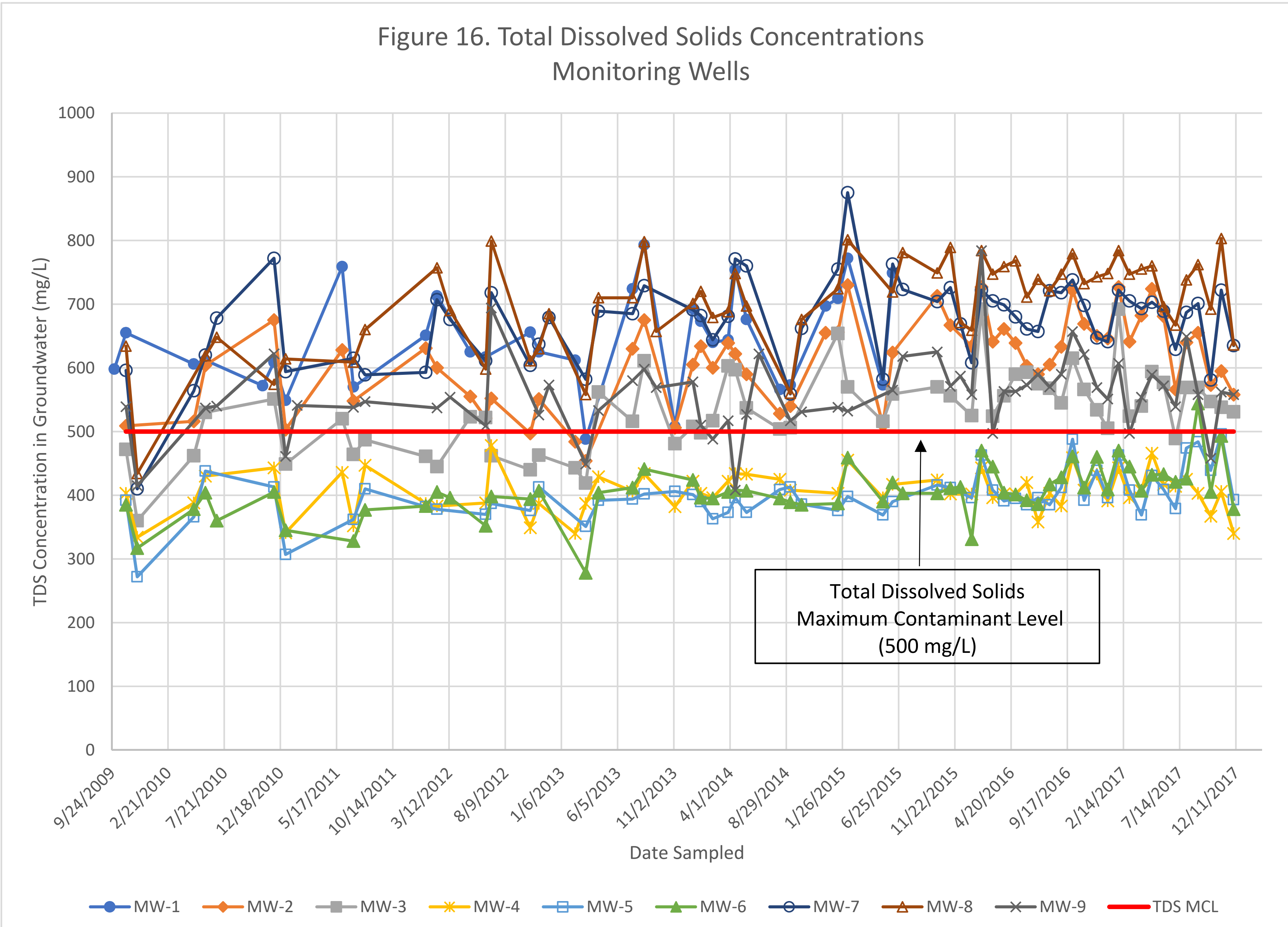


Figure 16. Total Dissolved Solids Concentrations
Monitoring Wells
TDS Concentration in Groundwater (mg/L)
1000
900
800
700
600
500
400
300
200
100
0
9/24/2009
2/21/2010
7/21/2010
12/18/2010
5/17/2011
10/14/2011
3/12/2012
8/9/2012
1/6/2013
6/5/2013
11/2/2013
4/1/2014
8/29/2014
1/26/2015
6/25/2015
11/22/2015
4/20/2016
9/17/2016
2/14/2017
7/14/2017
12/11/2017
Date Sampled
Total Dissolved Solids
Maximum Contaminant Level
(500 mg/L)
MW-1
MW-2
MW-3
MW-4
MW-5
MW-6
MW-7
MW-8
MW-9
TDS MCL

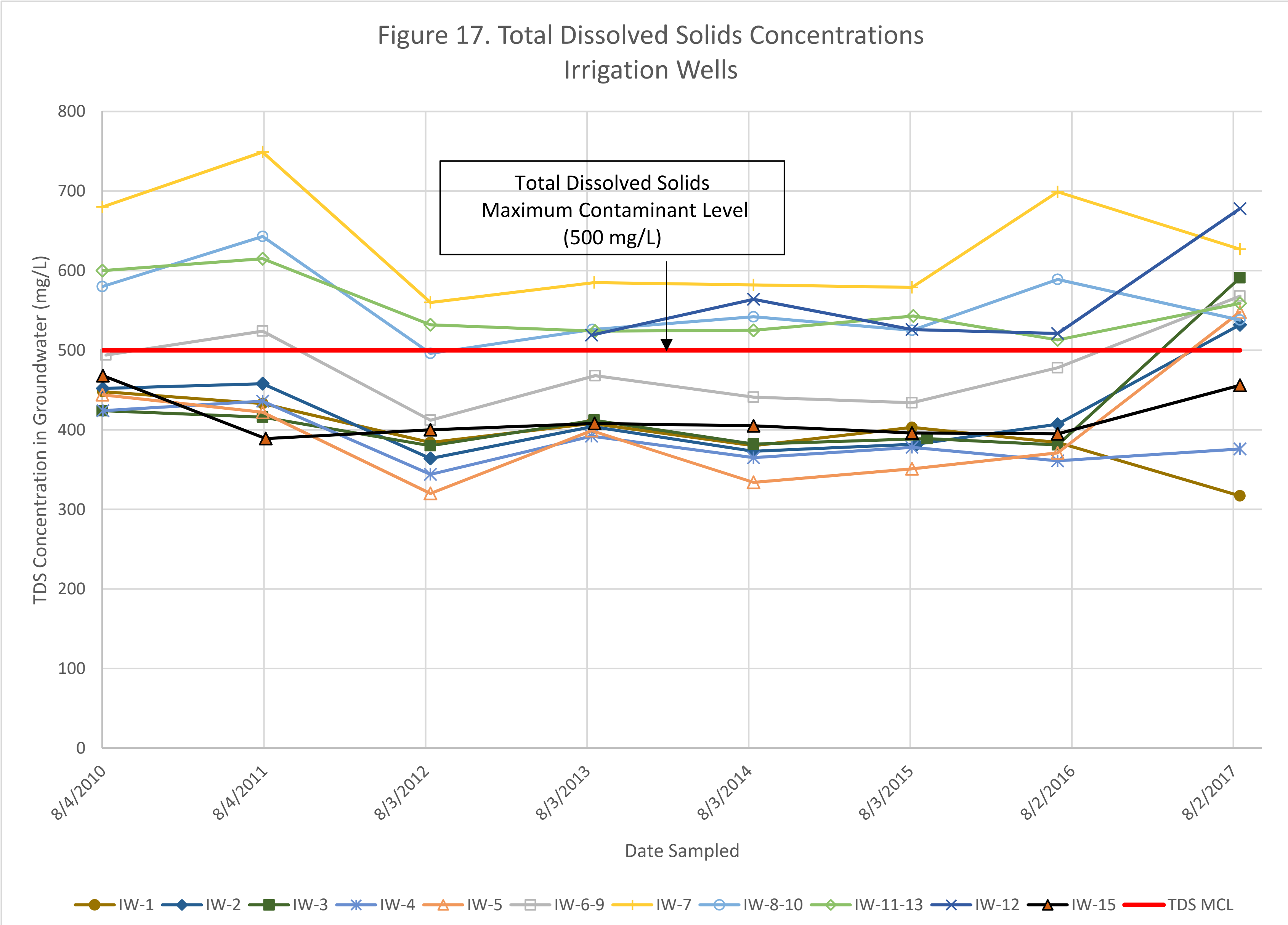


Figure 17. Total Dissolved Solids Concentrations
Irrigation Wells
Total Dissolved Solids
Maximum Contaminant Level
(500 mg/L)
TDS Concentration in Groundwater (mg/L)
0
100
200
300
400
500
600
700
800
8/4/2010
8/4/2011
8/3/2012
8/3/2013
8/3/2014
8/3/2015
8/2/2016
8/2/2017
Date Sampled
IW-1
IW-2
IW-3
IW-4
IW-5
IW-6-9
IW-7
IW-8-10
IW-11-13
IW-12
IW-15
TDS MCL

Appendix A
Well Logs

Irrigation Wells

IW-1

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

37710

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W49938
UNIQUE WELL I.D. #
Water Right Permit No. G3 24546 P

(1) OWNER: Name City of Pasco Address P.O. Box 293 Pasco WA

(2) LOCATION OF WELL: County Franklin SW 1/4 NE 1/4 NE 1/4 Sec 11 T. 9 N., R 30 E W.M.

(2a) STREET ADDRESS OF WELL (or nearest address)

(3) PROPOSED USE: ☐ Domestic ☒ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (If more than one)
Abandoned ☐ New well ☒ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☒ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 143 feet. Depth of completed well 143 ft.

(6) CONSTRUCTION DETAILS:
Casing Installed: 16 " Diam. from +1 ft. to 125'6" ft.
Welded ☒ " Diam. from ft. to ft.
Liner installed ☐
Threaded ☐ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Hydroma
Type Stainless Model No.
Diam. 16T Slot size Var from 126 ft. to 136 ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 40 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 119 ft. below top of well Date 1-16-97
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? Layne
Yield: 2100 gal./min. with 11 ft. drawdown after 4 hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest gal./min. with stem set at ft. for hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Sand Silty Tan	0	2
Silt Sandy Tan	2	38
Sand Black silty	38	41
Gravel, Sand Black	41	48
Sand Black	48	73
Gravel sand Black	73	136'6"
Sand Tan silty	136'6"	142
Sand Tan, gravel	142	143

RECEIVED
FEB 13 1997
DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

Work Started 12-17, 19. Completed 1-16, 1997

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Nelson Well Drilling Inc (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 8200 W Argent Pasco
(Signed) Jim Nelson (WELL DRILLER) License No. 361
Contractor's Registration No. NELSOWD198LQ Date 1-16, 1997

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

ECY 050-1-20 (9/93)

IW-2

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

Original and First Copy with
[De]partment of Ecology
[Seco]nd Copy — Owner's Copy
[Thi]rd Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Permit No. G3 20247

(1) OWNER: Name BURLINGTON NORTHERN INC. Address RESOURCES DIVISION, ST. PAUL, MINN. 55101

(2) LOCATION OF WELL: County FRANKLI[N] — NE ¼ NE ¼ Sec 11 T. 9 N., R 30E W.M.

[Bea]ring and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐
Irrigation ☒X Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) No. 35
New well XXX Method: Dug ☐ Bored ☐
Deepened ☐ Cable XX Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 152 ft. Depth of completed well 152 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 16 " Diam. from 0 ft. to 152 ft.
Threaded ☐ X " Diam. from X ft. to X ft.
Welded ☒X X " Diam. from X ft. to X ft.

Perforations: Yes ☐ No ☒XXX
Type of perforator used XXX
SIZE of perforations XXX in. by XXX in.
X perforations from XXX ft. to XXX ft.
X X perforations from X ft. to X ft.
X X perforations from XXX ft. to X ft.

Screens: Yes ☒X No ☐
Manufacturer's Name Johnson
Type ______ Model No. ______
Diam. ______ Slot size ______ from ______ ft. to ______ ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes ☐ No ☒X Size of gravel: XXXX
Gravel placed from XXXX X ft. to XXXX ft.

Surface seal: Yes ☒X No ☐ To what depth? 20 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? X Depth of strata X
Method of sealing strata off X

(7) PUMP: Manufacturer's Name X
Type: X H.P. X

(8) WATER LEVELS: Land-surface elevation above mean sea level 500 ft.
[St]atic level 98 ft. below top of well Date 3/17/75
[Ar]tesian pressure XXX lbs. per square inch Date XX
Artesian water is controlled by XX (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
[W]as a pump test made? Yes ☒X No ☐ If yes, by whom? LAYNE PUMPS
[Yi]eld: X gal./min. with X ft. drawdown after X hrs.
" " "
DID NOT RECIEVE A REPORT "

[R]ecovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
	DID NOT RECIEVE A REPORT				

Date of test XX
Bailer test X gal./min. with X ft. drawdown after X hrs.
Artesian flow XXXX g.p.m. Date XXXX
Temperature of water XXX Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
sandy silt	0	5
3 inch minus rock	5	10
Black basalt, gravel and sand	10	40
Yellow clay	40	45
Mixture , sand and gravel	45	115
Fine sand, pea gravel	115	117
Rock, 2 inch minus to sand	117	122
½ inch minus round all color river rock	122	124
Course black pea gravel	124	132
1½ inch minus rock to sand	132	137
Black sand	137	142
All color course sand and gravel	142	147
Large rocks and gravel	147	150
Ringold sand, brown and fine	150	152
Hit water	98 ft.	
Lakewood Drive shoe 16 inch		
Johnson well screen 38 foot set screen from 114 ft. through 152 foot. (Unknown slot size or type because Burlington Northern bought direct from Johnson well screen)		
22 ft. 80 slot		
3 ft. 60 slot		
5 ft. 14 inch blank casing		
2 ft. 60 slot		
6 ft. 100 slot		
5 ft. 11 inch casing, blank		
109 ft. to 152 ft.		

5760
2536
640
gpm
a ft
ac

Work started 1/16, 1975. Completed 41/17/75, 1975.

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME GOLDEN AUTUMN CONSTRUCTION CO., INC.
(Person, firm, or corporation) (Type or print)
0554
Address P.O. BOX 811, PASCO, WASHINGTON 99301

[Signed] David L Whitehead
(Well Driller)

License No. 0554 Date 1/17, 1975

54 h5

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71)
ECY-070-28

IW-4

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. 63-202-47

(1) **OWNER:** Name Burlington Northern R.R. Address Pasco, Wash. 99301

(2) **LOCATION OF WELL:** County Franklin — ¼ SW ¼ Sec. 11 T. 9 N., R. 30 W.M.
Bearing and distance from section or subdivision corner X

(3) **PROPOSED USE:** Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☐ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (if more than one) 34
New well ☐ Deepened ☐ Reconditioned ☒
Method: Dug ☐ Bored ☐ Cable ☒ Driven ☐ Rotary ☐ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 16 inches.
Drilled 205 ft. Depth of completed well ~~202~~ 205 ft.

(6) **CONSTRUCTION DETAILS:**
Casing installed: 16" Diam. from 0 ft. to 205 ft.
Threaded ☐ ....." Diam. from ..... ft. to ..... ft.
Welded ☒ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☒ No ☐
Type of perforator used Mills
SIZE of perforations 1 1/2 in. by 3/8 in.
every six inches
12 perforations from 202 ft. to 192 ft.
10 perforations from 192 ft. to 180 ft.
10 perforations from 176 ft. to 174 ft.
10 " " 155 " " 135 "

Screens: Yes ☐ No ☒
Manufacturer's Name .....
Type ..... Model No. .....
Diam. ..... Slot size ..... from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☒ No ☐ To what depth? 30 ft.
Material used in seal Bentonite & Sand
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ..... Depth of strata .....
Method of sealing strata off .....

(7) **PUMP:** Manufacturer's Name .....
Type: ..... H.P. .....

(8) **WATER LEVELS:** Land-surface elevation above mean sea level 500 ft.
Static level 112 ft. below top of well Date 3/8/75
Artesian pressure ..... lbs. per square inch Date .....
Artesian water is controlled by ..... (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? Layne Pumps
Yield: 1100 gal./min. with 78 ft. drawdown after 4 hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
unknown					

Date of test 5/23/75
Bailer test ..... gal./min. with ..... ft. drawdown after ..... hrs.
Artesian flow ..... g.p.m. Date .....
Temperature of water ..... Was a chemical analysis made? Yes ☐ No ☒

(10) **WELL LOG:**

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Pulled screen,		
drilled 205 ft.	135	205
perforated from	202 ft	180 ft
	176 ft	174 ft
	155 ft	135 ft
Sand & Gravel with Some Boulders	185	202
Yellow Clay & Sand with some Rock	202	205
Bedrock (Basalt)	205	
Poured 212 cement grout in bottom		

1100 gpm
5760 gpa
2586.6 A
25
640

Work started 1/22/1975 Completed 3/8/1975

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME B & H Drilling (Person, firm, or corporation) (Type or print)
Address Rt 3 Box 336 SA - Kennewick, Wash. 99336
[Signed] H. A. Bultena (Well Driller)
License No. 0046 Date 3/28/1975

OK

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

IW-5

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

ADDRESS R. Guy Sullivan

DATE DRILLED: Mar. 16 - April 8 1971 . TYPE OF WORK: New 13 USE: [illegible]

CASING: DIAMETER: 12 INCH WEIGHT: .375 WALL DRIVE SHOE Standard

TOTAL CASING: 129'-6" CASED BELOW SURFACE 127'-0"

TOTAL WELL DEPTH: 146'-1" Ground Surface OPEN END: SIZE:

ALL CASING JOINTS DOUBLE TAPERED AND TRIPLE WELDED. Elev 500

SCREEN: * 10FT 304 Stainless-Mill Pipe Size SURFACE SEAL: 3 Sacks Bentonite + Grout

TEST: STATIC WATER LEVEL 106'-7" Ground Level BAILER TEST PUMP TEST

YIELD: GAL./MIN. WITH FT. DRAWDOWN AFTER HRS.

YIELD: GAL./MIN. WITH FT. DRAWDOWN AFTER HRS.

TEMPERATURE: 54 Degrees WELL CHLORINATED: Yes

PUMP SETTING: Do not set any part of any pump installation deeper than 130 FT from present top of casing. This setting will keep pump suction just above the top of the stainless screen & 2FT into 10" riser

MATERIAL	S.W.L.	THICKNESS	DEPTH	CASING	
Soil		5	5		
Soil & Some Sand		10	15	Do not set	
Coarse Sand Trace F. Gr.		10	25	Any Pump	
Silty Sand		10	35	Below 130'	
Fine Black Sand		5	40		
Silty Black Sand		10	50		
Brown Silty Sand		27	77		
Black Sand & Silt		16	93		
Black Sand & F. Gr.		4	97		
Loose F. Gr. & S.		2	99		
Compact F. Gr. & Sand		7	106		
Mostly Sandy Clay, Tr. F. Gr.		13	119		
" Sand F. Gr. & Clay		4	123		
Compact Sand & F. Gr.		4	127		
Gravel & Sand (60-40%)	111	2½	129½	Inside	
Gravel & More Sand		1	130½	"	
Gravel & Sand (25-15%)	107	2	132½	"	
Loose F. Gr. & S. (75-25%)		4	136½	"	
Loose F. Gr. & S. (50-50%)		2	138	"	
Compact Sand & F. Gr. (Clayish)		3	141	Perf. Wall	
Compact Grey [illegible] Gravel		3	144	No	"
Compact Yellow S. & F. Gr.		1½	145½	"	"
Cemented F. Gr. & S.		5½	151	"	"
Basalt		1	152	"	"

Casing was pulled back to 146'-1" & screen set.

Screen is Johnson 304 Stainless Steel .060 Slot. Screen has Fig. K Packer welded to a 10" pipe riser. Riser & packer 2'-9" long, screen 10'-5½ long, 10 inch pipe bottom on screen 5'-6" long. Total screen lenght 21'-0", Stainless screen [illegible] between 135½ to 145½ FT - will [illegible]

Developing time was 14 hours on screen [illegible] developed until 10 min. surge yielded ½ cup sand [illegible]

ABBREVIATIONS USED	RECOVERY TIME	WATER LEVEL
GR.-GRAVEL		
S.-SAND BAS.-BASALT		
CL.-CLAY		
FR.-FRACTURED		
MED.-MEDIUM		
C.-COARSE		
DEC.-DECOMPOSED		

THIS WELL WAS DRILLED BY: [illegible] Drilling Co. [illegible]

(Signed) [signature] Driller

DATE April 8 1971

IW-6

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No. ......
Permit No. G3-20247

(1) OWNER: Name BURLINGTON NORTHERN, INC. Address ST. PAUL, MINN. 55101

(2) LOCATION OF WELL: County FRANKLIN NW¼ NW ¼ NW ¼ Sec. 11 T. 9 N., R. 30E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation XXX Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) 23
New well ☐ Method: Dug ☐ Bored ☐
Deepened ☐ Cable XXXX Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 156 ft. Depth of completed well 153 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 16" Diam. from 0 ft. to 115 ft.
Threaded ☐ ......" Diam. from ...... ft. to ...... ft.
Welded XXX ......" Diam. from ...... ft. to ...... ft.

Perforations: Yes ☐ No XXX
Type of perforator used ......
SIZE of perforations ...... in. by ...... in.
...... perforations from XXXXXXXXXXXXXXXX ft.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.

Screens: Yes XXX No ☐
Manufacturer's Name Johnson well screen
Type low carbon steel Model No. XX
Diam. 14 Slot size 100 from 115 ft. to 130 ft.
Diam. 14 Slot size 70 from 130 ft. to 140 ft.
14 150 140 153

Gravel packed: Yes ☐ No ☐ Size of gravel: ......
Gravel placed from ...... ft. to ...... ft.

Surface seal: Yes XXX No ☐ To what depth? 18 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes ☐ No XX
Type of water? XX Depth of strata XX
Method of sealing strata off XXX

(7) PUMP: Manufacturer's Name XXXXX
Type: XXXX H.P. XXX

(8) WATER LEVELS: Land-surface elevation above mean sea level.... ~~524~~ 500 ft.
Static level 98 ft. below top of well Date 6/11/75
Artesian pressure XXX lbs. per square inch Date XXXX
Artesian water is controlled by ...... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? XXXX
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" XXXXXXXXXXXXXXXXXXXXXXXXXXXX "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
XXXXX	XXXXXXXX	XXXXXXXXXX	XXXXX	XXXXXXXXX	

Date of test ......
Bailer test ...... gal./min. with ...... ft. drawdown after ...... hrs.
Artesian flow ...... g.p.m. Date ......
Temperature of water ...... Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Surface seal	1	18
Fine brown sand	1	28
Course black sand	28	50
Static water	98	
Course gravel and black sand	50	138
Hit first water	105	
Gravel and clay	138	140
Course gravel and sand	140	153
Ringold formation	153	156
16 inch Lakewood Drive Shoe		
Screen:		
13 ft. of 150 slot		
10 ft. of 70 slot		
15 ft. of 100 slot		

9 p.m. ac ft.
1540 ac
2530
640

Work started 5/12 1975. Completed 6/11 1975

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME GOLDEN AUTUMN CONST. CO., INC. (Person, firm, or corporation) (Type or print)

Address P.O. BOX 811, PASCO, WN. 99301

[Signed] Ed [signature] (Well Driller)

License No. 0158 Date 6/20, 1975

OK

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71)
ECY-070-28

IW-7

STATE OF WASHINGTON

Permit No. 33-20245

(1) OWNER: Name BURLINGTON NORTHERN INC. Address BILLINGS, MONTANA

(2) LOCATION OF WELL: County FRANKLIN CENTER OF SW ¼ ¼ Sec 5 T 9 N., R 30E W

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) #25

New well ☒ Method: Dug ☐ Bored ☐

Deepened ☐ Cable ☒ Driven ☐

Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.

Drilled 235 ft. Depth of completed well 235 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 16" Diam. from 0 ft. to 235 ft.

Threaded ☐ " Diam. from ft. to ft.

Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☒ No ☐

Type of perforator used MILLS

SIZE of perforations 2 in. by 3/8 in.

342 perforations from 200 ft. to 232 ft.

perforations from ft. to ft.

perforations from ft. to ft.

Screens: Yes ☐ No ☒

Manufacturer's Name

Type Model No.

Diam. Slot size from ft. to ft.

Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:

Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 20 ft.

Material used in seal BENTONITE

Did any strata contain unusable water? Yes ☐ No ☒

Type of water? Depth of strata

Method of sealing strata off

(7) PUMP: Manufacturer's Name did not enstall

Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level 520 ft.

Static level 155 ft. below top of well Date 10/16/74

Artesian pressure lbs. per square inch Date

Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? Yes ☒ No ☐ If yes, by whom? GREEN VALLEY

Yield: gal./min. with ft. drawdown after hrs.

did not give us a report

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test

Bailer test gal./min. with ft. drawdown after hrs.

Artesian flow g.p.m. Date

Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
FINE SAND AND SILT	1	25
FINE BROWN SAND	25	55
FINE SAND	55	147
FINE TO COURSE GRAY SAND	147	155
BROWN CLAY	155	170
FINE TO COURSE SAND	170	173
WATER CAME IN (small amount)	173	
3/4 INCH MINUS RIVER GRAVEL AND SAND	173	187
SAND SILT, RIVER ROCK, 3" minus river rock	187	200
HIT GOOD WATER TABLE	200	
COURSE GRAVEL AND SAND, 6" minus river rock	200	234
BEDROCK, BLACK BASALT	234	235

LAKEWOOD DRIVE SHOE 16 INCH

RECEIVED
DEC 6 1974
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

1775
2544.1 A
2544
1,42

Work started 9/11 1974 Completed 10/16 1974

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME GOLDEN AUTUMN CONST. CO., INC. 0554 (Person, firm, or corporation) (Type or print)

Address P.O. BOX 311, PASCO, WN. 99301

[Signed] (Well Driller)

License No. 0153 Date OCTOBER 25, 1974

(USE ADDITIONAL SHEETS IF NECESSARY)

12/6/74

S. F. No. 7356—OS—(Rev. 4-71).

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

IW-8

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. G3 23408
Permit No. TEST WELL

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

(1) OWNER: Name Jim Minnehan Address Highway East 410 Pasco, Wn. 99301

(2) LOCATION OF WELL: County Franklin SE ¼ SE ¼ Sec. 4 T. 9 N., R. 30E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation XX Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)....
New well XX Method: Dug ☐ Bored ☐
Deepened ☐ Cable XX Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 12 inches.
Drilled 186 ft. Depth of completed well 186 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 12 " Diam. from 0 ft. to 184 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded XX " Diam. from ft. to ft.

Perforations: Yes XX No ☐
Type of perforator used Mills
SIZE of perforations 3/8 in. by 3 in.
182 perforations from 171 ft. to 184 ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☐ No XX
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No XX Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes XX No ☐ To what depth? 20 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? Soft Depth of strata 40
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: did not install H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ~~540~~ 520 ft.
Static level 146 ft. below top of well Date 7/31/74
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes XX No ☐ If yes, by whom? Green Valley
Yield: 1212 gal./min. with 16 ft. drawdown after 4 hrs.
" "
" did not give us a report "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test 7/30/74
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Top soil, sandy and brown	0	16
Silt, light gray	16	26
Silt , light gray	26	93
Sand fine silty, brown	93	104
Silt, brown, sandy	104	160
Sand, fine, white (water bearing)	160	164
Gravel, course, sand	164	186
12 inch Gopher Drive shoe		

400 gpm
2 ac. ft.
240 acres

RECEIVED
DEC 6 1974
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started JUNE 5 1974 Completed July 31 1974

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME GOLDEN AUTUMN CONST. CO., INC. 0554
(Person, firm, or corporation) (Type or print)

Address P.O. BOX 811 PASCO, WN. 99301

[Signed] Frank A. Crowe
(Well Driller)

License No. 0090 Date JULY 31, 1974

12/08/74

(USE ADDITIONAL SHEETS IF NECESSARY)

IW-11

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. [redacted]

Water Right Permit No. G3 22499

(1) OWNER: Name Tippet Land and Morgage Address

(2) LOCATION OF WELL: County Franklin SW ¼ NE ¼ Sec 2 T. 9 N., R. 30 E W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) New well 12 feet East of old well

(3) PROPOSED USE: ☐ Domestic ☒ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) 4 A
Abandoned ☐ New well ☐ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☒ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 139'6" inches.
Drilled 16" feet. Depth of completed well 139'6" ft.

(6) CONSTRUCTION DETAILS: 375 Wall
Casing installed: 16" Diam. from +6 ft. to 120'6" ft.
Welded ☒ " Diam. from ft. to ft.
Liner installed ☐ " Diam. from ft. to ft.
Threaded ☐

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type Stainless Model No.
Diam. 16 T Slot size 150 from 120'6" ft. to 138'6" ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 35 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 89 ft. below top of well Date 12-30-88
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest gal./min. with stem set at ft. for hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Sand Tan	0	12
Silt Tan Sandy	12	20
Sand Blk Sandy silt	20	22
Silt Tan Sandy	22	43
Gravel 6" minus sand Black water @ 89'	43	100
Sand Black, gravel very silty	100	105
Gravel 6" minus sand Blk	105	114
Gravel, cobbles, boulders sand Blk	114	138'6"
Basalt Black	138'6	139'6

RECEIVED
JAN - 9 1989
DEPARTMENT OF ECOLOGY
SPOKANE REG. OFFICE

Work started , 19. Completed 12-30, 1988

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Nelson Well Drilling Inc (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 10036 W Argent Pasco
(Signed) James Nelson (WELL DRILLER) License No. 361
Contractor's Registration No. NELSOWD148CQ Date 12-30, 1988

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10/87) -1329- 3

IW-12

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. G3-22491
Permit No. G3-22491 P

(1) OWNER: Name Robert Tippett #1 Address 3400 W. Clearwater Kennewick, Wn. 99336

(2) LOCATION OF WELL: County Franklin NW 1/4 of SE 1/4 NE 1/4 Sec 2 T. 9 N., R. 30E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation XX Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) #1
New well XX Method: Dug ☐ Bored ☐
Deepened ☐ Cable XX Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 127 ft. Depth of completed well 127 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 16" Diam. from 0 ft. to 127 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded XX " Diam. from ft. to ft.

Perforations: Yes XX No ☐
Type of perforator used Mills
SIZE of perforations 3/8 in. by 1 1/2 in.
616 perforations from 97 ft. to 125 ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☐ No XX
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No XX Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes XX No ☐ To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No XX
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level 510 ft.
Static level 80 ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes XX No ☐ If yes, by whom? Green Valley
Yield: 2451 gal./min. with 8 ft. drawdown after 4 hrs.
" " " "
" did not send us a report "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Fine sand	0	38
Small gravel and sand	38	53
Course sand and gravel	53	68
Course sand and gravel	68	87
Water	90	
Course sand and gravel	87	90
Small gravel and black sand	90	110
Small gravel and black sand	110	125
16 inch Gopher Drive shoe		

RECEIVED
DEC 6 1974
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

2160 gpm
1160 ac. ft.
240 ac.

Work started 6-3, 1974 Completed 7-3, 1974

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME GOLDEN AUTUMN CONST. CO., INC. 0554
(Person, firm, or corporation) (Type or print)

Address P.O. BOX 811 PASCO, WN. 99301

[Signed] Col [signature]
(Well Driller)

License No. 0158 Date 7-3-74, 19

12/07/74

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

IW-15

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. G3 22491
Permit No. Test Well

(1) OWNER: Name Robert Tippitt Address 3400 W. Clearwater, Kenmewick, wn. 99301

(2) LOCATION OF WELL: County Franklin — SW ¼ NE ¼ Sec 2 T 9 N., R 30E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☒ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) 5
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 165 ft. Depth of completed well 165 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 16 " Diam. from 0 ft. to 165 ft.
Threaded ☐ x " Diam. from x ft. to x ft.
Welded ☒ x " Diam. from x ft. to xx ft.

Perforations: Yes ☒ No ☐
Type of perforator used Mills
SIZE of perforations 3/8 in. by 2 in.
432 perforations from 98 ft. to 134 ft.
228 perforations from 144 ft. to 163 ft.
x perforations from x ft. to x ft.

Screens: Yes ☐ No ☒
Manufacturer's Name XXX
Type XXXX Model No.
Diam. XXX Slot size x from x ft. to XX ft.
Diam. x Slot size x from x ft. to XX ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: XXXX
Gravel placed from XXX ft. to XXX ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? XXX Depth of strata XXXXX
Method of sealing strata off XXXXX

(7) PUMP: Manufacturer's Name XX
Type: XX H.P. X

(8) WATER LEVELS: Land-surface elevation above mean sea level ~~500~~ 510 ft.
Static level 98 ft. below top of well Date 3/19/75
Artesian pressure x lbs. per square inch Date x
Artesian water is controlled by xxxxx (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Surface seal	0	18
Sandy loam	0	45
Sandy loam, sand	45	55
Course black gravel, $1\frac{1}{2}$ minus	55	98
Course sand & gravel, all colors $1\frac{1}{2}$ minus	98	110
Hit water		98
Pea gravel, black, white, brown	110	120
Course black sand and gravel	120	123
Course black & white gravel, peasize	123	132
Course gravel, sand all colors	132	135
Fine brown sand	135	140
Gravel, black, pea size	140	141
Sand and gravel	141	143
Mix sand and gravel	143	151
$1\frac{1}{2}$ minus rock and sand	151	163
Black basalt	163	165
16 inch Lakewood Drive shoe		

Q e 2160 gpm 1 Sa.ft. 1116 acres 240

G O

Work started 2/20, 1975. Completed 3/19, 1975

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Golden Autumn Const. Co., Inc. (Person, firm, or corporation) (Type or print)
Address P.O. Box 811, PASCO, WN. 99301
[Signed] Terry Kelly (Well Driller)
License No. 0606 Date 3/25/75, 1975

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71)
ECY-070-28

Privately Owned Wells

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

195739

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W 22903
UNIQUE WELL I.D. #
Water Right Permit No. G3 28775 P

(1) OWNER: Name Earl Blasdel Address 2001 East Foster Wells Rd Pasco

(2) LOCATION OF WELL: County Franklin NW 1/4 SW 1/4 Sec 4 T. 9 N., R 30 W.M.

(2a) STREET ADDRESS OF WELL (or nearest address)

(3) PROPOSED USE: ☐ Domestic ☒ Irrigation ☐ DeWater ☐ Industrial ☐ Test Well ☐ Municipal ☐ Other

(4) TYPE OF WORK: Owner's number of well (If more than one)
Abandoned ☐ New well ☒ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Cable ☒ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 220 1/2 feet. Depth of completed well 220 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Diam. from +1 ft. to 197 ft.
Welded ☒ " Diam. from ft. to ft.
Liner installed ☐ " Diam. from ft. to ft.
Threaded ☐

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Huston
Type Stainless Steel Model No.
Diam. 16" Slot size 250 from 197 ft. to 217 ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 20 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 175 ft. below top of well Date 11-2-93
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? Layne Bowler
Yield: 1860 gal./min. with 20 ft. drawdown after 12 hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest gal./min. with stem set at ft. for hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Sand Tan	0	9
Sand Tan Silty	9	104
Sand Tan	104	135
Sand Tan Silty	135	162
Sand Black Silty	162	173
Sand Black water at 175'	170	180
Gravel fine sand TAN	180	181
Gravel 6" minus sand TAN	181	217
Gravel 6" minus sand Tan	217	
Silty water shut off		220 1/2

RECEIVED
NOV 24 1993
DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

Work Started 10-11, 19. Completed 11-2, 1993

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Nelson Well Drilling Inc (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 8200 W Argent Pasco
(Signed) Jim Nelson (WELL DRILLER) License No. 361
Contractor's Registration No. NELSOWD148(Q Date 11-2, 1993

(USE ADDITIONAL SHEETS IF NECESSARY)

ECL 050-1-20 (2/93)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

307574

WATER WELL REPORT

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Construction/Decommission (*"x" in circle*)

☒ Construction

○ Decommission *ORIGINAL INSTALLATION Notice of Intent Number* #1

CURRENT Notice of Intent No. R035442

Unique Ecology Well ID Tag No. APJ 201

Water Right Permit No. ______

Property Owner Name Carson Ag LLC

Well Street Address 28 Pasco Kahlotus Rd

City Pasco County Franklin

Location SW 1/4-1/4 NE 1/4 Sec 2 Twn 9 R 30 EWM or WWM (circle one)

Lat/Long (s, t, r Still **REQUIRED**) Lat Deg ______ Lat Min/Sec ______ Long Deg ______ Long Min/Sec ______

Tax Parcel No. 113 710 084

PROPOSED USE: ☐ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other Monitoring

TYPE OF WORK: Owner's number of well (if more than one) ______

☒ New well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven
☐ Deepened ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6x2 inches, drilled 96 ft.
Depth of completed well 96 ft.

CONSTRUCTION DETAILS

Casing Installed: ☐ Welded ______" Diam. from ______ ft. to ______ ft.
☐ Liner installed ______" Diam. from ______ ft. to ______ ft.
☒ Threaded 2" Diam. from +2 ft. to 96 ft.

Perforations: ☐ Yes ☒ No
Type of perforator used ______
SIZE of perfs ______ in. by ______ in. and no. of perfs ______ from ______ ft. to ______ ft.

Screens: ☒ Yes ☐ No ☐ K-Pac Location 76' to 96'
Manufacturer's Name ______
Type ______ Model No. ______
Diam. 2" Slot size ______ from 76' ft. to 96 ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel/Filter packed: ☒ Yes ☐ No ☐ Size of gravel/sand ______
Materials placed from 73 ft. to 96 ft.

Surface Seal: ☒ Yes ☐ No To what depth? 73 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 81 ½ ft. below top of well Date 4/9/08
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☒ No If yes, by whom? ______
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest ______ gal./min. with stem set at ______ ft. for ______ hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? ☐ Yes ☒ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
FINE TAN SAND	0	28
FINE BLACK SAND	28	35
COARSE BLACK SAND	35	42
FINE BLACK SAND	42	67
ABOVE WITH TRACE OF BROWN SILT	67	73
COARSE BLACK SAND	73	94
COARSE BLACK SAND & GRAVEL	94	96
TAN SAND & GRAVEL	96	

RECEIVED MAR 09 2009 DEPARTMENT OF ECOLOGY EASTERN REGIONAL OFFICE

RECEIVED MAY 14 2008 DEPARTMENT OF ECOLOGY EASTERN REGIONAL OFFICE

Start Date 4/8/08 Completed Date 4/9/08

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) Jim Nelson
Driller/Engineer/Trainee Signature [signature]
Driller or trainee License No. 361

If TRAINEE,
Driller's Licensed No. ______
Driller's Signature ______

Drilling Company NELSON WELL DRILLING
Address 7505 W. COURT ST.
City, State, Zip PASCO WA 99301
Contractor's Registration No. NELSOWD 198CQ Date 5/11/08

Ecology is an Equal Opportunity Employer.

ECY 050-1-20 (Rev 3/05) **The Department of Ecology does NOT warranty the Data and/or Information on this Well Report.**

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. G3-22491
Permit No. Test Well

(1) OWNER: Name Robert Tippitt Address 3400 W. Clearwater, Kennewick, wn. 99301

(2) LOCATION OF WELL: County Franklin — SW ¼ NE ¼ Sec. 2 T. 9 N., R. 30E W.M.
Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☒ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) 5
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 165 ft. Depth of completed well 165 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 16" Diam. from 0 ft. to 165 ft.
Threaded ☐ X" Diam. from X ft. to X ft.
Welded ☒ X" Diam. from X ft. to XX ft.

Perforations: Yes ☒ No ☐
Type of perforator used Mills
SIZE of perforations 3/8 in. by 2 in.
432 perforations from 98 ft. to 134 ft.
228 perforations from 144 ft. to 163 ft.
X perforations from X ft. to X ft.

Screens: Yes ☐ No ☒
Manufacturer's Name XXX
Type XXXX Model No.
Diam. XXX Slot size X from X ft. to XX ft.
Diam. X Slot size X from X ft. to XX ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: XXXX
Gravel placed from XXX ft. to XXX ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? XXX Depth of strata XXXXX
Method of sealing strata off XXXXX

(7) PUMP: Manufacturer's Name XX
Type: XX H.P. X

(8) WATER LEVELS: Land-surface elevation above mean sea level ~~500~~ 510 ft.
Static level 98 ft. below top of well Date 3/19/75
Artesian pressure X lbs. per square inch Date X
Artesian water is controlled by XXXXX (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Subsurface profile B - B', Well #10

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Surface seal	0	18
Sandy loam	0	45
Sandy loam, sand	45	55
Course black gravel, 1½ minus	55	98
Course sand & gravel, all colors 1½ minus	98	110
Hit water		98
Pea gravel, black, white, brown	110	120
Course black sand and gravel	120	123
Course black & white gravel, peasize	123	132
Course gravel, sand all colors	132	135
Fine brown sand	135	140
Gravel, black, pea size	140	141
Sand and gravel	141	143
Mix sand and gravel	143	151
1½ minus rock and sand	151	163
Black basalt	163	165

16 inch Lakewood Drive shoe

Q
1 e 2160 gpm
1116 acres
240 Sq. ft.

GO

Work started 2/20, 1975 Completed 3/19, 1975

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Golden Autumn Const. Co., Inc. (Person, firm, or corporation) (Type or print)
Address P.O. Box 811, PASCO, WN. 99301
[Signed] Terry Kelly (Well Driller)
License No. 0606 Date 3/25/75, 1975

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71)
ECY-070-28

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. [redacted]

Water Right Permit No. G3 22499

(1) OWNER: Name Tippet Land and Morgage Address

(2) LOCATION OF WELL: County Franklin SW ¼ NE ¼ Sec. 2 T. 9 N., R. 30 E W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) New well 12 feet East of old well

(3) PROPOSED USE: ☐ Domestic ☒ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) 4 A

Abandoned ☐ New well ☐ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☒ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 139'6" inches.
Drilled 16" feet. Depth of completed well 139'6" ft.

(6) CONSTRUCTION DETAILS: 375 Wall

Casing installed: 16 " Diam. from +6 ft. to 120'6" ft.
Welded ☒ ______ " Diam. from ______ ft. to ______ ft.
Liner installed ☐
Threaded ☐ ______ " Diam. from ______ ft. to ______ ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type Stainless Model No.
Diam. 16 T Slot size 150 from 120'6" ft. to 138'6" ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes ☐ No ☒ Size of gravel
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes ☒ No ☐ To what depth? 35 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ______ Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: ______ H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 89 ft. below top of well Date 12-30-88
Artesian pressure ______ lbs. per square inch Date
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest ______ gal./min. with stem set at ______ ft. for ______ hrs.
Artesian flow ______ g.p.m. Date
Temperature of water ______ Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Sand Tan	0	12
Silt Tan Sandy	12	20
Sand Blk Sandy silt	20	22
Silt Tan Sandy	22	43
Gravel 6" minus sand Black water @ 89'	43	100
Sand Black, gravel very silty	100	105
Gravel 6" minus sand Blk	105	114
Gravel, cobbles, boulders sand Blk	114	138'6"
Basalt Black	138'6	139'6

RECEIVED
JAN - 9 1989
DEPARTMENT OF ECOLOGY
SPOKANE REG. OFFICE

Work started ______, 19__. Completed 12-30, 1988

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Nelson Well Drilling Inc (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 10036 W Argent Pasco
(Signed) James Nelson (WELL DRILLER) License No. 361
Contractor's Registration No. NELSOWD198CQ Date 12-30, 1988

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10/87) -1329- 3

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

307573

WATER WELL REPORT

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Construction/Decommission *("x" in circle)*

☒ Construction

○ Decommission *ORIGINAL INSTALLATION Notice of Intent Number* #2

CURRENT Notice of Intent No. R 035441

Unique Ecology Well ID Tag No. APJ 203

Water Right Permit No. ______

Property Owner Name Carson Oe LK

Well Street Address 28 Pasco Kahlotus (HWY?)

City Pasco County Franklin

Location SE 1/4-1/4 NE 1/4 Sec 2 Twn 9 R 30 EWM (circle one) or WWM

Lat/Long (s, t, r Still REQUIRED) Lat Deg ______ Lat Min/Sec ______ Long Deg ______ Long Min/Sec ______

Tax Parcel No. 113 710 084

PROPOSED USE: ☐ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other Monitoring

TYPE OF WORK: Owner's number of well (if more than one) ______

☒ New well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven

☐ Deepened ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6 x 2 inches, drilled 98 ft.

Depth of completed well 94 ft.

CONSTRUCTION DETAILS

Casing Installed: ☐ Welded ___" Diam. from ___ ft. to ___ ft.

☐ Liner installed ___" Diam. from ___ ft. to ___ ft.

☒ Threaded 2" Diam. from 1½ ft. to 94 ft.

Perforations: ☐ Yes ☒ No

Type of perforator used ______

SIZE of perfs ___ in. by ___ in. and no. of perfs ___ from ___ ft. to ___ ft.

Screens: ☒ Yes ☐ No ☐ K-Pac Location 74' to 94'

Manufacturer's Name ______

Type PVC Model No. ______

Diam. 2" Slot size ___ from 74 ft. to 94 ft.

Diam. ___ Slot size ___ from ___ ft. to ___ ft.

Gravel/Filter packed: ☒ Yes ☐ No ☐ Size of gravel/sand ______

Materials placed from 70 ft. to 94 ft.

Surface Seal: ☒ Yes ☐ No To what depth? 70 ft.

Material used in seal BENTONITE

Did any strata contain unusable water? ☐ Yes ☒ No

Type of water? ______ Depth of strata ______

Method of sealing strata off ______

PUMP: Manufacturer's Name ______

Type: ______ H.P. ______

WATER LEVELS: Land-surface elevation above mean sea level ______ ft.

Static level 80 ft. below top of well Date 5/9/08

Artesian pressure ______ lbs. per square inch Date ______

Artesian water is controlled by ______ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? ☐ Yes ☒ No If yes, by whom? ______

Yield: ___ gal./min. with ___ ft. drawdown after ___ hrs.

Yield: ___ gal./min. with ___ ft. drawdown after ___ hrs.

Yield: ___ gal./min. with ___ ft. drawdown after ___ hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______

Bailer test ___ gal./min. with ___ ft. drawdown after ___ hrs.

Airtest ___ gal./min. with stem set at ___ ft. for ___ hrs.

Artesian flow ___ g.p.m. Date ___

Temperature of water ___ Was a chemical analysis made? ☐ Yes ☒ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
TAN SAND FINE	0	63
BLACK SAND FINE	63	84
BLACK SAND & GRAVEL	84	94
TAN SAND & GRAVEL FINE	94	98

RECEIVED MAR 09 2009 DEPARTMENT OF ECOLOGY EASTERN REGIONAL OFFICE

RECEIVED MAY 14 2008 DEPARTMENT OF ECOLOGY EASTERN REGIONAL OFFICE

Start Date 5/8/08 Completed Date 5/9/08

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) Jim Nelson

Driller/Engineer/Trainee Signature [signature]

Driller or trainee License No. 361

If TRAINEE, Driller's Licensed No. ______

Driller's Signature ______

Drilling Company NELSON WELL DRILLING

Address 7505 W. COURT ST. ~~PASCO~~

City, State, Zip PASCO WA. 99301

Contractor's Registration No. NELSOWD198CQ Date 5/11/08

Ecology is an Equal Opportunity Employer.

The Department of Ecology does NOT warranty the Data and/or Information on this Well Report.

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. G3-22491
Permit No. G3-22491 P

(1) OWNER: Name Robert Tippett #1 Address 3400 W. Clearwater Kennewick, Wn. 99336

(2) LOCATION OF WELL: County Franklin NW 1/4 of SE 1/4 NE 1/4 Sec 2 T. 9 N., R. 30E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) #1
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 127 ft. Depth of completed well 127 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 16" Diam. from 0 ft. to 127 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☒ No ☐
Type of perforator used Mills
SIZE of perforations 3/8 in. by 1 1/2 in.
616 perforations from 97 ft. to 125 ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☐ No ☒
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level 510 ft.
Static level 80 ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? Green Valley
Yield: 2451 gal./min. with 8 ft. drawdown after 4 hrs.
" " " "
" did not send us a report "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Fine sand	0	38
Small gravel and sand	38	53
Course sand and gravel	53	68
Course sand and gravel	68	87
Water	90	
Course sand and gravel	87	90
Small gravel and black sand	90	110
Small gravel and black sand	110	125
16 inch Gopher Drive shoe		

RECEIVED
DEC 6 1974
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

2160 gpm
1160 ac. ft.
240 ac.

Work started 6-3 1974 Completed 7-3 1974

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME GOLDEN AUTUMN CONST. CO., INC. 0554
(Person, firm, or corporation) (Type or print)

Address P.O. BOX 811 PASCO, WN. 99301

[Signed] Ed Maez
(Well Driller)

License No. 0158 Date 7-3-74, 19

12/07/74

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

195902

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W022910

Water Right Permit No. ____

(1) OWNER: Name Harold Cox Address 980 E Foster Wells Rd Pasco

(2) LOCATION OF WELL: County Franklin NW ¼ NE ¼ Sec 10 T. 9 N., R. 30E W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) ____

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater [ ] Industrial [ ] Test Well [ ] Municipal [ ] Other

(4) TYPE OF WORK: Owner's number of well (if more than one) ____
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ]
Method: Dug [ ] Cable [ ] Rotary [X] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 184 feet. Depth of completed well 182 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Diam. from +2 ft. to 182 ft.
Welded [X] ____ " Diam. from ____ ft. to ____ ft.
Liner installed [ ]
Threaded [ ] ____ " Diam. from ____ ft. to ____ ft.

Perforations: Yes [ ] No [X]
Type of perforator used ____
SIZE of perforations ____ in. by ____ in.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.

Screens: Yes [ ] No [X]
Manufacturer's Name ____
Type ____ Model No. ____
Diam. ____ Slot size ____ from ____ ft. to ____ ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel packed: Yes [ ] No [X] Size of gravel ____
Gravel placed from ____ ft. to ____ ft.

Surface seal: Yes [X] No [ ] To what depth? 30 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes [ ] No [ ]
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

(7) PUMP: Manufacturer's Name ____
Type: ____ H.P. ____

(8) WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level 142 ft. below top of well Date 10-7
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [ ] If yes, by whom? ____
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ____
Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.
Airtest 4 gal./min. with stem set at 175 ft. for 2 hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? Yes [ ] No [ ]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Sand Tan	0	4
Sand Blk Silty	4	11
Sand Tan Silty	11	17
Sand Black	17	21
Sand Tan	21	48
Sand Black Silty	48	76
Sand Black	76	102
Gravel, Sand Black	102	133
Sand Tan	133	141
Silt Tan	141	151
Gravel 4" minus Sand Black	151	
Water Bearing		153
Gravel, Sand Black silty	153	
Water Bearing		167
Gravel, sand Tan cemented	167	
Water Bearing		184
Gravel, sand Tan Very silty	184	

RECEIVED OCT 25 1993 DEPARTMENT OF ECOLOGY EASTERN REGIONAL OFFICE

Work started 10-6, 19. Completed 10-7, 1993

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Nelson Well Drilling (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 8200 N Argent Pasco
(Signed) [signature] (WELL DRILLER) License No. 361
Contractor's Registration No. NELSOWD198CQ Date 10-7, 1993

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10/87) -1329- 3

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

WATER WELL REPORT

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

ECOLOGY

Construction/Decommission ("x" in circle)
☒ Construction 270192
○ Decommission *ORIGINAL INSTALLATION Notice of Intent Number* W148966

CURRENT
Notice of Intent No. W 256467

Unique Ecology Well ID Tag No. AGM 117
Water Right Permit No.
Property Owner Name ERNEST & BONNIE LEE
Well Street Address 43903 SHANNON LN.
City N. RICHLAND County BENTON CDEF
Location ___1/4-1/4 NW 1/4 Sec 11 Twn 9 R30 EWM or WWM (circle one)
Lat/Long (s, t, r Still REQUIRED) Lat Deg ____ Lat Min/Sec ____ Long Deg ____ Long Min/Sec ____
Tax Parcel No. 1-1190-201-2180-012

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other ____

TYPE OF WORK: Owner's number of well (if more than one) ____
☐ New well ☒ Reconditioned ☒ Deepened
Method: ☐ Dug ☐ Bored ☐ Driven ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6 inches, drilled 261 ft.
Depth of completed well 261 ft.

CONSTRUCTION DETAILS
Casing Installed: ☐ Welded EXISTING Diam. from ____ ft. to ____ ft.
☐ Liner installed ____" Diam. from ____ ft. to ____ ft.
☐ Threaded ____" Diam. from ____ ft. to ____ ft.

Perforations: ☐ Yes ☒ No
Type of perforator used ____
SIZE of perfs ____ in. by ____ in. and no. of perfs ____ *from* ____ *ft. to* ____ *ft.*

Screens: ☐ Yes ☒ No ☐ K-Pac Location ____
Manufacturer's Name ____
Type ____ Model No. ____
Diam. ____ Slot size ____ from ____ ft. to ____ ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel/Filter packed: ☐ Yes ☒ No ☐ Size of gravel/sand ____
Materials placed from ____ ft. to ____ ft.

Surface Seal: ☐ Yes ☐ No To what depth? ____ ft.
Material used in seal EXISTING
Did any strata contain unusable water? ☐ Yes ☐ No
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

PUMP: Manufacturer's Name ____
Type: ____ H.P. ____

WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level 53 ft. below top of well Date ____
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☐ No If yes, by whom? ____
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ____
Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.
Airtest 55 gal./min. with stem set at 160 ft. for 1 hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? ☐ Yes ☒ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
BROKEN BASALT	183	243
PORUS BLACK BASALT H2O	243	252
BLACK BASALT	252	261

DEPT OF ECOLOGY Received AUG 17 2007 CENTRAL REGION OFFICE

Start Date 7/16/07 Completed Date 7/17/07

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) JEREMY RUDS
Driller/Engineer/Trainee Signature [signature]
Driller or trainee License No. 2691

If TRAINEE,
Driller's Licensed No. ____
Driller's Signature ____

Drilling Company NELSON WELL DRILLING
Address 7505 N. COURT ST
City, State, Zip PASCO WA. 99301
Contractor's Registration No. NELSOWD198CQ Date 7/17/07

Ecology is an Equal Opportunity Employer.

ECY 050-1-20 (Rev 3/05)

The Department of Ecology does NOT warranty the Data and/or Information on this Well Report.

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original with Department of Ecology
Second Copy - Owner's Copy
Third Copy - Driller's Copy 106860

WATER WELL REPORT

STATE OF WASHINGTON

Notice of Intent W148966
UNIQUE WELL I D # AGM 117
Water Right Permit No

(1) OWNER. Name Ernest + Bonnie Lee Address 2550 Dupertail G141 Rchland

(2) LOCATION OF WELL: County Benton 1/4 NW 1/4 Sec 11 T 9 N R 30 EWM

(2a) STREET ADDRESS OF WELL: (or nearest address) Shannon + Lenore

TAX PARCEL NO. CDEF

(3) PROPOSED USE: ☒ Domestic ☐ Irrigation ☐ DeWater ☐ Industrial ☐ Test Well ☐ Municipal ☐ Other

(4) TYPE OF WORK: Owner's number of well (if more than one)
☒ New Well ☐ Deepened ☐ Reconditioned ☐ Decommission
Method ☐ Dug ☐ Cable ☒ Rotary ☐ Bored ☐ Driven ☐ Jetted

(5) DIMENSIONS: Diameter of well 6 inches
Drilled 183' 2" feet Depth of completed well 183' 2" ft

(6) CONSTRUCTION DETAILS
Casing Installed:
☒ Welded 6" Diam from +1½ ft to 182'6" ft
☐ Liner installed " Diam from ft to ft
☐ Threaded " Diam from ft to ft

Perforations: ☐ Yes ☒ No
Type of perforator used
SIZE of perforations in by in
perforations from ft to ft

Screens: ☐ Yes ☒ No ☐ K-Pac Location
Manufacturer's Name
Type Model No
Diam Slot Size from ft to ft
Diam Slot Size from ft to ft

Gravel/Filter packed: ☐ Yes ☒ No ☐ Size of gravel/sand
Material placed from ft to ft

Surface seal: ☒ Yes ☐ No To what depth? 35 ft
Material used in seal Bentonite
Did any strata contain unusable water? ☐ Yes ☐ No
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type H P

(8) WATER LEVELS: Land-surface elevation above mean sea level ft
Static level 51 ft below top of well Date 12-2-01
Artesian pressure lbs per square inch Date
Artesian water is controlled by
(Cap, valve, etc)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☐ No If yes, by whom?
Yield gal /min with ft drawdown after hrs
Yield gal /min with ft drawdown after hrs
Yield gal /min with ft drawdown after hrs
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal /min with ft drawdown after hrs
Airtest 35 gal /min with 60 ft drawdown after 2 hrs
Artesian flow g p m Date
Temperature of water Was a chemical analysis made? ☐ Yes ☐ No

(10) WELL LOG or DECOMMISSIONING PROCEDURE DESCRIPTION
Formation Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information Indicate all water encountered

MATERIAL	FROM	TO
Sandy Soil	0	1
Gravel, sand	1	5
Sand Tan Sandy	5	13
Boulder Basalt	13	16
Sand Tan	16	24
Gravel, sand Black	24	31
Sand, Tan Gravel	31	
water @ 61 feet		67
Basalt Black	67	102
Basalt Black Fractured	102	
with Tan Sand water		144
Basalt Black	144	167
Gravel 1" minus sand	167	
Tan Water		171
Basalt Black vesicular	171	
Water Bearing		182
Basalt Black Fractured	182	
water		183

DEPT OF ECOLOGY Received DEC 24 2001 CENTRAL REGION OFFICE

Work Started 12-6-01 Completed 12-7-01

WELL CONSTRUCTION CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards Materials used and the information reported above are true to my best knowledge and belief

Type or Print Name Jim Nelson License No 361
(Licensed Driller/Engineer)
Trainee Name License No
Drilling Company Nelson Well Drilling Inc
(Signed) Jim Nelson License No
(Licensed Driller/Engineer)
Address 8200 W Argent Pasco
Contractor's Registration No NELSOWD198KQ Date 12-7-01

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer For special accommodation needs, contact the Water Resources Program at (360) 407-6600 The TDD number is (360) 407-6006

ECY 050-1-20 (11/98)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION
AND DEVELOPMENT

WELL LOG UNRECORDED No......./........-........

Date 4-30, 1962

Record by well driller

Source driller's record

Location: State of WASHINGTON

County Franklin

Area

Map

SW ¼ SW ¼ sec. 2 T. 9 N., R. 30 E.

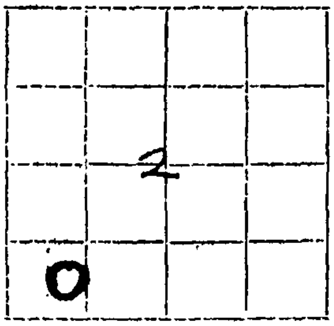


Diagram of Section

Drilling Co. Cascade Drilling Co.

Address 309 N. 12th, Pasco, Wash.

Method of Drilling .... Date 1-23, 1962

Owner Carl Marchbanks

Address 2017 W. 4th, Kennewick, Wash.

Land surface, datum .... ft. above / below

Correlation	Material	Thickness (feet)	Depth (feet)
	(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)		
	Brown sandy soil	3	3
	" sandy clay	9	12
	" silty sand	25	37
	" fine gravel & sand	11	48
	Grey loose sand	3	51
	Brown fine gr. sand & sed.	92	143
	" sand, silt & gravel	2	145
	" Cemented gravel	14	159
	" gravel, sand & sediment	7	166
	Grey Sediment, sand & some gravel	2	168
	" Sandstone (1+1½ gpm)	1	169
	" Cemented sand & gravel	7	176
	Bas. boulders, cemented sd.	1½	177½
	Basalt (1½ gpm)	2½	180
	Med. hardfrac. basalt	7	187
	Hd. bas. some fractures	11	198
	Very hard bas (blasted)	10	208
	Hd. bas. (badly fractured)	2'8"	210'8"

Turn up (over) Sheet.......of.......sheets

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

WELL LOG.—Continued No........../..........-..........

Correlation	Material	Thickness (feet)	Depth (feet)
	Depth forward	———	
	PUMP TEST:		
	Dim. 6"x210'8"		
	SWL: 153 ft. (Jan.23,1962)		
	Yield: bailer tested @ 7-10 g.p.m.		
	with 45 ft. d.d.		
	~~CASING: 6", 177x6"steel, 177'6"~~		
	~~Temp. 64°~~		

S. F. No. 7449—OS—6-61—2M.

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. [redacted] /

Water Right Permit No.

(1) OWNER: Name Greg Higgs Address E Foster Wells Rd Pasco

(2) LOCATION OF WELL: County Franklin SW ¼ SW ¼ Sec 2 T. 9 N., R. 30E W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address)

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater Industrial [X] (crossed out) Test Well [ ] Municipal [ ] Other [ ]

(4) TYPE OF WORK: Owner's number of well (if more than one)

Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ] Method: Dug [ ] Cable [ ] Rotary [X] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 8 inches.
Drilled 157 6 feet. Depth of completed well 157'6" ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 8" Diam. from +1 ft. to 152-8 ft.
Welded [X] " Diam. from ft. to ft.
Liner installed [ ]
Threaded [ ] " Diam. from ft. to ft.

Perforations: Yes [ ] No [X]
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes [X] No [ ]
Manufacturer's Name Huston
Type Stainless Model No.
Diam. 8 T Slot size 40 from 153-6 ft. to 157-6 ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes [ ] No [X] Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes [X] No [ ] To what depth? 25 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes [ ] No [ ]
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 122 ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [ ] If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest 100 gal./min. with stem set at 140 ft. for 2 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes [ ] No [ ]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Sand Tan Silty	0	25
Sand Black	25	29
Sand Black Silty	29	35
Sand Tan Silty	35	57
Sand Black Gravel	57	78
Gravel 4" Minus sand	78	
Black Water @ 122 ft		1576

RECEIVED
OCT 17 1991
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 9-30, 19. Completed 10-2, 1991

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME NELSON Well Drilling Inc (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 10036 W Argent Pasco
(Signed) [signature] (WELL DRILLER) License No. 361
Contractor's Registration No. NELSOWD 169Q2 Date 10-2, 1991

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10/87) -1329- 3

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

The Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. 1970
Permit No. G3-24546

(1) OWNER: Name Jim Lentz Address

(2) LOCATION OF WELL: County Franklin W½ NW ¼ NW ¼ Sec. 12 T. 9 N., R. 30 W.M.
Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 127 ft. Depth of completed well 97 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 16" Diam. from +1½ ft. to 84 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type Low carbon Model No.
Diam. 16 Tel Slot size 80 from 97 ft. to 90 ft.
Diam. 16 Tel Slot size 110 from 90 ft. to 84 ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 21 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level 510 ft.
Static level 77.6 ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: 1450 gal./min. with 12 ft. drawdown after 4 hrs.
" " "
" " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:
Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Soil - Silty Tan sand	0	18
Gravel Black with Sand	18	28
Sand - Gravel - Black	28	37
GRAVel Black - Sand Dense	37	45
Gravel To 12" Sand Black	45	54
Boulder Black Basalt	54	57
Gravel & Sand Black	57	66
Sand & Gravel	66	74
Boulder, Black Basalt	74	78
Sand Black & Gravel	78	97
Clay Tan	97	125
Basalt Black Firm	125	127

1200 gpm
84
6
132

Work started 10-13, 19 75. Completed 10 24, 19 75

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Nelson Well Drilling (Person, firm, or corporation) (Type or print)
Address P.O. Box 2814 Pasco
[Signed] James Nelson (Well Driller)
License No. 361 Date 10-25, 19 75

12/14/75

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. G325178
Permit No. G3 25178P

(1) OWNER: Name J E Lentz Address

(2) LOCATION OF WELL: County FRANKlin NW¼ SE ¼ SE ¼ Sec 4 T 9 N., R 30E W.M.
Bearing and distance from section or subdivision corner 1200'N - 1200' W of SE Cor

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 242 ft. Depth of completed well 242 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 16" Diam. from +1 ft. to 216 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☐ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type Low Carbon Shaped Wedwire
Diam. 16" Telescope Slot size 250 from 216 ft. to 237 ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 35 ft.
Material used in seal Bentonite + Sand
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level 530 ft.
Static level 165 ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:
Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Silt TAN Sandy	0	27
SAND BROWN Fine Silty	27	145
SAND Black Fine Silty	145	147
SAND Black 4" Minus Gravel Silty	147	149
SAND Tan 1" minus gravel Silty	149	152
Silt TAN	152	164
SAND Black 2" minus gravel Silt Balls	164	168
SAND - Gravel 3" minus Brown Tan + Gray Water Bear	168	196
Gravel + Sand Ringold Slow Water	196	212
Gravel 6" Minus Sand TAN Water Bearing Ringold	212	237
Gravel Sand Cemented	237	242
Basalt	242	

1600 gpm
333.5 AF/yr
160 Ac

Eltopia 15'

Work started 1-18, 1978 Completed 1-10, 1978

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Nelson Well Drilling Inc
(Person, firm, or corporation) (Type or print)

Address 10036 W Argent

[Signed] Dave Wellins
(Well Driller)

License No. 0659 Date 3-13, 1978

3/15/78

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. G3 23408

Permit No. TEST WELL

(1) OWNER: Name Jim Minnehan Address Highway East 410 Pasco, Wn. 99301

(2) LOCATION OF WELL: County Franklin SE ¼ SE ¼ Sec. 4 T. 9 N., R. 30E W.M.

Bearing and distance from section or subdivision corner

PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation XX Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....

New well X Method: Dug ☐ Bored ☐
Deepened ☐ Cable XX Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 12 inches.
Drilled 186 ft. Depth of completed well 186 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 12 " Diam. from 0 ft. to 184 ft.
Threaded ☐ ...... " Diam. from ...... ft. to ...... ft.
Welded X ...... " Diam. from ...... ft. to ...... ft.

Perforations: Yes XX No ☐
Type of perforator used Mills
SIZE of perforations 3/8 in. by 3 in.
182 perforations from 171 ft. to 184 ft.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.

Screens: Yes ☐ No XX
Manufacturer's Name
Type ...... Model No. ......
Diam. ...... Slot size ...... from ...... ft. to ...... ft.
Diam. ...... Slot size ...... from ...... ft. to ...... ft.

Gravel packed: Yes ☐ No XX Size of gravel: ......
Gravel placed from ...... ft. to ...... ft.

Surface seal: Yes XX No ☐ To what depth? 20 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? Salt Depth of strata 40
Method of sealing strata off ......

(7) PUMP: Manufacturer's Name ......
Type: did not install H.P. ......

(8) WATER LEVELS: Land-surface elevation above mean sea level ~~540~~ 520 ft.
Static level 146 ft. below top of well Date 7/31/74
Artesian pressure ...... lbs. per square inch Date ......
Artesian water is controlled by ...... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes XX No ☐ If yes, by whom? Green Valley
Yield: 1212 gal./min. with 16 ft. drawdown after 4 hrs.
" " " "
" did not give us a report "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

of test 7/30/74
...test ...... gal./min. with ...... ft. drawdown after ...... hrs.
Artesian flow ...... g.p.m. Date ......
Temperature of water ...... Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Top soil, sandy and brown	0	16
Silt, light gray	16	26
Silt , light gray	26	93
Sand fine silty, brown	93	104
Silt, brown, sandy	104	160
Sand, fine, white (water bearing)	160	164
Gravel, course, sand	164	186
12 inch Gopher Drive shoe		

40 gpf
2/1 dc
240 acres

RECEIVED
DEC 6 1974
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started JUNE 5 19 74 Completed July 31 19 74

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME GOLDEN AUTUMN CONST. CO., INC. 0554
(Person, firm, or corporation) (Type or print)

Address P.O. BOX 811 PASCO, WN. 99301

[Signed] Frank A. Crowe
(Well Driller)

License No. 0090 Date JULY 31, 1974 19

(USE ADDITIONAL SHEETS IF NECESSARY)

12/08/74

S. F. No. 7356—OS—(Rev. 4-71).

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

Appli. 10267
Per. 9823

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION
DIVISION OF WATER RESOURCES

WELL LOG

Record by
Source

Location: State of WASHINGTON
County Franklin
Area
Map
SW SE ¼ SE ¼ sec. 2 T. 9 N., R. 30 E.

Diagram of Section: 2

Drilling Co. Cascade Drilling Co.
Address P.O. Drawer E, Kennewick, Wa.
Method of Drilling Cable Date Dec. 10, 1970
Owner Carl Marchbanks
Address
Land surface, datum ft. above / below
SWL: 83'-6" Date Dec. 10, 1970 Dims.: 8" x 125'

Correlation	Material	From (feet)	To (feet)
	(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)		
	Irrigation		
	Soil	0	10
	F. 6R & S. loose, black	10	14
	C. S., Black	14	35
	F. S., black	35	42
	Clay, sandy, brpwm	42	55
	S., TR. GR. clay, compact	55	57
	S, Cl, Tr, Gr,	57	75
	Layers cl & s; cl & f. gr.	75	92
	Gr. & C.S. Heaving, Blk F	92	103
	Gr., S., SM. SED., heaving, blk	103	105
	Gr, S., loose, heaving, blk	105	107½
	Gr. S. heaving, blk	107½	110
	Gr (5-6") sand, coarser, blk	110	113
	Gr., S, loose & heaving, blk F	119	122

Turn up Sheet of sheets

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

WELL LOG.—Continued No........../..........-..........

Correlation	Material	From (feet)	To (feet)
	Depth forward		
	Gr. more FS. heaving. blk F	122	124
	Gr. FS & SED., Brownish F	124	125
	Casing: 8" from 0' to 114'		
	Screens: Stainless. dia.8. 065 from 114' to 124'		
	Sealed with Bentonite & Grout		
	Bailer test: 752 gpm with 3' dd after 5 hrs.		
	Temp.		

S. F. No. 7469—OS—12-65.

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

WATER WELL REPORT

ECOLOGY Original & 1st copy - Ecology, 2nd copy - owner, 3rd copy - driller

CURRENT Notice of Intent No. A 19677

Unique Ecology Well ID Tag No. ______

Water Right Permit No. ______

Construction/Decommission *("x" in circle)*
- ○ Construction
- ⊗ Decommission *ORIGINAL CONSTRUCTION Notice of Intent Number* N/A

154823

Property Owner Name Don Marchbanks

Well Street Address E Foster well

City Pasco County: Franklin

Location SE 1/4- 1/4 SE 1/4 Sec 02 Twn 09 R 30 EWM or WWM *circle one*

Lat/Long: (s,t,r still REQUIRED) Lat Deg ______ Lat Min/Sec ______ Long Deg ______ Long Min/Sec ______

Tax Parcel No. ______

PROPOSED USE: ☐ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other ______

TYPE OF WORK: Owner's number of well (if more than one) ______
☐ New Well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven
☐ Deepened ☐ Cable ☐ Rotary ☐ Jetted

DIMENSIONS: Diameter of well ______ inches, drilled ______ ft.
Depth of completed well ______ ft.

CONSTRUCTION DETAILS
Casing Installed: ☐ Welded ______" Diam. from ______ ft. to ______ ft.
☐ Liner installed ______" Diam. from ______ ft. to ______ ft.
☐ Threaded ______" Diam. from ______ ft. to ______ ft.

Perforations: ☐ Yes ☐ No
Type of perforator used ______
SIZE of perfs ______ in. by ______ in. and no. of perfs ______ from ______ ft. to ______ ft.

Screens: ☐ Yes ☐ No ☐ K-Pac Location ______
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ______ Slot Size ______ from ______ ft. to ______ ft.
Diam. ______ Slot Size ______ from ______ ft. to ______ ft.

Gravel/Filter packed: ☐ Yes ☐ No ☐ Size of gravel/sand ______
Materials placed from ______ ft. to ______ ft.

Surface Seal: ☐ Yes ☐ No To what depth? ______ ft
Materials used in seal ______
Did any strata contain unusable water? ☐ Yes ☐ No
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level ______ ft. below top of well Date ______
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (cap,valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level.
Was a pump test made? ☐ Yes ☐ No If yes, by whom? ______
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
Recovery data (time taken as zero when pump turned off)(water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest ______ gal./min. with stem set at ______ ft. for ______ hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? ☐ Yes ☐ No

CONSTRUCTION OR DECOMMISSION PROCEDURE
Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. Indicate all water encountered. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Well perforated		
from 114 To -4		
Filled with 3/8 Pure Gold		
Bentonite		

RECEIVED
MAR 24 2004
DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

Start Date 11-18-03 Completed Date 11-18-03

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) [signature]
Driller/Engineer/Trainee Signature [signature]
Driller or Trainee License No. ______

If trainee, licensed driller's Signature and License no. ______

Drilling Company Nelson Drilling
Address 250 W Court
City, State, Zip Pasco 99301
Contractor's Registration No. 194CQ Date 12-19-03

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

WATER WELL REPORT

ECOLOGY Original & 1st copy - Ecology, 2nd copy - owner, 3rd copy - driller

154817

Construction/Decommission *("x" in circle)*
☒ Construction
○ Decommission *ORIGINAL CONSTRUCTION Notice of Intent Number* ________

CURRENT Notice of Intent No. W 168823
Unique Ecology Well ID Tag No. AEW909
Water Right Permit No. A10267 P9823
Property Owner Name Don Marchbanks
Well Street Address E Foster Wells Rd
City Pasco County: Franklin
Location SE 1/4- 1/4 SE 1/4 Sec. 2 Twn 9 R 30 (EWM circle one or WWM)
Lat/Long: (s,t,r still REQUIRED) Lat Deg ____ Lat Min/Sec ____ Long Deg ____ Long Min/Sec ____
Tax Parcel No. ____

PROPOSED USE: ☐ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☒ Irrigation ☐ Test Well ☐ Other ____

TYPE OF WORK: Owner's number of well (if more than one) ____
☒ New Well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven
☐ Deepened ☒ Cable ☐ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 10 inches, drilled 128.6 ft.
Depth of completed well 128.6 ft.

CONSTRUCTION DETAILS Total Length 121
Casing Installed: ☒ Welded 6" Diam. from +5 10 ft. to 119 ft.
☐ Liner installed ____" Diam. from ____ ft. to ____ ft.
☐ Threaded ____" Diam. from ____ ft. to ____ ft.

Perforations: ☐ Yes ☒ No
Type of perforator used ____
SIZE of perfs ____ in. by ____ in. and no. of perfs ____ from ____ ft. to ____ ft.

Screens: ☒ Yes ☐ No ☐ K-Pac Location 114
Manufacturer's Name Alloy Machine Works
Type Stainless Model No. ____
Diam. 10T Slot Size 125 from 115 ft. to 125 ft.
Diam. ____ Slot Size ____ from ____ ft. to ____ ft.

Gravel/Filter packed: ☐ Yes ☒ No ☐ Size of gravel/sand ____
Materials placed from ____ ft. to ____ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 20 ft
Materials used in seal Bentonite
Did any strata contain unusable water? ☐ Yes ☐ No
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

PUMP: Manufacturer's Name ____
Type: ____ H.P. ____

WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level 84.6 ft. below top of well Date 12-17-03
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (cap,valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level.
Was a pump test made? ☐ Yes ☐ No If yes, by whom? ____
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Recovery data (time taken as zero when pump turned off)(water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ____
Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.
Airtest ____ gal./min. with stem set at ____ ft. for ____ hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? ☐ Yes ☐ No

CONSTRUCTION OR DECOMMISSION PROCEDURE
Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. Indicate all water encountered. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Sand Tan	0	10
Gravel 4" minus sand	10	13
Fine Gravel sand Black	13	29
Sand Brown Fine, silty	29	33
Sand Black coose	33	44
Clay Tan	44	53
Gravel, sand Black	53	61
Clay Tan	61	64
Sand Tan silty	64	72
Sand Black gravel	72	75
Sand Black	75	87
Gravel, sand Black	87	
Water		125
Gravel, sand silty	125	128.6

RECEIVED MAR 24 2004 DEPARTMENT OF ECOLOGY EASTERN REGIONAL OFFICE

Start Date 11-24 Completed Date 12-17-03

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) Jeremy Kudo
Driller/Engineer/Trainee Signature Jeremy Kude
Driller or Trainee License No. 2691

If trainee, licensed driller's Signature and License no. ____

Drilling Company Rude Drilling
Address 7505 W Court
City, State, Zip Pasco Wa
Contractor's Registration No. RUDEDD 1498CQ Date 12-19-03

Ecology is an Equal Opportunity Employer. ECY 050-1-20 (Rev 4/01)

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W 18928

UNIQUE WELL I.D. #

Water Right Permit No.

(1) OWNER: Name Bill Middelton Address 2141 Pasco Kahlotus Rd Pasco

(2) LOCATION OF WELL: County Franklin SW 1/4 SW 1/4 Sec. 11 T. 9 N., R. 30 E W.M.

(2a) STREET ADDRESS OF WELL (or nearest address)

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater [ ] Industrial [ ] Test Well [ ] Municipal [ ] Other

(4) TYPE OF WORK: Owner's number of well (if more than one)
[ ] Abandoned [X] New well [ ] Deepened [ ] Reconditioned
Method: [ ] Dug [ ] Cable [X] Rotary [ ] Bored [ ] Driven [ ] Jetted

(5) DIMENSIONS: Diameter of well 8 inches.
Drilled 185 6" feet. Depth of completed well 185 6" ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 8" Diam. from +16" ft. to 180 6" ft.
[X] Welded " Diam. from ft. to ft.
[ ] Liner installed " Diam. from ft. to ft.
[ ] Threaded

Perforations: Yes [ ] No [X]
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes [X] No [ ]
Manufacturer's Name Haston
Type Stainless Model No.
Diam. 8" Slot size 50 from 180' ft. to 185 6 ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes [ ] No [X] Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes [X] No [ ] To what depth? 25 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 163 6" ft. below top of well Date 6-18-94
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [ ] If yes, by whom?
Yield gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest 30 gal./min. with stem set at 180 ft. for 4 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes [ ] No [ ]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Sand Tan Silty	0	32
Sand Tan	32	58
Sand Black, gravel	58	72
Sand Black	72	75
Gravel 3" minus Sand Blk	75	135
Sand Black Fine gravel silty	135	160
Sand Black Gravel silty Water @ 163 6"	160	173
Gravel 3" minus Sand Black Water Bearing	173	185
Ringold	185	

Work Started 6-16 19 Completed 6-18 1994

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Nelson Well Drilling Inc (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 8200 W Argent Pasco
(Signed) [signature] (WELL DRILLER) License No. 361
Contractor's Registration No. NELSOWD199CO Date 6-18 1994

(USE ADDITIONAL SHEETS IF NECESSARY)

ECL 050-1-20 (2/93)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. 6324312
Permit No. 6324312P

(1) OWNER: Name William Middleton Address 1924 Irving Pasco WN 99301

(2) LOCATION OF WELL: County Franklin Centr ¼ NE ¼ Sec 14 T 9 N., R 30E W.M.
Bearing and distance from section or subdivision corner 1320'S - 1320'W of NE Cor

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☒ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Cable ☒ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 182 ft. Depth of completed well 182 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 16" Diam. from +1 ft. to 135-6 ft.
Threaded ☐ ____" Diam. from ____ ft. to ____ ft.
Welded ☒ ____" Diam. from ____ ft. to ____ ft.

Perforations: Yes ☐ No ☒
Type of perforator used ____
SIZE of perforations ____ in. by ____ in.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type Stainless Model No. ____
Diam. 16 Slot size .150 from 136 ft. to 146 ft.
Diam. 16 Slot size .150 from 166 ft. to 176 ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ____
Gravel placed from ____ ft. to ____ ft.

Surface seal: Yes ☒ No ☐ To what depth? 40 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

(7) PUMP: Manufacturer's Name ____
Type: ____ H.P. ____

(8) WATER LEVELS: Land-surface elevation above mean sea level 480 (M)
Static level 107 ft. below top of well Date 1-13-78
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? Green Valley Pump
Yield: 1800 gal./min. with 9 ft. drawdown after 3 hrs.
" 1200 " 4 " 4 "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
1 min	106				
2 "	106				
	106				

Date of test 1-19-78
Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Sand, tan + black silty	0	35
Silt, tan	35	49
Sand, black - 2-3" gravel, silty	49	69
Sand, black, occ. 3" gravel	69	79
Sand, black, 3" minus gravel silty	79	118
Sand, fine tan, some 2" gravel Ringold	118	125
Sand, black - 2" minus gravel very silty	125	127-6
Silt	127-6	128-6
Sand, black, coarse, no gravel silt balls	128-6	133
Sand, black, 4" minus gravel, silty	133	136
Sand, black, 6" minus gravel silty	136	143
Sand, fine tan, 2-4" gravel Ringold	143	148
Sand, fine tan, 2-4" gravel, cemented chunks + broken basalt - 4-6"	148	153
Sand, fine tan - 3-4" gravel some cemented chunks	153	168
Sand, fine grey - 3" minus gravel clay traces - silty	168	178
Sand, fine tan + grey - cemented gravel tight H2O slow	178	182

Screen measurements
4" packer Fig. K
2' blank
10-5' screen
20' blank
10-5 - screen top 2' tight wind
5' blank pump sump
Overall 48'

Eltopia 7½ Flat
47155711190100 (E)

Work started 12-20 1977 Completed ____ 19__

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Nelson Well Drilling Inc. (Person, firm, or corporation) (Type or print)
Address 10036 W. Argent Pasco WN
[Signed] Bruce Williams (Well Driller)
License No. 0659 Date 1-13-1978

(USE ADDITIONAL SHEETS IF NECESSARY)

2/2/78

S. F. No. 7356—OS—(Rev. 4-71)
ECY-070-28

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No. G324312
Permit No. G324312P

(1) OWNER: Name William Middleton Address Star Route Box 1020C Pasco, WA 99301

LOCATION OF WELL: County FRANKlin — ¼ NE ¼ Sec. 14 T. 9 N., R. 30E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 8 inches.
Drilled 158 ft. Depth of completed well 157-6 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 8 " Diam. from +1 ft. to 147 ft.
Threaded ☐ .... " Diam. from .... ft. to .... ft.
Welded ☐ .... " Diam. from .... ft. to .... ft.

Perforations: Yes ☐ No ☒
Type of perforator used ....
SIZE of perforations .... in. by .... in.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type Stainless Model No. ....
Diam. 8 Slot size 50 from 147 ft. to 157-6 ft.
Diam. .... Slot size .... from .... ft. to .... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ....
Gravel placed from .... ft. to .... ft.

Surface seal: Yes ☒ No ☐ To what depth? 20 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? .... Depth of strata ....
Method of sealing strata off ....

(7) PUMP: Manufacturer's Name ....
Type: .... H.P. ....

(8) WATER LEVELS: Land-surface elevation above mean sea level.... 480 ft.
Static level 117 ft. below top of well Date ....
Artesian pressure .... lbs. per square inch Date ....
Artesian water is controlled by .... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom? ....
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ....
Bailer test 50 gal./min. with 2 ft. drawdown after 2 hrs.
Artesian flow .... g.p.m. Date ....
Temperature of water .... Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Silt Tan	0	38
Sand Black coarse	38	46
Sand Black Gravel 1"	46	93
Gravel 1" minus sand Black	93	117
Sand Tan Med fine Water Bearing	117	136
Gravel 6" minus sand Tan water Bearing Ringold	136	157-6

RECEIVED
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 8-31, 1978. Completed 9-2, 1978

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Nelson Well Drilling Inc (Person, firm, or corporation) (Type or print)

Address 10036 West Argent Pasco

[Signed] James Nelson (Well Driller)

License No. 361 Date 9-2, 1978

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71)
ECY-070-28

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

35028

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W44461
Unique Well I.D. #
Water Right Permit No.

(1) OWNER: Name CITY OF PASCO Address PASCO, WA

(2) LOCATION OF WELL: County FRANKLIN - 1/4 1/4 Sec 12 T 09 N., R ~~28E~~ 30E WM
(2a) STREET ADDRESS OF WELL (or nearest address) OWNERS# PW-1,

(3) PROPOSED USE: INDUSTRIAL

(4) TYPE OF WORK: Owner's Number of well (If more than one)
NEW WELL Method: ROTARY

(5) DIMENSIONS: Diameter of well 8 inches
Drilled 235 ft. Depth of completed well 233 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 8 " Dia. from +4 ft. to 227 ft.
WELDED " Dia. from ft. to ft.
" Dia. from ft. to ft.

Perforations: NO
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: YES
Manufacturer's Name JOHNSON
Type STAINLESS STEEL Model No.
Diam. 8 slot size 20 from 227 ft. to 233 ft.
Diam. slot size from ft. to ft.

Gravel packed: NO Size of gravel
Gravel placed from ft. to ft.

Surface seal: YES To what depth? 20 ft.
Material used in seal CEMENT
Did any strata contain unusable water? NO
Type of water? Depth of strata ft.
Method of sealing strata off OVERBORE

(7) PUMP: Manufacturer's Name
Type H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ... ft.
Static level 175 ft. below top of well Date 01/16/95
Artesian Pressure lbs. per square inch Date
Artesian water controlled by

(9) WELL TESTS: Drawdown is amount water level is lowered below static level.
Was a pump test made? NO If yes, by whom?
Yield: gal./min with ft. drawdown after hrs.

Recovery data
Time Water Level Time Water Level Time Water Level

Date of test / /
Bailer test gal/min. ft. drawdown after hrs.
Air test 45+ gal/min. w/ stem set at 232 ft. for 2 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? NO

(10) WELL LOG

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change in formation.

MATERIAL	FROM	TO
FINE MEDIUM SAND	0	150
SMALL GRAVEL	150	160
FINE SAND	160	167
SILT	167	170
SAND SMALL GRAVEL	170	178
GRAVEL FINE SAND	178	189
SAND GRAVEL WITH WATER	189	233
	233	

RECEIVED
APR 5 1995
DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

Work started 01/12/95 Completed 01/16/95

WELL CONSTRUCTOR CERTIFICATION:
I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME PONDEROSA DRILLING
(Person, firm, or corporation) (Type or print)

ADDRESS E 6010 BROADWAY

[SIGNED] License No. 2004

Contractor's
Registration No. PO-ND-EI*240JE Date 03/27/95

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

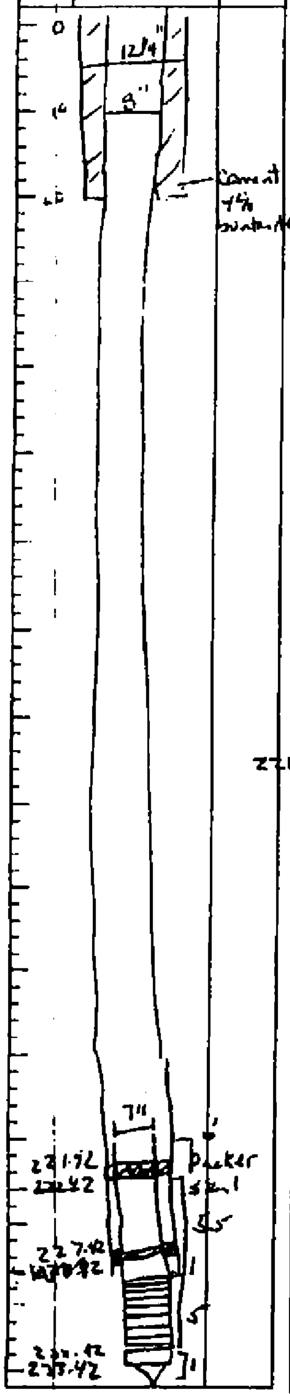
~~MONITORING WELL~~ CONSTRUCTION SUMMARY
Production Well

Project Name: Waste water Treatment - City of Pasco
Project No.:

Well No.: PW-1
Boring No.: —
Start Card No.: W-044461

Horizontal Coords: T 9N, R30E, Sect 4
Ground Surface Elevation:
Top of PVC Well Casing:

DEPTH	WELL DETAIL	GENERAL LITH.



DRILLING SUMMARY

Total Borehole Depth:	233.42'
Borehole Diameter:	
Drilling Contractor:	Ponderosa
Driller(s):	Roger Kelly
Rig(s):	Rush T625 Rotary/Circulating Med = Air
Bit(s):	12 1/2" Tricone; 7 7/8" Tricone Roller

TIME LOG

Task	Start Date	Start Time	Finish Date	Finish Time
Drilling Method: Air Rotary - Casing Drive	1-12-95	0807	1-13-95	1420
12" Surface Casing	1-12-95	0847	1-12-95	0915
Geophys. Logging	—		—	
Casing 8" steel Casing	1-12-95	0897	1-13-95	1420
Sand Pack None	—		—	
Grout Surface Seal	1-17-95	1355	1-17-95	
Bentonite Seal Rubber				
Development (Start)	1-16-95	1543	1-16-95	1709
~~Development (Finish)~~				

WELL INSTALLATION

Well Design and Specifications Basis:
Geologic Log: ✓ Geophysical Log: ___
Casing Material: 8" steel casing welded every 20'
Casing(s): B=blank; S=screen; EC=end cap

Depth (ft)	Casing	Elevation[1] (ft)
0 - 227.42	B	-
221.42 - 222.42	Rubber Seal	-
222.42 - 227.42	SB	-
227.42 - 232.42	S	-
233.42 - 232.42	EC	-

Screen Type/Size:	4" - 5' long Johnson Stainless Steel #20 slot
Surface Seal (ft):	0 to 20 Cement 4% bentonite
Mfr/Mtrl/Qty:	Cement, bentonite
Grout Seal (ft):	None
Mfr/Mtrl/Qty:	
Bentonite Seal (ft):	221.42 - 222.42
Mfr/Mtrl/Qty:	Rubber Packer Seal 8"
Sand Pack (ft):	None
Mfr/Mtrl/Qty:	
Bottom Seal (ft):	None
Mfr/Mtrl/Qty:	

WELL DEVELOPMENT

Method: Air Lift Evacuate Drop - Surge
Total Volume Purged: 3480 gal
Starting Level: 174.5 bgs
Finishing Level: 175.78 bgs

Stabilization Test Data

Date	Time	Volume	pH	Cond Spec	Temp (°C)	
1-16-95	1543	5	7.39	2.46 mS	17.1	v. turbid sediment
	1551	60	8.26	2.65 mS	15.5	MT
	1555	180	8.07	2.83 mS	15.4	ST
	1600	225	8.33	2.73 mS	16.4	ST
	1607	315	8.10	2.75	16.4	MT
	1618	495	8.11	2.60	15.8	clear some sand
	1624	270	8.44	2.70	16.5	"
	1634	450	8.28	2.70	16.4	"
	1645	495	8.21	2.69	16.5	"
	1701	720	8.23	2.70	16.5	"

Comments: [1]Tennison Coordinate System. [2]Oregon State Coordinate System
measured flow through pipe to 5g bucket 10sec + 9sec = 30 g/min
loosing 10-20 other places 40-50 gpm

See Wellhead Detail for surface construction information.

RUST ENVIRONMENT & INFRASTRUCTURE

Date: 1/12 - 1/17

Checked by:

Date:

Generated by:

cad/forms/wellsum2.for

DEPARTMENT ... EASTERN

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

3374
3860
3861

Application No. ....
Permit No. 63-23386

(1) OWNER: Name KENNETH PIEKARSKI Address STAR ROUTE, MESA, WASH

(2) LOCATION OF WELL: County FRANKLIN SE SE¼ SE ¼ Sec 35 T 10 N., R 30 W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☑ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)....
New well ☑ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 131 ft. Depth of completed well 130 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 16 " Diam. from 0 ft. to 112 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☑ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☑
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☑ No ☐
Manufacturer's Name JOHNSON
Type TELES Model No. 304
Diam. 16 Slot size 025 from 111 ft. to ft.
Diam. Slot size 075 from ft. to 130 ft.

Gravel packed: Yes ☐ No ☑ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☑ No ☐ To what depth? 30 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes ☐ No ☑
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level 518 ft.
Static level 93.6 ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water 63 Was a chemical analysis made? Yes ☐ No ☑

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Soil	2	2
Clayish Soil	35	37
Comp Blk S & Sed	6	43
Brn S & Cl	5	48
Clayish Soil	12	60
Sandy Silty TR F Gr	5	65
Compact Rocks & S	3	68
" Gr & S	10	78
S, 3/4 minus Gr	10	88
Compact F Gr & S	4	92
C S & F Gr	2	94
F Gr	4	98
Silty S & Sed	2	100
Sand & Gr	21	121
C Gr	5	126
Comp Gr	2	128
Coarse "	3	131
Clay		

1/4 300
1/4 1/4 30 1/4

RECEIVED
FEB 05 1975
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 1/21 1975 Completed 2/3 1975

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME CASCADE DRILLING CO (Person, firm, or corporation) (Type or print)

Address P.O. DRAWER E, KENN

[Signed] (Well Driller)

License No. 0466 Date 2/3 1975

(USE ADDITIONAL SHEETS IF NECESSARY)

2/5/75

S. F. No. 7356—OS—(Rev. 4-71).

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No. ______

Permit No. G3-2386

(1) OWNER: Name KENNETH PIEKARSKI Address STAR ROUTE, BOX 205, MESA

(2) LOCATION OF WELL: County FRANKLIN SE 1/4 SE 1/4 SE 1/4 Sec 35 T 10 N., R 30 W

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☑ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☑ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ______
New well ☑ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☑ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 147 ft. Depth of completed well 126 1/2 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from 0 ft. to 122 ft.
Threaded ☐ ______" Diam. from ______ ft. to ______ ft.
Welded ☑ ______" Diam. from ______ ft. to ______ ft.

Perforations: Yes ☐ No ☑
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☑ No ☐
Manufacturer's Name JOHNSON
Type TELESCOPE Model No. 304
Diam. 5 Slot size 040 from 126 1/2 ft. to 122 ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes ☐ No ☑ Size of gravel: ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes ☑ No ☐ To what depth? 40 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes ☐ No ☑
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level 518 ft.
Static level 93'-4 ft. below top of well Date 2/3/75
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☑ No ☐ If yes, by whom? CDC
Yield: gal./min. with ft. drawdown after hrs.
" 18 " 8 INCHES " 1 1/2 "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test 2/3/75
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water 63 Was a chemical analysis made? Yes ☐ No ☑

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
SOIL	1 1/2	1 1/2
CLAYISH SOIL	35 1/2	37
COMPACT BLK S. + SED	6	43
BROWNISH S&CL	5	48
CLAYISH SOIL	12	60
SANDY + SILTY TR. F GR	5	65
COMPACT GR + S	12	77
F GR + S	10	87
COMPACT F GR + S	8	95
SILTY S & SED	2	97
" " TR F GR & SED	4	101
BLK S & F GR	7	108
F GR + S	5	113
SAND	3	116
C S + F GR MUCH SED	3	119
" " " " "	2	121
" " " "	4	125
F GR	4	129
YELLOW CLAY (CASED)	3	132
" "	5	138
SILTY S	4	142
CEM. GR + S	4	146
BAS. (??)	1	147

RECEIVED
FEB 05 1975
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

230
160
320

Work started Jan 9, 1975. Completed 2/3, 1975

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME CASCADE DRILLING CO.
(Person, firm, or corporation) (Type or print)

Address P.O. DRAWER E, KENN.

[Signed] [signature]
(Well Driller)

License No. 0466 Date 2/3, 1975

2/5/75 CR

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

Third Copy — Driller's Copy

STATE OF WASHINGTON

Permit No. G3-2336

B - B' Soil Profile, Well #131

(1) OWNER: Name KENNETH PIEKARSKI Address STAR ROUTE BOX 205 MESA WN.

(2) LOCATION OF WELL: County FRANKLIN R 30 E.W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☑ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)....
New well ☐ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☑ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 136 ft. Depth of completed well 122-6 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 16" Diam. from 0 ft. to 105-6 ft.
Threaded ☐ ......" Diam. from ...... ft. to ...... ft.
Welded ☑ ......" Diam. from ...... ft. to ...... ft.

Perforations: Yes ☐ No ☑
Type of perforator used
SIZE of perforations ...... in. by ...... in.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.

Screens: Yes ☑ No ☐
Manufacturer's Name JOHNSON
Type 304 STAINLESS Model No. TELES
TELESCOPE Diam. 16 Slot size 070 from 104½ ft. to 117 ft.
Diam. ...... Slot size 100 from 117 ft. to 122½ ft.

Gravel packed: Yes ☐ No ☑ Size of gravel:
Gravel placed from ...... ft. to ...... ft.

Surface seal: Yes ☑ No ☐ To what depth? 30 ft.
Material used in seal
Did any strata contain unusable water? Yes ☐ No ☑
Type of water? ...... Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: ...... H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level.... 520 ft.
Static level 94 ft. below top of well Date 3/3/75
Artesian pressure ...... lbs. per square inch Date
Artesian water is controlled by ...... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: ...... gal./min. with ...... ft. drawdown after ...... hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test ...... gal./min. with ...... ft. drawdown after ...... hrs.
Artesian flow ...... g.p.m. Date
Temperature of water 63 Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
GRAYISH SOIL	0	34
SILTY BLACK S.	10	46
GRAYISH SOIL	10	56
SILTY S.	2	58
GRAYISH SOIL	10	68
F.GR. + S	9	77
F.S.	3	80
F.GR., C.S.	17	97
F.GR. S.	2	99
S. SOME F.GR.	3	102
C.S. & F.GR.	8	110
" " SOME F.GR.	4	114
" " TRACE " "	4	118
" " SOME " "	3	121
F.GR., C.S.	2	123
YELLOW CLAY	13	136

9 pm
3 AF/4 1
23 Acres
16
2300
1720
3

RECEIVED
APR 25 1975
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 2/14, 1975. Completed 3/3, 1975

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME GESCHAPE DRILLING Co. (Person, firm, or corporation) (Type or print)

Address P.O. DRAWER E, KENNEWICK

[Signed] ...... (Well Driller)

License No. 0466 Date 3/4, 1975

4/25/75

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

A[redacted]on No. ....
Permit No. ....

(1) OWNER: Name RAY VOSS Address RT. 1 PASCO, WASH.

(2) LOCATION OF WELL: County FRANKLIN — ¼ SW ¼ Sec 35 T. 10 N., R. 32 W.M.

Bearing and distance from section or subdivision corner Eltopia

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☐ Test ~~Well~~ HOLE ☒ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☐ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 152½ ft. Depth of completed well 0 ft.

(6) CONSTRUCTION DETAILS: PULLED
Casing installed: ....." Diam. from ..... ft. to ..... ft.
Threaded ☐ ....." Diam. from ..... ft. to ..... ft.
Welded ☐ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☐ No ☐
Type of perforator used .....
SIZE of perforations ..... in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☐ No ☐
Manufacturer's Name .....
Type ..... Model No. .....
Diam. ..... Slot size ..... from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☐ Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☐ No ☐ To what depth? ..... ft.
Material used in seal .....
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? ..... Depth of strata .....
Method of sealing strata off .....

(7) PUMP: Manufacturer's Name .....
Type: ..... H.P. .....

(8) WATER LEVELS: Land-surface elevation above mean sea level .... 520 ft.
Static level ..... ft. below top of well Date .....
Artesian pressure ..... lbs. per square inch Date .....
Artesian water is controlled by ..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? .....
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test .....
Bailer test ..... gal./min. with ..... ft. drawdown after ..... hrs.
Artesian flow ..... g.p.m. Date .....
Temperature of water 63 Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG: B - B' Soil Profile, Well #130

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
SANDY SOIL	0	29
COMPACT GR	3	32
CLAYISH SOIL	19	57
BLK. S. & SED	1	58
CLAYISH SANDY SOIL	4	62
COMPACT F. S TR. F. GR	10	72
" SAND F. GR & SED.	3	75
LOOSE C. BLK S.	6	81
SANDY CLAY	13	94
C. BLK. S.	2	96
CLAY	5	101
SANDY CLAY	14	115
BLK S & SED.	2	117
SILTY SAND	2	119
C. S & F. GR.	3	122
" " " " TIGHT	2	124
" " " "	1	125
CLAY	12	137
CLAYISH SILTY S.	8	145
SILTY S., TR. F. GR	1	146
F. GR. & S	3½	149½
GREY F. GR. & S	1½	151
" GREEN COMPACT GR — S	½	151½
BASALT	1	152½

Eltopia

RECEIVED
APR 25 1975
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 2/5, 1975. Completed 2/11, 1975.

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME CASCADE DRILLING CO. (Person, firm, or corporation) (Type or print)

Address P.O. DRAWER E, KENN.

[Signed] [signature] (Well Driller)

License No. 0466 Date 2/10, 1975

4/26/75

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. [redacted]

Water Right Permit No. ______

(1) OWNER: Name Bruce & Lori Stiggy Address 3321 East Foster Wells Rd Pasco

LOCATION OF WELL: County Franklin SE ¼ SW ¼ Sec 2 T. 9 N., R. 30 W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) ______

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater Industrial [ ] Test Well [ ] Municipal [ ] Other [ ]

(4) TYPE OF WORK: Owner's number of well (if more than one) ______

Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ]
Method: Dug [ ] Cable [ ] Rotary [X] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 158 feet. Depth of completed well 158 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Diam. from +2 ft. to 158 ft.
Welded [ ] ______ " Diam. from ______ ft. to ______ ft.
Liner installed [ ]
Threaded [ ] ______ " Diam. from ______ ft. to ______ ft.

Perforations: Yes [ ] No [X]
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes [ ] No [X]
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ______ Slot size ______ from ______ ft. to ______ ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes [ ] No [X] Size of gravel ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes [X] No [ ] To what depth? 25 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 123 ft. below top of well Date 6-4
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [ ] If yes, by whom? ______
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest 90+ gal./min. with stem set at 150 ft. for 4 hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? Yes [ ] No [ ]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
SAnd TAN Silty	0	47
SAnd Black Trace gravel 1"	47	55
Sand TAN silty	55	59
Sand Black fine	59	65
Sand TAN	65	69
Gravel 4" minus sand Black	69	97
Sand Black course	97	105
Silt TAN	105	107
Gravel 4" mins sand Blk Water at 123 feet	107	126
Sand Black Water Bearing	126	133
Gravel 4" mins sand Blk Water Bearing	133	158

RECEIVED [redacted] 23 1993 DEPARTMENT OF ECOLOGY EASTERN REGIONAL OFFICE

Work started 6-3, 19__ Completed 6-4, 1993

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Nelson Well Drilling Inc (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 10036 W Airport Pasco
(Signed) [signature] (WELL DRILLER) License No. 361
Contractor's Registration No. NELSOWD198CQ Date 6-4, 1993

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10/87) -1329- 3

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. 54907

Water Right Permit No. G3-28829 P

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

(1) OWNER: Name H&G SOD Co, Inc. Address 2951 E. Foster Wells Pasco, WA. 99301

(2) LOCATION OF WELL: County FRANKLIN SE 1/4 SE 1/4 SW 1/4 Sec. 2 T. 9 N., R. 30 W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address)

(3) PROPOSED USE: ☑ Domestic ☑ Irrigation ☐ DeWater Industrial ☑ Test Well ☐ Municipal ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)
Abandoned ☐ New well ☑ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Cable ☐ Rotary ☑ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 8 inches.
Drilled 157'6" feet. Depth of completed well 157'6" ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 8 " Diam. from +1 ft. to 152-8 ft.
Welded ☑ Liner installed ☐ Threaded ☐ " Diam. from ft. to ft.
" Diam. from ft. to ft.

Perforations: Yes ☐ No ☑
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☑ No ☐
Manufacturer's Name Huston
Type STAINLESS Model No.
Diam. 8T Slot size 40 from 153-6 ft. to 157-6 ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☑ Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes ☑ No ☐ To what depth? 25 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 122 ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest 100 gal./min. with stem set at 140 ft. for 2 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
SAND TAN Silty	0	25
SAND BLACK	25	29
SAND BLACK Silty	29	35
SAND TAN Silty	35	57
SAND BLACK GRAVEL	57	78
GRAVEL 4" MINUS SAND	78	
BLACK WATER @ 122 Ft.		157-6

2 A

Work started 9/30 19 Completed 10/2 1991

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME NELSON WELL DRILLING INC. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 10036 W. ARGENT PASCO
(Signed) James Nelson (WELL DRILLER) License No. 361
Contractor's Registration No. NELSOWD 198 CQ Date 10-2 1991

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10/87) -1329-

NAME F. Guy Sullivan
ADDRESS
DATE DRILLED: March 16 - April 8 1971

[illegible] ¼ SECTION [illegible] T. [illegible] R. [illegible]
TYPE OF WORK: New [illegible] USE: [illegible]

CASING: DIAMETER: 12 INCH WEIGHT: .375 WALL DRIVE SHOE Stanley
TOTAL CASING: 129'-6" CASED BELOW SURFACE 127'-0"
TOTAL WELL DEPTH: 146'-6" Ground Surface OPEN END: SIZE:
ALL CASING JOINTS DOUBLE TAPERED AND TRIPLE WELDED.

Elev 500

SCREEN: 10 FT 304 Stainless - 10 in. Pipe Size SURFACE SEAL: 3 sacks Bentonite + Grout
TEST: STATIC WATER LEVEL 106'-7" Ground Level BAILER TEST PUMP TEST
YIELD: GAL./MIN. WITH FT. DRAWDOWN AFTER HRS.
YIELD: GAL./MIN. WITH FT. DRAWDOWN AFTER HRS.
TEMPERATURE: 54 Degrees WELL CHLORINATED: Yes

PUMP SETTING: Do not set any part of any pump installation deeper than 130 ft from present top of casing. This setting will keep pump suction just above the top of the stainless screen + 2 ft into 10" riser

MATERIAL	S.W.L.	THICKNESS	DEPTH	CASING	
Soil		5	5		
Soil + Some Sand		10	15	Do not set	
Coarse Sand Trace F. Gr.		10	25	Any Below	
Silty Sand		10	35	Below 130'	
Fine Black Sand		5	40		
Silty Black Sand		10	50		
Brown Silty Sand		27	77		
Black Sand + Silt		16	93		
Black Sand & F. Gr.		4	97		
Loose F. Gr. + S.		2	99		
Compact F. Gr + Sand		7	106		
Mostly Sandy Clay, Tr. F. Gr		13	119		
" Sand, F. Gr + Clay		4	123		
Compact Sand + F. Gr.		4	127		
Gravel + Sand (60-40%)	111	2½	129½	water	
Gravel + More Sand		1	130½	"	
Gravel + Sand (55-45%)	107	2	132½	"	
Loose F. Gr. + S. (75-25%)		4	136½	"	
Loose F. Gr. + S. (50-50%)		2	138	"	
Compact Sand + F. Gr. (Clayish)		3	141	Poor water	
Compact Grey Sand Gravel		3	144	No	"
Compact Yellow S + F. Gr.		1½	145½	"	"
Cemented F. Gr. + S.		5½	151	"	"
Basalt		1	152	"	"

Casing was pulled back to 146'-6" + screen set.

Screen is Johnson 304 Stainless Steel .060 slot
Screen has Fig. K packer welded to a 10" pipe riser. Riser + packer 2'-9" long + screen 10'-5½" long; 10 inch pipe bottom on screen 5'-6" long
Total screen length 21'-0". Stainless screen [illegible] between 131½ ft. to 145½ ft. - [illegible]

Developing time was 14 hours on screen
Developed until 10 min. surge yielded ½ gal. sand

ABBREVIATIONS USED	
GR.—GRAVEL	BAS.—BASALT
S.—SAND	
CL.—CLAY	
FR.—FRACTURED	
MED.—MEDIUM	
C.—COARSE	
DEC.—DECOMPOSED	

RECOVERY TIME	WATER LEVEL

THIS WELL WAS DRILLED BY:
[illegible] Drilling Co.
[illegible]

(Signed) [signature]
Driller

DATE April 8 1971

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report

The Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. TEST WEL G3 22491
Permit No. XXXXXXXXXXX

(1) OWNER: Name ROBERT TIPPETT Address 3400 W. CLEARWATER, KENNEWICK, WN. 99336

(2) LOCATION OF WELL: County FRANKLIN 1300ft.N. & 1300ft.W. from center 2 ¼ ¼ Sec. T.9 N., R.30E W.M.
Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation XX Test Well ☒ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) #3
New well XX Method: Dug ☐ Bored ☐
Deepened ☐ Cable XX Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 159 ft. Depth of completed well 159 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 16 " Diam. from 0 ft. to 158.6 ft.
Threaded ☐ ....." Diam. from ..... ft. to ..... ft.
Welded ☐ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes XX No ☐
Type of perforator used .....
SIZE of perforations ..... in. by ..... in.
..... perforations from 145 ft. to 157 ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☐ No XX
Manufacturer's Name .....
Type ..... Model No. .....
Diam. ..... Slot size ..... from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No XX Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes XX No ☐ To what depth? 20 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? ..... Depth of strata .....
Method of sealing strata off .....

(7) PUMP: Manufacturer's Name did not enstall
Type: ..... H.P. .....

(8) WATER LEVELS: Land-surface elevation above mean sea level 502 ft.
Static level 95 ft. below top of well Date 9-11-74
Artesian pressure ..... lbs. per square inch Date .....
Artesian water is controlled by ..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes XX No ☐ If yes, by whom? Green Valley
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" did do not give us a report " "
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test .....
Bailer test ..... gal./min. with ..... ft. drawdown after ..... hrs.
Artesian flow ..... g.p.m. Date .....
Temperature of water ..... Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:
Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Fine sand	0	20
Fine sand	20	30
Fine sand	30	50
Course sand	50	62
Small course gravel	62	75
Course sand and gravel	75	85
Course sand	85	95
Course gravel and sand	95	105
Course gravel and sand	105	118
Silt and sand	118	130
Silt and sand	130	145
Course gravel and sand	145	157
Water came in	145	
Basalt	157	
16 inch Lakewood Drive shoe		

2160 gpm
1900 ac.ft.
1240 ac.

RECEIVED
DEC 6 1974
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 8-8, 19 74 Completed 10-10, 19 74

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME GOLDEN AUTUMN CONST. CO., INC. 0554
(Person, firm, or corporation) (Type or print)
Address P.O. BOX 811, PASCO, WN. 99301

[Signed] Ed Goertz
(Well Driller)

License No. 0158 Date 10-10, 19 74

12/08/74

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. 15061
Permit No. TEST WELL

(1) OWNER: Name ROBERT TIPPET Address 3400 W. CLEARWATER, KENNEWICK, WN. 99336

(2) LOCATION OF WELL: County FRANKLIN — SE ¼ NW ¼ Sec 2 T. 9N N., R. 30E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well XXXX Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) 4
New well XXX Method: Dug ☐ Bored ☐
Deepened ☐ Cable XXX Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 140 ft. Depth of completed well 140 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 140 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded XXX " Diam. from ft. to ft.

Perforations: Yes XXX No ☐
Type of perforator used MILLS
SIZE of perforations ¼ in. by 1 in.
perforations from 102 ft. to 108 ft.
x perforations from x ft. to x ft.
x perforations from x ft. to x ft.

Screens: Yes ☐ No XXX
Manufacturer's Name
Type XXXXXXXXXXXXXXXXXXXXXXXXX Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No XXX Size of gravel:
Gravel placed from XXXXXXXXXXXXXXXXXX ft. to ft.

Surface seal: Yes XXX No ☐ To what depth? 18 ft.
Material used in seal
Did any strata contain unusable water? Yes ☐ No XX
Type of water? XX Depth of strata XXXX
Method of sealing strata off XXXX

(7) PUMP: Manufacturer's Name XXX
Type: XXXX H.P. XXX

(8) WATER LEVELS: Land-surface elevation above mean sea level.... XX 520 ft.
Static level XXX 68 ft. below top of well Date 6/21/75
Artesian pressure XXXX lbs. per square inch Date XXX
Artesian water is controlled by XXXX (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No XX If yes, by whom? XXX
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" XXXXXXXXXXXXXXXXXXXXXXXXX "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
	XXXXXXXXXXXXXXX				

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water XXXXXXXXXXXXXXXXXXXXXXXXXXXX Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
~~Top soil~~ Surface Seal	0	18
Top soil	0	42
Black gravel and course sand	42	105
Black gravel and course sand	105	140
6 inch drive shoe (Blue Crown)		
Perforated by Mills perforator from 102 ft. to 108 ft.		

Copied

Work started Jan. 24 1975 Completed JUNE 2 ~~May 27~~ 1975

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME GOLDEN AUTUMN CONST. CO., INC. (Person, firm, or corporation) (Type or print)

Address P.O. BOX 811, PASCO, WN. 99301

[Signed] David L. Whitehead (Well Driller)

License No. 0554 Date July 7, 1975

11/20/75

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71)
ECY-070-28

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

4533 [redacted]

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. [redacted]

Water Right Permit No. B

(1) OWNER: Name ED TOMS Address ~~[illegible]~~ Rt 3 BOX 3344 Ken 99336

(2) LOCATION OF WELL: County ~~Benton~~ Franklin — ~~[illegible]~~ Sec ~~[illegible]~~ T. ~~[illegible]~~ N., R. ~~[illegible]~~ W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) Tierry NW, NE, 12, 9, 30

(3) PROPOSED USE: ☒ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)

Abandoned ☐ New well ☒ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☐ Rotary ☒ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 265 feet. Depth of completed well 260 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from +1 ft. to 79 ft.
Welded ☒ ___ " Diam. from ___ ft. to ___ ft.
Liner installed ☐
Threaded ☐ ___ " Diam. from ___ ft. to ___ ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations ___ in. by ___ in.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.

Screens: Yes ☐ No ☒
Manufacturer's Name
Type ___ Model No.
Diam. ___ Slot size ___ from ___ ft. to ___ ft.
Diam. ___ Slot size ___ from ___ ft. to ___ ft.

Gravel packed: Yes ☐ No ☒ Size of gravel
Gravel placed from ___ ft. to ___ ft.

Surface seal: Yes ☒ No ☐ To what depth? 20 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? ___ Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: ___ H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ___ ft.
Static level 89 ft. below top of well Date
Artesian pressure ___ lbs. per square inch Date
Artesian water is controlled by ___ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: ___ gal./min. with ___ ft. drawdown after ___ hrs.
" " "
" " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test

Bailer test ___ gal./min. with ___ ft. drawdown after ___ hrs.
Airtest 16 gal./min. with stem set at 260 ft. for 4 hrs.
Artesian flow ___ g.p.m. Date
Temperature of water ___ Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure; and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Ash	0	12
Ash + Basalt Bolders	12	16
Basalt Gravel + Blueclay	16	79
Hard Black Basalt	79	126
Brocken Black Basalt	126	142
Hard Black Basalt	142	163
Redsh Brown Brocken Basalt	163	177
Hard Black Basalt	177	193
Redsh Brocken Basalt	193	210
Hard Black Basalt	210	251
Brocken Black Basalt Bearing Water Apk 16 Gpm	251	265

RECEIVED
MAR 1 1991
DEPARTMENT OF ECOLOGY
CENTRAL REGION OFFICE

Work started ~~3/~~ 1/31/91, 19. Completed 3/~~8~~/91 19

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME ST. GEORGE Drilling CO
(PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)

Address 7015 45th Ave, W Rhld, WA 99352

(Signed) [signature] License No. 0483
(WELL DRILLER)

Contractor's Registration No. 601-048-715 Date 3/~~8~~, 1991

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10/87) -1329- 3

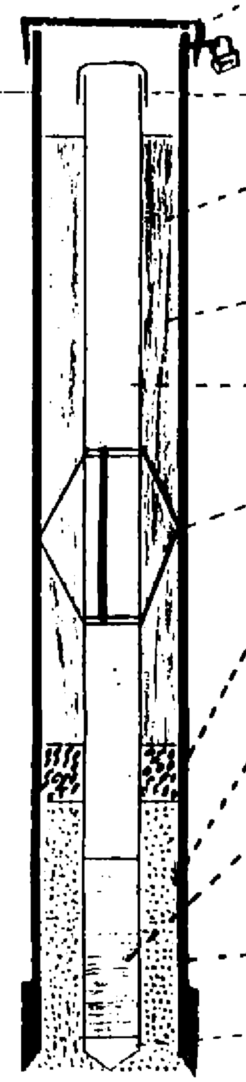
RESOURCE PROTECTION WELL REPORT

START CARD No. 30921

PROJECT NAME: Universal Frozen Foods
WELL IDENTIFICATION No. MW-4
DRILLING METHOD: Air Rotary
DRILLER: Douglas E Lane
FIRM: PONDEROSA DRILLING & DEVELOPMENT
SIGNATURE: Douglas E. Lane
CONSULTING FIRM:
REPRESENTATIVE:

COUNTY: Franklin
LOCATION: SW¼ NW ¼ Sec 1 Twn 9N R 30E
STREET ADDRESS OF WELL:

WATER LEVEL ELEVATION: 95
GROUND SURFACE ELEVATION:
INSTALLED:
DEVELOPED:

AS-BUILT	WELL DATA	FORMATION DESCRIPTION
	CAP OR VAULT: 6" x 6" x 6' steel	Brown Blow Sand (to 35)
	TYPE: 3' above surface	
	SIZE:	
	LOCK: yes	
	PVC CAP: 2" yes	
	CEMENT: Ready Mix	
	DEPTH: -3 TO +6"	
	BAGS:	
	GROUT TYPE: Cement & Bento.	Gray Black Coarse Sand & gravel (35 to 95)
	DEPTH: -3 TO 101	
	BAGS:	
	PVC TYPE: 2" Sch 80	
	PVC SIZE:	
	DEPTH: +2.5 TO 108	
	CENTRALIZERS: yes	
	PELLETS SIZE: 3/8 - 1/4	Brown Coarse sand gravel & silt w/water (95 to 115)
	DEPTH: 101 TO 105	
	BUCKETS: 1-5 gal	
	SILICA SAND: 20/40	
	DEPTH: 105 TO 120	
	BAGS:	
	SCREEN TYPE: 2" PVC 10'	
	DEPTH: 108 TO 118	
	SIZE: 10 Slot	
	CASING SIZE: 6" surface	Broken Basalt (115 to 120)
	DRIVE SHOE: pipe pulled	
	BOTTOM: Back 118	
	GUARD POSTS: 3- steel	
	MISC: Pressure grouted Bottom-up	

1 9 1991

SCALE: 1" =
PAGE ___ OF ___

ECY 050-12 (Rev. 11/89)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

RESOURCE PROTECTION WELL REPORT

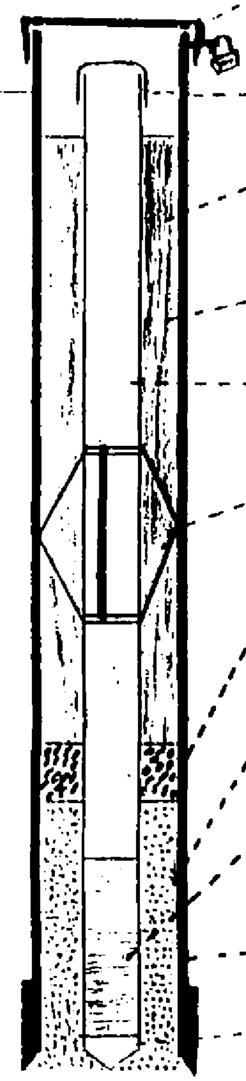
START CARD No. 30921

PROJECT NAME: Universal Frozen Foods
WELL IDENTIFICATION No. MW-5
DRILLING METHOD: Air Rotary
DRILLER: Douglas E Lane
FIRM: PONDEROSA DRILLING & DEVELOPMENT INC.
SIGNATURE: Douglas E. Lane
CONSULTING FIRM:
REPRESENTATIVE:

COUNTY: Franklin
LOCATION: SW 1/4 SW 1/4 Sec 1 Twn 9N R 30E
STREET ADDRESS OF WELL:

WATER LEVEL ELEVATION: 94
GROUND SURFACE ELEVATION:
INSTALLED:
DEVELOPED:

AS-BUILT



HOLE PLUG
122-135

WELL DATA

6"x6"x6' Steel

CAP OR VAULT			
TYPE:			3'above surface
SIZE:			
LOCK:			yes
PVC CAP:			2" yes
CEMENT:			Ready Mix
DEPTH:	-3	TO	+6"
BAGS:			
GROUT TYPE:			Cement & Bento.
DEPTH:	-3	TO	104
BAGS:			
PVC TYPE:			2" Sch 80
PVC SIZE:			
DEPTH:	+2.5	TO	110
CENTRALIZERS:			yes
PELLETS SIZE:			3/8 - 1/4
DEPTH:	104	TO	108
BUCKETS:			1-5 gal
SILICA SAND:			20/40
DEPTH:	108	TO	122
BAGS:			
SCREEN TYPE:			2" PVC -10'
DEPTH:	110	TO	120
SIZE:			10 Slot
CASING SIZE:			6" Surface
DRIVE SHOE:			Pipe pulled
BOTTOM:			Back 135
GUARD POSTS:			3- steel
MISC:			Pressure grouted Bottom - up

FORMATION DESCRIPTION

Brown gray blow sand

15

Brown gray sand & gravel

90

Black gray sand & gravel w/ water

110

Brown gray sand & gravel w/silt

135

9

SCALE: 1" =

PAGE ____ OF ____

ECY 050-12 (Rev. 11/89)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

Site Monitoring Wells

MONITORING WELL CONSTRUCTION SUMMARY

oject Name: City of Pasco Wastewater Treatment Facility
oject No.: 89534

Well No.: MW-01a
Boring No.: MW-01a
Start Card No.:

Horizontal Coords:
Ground Surface Elevation:
Top of PVC Well Casing:

DRILLING SUMMARY
Total Borehole Depth: 116 ft. bgs
Borehole Diameter: 8.6 in.
Drilling Contractor: Ponderosa Drilling -
Spokane, WA
Driller(s): Roger Kelly
Rig(s): Reichdrill T625
Rotary (Air)/Casing drive
Bit(s): 7-7/8 in. Tricone roller bit

TIME LOG	Start		Finish	
Task	Date	Time	Date	Time
Drilling Method:				
Air Rotary	3/3/95	0821	3/3/95	1441
Pulling Center Rod	3/6/95	1035	3/6/95	1101
Geophys. Log.	NA	NA	NA	NA
Casing	3/6/95	1116	3/6/95	1130
Surge Sand Pack	3/6/95	1347	3/6/95	1400
Sand Pack	3/6/95	1144	3/6/95	1344
Grout	3/6/95	1552	3/6/95	1800
Bentonite Seal	3/6/95	1402	3/6/95	1446
Development	3/30/95	0729	3/30/95	0740

WELL INSTALLATION

Well Design and Specifications Basis:

Geologic Log: X Geophysical Log: ___

Casing Material: 4 in., Sched. 80, Flush-threaded PVC

Casing(s): B=blank; S=screen; EC=end cap

Depth (ft)	Casing	Elevation (ft)
+2.0 - 92.97	B	-
92.97 - 112.96	S	-
112.96 - 114.96	B	-
114.96 - 115.72	EC	-
-		-

Screen Type/Size: 20 ft. lengths; 0.010 in. slot; Schedule 80 PVC

Surface Seal (ft): 2.5 ft. - 0.0 ft. bgs

Mfr/Mtrl/Qty: Pre-Mix Concrete

Grout Seal (ft): 63.0 ft. - 2.5 ft. bgs

Mfr/Mtrl/Qty: Ash Grove P.C. / 94# / 8 bags; Wyo-Ben Big Horn Bent./ 100# / 1 bag

Bentonite Seal (ft): 89.0 ft.- 63.0 ft. bgs

Mfr/Mtrl/Qty: Enviroplug bentonite / 50# / 10 bags

Sand Pack (ft): 115.7 ft. - 89.0 ft.

Mfr/Mtrl/Qty: CSSI / #10-12 / 9.75 bags

Bottom Seal (ft:) N/A

Mfr/Mtrl/Qty: N/A

WELL DEVELOPMENT

Method: Grundfos Submersible Pump.

Total Volume Purged: 75 gallons

Starting Level: 115.72 BTOC

Finishing Level:

Stabilization Test Data

Date	Time	Volume (gal.)	pH	Spec Cond. (µS)	Temp. (°C)
3/30/95	0729	5.0	7.80	452	19.4
3/30/95	0731	5.0	7.34	516	20.4
3/30/95	0731	5.0	7.39	520	22.3
3/30/95	0734	10.0	7.51	508	22.6
3/30/95	0736	15.0	7.58	488	22.7
3/30/95	0738	15.0	7.57	488	22.8
3/30/95	0740	20.0	7.58	490	22.6

Comments: Four centralizers located below and above screen and every 40 ft. Bentonite chips above water table to reduce impact of grout on ground water.

See Wellhead Detail for surface construction information.

RUST ENVIRONMENT & INFRASTRUCTURE

DRAFT

PROJECT: CITY OF PASCO - IWWTF
PROJECT LOCATION: PASCO, WA
PROJECT NUMBER: 89534

RECORD OF BOREHOLE/WELL NO. MW-01a

BORING DATE: 3/3/95
BORING LOCATION:

FILENAME: MW01A-01.DWG
SHEET: 1 OF 3
DATUM: GS

FEET	BORING METHOD	DESCRIPTION (PROFILE)	FM/USCS	GRAPHIC LOG	OVM READING	NUMBER (SAMPLES)	TYPE	BLOWS/6 in.	REC/ATT	REMARKS
0	AIR ROTARY	0.0 ft. – 10.0 ft.: Silt: grayish brown (10YR, 5/2), dry, loose, soft. Silt 100%	ML							3/3/95 0821 Start drilling; first casing = 20.48 ft.
7							GRAB			0827 Grab sample at 7.0 ft., easy drilling; no hammer needed
10		10.0 ft. – 25.0 ft.: Silty Fine Grained Sand; dark grayish brown (10YR, 4/2), dry, loose, well sorted, subrounded with some very fine grained sand. Sand 70%, Silt 30%	SM							
16							GRAB			0830 Grab sample at 16.0 ft. 0832 Installing second 8 in. casing and center rod (total = 40.48 ft.) 0924 Resume drilling; moderate drilling hammer driving
25		25.0 ft. – 42.0 ft.: Fine to Medium Grained Sand; very dark grayish brown (10YR, 3/2), dry, loose, moderately sorted, rounded to subrounded; increase in mafic grains from above, 15% mafic. Sand 95%, Silt 5%	SP							
34							GRAB			0937 Grab sample at 34.0 ft 0939 Installing third 8 in. casing and center rod (total = 60.48 ft.) 1031 Resume drilling
42		42.0 ft. – 47.0 ft.: Fine to Coarse Grained Sand; black (7.5YR, 2.5/1), dry, medium dense, gravel from fine to pea. Sand 70%, Gravel: 30%	SW				GRAB			1032 Grab Sample at 42.0 ft.; black sand, looks like sand on top of dune just to the north
47		47.0 ft. — 49.0 ft.: Siltstone: brown (10YR, 5/3), dry, hard, non-plastic. Silt 70%, Fine Grained Sand 30%	SS				GRAB			1037 Grab sample at 47.0 ft.: slow drilling, rig chatter, siltstone reduced to flour and small fragments
49–50		49.0 ft. — 56.0 ft.: Silt: brown (10YR, 5/3), dry, soft, loose, non-plastic. Silt 90%, Very Fine Grained Sand 10%	ML							

DRILL RIG: REICHDRILL T625
DRILLING CONTRACTOR: PONDEROSA DRILLING
DRILLER: ROGER KELLY
LOGGED: SUZANNE DAHL
CHECKED: DWAYNE CRUMPLER
DATE: 5/24/95

RUST ENVIRONMENT & INFRASTRUCTURE
(509) 545-4402 Fax (509) 547-8702 Pasco, WA

DRAFT

PROJECT: CITY OF PASCO - IWWTF
PROJECT LOCATION: PASCO, WA
PROJECT NUMBER: 89534

RECORD OF BOREHOLE/WELL NO. MW-01a

BORING DATE: 3/3/95
BORING LOCATION:

FILENAME: MW01A-02.DWG
SHEET: 2 OF 3
DATUM: GS

FEET	BORING METHOD	DESCRIPTION	FM/USCS	GRAPHIC LOG	OVM READING	NUMBER	TYPE	BLOWS/6 in.	REC/ATT	REMARKS
50										
							GRAB			1043 Grab sample at 52.0 ft.
55		56.0 ft. - 70.0 ft.: Clayey Silt: brown (10YR, 5/3), dry, soft, minor plasticity. Silt 70%, Clay 30%								1044 At 56.0 ft. installing fourth casing and center rod (total = 80.48 ft.)
60										Increasing clay content with depth at 60.0 ft.
65										
			ML							
70		70.0 ft. - 74.0 ft.: Clayey Silt: brown (10YR, 5/3), moist, soft, minor plasticity. Silt 70%, Clay 30%					GRAB			
75	AIR ROTARY	74.0 ft. - 76.0 ft.: Clayey Silt: very dark grayish brown (10YR, 3/2), wet, minor plasticity, trace of sand. Silt 55%, Clay 40%, Sand 5%.					GRAB			1200 Grab sample at 76.0 ft., saturated; resumed drilling from 76.0 ft.
		76.0 ft. - 85.0 ft.: Clayey Silt: as above, saturated								1306 Measured with water level meter, no water; total depth at 76.0 ft.; slow drilling, mild rig chatter.
80										
										1310 Measured with water level meter, no water; TD 83.0 ft.; slow drilling, mild rig chatter at 85.0 ft. bgs
85		85.0 ft. - 88.0 ft.: Clayey Siltstone: pale brown (10YR, 6/3), wet. Silt 60%, Clay 40%.	SS				GRAB			
		88.0 ft. - 112.0 ft.: Clayey Silt: light gray (10YR, 7/2), saturated, soft, some sand. Silt 60%, Clay 30%, Sand 10%					GRAB			1316 Grab sample at 88.0 ft. bgs; saturated hole producing water. 1317 Installing fifth 8 in. casing and center rod; welding fifth casing.
90										
95			ML							1420 Resume drilling from 96.0 ft.
100										

DRILL RIG: REICHDRILL T625
DRILLING CONTRACTOR: PONDEROSA DRILLING
DRILLER: ROGER KELLY

LOGGED: SUZANNE DAHL
CHECKED: DWAYNE CRUMPLER
DATE: 5/24/95

RUST ENVIRONMENT & INFRASTRUCTURE
(509) 545-4402 Fax (509) 547-8762 Pasco, WA

DRAFT

ROJECT: CITY OF PASCO - IWWTF	RECORD OF BOREHOLE/WELL NO. MW-01a	FILENAME: MW01A-03.DWG
ROJECT LOCATION: PASCO, WA	BORING DATE: 3/3/95	SHEET: 3 OF 3
ROJECT NUMBER: 89534	BORING LOCATION:	DATUM: GS

FEET	BORING METHOD	DESCRIPTION	FM/USCS	GRAPHIC LOG	OVM READING	NUMBER	TYPE	BLOWS/6 in.	REC/ATT	REMARKS
100–112	AIR ROTARY		SM							
112–115	AIR ROTARY	112.0 ft. - 115.0 ft.: Gravelly Sand with Silt; very dark grayish brown (10YR, 3/2), saturated, medium dense, moderately sorted; Sand: fine to medium grained; Gravel: fine. Sand 60%, Gravel 30%, Silt 10%	SP							Rig chatters - gravels at 112.0 ft. bgs 1441 TD hole at 115.0 ft. 3/3/95
115–150										

DRILL RIG: REICHDRILL T625	LOGGED: SUZANNE DAHL
DRILLING CONTRACTOR: PONDEROSA DRILLING	CHECKED: DWAYNE CRUMPLER
DRILLER: ROGER KELLY	DATE: 5/24/95

RUST ENVIRONMENT & INFRASTRUCTURE
(509) 545-4402 Fax: (509) 547-8752 Pasco, WA

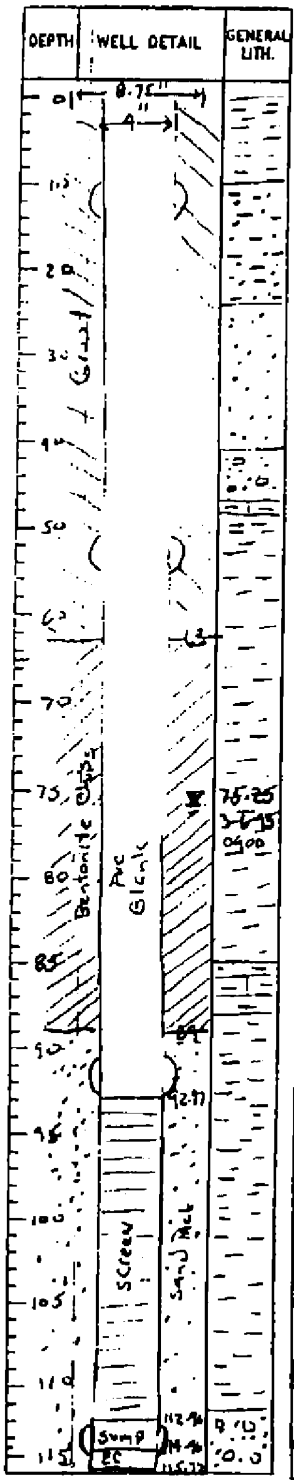
The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

MONITORING WELL CONSTRUCTION SUMMARY

Project Name: WWTP
Project No.: 89534

Well No.: MW01A
Boring No.:
Start Card No.: R-14348

Horizontal Coords: [1] ________ Ground Surface Elevation: ________
[2] ________ Top of PVC Well Casing: ________



DRILLING SUMMARY

Total Borehole Depth: 116

Borehole Diameter: 8.75"

Drilling Contractor: Ponderosa

Driller(s): Roger Kelly

Rig(s): Reichdrill T625

Bit(s): 7.75" - Tricone

WELL INSTALLATION

Well Design and Specifications Basis:

Geologic Log: ✓ Geophysical Log: ___

Casing Material: 4" Schedule 80 Flush Thread

Blank = 94.96' Sump endcap = 2.76'

Casing(s): B=blank; S=screen; SC=end cap

Depth (ft)	Casing	Elevation [1] (ft)
+2 – 92.97	B	
92.97 – 112.96	S	
112.96 – 114.96	Sump	
114.96 – 115.72	EC	

Screen Type/Size: Left length 4" 0.010; PVC sch 80

Surface Seal (ft):

Mfr/Mtrl/Qty:

Grout Seal (ft): 63' – bgs

Mfr/Mtrl/Qty: Ashgrove Cement 282 lbs, Wyoming Bentonite 91 lbs

Bentonite Seal (ft): 89-63' bgs

Mfr/Mtrl/Qty: 10 bags of 50 lbs, 50 lb/bag Enviroplug medium chips

Sand Pack (ft): 115.5 to 89, using 9.75 bags

Mfr/Mtrl/Qty: 100 lb/bag Colorado Silica Sand 8x20 w/Zeolite bags = 9.75

Bottom Seal (ft:) NA

Mfr/Mtrl/Qty: NA

TIME LOG

Task	Start Date	Start Time	Finish Date	Finish Time
Drilling Method:				
Air Rotary	3-3-95	0821	3-3-95	1441
Pulling center rod	3-6-95	1035	3-6-95	1101
Geophys. Logging	NA	NA	NA	NA
Casing	3-6-95	1116	3-6-95	1130
Surge Sand Pack	3-6-95	1357	3-6-95	1400
Sand Pack	3-6-95	1144	3-6-95	1349
Grout	3-6-95	1552	3-6-95	1800
Bentonite Seal	3-6-95	1402	3-6-95	1446
Development (Start)				
Development (Finish)				

WELL DEVELOPMENT

Method:

Total Volume Purged:

Starting Level:

Finishing Level:

Stabilization Test Data

Date	Time	Volume	pH	Cond Spec.	Temp (°C)

Comments: ~~[1]Tennison Coordinate System. [2]Oregon State Coordinate System.~~

Centralizers located below and above screen and every 40 feet.

• Bentonite chip above water table to reduce impact of grout on ground water

See Wellhead Detail for surface construction information.

Generated by: Suzanne Dahl Date: 3-6-95 Checked by: ________ Date: ________

RUST ENVIRONMENT & INFRASTRUCTURE

c:\dfforms\wellsum2.frm

Sec. 11 T.9N R.30E WM

DRAFT

PROJECT: CITY OF PASCO - IWWTF

RECORD OF BOREHOLE/WELL NO. MW-02

FILENAME: MW02-01.DWG
SHEET: 1 OF 4
DATUM: GS

PROJECT LOCATION: PASCO, WA
PROJECT NUMBER: 89534
BORING DATE: 1/18/95
BORING LOCATION:

FEET	BORING METHOD	DESCRIPTION (PROFILE)	FM/USCS	GRAPHIC LOG	OVM READING	NUMBER (SAMPLES)	TYPE (SAMPLES)	BLOWS/6 in. (SAMPLES)	REC/ATT (SAMPLES)	REMARKS
0	AIR ROTARY	0.0 ft. - 20.0 ft.: Clayey Silt; brown (10YR, 4/3), moist, soft, slightly plastic. Silt 70%, Clay 30%.	ML							1/18/95 0830 Start drilling Air Rotary with some water added
20		20.0 ft. - 40.0 ft.: Clayey Silt; brown (10YR, 4/3), moist, soft, slightly plastic. Silt 70%, Clay 30%.					GRAB			0840 Grab sample at 20.0 ft. bgs 0845 Weld second 20.0 ft. casing 0915 Start drilling with some drilling water
40		40.0 ft. - 60.0 ft.: Fine to Medium Grained Sand; dark grayish brown (2.5YR, 4/2), dry, very loose, poorly sorted, subangular to subrounded, no fines, mafic/felsic, quartz, plagioclase, biotite. Sand 100%.	SW				GRAB			0945 Grab sample at 40.0 ft. bgs; stop drilling for phone calls about supplies, and to add third 8-in. casing 1020 Resume drilling; easy drilling

DRILL RIG: REICHDRILL T625
DRILLING CONTRACTOR: PONDEROSA DRILLING
DRILLER: ROGER KELLY
LOGGED: SUZANNE DAHL
CHECKED: DWAYNE CRUMPLER
DATE: 5/24/95

RUST ENVIRONMENT & INFRASTRUCTURE
(509) 545-4402 Fax (509) 547-8782 Pasco, WA

DRAFT

RECORD OF BOREHOLE/WELL NO. MW-02

PROJECT: CITY OF PASCO - IWWTF			FILENAME: MW02-02.DWG
PROJECT LOCATION: PASCO, WA	BORING DATE: 1/18/95		SHEET: 2 OF 4
PROJECT NUMBER: 89534	BORING LOCATION:		DATUM: GS

FEET	BORING METHOD	DESCRIPTION	FM/USCS	GRAPHIC LOG	OVM READING	NUMBER	TYPE	BLOWS/6 in.	REC/ATT	REMARKS
50										
55										
60		60.0 ft. - 80.0 ft.: <u>Fine to Medium Grained Sand:</u> very dark grayish brown (10YR, 3/2), dry, very loose, poorly sorted, subangular to subrounded, mafic/felsic grains, quartz, plagioclase, and mafic minerals, no fines. Sand 100%.					GRAB			1136 Grab sample at 60.0 ft. bgs 1140 Add fourth 8-in. casing and weld 1230 Resume drilling with no additional water
65			SW							
70										
75	AIR ROTARY									
80		80.0 ft. - 100.0 ft.: <u>Very Fine to Fine Grained Sand:</u> dark yellowish brown (10YR, 4/4), moist, medium dense, moderately to well sorted, rounded, quartz grains, biotite and plagioclase. Sand 95%, Fines 5%.								1238 Grab sample at 80.0 ft. bgs 1242 Weld fifth 8-in. casing 1300 Resumed drilling; additional water needed in drilling fluid
85										
90			SP							
95										
100										

DRILL RIG: REICHDRILL T625	LOGGED: SUZANNE DAHL	RUST ENVIRONMENT & INFRASTRUCTURE
DRILLING CONTRACTOR: PONDEROSA DRILLING	CHECKED: DWAYNE CRUMPLER	(509) 545-4402 Fax (509) 547-8752 Pasco, WA
DRILLER: ROGER KELLY	DATE: 5/24/95	

DRAFT

PROJECT: CITY OF PASCO – IWWTF

RECORD OF BOREHOLE/WELL NO. MW-02

FILENAME: MW02-03.DWG
SHEET: 3 OF 4
DATUM: GS

PROJECT LOCATION: PASCO, WA
PROJECT NUMBER: 89534
BORING DATE: 1/18/95
BORING LOCATION: -

BORING METHOD: AIR ROTARY

FEET	DESCRIPTION	FM/USCS	SAMPLES TYPE	REMARKS
100	100.0 ft. – 120.0 ft.: <u>Silty Fine Grained Sand</u>: dark yellowish brown (10YR, 4/4), saturated, medium dense, moderately sorted, rounded. Sand 60%, Silt 40%.	SM	GRAB	1301 Grab sample at 100.0 ft. bgs 1302 Weld sixth 8-in. casing (20.0 ft. long) 1323 Resume drilling with water in drilling fluid
120	120.0 ft. – 125.0 ft.: <u>Fine Grained Sand</u>: light olive brown (2.5Y, 5/3), dry, loose, well sorted, subrounded to rounded, grains: quartz, mica, plagioclase, mafic/felsic. Sand 95%, Silt 5%.	SP	GRAB	1330 Grab sample at 120.0 ft. bgs; weld seventh 8-in. casing 1340 Resume drilling; no water
123			GRAB	1345 Grab sample at 123.0 ft. bgs 1400 Series of four grab samples in small intervals in interbedded units from 127.0 ft. – 135.0 ft. bgs
125	125.0 ft. – 129.0 ft.: <u>Coarse Grained Sand</u>: black (2.5Y, 2.5/1), dry, loose, well sorted, subangular. Sand 100%.	SP	GRAB	
129	129.0 ft. – 130.0 ft.: <u>Clayey Silt</u>: olive brown (2.5Y, 3/4), moist, firm to stiff, moderate plasticity.	ML	GRAB	
130	130.0 ft. – 132.0 ft.: <u>Silty Clay</u>: as above.	CL		
132	132.0 ft. – 134.0 ft.: <u>Clayey Silt</u>: olive brown (2.5Y, 3/4), moist, firm to stiff, moderate plasticity.	ML	GRAB	
134	134.0 ft. – 139.0 ft.: <u>Silty Fine Grained Sand</u>: light olive brown (2.5Y, 3/4), moist, loose, poorly sorted, subrounded, felsic/mafic. Sand 80%, Silt 20%.	SM	GRAB	
139	139.0 ft. – 140.0 ft.: <u>Clayey Silt</u>: olive brown (2.5Y, 3/4), moist, firm to stiff, moderate plasticity.	ML		
140	140.0 ft. – 157.0 ft.: <u>Fine to Medium Grained Sand</u>: olive brown, (2.5Y, 4/3), wet to saturated, loose, moderately sorted, subrounded. Sand 95%, Silt 5%.	SP	GRAB	1450 Grab sample at 140.0 ft. bgs 1455 Weld eighth 8-in. casing 1620 Resume drilling; no water in drilling fluid

DRILL RIG: REICHDRILL T625
DRILLING CONTRACTOR: PONDEROSA DRILLING
DRILLER: ROGER KELLY
LOGGED: SUZANNE DAHL
CHECKED: DWAYNE CRUMPLER
DATE: 5/24/95

RUST ENVIRONMENT & INFRASTRUCTURE
(509) 545-4402 Fax: (509) 547-8762 Pasco, WA

DRAFT

PROJECT: CITY OF PASCO - IWWTF
PROJECT LOCATION: PASCO, WA
PROJECT NUMBER: 89534

RECORD OF BOREHOLE/WELL NO. MW-02

BORING DATE: 1/18/95
BORING LOCATION:

FILENAME: MW02-04.DWG
SHEET: 4 OF 4
DATUM: GS

FEET	BORING METHOD	DESCRIPTION	FM/USCS	OVM READING	SAMPLE TYPE	REMARKS
150	AIR ROTARY		SP		GRAB	1630 Grab sample at 150.0 ft. bgs
157		157.0 ft. - 163.0 ft.: <u>Medium Grained Sand</u>; dark grayish brown, (2.5Y, 4/2), saturated, well sorted, subrounded. Sand 100%.	SP		GRAB	1648 Grab sample at 157.0 ft. bgs; inferred water table at 156.5 ft. bgs; stop drilling for the day 1/19/95 0830 Measure water table at 157.0 ft. bgs 0845 Start drilling; Rig chatter; water produced
163		163.0 ft. - 170.0 ft.: <u>Sandy Gravel</u>; grayish brown, (2.5Y, 4/2), saturated, angular, ground-up, minor sand. Gravel 90%, Sand 10%.	GW		GRAB	
170		170.0 ft. - 175.0 ft.: <u>Sandy Gravel</u>; very dark brown, (7.5YR, 2.5/2), saturated, medium dense, poorly sorted, sand grain size is coarse. Gravel 80%, Sand 20%.	GW		GRAB	
175		175.0 ft. - 176.25 ft.: <u>Sandy Gravel</u>; as above.	GW		GRAB	T.D. hole at casing= 175.25 ft. bgs; T.D. hole at bit= 176.25 ft. bgs on 1/19/95

Depth scale: 150, 155, 160, 165, 170, 175, 180, 185, 190, 195, 200

DRILL RIG: REICHDRILL T625
DRILLING CONTRACTOR: PONDEROSA DRILLING
DRILLER: ROGER KELLY
LOGGED: SUZANNE DAHL
CHECKED: DWAYNE CRUMPLER
DATE: 5/24/95

RUST ENVIRONMENT & INFRASTRUCTURE
(509) 545-4402 Fax (509) 547-8752 Pasco, WA

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

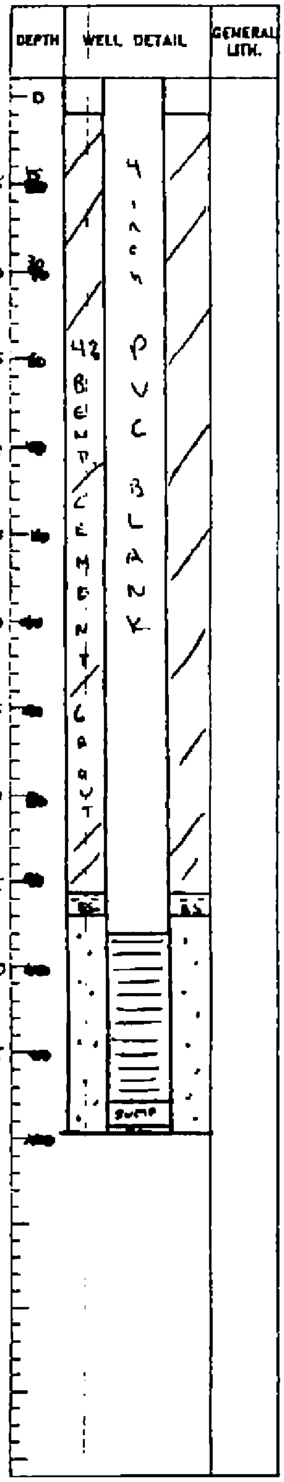
MONITORING WELL CONSTRUCTION SUMMARY

Project Name: City of Pasco - WWTP
Project No.: 89534

Well No.: MW-02a
Boring No.: MW-02a
Start Card No.: R-14349

Horizontal Coords: [1] ______ Ground Surface Elevation: ______
[2] ______ Top of PVC Well Casing: ______

Section 4 T.9N R.30 EWM Franklin Co.



DRILLING SUMMARY
Total Borehole Depth: 178 ft bgs
Borehole Diameter: 8.6-inches
Drilling Contractor: Ponderosa Drilling - Spokane WA
Driller(s): Roger Kelly
Rig(s): Rockwell T625 Air-Rotary / Casing Drive
Bit(s): 7 7/8-inch Tricone Roller Bit

TIME LOG	Start		Finish	
Task	Date	Time	Date	Time
Drilling Method:				
Air Rotary	2-20	1220	2-21	1352
Geophys. Logging	NA			
Casing	2-22	0610	2-22	0848
Sand Pack	2-22	0857	2-22	1238
Grout	2-23	0719	2-23	1348
Bentonite Seal	2-22	1243	2-22	1313
Development (Start)				
Development (Finish)				

WELL INSTALLATION

Well Design and Specifications Basis:
Geologic Log: ✓ Geophysical Log: ___
Casing Material: Sched. 80, 4-inch Flush-threaded, PVC
Casing(s): B = blank; S = screen; EC = end cap

Depth (ft)	Casing	Elevation [1] (ft)
+3.5 - 145.27	B	-
145.27 - 175.21	S	-
175.28 - 177.68	B	-
177.68 - 178.0	EC	-
-		-

Screen Type/Size: [illegible] Factory 30 slot
Surface Seal (ft):
Mfr/Mtrl/Qty:
Grout Seal (ft): 137.2 to 3.0 ft
Mfr/Mtrl/Qty: [illegible]
Bentonite Seal (ft): 141.2 to 137.2 ft
Mfr/Mtrl/Qty: [illegible] / 3/8-inch [illegible] /
Sand Pack (ft): 178.0 to 141.2 ft
Mfr/Mtrl/Qty: CSSI / #6-12 / 12 bags [illegible]
Bottom Seal (ft): N/A
Mfr/Mtrl/Qty: ______

WELL DEVELOPMENT

Method:
Total Volume Purged:
Starting Level:
Finishing Level:
Stabilization Test Data

Date	Time	Volume	pH	Cond Spec.	Temp (°C)

RECEIVED
DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

Comments: [1] ~~Yamhill Coordinate System~~ [2] Oregon State Coordinate System
Stainless steel centralizers placed @ 177 ft, 144 ft, 104 ft, 64 ft, & 24 ft bgs.

See Wellhead Detail for surface construction information.

RUST ENVIRONMENT & INFRASTRUCTURE

c:\forms\wellsum2.for

Date: ______
Checked by: ______
Date: ______
Generated by: ______

DRAFT

RECORD OF BOREHOLE/WELL NO. MW-02a

PROJECT:	CITY OF PASCO – IWWTF
PROJECT LOCATION:	PASCO, WA
PROJECT NUMBER:	89534
BORING DATE:	2/20/95
BORING LOCATION:	--
FILENAME:	MW02A-01.DWG
SHEET:	1 OF 4
DATUM:	GS

FEET	BORING METHOD	DESCRIPTION	FM/USCS	GRAPHIC LOG	OVM READING	NUMBER	TYPE	BLOWS/6 in.	REC/ATT	REMARKS
0 – 26.0	AIR ROTARY	0.0 ft. – 26.0 ft.: <u>Sandy Silt</u>: very dark grayish brown (10YR, 3/2), dry, soft; very fine to medium grained sand, loose, poorly sorted, subrounded. Silt 60%, Sand 40%.	ML				GRAB (20 ft)			2/20/95 First casing & rod (casing total= 21.0 ft.) 1220 Drilling begins 1225 Grab sample at 20.0 ft. (18.0 ft. – 20.0 ft.) 1227 Making connection with second casing & rod (casing total= 41.0 ft.) 1315 Completed welding 1319 Drilling resumes at 20.0 ft.
26.0 – 40.0	AIR ROTARY	26.0 ft. – 40.0 ft.: <u>Silty Very Fine to Medium Grained Sand</u>: very dark gray (10YR, 3/1), dry, loose, poorly sorted, subangular to subrounded. Sand 80%, Silt 20%.	SM				GRAB (30 ft), GRAB (38–40 ft)			1323 Grab sample at 30.0 ft. 1327 Grab sample at 38.0 ft. – 40.0 ft. 1331 Making connection with third casing & rod (casing total= 61.0 ft.) 1420 Completed welding 1424 Drilling resumes at 40.0 ft.
40.0 – 50	AIR ROTARY	40.0 ft. – 60.0 ft.: <u>Silty Very Fine to Fine Grained Sand</u>: dark grayish brown (10YR, 4/2), dry, loose, moderately sorted, subrounded. Sand 80%, Silt 20%.	SM							

DRILL RIG:	REICHDRILL T625
DRILLING CONTRACTOR:	PONDEROSA DRILLING
DRILLER:	ROGER KELLY
LOGGED:	TERRY MC PHETRIDGE
CHECKED:	DWAYNE CRUMPLER
DATE:	5/24/95

RUST ENVIRONMENT & INFRASTRUCTURE
(509) 545-4402 Fax: (509) 547-8752 Pasco, WA

DRAFT

PROJECT: CITY OF PASCO - IWWTF

RECORD OF BOREHOLE/WELL NO. MW-02a

FILENAME: MW02A-02.DWG

PROJECT LOCATION: PASCO, WA

BORING DATE: 2/20/95

SHEET: 2 OF 4

PROJECT NUMBER: 89534

BORING LOCATION: --

DATUM: GS

FEET	BORING METHOD	DESCRIPTION	FM/USCS	GRAPHIC LOG	OVM READING	NUMBER	TYPE	BLOWS/6 in.	REC/ATT	REMARKS
50	AIR ROTARY									
55										
							GRAB			1430 Grab sample at 58.0 ft. - 60.0 ft. 1435 Making connection with fourth casing & rod (casing total= 81.0 ft.)
60		60.0 ft. - 78.0 ft.: Silty Sand; As above.								1530 Completed welding 1537 Drilling resumes at 60.0 ft.; smooth drilling
65										
70										
75			SM							
		78.0 ft. - 95.0 ft.: Silty Very Fine to Fine Grained Sand; brown (10YR, 4/3), moderately well sorted, subrounded, trace of medium grained sand. Sand 70%, Silt 30%.								
80							GRAB			1544 Grab sample at 80.0 ft. 1549 Making connection with fifth casing & rod (casing total= 101.0 ft.) 1632 Completed welding 1636 Drilling resumes at 80.0 ft.
85										
90										
95		95.0 ft. - 100.0 ft.: Silty Sand; As above, with trace of clay at 95.0 ft. Sand 70%, Silt 25%, Clay 5%.								
100										

DRILL RIG: REICHDRILL T625

LOGGED: TERRY MC PHETRIDGE

DRILLING CONTRACTOR: PONDEROSA DRILLING

CHECKED: DWAYNE CRUMPLER

DRILLER: ROGER KELLY

DATE: 5/24/95

RUST ENVIRONMENT & INFRASTRUCTURE
(509) 946-4402 Fax (509) 947-8762 Pasco, WA

DRAFT

PROJECT: CITY OF PASCO - IWWTF
PROJECT LOCATION: PASCO, WA
PROJECT NUMBER: 89534

RECORD OF BOREHOLE/WELL NO. MW-02a

BORING DATE: 2/20/95
BORING LOCATION: --

FILENAME: MW02A-03.DWG
SHEET: 3 OF 4
DATUM: GS

FEET	BORING METHOD	DESCRIPTION	FM/USCS	GRAPHIC LOG	OVM READING	NUMBER	TYPE	BLOWS/6 in.	REC/ATT	REMARKS
100	AIR ROTARY	100.0 ft. - 120.0 ft.: <u>Silty Sand</u>; As above, decreasing clay.	SM				GRAB			1649 Grab sample at 100.0 ft. 1655 Drilled to 100.0 ft. 1700 Stopped work for the day. 2/21/95 0725 Making connection with sixth casing & rod (casing total= 121.0 ft.) 0803 Completed welding 0808 Drilling resumes at 100.0 ft.
120		120.0 ft. - 130.0 ft.: <u>Silty Fine Grained Sand</u>; grayish brown (10YR, 5/2), moderately well to well sorted, subrounded, trace of medium grained sand. Sand 90%, Silt 10%.					GRAB			0816 Grab sample at 120.0 ft. 0820 Making connection with seventh casing & rod (casing total= 141.0 ft.) 0905 Completed welding 0915 Drilling resumes at 120.0 ft.
130		130.0 ft. - 140.0 ft.: <u>Silty Sand</u>; As above; with trace of clay. Sand 80%, Silt 15%, Clay 5%.					GRAB			0923 Grab sample at 130.0 ft.
140		140.0 ft. - 150.0 ft.: <u>Sandy Silt</u>; brown (10YR, 4/3), soft, subrounded; very fine to fine grained sand; trace of clay. Silt 60%, Sand 35%, Clay 5%.	ML				GRAB			0928 Grab sample at 140.0 ft. 0930 Making connection with eighth casing & rod (casing total= 161.0 ft.) 1022 Completed welding 1026 Drilling resumes at 140.0 ft.

Depth scale: 100, 105, 110, 115, 120, 125, 130, 135, 140, 145, 150

DRILL RIG: REICHDRILL T625
DRILLING CONTRACTOR: PONDEROSA DRILLING
DRILLER: ROGER KELLY

LOGGED: TERRY MC PHETRIDGE
CHECKED: DWAYNE CRUMPLER
DATE: 5/24/95

RUST ENVIRONMENT & INFRASTRUCTURE
(509) 546-4402 Fax (509) 547-6752 Pasco, WA

DRAFT

RECORD OF BOREHOLE/WELL NO. MW-02a

PROJECT: CITY OF PASCO – IWWTF
PROJECT LOCATION: PASCO, WA
PROJECT NUMBER: 89534

BORING DATE: 2/20/95
BORING LOCATION: --

FILENAME: MW02A-04.DWG

DATUM: GS

FEET	BORING METHOD	DESCRIPTION	FM/USCS	OVM READING	SAMPLE NUMBER	TYPE	BLOWS/6 in.	REC/ATT	REMARKS
150	AIR ROTARY	150.0 ft. – 155.0 ft.: <u>Silty Fine Grained Sand</u>; brown (10YR, 3/3), moist, loose, well sorted, subangular to subrounded. Sand 80%, Silt 20%.	SM			GRAB			1035 Grab sample at 150.0 ft.
155		155.0 ft. – 163.0 ft.: <u>Silty Sand</u>; As above; increased fine to medium grained sand, moist, moderately well sorted. Sand 80%, Silt 20%.	SM						
160						GRAB			1045 Grab sample at 160.0 ft.; moist zone at 155.0 ft. – 156.0 ft.; started collecting sample in 5-gal. bucket for sieve analysis. 1050 Making connection with ninth casing & rod (casing total= 181.0 ft.) 1135 Completed welding 1140 Drilling resumes at 160.0 ft. 1144 Drilling at 163.0 ft.; mild to moderate rig chatter; possibly in gravel.
165		163.0 ft. – 178.0 ft.: <u>Sandy Fine to Coarse Gravel</u>; black (N2.5/), moist, medium dense, poorly sorted, subangular; fine to medium grained sand, subrounded, trace of silt. Gravel 60%, Sand 35%, Silt 5%.	GW						
175						GRAB			1221 Grab sample at 175.0 ft. 1231 Bottom of casing at 177.0 ft.; circulating 1315 Tagged bottom of hole at 176.5 ft.; plan to T.D. hole at 178.0 ft. Adding 4.0 ft. extension 1320 Drove casing to 178.0 ft.; circulating 1352 Tagged bottom of hole at 178.0 ft. T.D. = 178.0 ft. 2/21/95

Depth scale: 150, 155, 160, 165, 170, 175, 180, 185, 190, 195, 200

DRILL RIG: REICHDRILL T625
DRILLING CONTRACTOR: PONDEROSA DRILLING
DRILLER: ROGER KELLY

LOGGED: TERRY MC PHETRIDGE
CHECKED: DWAYNE CRUMPLER
DATE: 5/24/95

RUST ENVIRONMENT & INFRASTRUCTURE
(509) 545-4402 Fax (509) 547-8752 Pasco, WA

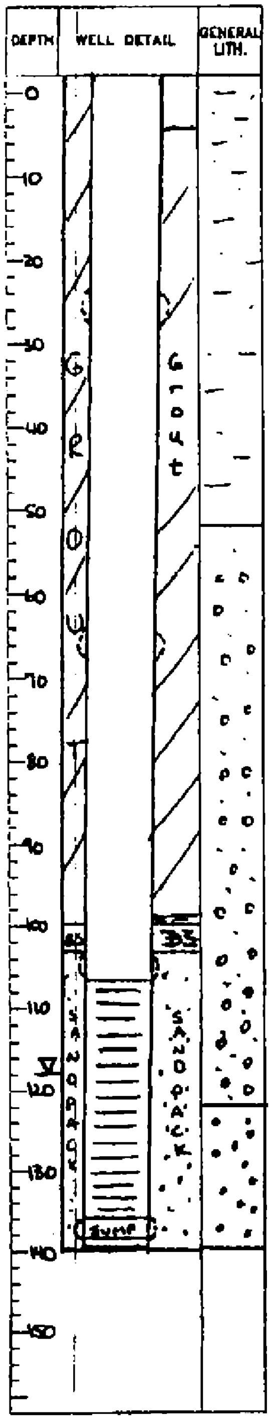
MONITORING WELL CONSTRUCTION SUMMARY

Project Name: City of Pasco / Wastewater Treatment
Project No.: 89534

Well No.: MW-03
Boring No.: MW-03
Start Card No.: R-02816

Horizontal Coords: ¹ ____________ Ground Surface Elevation: ____________
² ____________ Top of PVC Well Casing: ____________

Section 3 T.9N R.30 EWM Franklin Co.



DRILLING SUMMARY	
Total Borehole Depth:	139.6 ft bgs
Borehole Diameter:	8.0 - inches
Drilling Contractor:	Ponderosa Drilling - Spokane, WA
Driller(s):	Roger Kelly
Rig(s):	Reichdrill T625 Rotary / Circulating Medium: Air
Bit(s):	Tricone Roller

TIME LOG	Start		Finish	
Task	Date	Time	Date	Time
Drilling Method:				
Air Rotary	1/20/95	1418	1/24/95	0930
Geophys. Logging	N/A			
Casing	1/24/95	0917	1/24/95	1109
Sand Pack	1/26	1130	1/26	1535
Grout	1/27	0824	1/27	1743
Bentonite Seal	1/26	1548	1/26	1610
Development (Start)				
Development (Finish)				

WELL INSTALLATION

Well Design and Specifications Basis:
Geologic Log: ✓ Geophysical Log: ___
Casing Material: Schedule 80, 4-inch PVC, Flush-threaded
Casing(s): B = blank; S = screen; EC = end cap

Depth (ft)	Casing	Elevation ¹ (ft)
+3.3 - 106.7	B	
106.7 - 136.7	S	
136.7 - 139.15	B	
139.15 - 139.43	EC	

Screen Type/Size: Factory slot / 0.030
Surface Seal (ft):
Mfr/Mtrl/Qty: 0
Grout Seal (ft): 98.95 - 3 bgs
60 bags 22.4 ft³ Mfr/Mtrl/Qty: Cement - High Early 96% Bentonite, Aqua Gel 4% 11.2 Hr + 48.45 bgs
Bentonite Seal (ft): 103.5 ft to 100.0 ft
1.5 Bucket Mfr/Mtrl/Qty: Enviroplug Tablets 3/8-inch (#8) Bucket
Sand Pack (ft): 139.6 ft to 103.5 ft bgs
25 bags Mfr/Mtrl/Qty: Colorado Silica Sand #8-12 (50# bags)
Bottom Seal (ft): N/A
Mfr/Mtrl/Qty: ______

WELL DEVELOPMENT					
Method:					
Total Volume Purged:					
Starting Level:					
Finishing Level:					
Stabilization Test Data					
Date	Time	Volume	pH	Cond Spec.	Temp (°C)

RECEIVED
DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

Comments: ~~¹Tennessee Coordinate System.~~ ~~²Oregon State Coordinate System~~
Stainless steel centralizers @ 24 ft, 64 ft, 104 ft, and 137 ft bgs.

See Wellhead Detail for surface construction information.

RUST ENVIRONMENT & INFRASTRUCTURE

c:\forms\welsum2.for

Generated by: Terry McPherson Date: 1/26/95 Checked by: ______ Date: ______

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

MONITORING WELL CONSTRUCTION SUMMARY

Project Name: City of Pasco Wastewater Treatment Facility
Project No.: 89534

Well No.: MW-03
Boring No.: MW-03
Start Card No.: ________

Horizontal Coords: ________
Ground Surface Elevation: ________
Top of PVC Well Casing: ________

DRILLING SUMMARY	TIME LOG				
Total Borehole Depth: 139.6 ft. bgs		Start		Finish	
Borehole Diameter: 8.6 in.	Task	Date	Time	Date	Time
Drilling Contractor: Ponderosa Drilling -	Drilling Method:				
Spokane, WA	Air Rotary	1/20/95	1418	1/24/95	0930
Driller(s): Roger Kelly					
Rig(s): Reichdrill T625	Geophys. Log.	NA	NA	NA	NA
Rotary (Air)/Casing drive	Casing	1/26/95	0917	1/26/95	1109
Bit(s): 7-7/8 in. Tricone roller bit	Surge Sand Pack	1/26/95	1500	1/26/95	1535
	Sand Pack	1/26/95	1130	1/26/95	1535
	Grout	1/27/95	0824	1/26/95	1743
WELL INSTALLATION	Bentonite Seal	1/26/95	1548	1/26/95	1610
Well Design and Specifications Basis:					
Geologic Log: X Geophysical Log: ___	Development	3/29/95	1512	3/29/95	1527
Casing Material: 4 in., Sched. 80					
Flush-threaded PVC					
Casing(s): B=blank; S=screen; EC=end cap					

Depth (ft)	Casing	Elevation (ft)
+3.30 - 106.70	B	-
106.70 - 136.70	S	-
136.70 - 139.15	B	-
139.15 - 139.43	EC	-
-		-

WELL DEVELOPMENT

Method: Grundfos submersible pump
Total Volume Purged: 42.5 gallons
Starting Level: 119.24 ft. BTOC
Finishing Level:
Stabilization Test Data

Date	Time	Volume (gal.)	pH	Spec Cond. (μS)	Temp. (°C)
3/29/95	1512	10.0	7.92	315	24.1
3/29/95	1514	5.5	7.68	307	23.9
3/29/95	1516	7.0	7.71	309	24.0
3/29/95	1524	5.0	7.70	309	24.0
3/29/95	1525	5.0	7.71	309	24.1
3/29/95	1526	5.0	7.67	309	24.0
3/29/95	1527	5.0	7.67	309	24.1

Screen Type/Size: Environmental Well Products
Factory 0.030 in. slot; Sch. 80 PVC
Surface Seal (ft): 3.0 ft. - 0.0 ft.
Mfr/Mtrl/Qty: Pre-mix concrete
Grout Seal (ft): 98.95 ft. - 3.0 ft. bgs
Mfr/Mtrl/Qty: Ash Grove P.C. 94# 60 bags;
Am. Colloid 4%
Bentonite Seal (ft): 103.5 ft. - 100.0 ft. bgs
Mfr/Mtrl/Qty: Enviroplug / 3/8 in. / 1.5 buckets
Sand Pack (ft): 139.6 ft. - 103.5 ft. bgs
Mfr/Mtrl/Qty: CSSI / #8-12 / 50# / 25 bags
Bottom Seal (ft:) NA
Mfr/Mtrl/Qty: NA

Comments: Stainless steel centralizers placed at 24.0 ft., 64.0 ft., 104.0 ft., and 137.0 ft. bgs

See Wellhead Detail for surface construction information.

RUST ENVIRONMENT & INFRASTRUCTURE

C:\WPWIN60\WPDOCS\WCS\WWMW03.WCS 9/12/95

DRAFT

RECORD OF BOREHOLE/WELL NO. MW-03

PROJECT: CITY OF PASCO - IWWTF
PROJECT LOCATION: PASCO, WA
PROJECT NUMBER: 89534
BORING DATE: 1/20/95
BORING LOCATION:
FILENAME: MW03-01.DWG
SHEET: 1 OF 3
DATUM: GS

FEET	BORING METHOD	DESCRIPTION	FM/USCS	GRAPHIC LOG	OVM READING	NUMBER	TYPE	BLOWS/6 in.	REC/ATT	REMARKS
0	AIR ROTARY	0.0 ft. - 40.0 ft.: Sandy Silt: dark grayish brown (10YR, 4/2), dry, soft; very fine grained sand, subangular to subrounded. Silt 70%, Sand 20%, Fines 10%.	ML							1/20/95 1418 Drilling begins; rotary drilling with 7-7/8 in. tricone bit; circulating medium= air, 650 psi max.; 8 in. I.D. steel casing; 5 in. I.D. drill rod.
18							GRAB			1421 Grab sample at 18.0 ft. - 20.0 ft.; same material from 0.0 ft. - 20.0 ft. 1428 Making connection with second casing & rod (casing total= 40.0 ft.) 1509 Completed welding 1512 Drilling resumes at 20.0 ft.
38							GRAB			1521 Grab sample at 38.0 ft. - 40.0 ft. 1527 Making connection with third casing & rod (casing total= 60.0 ft.) 1600 Completed welding 1603 Drilling resumes at 40.0 ft.
40		40.0 ft. - 49.0 ft.: Sandy Silt: dark gray (10YR, 4/1), dry, soft; very fine grained sand, subangular to subrounded. Silt 60%, Sand 30%, Fines 10%.								
49		49.0 ft. - 52.0 ft: Sandy Silt: As above, increasing fine to medium grained sand.								

DRILL RIG: REICHDRILL T625
DRILLING CONTRACTOR: PONDEROSA DRILLING
DRILLER: ROGER KELLY
LOGGED: TERRY MC PHETRIDGE
CHECKED: DWAYNE CRUMPLER
DATE: 5/24/95

RUST ENVIRONMENT & INFRASTRUCTURE
(509) 545-4402. Fax (509) 547-8752. Pasco, WA

DRAFT

RECORD OF BOREHOLE/WELL NO. MW-03

PROJECT: CITY OF PASCO – IWWTF
PROJECT LOCATION: PASCO, WA
PROJECT NUMBER: 89534

BORING DATE: 1/20/95
BORING LOCATION:

FILENAME: MW03-02.DWG
SHEET: 2 OF 3
DATUM: GS

FEET	BORING METHOD	DESCRIPTION	FM/USCS	GRAPHIC LOG	OVM READING	NUMBER	TYPE	BLOWS/6 in.	REC/ATT	REMARKS
50			ML							
		52.0 ft. – 80.0 ft.: <u>Sandy Gravel</u>; very dark gray (5Y, 3/1), dry, medium dense; fine to medium grained sand, poorly sorted, subangular to subrounded. Gravel 70%, Sand 30%.					GRAB			1609 Mod. rig chatter at 52.0 ft. 1610 Grab sample at 52.0 ft. – 53.0 ft.
55										1618 Strong rig chatter at 56.0 ft.
										1632 Drilling at 58.0 ft. O-ring blew on hydraulic lever; will repair on Monday. 1635 Stopped drilling for the day.
60										1/23/95 1300 Welded on fourth section (total= 80.0 ft.) 1348 Drilling resumes at 58.0 ft.; strong rig chatter
65										
70										
75	AIR ROTARY		GW							
							GRAB			1405 Grab sample at 78.0 ft. – 80.0 ft. 1412 Making connection with fifth casing & rod (casing total= 100.0 ft.)
80		80.0 ft. – 100.0 ft.: <u>Sandy Gravel</u>; as above.								1453 Completed welding 1458 Drilling resumes at 80.0 ft.; moderate rig chatter
85										
90										
95										1510 Grab sample at 98.0 ft. – 100.0 ft. 1510 – 1528 Circulating to remove cuttings. 1529 Making connection with sixth casing & rod (casing total= 120.0 ft)
100							GRAB			1602 Completed welding.

DRILL RIG: REICHDRILL T625
DRILLING CONTRACTOR: PONDEROSA DRILLING
DRILLER: ROGER KELLY

LOGGED: TERRY MC PHETRIDGE
CHECKED: DWAYNE CRUMPLER
DATE: 5/24/95

RUST ENVIRONMENT & INFRASTRUCTURE
(509) 546-4402. Fax (509) 547-8782 Pasco, WA

DRAFT

PROJECT: CITY OF PASCO - IWWTF
PROJECT LOCATION: PASCO, WA
PROJECT NUMBER: 89534

RECORD OF BOREHOLE/WELL NO. MW-03

BORING DATE: 1/20/95
BORING LOCATION:

FILENAME: MW03-03.DWG
SHEET: 3 OF 3
DATUM: GS

FEET	BORING METHOD	DESCRIPTION	FM/USCS	OVM READING	NUMBER	TYPE	BLOWS/6 in.	REC/ATT	REMARKS
100	AIR ROTARY	100.0 ft. - 110.0 ft.: Gravel; black (5Y, 2/1), as above.	GW						1609 Drilling resumes at 100.0 ft.; moderate rig chatter
110		110.0 ft. - 115.0 ft.: Sandy Silt; black (5Y, 3/1), dry, soft; fine grained sand with trace of medium grained sand, subangular to subrounded. Silt 60%, Sand 40%.	ML			GRAB			1614 No rig chatter at 111.0 ft. Grab sample collected from 111.0 ft. - 114.0 ft. 1615 Moderate rig chatter returns at 114.0 ft.
115		115.0 ft. - 122.0 ft.: Sandy Gravel; black (5Y, 2/1), moist, medium dense; fine to medium grained sand, poorly sorted, subangular to subrounded. Gravel 70%, Sand 30%.	GW			GRAB			1619 Added extension to 8 in. casing to drive 1635 Grab sample at 118.0 ft. - 120.0 ft. 1635 - 1645 Circulating to remove cuttings 1650 Stopped drilling for the day 1/24/95 0730 Making connection with seventh casing & rod (casing total= 140.0 ft.)
122		122.0 ft. - 139.0 ft.: Gravelly Fine to Medium Grained Sand; black (N2.5/), wet, medium dense, very loose, poorly sorted, subangular to subrounded, trace of coarse grained sand, trace of gravel up to 0.5 in. dia. Sand 90%, Gravel 10%.	SW			GRAB			0810 Completed welding 0815 Drilling resumes at 120.0 ft.; moderate rig chatter; cuttings are moist. 0820 Sieve sample collected from 120.0 ft. - 135.0 ft. in 5-gal. bucket 0825 Grab sample at 135.0 ft. 0828 M. Anderson left with sieve sample; top of water approx. 120.0 ft. 0830 Ream hole to remove cuttings in well bore 0845 Fine sand heaving into well bore 0910 Static water level= 139.0 ft.; Total depth drilled= 139.0 ft. 0930 Completed drilling T.D.= 139.0 ft.

DRILL RIG: REICHDRILL T625
DRILLING CONTRACTOR: PONDEROSA DRILLING
DRILLER: ROGER KELLY
LOGGED: TERRY MC PHETRIDGE
CHECKED: DWAYNE CRUMPLER
DATE: 5/24/95

RUST ENVIRONMENT & INFRASTRUCTURE
(509) 545-4402 Fax (509) 547-8702 Pasco, WA

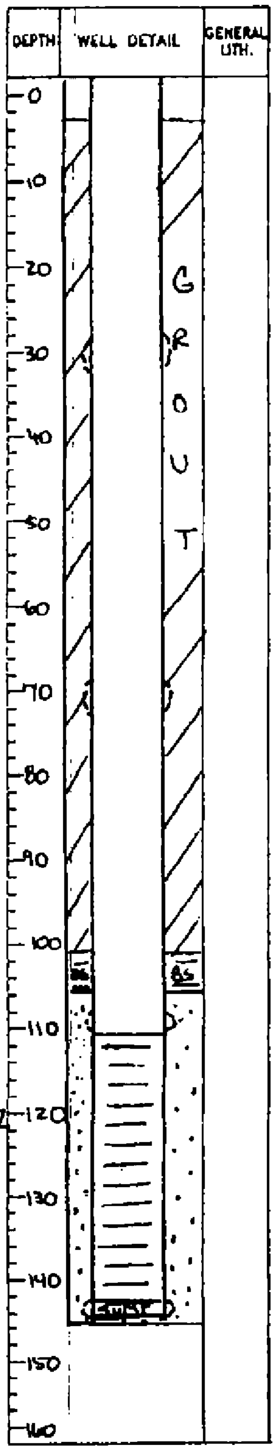
MONITORING WELL CONSTRUCTION SUMMARY

Project Name: City of Pasco/Wastewater Treatment
Project No.: 89584

Well No.: MW-04
Boring No.: MW-04
Start Card No.: R-02815

Horizontal Coords: [1] ______ [2] ______
Ground Surface Elevation: ______
Top of PVC Well Casing: ______

Section 34 T. 10N R. 30 EWM Franklin Co



DRILLING SUMMARY

Total Borehole Depth: 145 ft bgs
Borehole Diameter: 8.6-inches
Drilling Contractor: Ponderosa Drilling - Spokane, WA
Driller(s): Roger Kolk
Rig(s): Reichdrill T625 Rotary/Circulating Medium = Air
Bit(s): 7 7/8-inch Tri-cone Roller Bit.

TIME LOG

Task	Start Date	Start Time	Finish Date	Finish Time
Drilling Method:				
Air Rotary	2/2/95	1332	2/3/95	1436
Geophys. Logging	N/A	—		
Casing	2/6	0950	2/6	1115
Sand Pack	2/6	1128	2/6	1616
Grout	2/7	0735	2/7	1256
Bentonite Seal	2/6	1624	2/6	1648
Development (Start)				
Development (Finish)				

WELL INSTALLATION

Well Design and Specifications Basis:
Geologic Log: ✓ Geophysical Log: ___
Casing Material: Sched. 80, 4-inch Flush-Threaded PVC.
Casing(s): B = blank; S = screen; EC = end cap

Depth (ft)	Casing	Elevation [1] (ft)
+3.0 - 110.57	B	
110.57 - 140.60	S	
140.60 - 142.95	B	
142.95 - 143.29	EC	

Screen Type/Size: Louvered Fact. Slot/30 mesh
Surface Seal (ft):
Mfr/Mtrl/Qty: ~~[illegible]~~
Grout Seal (ft): 100.0 ft to 3.0 ft bgs
Mfr/Mtrl/Qty: [illegible]
Bentonite Seal (ft): 106.5 ft to 100.0 ft bgs
Mfr/Mtrl/Qty: Enviroplug/3/8-inch/2 bags
Sand Pack (ft): 145.0 ft to 106.5 ft bgs
Mfr/Mtrl/Qty: CSSI/#8-12/25 bags
Bottom Seal (ft): N/A
Mfr/Mtrl/Qty: ———

WELL DEVELOPMENT

Method:
Total Volume Purged:
Starting Level:
Finishing Level:
Stabilization Test Data

Date	Time	Volume	pH	Cond Spec.	Temp (°C)

RECEIVED DEC 1995 DEPARTMENT OF ECOLOGY EASTERN REGIONAL OFFICE

Comments: ~~[1]Tennison Coordinate System~~ ~~[2]Oregon State Coordinate System~~
Stainless Steel Centralizers @ 30 ft, 70 ft, 110 ft, and 141 ft bgs.

See Wellhead Detail for surface construction information.

Generated by: Tom McPherson Date: 2-6-95 Checked by: ______ Date: ______

RUST ENVIRONMENT & INFRASTRUCTURE

cld/forms/wellsum2.for

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

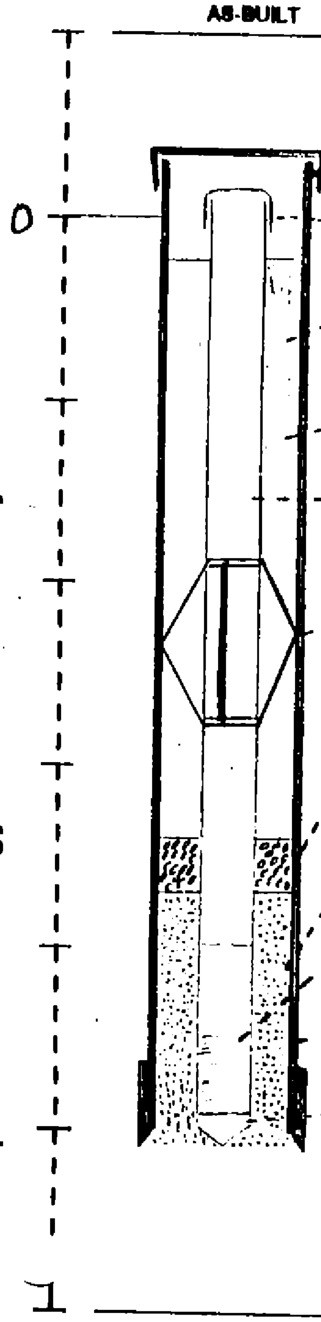
RESOURCE PROTECTION WELL REPORT

START CARD NO. R 14347

PROJECT NAME: PASCO WASTE WATER TREATMENT
WELL IDENTIFICATION NO. M-W-05
DRILLING METHOD: AIR ROTARY
DRILLER: ROGER KELLY
FIRM: PONDEROSA DRILLING & DEVELOPMENT
SIGNATURE:
CONSULTING FIRM: RUST ENV.
REPRESENTATIVE:

COUNTY: FRANKLIN
LOCATION: ___ ¼ SW ¼ Sec 11 Twn 9N R 30E
STREET ADDRESS OF WELL:
WATER LEVEL ELEVATION:
GROUND SURFACE ELEVATION:
INSTALLED:
DEVELOPED:

AS-BUILT



WELL DATA

CAP OR VAULT
TYPE: LOCKING
SIZE: 10"
LOCK: PADLOCK
PVC CAP: SLIP CAP

CEMENT: REDI-MIX
DEPTH: +6 TO -2
BAGS: 22 BAGS

GROUT TYPE: PORTLAND
DEPTH: -2 TO 100
BAGS: 45
PVC TYPE: THREADED
PVC SIZE: 4"
DEPTH: +3.5 TO 110.21
CENTRALIZERS: 4
PELLETS SIZE: 3/8
DEPTH: 100 TO 106
BUCKETS: 2

SILICA SAND: 8-12
DEPTH: 106.0 TO 143.0
BAGS: 32 BAGS 50#

SCREEN TYPE: FACTORY
DEPTH: 110.21 TO 140.22
SIZE: 30 SLOT

CASING SIZE: 8"
DRIVE SHOE: NONE

BOTTOM: 143

GUARD POSTS:

MISC:

FORMATION DESCRIPTION

SCALE: 1" =
PAGE ___ OF ___

ECY 050-12 (Rev. 11/89)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

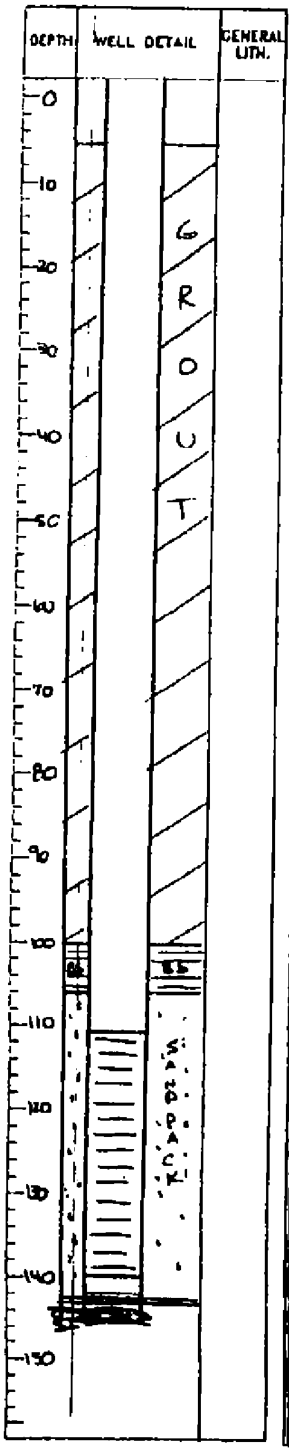
MONITORING WELL CONSTRUCTION SUMMARY

Project Name: City of Pasco/Wastewater Treatment
Project No.: 89534

Well No.: MW-05
Boring No.: MW-05
Start Card No.: R-13401

Horizontal Coords: [1] ______
[2] ______

Ground Surface Elevation: ______
Top of PVC Well Casing: ______



DRILLING SUMMARY

Total Borehole Depth: 143 ft bgs
Borehole Diameter: 8.6-inches
Drilling Contractor: Ponderosa Drilling - Spokane, WA
Driller(s): Roger Kelly
Rig(s): Reichdrill T625
Bit(s): 7 7/8-inch tricone roller bit

WELL INSTALLATION

Well Design and Specifications Basis:
Geologic Log: ✓ Geophysical Log: ___
Casing Material: 4-inch, Schedule 80 PVC
Casing(s): B = blank; S = screen; EC = end cap

Depth (ft)		Casing	Elevation [1] (ft)
+3.5	110.21	B	
110.21	140.22	S	
140.22	142.6	B	
142.6	142.91	EC	

Screen Type/Size: Env. Well Prod. Factory Slot/30 slot
Surface Seal (ft):
Mfr/Mtrl/Qty:
Grout Seal (ft): 100.0 to 3.0 ft bgs
Mfr/Mtrl/Qty: Ash Grove PC 45 bags; Bent. 1.75 bags
Bentonite Seal (ft): 106.0 to 100.0 ft bgs
Mfr/Mtrl/Qty: Enviroplug/3/8" [illegible]/2 buckets
Sand Pack (ft): 143.0 to 106.0 ft bgs
Mfr/Mtrl/Qty: CSSI/#8-12/32 (50#) bags
Bottom Seal (ft): N/A
Mfr/Mtrl/Qty: N/A

TIME LOG

Task	Start Date	Start Time	Finish Date	Finish Time
Drilling Method:				
Air Rotary	2/8/95	0919	2/9	0928
Geophys. Logging	N/A			
Casing	2/9	1507	2/9	1521
Sand Pack	2/9	1601	2/10	1024
Grout	2/10	1150	2/10	1540
Bentonite Seal	2/10	1030	2/10	1040
Development (Start)				
Development (Finish)				

WELL DEVELOPMENT

Method:
Total Volume Purged:
Starting Level:
Finishing Level:
Stabilization Test Data

Date	Time	Volume	pH	Cond Spec.	Temp (°C)

Comments: [1]Tennison Coordinate System. [2]Oregon State Coordinate System

See Wellhead Detail for surface construction information.

Date: ______
Checked by: ______
Date: ______
Generated by: ______

RUST ENVIRONMENT & INFRASTRUCTURE

c:\dforms\wellsum2.for

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

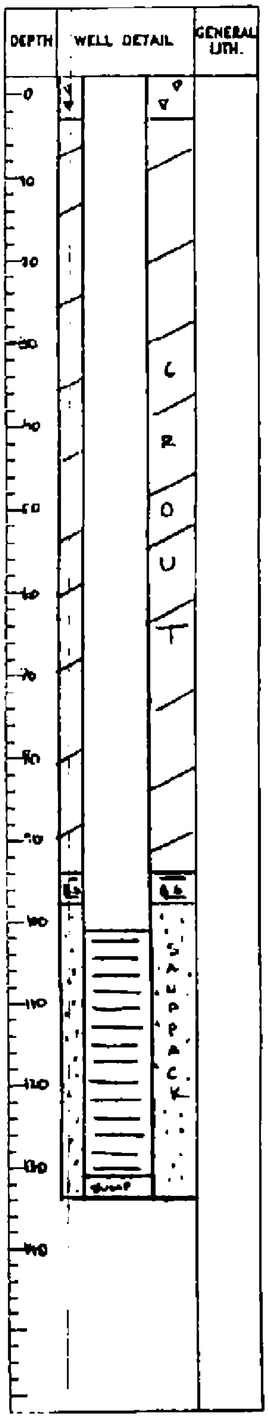
MONITORING WELL CONSTRUCTION SUMMARY

Project Name: City of Pasco / Wastewater Treatment
Project No.: 89534

Well No.: MW-06
Boring No.: MW-06
Start Card No.: R-14345

Horizontal Coords: [1] ______ [2]
Ground Surface Elevation: ______
Top of PVC Well Casing: ______

NW 1/4 Section 11 T. 9N R. 30 EWM Franklin Co



DRILLING SUMMARY

Total Borehole Depth: 134 ft bgs
Borehole Diameter: 8.6-inches
Drilling Contractor: Ponderosa Drilling - Spokane, WA
Driller(s): Roger Kelly
Rig(s): Reichdrill T625 Rotary (air) / casing drive
Bit(s): 7 7/8-inch tricone roller bit

TIME LOG

Task	Start Date	Start Time	Finish Date	Finish Time
Drilling Method:				
Air Rotary	2-14	1530	2-16	0820
Geophys. Logging	N/A	—		
Casing	2-16	1131	2-16	1152
Sand Pack	2-16	1208	2-16	1532
Grout	2-17	0800	2-17	1450
Bentonite Seal	2-16	1536	2-16	1607
Development (Start)				
Development (Finish)				

WELL INSTALLATION

Well Design and Specifications Basis:
Geologic Log: ✓ Geophysical Log: ___
Casing Material: Sched. 80, 4-inch flush-threads, PVC
Casing(s): B = blank; S = screen; EC = end cap

Depth (ft)	Casing	Elevation [1] (ft)
43.5 - 101.23	B	
101.23 - 131.31	S	
131.31 - 133.70	B	
133.70 - 134.0	EC	

Screen Type/Size: Env. well products factory 30 slot
Surface Seal (ft): 3.0 to 0.0 ft
Mfr/Mtrl/Qty: Pre-mix concrete
Grout Seal (ft): 94.0 to 3.0 ft
Mfr/Mtrl/Qty: Ash grove PC type 48 bags, Bio-Seal Bent. 10# 2 bags
Bentonite Seal (ft): 97.8 to 94.0 ft
Mfr/Mtrl/Qty: Enviroplug / 3/8-inch chips / 2 (50#) bags
Sand Pack (ft): 134.0 to 97.8 ft
Mfr/Mtrl/Qty: CSS I / #8-12 / 26 bags (50#)
Bottom Seal (ft): N/A
Mfr/Mtrl/Qty: —

WELL DEVELOPMENT

Method:
Total Volume Purged:
Starting Level:
Finishing Level:
Stabilization Test Data

Date	Time	Volume	pH	Cond Spec.	Temp (°C)

RECEIVED [illegible] 5 [illegible]
DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

Comments: [1]Tennison Coordinate System. [2]Oregon State Coordinate System

See Wellhead Detail for surface construction information.

RUST ENVIRONMENT & INFRASTRUCTURE

Generated by: Terry McPherson Date: 2-20-95 Checked by: ______ Date: ______

c:\forms\wellsum2.for

MONITORING WELL CONSTRUCTION SUMMARY

Project Name: City of Pasco Wastewater Treatment Facility
Project No.: 89534

Well No.: MW-06
Boring No.: MW-06
Start Card No.: ________

Horizontal Coords: ________________
____

Ground Surface Elevation: ________________
Top of PVC Well Casing: ________________

DRILLING SUMMARY	TIME LOG				
		Start		Finish	
Total Borehole Depth: 134 ft. bgs	Task	Date	Time	Date	Time
Borehole Diameter: 8.6 in.	Drilling Method:				
Drilling Contractor: Ponderosa Drilling - Spokane, WA	Air Rotary	2/14/95	1530	2/16/95	0820
Driller(s): Roger Kelly					
Rig(s): Reichdrill T625	Geophys. Log.	NA	NA	NA	NA
Rotary (Air)/Casing drive	Casing	2/16/95	1131	2/16/95	1152
Bit(s): 7-7/8 in. Tricone roller bit	Surge Sand Pack	2/16/95	1420	2/16/95	1435
	Sand Pack	2/16/95	1208	2/16/95	1532
	Grout	2/17/95	0800	2/17/95	1450
WELL INSTALLATION	Bentonite Seal	2/16/95	1538	2/16/95	1607
Well Design and Specifications Basis:					
Geologic Log: X Geophysical Log: ___	Development	3/30/95	0922	3/30/95	1104
Casing Material: 4 in., Sched. 80 Flush-threaded PVC					
Casing(s): B=blank; S=screen; EC=end cap					

Depth (ft)	Casing	Elevation (ft)
+3.50 - 101.23	B	-
101.23 - 131.31	S	-
131.31 - 133.70	B	-
133.70 - 134.00	EC	-
-		-

Screen Type/Size: Environmental Well Products 0.030 in. slot Sch. 80 PVC
Surface Seal (ft): 3.0 ft. - 0.0 ft.
Mfr/Mtrl/Qty: Pre-Mix Concrete
Grout Seal (ft): 94.0 ft. - 3.0 ft. bgs
Mfr/Mtrl/Qty: Ash Grove P.C. / 94# / 45 bags; Wyo-Ben Big Horn Bent. / 100# / 2 bags
Bentonite Seal (ft): 97.8 ft. - 94.0 ft. bgs
Mfr/Mtrl/Qty: Enviroplug / 3/8 in. / 2 buckets
Sand Pack (ft): 134.0 ft. - 97.8 ft. bgs
Mfr/Mtrl/Qty: CSSI / #8-12 / 50# / 26 bags
Bottom Seal (ft:) NA
Mfr/Mtrl/Qty: NA

WELL DEVELOPMENT
Method: Grundfos submersible pump
Total Volume Purged: 68.0 gallons
Starting Level: 113.43 ft. BTOC
Finishing Level:
Stabilization Test Data

Date	Time	Volume (gal.)	pH	Spec Cond. (μS)	Temp. (°C)
3/30/95	0922	9.0	7.96	234	21.2
3/30/95	0924	6.0	8.04	237	21.8
3/30/95	0936	10.0	7.84	239	21.9
3/30/95	0952	9.0	7.92	238	22.0
3/30/95	1014	11.0	7.96	238	22.4
3/30/95	1035	11.5	7.90	238	22.5
3/30/95	1104	11.5	7.91	238	22.6

Comments: Stainless steel centralizers placed at 20.0 ft., 60.0 ft., 100.0 ft., and 133.0 ft. bgs.

See Wellhead Detail for surface construction information.

RUST ENVIRONMENT & INFRASTRUCTURE

C:\WPWIN60\WPDOCS\WCS\IWWMW06.WCS 9/12/95

DRAFT

PROJECT: CITY OF PASCO - IWWTF
PROJECT LOCATION: PASCO, WA
PROJECT NUMBER: 89534

RECORD OF BOREHOLE/WELL NO. MW-06

BORING DATE: 2/14/95
BORING LOCATION:

FILENAME: MW06-01.DWG
SHEET: 1 OF 3
DATUM: GS

FEET	BORING METHOD	DESCRIPTION	FM/USCS	GRAPHIC LOG	OVM READING	NUMBER	TYPE	BLOWS/6 in.	REC/ATT	REMARKS
0	AIR ROTARY	0.0 ft. - 20.0 ft.: Sandy Silt: brown (10YR, 4/3), dry, soft; trace of very fine grained sand. Silt 90%, Sand 10%	ML							2/14/95 1530 Drilling begins at MW-06. Mark Anderson overseeing drilling. 1545 Drilled to 18.0 ft. - 20.0 ft. bgs; Silt (LOESS); (Casing total= 20 ft.) 1600 Making connection with second casing & rod (casing total= 40 ft.) 1645 Completed welding 1700 Left for the day
15										2/15/95 0744 Drilling resumes at 18.0 ft.
20		20.0 ft. - 40.0 ft.: Sandy Silt: As Above.					GRAB			0746 Grab sample at 20.0 ft.
38										0753 Drilling at 38.0 ft.; casing hammer thawing out. 0806 Making connection with third casing & rod (casing total= 60.0 ft.) 0858 Completed welding
40		40.0 ft. - 45.0 ft.: Sandy Silt: As Above.					GRAB			0901 Drilling resumes at 38.0 ft. Grab sample at 40.0 ft. 0906 Moderate rig chatter at 44.0 ft.; Grab sample at 45.0 ft.
45		45.0 ft. - 75.0 ft.: Silty Fine Gravel with Sand: black (N, 2.5/), dry, medium dense; very fine to fine grained sand, subangular to subrounded; silt. Gravel 50%, Sand 30%, Silt 20%.	GM				GRAB			
50										

DRILL RIG: REICHDRILL T625
DRILLING CONTRACTOR: PONDEROSA DRILLING
DRILLER: ROGER KELLY
LOGGED: TERRY MC PHETRIDGE
CHECKED: DWAYNE CRUMPLER
DATE: 5/24/95

RUST ENVIRONMENT & INFRASTRUCTURE
(509) 545-4402 Fax (509) 547-6752 Pasco, WA

DRAFT

PROJECT: CITY OF PASCO - IWWTF
PROJECT LOCATION: PASCO, WA
PROJECT NUMBER: 89534

RECORD OF BOREHOLE/WELL NO. MW-06

BORING DATE: 2/14/95
BORING LOCATION:

FILENAME: MW06-02.DWG
SHEET: 2 OF 3
DATUM: GS

FEET	BORING METHOD	DESCRIPTION	FM/USCS	GRAPHIC LOG	OVM READING	NUMBER	TYPE	BLOWS/6 in.	REC/ATT	REMARKS
50	AIR ROTARY	Boulder encountered between 51.0 ft. - 53.0 ft.	GM							0911 Strong rig chatter at 51.0 ft. (driller reports boulder) 0957 Making connection with fourth casing & rod (casing total= 80.0 ft.) 1038 Completed welding 1044 Drilling resumes at 58.0 ft., mild to moderate rig chatter at 73.0 ft.; rewelding a weld.
75		75.0 ft. - 95.0 ft.: Silty Gravel with Sand: As above.					GRAB			1112 Grab sample at 75.0 ft. 1131 Making connection with fifth casing & rod (casing total= 99.92 ft.) 1220 Drilling resumes at 78.0 ft.
95		95.0 ft. - 105 ft.: Fine to Medium Grained Sand with Silt and Gravel: dark brown (10YR, 3/3), moist, loose, poorly sorted, subangular to subrounded; fine gravel. Sand 60%. Gravel 30%. Silt 10%.	SW				GRAB			1245 Grab sample at 95.0 ft. 1246 Adding 4.0 ft. casing extension; drove casing to 98.0 ft. 1300 Making connection with sixth casing & rod (casing total= 119.75 ft.) 1345 Completed welding
100										

DRILL RIG: REICHDRILL T625
DRILLING CONTRACTOR: PONDEROSA DRILLING
DRILLER: ROGER KELLY
LOGGED: TERRY MC PHETRIDGE
CHECKED: DWAYNE CRUMPLER
DATE: 5/24/95

RUST ENVIRONMENT & INFRASTRUCTURE
(509) 545-4402 Fax (509) 547-6752 Pasco, WA

DRAFT

PROJECT: CITY OF PASCO – IWWTF

RECORD OF BOREHOLE/WELL NO. MW-06

FILENAME: MW06-03.DWG
SHEET: 3 OF 3
DATUM: GS

PROJECT LOCATION: PASCO, WA
PROJECT NUMBER: 89534
BORING DATE: 2/14/95
BORING LOCATION:

FEET	BORING METHOD	DESCRIPTION	FM/USCS	OVM READING	NUMBER	TYPE	BLOWS/6 in.	REC/ATT	REMARKS
100	AIR ROTARY								
105		105.0 ft. – 115.0 ft.: <u>Fine to Medium Grained Sand with Gravel</u>; black (N, 2.5/), slightly moist to moist, loose, poorly sorted; fine gravel. Sand 60%, Gravel 40%.	SW			GRAB			1348 Drilling resumes; grab sample at 105.0 ft.; moist zone at about 108.0 ft.; collecting sample in 5-gal. bucket for sieve analysis; grab sample at 115.0 ft. 1408 Adding 4.0 ft. casing extension; drove casing to 118.0 ft.; sieve sample – 108.0 ft. – 120.0 ft.
110									1421 Static water level= 113.1 ft. 1440 Static water level= 113.0 ft. 1500 Static water level= 112.9 ft.
115		115.0 ft. – 125.0 ft.: <u>Clayey Silt</u>; brown (10YR, 5/3), wet, slightly plastic. Silt 70%, Clay 30%.	ML			GRAB			1501 Making connection with seventh casing & rod (casing total= 139.75 ft.); plan to drill to 135.0 ft. – 136.0 ft. 1540 Completed welding
120									1544 Drilling resumes at 120.0 ft. (Gravel with Fines). 1555 Cuttings/Water are not discharging between 123.0 ft. – 130.0 ft., casing probably caked with fines.
125		125.0 ft. – 132.0 ft.: <u>Sandy Fine Gravel</u>; black (N, 2.5/), wet, medium dense; fine to coarse grained sand, poorly sorted, subangular, trace of fines. Gravel 50%, Sand 45%, Fines 5%.	GW			GRAB			1610 Cuttings begin discharging; Grab sample estimated to be 125.0 ft.
130		132.0 ft. – 136.0 ft.: <u>Clayey Fine to Coarse Gravel with Sand</u>; black (N2.5/), wet, medium dense; fine to medium grained sand; clay. Gravel 50%, Sand 30%, Clay 20%.	GC			GRAB			1627 Grab sample at 134.0 ft. – 135.0 ft.; drilled to 135.0 ft., circulating. 1640 Tagged bottom at 132.0 ft. 1641 – 1705 Circulating; Removing heaving sands. 2/16/95 0730 Tagged bottom at 128.0 ft. 0802 Drove casing to 136.0 ft. & drilled to 134.0 ft.; circulating. 0820 Tagged bottom at 134.0 ft. T.D.= 134.0 ft. 2/16/95
135									
140									
145									
150									

DRILL RIG: REICHDRILL T625
DRILLING CONTRACTOR: PONDEROSA DRILLING
DRILLER: ROGER KELLY

LOGGED: TERRY MC PHETRIDGE
CHECKED: DWAYNE CRUMPLER
DATE: 5/24/95

RUST ENVIRONMENT & INFRASTRUCTURE
(509) 545-4402 Fax (509) 547-8732 Pasco, WA

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

MONITORING WELL CONSTRUCTION SUMMARY

Project Name: City of Pasco - WWTP
Project No.: 89534

Well No.: MW-07
Boring No.: MW-07
Start Card No.: R-14346

Horizontal Coords: [1]
[2] NW1/4 SW1/4 Section 11 T9N R.30 EWM Franklin Co.

Ground Surface Elevation:
Top of PVC Well Casing:

DEPTH	WELL DETAIL	GENERAL LITH.
0, 15, 30, 45, 60, 75, 90, 105, 120, 135, 150, 165, 180, 195, 210	H2O; CEMENT GROUT; 4 inch PVC BLANK; 20 slot; 10 slot; SAND PACK	

DRILLING SUMMARY

Total Borehole Depth: 197 ft bgs
Borehole Diameter: 8.6-inches
Drilling Contractor: Ponderosa Drilling - Spokane, WA
Driller(s): Roger Kelly
Rig(s): Reichdrill T625
Bit(s): 7 7/8-inch Tricone Roller Bit

TIME LOG

Task	Start Date	Start Time	Finish Date	Finish Time
Drilling Method:				
Air Rotary	3-7	1036	3-8	1300
Geophys. Logging	NA			
Casing	3-14	0959	3-14	1023
Sand Pack	3-14	1027	3-14	1310
Grout	3-15	0741	3-15	1425
Bentonite Seal	3-14	1315	3-14	1320
Development (Start)				
Development (Finish)				

WELL INSTALLATION

Well Design and Specifications Basis:
Geologic Log: ✓ Geophysical Log: ___
Casing Material:
Casing(s): B = blank; S = screen; EC = end cap

Depth (ft)		Casing	Elevation [1] (ft)
43.5	164.08	B	
164.08	179.09	S	
179.09	196.48	B	
196.48	196.8	EC	

Screen Type/Size
Surface Seal (ft):
Mfr/Mtrl/Qty:
Grout Seal (ft): 157.8 to 3 ft bgs
Mfr/Mtrl/Qty: Ash Grove PC (14 #3 65 [illegible]) [illegible] Bent. (gel) 2.5 lbs
Bentonite Seal (ft): 160.9 to 157.8 ft bgs
Mfr/Mtrl/Qty: used 75 lbs Baroid 3/8 inch pellets / 50#
Sand Pack (ft): 197.0 to 160.9 ft bgs
Mfr/Mtrl/Qty: 10-20 [illegible] 197 to 187 → 3 bags; [illegible] 8-16 187 to 160.9 ft bgs → 9 bags
Bottom Seal (ft:) N/A
Mfr/Mtrl/Qty: ______

WELL DEVELOPMENT

Method:
Total Volume Purged:
Starting Level:
Finishing Level:
Stabilization Test Data

Date	Time	Volume	pH	Cond Spec.	Temp (°C)

RECEIVED
[illegible] 5
DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

Comments: [1] Tennison Coordinate System. [2] Oregon State Coordinate System
Stainless steel centralizers placed @ 196 ft, 163 ft, 123 ft, 83 ft, and 43 ft bgs.
- Plugged with a problem w/ heaving sand

See Wellhead Detail for surface construction information.

Date:
Checked by:
Date: 3-16-95
Generated by: [illegible]

RUST ENVIRONMENT & INFRASTRUCTURE

c:\forms\wellsum2.for

MONITORING WELL CONSTRUCTION SUMMARY

Project Name: City of Pasco Wastewater Treatment Facility
Well No.: MW-07
Project No.: 89534
Boring No.: MW-07
Start Card No.: ________

Horizontal Coords: ________
Ground Surface Elevation: ________
Top of PVC Well Casing: ________

DRILLING SUMMARY	TIME LOG				
Total Borehole Depth: 197 ft. bgs		Start		Finish	
Borehole Diameter: 8.6 in.	Task	Date	Time	Date	Time
Drilling Contractor: Ponderosa Drilling -	Drilling Method:				
Spokane, WA	Air Rotary	3/7/95	1036	3/8/95	1300
Driller(s): Roger Kelly					
Rig(s): Reichdrill T625	Geophys. Log.	NA	NA	NA	NA
Rotary (Air)/Casing drive	Casing	3/14/95	0959	3/14/95	1023
Bit(s): 7-7/8 in. Tricone roller bit	Surge Sand Pack	3/14/95	1220	3/14/95	1231
	Sand Pack	3/14/95	1027	3/14/95	1310
	Grout	3/15/95	0741	3/15/95	1425
WELL INSTALLATION	Bentonite Seal	3/14/95	1315	3/14/95	1320
Well Design and Specifications Basis:					
Geologic Log: X Geophysical Log: ___	Development	3/29/95	0731	3/29/95	1207
Casing Material: 4 in., Sched. 80					
Flush-threaded PVC					
Casing(s): B=blank; S=screen; EC=end cap					

Depth (ft)	Casing	Elevation (ft)
+3.50 - 164.08	B	-
164.08 - 194.09	S	-
194.09 - 196.48	B	-
196.48 - 196.80	EC	-
-		-

Screen Type/Size: Environmental Well Products 0.030 in. slot; Sch. 80 PVC
Surface Seal (ft): 3.0 ft. - 0.0 ft.
Mfr/Mtrl/Qty: Pre-Mix Concrete
Grout Seal (ft): 157.8 ft. - 3.0 ft. bgs
Mfr/Mtrl/Qty: Ash Grove P.C. / 94# / 65 bags; Wyo-Ben Big Horn Bent. / 100# / 2.5 bags
Bentonite Seal (ft): 160.9 ft. - 157.8 ft. bgs
Mfr/Mtrl/Qty: Baroid / 3/8 in. / 75 lbs
Sand Pack (ft): 197.0 ft. - 160.9 ft. bgs
Mfr/Mtrl/Qty: CSSI / #10-20 / 3 bags 197.0 ft. - 187.0 ft.; CSSI / #8-12 / 8 bags 187.0 ft. - 160.9 ft.
Bottom Seal (ft:) NA
Mfr/Mtrl/Qty: NA

WELL DEVELOPMENT

Method: Grundfos submersible pump
Total Volume Purged: 41 gallons
Starting Level: 178.55 ft. BTOC
Finishing Level:
Stabilization Test Data

Date	Time	Volume (gal.)	pH	Spec Cond. (µS)	Temp. (°C)
3/29/95	0815	12.0	7.94	325	24.3
3/29/95	1003	4.0	7.72	309	24.1
3/29/95	1045	7.0	7.83	311	24.4
3/29/95	1131	7.5	7.81	311	24.4
3/29/95	1207	10.5	7.80	311	24.5

Comments: Stainless steel centralizers placed at 43.0 ft., 83.0 ft., 123.0 ft., 163.0 ft., and 196.0 ft. bgs. *Please note a problem with heaving sand. See Wellhead Detail for surface construction information.

RUST ENVIRONMENT & INFRASTRUCTURE

C:\WPWIN60\WPDOCS\WCS\WWMW07.WCS 9/12/95

DRAFT

PROJECT: CITY OF PASCO - IWWTF
PROJECT LOCATION: PASCO, WA
PROJECT NUMBER: 89534

RECORD OF BOREHOLE/WELL NO. MW-07

BORING DATE: 3/7/95
BORING LOCATION:

FILENAME: MW07-01.DWG
SHEET: 1 OF 4
DATUM: GS

FEET	BORING METHOD	DESCRIPTION	FM/USCS	OVM READING	SAMPLE NUMBER	SAMPLE TYPE	BLOWS/6 in.	REC/ATT	REMARKS
0	AIR ROTARY	0.0 ft. - 29.0 ft.: Sandy Silt; brown (10YR, 4/3), dry, soft; very fine to fine grained sand, loose, subrounded. Silt, 80%, Sand 20%.	ML						3/7/95 1036 Drilling begins, first casing and rod (casing total= 20.0 ft.)
15						GRAB			1039 Grab sample at 15.0 ft. bgs 1043 Making connection with second casing and rod (casing total= 40.0 ft.) 1133 Completed welding 1142 Drilling resumes at 19.0 ft. bgs
29		29.0 ft. - 42.0 ft.: Silty Very Fine to Fine Grained Sand; brown (10YR, 4/3), dry, loose, moderately well sorted, subrounded. Sand 80%, Silt 20%.	SM						
35						GRAB			1145 Grab sample at 35.0 ft. bgs 1149 Making connection with third casing and rod (casing total= 59.42 ft.) 1235 Completed welding 1250 Drilling resumes at 38.0 ft. bgs
42		42.0 ft. - 50.0 ft.: Silty Very Fine to Fine Grained Sand; very dark grayish brown (2.5Y, 3/2), dry, loose, poorly sorted, subangular to subrounded, trace of medium grained sand. Sand 90%, Silt, 10%.							
45						GRAB			1251 Grab sample at 45.0 ft. bgs
50									

DRILL RIG: REICHDRILL T625
DRILLING CONTRACTOR: PONDEROSA DRILLING
DRILLER: ROGER KELLY
LOGGED: TERRY MC PHETRIDGE
CHECKED: DWAYNE CRUMPLER
DATE: 5/24/95

RUST ENVIRONMENT & INFRASTRUCTURE
(509) 545-4408; Fax (509) 547-8758; Pasco, WA

DRAFT

PROJECT: CITY OF PASCO - IWWTF
PROJECT LOCATION: PASCO, WA
PROJECT NUMBER: 89534

RECORD OF BOREHOLE/WELL NO. MW-07

BORING DATE: 3/7/95
BORING LOCATION:

FILENAME: MW07-02.DWG
SHEET: 2 OF 4
DATUM: GS

FEET	BORING METHOD	DESCRIPTION	FM/USCS	GRAPHIC LOG	OVM READING	NUMBER	TYPE	BLOWS/6 in.	REC/ATT	REMARKS
50	AIR ROTARY	50.0 ft. - 75.0 ft.: <u>Silty Very Fine to Fine Grained Sand</u>; grayish brown (10YR, 5/2), dry, loose, moderately well sorted, subrounded. Sand 70%, Silt 30%.								
55							GRAB			1254 Grab sample at 55.0 ft. bgs 1257 Making connection with fourth casing and rod (casing total= 79.09 ft.) 1335 Completed welding 1340 Drilling resumes at 58.0 ft. bgs
60										
65										
70										
75		75.0 ft. - 86.0 ft.: <u>Silty Sand</u>; as above.	SM				GRAB			1345 Grab sample at 75.0 ft. bgs 1347 Making connection with fifth casing and rod (casing total= 98.88 ft.) 1436 Drilling resumes at 77.0 ft. bgs
80										
85		86.0 ft. - 104.0 ft.: <u>Silty Very Fine to Fine Grained Sand</u>; brown (10YR, 4/3), dry, loose, moderately well sorted, subrounded. Sand 60%, Silt 40%.								
90										
95							GRAB			1442 Grab sample at 95.0 ft. bgs 1443 Making connection with sixth casing and rod (casing total= 118.42 ft.) 1535 Completed welding 1544 Drilling resumes at 96.0 ft. bgs
100										

DRILL RIG: REICHDRILL T625
DRILLING CONTRACTOR: PONDEROSA DRILLING
DRILLER: ROGER KELLY

LOGGED: TERRY MC PHETRIDGE
CHECKED: DWAYNE CRUMPLER
DATE: 5/24/95

RUST ENVIRONMENT & INFRASTRUCTURE
(509) 546-4402 Fax: (509) 547-6752 Pasco, WA

RECORD OF BOREHOLE/WELL NO. MW-07

PROJECT: CITY OF PASCO - IWWTF
PROJECT LOCATION: PASCO, WA
PROJECT NUMBER: 89534
BORING DATE: 3/7/95
BORING LOCATION:
FILENAME: MW07-03.DWG
SHEET: 3 OF 4
DATUM: GS

FEET	BORING METHOD	DESCRIPTION	FM/USCS	GRAPHIC LOG	OVM READING	NUMBER	TYPE	BLOWS/6 in.	REC/ATT	REMARKS
100										
105		104.0 ft. - 125.0 ft.: Silty Fine Grained Sand; grayish brown (2.5Y, 5/2), dry, loose, well sorted, subrounded. Sand 90%, Silt 10%.								
110							GRAB			1549 Grab sample at 110.0 ft. bgs 1554 Making connection with seventh casing and rod (casing total= 138.25 ft.) 1641 Completed welding
115										1645 Drilling resumes at 115.0 ft. bgs
120										
125	AIR ROTARY	125.0 ft. - 131.0 ft.: Silty Sand; as above.	SM				GRAB			1649 Grab sample at 125.0 ft. bgs
130		131.0 ft. - 150.0 ft.: Silty Very Fine to Fine Grained Sand; brown (10YR, 4/3), dry to slightly moist, loose, moderately well sorted, subrounded. Sand 70%, Silt 30%.								
135							GRAB			1653 Grab sample at 135.0 ft. bgs 1700 Stopped for the day; total drilled depth= 136.0 ft. bgs 3/8/95 0745 Making connection with eighth casing and rod (casing total= 158.0 ft. bgs) 0850 Drilling resumes at 136.0 ft. bgs
140										
145										
150										

DRILL RIG: REICHDRILL T625
DRILLING CONTRACTOR: PONDEROSA DRILLING
DRILLER: ROGER KELLY
LOGGED: TERRY MC PHETRIDGE
CHECKED: DWAYNE CRUMPLER
DATE: 5/24/95

RUST ENVIRONMENT & INFRASTRUCTURE
(509) 545-4402 Fax (509) 547-8752 Pasco, WA

DRAFT

RECORD OF BOREHOLE/WELL NO. MW-07

PROJECT: CITY OF PASCO - IWWTF
PROJECT LOCATION: PASCO, WA
PROJECT NUMBER: 89534

BORING DATE: 3/7/95
BORING LOCATION:

FILENAME: MW07-04.DWG
SHEET: 4 OF 4
DATUM: GS

FEET	BORING METHOD	DESCRIPTION	FM/USCS	SAMPLE TYPE	REMARKS
150	AIR ROTARY	150.0 ft. - 170.0 ft.: <u>Silty Sand</u>: as above. Sand 60%, Silt 40%.	SM		
155				GRAB	0855 Grab sample at 155.0 ft. bgs 0903 Making connection with ninth casing and rod (casing total= 177.75 ft.) 0955 Completed welding 1001 Drilling resumes 156.0 ft. bgs
170		170.0 ft. - 174.0 ft.: <u>Silty Sand</u>: as above.		GRAB	1009 Grab sample at 170.0 ft. bgs
174		174.0 ft. - 183.0 ft.: <u>Silty Fine to Medium Grained Sand</u>: dark gray (2.5Y, 4/1), moist, loose, poorly sorted, subangular to subrounded. Sand 80%, Silt 20%.		GRAB	1013 Grab sample at 175.0 ft. bgs; soil moist at 174.0 ft. - 175.0 ft. bgs 1014-1022 Circulating; begin collecting sample (5-gal.) for sieve analysis 1025 Making connection with 4.0 ft. section of casing (casing total= 181.75 ft.) 1117 Completed welding 1122 Drilling resumes at 175.0 ft. bgs 1129 Making connection with tenth casing and rod (casing total= 201.67 ft.) 1216 Completed welding 1221 Drilling resumes at 178.0 ft. bgs
183		183.0 ft. - 197.0 ft.: <u>Sandy Coarse Grained Gravel</u>: grayish brown (10YR, 4/2), wet, very dense, poorly sorted. Gravel 90%, Sand 10%.	GW	GRAB	1232 Grab sample at 185.0 ft. bgs
195					1244 Drilled hole to 197.0 ft. bgs; circulating; letting static water level rise to help clean out hole 1300 Producing water 1325 TRM departs site to deliver sample to laboratory 1400 TRM back at well site, static water level= 178.38 ft. bgs T.D.= 197.0 ft. bgs 3/8/95

DRILL RIG: REICHDRILL T625
DRILLING CONTRACTOR: PONDEROSA DRILLING
DRILLER: ROGER KELLY

LOGGED: TERRY MC PHETRIDGE
CHECKED: DWAYNE CRUMPLER
DATE: 5/24/95

RUST ENVIRONMENT & INFRASTRUCTURE
(509) 545-4402 Fax (509) 547-8782, Pasco, WA

DRAFT

RECORD OF BOREHOLE/WELL NO. MW-08

PROJECT: CITY OF PASCO - IWWTF
PROJECT LOCATION: PASCO, WA
PROJECT NUMBER: 89534
BORING DATE: 3/16/95
BORING LOCATION:
FILENAME: MW08-01.DWG
SHEET: 1 OF 4
DATUM: GS

FEET	BORING METHOD	DESCRIPTION	FM/USCS	GRAPHIC LOG	OVM READING	NUMBER	TYPE	BLOWS/6 in.	REC/ATT	REMARKS
0	AIR ROTARY	0.0 ft. - 36.0 ft.: Sandy Silt; very dark grayish brown, (10YR, 3/2), dry, loose; very fine grained sand, subrounded. Silt 85%, Sand 15%.	ML							3/16/95 1132 Drilling begins; materials: 10-in. I.D. (10.75-in. O.D.) steel casing; bottom 5.0 ft. of schedule 20 (approx. 11-in. O.D. steel casing); 9 7/8-in. tricone roller bit. First casing and rod (casing total= 25.0 ft.)
20							GRAB			1138 Grab sample at 20.0 ft. bgs 1143 Making connection with second casing and rod (casing total= 45.0 ft.) 1254 Completed welding 1310 Drilling resumes
36		36.0 ft. - 50.0 ft.: Silty Very Fine to Fine Grained Sand; dark brown, (10YR, 3/3), dry, loose, moderately well sorted, subrounded, trace of clay. Sand 60%, Silt 35%, Clay 5%.	SM				GRAB			1317 Grab sample at 36.0 ft. 1319 Making connection with third casing and rod (casing total= 65.0 ft.) 1411 Completed welding
42										1417 Drilling resumes at 42.0 ft bgs
49										1425 Harder drilling and driving at 49.0 ft. - 50.0 ft.

DRILL RIG: REICHDRILL T625
DRILLING CONTRACTOR: PONDEROSA DRILLING
DRILLER: ROGER KELLY
LOGGED: TERRY MC PHETRIDGE
CHECKED: DWAYNE CRUMPLER
DATE: 5/24/95

RUST ENVIRONMENT & INFRASTRUCTURE
(509) 545-4402 Fax (509) 547-8752 Pasco, WA

DRAFT

PROJECT: CITY OF PASCO - IWWTF	RECORD OF BOREHOLE/WELL NO. MW-08		FILENAME: MW08-02.DWG
PROJECT LOCATION: PASCO, WA	BORING DATE: 3/16/95		SHEET: 2 OF 4
PROJECT NUMBER: 89534	BORING LOCATION:		DATUM: GS

FEET	BORING METHOD	DESCRIPTION	FM/USCS	GRAPHIC LOG	OVM READING	NUMBER	TYPE	BLOWS/6 in.	REC/ATT	REMARKS
50	AIR ROTARY	50.0 ft. - 70.0 ft.: Silty Fine to Medium Grained Sand: very dark grayish brown, (10YR, 3/2), dry, loose, poorly sorted, subangular to subrounded; trace of fine gravel. Sand 80%, Silt 15%, Gravel 5%.					GRAB			1430 Grab sample at 50.0 ft. bgs 1435 Making connection with fourth casing and rod (casing total= 85.0 ft.) 1440 Before making connection, adding 4.0 ft. casing extension to drive casing down about 1.0 ft. 1450 Making connection; drilled to 63.0 ft. bgs 1515 M. Anderson overseeing activity 1530 Completed welding
55										
60										1536 Drilling resumed at 63.0 ft.
65										
70		70.0 ft. - 83.0 ft.: Silty Fine to Medium Grained Sand: very dark gray, (10YR 3/1), dry, loose, poorly sorted, subangular to subrounded. Sand 80%, Silt 20%.	SM				GRAB			1542 Grab sample at 70.0 ft. bgs
75										
80										
		83.0 ft. - 92.0 ft.: Silty Fine to Medium Grained Sand: dark grayish brown, (10YR, 4/2), dry, loose, poorly sorted, subangular to subrounded; fine gravel; trace of clay. Sand 60%, Silt 25%, Gravel 10%, Clay 5%.					GRAB			1554 Grab sample at 83.0 ft. bgs 1603 Making connection fifth casing and rod (casing total= 105.0 ft.) 1650 Completed welding 1700 Stopped for the day. 3/17/95 0706 Rigging up. 0720 Repair 0726 Drilling resumes at 83.0 ft. bgs
85										
90										
		92.0 ft. - 97.0 ft.: Silty Sand: as above.					GRAB			0742 Grab sample at 93.0 ft. bgs
95										
		97.0 ft. - 110.0 ft.: Sandy Silt: brown, (10YR, 4/3), dry, loose; very fine grained sand, subrounded. Silt 90%. Sand 10%.	ML				GRAB			0748 Grab sample at 97.0 ft. bgs. 0754 Making connection with sixth casing and rod (casing total= 125.0 ft.) 0853 Completed welding
100										

DRILL RIG: REICHDRILL T625	LOGGED: TERRY MC PHETRIDGE	RUST ENVIRONMENT & INFRASTRUCTURE
DRILLING CONTRACTOR: PONDEROSA DRILLING	CHECKED: DWAYNE CRUMPLER	(509) 545-4402; Fax (509) 547-8788, Pasco, WA
DRILLER: ROGER KELLY	DATE: 5/24/95	

DRAFT

PROJECT: CITY OF PASCO - IWWTF

RECORD OF BOREHOLE/WELL NO. MW-08

FILENAME: MW08-03.DWG

PROJECT LOCATION: PASCO, WA

BORING DATE: 3/16/95

SHEET: 3 OF 4

PROJECT NUMBER: 89534

BORING LOCATION: -

DATUM: GS

FEET	BORING METHOD	DESCRIPTION	FM/USCS	GRAPHIC LOG	OVM READING	NUMBER	TYPE	BLOWS/6 in.	REC/ATT	REMARKS
100	AIR ROTARY									
103										0855 Drilling resumes at 103.0 ft. bgs
105			ML							
110		110.0 ft. - 119.0 ft.: <u>Gravelly Fine to Medium Grained Sand</u>; very dark gray, (7.5YR,3/1), dry, loose, poorly sorted, subangular; fine gravel, silt. Sand 70%, Gravel 20%, Silt 10%.	SW				GRAB			0909 Hard driving at 110.0 ft. bgs (tight hole) 0910 Grab sample at 110.0 ft. bgs
115										
119		119.0 ft. - 132.0 ft.: <u>Silty Fine Grained Sand</u>; dark gray, (7.5YR, 4/1), dry, loose, subangular, trace of medium grained sand; trace of fine gravel. Sand 70%, Silt 25%, Gravel 5%.	SM				GRAB			0924 Grab sample at 119.0 ft. bgs 0935 Drilled to 121.0 ft. bgs; circulating 0943 Adding 4.0 ft. extension, drove casing to 123.0 ft. bgs 0950 Making connection with seventh casing and rod (casing total= 145.0 ft.) 1045 Completed welding 1055 Drilling resumes at 123.0 ft. bgs
125										
130										
132		132.0 ft. - 143.0 ft.: <u>Clayey Silt</u>; brown, (10YR, 4/3), dry to slightly moist, soft, slight plasticity. Silt 70%, Clay 30%.	ML				GRAB			1120 Grab sample at 132.0 ft. bgs (clays); potential water at 128.0 ft. bgs
135										
140										1131 Drilled to 140.0 ft.; circulating 1200 Stopped for the day 3/20/95 1044 POH with drill rods 1203 Completed POH with drill rods 1222 - 1543 Welding 8-in. casing and placing down hole (total= 138.07 ft.)
143		143.0 ft. - 165.0 ft.: <u>Gravelly Medium to Coarse Grained Sand</u>; black, (N2.5/), wet, loose, poorly sorted, subangular; fine gravel; trace of silt. Sand 70%, Gravel 25%, Silt 5%.	SW				GRAB			1554 Placing 140.0 ft. of drill rod down hole; 7 7/8-in. Tricone roller bit 1604 Making connection with eighth casing and rod (casing total= 157.7 ft.) 1625 Completed welding 1630 Drilling resumes at 140.0 ft. 1631 Grab sample at 143.0 ft. bgs
145										
150										

DRILL RIG: REICHDRILL T625

LOGGED: TERRY MC PHETRIDGE

DRILLING CONTRACTOR: PONDEROSA DRILLING

CHECKED: DWAYNE CRUMPLER

DRILLER: ROGER KELLY

DATE: 5/24/95

RUST ENVIRONMENT & INFRASTRUCTURE

(509) 545-4402 Fax (509) 547-8758 Pasco, WA

MONITORING WELL CONSTRUCTION SUMMARY

Project Name: City of Pasco Wastewater Treatment Facility
Project No.: 89534

Well No.: MW-08
Boring No.: MW-08
Start Card No.:

Horizontal Coords:
Ground Surface Elevation:
Top of PVC Well Casing:

DRILLING SUMMARY

Total Borehole Depth: 170 ft. bgs
Borehole Diameter: 10.75 in. (0-140 ft.) 8.6 in. (140-170 ft.)
Drilling Contractor: Ponderosa Drilling - Spokane, WA
Driller(s): Roger Kelly
Rig(s): Reichdrill T625
Rotary (Air)/Casing drive
Bit(s): 9-7/8 in. Tricone roller bit (0-140 ft.), 7-7/8 in. Tricone roller bit (140-170 ft.)

TIME LOG

Task	Start Date	Start Time	Finish Date	Finish Time
Drilling Method:				
Air Rotary (10 in.)	3/16/95	1145	3/17/95	1200
Air Rotary (8 in.)	3/20/95	1222	3/21/95	1000
Geophys. Log.	NA	NA	NA	NA
Casing	3/22/95	0801	3/22/95	0820
Surge Sand Pack	3/22/95	1012	3/22/95	1026
Sand Pack	3/14/95	1027	3/14/95	1310
Grout	3/23/95	1120	3/23/95	1412
Bentonite Seal	3/22/95	1323	3/22/95	1340
Development	3/30/95	0809	3/30/95	0855

WELL INSTALLATION

Well Design and Specifications Basis:
Geologic Log: X Geophysical Log: ___
Casing Material: 4 in., Sched. 80 Flush-threaded PVC
Casing(s): B=blank; S=screen; EC=end cap

Depth (ft)		Casing	Elevation (ft)
+2.50	145.89	B	-
145.89	165.90	S	-
165.90	167.80	B	-
167.80	168.00	EC	-

Screen Type/Size: 0.030 in. slot; Sch. 80 PVC
Surface Seal (ft): 3.0 ft. - 0.0 ft. bgs.
Mfr/Mtrl/Qty: Pre-mix concrete
Grout Seal (ft): 132.0 ft. - 3.0 ft. bgs
Mfr/Mtrl/Qty: Ash Grove P.C. / 94# / 50 bags; Wyo-Ben Big Horn Bent. / 100# / 2 bags
Bentonite Seal (ft): 141.9 - 132.0 ft. bgs
Mfr/Mtrl/Qty: Enviroplug / 3/8 in. / 50# / 6bags
Sand Pack (ft): 170.0 ft. - 141.9 ft. bgs
Mfr/Mtrl/Qty: CSSI / #8-12 / 100# / 12 bags
Bottom Seal (ft:) NA
Mfr/Mtrl/Qty: NA

WELL DEVELOPMENT

Method: Grundfos submersible pump
Total Volume Purged: 63.0 gallons
Starting Level: 137.46 BTOC
Finishing Level:
Stabilization Test Data

Date	Time	Volume (gal.)	pH	Spec Cond. (µS)	Temp. (°C)
3/30/95	0809	10.0	7.86	335	22.4
3/30/95	0810	5.0	7.82	323	22.9
3/30/95	0813	5.0	7.83	320	23.4
3/30/95	0815	2.0	7.85	316	23.5
3/30/95	0828	5.0	7.84	316	23.6
3/30/95	0835	15.0	7.83	313	23.6
3/30/95	0846	16.0	7.83	313	23.7
3/30/95	0855	5.0	7.83	312	23.8

Comments: Stainless Steel Centralizers placed about 24.0 ft., 64.0 ft., 104.0 ft., 144.0 ft., and 167.0 ft. bgs. Please note 10-in. steel casing was left in the borehole after a weld broke. The steel casing exists from about 134.0 ft. - 29.0 ft. bgs.

See Wellhead Detail for surface construction information.

RUST ENVIRONMENT & INFRASTRUCTURE

DRAFT

PROJECT: CITY OF PASCO – IWWTF
PROJECT LOCATION: PASCO, WA
PROJECT NUMBER: 89534

RECORD OF BOREHOLE/WELL NO. MW-08

BORING DATE: 3/16/95
BORING LOCATION: -

FILENAME: MW08-04.DWG
SHEET: 4 OF 4
DATUM: GS

FEET	BORING METHOD	DESCRIPTION	FM/USCS	GRAPHIC LOG	OVM READING	NUMBER	TYPE	BLOWS/6 in.	REC/ATT	REMARKS
150–165	AIR ROTARY		SW							1634 Drilled to 155.0 ft. bgs; circulating 1640 8-in. casing dropped to ground surface (1.0 ft below top of 10-in.). Drilled down and pulled drill rods up which brought the 8-in. casing back up. 1715 Stopped for the day; total drill depth= 155.0 ft. bgs; will resume drilling tomorrow. 3/21/95 0730 Measured static water level at 136.5 ft. Sand heaving into casing 0813 Drilling out heaving sand; drilled back to 155.0 ft. bgs and circulating.
165–170	AIR ROTARY	165.0 ft. – 170.0 ft.: <u>Gravelly Fine to Medium Grained Sand</u>; black, (N2.5/), wet, loose, poorly sorted, subangular; fine to coarse gravel; trace of silt. Sand 60%, Gravel 35%, Silt 5%.	SW				GRAB			0830 Making connection with ninth casing and rod (casing total= 177.6 ft.) 0905 Completed welding 0915 Drilling resumes; collecting sample for sieve analysis 0921 Grab sample at 165.0 ft. bgs 0924 Drilled to 170.0 ft. bgs; circulating 0945 Tagged bottom of hole at 169.5 ft. bgs 1000 POH with drill rods; TRM to drop off sample to Shannon & Wilson 1100 Completed POH with drill rods 3/21/95 T.D.= 170.0 ft. bgs
170–200	AIR ROTARY									

DRILL RIG: REICHDRILL T625
DRILLING CONTRACTOR: PONDEROSA DRILLING
DRILLER: ROGER KELLY

LOGGED: TERRY MC PHETRIDGE
CHECKED: DWAYNE CRUMPLER
DATE: 5/24/95

RUST ENVIRONMENT & INFRASTRUCTURE
(509) 545-4402 Fax (509) 547-6732. Pasco, WA

93237

RESOURCE PROTECTION WELL REPORT

START CARD NO R43241

PROJECT NAME City of Pasco Process water reuse facility

COUNTY Franklin

WELL IDENTIFICATION NO MW-9 AFF590

LOCATION NE 1/4 NE 1/4 Sec 2 Twn 9N R 30E

DRILLING METHOD Air Rotary

STREET ADDRESS OF WELL

DRILLER Ronald Sink

FIRM Environmental West Exp

WATER LEVEL ELEVATION 104

SIGNATURE [signature]

GROUND SURFACE ELEVATION

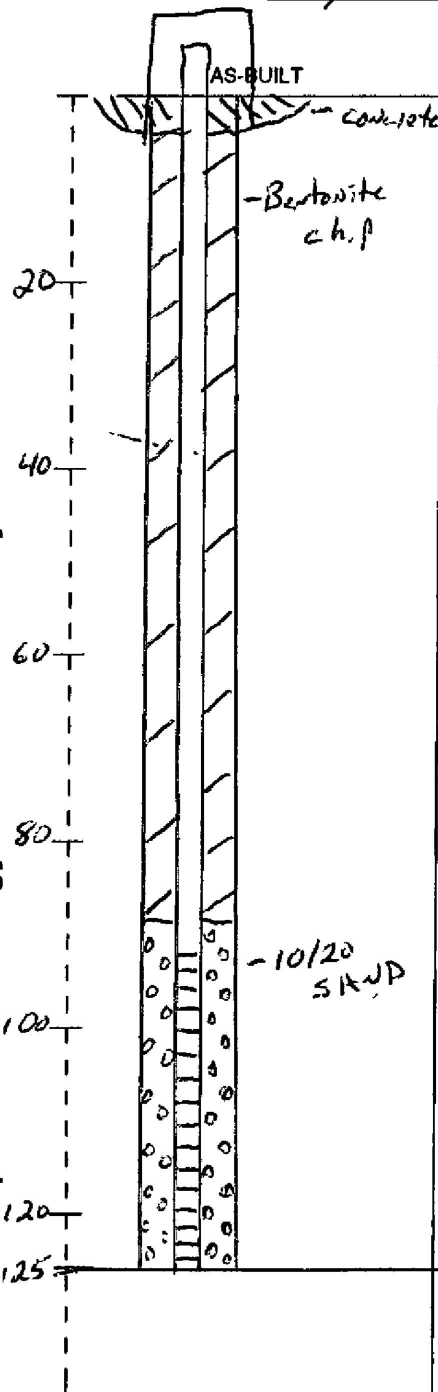
CONSULTING FIRM Landau

INSTALLED 4/16 - 4/18/01

REPRESENTATIVE Ryan Reich

DEVELOPED 4/18/01

AS-BUILT



WELL DATA

Use of Well: Monitor

Bore hole: 9"

Screen: .010 95' to 125' 4" PVC

Casing: +3' to 95' 4" PVC

Sand: 10/20 92' to 125'

Bentonite chps 2' to 92'

FORMATION DESCRIPTION

Depth	Formation
0–30	Fine Sand
30–55	Med. to Coarse Sand
55–63	Sandy gravels
63–67	Silty Sand
67–90	Gravels w/some sand
90–125	Gravely sand

RECEIVED APR 2001 DEPARTMENT OF ECOLOGY EASTERN REGIONAL OFFICE

SCALE 1" = 20'

PAGE 1 OF 1

ECY 050-12 (Rev 11/89)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

Soil Classification System

MAJOR DIVISIONS			GRAPHIC SYMBOL	USCS LETTER SYMBOL[1]	TYPICAL DESCRIPTIONS[2][3]
COARSE-GRAINED SOIL (More than 50% of material is larger than No. 200 sieve size)	GRAVEL AND GRAVELLY SOIL (More than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVEL (Little or no fines)		GW	Well-graded gravel; gravel/sand mixture(s); little or no fines
				GP	Poorly graded gravel; gravel/sand mixture(s); little or no fines
		GRAVEL WITH FINES (Appreciable amount of fines)		GM	Silty gravel; gravel/sand/silt mixture(s)
				GC	Clayey gravel; gravel/sand/clay mixture(s)
	SAND AND SANDY SOIL (More than 50% of coarse fraction passed through No. 4 sieve)	CLEAN SAND (Little or no fines)		SW	Well-graded sand; gravelly sand; little or no fines
				SP	Poorly graded sand; gravelly sand; little or no fines
		SAND WITH FINES (Appreciable amount of fines)		SM	Silty sand; sand/silt mixture(s)
				SC	Clayey sand; sand/clay mixture(s)
FINE-GRAINED SOIL (More than 50% of material is smaller than No. 200 sieve size)	SILT AND CLAY (Liquid limit less than 50)			ML	Inorganic silt and very fine sand; rock flour; silty or clayey fine sand or clayey silt with slight plasticity
				CL	Inorganic clay of low to medium plasticity; gravelly clay; sandy clay; silty clay; lean clay
				OL	Organic silt; organic, silty clay of low plasticity
	SILT AND CLAY (Liquid limit greater than 50)			MH	Inorganic silt; micaceous or diatomaceous fine sand
				CH	Inorganic clay of high plasticity; fat clay
				OH	Organic clay of medium to high plasticity; organic silt
	HIGHLY ORGANIC SOIL			PT	Peat; humus; swamp soil with high organic content

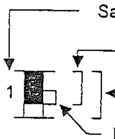
OTHER MATERIALS	GRAPHIC SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
PAVEMENT		AC or PC	Asphalt concrete pavement or Portland cement pavement
ROCK		RK	Rock (See Rock Classification)
WOOD		WD	Wood, lumber, wood chips
DEBRIS		DB	Construction debris, garbage

Notes:
1. USCS letter symbols correspond to the symbols used by the Unified Soil Classification System and ASTM classification methods. Dual letter symbols (e.g., SP-SM) for a sand or gravel indicate a soil with an estimated 5-15% fines. Multiple letter symbols (e.g., ML/CL) indicate borderline or multiple soil classifications.
2. Soil descriptions are based on the general approach presented in the *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*, as outlined in ASTM D 2488. Where laboratory index testing has been conducted, soil classifications are based on the *Standard Test Method for Classification of Soils for Engineering Purposes*, as outlined in ASTM D 2487.
3. Soil description terminology is based on visual estimates (in the absence of laboratory test data) of the percentages of each soil type and is defined as follows:

Primary Constituent:	> 50% - "GRAVEL," "SAND," "SILT," "CLAY," etc.
Secondary Constituents:	> 30% and ≤ 50% - "very gravelly," "very sandy," "very silty," etc.
	> 15% and ≤ 30% - "gravelly," "sandy," "silty," etc.
Additional Constituents:	> 5% and ≤ 15% - "with gravel," "with sand," "with silt," etc.
	≤ 5% - "trace gravel," "trace sand," "trace silt," etc., or not noted.

Drilling and Sampling Key

SAMPLE NUMBER & INTERVAL



SAMPLER TYPE

Code	Description
a	3.25-inch O.D., 2.42-inch I.D. Split Spoon
b	2.00-inch O.D., 1.50-inch I.D. Split Spoon
c	Shelby Tube
d	Grab Sample
e	Other - See text if applicable
1	300-lb Hammer, 30-inch Drop
2	140-lb Hammer, 30-inch Drop
3	Pushed
4	Other - See text if applicable

Groundwater

▽ ATD — Approximate water elevation at time of drilling (ATD) or on date noted. Groundwater levels can fluctuate due to precipitation, seasonal conditions, and other factors.

Field and Lab Test Data

Code	Description
PP = 1.0	Pocket Penetrometer, tsf
TV = 0.5	Torvane, tsf
PID = 100	Photoionization Detector VOC screening, ppm
W = 10	Moisture Content, %
D = 120	Dry Density, pcf
-200 = 60	Material smaller than No. 200 sieve, %
GS	Grain Size - See separate figure for data
AL	Atterberg Limits - See separate figure for data
GT	Other Geotechnical Testing
CA	Chemical Analysis

Landau Associates | City of Pasco | Soil Classification System and Key | Figure A-1

MW-9

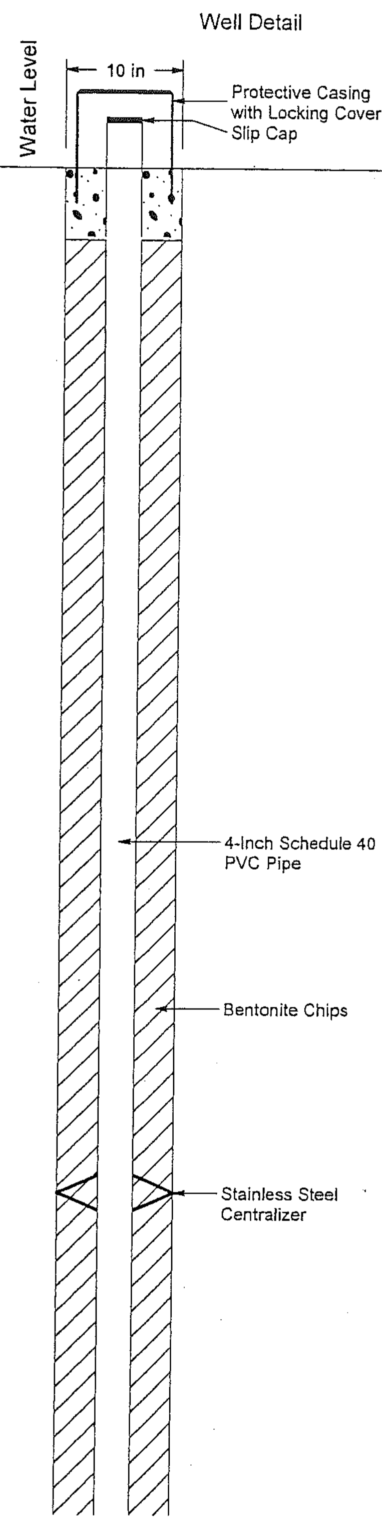
SAMPLE DATA | SOIL PROFILE | GROUNDWATER

Drilling Method: 10-Inch Air Rotary

Ground Elevation (ft):

Drilled By: Environmental West Exploration

Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Description
				SM	Very fine silty SAND, grayish brown, homogeneous (loose, damp)
				ML	Lean SILT, grayish brown, loess with volcanic ash, (damp)
S-1	a2	50/4			Lean SILT, grayish brown, bedded, loess with volcanic ash, (very dense, damp)
				SM	Very fine silty SAND, brown, (damp)
					Very fine silty SAND, brown, (damp)
S-2	a2	50/5.5			Very fine silty SAND, grayish brown, laminated, (very dense, damp)
				ML	
S-3	d				Lean SILT with very fine sand, brown, (damp)
S-4	a2	50/4			Lean SILT interbedded with fine sand, brown, stratified, silt layers are slightly blocky, (very dense, damp)
S-5	d				Lean SILT with very fine sand, brown, (damp)
S-6	a2	68			Lean SILT with very fine sand, brown, homogeneous, (dense, damp)



Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

MW-9

Drilling Method: 10-Inch Air Rotary

Ground Elevation (ft):

Drilled By: Environmental West Exploration

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Description
40					ML	
	S-7	d			SP	Poorly graded coarse SAND with fine gravel, subrounded, brown, (damp)
45					GW	Well graded GRAVEL, subrounded to subangular, grayish brown, (medium dense, damp)
	S-8	a2	50/5		SP	Poorly graded coarse basalt SAND, subrounded, dark gray, (very dense, damp)
50	S-9	d			SW	Well graded SAND with fine gravel, subrounded, grayish brown, (damp)
55	S-10	a2	50/5		SP	Poorly graded medium to coarse basalt SAND, subrounded to subangular, dark gray, homogeneous, (very dense, damp)
60	S-11	d				Poorly graded coarse SAND with fine gravel, subrounded to subangular, (damp)
65	S-12	a2	50/4		GW	Well graded basalt GRAVEL with trace of very fine silty SAND, subrounded to subangular, dark gray, (very dense, damp)
70	S-13	d				Well graded basalt GRAVEL with coarse sand, angular, dark gray
					SM	Fine silty SAND, rounded to subrounded, brown
75	S-14	a2	50/2		GW	Well graded basalt GRAVEL, subrounded to subangular, dark gray, homogeneous, (very dense, damp)
80					SP	

GROUNDWATER — Water Level; Well Detail:

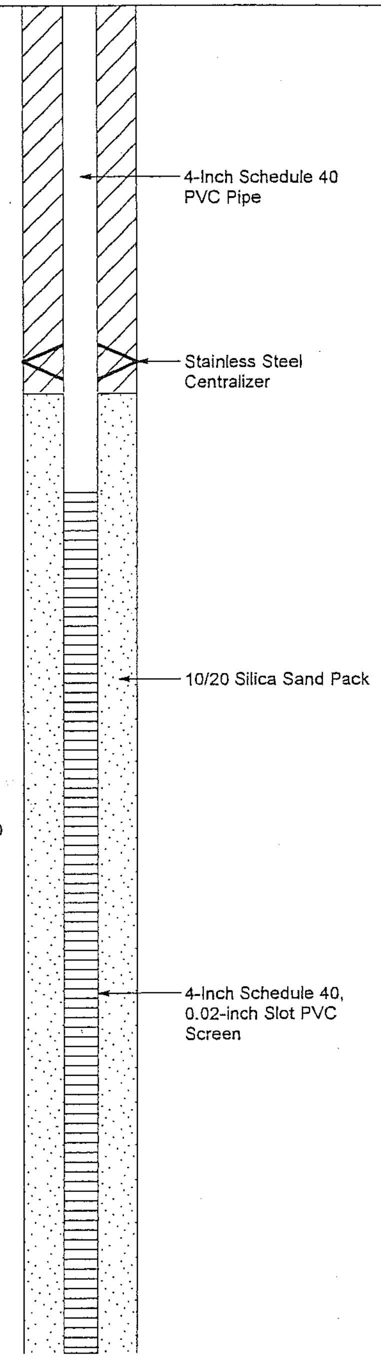
- Bentonite Chips
- Stainless Steel Centralizer
- 4-Inch Schedule 40 PVC Pipe

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

MW-9

SAMPLE DATA					SOIL PROFILE		GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Drilling Method: 10-Inch Air Rotary Ground Elevation (ft): Drilled By: Environmental West Exploration	Water Level
80					SP		
85							
	S-15	a2	83			Poorly graded coarse basalt SAND with gravel, subrounded to subangular, homogeneous, (very dense, damp)	
90							
95							
		a2				Poorly graded coarse basalt SAND with trace of gravel, subangular, dark gray	
100							
	S-16	d				Poorly graded coarse SAND with gravel, subrounded to subangular, grayish brown	
							ATD
105							
110							
	S-17	a2	14			Poorly graded coarse basalt SAND, subangular, dark grayish brown, homogeneous (medium dense, wet)	
115					GP	Poorly graded fine basalt GRAVEL with coarse sand, subrounded to subangular, dark grayish brown	
	S-18	d					
					SP		
120							

Well Detail



Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

9/7/01 C:\PROGRA~1\GINTW\PROJECTS\PASCO.GPJ WELL LOG

Landau Associates

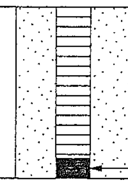
IWWTF Hydrogeologic Study
Pasco, Washington

Log of Boring and Well MW-9

Figure A-2 (3 of 4)

MW-9

SAMPLE DATA					SOIL PROFILE			GROUNDWATER	
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: 10-Inch Air Rotary Ground Elevation (ft): Drilled By: Environmental West Exploration	Water Level	Well Detail
120						SP			
	S-19	d					Poorly graded coarse basalt SAND, subrounded to subangular, dark grayish brown		
	S-20	d							End Cap
125									



Boring Completed 04/17/01
Total Depth of Boring = 125.0 ft.

Well Completed 04/18/01
Total Depth of Well = 125.0 ft.

130

135

140

145

150

155

160

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

Landau Associates	IWWTF Hydrogeologic Study Pasco, Washington	Log of Boring and Well MW-9	Figure A-2 (4 of 4)

Appendix B
Monitoring and Irrigation Well Analytical Data

	Sample Date	Well Name	Static Water Elevation (ft)	pH	TDS (mg/L)	NO_3-N (mg/L)	Ca (mg/L)	K (mg/L)	Mg (mg/L)	Na (mg/L)	Cl (mg/L)	SO_4 (mg/L)	HCO_3 (mg/L)
1	12/5/2017	MW-2	370.82	6.9	558	22.4							
2	12/5/2017	MW-3	392.56	7.1	531	17.7							
3	12/5/2017	MW-4	389.03	7.5	340	10							
4	12/5/2017	MW-5	382.12	7.5	393	11							
5	12/5/2017	MW-6	386.57	7.3	378	9.6							
6	12/5/2017	MW-7	365.05	7.1	635	33.1							
7	12/5/2017	MW-8	373.74	6.7	636	33.6							
8	12/5/2017	MW-9	411.23	7.2	558	26.1							
9	11/2/2017	MW-2	369.92	7.1	595	24.5							
10	11/2/2017	MW-3	391.06	7.3	538	20.5							
11	11/2/2017	MW-4	391.73	7.1	406	10.9							
12	11/2/2017	MW-5	380.62	7.4	496	11.4							
13	11/2/2017	MW-6	385.07	7	493	9.5							
14	11/2/2017	MW-7	363.85	6.9	722	34.3							
15	11/2/2017	MW-8	372.47	6.5	803	35							
16	11/2/2017	MW-9	407.93	7.2	562	26.7							
17	10/5/2017	MW-2	367.92	7.2	573	22.8							
18	10/5/2017	MW-3	389.36	7.6	547	20.1							
19	10/5/2017	MW-4	384.73	7.2	367	8.2							
20	10/5/2017	MW-5	379.82	7.3	439	11.3							
21	10/5/2017	MW-6	384.57	7.2	405	9.7							
22	10/5/2017	MW-7	362.05	7.2	581	34.1							
23	10/5/2017	MW-8	371.69	6.7	692	33.3							
24	10/5/2017	MW-9	407.03	6.9	458	25.3							
25	9/1/2017	MW-2	365.92	7.2	655	26.6							
26	9/1/2017	MW-3	388.76	7.3	569	20.1							
27	9/1/2017	MW-4	383.43	7.3	403	9.3							
28	9/1/2017	MW-5	380.12	7.3	484	11							
29	9/1/2017	MW-6	384.87	7.3	544	9.6							
30	9/1/2017	MW-7	363.25	7.2	701	33.7							
31	9/1/2017	MW-8	371.24	7.1	762	33.3							
32	9/1/2017	MW-9	405.73	7.1	558	26							
33	8/1/2017	MW-2	369.37	7.22	640	25.1							
34	8/1/2017	MW-3	390.54	7.39	569	19.8							
35	8/1/2017	MW-4	385.84	7.47	425	9.1							
36	8/1/2017	MW-5	380.87	7.34	474	10.8							
37	8/1/2017	MW-6	385.77	7.34	426	9.5							
38	8/1/2017	MW-7	363.31	7.17	687	32.7							

	Sample Date	Well Name	Static Water Elevation (ft)	pH	TDS (mg/L)	NO_3-N (mg/L)	Ca (mg/L)	K (mg/L)	Mg (mg/L)	Na (mg/L)	Cl (mg/L)	SO_4 (mg/L)	HCO_3 (mg/L)
39	8/1/2017	MW-8	372.64	7.32	738	32.8							
40	8/1/2017	MW-9	406.88	7.32	649	25.7							
41	7/3/2017	MW-2	376.92	7.32	566	25.1							
42	7/3/2017	MW-3	391.94	7.1	489	20.5							
43	7/3/2017	MW-4	387.95	7.5	414	9.3							
44	7/3/2017	MW-5	382.92	7.4	379	10							
45	7/3/2017	MW-6	387.67	7.2	421	9.6							
46	7/3/2017	MW-7	364.15	7.5	629	34.5							
47	7/3/2017	MW-8	374.69	6.8	667	32.4							
48	7/3/2017	MW-9	410.15	7.2	539	25.6							
49	6/1/2017	MW-2	372.4	7.1	681	27.8							
50	6/1/2017	MW-3	394.73	7.3	577	21.6							
51	6/1/2017	MW-4	389.61	7.4	417	8.7							
52	6/1/2017	MW-5	384.62	7.7	409	8.8							
53	6/1/2017	MW-6	389.25	7.2	433	8.7							
54	6/1/2017	MW-7	365.95	7.3	689	34.2							
55	6/1/2017	MW-8	375.89	6.8	696	33.9							
56	6/1/2017	MW-9	411.53	7.2	572	25.6							
57	5/1/2017	MW-2	374.3	7.28	724	30.7							
58	5/1/2017	MW-3	395.84	7.71	594	22.8							
59	5/1/2017	MW-4	391.03	7.36	466	12							
60	5/1/2017	MW-5	385.6	7.81	431	9.3							
61	5/1/2017	MW-6	389.85	7.69	432	10.1							
62	5/1/2017	MW-7	368.63	7.31	703	38.2							
63	5/1/2017	MW-8	377.52	7.18	760	34.8							
64	5/1/2017	MW-9	412.53	7.73	589	25.1							
65	4/3/2017	MW-2	374.32	7	682	28.2							
66	4/3/2017	MW-3	395.76	6.9	540	19.4							
67	4/3/2017	MW-4	390.73	7.1	407	9.5							
68	4/3/2017	MW-5	385.42	7.1	369	7.8							
69	4/3/2017	MW-6	389.57	7	407	9.2							
70	4/3/2017	MW-7	368.35	7.3	693	33.5							
71	4/3/2017	MW-8	376.64	6.8	755	33.4							
72	4/3/2017	MW-9	412.13	7	554	22.2							
73	3/2/2017	MW-2	373.42	7	641	32.6							
74	3/2/2017	MW-3	394.66	7	524	16.8							
75	3/2/2017	MW-4	389.63	7.4	396	9.9							
76	3/2/2017	MW-5	384.42	7.5	408	8.7							

Appendix B

Monitoring Well Analytical Data

City of Pasco Process Water Reuse Facility

	Sample Date	Well Name	Static Water Elevation (ft)	pH	TDS (mg/L)	NO_3-N (mg/L)	Ca (mg/L)	K (mg/L)	Mg (mg/L)	Na (mg/L)	Cl (mg/L)	SO_4 (mg/L)	HCO_3 (mg/L)
77	3/2/2017	MW-6	388.47	7.6	445	9.7							
78	3/2/2017	MW-7	367.85	6.8	705	33.1							
79	3/2/2017	MW-8	376.24	6.9	747	35.1							
80	3/2/2017	MW-9	411.93	7.5	497	22.4							
81	2/1/2017	MW-2	372.32	7.3	727	28.6							
82	2/1/2017	MW-3	393.76	7.1	692	15.2							
83	2/1/2017	MW-4	388.73	7.1	443	10.7							
84	2/1/2017	MW-5	383.42	7.7	463	9.7							
85	2/1/2017	MW-6	387.67	7.5	470	10.8							
86	2/1/2017	MW-7	366.83	6.9	722	37.8							
87	2/1/2017	MW-8	375.14	6.8	784	37.1							
88	2/1/2017	MW-9	411.53	7.6	607	24.1							
89	1/3/2017	MW-2	371.12	6.8	646	28.7							
90	1/3/2017	MW-3	393.33	6.8	505	16.6							
91	1/3/2017	MW-4	387.8	6.9	391	10.1							
92	1/3/2017	MW-5	382.58	7.5	396	9.2							
93	1/3/2017	MW-6	386.52	6.8	409	10.1							
94	1/3/2017	MW-7	365.99	6.8	641	34.3							
95	1/3/2017	MW-8	373.84	6.7	748	34.9							
96	1/3/2017	MW-9	411.3	6.8	551	25.2							
97	10/1/2016	MW-2	159.85	7.2	722	27.6							
98	10/1/2016	MW-3	120.4	7.1	615	21.4							
99	10/1/2016	MW-4	121.82	7.2	459	9.6							
100	10/1/2016	MW-5	125.27	7.2	488	10.8							
101	10/1/2016	MW-6	113.4	7.1	461	9.2							
102	10/1/2016	MW-7	181	7	738	36							
103	10/1/2016	MW-8	138.18	6.9	779	34.4							
104	10/1/2016	MW-9	111.74	7.5	657	26.5							
105	9/1/2016	MW-2	160.28	7.21	633	24.7							
106	9/1/2016	MW-3	120.27	7.49	545	21.5							
107	9/1/2016	MW-4	121.88	7.47	383	8.3							
108	9/1/2016	MW-5	125.11	7.47	412	10.6							
109	9/1/2016	MW-6	112.83	7.52	428	9.2							
110	9/1/2016	MW-7	181.5	7.45	718	33.7							
111	9/1/2016	MW-8	138.36	6.81	747	34.4							
112	9/1/2016	MW-9	111.8	7.51	590	25.9							
113	8/1/2016	MW-2	159	7.17	605	26.8							
114	8/1/2016	MW-3	119.1	7.16	568	21.2							

Appendix B

Monitoring Well Analytical Data

City of Pasco Process Water Reuse Facility

	Sample Date	Well Name	Static Water Elevation (ft)	pH	TDS (mg/L)	NO_3-N (mg/L)	Ca (mg/L)	K (mg/L)	Mg (mg/L)	Na (mg/L)	Cl (mg/L)	SO_4 (mg/L)	HCO_3 (mg/L)
115	8/1/2016	MW-4	120.34	7.7	403	9.5							
116	8/1/2016	MW-5	123.64	7.71	385	10.1							
117	8/1/2016	MW-6	111.45	7.62	417	9.5							
118	8/1/2016	MW-7	178.5	7.6	721	33.8							
119	8/1/2016	MW-8	137.18	7.34	721	33.8							
120	8/1/2016	MW-9	110.26	7.7	570	26.7							
141	5/2/2016	MW-6		7.35	401	9.5							
142	5/2/2016	MW-7		6.75	680	33							
143	5/2/2016	MW-8		7.31	768	34							
144	5/2/2016	MW-9		7.45	563	24.2							
145	4/1/2016	MW-2		7.15	661	29.7							
146	4/1/2016	MW-3		7.08	556	17.3							
147	4/1/2016	MW-4		7.15	402	9.3							
148	4/1/2016	MW-5		7.67	391	8.1							
149	4/1/2016	MW-6		7.29	404	9.1							
150	4/1/2016	MW-7		6.86	699	32.6							
151	4/1/2016	MW-8		6.93	759	34.4							
152	4/1/2016	MW-9		7.06	563	22.7							
153	3/2/2016	MW-2		7.02	641	32.6							
154	3/2/2016	MW-3		6.98	524	16.8							
155	3/2/2016	MW-4		7.44	396	9.9							
156	3/2/2016	MW-5		7.49	408	8.7							
157	3/2/2016	MW-6		7.57	445	9.7							
158	3/2/2016	MW-7		6.83	705	33.1							
159	3/2/2016	MW-8		6.85	747	35.1							
160	3/2/2016	MW-9		7.45	497	22.4							
181	12/7/2015	MW-6		6.7	413	9.8							
182	12/7/2015	MW-7		7.43	669	32.6							
183	12/7/2015	MW-8		6.9	671	33.9							
184	12/7/2015	MW-9		7.11	587	25.7							
185	11/10/2015	MW-2		7.7	667	30.5							
186	11/10/2015	MW-3		7.24	556	21.2							
187	11/10/2015	MW-4		7.37	402	10.5							
188	11/10/2015	MW-5		7.88	412	9.7							
189	11/10/2015	MW-6		7.91	411	9.7							
190	11/10/2015	MW-7		7.1	726	36.6							
191	11/10/2015	MW-8		7.56	789	37.9							
192	11/10/2015	MW-9		7.77	571	27.3							

Appendix B

Monitoring Well Analytical Data

City of Pasco Process Water Reuse Facility

	Sample Date	Well Name	Static Water Elevation (ft)	pH	TDS (mg/L)	NO_3-N (mg/L)	Ca (mg/L)	K (mg/L)	Mg (mg/L)	Na (mg/L)	Cl (mg/L)	SO_4 (mg/L)	HCO_3 (mg/L)
193	10/6/2015	MW-2		7.46	713	28.1							
194	10/6/2015	MW-3		7.12	570	20.2							
195	10/6/2015	MW-4		7.72	424	10.1							
196	10/6/2015	MW-5		7.7	416	10.1							
197	10/6/2015	MW-6		7.14	403	10.2							
198	10/6/2015	MW-7		7.14	704	36							
199	10/6/2015	MW-8		7.08	749	34.5							
200	10/6/2015	MW-9		7.73	625	25.2							
221	7/6/2015	MW-6		7.24	403	8.9							
222	7/6/2015	MW-7		7.42	723	31.1							
223	7/6/2015	MW-8		6.91	781	32.8							
224	7/6/2015	MW-9		7.25	618	25.5							
225	6/9/2015	MW-1			749	38.8							
226	6/9/2015	MW-2			624	25.2							
227	6/9/2015	MW-3			559	18.9							
228	6/9/2015	MW-4			417	9							
229	6/9/2015	MW-5			390	7.9							
230	6/9/2015	MW-6			420	8.9							
231	6/9/2015	MW-7			763	29.2							
232	6/9/2015	MW-8			719	30.2							
233	6/9/2015	MW-9			565	21.8							
234	5/14/2015	MW-1		7.54	573	30.9	95	5.3	32.2	32.1	71.2	70.2	139.4
235	5/14/2015	MW-2		7.52	510	25.9	81.4	8.5	31.3	35.9	44.9	86.3	190.1
236	5/14/2015	MW-3		7.69	516	19.6	81.5	7.3	31.6	34.2	65	92.1	190.4
237	5/14/2015	MW-4		7.41	396	10	58.9	7.1	24.3	29.8	21.7	53.8	200.6
238	5/14/2015	MW-5		7.37	369	8	56.2	6.9	22.6	29	18.8	48.2	240.1
239	5/14/2015	MW-6		7.06	390	9.6	58.8	7.1	22.1	32.7	23.7	58.1	198.5
240	5/14/2015	MW-7		7.11	582	29.6	90.2	8.4	34.9	36.2	60.8	96.5	179.8
261	2/9/2015	MW-1		7.51	772	44.1							
262	2/9/2015	MW-2		7.01	730	30.8							
263	2/9/2015	MW-3		7.49	570	16.3							
264	2/9/2015	MW-4		7.1	455	9.3							
265	2/9/2015	MW-5		7.08	398	8.6							
266	2/9/2015	MW-6		6.98	459	9.5							
267	2/9/2015	MW-7		7.4	875	34.3							
268	2/9/2015	MW-8		6.81	801	34.8							
269	2/9/2015	MW-9		7.64	532	20.4							
270	1/14/2015	MW-1			709	40.1							

Appendix B

Monitoring Well Analytical Data

City of Pasco Process Water Reuse Facility

	Sample Date	Well Name	Static Water Elevation (ft)	pH	TDS (mg/L)	NO_3-N (mg/L)	Ca (mg/L)	K (mg/L)	Mg (mg/L)	Na (mg/L)	Cl (mg/L)	SO_4 (mg/L)	HCO_3 (mg/L)
271	1/14/2015	MW-2			656	32.6							
272	1/14/2015	MW-3			654	16.7							
273	1/14/2015	MW-4			403	9.5							
274	1/14/2015	MW-5			376	9.3							
275	1/14/2015	MW-6			387	9.9							
276	1/14/2015	MW-7			755	36.2							
277	1/14/2015	MW-8			724	35.5							
278	1/14/2015	MW-9			538	21.7							
279	12/12/2014	MW-1			697	40.4							
280	12/12/2014	MW-2			655	29.8							
301	10/9/2014	MW-5			386	8.4							
302	10/9/2014	MW-6			385	8.3							
303	10/9/2014	MW-7			662	32.5							
304	10/9/2014	MW-8			676	30.9							
305	10/9/2014	MW-9			531	22.8							
306	9/9/2014	MW-1			573	32.4							
307	9/9/2014	MW-2			540	24.7							
308	9/9/2014	MW-3			506	18.8							
309	9/9/2014	MW-4			408	8.92							
310	9/9/2014	MW-5			413	9.15							
311	9/9/2014	MW-6			389	9							
312	9/9/2014	MW-7			559	29.1							
313	9/9/2014	MW-8			560	29.2							
314	9/9/2014	MW-9			517	24.1							
315	8/12/2014	MW-1		7.35	566	31.7							
316	8/12/2014	MW-2		7.03	528	23.5							
317	8/12/2014	MW-3		7.44	504	19							
318	8/12/2014	MW-4		7.62	425	9.49							
319	8/12/2014	MW-5		7.58	409	9.31							
320	8/12/2014	MW-6		7.58	395	9.2							
341	6/17/2014	MW-9			622	22							
342	5/15/2014	MW-1		6.81	676	41.4	92.3	6.3	30.9	31.6	69.1	69.2	142.3
343	5/15/2014	MW-2		7.17	590	31.7	82.5	9.9	30.4	35.2	47	87.7	188.4
344	5/15/2014	MW-3		7.61	537	19.9	74.9	7.8	28.3	30.7	32.8	73.7	193.6
345	5/15/2014	MW-4		7.61	433	10.3	63.9	7.8	24.4	28.7	23.7	60.2	199.6
346	5/15/2014	MW-5		7.55	373	7.1	57.8	7.4	22.5	27.1	20.3	49.8	238.8
347	5/15/2014	MW-6		7.58	407	8.5	58	7.3	21.1	29.8	22.4	55.7	193.7
348	5/15/2014	MW-7		7.49	760	33.6	88.6	9	34	34.5	62.2	93.4	170.5

Appendix B

Monitoring Well Analytical Data

City of Pasco Process Water Reuse Facility

	Sample Date	Well Name	Static Water Elevation (ft)	pH	TDS (mg/L)	NO_3-N (mg/L)	Ca (mg/L)	K (mg/L)	Mg (mg/L)	Na (mg/L)	Cl (mg/L)	SO_4 (mg/L)	HCO_3 (mg/L)
349	5/15/2014	MW-8		7.53	697	34.9	89.1	8.9	35.6	35.7	54.2	98.5	161.5
350	5/15/2014	MW-9		7.64	527	33.2	73.1	8	31.4	33.6	35	74.4	200.2
351	4/15/2014	MW-1			754	36.4							
352	4/15/2014	MW-2			622	25.6							
353	4/15/2014	MW-3			597	18.9							
354	4/15/2014	MW-4			434	8.9							
355	4/15/2014	MW-5			396	6.9							
356	4/15/2014	MW-6			408	8.4							
357	4/15/2014	MW-7			771	31.6							
358	4/15/2014	MW-8			748	31.7							
359	4/15/2014	MW-9			408	8.4							
360	3/27/2014	MW-1			644	35.9							
381	1/13/2014	MW-4			403	7.8							
382	1/13/2014	MW-5			390	7.2							
383	1/13/2014	MW-6			396	7.5							
384	1/13/2014	MW-7			682	27.1							
385	1/13/2014	MW-8			720	27.6							
386	1/13/2014	MW-9			510	18.1							
387	12/23/2013	MW-1			693	46.1							
388	12/23/2013	MW-2			605	23.8							
389	12/23/2013	MW-3			508	13.8							
390	12/23/2013	MW-4			422	8.3							
391	12/23/2013	MW-5			401	7.9							
392	12/23/2013	MW-6			424	7.9							
393	12/23/2013	MW-7			691	30.5							
394	12/23/2013	MW-8			701	28.9							
395	12/23/2013	MW-9			578	21.1							
396	11/5/2013	MW-1		6.85	508	33.2	86.2	5.8	31.7	36	65.5	65.7	145.2
397	11/5/2013	MW-2		7.45	506	26	73.4	8.6	32.1	41.8	45.2	75.4	192.5
398	11/5/2013	MW-3		7.62	481	17.7	65.2	7.9	29.3	38.2	30.9	73.2	207.8
399	11/5/2013	MW-4		7.67	382	11.3	67.8	8.2	24.2	35	25.4	53.8	223
400	11/5/2013	MW-5		7.68	406	10	55.8	7.5	23.9	33.5	21.1	51.5	245.1
421	9/16/2013	MW-8			657	36.2							
422	9/16/2013	MW-9			569	35.7							
423	8/15/2013	MW-1		6.57	793	42.2							
424	8/15/2013	MW-2		6.92	675	25.6							
425	8/15/2013	MW-3		7.42	611	21.1							
426	8/15/2013	MW-4		7.09	434	8.7							

Appendix B

Monitoring Well Analytical Data

City of Pasco Process Water Reuse Facility

	Sample Date	Well Name	Static Water Elevation (ft)	pH	TDS (mg/L)	NO_3-N (mg/L)	Ca (mg/L)	K (mg/L)	Mg (mg/L)	Na (mg/L)	Cl (mg/L)	SO_4 (mg/L)	HCO_3 (mg/L)
427	8/15/2013	MW-5		7.09	402	9.4							
428	8/15/2013	MW-6		7.43	441	8.2							
429	8/15/2013	MW-7		6.97	729	32.5							
430	8/15/2013	MW-8		7.35	798	32.7							
431	8/15/2013	MW-9		7.48	598	32.5							
432	7/15/2013	MW-1			724	43.2							
433	7/15/2013	MW-2			630	26.2							
434	7/15/2013	MW-3			516	22							
435	7/15/2013	MW-4			406	9.6							
436	7/15/2013	MW-5			394	9.2							
437	7/15/2013	MW-6			412	8.8							
438	7/15/2013	MW-7			685	33.5							
439	7/15/2013	MW-8			710	33.8							
440	7/15/2013	MW-9			580	26.7							
461	4/15/2013	MW-3			562	17							
462	4/15/2013	MW-4			429	9.3							
463	4/15/2013	MW-5			392	7.6							
464	4/15/2013	MW-6			404	7.9							
465	4/15/2013	MW-7			689	32							
466	4/15/2013	MW-8			710	31.8							
467	4/15/2013	MW-9			533	22.3							
468	3/12/2013	MW-1			488	35.9							
469	3/12/2013	MW-2			454	26.1							
470	3/12/2013	MW-3			419	16.5							
471	3/12/2013	MW-4			387	8.7							
472	3/12/2013	MW-5			351	8							
473	3/12/2013	MW-6			278	8							
474	3/12/2013	MW-7			582	30.9							
475	3/12/2013	MW-8			558	32.2							
476	3/12/2013	MW-9			449	33.4							
477	2/12/2013	MW-1		6.56	612	38.3							
478	2/12/2013	MW-2		6.73	484	27.9							
479	2/12/2013	MW-3		6.37	443	16.3							
480	2/12/2013	MW-4		7.03	340	9.3							
501	12/4/2012	MW-7			679	33							
502	12/4/2012	MW-8			685	33.4							
503	12/4/2012	MW-9			573	33.3							
504	11/7/2012	MW-1		6.79	625	40.9	88.6	6.5	30.9	34.4	65	69.3	144

Appendix B

Monitoring Well Analytical Data

City of Pasco Process Water Reuse Facility

	Sample Date	Well Name	Static Water Elevation (ft)	pH	TDS (mg/L)	NO_3-N (mg/L)	Ca (mg/L)	K (mg/L)	Mg (mg/L)	Na (mg/L)	Cl (mg/L)	SO_4 (mg/L)	HCO_3 (mg/L)
505	11/7/2012	MW-2		6.79	551	26.8	79.5	10.1	31.7	39.2	48.6	88.8	190.4
506	11/7/2012	MW-3		6.77	463	19.3	71.3	8.2	27.9	34.7	32	72.8	214.8
507	11/7/2012	MW-4		6.88	387	9.5	58.1	8.5	24.9	2.2	20.6	57.8	227
508	11/7/2012	MW-5		6.94	413	9.3	58.7	8.4	25.1	31.8	20.2	29.3	239.2
509	11/7/2012	MW-6		7.02	407	8.5	55.6	8.2	22.4	34.1	23.4	59.1	229.4
510	11/7/2012	MW-7		6.52	637	33.4	87.2	9.8	34.5	38.3	58.6	96.6	173.3
511	11/7/2012	MW-8		6.95	630	33.4	89.6	9.8	36	38.5	57.8	104.6	175.7
512	11/7/2012	MW-9		6.92	526	33.6	82.6	9.1	33	36.4	39.6	83.2	205
513	10/15/2012	MW-1			656	40.9							
514	10/15/2012	MW-2			497	26.5							
515	10/15/2012	MW-3			440	20.6							
516	10/15/2012	MW-4			349	9.5							
517	10/15/2012	MW-5			376	9.9							
518	10/15/2012	MW-6			394	9							
519	10/15/2012	MW-7			604	34.4							
520	10/15/2012	MW-8			611	35.2							
541	7/3/2012	MW-2			552	26.4							
542	7/3/2012	MW-3			462	22.4							
543	7/3/2012	MW-4			478	9.9							
544	7/3/2012	MW-5			387	9.1							
545	7/3/2012	MW-6			398	8.8							
546	7/3/2012	MW-7			718	34.8							
547	7/3/2012	MW-8			799	35.8							
548	7/3/2012	MW-9			694	35.8							
549	6/18/2012	MW-1			617	40.5							
550	6/18/2012	MW-2			521	26.7							
551	6/18/2012	MW-3			522	20.6							
552	6/18/2012	MW-4			388	9.7							
553	6/18/2012	MW-5			370	8.6							
554	6/18/2012	MW-6			352	8.7							
555	6/18/2012	MW-7			611	34							
556	6/18/2012	MW-8			598	35.2							
557	6/18/2012	MW-9			509	35.2							
558	5/8/2012	MW-1		7.22	625	33	90.3	7	30.8	35	64.1	67.5	138
559	5/8/2012	MW-2		7.33	555	22.1	77.9	10.3	29.9	39.1	40.8	85.2	192.6
560	5/8/2012	MW-3		7.41	523	16.9	71.8	8.2	27.9	35	30.3	73.5	201.7
581	3/15/2012	MW-6			396	7.8							
582	3/15/2012	MW-7			676	28.3							

Appendix B

Monitoring Well Analytical Data

City of Pasco Process Water Reuse Facility

	Sample Date	Well Name	Static Water Elevation (ft)	pH	TDS (mg/L)	NO_3-N (mg/L)	Ca (mg/L)	K (mg/L)	Mg (mg/L)	Na (mg/L)	Cl (mg/L)	SO_4 (mg/L)	HCO_3 (mg/L)
583	3/15/2012	MW-8			690	31							
584	3/15/2012	MW-9			554	20.6							
585	2/9/2012	MW-1		6.89	713	40.6							
586	2/9/2012	MW-2		7.3	600	27.1							
587	2/9/2012	MW-3		7.19	445	14.1							
588	2/9/2012	MW-4		7.6	383	9.8							
589	2/9/2012	MW-5		7.48	378	9.2							
590	2/9/2012	MW-6		7.54	405	9.3							
591	2/9/2012	MW-7		7.33	707	34.6							
592	2/9/2012	MW-8		6.76	757	35.5							
593	2/9/2012	MW-9		7.67	537	35.4							
594	1/10/2012	MW-1			651	37.2							
595	1/10/2012	MW-2			631	26.9							
596	1/10/2012	MW-3			461	13.8							
597	1/10/2012	MW-4			387	9.2							
598	1/10/2012	MW-5			382	8.7							
599	1/10/2012	MW-6			383	8.5							
600	1/10/2012	MW-7			593	32							
641	8/1/2011	MW-3		7.24	487	22.1							
642	8/1/2011	MW-4		7.6	447	9.5							
643	8/1/2011	MW-5		7.26	410	10.5							
644	8/1/2011	MW-6		7.66	377	8.7							
645	8/1/2011	MW-7		7.41	589	32.9							
646	8/1/2011	MW-8		6.81	660	36.7							
647	8/1/2011	MW-9		7.7	547	27.6							
648	7/1/2011	MW-1			570	40.4							
649	7/1/2011	MW-2			548	26.2							
650	7/1/2011	MW-3			464	20.2							
651	7/1/2011	MW-4			352	8.5							
652	7/1/2011	MW-5			362	7.8							
653	7/1/2011	MW-6			328	7.3							
654	7/1/2011	MW-7			615	33.7							
655	7/1/2011	MW-8			609	34							
656	7/1/2011	MW-9			538	23.2							
657	6/1/2011	MW-1			759	39.7							
658	6/1/2011	MW-2			628	25.8							
659	6/1/2011	MW-3			520	17.1							
660	6/1/2011	MW-4			436	10.2							

	Sample Date	Well Name	Static Water Elevation (ft)	pH	TDS (mg/L)	NO_3-N (mg/L)	Ca (mg/L)	K (mg/L)	Mg (mg/L)	Na (mg/L)	Cl (mg/L)	SO_4 (mg/L)	HCO_3 (mg/L)
701	2/1/2011	MW-9		6.44	541	21.3							
702	1/1/2011	MW-1			549	38							
703	1/1/2011	MW-2			503	27							
704	1/1/2011	MW-3			449	13.5							
705	1/1/2011	MW-4			341	9.5							
706	1/1/2011	MW-5			307	8.8							
707	1/1/2011	MW-6			345	8.8							
708	1/1/2011	MW-7			594	34.1							
709	1/1/2011	MW-8			614	34.6							
710	1/1/2011	MW-9			461	23.4							
711	12/1/2010	MW-1			609	39.4							
712	12/1/2010	MW-2			675	27.2							
713	12/1/2010	MW-3			551	16.1							
714	12/1/2010	MW-4			443	10.8							
715	12/1/2010	MW-5			413	9.2							
716	12/1/2010	MW-6			405	9.1							
717	12/1/2010	MW-7			772	36.2							
718	12/1/2010	MW-8			574	35.9							
719	12/1/2010	MW-9			622	26.2							
720	11/1/2010	MW-1		7.3	572	39.9	88.2	5.3	30	33.6	69	66.5	142
761	7/1/2010	MW-6			360	8.4							
762	7/1/2010	MW-7			678	32							
763	7/1/2010	MW-8			648	39.6							
764	7/1/2010	MW-9			540	25.2							
765	6/1/2010	MW-1			612	41.1							
766	6/1/2010	MW-2			604	29.7							
767	6/1/2010	MW-3			530	23.2							
768	6/1/2010	MW-4			430	11.4							
769	6/1/2010	MW-5			438	11							
770	6/1/2010	MW-6			404	10.7							
771	6/1/2010	MW-7			620	38.6							
772	6/1/2010	MW-8			619	42.2							
773	6/1/2010	MW-9			537	32.2							
774	5/1/2010	MW-1		6.78	606	38.7	88.3	5.1	30.3	34.4	68.4	63.3	140.3
775	5/1/2010	MW-2		6.91	516	27	73.1	8.4	29.3	38	46	78.3	194
776	5/1/2010	MW-3		7.07	462	22.8	71	6.8	29.3	34.5	34.5	69.6	212.3
777	5/1/2010	MW-4		7.69	388	12.7	58.7	6.8	24.7	32.8	25.5	56.1	228.2
778	5/1/2010	MW-5		7.54	366	8.9	53.5	6.5	23.7	31.4	21	50.1	227

Appendix B

Monitoring Well Analytical Data

City of Pasco Process Water Reuse Facility

	Sample Date	Well Name	Static Water Elevation (ft)	pH	TDS (mg/L)	NO_3-N (mg/L)	Ca (mg/L)	K (mg/L)	Mg (mg/L)	Na (mg/L)	Cl (mg/L)	SO_4 (mg/L)	HCO_3 (mg/L)
779	5/1/2010	MW-6		7.31	378	9.5	55.1	6.4	22.6	34.5	25	54.3	223.3
780	5/1/2010	MW-7		7.06	564	35.2	79.8	7.7	32.9	36.8	55.5	89.3	170.4
821	12/1/2009	MW-3			360	14.9							
822	12/1/2009	MW-4			334	10.2							
823	12/1/2009	MW-5			272	9							
824	12/1/2009	MW-6			317	8.3							
825	12/1/2009	MW-7			410	33.4							
826	12/1/2009	MW-8			434	35.4							
827	12/1/2009	MW-9			415	28.9							
828	11/1/2009	MW-1		7.46	655	39.3	88.2	5.3	30	33.6	69	66.5	142
829	11/1/2009	MW-2		7.31	509	24.6	78.2	8	29.4	37.4	49.4	86.4	192.8
830	11/1/2009	MW-3		7.44	472	16.8	69.8	6.6	30.2	34.2	33.2	72.6	216.7
831	11/1/2009	MW-4		7.53	403	9.8	59.6	6.9	23.8	32.4	25	55	228.2
832	11/1/2009	MW-5		7.86	392	8.7	59.1	6.7	23.7	21.4	23	54.8	228.2
833	11/1/2009	MW-6		7.61	385	8.2	58.6	6.7	22.5	35.3	26.3	57.8	224.5
834	11/1/2009	MW-7		7.47	596	34.8	88	8	33.8	37.7	58.6	93.8	163.5
835	11/1/2009	MW-8		7.09	634	36.4	89.9	8	34.8	37.5	54.8	96.2	166
836	11/1/2009	MW-9		7.75	539	30.9	81.8	7.6	33	35	36	80.5	205
837	10/1/2009	MW-1			598	38.9							

Notes:

Ca = calcium

Cl = chloride

ft = foot/feet

HCO_3 = bicarbonate

K = potassium

Mg = magnesium

mg/L = milligram(s) per liter

Na = sodium

NO_3-N = nitrate as nitrogen

pH = a measure of the acidity or alkalinity of a solution

SO_4 = sulfate

TDS = total dissolved solids

Appendix B

Irrigation Well Analytical Data

City of Pasco Process Water Reuse Facility

	Sample Date	Well Name	TDS (mg/L)	NO_3-N (mg/L)
1	8/17/2017	IW-1	317	10.3
2	8/17/2017	IW-2	532	10.9
3	8/17/2017	IW-3	591	10.2
4	8/17/2017	IW-4	376	11
5	8/17/2017	IW-5	548	10.1
6	8/17/2017	IW-6-9	568	17.6
7	8/17/2017	IW-7	627	31.6
8	8/17/2017	IW-8-10	538	26.8
9	8/17/2017	IW-11-13	559	27.7
10	8/17/2017	IW-12	678	30.2
11	8/17/2017	IW-15	456	11.1
12	7/1/2016	IW-1	384	10
13	7/1/2016	IW-2	407	10.5
14	7/1/2016	IW-3	381	9.5
15	7/1/2016	IW-4	361	9.8
16	7/1/2016	IW-5	371	9.6
17	7/1/2016	IW-6-9	478	17.8
18	7/1/2016	IW-7	699	33.1
19	7/1/2016	IW-8-10	589	27
20	7/1/2016	IW-11-13	513	21.8
21	7/1/2016	IW-12	521	22.4
22	7/1/2016	IW-15	395	9.4
23	9/10/2015	IW-3	389	11.1
24	8/18/2015	IW-2	382	11.2
25	8/10/2015	IW-11-13	543	27.6
26	8/7/2015	IW-1	403	10
27	8/7/2015	IW-4	378	9.93
28	8/7/2015	IW-5	351	9.74
29	8/7/2015	IW-6-9	434	17.3
30	8/7/2015	IW-7	579	26.5
31	8/7/2015	IW-8-10	525	24
32	8/7/2015	IW-12	526	23.3
33	8/7/2015	IW-15	396	10.5
34	8/14/2014	IW-1	380	9.2
35	8/14/2014	IW-2	373	10
36	8/14/2014	IW-3	382	9.17
37	8/14/2014	IW-4	365	9.2
38	8/14/2014	IW-5	334	9.31
39	8/14/2014	IW-6-9	441	18
40	8/14/2014	IW-7	582	31.6
41	8/14/2014	IW-8-10	542	28
42	8/14/2014	IW-11-13	525	25.3
43	8/14/2014	IW-12	564	24.4
44	8/14/2014	IW-15	405	10.7
45	8/21/2013	IW-6-9	468	15.7
46	8/21/2013	IW-11-13	524	22.5
47	8/20/2013	IW-15	408	9.3
48	8/19/2013	IW-3	412	9.82
49	8/19/2013	IW-7	585	27.9
50	8/15/2013	IW-2	404	9.13
51	8/15/2013	IW-8-10	526	24.2

Appendix B

Irrigation Well Analytical Data

City of Pasco Process Water Reuse Facility

	Sample Date	Well Name	TDS (mg/L)	NO_3-N (mg/L)
52	8/13/2013	IW-1	408	8.81
53	8/13/2013	IW-4	392	7.56
54	8/13/2013	IW-5	399	8.56
55	8/13/2013	IW-12	519	21.9
56	8/14/2012	IW-1	384	9.57
57	8/14/2012	IW-2	364	9.48
58	8/14/2012	IW-3	380	8.91
59	8/14/2012	IW-4	344	3.39
60	8/14/2012	IW-5	320	8.67
61	8/14/2012	IW-6-9	412	15.2
62	8/14/2012	IW-7	560	21.6
63	8/14/2012	IW-8-10	496	20.4
64	8/14/2012	IW-11-13	532	21.3
65	8/14/2012	IW-15	400	10.8
66	8/8/2011	IW-15	389	9.9
67	8/1/2011	IW-1	433	9.5
68	8/1/2011	IW-2	458	13.2
69	8/1/2011	IW-3	416	11.4
70	8/1/2011	IW-4	436	10.4
71	8/1/2011	IW-5	422	12.3
72	8/1/2011	IW-6-9	524	18.7
73	8/1/2011	IW-7	749	39.1
74	8/1/2011	IW-8-10	643	28.8
75	8/1/2011	IW-11-13	615	31.8
76	8/12/2010	IW-6-9	494	10.4
77	8/5/2010	IW-1	448	10.7
78	8/5/2010	IW-2	452	10.9
79	8/5/2010	IW-4	424	9.7
80	8/5/2010	IW-15	468	11.4
81	8/4/2010	IW-3	424	10.4
82	8/4/2010	IW-5	444	9.8
83	8/4/2010	IW-7	680	29.8
84	8/4/2010	IW-8-10	580	24.7
85	8/4/2010	IW-11-13	600	24.5

Notes:

mg/L = milligram(s) per liter

NO_3-N = nitrate as nitrogen

TDS = total dissolved solids

Appendix C
PWRF Effluent Sampling Data 2016

Appendix C

Process Water Reuse Facility Effluent Sampling Data 2016

City of Pasco Process Water Reuse Facility

Analyte	IPST Flow (mgd)	NO_2+NO3-N (mg/L)	TDS (mg/L)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Chloride (Cl)	Sulfate (SO4)	Alkalinity as CaCO3	Total Phosphorus (P)
Method		**SM 4500 NO3 F**	**SM 2540 C**							
MRL		**0.1**	**20**							
6/9/2016	1.776	0.26	754							
6/16/2016	1.707	0.34	818							
6/23/2016	2.045	0.29	975							
6/30/2016	2.421	0.16	852							
7/7/2016	2.351	0.2	806							
7/21/2016	2.735	0.32	771							
7/28/2016	5.663	0.32	771							
8/4/2016	5.606	0.23	988							
8/18/2016	2.675	0.47	1,005							
8/25/2016	4.072	0.41	974							
9/1/2016	4.986	0.41	794							
9/8/2016	3.428	0.33	771	65.2	27.1	42.2	39.4	36.7	ND	4.2
9/15/2016	3.043	0.38	639							
9/22/2016	3.446	0.22	773							
9/29/2016	3.546	0.34	755							
10/6/2016	3.440	0.55	756							
10/13/2016	4.245	0.56	805							
10/20/2016	3.079	0.56	805							
10/27/2017	1.292	0.92	472							

	Flow	NO_2+NO3-N	TDS							
	mgd	**mg/L**	**mg/L**							
Average	3.348	0.35	823							
Median	3.254	0.34	800							
Maximum	5.663	0.56	1,005							
Minimum	1.707	0.16	639							

Notes:

mgd = million gallons per day

mg/L = milligram(s) per liter

MRL = method reporting limit

IPST = Irrigation Pump Station Total

NO_3-N = nitrate as nitrogen

TDS = total dissolved solids

CHAPTER 3
FUTURE FLOW AND LOADING DEMAND FORECAST

3.1 EXISTING AND FUTURE PROCESSORS

Reser's, Freeze Pack, Pasco Processing, and Twin City Foods will continue to discharge process wastewater to the PWRF. Reser's anticipates approximately 30 percent growth in the near future. Pasco Processing, Freeze Pack, and TCF anticipate that future operation will remain consistent with current flows and loadings. In addition to the existing processors, it is anticipated that several other processors will discharge process wastewater to the PWRF. Simplot is renovating the existing CRF facility and will begin operating and discharging process wastewater to the PWRF in 2018. Grimmway is currently located in the Columbia East Service Area and discharges process wastewater to the City municipal sewer plant. Grimmway is planning to divert flows to the PWRF as soon as capacity becomes available. The City also plans to provide capacity for one additional future processor with a total year-round flow rate that does not exceed 2.5 mgd.

The City plans to phase in new processors and additional treatment capacity at the PWRF. It is anticipated that phasing will occur in the following order:

- Existing – Reser's, Freeze Pack, Pasco Processing, and Twin City Foods
- Phase 1 (2019) – Existing processors plus Simplot
- Phase 2 (2020) – Phase 1 processors plus Grimmway plus 30 percent growth at Reser's

3.2 PROCESSOR FLOW CHARACTERIZATION

Figure 3-1 presents individual average monthly flow rates for each processor based on processor effluent discharge monitoring reports (DMRs) and the total average monthly flow. The total monthly flow is representative of influent flow to the PWRF. Peak seasonal flows remained relatively constant between 2014 and 2017 despite CRF closing their facility in early 2016. This is primarily due to the steady increase in production at Grimmway and TCF over the years. Although Grimmway doesn't currently discharge to the PWRF, they will be connecting in Phase 2 and are included in Figure 3-1 to demonstrate the anticipated future contribution to seasonal flow fluctuations.

There is a sharp contrast in flow rates between the summer and winter months, because of processors like TCF and PP. These processors are the largest flow and loading contributors to the PWRF and have high fluctuations between summer and winter. The seasonal variations are accounted for by splitting the flow and loading criteria into summer and winter seasons. The summer season includes May through October and the winter season includes November through April. The individual processor flow and loadings were combined to create representative characterizations of PWRF influent during each season. These characterizations were used to develop the PWRF demand forecast described in the next section.

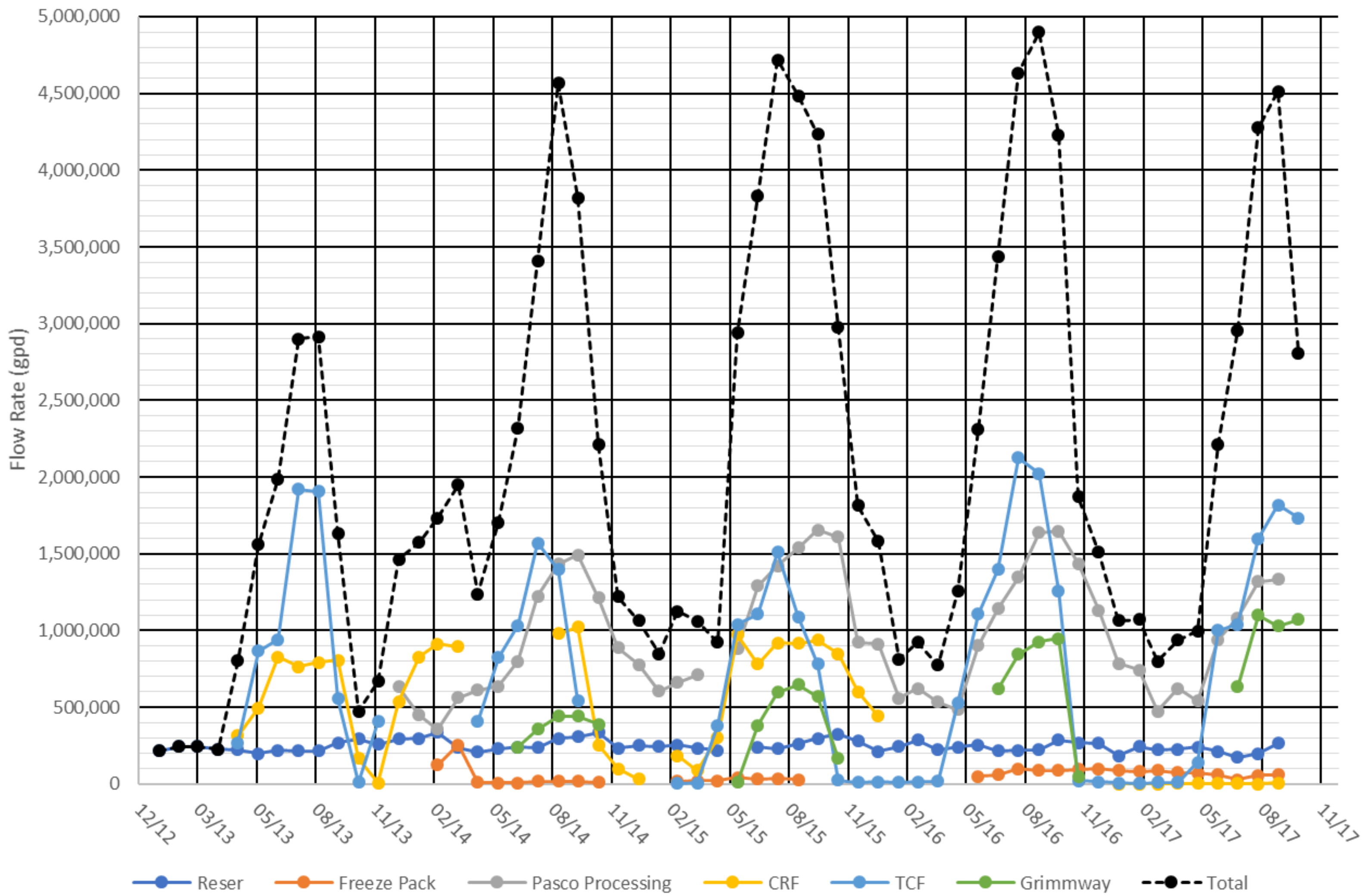


Figure 3-1	***Processor Average Monthly Flow Rates***	17454.00
		rev. 06.2019

THIS PAGE IS INTENTIONALLY LEFT BLANK.

3.3 FLOW AND LOADING DEMAND FORECAST

The following assumptions were made in the development of the demand forecast for each phase of buildout at the PWRF:

- November 2016 – October 2017 DMR results for Reser's, Pasco Processing, Freeze Pack, and Twin City foods were assumed to be representative of current operations at these facilities This data was used to develop the demand forecast.
- Simplot flow and loadings were assumed to be equal to historical CRF flow and loadings between November 2014 and October 2015.

Future flows are proposed as follows:

- December 1 through April 30: No flow
- May 1 through May 30: max flow 40,000 gpd (avg. 20,000 gpd)
- June 1 through October 31: 1.8 mgd
- November 1 through 10 days after the PWRF can no longer send water to the land treatment site: 1.1 mgd
- November 1 through November 30: 0.70 mgd

Grimmway would like to explore increasing their BOD and total suspended solids (TSS) limits from the municipal requirements of 300 mg/L to 2,500 – 8,000 lb/day BOD and 300 – 1,000 lb/day TSS in order to align with the other processors that discharge to the PWRF. Grimmway's projected BOD and TSS loadings are included in Table 3-3 and Table 3-4 defining summer and winter Phase 2 demands. Grimmway BOD was forecast at 5,282 lb/d during summer operations and 1,413 lb/d during winter operations. Their TSS was forecast at 3,064 lb/d during summer operations and 820 lb/d during winter operations. These BOD and TSS ranges correspond to summer season (May – October) limits on the low end and winter season (November – April) limits on the high end. These modifications are documented and discussed in Appendix A Grimmway Flow and Loading Technical Memorandum.

Lab reported DMR data and calculated values were tabulated and separated by season (summer and winter) for each existing processor (Reser's, Freeze Pack, Pasco Processing, and Twin City Foods). The demand forecast for the existing condition were based on the average reported flows and loadings for each processor between November 2016 and October 2017. The individual processor flow and loadings were rounded up and combined to create a single stream representative of PWRF influent during each season. The combined flows for the four processors for the summer season (Table 3-1) and the winter season (Table 3-2) for existing conditions are presented.

Table 3-1: Existing Summer Condition Demand Forecast

Parameter	Reser's	Pasco Processing	Twin City Foods	Freeze Pack	Existing Condition
Total Volume (MG)	44	220	259	14	537
Max Flow (mgd)	0.57	2.41	2.47	0.15	5.60
Average Flow (mgd)	0.24	1.19	1.41	0.08	2.92
BOD_5 (mg/L)	2,310	306	593	343	752
BOD_5 (lb/d)	4,627	3,048	6,958	220	18,313
TSS (mg/L)	2,145	679	242	1,998	653
TSS (lb/d)	4,297	6,766	2,841	1,279	15,902
TN (mg/L)	180	58	73	117	75
TN (lb/d)	361	575	855	75	1,826

Table 3-2: Existing Winter Condition Demand Forecast

Parameter	Reser's	Pasco Processing	Twin City Foods	Freeze Pack	Existing Condition
Total Volume (MG)	43	160	2	16	221
Max Flow (mgd)	0.40	2.28	0.06	0.19	3.00
Average Flow (mgd)	0.24	0.88	0.01	0.09	1.20
BOD_5 (mg/L)	2,829	325	542	346	620
BOD_5 (lb/d)	5,556	2,394	52	253	6,205
TSS (mg/L)	1,814	1,701	165	447	1,618
TSS (lb/d)	3,563	12,532	16	326	16,193
TN (mg/L)	85	62	70	85	63
TN (lb/d)	168	457	7	62	631

Phase 1 demand forecasts were calculated by adding the flow and loadings from Simplot (formerly CRF) to the existing condition (i.e., what is discharged now). Because now other data exists and Simplot's permit is the same as CRFs, average CRF DMR data observed in the November 2014 – April 2015 and May 2015 – October 2015 seasons were assumed to be representative of Simplot's flow and loading.

The demand forecasts for Phase 2 were calculated by adding Grimmway's projected future flow and loadings (after the assumed expansion) to Phase 1. Reser's plans to expand their operation by approximately 30 percent in Phase 2. A 30 percent growth factor was included in the Phase 2 demand forecast based on Reser's existing conditions. Tables 3-3 and 3-4 present the Phase 2 demand forecasts for summer and winter, respectively.

Table 3-3: Phase 2 PWRF Summer Demand Forecast

Parameter	Existing	Simplot	Phase 1	Grimmway	30% Reser's Growth	Phase 2
Total Volume (MG)	537	148	685	322	13	1020
Max Flow (mgd)	5.60	1.15	6.75	2.1	0.17	9.02
Average Flow (mgd)	2.92	0.80	3.72	2.1	0.07	5.83
BOD_5 (mg/L)	752	2,568	1,136	362	693	890
BOD_5 (lb/d)	18,313	17,229	35,542	6,340	416	43,274
TSS (mg/L)	653	1,037	734	210	644	570
TSS (lb/d)	15,902	6,958	22,772	3,678	387	27,715
TN (mg/L)	75	42	68	24	54	54
TN (lb/d)	1,826	281	2,109	343	32	2,486

Table 3-4: Phase 2 PWRF Winter Demand Forecast

Parameter	Existing	Simplot	Phase 1	Grimmway	30% Reser's Growth	Phase 2
Total Volume (MG)	217	24	241	85	13	339
Max Flow (mgd)	3.00	0.62	3.62	0.7	0.12	4.44
Average Flow (mgd)	1.20	0.13	1.33	0.7	0.07	2.1
BOD_5 (mg/L)	620	737	632	362	550	561
BOD_5 (lb/d)	6,205	815	7,020	2,114	324	9,826
TSS (mg/L)	1,618	187	1,476	210	544	1,124
TSS (lb/d)	16,193	207	16,400	1,226	321	19,686
TN (mg/L)	63	29	60	24	14	49
TN (lb/d)	631	32	662	92	8	762

The development of these demand forecasts is further discussed in Appendix B: PWRF Flow and Loading Technical Memorandum. These conditions, along with the land treatment system capacity discussed in Chapter 1 provide the basis for the evaluation of capacity deficiencies at the PWRF, during each phase of expansion and the treatment technologies available to resolve the capacity and treatment deficiencies. The PWRF influent process water is below the land treatment system flow threshold of 1,359 MG/yr, the nitrogen threshold of 496,492 lbs/yr, and the BOD_5 threshold of 100 lbs/ac/day. However, TSS concentrations should be reduced to less than 250 mg/L to prevent plugging of spray nozzles and damage to downstream equipment.

THIS PAGE IS INTENTIONALLY LEFT BLANK.

CHAPTER 4
PWRF IRRIGATION PUMP STATION IMPROVEMENTS

4.1 INTRODUCTION

The City of Pasco (City) pretreats process water received from various vegetable processors to be discharged into a permitted land treatment site. Process water augments fresh well water for irrigating crops on City-owned agricultural land. This Technical Memorandum has been prepared to summarize the conceptual design to replace the existing Irrigation Pump Station for the Process Water Reuse Facility (PWRF) plant site. The existing PWRF Irrigation Pump Station (IPS) was constructed in 1995 at the PWRF site along with the original PWRF plant improvements (see Figure 1-1 for the PWRF Vicinity Map).

The existing PWRF Irrigation Pump Station is owned, operated, and maintained by the City of Pasco Public Works Department, 525 N. 3rd Avenue, Pasco, Washington 99301; Phone: 509.545.3444. The City's authorized representative for this facility is Steve Worley, P.E., Public Works Director.

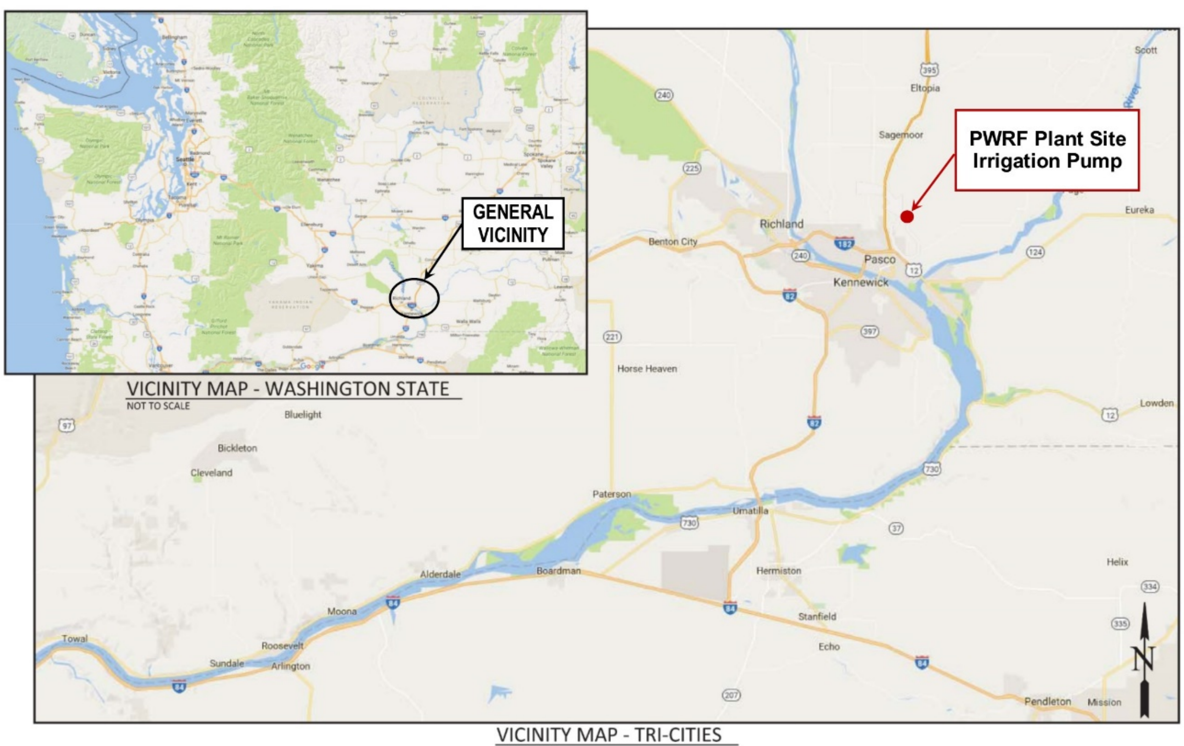


Figure 4-1	*PWRF Vicinity Map*	17454.06
		03.2018

The IPS was designed to pump effluent from the PWRF plant site to the land treatment site located generally east/southeast of the plant site as shown in Figure 1-2: PWRF Irrigation Spray Fields. A total of 803 million gallons (MG) of processed wastewater was used as irrigation for the land treatment site in the 2017 operating year and ranged from 35.7 to 96.53 MG per month in November and April, respectively (as reported in the Discharge Monitoring Reports for 2017 for the City's PWRF). There was no process water pumped to irrigation during December 2016, nor January and March 2017. Please see Appendix C for discharge monitoring reports.

The topics addressed within this report for the new IPS include Background, Existing Conditions, Existing IPS Basis of Design, Process Irrigation Flowrates Assessment, and New IPS Basis of Design. The Existing and New Basis of Design sections include an explanation of key design criteria, pump station design flows, pump sizes, existing irrigation discharge main sizes, and suction manifold connection locations to plant treatment basins to convey plant effluent flows to the IPS wet well, along with operational strategy for the new IPS. It also provides a current updated status of this operational information.

This chapter is supplemented with the IPS Influent Piping Alternatives Analysis which is included in Volume 2

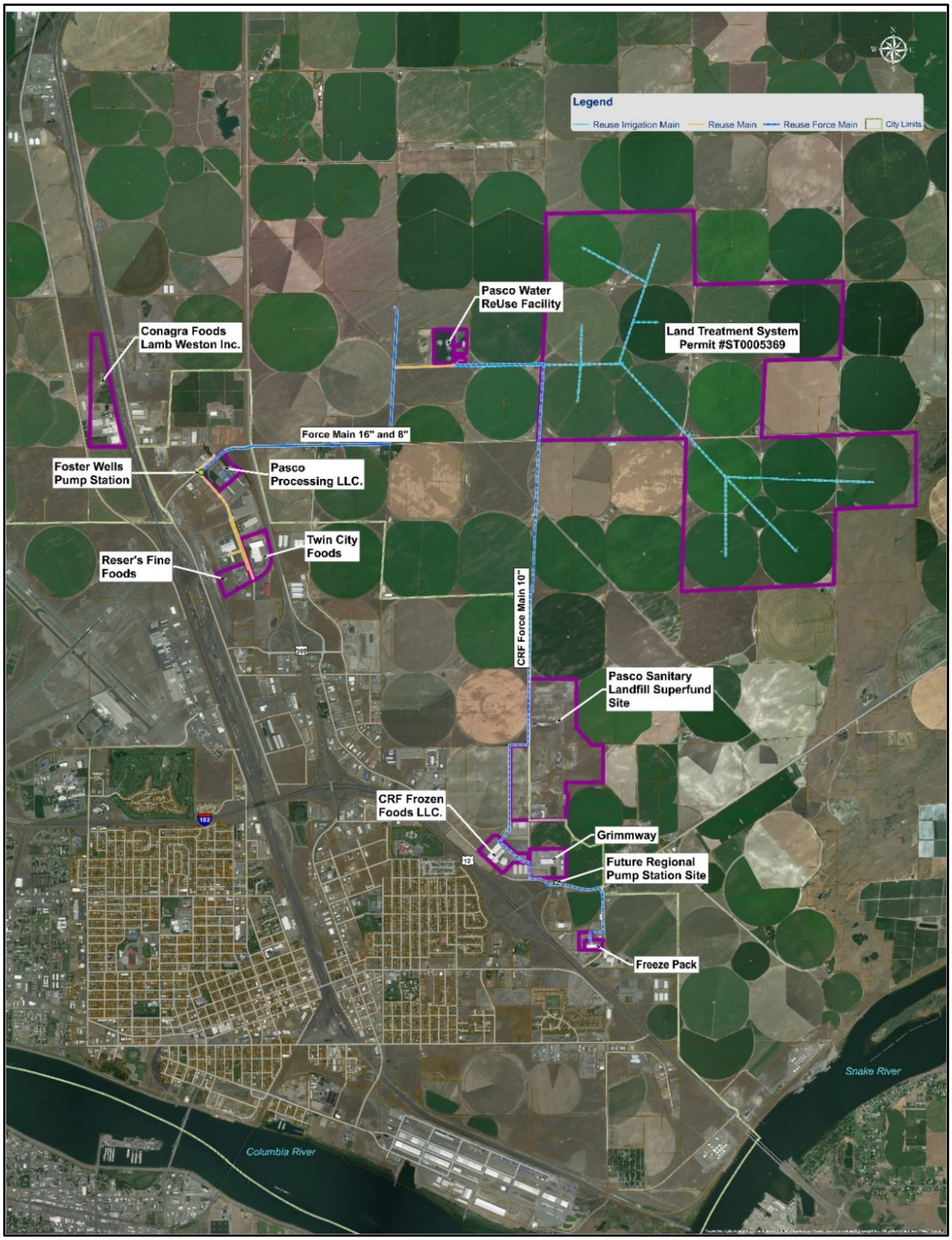


Figure 4-2	Irrigation Spray Fields	17454.00
		02.2018

THIS PAGE IS INTENTIONALLY LEFT BLANK.

4.2 PWRF FLOW PROJECTIONS

4.2.1 Flow Analysis

A Flow Analysis and Loadings Projections technical memorandum completed by CH2M in December 2017 developed phases for projected flows, incorporating existing and new food processors and future treatment capacity for growth within the service area. That technical memorandum anticipated that phasing will occur in the following order:

- Existing: Reser's, Freeze Pack, Pasco Processing, and Twin City Foods (2017)
- Phase 1: Existing Processors plus Simplot (2018)
- Phase 2: Phase 1 Processors plus Grimmway (2020)
- Phase 3: Phase 2 Processors plus Lamb Weston (2026)
- Phase 4: Phase 3 Processors plus one 2.5 MGD year-round new processor (2030)
- Phase 5: Phase 4 Processors plus one 2.5 MGD year-round new processor (2040)

Those flow projections for the phases as described above and listed in Table 4-1.

Table 4-1: PWRF Flow Projections

Metric	Unit	Existing Condition – 2017		
		Nov - Apr	May - Oct	Full Year
Total Annual	MG/Period	256	548	803
Average	GPD	1,400,000	3,000,000	
Maximum	GPD	3,000,000	6,200,000	

Metric	Unit	Phase 1 – 2018		
		Nov - Apr	May - Oct	Full Year
Total Annual	MG/ Period	383	639	1,022
Average	GPD	2,100,000	3,500,000	
Maximum	GPD	7,200,000	6,800,000	

Metric	Unit	Phase 2 – 2020		
		Nov - Apr	May - Oct	Full Year
Total Annual	MG/ Period	507	814	1,321
Average	GPD	2,776,548	4,459,797	
Maximum	GPD	8,325,316	7,994,947	

Metric	Unit	Phase 3 – 2026		
		Nov - Apr	May - Oct	Full Year
Total Annual	MG/ Period	768	1,075	1,843
Average	GPD	4,206,548	5,889,797	
Maximum	GPD	9,829,426	9,499,057	

Metric	Unit	Phase 4 – 2030

		Nov - Apr	May - Oct	Full Year
Total Annual	MG/ Period	1,224	1,531	2,755
Average	GPD	6,706,548	8,389,797	
Maximum	GPD	9,829,426	9,499,057	

Metric	Unit	Phase 5 – 2040		
		Nov - Apr	May - Oct	Full Year
Total Annual	MG/ Period	1,680	1,987	3,668
Average	GPD	9,206,548	10,889,797	
Maximum	GPD	9,829,426	9,499,057	

4.2.2 Seasonal Flow Variations for the Irrigation Pump Station

The operations of the PWRF requires that the basins routinely be drained and cleaned at the end of November to begin winter flow storage at the reuse facility. Currently the winter storage volume required for the existing flows coming to the plant from the beginning of December to the beginning of first week of April will completely fill the 115 MG storage basin. Near the beginning of April the operators begin to pump down the 115 MG storage basin and send irrigation water to the City's agricultural crop fields at a rate to completely empty the 115 MG storage basin by mid-June and concurrently with summer (May-October) flow from processors. This spring pumping strategy is necessary to prevent the storage basins from becoming more anaerobic and to reduce the offensive and nuisance odors. If the basins are not emptied, the higher summer temperatures will cause the ponds to turn over and emit further offensive odors.

In the spring of 2017, the basin emptying operation for the IPS required operating the existing three (3) pumps continuously (24 hours a day/7 days a week) from the first week of April to mid-June. This basin emptying operation concurrently coincides with pumping process water that is being received into the storage basin as the summer processors' operations begin in May. For 2017 the influent flow storage volume from December 1 to April 15 amounted to 200.94 MG. The IPS effluent pumped amounted to a total of 220.23 MG from April 3 to June 15 (over a period of 50 days).

- 2017 Spring Basins Draining
  = [(220.23 MG x 1,000,000 gal/MG) / (50 day x 24 hr/day x 60 min/hr)]
  = 3,059 GPM

Current summer operations for the Irrigation Pump Station begin in mid-June. The storage basins are near empty as the processors ramp up operation flows to the plant near a maximum flow of 6.2 MGD, exceeding IPS normal operations capacity. Flows then begin to fill the 115 MG storage basin. During the fall season the flows to the plant begin to drop, and by the end of November the 115 MG storage basin is emptied for solids removal. For the period of June 15 to November 30 (over a period of 106 days) 361.7 MG were pumped by the IPS running continuously (24/7), equaling the following:

- 2017 Summer Basins Draining
  = [(361.7 MG x 1,000,000 gal/MG)/(106 day x 24 hrs/day x 60 min/hr)]
  = 2,370 GPM

The use of process water on the spray fields is highly variable depending on weather conditions, the number of fields in production, the types of crop vegetation being irrigated, and the occasional down time required for harvesting and crop rotations. Currently the plant effluent that is pumped to land treatment site has relatively high nitrogen, low pH (5.0 to 3.5). When pH is consistently at the lower pH levels typical for the plant effluent, the field crops may suffer if the flow is not blended with well water to supplement the water quality and raise the pH. For this reason well water is almost always supplementing the quality, and the various wells associated with the fields are run in conjunction with the IPS flows to the fields to accomplish that.

For these reasons the variation of flows from the IPS pump station is highly irregular, but tends to require the three (3) existing pumps to run at full capacity much of the time in order be able to accomplish the objective to empty the storage basins at the ends of both the spring and fall seasons (mid-June and end of November, respectively). Existing maximum pumping capacity of the IPS is 5,000 gpm with all three pumps running (1,700 + 1,700 + 1,600). Typical design peak flow is 3,300 gpm (1,700 + 1,600) with two (2) pumps in operation.

4.3 PUMP STATION DESIGN CRITERIA

4.3.1 Irrigation Pump Station Design Flow Criteria

Future projected design flow pumping operations for the IPS will need to include storage basin draining and cleaning operations similar to the current PWRF plant operations in order to direct flows to the spray fields. The goal set by the City for the PWRF upgrade and expansion is for Phase 3 flows to be the Design Criteria. For future expansion of Phases 4 & 5, the design will consider pump replacements. Peak IPS capacity will be based on matching the projected future flows (to enable winter storage from December 1 through April 15), to be pumped out over a similar period of 50 days (beginning in early April and emptying the storage basin by mid-June), to current operations. A safety factor will also be applied to calculate the required firm capacity of the IPS for the operational flexibility to meet the crop requirements for the land treatment site.

From the plant information for flows in 2017, a total of effluent of 581.93 MG was recorded by the IPS flow meter. Using this amount and applying a total of 156 days of constant pumping to the land treatment site, the IPS average flow rate is calculated to be as follows:

- Existing Condition IPS average rate
  = [(581.93 MG x 1,000,000 gal/MG)/(106 days x 24 hr/day x 60 min/hr)]
  = 3,812 gpm

Knowing that all three pumps were required to run sometimes nearly constantly at full VFD rates for a total of 5,000 gpm, the Safety Factor (SF) for the firm capacity equals the following:

- Existing Safety Factor = 5,000 gpm / 3,059 gpm = 1.63

Currently, the PWRF is permitted with its food processors to discharge a total annual flow amount of 803 MG to the land treatment site. Considering this is pumped as effluent over a period of 106 days, this amounts to the following:

- IPS average overall annual pumping rate
  = [(803 MG x 1,000,000 gal/MG)/(106 days x 24 hr/day x 60 min/hr)]
  = 5,260 gpm

However, knowing that the critical time element for the IPS is the spring basins draining operation for storage emptying over a period of 50 days as calculated in Section 2.2 as being 3,059 gpm, and using this to calculate the known peaking factor for the existing IPS firm capacity of 5,000 gpm, the actual Peaking Factor is:

- PF = 5,000 GPM / 3,059 GPM = 1.63

Using a peaking factor of 1.63, the projected IPS flow projections as applied in Table 3-1 for the flow period of December 1 through April 15 is as follows:

Table 4-2: PWRF Irrigation Pump Station Flow Projections and Firm Pumping Capacity

		Existing Condition – 2017				Pump Station Capacity	
Metric	Unit	Nov. to Apr.	Dec. 1 to Apr. 15 *	May to Oct.	Full Year		
Total Annual	MG/ Period	256	220.23	548	803	5,000	GPM**
		Phase 1 – 2018					
Metric	Unit	Nov. to Apr.	Dec. 1 to Apr. 15 *	May to Oct.	Full Year		
Total Annual	MG/ Period	383	329.38	639	1,022	7,478	GPM**
		Phase 2 – 2020					
Metric	Unit	Nov. to Apr.	Dec. 1 to Apr. 15 *	May to Oct.	Full Year		
Total Annual	MG/ Period	507	436.02	814	1,321	9,899	GPM**
		Phase 3 – 2026					
Metric	Unit	Nov. to Apr.	Dec. 1 to Apr. 15 *	May to Oct	Full Year		
Total Annual	MG/ Period	768	660.48	1,075	1,843	14,995	GPM**
		Phase 4 – 2030					
Metric	Unit	Nov. to Apr.	Dec. 1 to Apr. 15 *	May to Oct.	Full Year		
Total Annual	MG/ Period	1,224	1,052.64	1,531	2,755	23,899	GPM**
		Phase 5 – 2040					
Metric	Unit	Nov. to Apr.	Dec. 1 to Apr. 15 *	May to Oct.	Full Year		
Total Annual	MG/ Period	1,680	1,512.00	1,987	3,668	32,802	GPM**

Notes:
* Spring Basin emptying capacity for period from December 1 through April 15 is based on 86% of the flow amount received for the period from November 1 through April 30 as determined from PWRF flow meter influent records for 2017 and applied to future flow projections.
** Irrigation Pump Station firm capacity flow rate assumes peaking factor of 1.63 along with Spring Basin Emptying operation over a 50 day period for pumping to occur concurrently with incoming flows being pumped out starting in early April through mid–June with constant pumping.

For the operational strategy of how these PWRF flows are pumped to the spray fields, there will need to be consideration for the hydraulic capacity of the land treatment site for the five phases. If water quality of PWRF effluent is a problem for certain crops, then irrigation demands augmented with well water should be considered, which may reduce the level of demand for the process water supplied by the PWRF.

4.3.2 Pump Sizing for Future Phasing, Capacity, and Operations

4.3.2.1 Design Considerations

The pump station will be designed to operate over a wide range of flows to improve operations at the PWRF and accommodate agricultural practices at the land treatment site. Previously in this report, the ability to pump winter storage and summer flows concurrently was used to determine pump station capacity for the future flow demands. The report also stated that Phase 3 flows are to be used for this immediate to near term basis for design. However, in anticipation of future long term expansion (Phase 4 and 5), the IPS design would provide the capability for increasing pumping capacity without expanding the structure.

Operators also expressed their preference for a wet well – dry pit pump station. Again, the reasoning for this selection included better access for maintenance, safety, and pump performance. Several pump manufacturers and models were evaluated including Wemco and Flygt. Given the operators familiarity, reliability, and ease of maintenance, the Flygt pump manufacturer was selected to serve as the basis for pump design.

PWRF operators indicated the need for the flow rate to the land treatment site to include variability from approximately 1,100 gpm to 15,000 gpm. This pumping range is based on past irrigation practices at the land treatment site including downtime due to agricultural practices, crop mixes, weather, maintenance needs, well water mixing, and future flow projections.

This flow range cannot be accomplished with a duplex pumping arrangement. Therefore, a multiple pump arrangement equipped with Variable Frequency Drives (VFD) was found to best serve the requested flow range and provide the flexibility for operations. To provide reliability and redundancy, two pumps equally sized will be provided to meet the low range flows. Three equally sized larger pumps equipped with VFDs will be provided to serve the higher flow range and meet Phase 3 flow projections.

The pump selection must also consider the irrigation system requirements and account for hydraulics of the pumping system and conveyance piping. City operators requested 60 psi maintained at the irrigation pivots to ensure satisfactory flow through the sprinkler heads.

4.3.2.2 Pump Selection

A system curve was developed to document operational considerations discussed above, as well as suction, discharge, and forcemain piping configurations, and changes in elevation. The following Section 3.3 discusses the suction and discharge piping basis for design. The appropriately sized piping recommended in Section 3.3 was used to determine friction and minor losses required for pump selection.

Table 3-2 summarizes the pump selection along with key pump characteristics, again as the basis for design.

Table 4-3: Pump Selection

Pump Make and Model	Flow (GPM)	TDH (FT)	Efficiency (%)	Power (HP)	NPSHre (GPM)
Pumps #1, #2, #3 **Flygt (CZ 3240.845)**	5,271	207	78.9	455	31.5
Pumps #4 and #5 **Flygt (NZ3202 HT 465)**	1,053	167	70.8	70	14
Pump #6* **Flygt (NZ3202 MT 460)**	1,967	71	70.8	60	14

*Pump #6 is a recirculation pump used to transfer process water between storage ponds. It will be same size pump as pumps 4 and 5 but will be equipped with a smaller impeller and motor.

Pumps #1, #2, and #3 will provide the higher flow range flexibility. At the rated speed of 1,790 rpm, each pump is capable of 6,400 gpm. With two pumps operating simultaneously and at rated speed, pump capacity is 11,300 gpm. When all three pumps operate simultaneously and at rated speed, pump capacity is 15,083 gpm.

Pumps #4 and #5 will provide the lower flow range. With either pump #4 or #5 in operation and at rated speed of 1,775 rpm, flow capacity is 1,053 gpm. With both pumps in operation and at rated speed, the pumps are capable of delivering 2,102 gpm.

This multiple pump configuration will be capable of a pump range at rated speeds between 1,053 gpm to a maximum capacity of 15,083 gpm. VFDs will be provided to not only provide further variability, but allow a “soft start” to control the amperage at initial pump starts and stops, allowing control of pump speed to limited surge pressures.

The selected pump curves and overall system curve are provided in Appendix D for reference. Future phases pump selection data is in Appendix E.

4.3.3 Suction and Discharge Pipes Summary

Pump station suction pipelines for wastewater are typically sized to sustain velocities ranging from 2 to 5 feet per second. Pump discharge pipes are typically sized to sustain velocities ranging from 5 to 8 feet per second before flow is introduced into the discharge manifold where the diameter may be increased to lower friction pipeline velocities. Pump capacities and pipe size selections are summarized in Table 3-3 for Phases 3, 4, and 5 for obtaining the ideal suction and discharge velocities as mentioned above.

Table 4-4: Pipe Sizes and Pump Selections for Design Flow Phases

	Total Pump Station Firm Capacity Required (GPM)	3 Each Larger Pumps (GPM)	Large Pumps Pipe Sizes (Inches)	Large Pumps Pipe Velocities (Ft/sec)	2 Each Smaller Pumps (GPM)	Small Pumps Pipe Sizes (Inches)	Small Pumps Pipe Velocities (Ft/sec)	Total Pump Station Firm Capacity (GPM)
PHASE 3	14,995	5,271			1,1053			15,000
Suction			24	4.66		14	4.06	
Discharge			18	7.71		10	7.97	
PHASE 4	23,899	15,900			1,1053			23,900
Suction			36	3.90		12	4.66	
Discharge			30	5.62		10	7.71	
PHASE 5	32,802	15,900			1,1053			27,500
Suction			36	3.90		12	3.90	
Discharge			30	5.62		10	5.62	

4.4 PUMP STATION LAYOUT

An overall hydraulic profile of the PWRF is shown in Figure 4-1, indicating the required elevation of the new IPS for service to empty the existing 115 MG storage basin or future similar depths for future storage basins. A 30-inch-diameter PVC C900 gravity drain provides the needed hydraulic capacity from each of the storage basins to the new IPS wet well. For lower water levels in the storage basins, the bottom 2 to 3 feet above the low floor sump area should be drained by using the transfer pump to send those solids-laden waters to the solids handling basins for further dewatering.

The wet well arrangement for the new IPS is a trench-type configuration that allows the wet well to have cleansing velocities so as to reduce the likelihood of solids deposition. The hydraulic profile in Figure 4-1 illustrates the need to either raise the top of the wet well structure above the storage basins maximum water surface elevation or to employ a more complicated control valve strategy to limit flow to the wet well to avoid over-topping the wet well structure. Due to the operational complexity and additional costs for control valves with electrical instrumentation to control flow, it is recommended to increase the height of the wet well structure by 8 feet above the building top floor elevation to provide 2 feet of freeboard above the maximum high water level of the storage basins.

The Irrigation Pump Station replacement structure is laid out showing the arrangement of pumps and piping for Phases 3, 4, and 5 in Figure 4-2. Note that pump and pipe sizes for the future Phase 5 determine the overall size of the dry-pit and building horizontal layout dimensions. The design criteria for Phase 3 requires a firm pumping capacity of 15,000 gpm whereas for Phase 5 it becomes 32,802 gpm. For Phase 3, a single 24-inch-diameter irrigation main is needed to convey flow exiting the IPS as it extends to the point of connection to the existing 18-inch main that extends to the irrigation spray fields. For Phase 4, a 30-inch pipeline is added to convey the flow for the increased capacity needed for both Phases 4 and 5.

A more detailed preliminary plan shown in Figure 4-3 for Phase 3 shows the dry pit/wet well arrangement at the lower floor plan of the dry pit. Figure 4-4 illustrates the arrangement for the upper floor plan of the IPS along with the metal building situated above the dry pit of the pump station. Figures 4-5 and 4-6 show the sectional elevation views through the pump station for Phase 3.

The pump layouts for these figures in this concept plan anticipate that the pumps will be a vertical motor non-clog solids-handling pump Xylem Flygt manufacturer assemblies which utilize a submersible-type motor that can be used in a dry-pit environment. Initially, horizontal split case pumps for wastewater pumping were considered, but the additional space required for the motors to be located horizontally adjacent to the pumps increases the overall dry-pit length dimensions substantially (possibly as much as 15 to 20 feet in length). The motors for the horizontal split case pumps are not available for submersible applications.

The concern that the dry-pit can become flooded in a pipe or pump catastrophic failure, thereby damaging and blowing out electrical motor on the pumps, is too likely to occur to warrant using split case pump types. The vertical submersible motors on the solids handling wastewater-type pumps reduce the overall below-grade dry-pit structure size (thereby reducing structure costs) and also enable the pump motors to avoid damage during a flooded dry-pit scenario. Although the split case pumps are available as a vertical arrangement for reduced footprint size, the motors available for these pumps are not available as either submersible or immersible type motors. Therefore, the dry-pit submersible type of pumps and motor arrangement is highly recommended and is being shown for the new IPS pump configuration layouts.

THIS PAGE IS INTENTIONALLY LEFT BLANK.

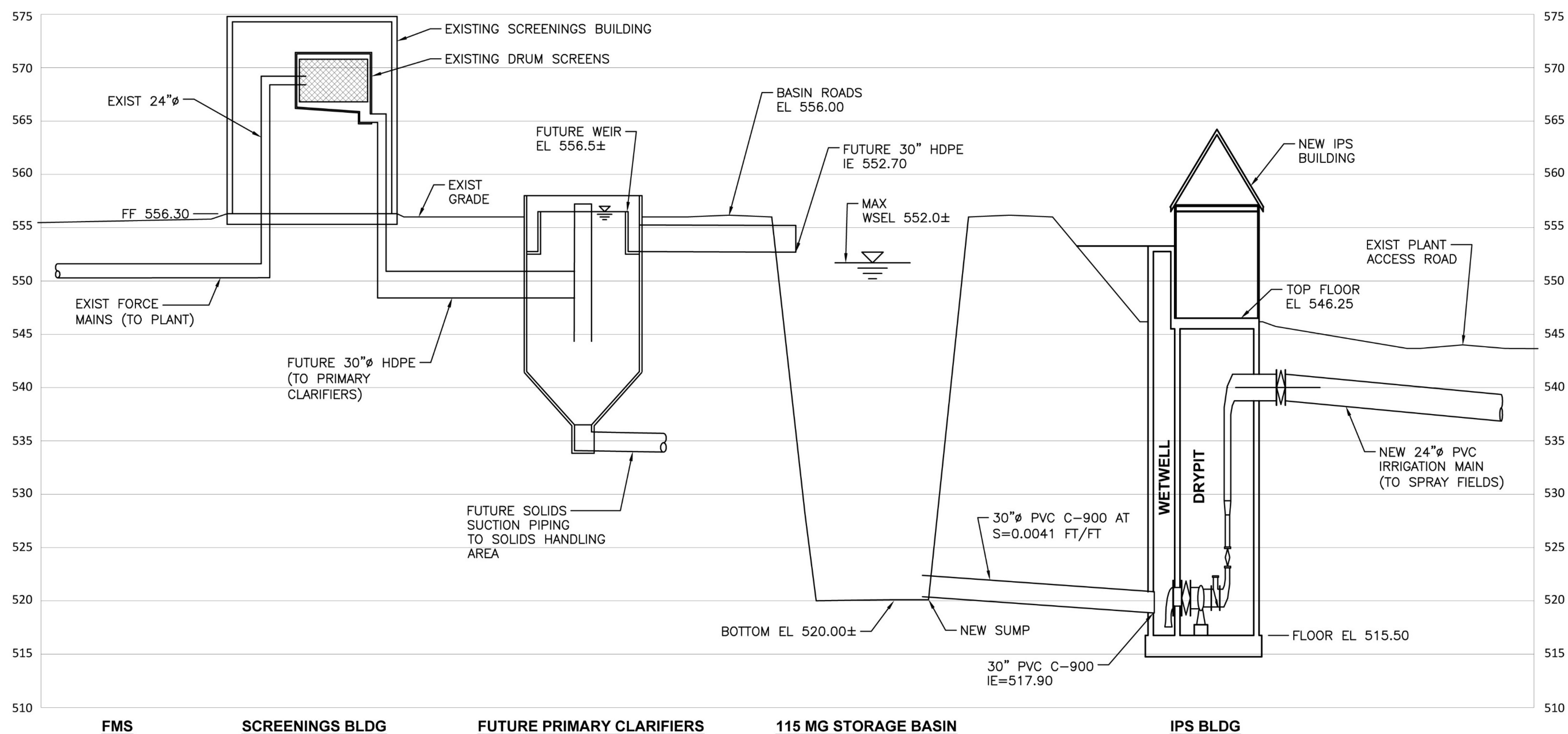
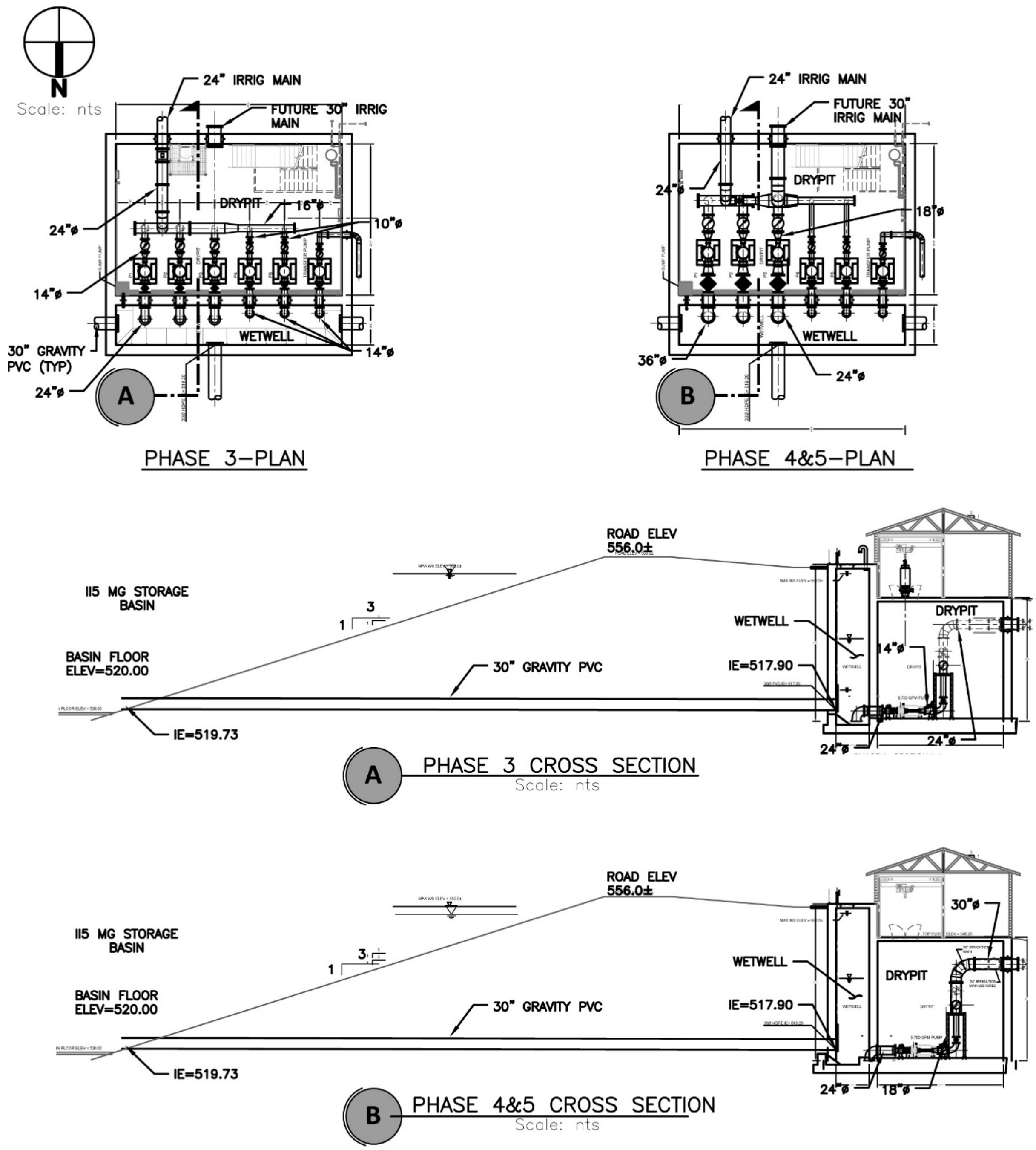


Figure 4-3	***Hydraulic Profile***	17454.06 06.06.2019

THIS PAGE IS INTENTIONALLY LEFT BLANK.



NOTES:
PHASE 3– PUMPS = 3 EACH ~ 5,271 GPM & 2 EACH ~ 1,053 GPM
PHASE 4– PUMPS = 3 EACH ~ 11,000 GPM & 2 EACH ~ 1,053 GPM
PHASE 5– PUMPS = 5 EACH ~ 11,000 GPM

Figure 4-4	*Pump Station Layout Phasing*	17454.06
		06.06.2019

THIS PAGE IS INTENTIONALLY LEFT BLANK.

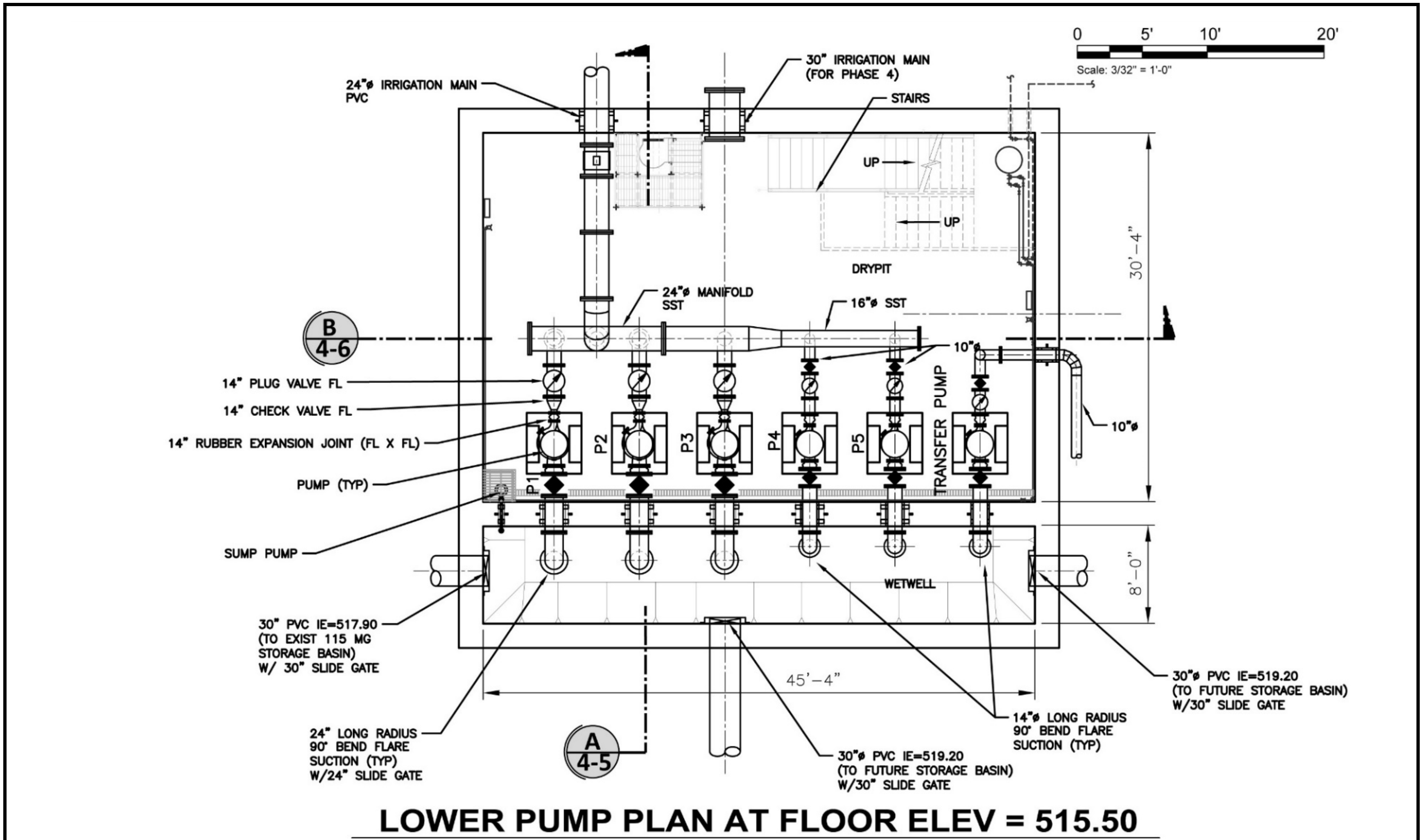


Figure 4-5	*IPS Building Lower Floor Plan*	17454.06
		06.06.2019

THIS PAGE IS INTENTIONALLY LEFT BLANK.

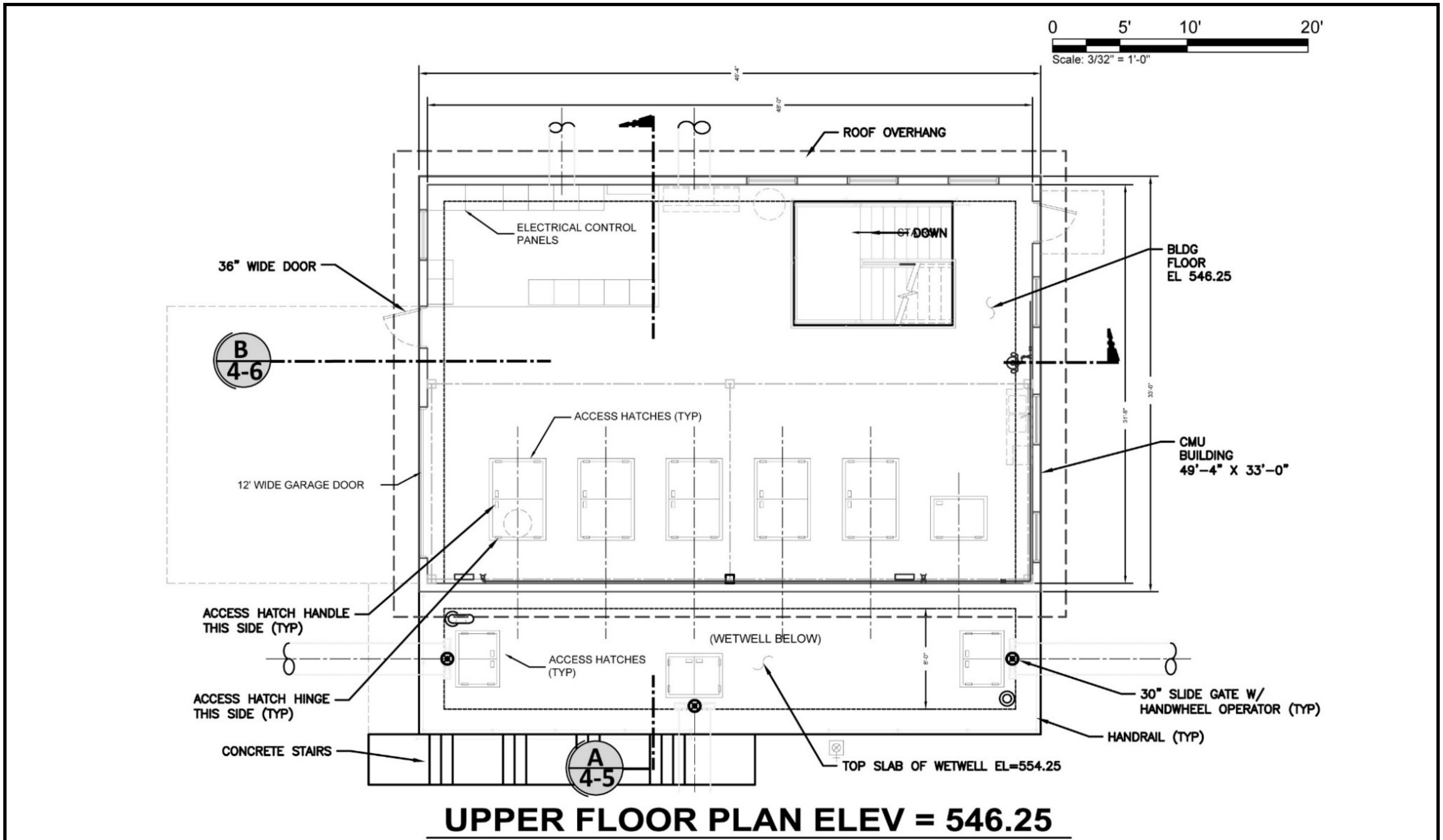


Figure 4-6	*IPS Building Upper Floor Plan*	17454.06
		06.06.2019

THIS PAGE IS INTENTIONALLY LEFT BLANK.

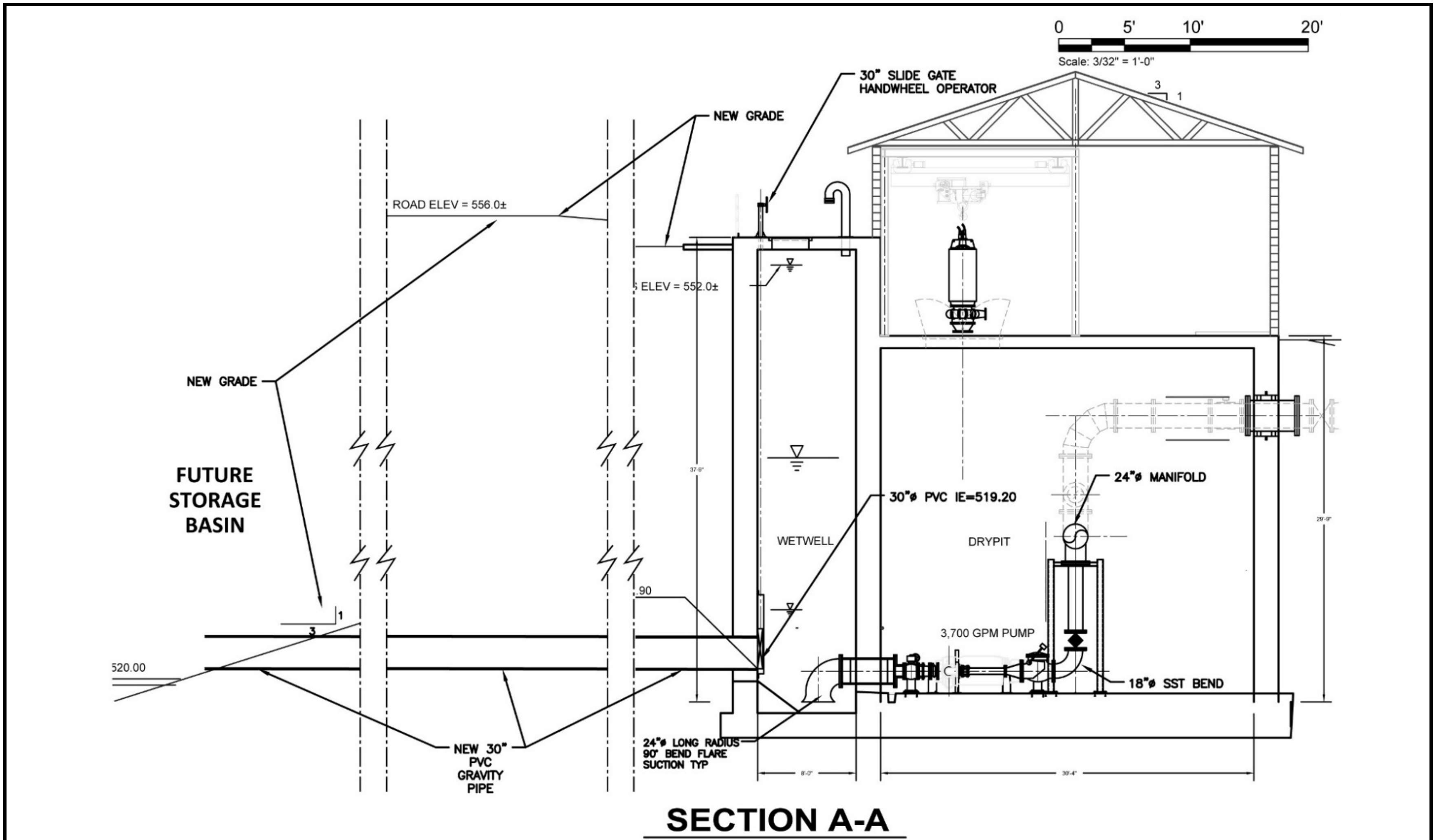


Figure 4-7	IPS Building Section A-A	17454.06
		06.06.2019

THIS PAGE IS INTENTIONALLY LEFT BLANK.

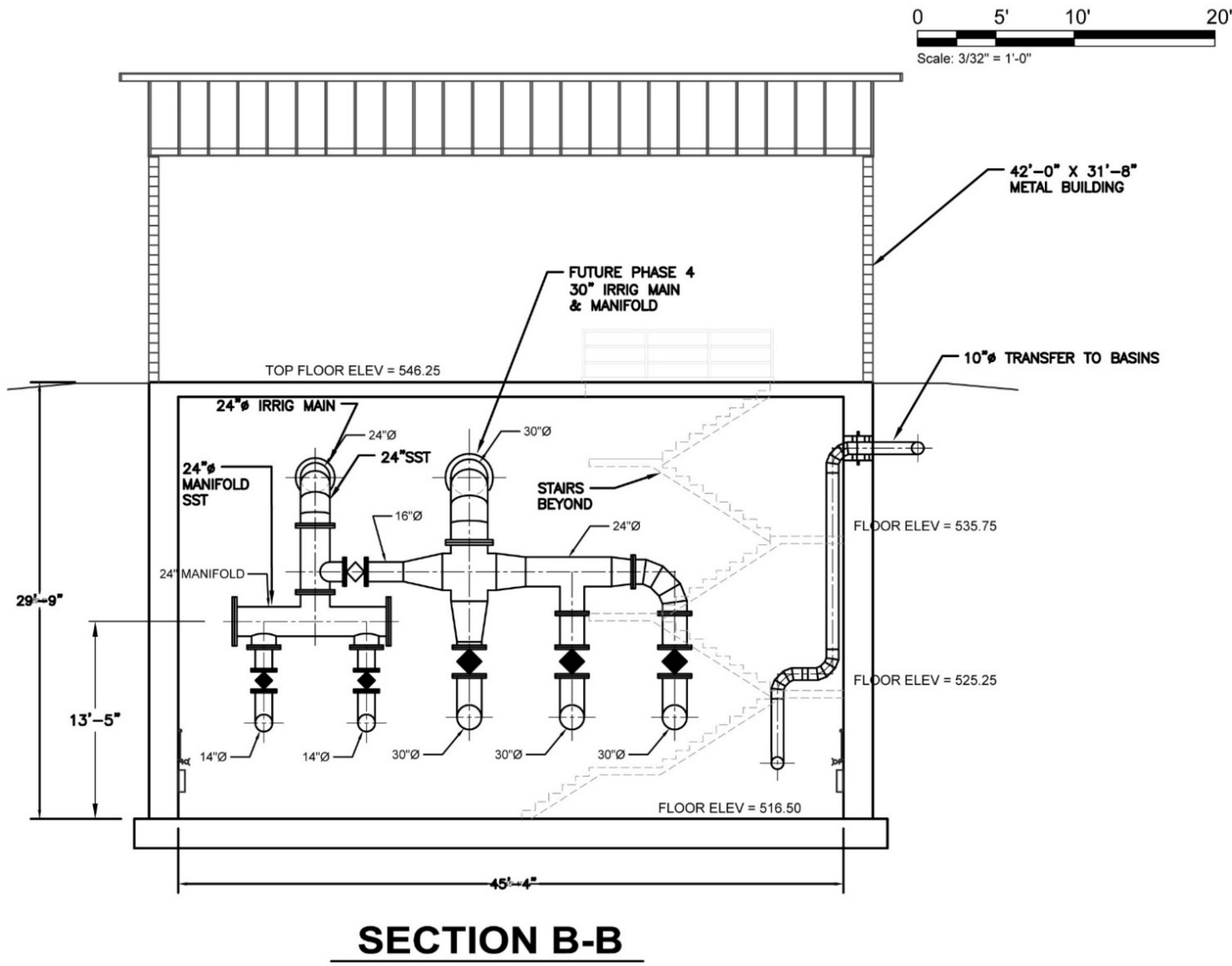


Figure 4-8	*IPS Building Section B-B*	17454.06 06.06.2019

THIS PAGE IS INTENTIONALLY LEFT BLANK.

4.5 PRELIMINARY SITE LOCATION AT PWRF FOR NEW IRRIGATION PUMP STATION

The configuration of future additional storage basins for the PWRF is limited to being located in the area west of the existing 115 MG large storage basin. The structural depth of the new IPS pump station approaches 32 feet to the bottom of the excavation from the floor elevation of 546.25, requiring the new IPS to be located far enough away from the existing forcemains on the south side of the access road to the plant site. Figure 5-1 shows the preliminary IPS site location and layout for the pump station near future storage basins on the north side of the access road to the plant at the west side of the existing 115 MG storage basin and entrance gate.

New 30-inch gravity drain piping from the existing 115 MG storage basin and from the future storage basins will serve to allow complete emptying of the storage basins to enable soluble solids in the basins to be removed. Basins can then be left to dry out and drain more so deposited solids on the basin floors to be removed via front end loader and dump trucks.

In order to remain below the rated pressure capacity of the existing 18-inch irrigation main, a new 24-inch irrigation main will need to be constructed for Phase 3 plant effluent to be pumped through both mains to the spray fields. This 24-inch irrigation main will tie into the existing 18 inch irrigation main near the southeast corner of the PWRF site.

THIS PAGE IS INTENTIONALLY LEFT BLANK.

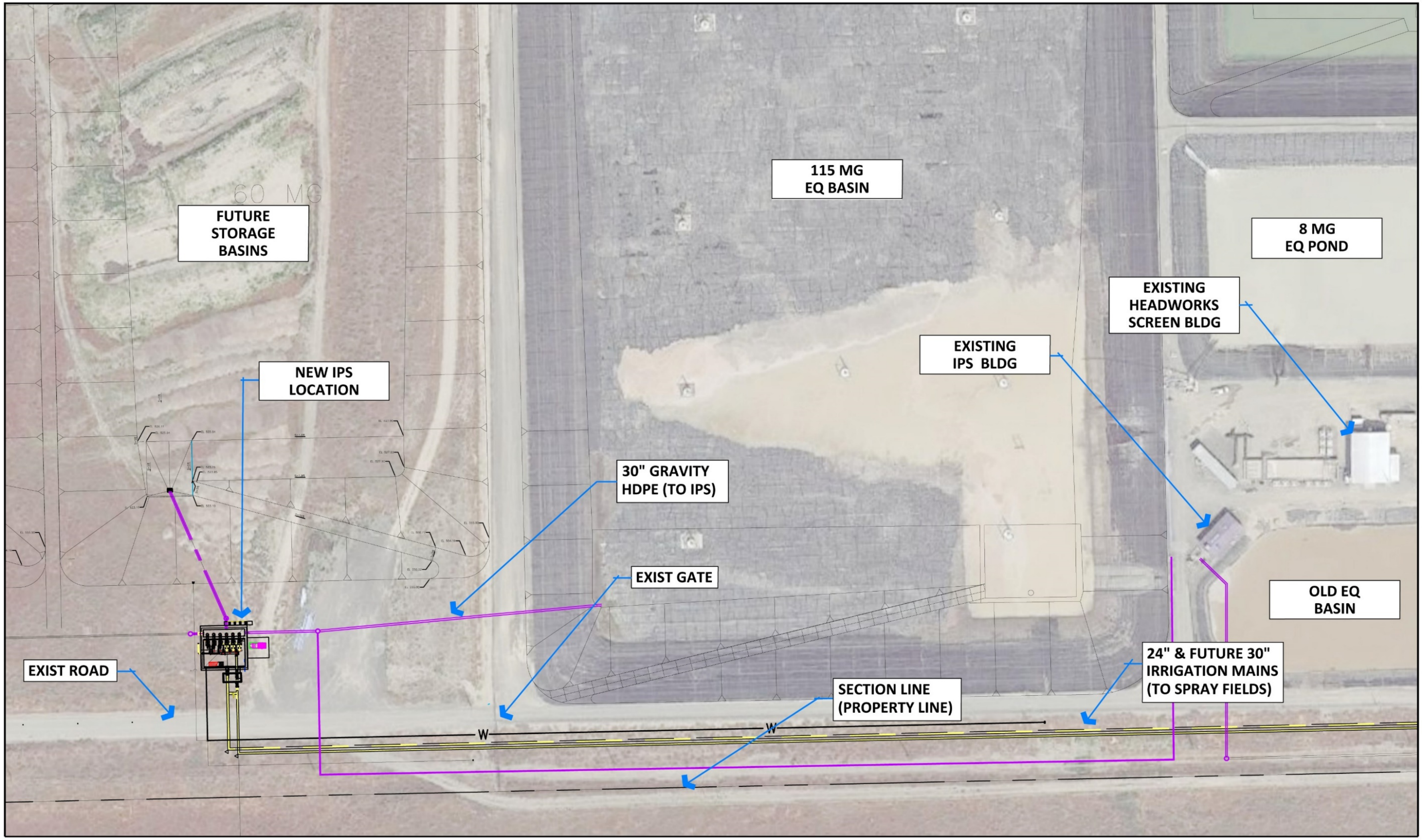


Figure 4-9	*Irrigation Pump Station Site Plan*	17454.06
		06.06.2019

THIS PAGE IS INTENTIONALLY LEFT BLANK.

4.6 PRELIMINARY COST ESTIMATE FOR NEW IRRIGATION PUMP STATION IMPROVEMENTS

4.6.1 KEY PERFORMANCE CRITERIA

There is a small range of irrigation discharge main diameters that fall within the acceptable range of flow velocities. In order to make a preliminary main diameter selection, the other variables listed must also be considered. Those key variables include TDH and associated system pressure, and horsepower requirements. The following is the recommended criteria for each variable:

- Flow velocities for each phase should fall within the range of 4 to 8 fps to enabling scouring.
- Standard operating pressures should not exceed 100 psi to limit stresses on system components. This allows for more standard and less expensive system components. Lower pressures are also safer for maintenance and repair operations.

For the Phase 3 design, a 24-inch manifold inside the pump station and a 24-inch-diameter irrigation main to convey flow to where it can tie into the existing 18 in meets the above criteria. From that tie-in location out to the spray fields, the existing 18-inch will need to paralleled with another larger main for Phase 3 but may also need to sized even larger if flow is to be conveyed completely to the existing spray fields. Another option would be for flow to be split and sent to future spray fields either to the north or south areas near the PWRF plant site. For this memorandum, the costs and options for the irrigation mains are not included in this analysis.

The existing IPS conveys flows to the land treatment site with the TDH at the pumps of approximately 144 feet (62 psi). During Phase 3 the peak IPS flowrate of 15,000 gpm be conveyed through the 24-inch irrigation main and to the spray filed with the assumption that the TDH may need to be increased slightly to be about 207 feet (91 psi).

Additional design applications to consider associated with the pump stations are as follows:

1. Ventilation: Ventilation must be provided within the wet well and dry-pit areas to provide an environment suitable for human occupancy. Ventilation purges the structure of odorous, toxic, and hazardous gases with outside fresh air. Ventilation must also manage flammable gases present in the wastewater to a level appropriate for the desired electrical equipment. The latest version of the NFPA Standard 820 requires ventilation at a rate of 12 air exchanges per hour to maintain a Class 1 Division 2 rating. The blower motor used to ventilate the wet well must be spark proof so as not to create a spark while rotating.
2. Generator: The Department of Ecology recommends the installation of permanent engine generators for larger pump stations and permanent facilities.

However, since the PWRF has the capability of handling flows to the plant during temporarily power loss or if electrical service is taken down for operations or maintenance, then there is no need for an auxiliary generator.

3. Water: A single fire hydrant will be installed adjacent to the wet well. The pressurized potable water supply from this hydrant will be used to facilitate cleaning of the wet well and general site washdown. A second smaller yard hydrant will be installed for general hosing down of the site. An RPBA (reverse pressure backflow assembly) connection will be made at the point of connection to the water system.

4. Telemetry: Telemetry will be included as part of the communication system for the pump station. Telemetry will allow the City operator(s) to monitor the various aspects of the operation of the pump station including, but not limited to, pumping volume, pump(s) operation status, wet well water level, etc. Telemetry will allow the operator to interface remotely with the pump station.

5. Wet well Lining: When the inside surface of the wet well is exposed to carbon dioxide and hydrogen sulfide gas carried in the wastewater, along with low pH levels, a complex, multi-phase process of corrosion is set in motion. These acidic gases reduce the pH of the concrete from 12 to as low as 9. Sulfur oxidizing bacteria (SOB) attach to the surface as sulfates are produced. The acid attacking the concrete creates a layer of gypsum (calcium sulfate) that allows the microorganisms to reproduce, and more acid is created. Eventually the inside wall of the concrete wet well begins to fail.

   High-performance chemical-resistant coatings are available to protect the interior of the wet well against deterioration by creating a protective barrier between the substrate and the waste flow. Coatings come in a variety of formulations with different functional characteristics and application requirements. For our installation an epoxy liner or a polymer lining system is recommended. Epoxy liners or polymer lining systems have long been favored by owners. They are specifically formulated for municipal and industrial wastewater environments and offer an economic solution to resist high concentrations of sulfuric acid and treatment chemicals. In addition to their excellent chemical-resistant properties, they are strong and unaffected by wetness/humidity, making them ideal for applying to damp substrates. Epoxy liners are typically bonded directly to the substrate and may require the use of primer. They are spray applied at dry film thicknesses of 60 to 250 mils. Polymer lining systems are also spray-applied and have a few options for both municipal and industrial applications to specifically address the chemical make-up that attacks the concrete structures.

6. Abrasion: Abrasion has been shown to greatly harm existing pump station forcemains currently operated by the City. Inorganics, such as dirt, found in the conveying wastewater eat away at the cement mortar lining commonly found in

ductile iron pipe. Once this lining is removed, the abrasion caused by the inorganics slowly scours away the metal until failure occurs.

History has shown that both Polyvinyl Chloride (PVC) and High Density Polyethylene (HDPE) pipe are minimally affected by scouring associated with conveying inorganics within a forcemain.

7. pH Corrosion: The City of Pasco has similar pH concerns for the IPS irrigation main discharge piping to the spray fields as they have for the PWRF forcemains coming to the plant. Both HDPE and PVC pipeline materials are acceptable for the pH conditions expected for the forcemains and the irrigation mains.

   A pH below 7 is acidic; above 7 is alkaline. The more below or above 7 a solution is, the more acidic or alkaline it is. The scale is not linear – a drop from pH 8.2 to 8.1 indicates a 30 percent increase in acidity, or concentration of hydrogen ions; a drop from 8.1 to 7.9 indicates a 150 percent increase in acidity. The pH level within the wet well will need to be monitored and maintained to not go below 8.0.

8. Odor: A common issue related to wastewater pump station operation is that of odor accumulation. Wastewater gas that has collected in the confined space of the wet well poses risks of toxicity, underground explosions, and damage to inlet and outlet lines. Methods for alleviating the dangers include turning over the volume of wastewater within the wet well and not letting it accumulate for an excessive time to reduce the potential for nuisance odors. During off-season when not pumping to the spray fields or as necessary, the transfer pump can be used to pump down the wet well and or ready it for washdown clean-up.

9. Forcemain and Gravity Main Materials: It is recommended that all force mains and gravity mains to the IPS be manufactured out of HDPE with shaved inner beads or C-900 PVC, with custom fittings made of equal material. Where HDPE or C-900 fittings are not manufacturable all other fittings must come with an epoxy or powder coated interior. No bends greater than 45 degrees should be used on these discharge pipelines.

10. Valves: Valves shall be as recommended by the City; stainless steel gates or Dezurik plug valves. Check valves shall be Series 41 (Series 40 has been replaced) as manufactured by AVK International. All valves shall come with interior epoxy coatings from the factory.

11. Lubrication: An automatic lubrication system is recommended where applicable.

4.6.2 ELECTRICAL CONSIDERATIONS

Franklin Public Utility District (FPUD) will require a new pad mounted utility transformer for primary electrical service to the pump station. A new 3,000A service is required.

The pump control system will include a submersible pressure transducer for primary level control with redundant level control floats. A programmable logic controller (PLC) and operator interface terminal will be provided for station monitoring and operator control. A fiber-optic-based communication system will communicate status and alarms. An industrial grade uninterruptible power supply (UPS) will be provided to maintain power to the alarm/telemetry system. Outside lighting will be provided to illuminate the wet well area. A motor control center (MCC) will be used to house electrical equipment, motor controllers, and the PLC.

Other recommended elements of the new Irrigation Pump Station include the following:

1. Variable Frequency Drives (VFDs) to allow for pumping capacity adjustments.
2. Spare pump and spare parts kit stored at City's PWRF plant site.
3. Consider influent pH ranges as it may impact pump coating specifications.
4. Indoor NEMA 4 controls cabinet housing the Motor Controls Center (MCC) for inside the pump station building, PLC with level controller to Pumps VFDs, alarms, and telemetry equipment.
5. New plant water main service including reduced pressure backflow preventer (RPBP), fire hydrant for wet well annual clean-up, and non-freeze yard hydrant for normal wet well and pump station outdoor washdown.
6. Building-mounted area light illuminating the wet well and valve vault areas.
7. Security equipment including lighting and CCTV cameras are recommended. Cameras can assist Operators with exact-time remote viewing.

4.6.3 CONSTRUCTION COST

A construction cost estimate was prepared for the new Irrigation Pump Station and summarized in Table 6-1, as follows. In all cases, the cost of the irrigation discharge mains to the spray fields has not been included in the Total Construction Estimate.

Table 4-5: Estimate of IPS Probable Construction Cost

	CITY OF PASCO		UNIT COST 3/2/2018	PROJECT NUMBER 17454	
PWRF - Irrigation Pump Station			Estimated By: PACE		
Option: Wet well / Dry Pit Pumps			Design Status: 30%		
Line No.	**ITEM**	**QTY**	**UNIT**	**UNIT COST**	**TOTAL**
	GENERAL				
1	Mobilization/Demobilization	1	LS	$175,000	$175,000
2	Testing and Commissioning	1	LS	$40,000	$40,000
3	Construction Surveying	1	LS	$20,000	$20,000
4	Temporary Erosion Controls	1	LS	$5,000	$5,000
5	Clearing and Grubbing	0.75	ACRE	$10,000	$7,500
Subtotal General					**$247,500**
PUMP STATION SITE					
6	Excavation	7074	CY	$4	$28,296
7	Backfill	4790	CY	$8	$38,320
8	Cast In-Place Wet well/Dry Pit	804	CY	$550	$442,200
9	CMU Block Wall for Building	1800	SF	$75	$135,000
10	Wood Truss Roofing	1	LS	$20,000	$20,000
11	Metal Roofing and Peak Siding	1	LS	$5,000	$5,000
12	Building Insulation	3192	SF	$4	$12,768
13	Gypsum Board and Drywall	3192	SF	$5	$15,960
14	Interior Painting	1	LS	$4,500	$4,500
15	Crushed Gravel Surfacing & CSBC	150	CY	$30	$4,500
16	Concrete Driveway and Sidewalk	9	CY	$350	$3,150
17	Concrete Stairs	6	CY	$500	$3,000
18	Handrails	60	LF	$50	$3,000
19	Steel I-Beams and Posts for Traveling Crane Hoist	1	LS	$12,000	$12,000
20	Doors and Garage Door	1	LS	$10,800	$10,800
21	Windows (32" high x 48" long)	7	EA	$500	$3,500
22	Bollards	5	EA	$1,000	$5,000
23	4-inch Water Main Pipe	370	LF	$45	$16,650
24	30-inch PVC Gravity Drain Pipe - Up to 25' Deep	405	LF	$250	$101,250
25	12” PVC Supply Forcemain	1150	LF	$120	$138,000
26	24” PVC C900 Irrigation Forcemain	1550	LF	$175	$271,250
Subtotal Pump Station Site					**$1,274,144**

PUMP STATION MECHANICAL					
25	Flygt (CZ 3240.845) Pump	3	EA	$243,225	$ 729,675
26	Flygt (NZ3202 HT 465) Pump	2	EA	$161,000	$322,000
27	Flygt (NZ3202 MT 460)	1	EA	$75,670	$75,670
28	HVAC - Heaters Explosion Proof	1	LS	$18,000	$18,000
29	Mechanical (Air Exhaust Blower & Piping for Dry pit/Wet well)	1	LS	$15,000	$15,000
30	Eccentric Plug Valves	12	EA	$6,500	$78,000
31	Swing Check Valves	6	EA	$7,000	$42,000
32	Suction Bell Piping	1	LS	$5,700	$5,700
33	Discharge Piping and Manifold	1	LS	$28,000	$28,000
34	Pipe Supports and Brackets	1	LS	$4,500	$4,500
35	Magnetic Flow Meter	1	LS	$14,000	$14,000
36	Ultrasonic Level Indicator	1	LS	$6,000	$6,000
37	2-inch Copper Water Line	100	LF	$30	$3,000
38	Yard Hydrant	1	EA	$2,000	$2,000
39	2-inch RPBA	1	EA	$1,200	$1,200
40	Under Running Single Girder Electric Traveling Crane & Hoist	1	EA	$27,000	$27,000
41	Pressure Gages w/ Instrumentation	1	LS	$7,000	$7,000
42	24-inch Slide Gates in Wet well w/ Handwheel Floorstand	3	EA	$10,000	$30,000
	Subtotal Pump Station Mechanical				**$1,408,745**
PUMP STATION ELECTRICAL					
42	PUD Line Extension and Transformer	1	LS	$95,000	$95,000
43	Meter Main and Disconnect	1	EA	$5,000	$5,000
44	General Receptacles and Wiring	1	LS	$12,000	$12,000
45	Grounding	1	LS	$7,000	$7,000
46	Motor Control Center	1	LS	$200,000	$200,000
47	Telemetry Panel	1	LS	$25,000	$25,000
48	Programmable Logic Controller	1	LS	$10,000	$10,000
49	Electrical Cabinets	1	LS	$25,000	$25,000
50	Pump Disconnects Enclosures	1	LS	$23,000	$23,000
51	Float Switches	1	LS	$600	$600
52	Combustible Gas Detector	1	EA	$2,000	$2,000
53	Radio Antennae mounted on building	1	LS	$8,000	$8,000
54	Exterior Lighting on Building	1	LS	$2,000	$2,000
55	Conduit, Receptacles, Wire, Miscellaneous	1	LS	$20,000	$20,000
56	Interior Lighting Building	1	LS	$2,500	$2,500
	Subtotal Pump Station Electrical				**$437,100**

Subtotal Construction	**$2,874,489**
Contingency (Construction Engineering, Const. Admin., and permitting (40%)	$1,149,796
Washington State Sales Tax (8.6%)	$247,206
Total Estimated Construction Cost	**$4,271,491**

4.6.4 OPERATION ENERGY COSTS

The annual operation energy costs were evaluated for Phase 3, 4, and 5 for the new Irrigation Pump Station. Table 4-6 illustrates the monthly power cost for each of the phases using an average Commercial rate of $.0591/kW-h. The basin emptying operation for the IPS requires operating all three (3) of the new larger pumps (at 5,270 gpm each) that make up the firm capacity of the pump station. Using Table 4-2, the full-year flow for Phase 3 at 1,843 MG was used to calculate the monthly power cost.

Table 4-6 Peak Monthly Power Cost

Phase Number	Description	Energy Generated	Monthly Power Cost
3	3 each - 5,270 GPM Pumps Operating	892 KWh / MG	$ 8,100
4 & 5	3 each – 11,000 GPM Pumps Operating	928 KWh / MG	$ 8,425

THIS PAGE IS INTENTIONALLY LEFT BLANK.

CHAPTER 5
PRE-TREATMENT ASSESSMENT

5.1 PWRF PURPOSE

The PWRF was designed and constructed in order to meet the following broad objectives:

- Provide centralized land treatment of food processing wastewater to achieve economies of scale for an important Tri-Cities economic sector, while meeting regulatory requirements for discharge water quality.
- Provide storage of off-season (predominantly winter) flows from those processors with year-round operations.

The process waste stream from the Pasco Processing Center near the PWRF is pumped approximately 2 miles from the Foster Wells Lift Station to the PWRF through a 16-inch and an 8-inch PVC forcemain. Sections of the 16- and 8-inch forcemains have been replaced with ductile iron. The waste stream from Simplot (formally CRF) and Freeze Pack is pumped via a separate 10-inch PVC forcemain directly to the PWRF. The three forcemains enter the headworks building at the PWRF. Each forcemain has a magnetic flow meter. The influent flows are summed by the City in order to record total influent flow. The effluent magnetic flow meter is located in the industrial pump station. This pump station conveys the process wastewater to the spray fields during the spray season of March 1 to November 30 of each year. The waste streams that are received from the processors from December until February are stored in the on-site HDPE lined 115 million gallon (MG) and 35 MG storage ponds. The site also has an 8 MG equalization pond and temporary 5 MG solids storage pond.

There are eleven wells onsite that supplement the process water with fresh water as it is spray irrigated on the spray fields through 16 center pivots. The City leases the land to area farmers who grow a variety of crops included alfalfa, potatoes and corn.

5.2 SEASONAL OPERATIONS

The PWRF functions in two seasons: Non-Growing Season (December-February/March), when wastewater cannot be land applied; and Growing Season (March-November) when wastewater is land applied. During the winter non-growing season, the City has the capability of storing up to 158 MG of combined waste streams from all of the processors in high-density polyethylene (HDPE) lined 115 MG and 35 MG storage ponds and an 8 MG equalization basin. The City manages the irrigation system so that the storage ponds are completely emptied by mid-summer.

5.3 FACILITY CAPACITY INFORMATION

5.3.1 General

The City of Pasco (City) has owned and operated the Process Water Re-Use Facility (PWRF) since 1995. The PWRF and associated irrigated farm properties are located north of the City of Pasco, WA and east of Highway 395 in Franklin County. The farm properties is irrigated via center pivot irrigators with the effluent from the PWRF facilities.

The City designed the PWRF to manage process wastewater from a variety of potential vegetable processing facilities. It currently receives process wastewater from four food processors; no sanitary wastewater is discharged into the industrial system. The processors include Pasco Processing, Twin City Foods, Freeze Pack and Reser's Fine Foods. Freeze Pack is connected to Simplot (formerly known as Simplot RDO (CRF)), which is located on the eastern boundary of the city along State Highway 12. It is important to note the Simplot is in the process of purchasing the CRF facility at the time of the preparation of this document and will assume the same permit currently applicable to CRF. CRF has stopped processing as of January 2016 and therefore the PWRF does not receive process water from this facility.

The City provides potable water to all of the discharge processors. Currently, Pasco Processing is the only food processor permitted by Ecology; the other processors are permitted through the city via industrial wastewater discharge permits. Each processor provides pre-treatment of its waste stream before discharge, in accordance with its discharge permit and the City's pre-treatment requirements. These permits can be found in Appendix F: Discharge Permits.

The City's Department of Public Works is responsible for the operation of the PWRF. The center pivot irrigators are operated by both the City and lease tenants. Land management and crop production are managed by the agricultural lease tenants.

5.3.1.1 Irrigation Water

The processed water produced from the PWRF is used for irrigation of the crop circles east of the PWRF. The City owns and maintains a separate irrigation system apart form domestic supply. To assure the crop circles are maintaining sufficient water, the City supplements the crop circles when needed through this separate irrigation supply water. The source of the City-owned and maintained irrigation supply is through eleven irrigation wells, and the water rights for these wells are shown in Table 8-3.

Table 5-1: Irrigation Wells Water Rights

Water Right No.	Permitted Right (Ac-ft)	Farm Circle Nos.
G3-24546P	609.6	C01
G3-25175P	520.0	C10
G3-20245P	2101.6	C06, C07, C08, C09
G3-20247P	2101.6	C02, C03, C04, C05
G3-22491P	1037.0	C11, ½ of C12
G3-22499P	744.0	C13
G3-23867P	116.0	½ of C12, C15
Total Area	**8229.8**	**–**

5.3.2 Existing Processors

The City has a State Waste Discharge Permit (ST0005369) for the industrial wastewater facility (i.e., PWRF) and spray irrigates the combined waste streams from the food processors onto approximately 1,856 acres of land for further treatment. The application of this process wastewater is limited to March 1 to November 30. The City's permit requires that the City continue to comply with effluent limits, to not exceed the agronomic rate for water and nitrogen, and to protect the groundwater for existing and future beneficial uses. The permit includes groundwater enforcement limits for nitrate (38.6 milligrams per liter (mg/L) = background value) and pH (6.5 – 8.5) and performance-based fixed dissolved solids limits for the irrigated wastewater. In addition, the permit includes a fixed dissolved solids limits of 794 mg/L average month and 957 mg/L maximum day.

The food processors that discharge to the PWRF and their characteristics are as follows:

1. Pasco Processing (State Waste Discharge Permit No. ST0005388)
   - Year-round processing of assorted vegetable types (potatoes, carrots, and cob and kernel corn), apples, peppers, cherries, asparagus and sugar snap peas.
   - No oil-cooked products
2. Twin City Foods (Industrial Waste Discharge Permit No. 000100)
   - Seasonal corn processing that includes blanching and cold storage.

3. Reser's Fine Foods (Industrial Waste Discharge Permit No. 000300)
   - Year-round production of contract-specific potato and other hot side dishes
4. Simplot (formerly known as CRF Frozen Foods) (Industrial Waste Discharge Permit No. 000200)
   - Seasonal processing of assorted vegetables (peas, corn, and green beans) (It is assumed that once Simplot purchases CRF. the same types and quantities of vegetables will be processes as was previously processed by CRF)
   - No oil-cooked products
5. Freeze Pack (Industrial Waste Discharge Permit No. 000300)
   - Year-round processing of onions and seasonal blueberries
   - Permitted by the Washington State Department of Ecology (Ecology) to spray irrigate waste stream during crop growing season for final treatment (State Waste Discharge Permit No. ST0008108)
   - Discharges waste stream via pipeline to Simplot (formerly known as CRF)

Table 5-2: Food Processor Waste Stream Quantities (2017)

Food Processor	Total Annual Permitted Flow (MG)	Average Flow — Maximum Month (mgd)	BOD_5 Load — Maximum Month (pounds per day)	BOD_5 Load — Monthly Average (pounds per day)	Total Annual Nitrogen Load (pounds)
Pasco Processing, LLC	383.4	2.5	127,000	—	270,000
Twin City Foods	220	2.4*	160,000	140,000	225,000
Reser's Fine Foods	115	0.3*	—	7,200	72,000
Simplot (formerly CRF Frozen Foods, LLC)#	205	1.25^	—	70,000	150,000
Total	**923.4**	**6.45**	**287,000**	**217,200**	**717,000**
PWRF Design	1003.4	10.6	355,600	—	866,246
PWRF Reserve	80	4.15	68,600	—	149,246

BOD_5 = 5-day biochemical oxygen demand.
MG = million gallons.
mgd = million gallons per day.
* Value is monthly average
^ Value is daily maximum
# Includes Freeze Pack's discharge of approximately 60,000 to 80,000 gallons

Table 5-2 presents the flows and loadings that are permitted to go to the PWRF.

The City requires each of the food processors to screen and provide for pH adjustment of its waste stream before discharging into the collection system. Reser's Fine Foods waste stream meets the City's pH requirements (5 to 11 standard units) without adjustment.

5.4 EQUIPMENT OVERVIEW

The PWRF receives process wastewater from the Foster Wells and CRF lift stations and has the capability to treat and store the process wastewater until transfer to the land application areas.

The major components of the PWRF are:

- Rotary Screening – large solids are removed by two rotary drum screens. Solids are removed via an auger to the screw press while the liquid stream continues to the clarifier/sedimentation basin.
- Clarification/Sedimentation Basin – A single rectangular clarifier is used to remove settleable solids (primarily sand) from the process water. Settled solids in the clarifier are removed via a wasting pump and further settled out in a parallel series of sand traps. The settled solids in the sand traps are periodically remove by vacuum truck to a 5 MG HDPE lined basin.
- Screw Press – A screw press is used to dewater the solids that are removed by the rotary screens. The solids are stored to be used as livestock feed supplement during the corn processing season or landfilled during other processing seasons.
- Storage Ponds (115 MG, 35 MG) – two lined ponds are used to store excess process wastewater, primarily due to winter flows from those processors continuing operations year-round.
- Equalization Basin (8 MG) – a 8 MG equalization pond is used to buffer influent flow surges and allow a constant flow to the irrigation pump station.
- Temporary Solids Settling Basin (5 MG) – a 5 MG temporary solids setting basin (formerly the equalization basin) located at the southeast corner of the PWRF is used to settle and store solids from the sedimentation basin and screw press filtrate, sand traps, rotary screen overflow.
- Irrigation Pump Station (IPS) – The IPS wet well is fed by any combination of pumps from the 8 MG pond, 115 MG pond gravity line, 115 MG transfer pump and directly from the sedimentation basin. The IPS transfers flow to the Farm Operations Distribution System using vertical turbine pumps.
- Farm Operations Distribution System – irrigation water is distributed to fourteen full size and two smaller center pivot irrigation systems owned by the City and leased to growers. Field water is supplemented by several wells. Most of the circular fields are approximately 128 acres each; a total of 1,856 acres of cropland exists. The irrigated pivot circles, which comprise the Land Application Area, are arranged in two blocks,

with circles 1 through 5 being grouped south of Foster Wells Road and circles 6 through 13 and 15 (14 is not used) being grouped north of the road.

The existing PWRF facility was upgraded in the fall of 2014 to remove additional constituents and improve the quality of the process water to the spray fields. These improvements include a new headworks to house screening equipment and other smaller components and the installation of a rectangular sedimentation basin. According to the record drawings prepared by Cascade Earth Sciences in September 2014, the basis of design for the PWRF are presented in Table 5-2.

Table 5-3: PWRF Design Basis (2014)

Parameter	Units	2012/2013 Flow	Design Flow
Minimum System Flow Rate	GPM	—	750
FWLS Maximum Instantaneous Flow Rate	GPM	--	4,000
CRF Maximum Instantaneous Flow Rate	mgd	--	1,500
Jun to Oct Average Flow	mgd	2.8	3.3
Nov to May Average Flow	mgd	0.9	1.1
Maximum Month Average Flow	mgd	4.1	4.8
Peak Day Flow	mgd	5.4	6.3
Annual Flow	MG	607	710

Peaking factors are the ratio of higher flows, such as maximum day flows, to average annual flow.

The peaking factors for the 2014 upgrades are the following:

- June to October Annual/Maximum Month Flow = 1.45
- June to October Average Annual/Maximum Day Flow = 1.90

Since the maximum month and day flows occur in the June to October processing season, peaking factors outside of this time period are not pertinent.

The flows to the facility, in general, align with the design flows and associated peaking factors.

5.4.1 Rotary Screens

In 2014, two WesTech Cleanflo shear internally-fed drum screens were added to the beginning of the pre-treatment process to remove solids from the system. The two rotary screens are used to remove solids greater than 0.02 inches to improve the quality of stored process water prior to discharge to the farm distribution system. Process wastewater enters the process from the 3 influent pipes from the two lift stations and falls onto the screen surface allowing liquid to fall through the cylinder, capturing solids larger than 0.02 inches, and conveys them to the discharge point using spiral flights inside the rotating cylinder.

The existing rotary drum screens have a rated capacity of 3,000 gpm each (8.65 mgd combined). The maximum demonstrated flow to the screens is approximately 5 mgd. The existing screening building was designed and constructed for three screens although only two screens were installed in 2014. The piping and valving for the third screen is in place and allows for a “plug and play” installation of a third rotary drum screen.

An analysis of screen performance using data from 2015 and 2016 is discussed in Appendix G. A plot of screen influent vs. solids mass balance indicated that approximately 10 to 20 percent of the influent suspended solids were removed below an influent mass load of 8,000 to 12,000 lbs/day and above this range, the suspended solids removal was linear at 95 percent (Figure 4 of Appendix G). It appears that it is necessary for a layer of solids to form on the screen to efficiently screen and remove suspended material that are smaller than the screen slot size. The data range of this analysis included flows of 2.2 to 3.8 mgd and influent TSS mass loads up to 50,000 lbs/day. The Phase 2 peak flow of 8.67 mgd exceeds the rated capacity of the existing screens.

The existing West Tech screens experience a buildup of starch, especially at average day and higher flows. This layer of film expands during operation and reduces the preformation size and capacity of the screen. Ultimately, the hydraulic capacity of the screens is compromised and has resulted in overflow conditions both to the FKC screw press used to dewater the screenings and onto the screening building floor.

Operations crews have experimented with various methods to reduce or inhibit the buildup of this starch on the interior of the screens. Also, West Tech and other screen manufacturers have been contacted for resolution of this screen blinding phenomenon. All manufacturers have suggested using heated water and increasing internal spray bar pressure to retard the growth of this film. The City has experimented with steam pressure washers to simulate this suggestion with success. However, to realize the capacity of the screens and prevent overflows, this steam cleaning is provided throughout the day, requiring operations staff undivided attention.

Do the observed success of the high-pressure, heated water spray in removing the film and preventing screen blinding, City operations purchased two on demand unit water heaters for installation in order to automate this practice. Unfortunately, due to limited electrical power supply this system has not been installed.

The Phase 2 pretreatment improvements will require increased power supply to the PWRF. The electrical demand for the unit heaters along with an in-line booster pump would be installed to implement the manufacturers recommendations and automate the currently successful manual practice implemented by PWRF operations staff.

5.4.2 Clarifier/Sedimentation Basin

During the 2014 PWRF expansion, a 900 square foot rectangular clarifier was added to remove smaller settleable solids from the process flow. Designed to consist ultimately of four side-by-side clarifiers, the initial installation was limited to a single unit intended to process winter flows.

The rectangular clarifier is a conventional design utilizing two sets of lightweight flights mounted on a chain drive. In the main basin, these flights are approximately the width of the basin and serve to both move settled solids to the waste trough and to skim the surface scum. The main flights failed in 2016 and have been removed and replaced with wood baffles and spray bars. The end cross flight is in need of repairs.

In the PWRF rectangular clarifier, a second set of flights is mounted transversely in the sludge well to move solids from one end of the trough to the sump end with the wasting pump inlet. The PWRF design parameters are shown in Table 5-3.

Table 5-4: PWRF Rectangular Clarifier Design Parameters

Parameter	PWRF
Basin Depth	9.5 feet
Basin Width	20 feet
Basin aspect ratio (L:W)	3:75:1
Detention Time	5.8 hrs (ADF) 2.0 hrs (MDF)
Overflow Rate	1,133 gpd/ft^2 (ADF) 3,333 gpd/ft^2 (MDF)
Weir Loading	26,771 gpd/ft (ADF) 78,740 gpd/ft (MDF)

ADF = Average Day Flow
MDF = Maximum Day Flow
gpd/ft^2 = gallons per day per square foot

Vegetable processing generates large volumes of suspended solids in their waste stream. These suspended solids (TSS) are typically categorized as organic (food particulate) and inorganic (silts/clays). Removal of TSS from the vegetable waste water is required to prevent premature failure of pumps and pipes, reduce solids build-up in winter storage ponds, and improve quality of effluent applied to the Land Treatment system. Agricultural TSS contained in the influent received at the PWRF is generally characterized by larger solids, greater than 200 sieve, and the smaller silts and organics passing the 200 sieve size.

Larger or heavier particulate is typically removed early in the treatment process. Screening will remove the larger particles as discussed previously in section 5.4.1. The smaller, heavier particles, such as silts and organics are can be removed through primary clarification means (settling). This process can be enhanced if needed by adding polymers to increase the particulate size and weight to improve settleability. Typically, these settling basins or clarifies are equipped with skimmers to remove any floating solids that passed through primary screening. The settled solids and capture floating solids are removed from the process and stored on-site for future disposal.

Typical removal of the total suspended solids (TSS) from a rectangular clarifier can be in the range of 35 to 65 percent. In addition, 20 to 40 percent of biochemical oxygen demand (BOD) that is associated with the TSS may also be removed.

The existing primary clarifier is significantly hydraulically overloaded during summer operation. A new primary clarifier and accompanying solids dewatering equipment will reduce the TSS and the BOD5 and TN associated with the TSS that is applied to the fields during the irrigation season or stored during winter operation. Less solids will accumulate in the 115 and 35 million gallons (MG) storage basins.

An analysis of primary clarifier performance using data from 2015 and 2016 is discussed in Appendix G.

A plot of clarifier effluent TSS removal efficiency vs. flow for January to September 2015 (Figure 6 of Appendix G) shows the following:

- At flows below 1 mgd (approximately 1,100 gallons per day/square foot surface loading (gpd/sf)), the clarifier effluent TSS remained between 200 to 400 mg/L.
- At flows above 1 mgd, the 2015 data suggests that the TSS removal efficiency decreases linearly with flow to 1,200 mg/L at 4.5 mgd (5,000 gpd/sf surface loading).

The 2016 data indicated that the PWRF influent TSS ranged between 200 to 500 mg/L at flows of 2.2 to 3.6 mgd with minimal removal.

5.4.3 As Modified/Temporary Sedimentation Removal

In April 2016, the rectangular clarifier mechanism failed catastrophically, resulting in the basin being inoperable in the manner it was originally intended. As a key process at the PWRF, corrective action was prioritized. As a temporary solution, the broken longitudinal flights were removed from the basin and two timber baffle walls were constructed. These baffle walls were intended to provide energy dissipation of influent flow, allowing the sand to be trapped in the wasting sump (the transverse flights were repaired, and the waste pump continues in use). The sand is passed to the sand traps and liquid returned to the clarifier as previously operated.

In 2016, a series of sand traps was added to the clarifier unit process. The purpose of these traps is to provide additional settling of the relatively heavy sand load taken in by the PWRF from the processors. Figure 5-1 shows these traps. With the modifications to the rectangular clarifier, an additional set of sand traps was installed to provide more flexibility in operations.

Figure 5-1	*PWRF Sand Traps*	17454.00
		04.15.2016

The traps take the flow from the wasting pump and pass it through twelve 1,000-gallon concrete tanks. Flow through these tanks is by overflow from the proceeding tank; the resulting energy dissipation allows the sand to settle in the traps. Sand is removed using a Vactor truck and the sand is deposited into the 5 MG temporary solids storage basin.

5.4.4 Screw Press

In 2014, a screw press was installed to dewater the solids that were removed through the rotary screens. This operational screw press dewaters the rotary screen screenings, with the effluent going to the sedimentation basin. The dewatered screenings containing vegetable matter is conveyed and deposited in a truck for feed supplement during corn processing. All other times, the dewatered material goes to the landfill.

5.4.5 Storage Lagoons

The PWRF has three existing lined ponds that are used for storage on the property:

- 115 MG storage lagoon (114 MG capacity)
- 35 MG storage lagoon (34 MG capacity)

- 8 MG treatment pond

All three ponds are lined for a 60- mil single lined HDPE liner that is electronically leak tested every permit cycle. Currently, the ponds are not connected to each other. The City uses temporary pumping to transfer the process water from the 115 MG pond to the 35 MG pond. The 8 MG pond is currently being used for equalization.

There is also a lined 5 MG pond on the site. It had been previously used as an equalization (EQ) pond but was converted to a temporary solids storage pond in 2016. The 8 MG treatment pond was converted to the new EQ pond.

The existing ponds were surveyed and it was discovered that the 115 MG pond can only hold 114 MG before it needs to be transferred to the 35 MG pond. The 35 MG pond only holds 34 MG therefore, the total winter storage is 148 MG.

The primary purpose of the EQ pond is short-term storage of the PWRF product water to buffer the operation of irrigation pumps for land treatment. If the waste stream inflow exceeds the amount that can be delivered for land treatment, the excess flow will go directly to the 115 and 35 MG storage lagoons. The EQ pond has no over overflow piping to the other storage lagoons.

Current operations are to take the ponds off-line (i.e., all water is removed) by the fall so that the solids that have settled can be removed to regain capacity. City staff would like to expand the winter storage season (currently December 1 to February 28) to five months. This will allow storage to begin one month sooner (November 1) and will allow storage for one additional month in the spring (through March 31). This will allow flexibility in operations including the time allotted for cleaning and maintenance in the fall. Storing the process water one additional month will allow the City to not be applying process water to the fields when the environmental conditions may not be conducive to spray irrigation.

The additional two months (one month in the fall and one month in the spring) requires additional storage. The projected future flow for Phase 1 and 2 processors will also require additional storage.

5.4.5.1 115 MG Storage Lagoon

The 115 MG storage lagoon (Figure 5-2) is intended for use during cold weather or other periods when land application rates cannot be maintained at the desired production rate because of conditions in the irrigation area. The lagoon was initially designed to store approximately two months of process water output from the processors from December 1 to processor startup. The estimated volume for storage for cold weather is 50 days at 2.0 mgd or 100 MG, roughly approximating current cold weather flows.

Figure 5-2	115 MG Storage Lagoon	17454.00
		12.14.2017

5.4.5.2 35 MG Storage Lagoon

The 35 MG storage lagoon was constructed in 2014 to provide additional cold-weather storage. By adding approximately 17 days of storage at current winter flows, the overall cold weather storage capacity of the PWRF was restored to be greater than 60 days (Table 5-4).

Table 5-5: Storage Pond Parameters

Lagoon Volume (MG)	Storage Days[1]	Lagoon Dimensions (ft)
115	50	1400 x 800
35	17	600 x 525

[1] Assumes a flowrate of 2.0 million gallons per day (mgd). Actual winter flows are currently less than 1.25 mgd

The 35 MG pond was constructed without outlet pipes to connect to the other on-site ponds. In 2016, the 35 MG pond was temporarily connected to the 115 MG Storage basin and the 8 MG Equalization basin via overland piping and electrical transfer pumps to provide additional storage pond capacity during cold weather periods.

5.4.5.3 8 MG EQ Pond (Formerly Treatment Pond)

Constructed as part of the 2014 capital improvements, the 8 MG EQ (formerly treatment) pond was initially intended to contain a Capped Anaerobic Process (CAP) to achieve a level of BOD reduction to improve product water quality. During the late phases of the design and construction, however, the City re-evaluated the use of CAP.

Due to a need to temporarily store solids in a lined basin, the 5 MG pond was converted from the EQ pond to a solids holding basin in 2016. The 8 MG pond was converted to an EQ pond.

The primary purpose of the EQ pond is short-term storage of the PWRF product water to buffer the operation of irrigation pumps for land application. If the waste stream inflow exceeds the amount that can be delivered for land application, the excess flow will go directly to the 115 and 35 MG storage lagoons. The EQ pond has no over overflow piping to the other storage lagoons.

5.4.5.4 Temporary Solids Storage (Formerly EQ) Pond

As discussed above, the 5 MG pond was initially constructed to provide a buffer for the irrigation pumps. The 5 MG pond is lined with the same HDPE material as the storage lagoons onsite (60 mm HDPE). The inlet, which is located on the southwest corner of the pond, is a 24-inch diameter cast iron pipe embedded in a concrete block in the basin bottom. The pipe is oriented vertically, where it penetrates the basin floor, and discharges 12 inches above the floor of the basin.

In 2016, the 5 MG pond was converted to a temporary solids storage basin since it was lined and was the smallest available basin of the lined on-site ponds. The 5 MG pond has been dredged once to remove the solids to be land applied. A permanent solids handling solution will be evaluated.

Figure 5-3	***5 MG Pond***	17454.00
		04.16.2016

5.5 PWRF EQUIPMENT CAPACITY DATA

As previously mentioned, additional equipment was installed in the fall of 2014 in order to increase the water quality of the process water with the installation of two fine rotary drum screens (0.02 inch mesh) and a sedimentation basin.

A review of the existing permits for the processors reveals that they are not sending their fully permitted flows to the PWRF. It can be reasonably assumed that the processors will eventually send their full permitted flows to the facility since the City has committed to those flows and loads. The existing headworks/screen system is rated for a flow of 8.65 mgd. The July/August 2017 high flow processing month peak flows were approximately 4.6 mgd which is approximately 53 percent of design capacity.

The PWRF has reached a peak day flow rate of approximately 4.9 to 5.0 mgd over the last several years. The base flows during the winter time period (November – March) have been approximately 1.0 to 1.2 mgd. Review of the City's existing industrial permits indicates that the processors are permitted to send a combined maximum month average flow of 6.5 mgd to the PWRF (see Table 5-5). Peak day flows could be higher.

Table 5-6: Industrial Processor Permitted Flow Summary

Permit and Fact Sheet Data Summary	Twin City Foods	Pasco Processing	Reser's Fine Foods	CRF	Total
Total Flow (MG)	200	383	115	205	903
Average Flow – Max Month (mgd)	2.4	2.5	0.3	1.25	6.5

City staff started the collection of additional samples within the treatment process train from January to September 2015 to determine the effectiveness of the equipment and to provide a basis for constituent removal assumptions for the design of further treatment. City staff collected samples at the following locations: upstream of screening, upstream of the sedimentation basin, and post sedimentation basin. Tables 5-6 through 5-9 provide a summary of this additional sampling and the associated removal efficiencies of the constituents. As noted in Table 5-6, the process (screening plus sedimentation basin) removed 65-70 percent TSS and 25-30 percent BOD for the nine months of data available in 2015.

Table 5-7: Screening Removal Efficiency

	Average TSS (lb/day)	Average BOD (lb/day)	Average TKN (lb/day)	Average TN (lb/day)	Average TDS (lb/day)	Average FDS (lb/day)
Pre-screen	37,645	68,601	1,519	1,447	29,050	10,020
Post-screen	24,878	56,690	1,729	1,743	28,252	9,748
Removal	12,767	11,911	-211	-296	798	272
Screening Percent Removal	**33.9%**	**17.4%**	**-13.9%**	**-20.4%**	**2.7%**	**2.7%**

Table 5-8: Clarifier Removal Efficiency

	Average TSS (lb/day)	Average BOD (lb/day)	Average TKN (lb/day)	Average TN (lb/day)	Average TDS (lb/day)	Average FDS (lb/day)
Pre-clarifier	24,878	56,690	1,729	1,743	28,252	9,748
Post-clarifier	11,695	49,536	1,428	1,439	22,494	9,363
Removal	13,183	7,154	302	304	5,757	384
Clarifier Percent Removal	**53.0%**	**12.6%**	**17.4%**	**17.4%**	**20.4%**	**3.9%**

Table 5-9: Overall Removal Efficiency (Pre-screen to Post-Clarifier)						
	Average TSS (lb/day)	Average BOD (lb/day)	Average TKN (lb/day)	Average TN (ppd)	Average TDS (lb/day)	Average FDS (lb/day)
Pre-screen	37,645	68,601	1,519	1,447	29,050	10,020
Post-clarifier	11,695	49,536	1,428	1,439	22,494	9,363
Removal	25,950	19,065	91	8	6,556	657
Screening + Clarifier Percent Removal	**68.9%**	**27.8%**	**6.0%**	**0.6%**	**22.6%**	**6.6%**

The sampling data was further analyzed by dividing the processing season down into two periods. It was noted that the flow during the July to October period was approximately double the first half of the year. Based on this, it was determined that it would be prudent to evaluate the TSS removal by the screens and clarifier using two periods (Jan to Jun) and (July to Dec). This data is presented in Table 5-9.

Table 5-10: TSS Average Removal Efficiencies				
	Units	Jan-Jun	July-Dec	Total
Total Flow	MG	213.8	587.4	
Pre-Screen	mg/L	3,030	2,031	
Post-Screen	mg/L	1,327	1,884	
Screen TSS Removal	mg/L	1702	147	1,850
Screen TSS Removal	Lbs	3,035,743	721,389	3,757,132
Screen TSS Removal	Tons	1,518	361	1,879
Clarifier TSS Effluent	mg/L	293	1,201	
Clarifier TSS Removal	mg/L	1,034	683	1,717
Clarifier TSS Removal	Lbs	1,844,526	3,344,843	5,189,370
Clarifier TSS Removal	Tons	922	1,672	2,595

The following observations were made from Table 5-9:

- Flows to the PWRF were double during the latter six months of the year compared to the first part of the processing year.
- The pounds of TSS removed through the screens during the latter six months was a quarter of the amount removed during the first six months.
- The clarifiers removed approximately three times the amount of TSS during the latter six months compared to the first six months.

Pasco Processing upgraded their pre-treatment system in 2016 to improve the removal of suspended and settleable solids. The City performed additional sampling between June and

October 2016 across the PWRF pre-treatment train. Flows ranged from 2.2 to 3.8 mgd. The median values of 16 data sets are summarized on Table 5-10. The median, rather than average values, were used to minimize the impact of one day when influent constituent concentrations were approximately 3 to 6 times higher than the maximum value of the remaining 15 data points.

Table 5-11: PWRF Performance: June – October 2016

	Total BOD			Total Suspended Solids			Total Nitrogen		
Flow: 3.51 mgd	**mg/L**	**lb/day**	**Removal**	**mg/L**	**lb/day**	**Removal**	**mg/L**	**lb/day**	**Removal**
Influent	732	21,437	—	393	11,509	—	68	1,981	—
Screen Effluent	941	27,558	-28.6%	400	11,714	-1.8%	71	2,078	-4.9%
Clarifier Effluent	816	23,897	13.3%	319	9,342	20.3%	66	1,938	6.8%
Final Effluent (IPS)	579	16,957	29.0%	191	5,594	40.1%	41	1,205	37.8%
Overall Removal		**4,481**	**20.9%**		**5,916**	**51.4%**		**776**	**39.2%**

BOD = biochemical oxygen demand
IPS = irrigation pump station
mg/L = milligrams per litter
lb/day = pounds per day

5.5.1 Screen Performance Analysis

The influent BOD_5, TSS and total nitrogen (TN) median values were all less than the screen effluent values for these parameters. This is likely attributed to an issue with the sampling and this resulted in influent characteristics being lower than actual. An analysis of screen performance based on mass loading was completed using 2015 and 2016 data sets (Figure 5-4).

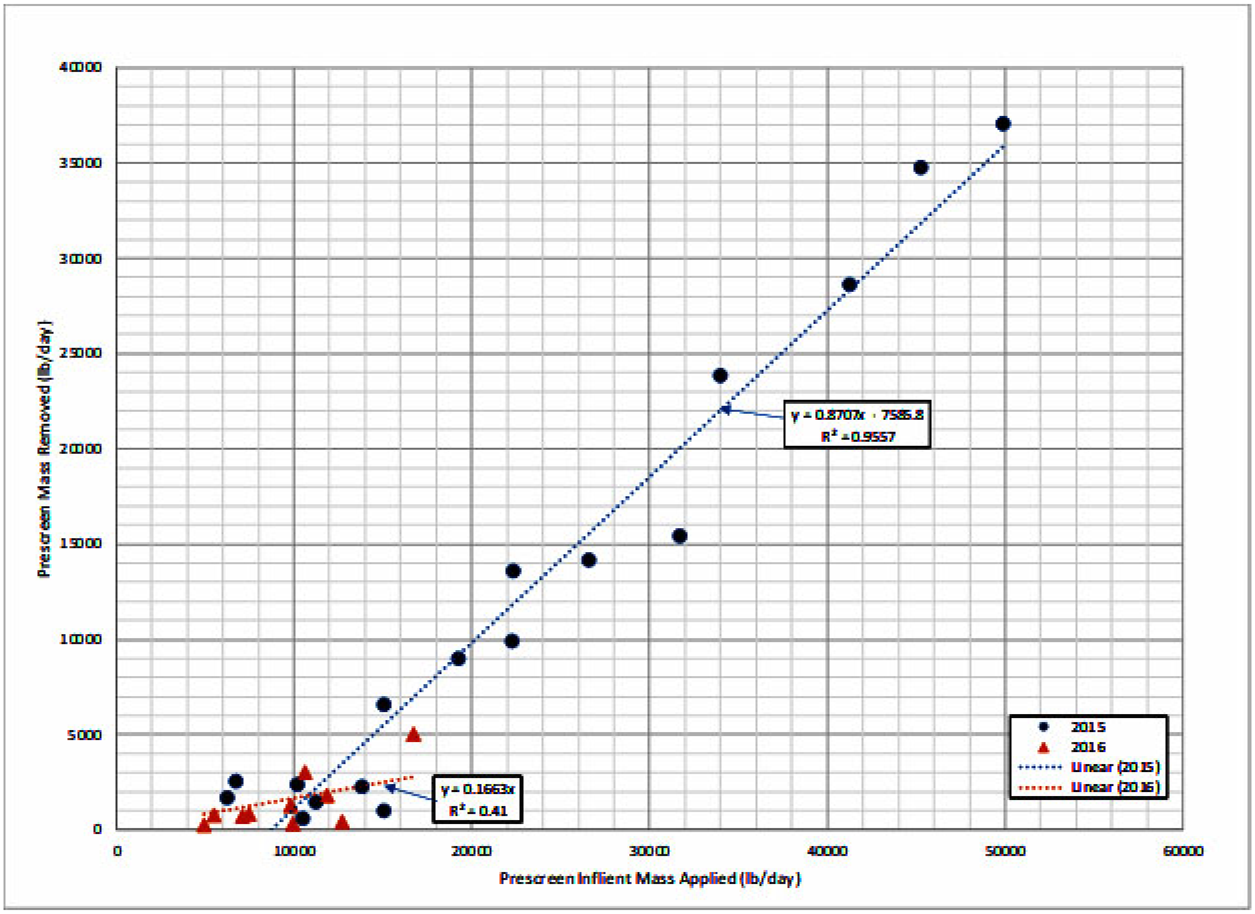


Figure 5-4	***Prescreen Influent Mass vs Mass Applied (2015 and 2016 data)***	17454.00
		12.14.2017

The plot of screen influent versus effluent solids mass (Figure 5-5) indicates that approximately 10 to 20 percent of the influent suspended solids are removed below an influent mass load of approximately 8,000 to 12,000 lb/day. Above this range, the suspended solid removal is approximately 95 percent. It appears that it is necessary for a layer of solids to form on the screen to efficiently screen and remove suspended material that are smaller the screen slot size.

Based on the screen data analysis, an estimated median influent TSS mass load was recalculated assuming 17 percent removal of the first 11,000 pounds of TSS applied and 95 percent TSS removal thereafter. Influent total BOD and TN concentrations were estimated from particulate BOD_5/TSS and TKN ratios developed from the 2016 data set. Using this approach, the revised 2016 PWRF performance is summarized in Table 5-11.

Table 5-12: Revised PWRF Performance: June – October 2016									
	Total BOD			Total Suspended Solids			Total Nitrogen		
Flow: 3.51 mgd	mg/L	lb/day	Removal	mg/L	lb/day	Removal	mg/L	lb/day	Removal
Influent	977	28,624	—	476	13,932	—	83	2,425	—
Prescreen Effluent	941	27,558	3.7%	400	11,714	15,9%	71	2,078	14.3%
Clarifier Effluent	816	23,897	13.3%	319	9,342	20.3%	66	1,938	6.8%
Final Effluent (IPS)	579	16,957	29.0%	191	5,594	40.1%	41	1,205	37.8%
Overall Removal		**11,668**	**59.2%**		**8,338**	**40.2%**		**1,220**	**49.7%**

Comparing the revised 2016 to 2015 data set, the TSS loading was reduced by approximately 63 percent and BOD_5 by 58 percent. The 2015 influent TN concentrations were lower than the screen effluent. Comparing the screen effluent TN, the 2016 data indicated a 19 percent increase over 2015.

Based on the 2016 data, overall approximate removals in the PWRF including settling in the EQ basin indicate BOD_5 reductions of 59 percent, TSS reductions of 40 percent and TN reductions of 50 percent.

While the significant pre-treatment system performance improvements made by Pasco Processing are apparent in the wasteload reductions between 2015 and 2016, it is important to note that the CRF facility (being purchased by Simplot), was not operating in 2016.

The City did not conduct a PWRF sampling and analysis program in 2017. It is strongly encouraged that the City continue the sampling program implemented in 2016 to confirm or revise the data from which design criteria are being developed to accommodate the phased expansion of the PWRF.

5.5.2 Clarifier Performance Analysis

At a flow range of 2.2 to 3.6 mgd, the 2016 screen effluent concentration were in the range of 200 to 500 mg/L. The 2016 clarifier TSS removal efficiencies were low, in the range of 0 to 20%, and did not correlate to flow.

Clarifier effluent TSS vs flow for the 2015 and influent and effluent TSS for 2016 data sets are presented in Figure 5-5.

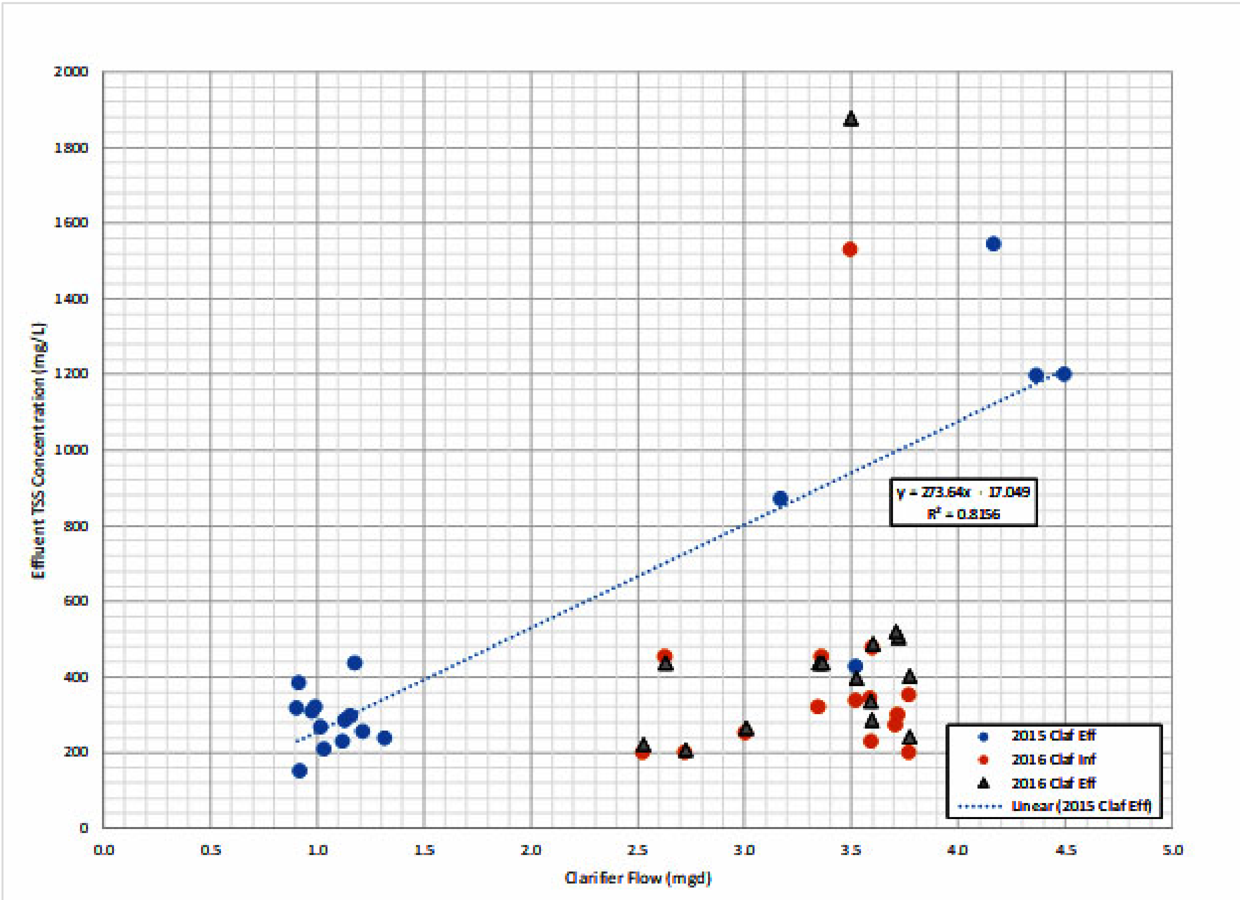


Figure 5-5	Existing 900 SF Clarifier Effluent TSS Concentration vs Flow (Jan. to Sept. 2015 and July to Oct. 2016)	17454.00 12.14.2017

At flows above 1 mgd (approximately 1,100 gallons per day (gpd)/sf surface loading), the clarifier effluent TSS remained between 200 to 400 mg/L. At flows above 1 mgd, the 2015 data suggests that the TSS removal efficiency increases linearly with flow. Figure 5-6 presents the clarifier effluent TSS removal efficiency vs. flow for January to September 2015.

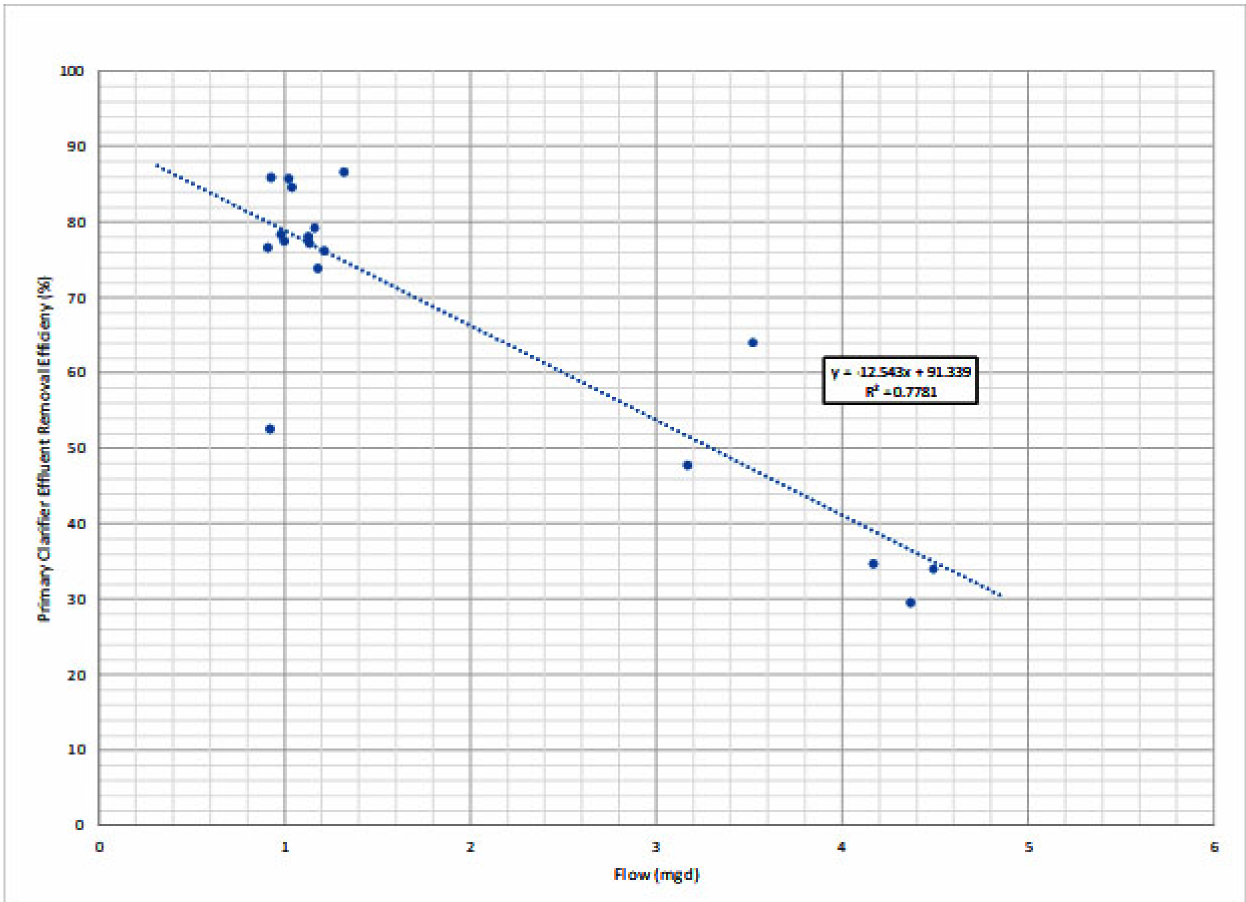


Figure 5-6	***Clarifier Effluent TSS Removal Efficiency vs Flow (Jan. to Sept. 2015)***	17454.00 12.14.2017

The 2016 and 2017 has revealed that the influent TSS from the processors has been significantly reduced compared to the 2015 and earlier data. If the influent TSS remains below 500 to 600 mg/L, the installation of a new primary clarifier and solids handling system may be able to be delayed to later phases. Based on Figure 5-7, the recommended surface loading for a new primary clarifier would be 1,000 gpd/sf for average flow and 1,500 gpd/sf for peak flow conditions.

5.6 STATE WASTE DISCHARGE PERMIT REQUIREMENTS

The City's permit requires that the City indicate how they are going to comply with the anti-degradation policy of groundwater standards relative to the total dissolved solids concentration in the groundwater.

The results of the performance-based determination resulted in the following interim performance-based irrigated process wastewater effluent limits for TDS:

- Maximum daily limit = 957 mg/L
- Average monthly limit = 794 mg/L

The State Waste Discharge Permit included final groundwater enforcement limits (Table 5-12), but did not define a time when the City must comply with these final enforcement limits. Instead, the City is required to outline how it will comply with the final enforcement limits as part of an Engineering Report or Facility Plan.

Table 5-13: Final Groundwater Enforcement Limits

Nitrate	38.6 mg/L
Total Dissolved Solids	631 mg/L
pH	6.5 – 8.5 standard units

The current state waste discharge permit requires the following to be addressed:

- Determination of the design limiting parameter for the spray field site.
- Design treatment capacity of the facility for nitrogen.
- Water balance such that the leaching fraction is less than or equal to the leaching requirement.
- A salt management plan that describes how the City will operate the system to comply with the groundwater enforcement limit for TDS of 631 mg/L and comply with the non-degradation policy of the groundwater standards.
- The organic loading in terms of the BOD (lbs/acre/day) that will not cause anaerobic or reducing chemical conditions in the vadose zone.
- All known and available technologies will be applied that results in the compliance with the pH groundwater standards.
- Discussion of water rights and assurance that the well water used is in compliance with the water right law.

In addition, the City's State Waste Discharge permit requires an update to their Land Management Plan. The assumed percentages for the organic and inorganic nitrogen contributions and the assumed losses due to volatilization and denitrification are required to be re-evaluated. According to the permit, the nitrogen design values assumed during the predesign/design of the PWRF in 1992 are obsolete and based on planning assumptions. Actual data submitted by the City contradicts these design values and data exists for the Facility that should be used to update these values.

CHAPTER 6
PRETREATMENT ALTERNATIVES

This chapter discusses short-term treatment alternatives for the City to consider and the performance, complexity, and scalability implications of each. The alternatives presented are not suitable for treatment to reclaimed water standards, but instead aim to provide sufficient treatment at the PWRF for permit compliance through Phase 2. The following pretreatment targets shown in Table 6-1 are set based on the land treatment system requirements in Chapter 1. Alternatives were evaluated to meet these treatment criteria. Considerations are made with respect to odor control, power consumption, ease of operability, solids generation, and footprint.

Table 6-1: PWRF Discharge Criteria

System Criteria	Unit	Value
Flow	MG/yr	1,359
BOD_5	lb/ac/day	100
TN	lb/yr	496,492
pH	s.u.	5.5

Chapter 1 defines agronomic capacity of the Land Treatment Site. While adequate to continue to treat current flow and loading from existing processors and with expanded pretreatment discussed in Chapter 6, the capacity to treat projected Phase 2 flow and loading. Phase 3 flow and loading and beyond will require significant reductions in BOD, Nitrogen, and salts in order to meet groundwater recharge requirements for the existing footprint or expand the PWRF Land Treatment Site.

6.1 TREATMENT TECHNOLOGY BACKGROUND

For Phase 3 and beyond, secondary treatment would be considered to reduce BOD_5 and nitrogen loading to the existing land treatment system. The alternatives include several aerobic and anaerobic processes to improve the quality of the process water. A brief description of these technologies is presented in the next section.

6.1.1 Aerobic Treatment

Aerobic treatment is a process which converts BOD and other organics into carbon dioxide, water, and biomass in an oxygen rich environment. Some nitrogen can also be removed with synthesis of biomass from soluble organics. Aerobic systems can be designed to remove nitrogen beyond that necessary for biomass synthesis. Aerobic treatment can produce 0.4 to 0.7 pounds of biomass per pound of BOD_5 removed. The operations and maintenance costs associated with power required for aeration and waste solids handling are generally significantly higher compared to anaerobic treatment.

Aerobic treatment technologies considered include:

- Aerated Stabilization Basin (ASB) – The aerated stabilization basin is a flow through aerobic process. Surface aerators typically provide continuous aeration, providing oxygen for conversion of soluble organics to biomass, carbon dioxide and water. Depending on the power level (less than 10 to 20 horsepower (hp)/MG), the biomass produced can settle in the aeration basin and will require periodic removal. At higher power levels (greater than 50 to 60 hp/MG) most of the biomass produced will remain suspended and leave with the ASB effluent.
- Sequencing Batch Reactor (SBR) – The SBR technology is a form of the activated sludge process. Biomass is formed with the biological conversion of degradable organic matter under aerobic conditions to carbon dioxide, water and biomass, similar to that described for the ASB process. During aeration, organic nitrogen is converted to ammonia and ammonia oxidized to nitrite and nitrate. As part of the process, aeration occurs for a period of time and then stopped to allow the biomass to settle. When the settling is substantially complete, excess biomass is withdrawn for disposal. The settled biomass is mechanically mixed for a period of time without aeration to produce an anoxic condition, during which nitrite and nitrate are reduced to elemental nitrogen gas and exit the SBR to the air above the reactor. Aeration is started again, and the process cycle repeated.

6.1.2 Anaerobic Treatment

Anaerobic treatment converts degradable organic matter in the absence of oxygen to produce carbon dioxide, water, methane and biomass. Degradable organic compounds are both oxidized and reduced, resulting in 70 to 80 percent less biomass produced compared to aerobic treatment. Only a minimal amount of nitrogen is removed by biomass synthesis compared to aerobic treatment, because of the small amount of biomass production. Organic nitrogen is converted to ammonia. Supplemental aerobic treatment is generally necessary, when significant nitrogen (ammonia) removal is required.

Anaerobic treatment requires approximately 80 percent less power and produces 1/5 to 1/3 the amount of waste biomass solids compared to aerobic treatment. Design considerations can mitigate odors. Anaerobic treatment will generally have higher capital costs compared to aerobic treatment technologies, but lower operating costs due to lower power consumption and less sludge production. Anaerobic technologies generally can handle larger BOD variations. Depending on the technology, startup time can be longer than aerobic systems.

Anaerobic treatment technologies considered include:

- Upflow Anaerobic Sludge Blanket (UASB) – Wastewater flows upward through a bed of granular sludge in the tank. Anaerobic microorganisms in the sludge reduce BOD in the wastewater and produce methane, which can be captured and used to provide heat and/or generate power. An internal clarification system provides liquid/solids/biogas separation. The treated effluent decants off the top of the UASB reactor. Optimal treatment occurs at 95 to 98 degrees Fahrenheit (°F), although UASB reactors have successfully operated at temperatures below 60 °F. Heat exchange between the influent and effluent with additional heat injection into the reactor is needed to maintain optimum treatment efficiency, where the influent source is less than 80 to 85 °F. Hydraulic retention times are typically 12 to 24 hours and are dependent on the waste strength. Seeding the reactor with acclimated seed sludge can significantly shorten the startup time from months to a few weeks compared to some other anaerobic technologies. BOD removal efficiencies are generally in the range of 85 to 90 percent.
- Engineered Anaerobic Lagoon – BOD in the wastewater is treated by anaerobic microorganisms in the covered lagoon. Carbon dioxide, methane, ammonia, water and a small amount of biomass are produced. Biogas is captured under the lagoon cover and can be used to generate heat and/or power. It is generally not practical to insulate engineered anaerobic lagoons and therefore they are designed to operate at lower temperatures than the optimal temperature range of 95 to 98 °F. BOD removal efficiencies are normally slightly lower than UASB and other higher rate anaerobic technologies. Hydraulic retention times are typically five days or longer. A potential advantage of engineered anaerobic lagoons is the ability to settle and degrade particulate organic matter that will pass through UASB and other higher rate anaerobic technologies. Startup time can be longer than UASB and other higher rate anaerobic technologies but are generally more robust in handing large changes in flow and wasteloads.

6.2 PRE-TREATMENT ALTERNATIVES

The short-term treatment objective is to maintain permit compliance and equipment efficiency through Phase 2 by reusing or repurposing existing facilities as much as possible in order to reduce costs. These alternatives are intended to service the short term and to not be used for flow and loading beyond Phase 2.

1. Second Primary Clarifier – moderate TSS removal with low capital and operation and maintenance costs. There is a very high susceptibility to additional odors being generated. Solids would need to be removed via dredging.
2. Aerated Stabilization Basin – mitigates odors, eliminates VFAs, and provides BOD, TSS and some TN reduction.

3. Sequencing Batch Reactor (SBR) – higher BOD and TN reduction compared to ASB, with the potential to mitigate odors. Semi-continuous solids removal. Higher power and capital cost than conversion to ASB.
4. Anaerobic Digester – Digestion of BOD anaerobically requires less power and produces less solids than aerobic alternatives. Digestion would eliminate VFAs and reduce BOD and TSS concentrations.

6.2.1 Alternative 1 – Convert Existing 8 MG EQ Pond to Clarifier

6.2.1.1 Primary Treatment

The existing 8 MG EQ pond may be able to be repurposed as a clarifier. This would remove additional solids during the summer peak periods and reduce the loading to the existing sedimentation basin. Minimal capital investments are required for this alternative. The solids that settle would need to be periodically removed via dredging or other methods. The disadvantage would be a high potential for significant odors beyond what is existing.

- Odor Control
  This alternative allows for significant odors, beyond what is existing, at the PWRF. No odor control is provided.
- Solids Handling
  Solids would be manually removed as required and stored in the existing 5 MG solids storage pond.
- Future Expansion
  This alternative is not viable for future expansion. It will quickly become undersized and is only intended to delay significant capital expenditures in the short-term. It was considered as an alternative due to the low capital investment and ability to offload the existing sedimentation basin, reducing high TSS loads which cause plugging of nozzles at the land treatment system.

6.2.2 Alternative 2 – Convert Existing 8 MG EQ Pond to Aerated Stabilization Basin

6.2.2.1 Secondary Treatment

The conversion of the 8 MG EQ pond to an ASB was evaluated as a way of cost-effectively reducing odors in the PWRF discharge. Surface aerators would be used to reduce BOD and TN in winter flows with the purpose of odor mitigation and some biological treatment to remove soluble organics. BOD would be converted to TSS, due to the conversion of soluble organics to biomass, which would be deposited in the 115 MG and 35 MG storage ponds. This short-term treatment alternative has the advantage of providing a relatively inexpensive way to mitigate odor and provide some nitrogen reduction.

- Odor Control
  The conversion of the 8 MG storage basin to an ASB process following primary treatment will have a significant impact on odor mitigation at the PWRF during the winter operation. In addition, it will reduce the organic loading in the 115 and 35 MG storage basins. This will minimize odor when the stored process water is combined with the PWRF effluent for land treatment.
- Solids Handling
  Solids would be manually removed as required and stored in the existing 5 MG solids storage pond.
- Future Expansion
  Coupling this system with anaerobic treatment in future phases, may provide sufficient BOD_5 and nitrogen removal to allow continued application of all of the wastewater processed by the PWRF on the existing land treatment system.

6.2.3 Alternative 3 – Convert Existing 8 MG EQ Pond to Sequencing Batch Reactor

6.2.3.1 Secondary Treatment

It may be possible to convert the 8 MG EQ basin to a sequencing batch reactor (SBR), which would be capable of achieving greater than 90 percent BOD and nitrogen removal.

Because aeration is only provided for up to half the total time of the process cycle, the installed power can be twice that of a continuously aerated process (i.e., ASB). Mixing during the anoxic period also requires additional power.

Thus, the power requirement for SBR operation are on the order of two to three times greater compared to an ASB.

Waste sludge must be handled on a semi-continuous basis. It will need to be pumped to a storage basin and disposed of with the solids generated from the primary clarifier.

- Odor Control
  The 8 MG pond SBR can potentially be designed to mitigate odors.
- Solids Handling
  Solids would be manually removed as required and stored in the existing 5 MG solids storage pond.

- Future Expansion
  The feasibility of implementing this concept requires further evaluation. If conversion of the 8 MG EQ Pond to SBR is feasible, coupling with anaerobic treatment in future phases (beyond Phase 2), may provide sufficient BOD_5 and nitrogen removal to allow continued application of all of the wastewater processed by the PWRF on the existing land treatment system.

6.2.4 Alternative 4 – Convert Existing 8 MG EQ Pond to Anaerobic Digester

6.2.4.1 Secondary Treatment

Design Criteria

An Engineered Anaerobic Lagoon assumed converting the 8 million gallon pond into a low rate anerobic reactor digester would be installed to provide a minimum 15-day SRT during peak loading events. This alternative is discussed in Appendix H and Design Criteria included in attachment B to Appendix H.

Temperature is an important variable in anaerobic digester design because it influences biological kinetics. Anaerobic digestion processes are typically operated at temperatures in either the mesophilic (95 to 98 degrees F) or thermophilic (115 to 130 degrees F) range. Most anaerobic digesters operate at mesophilic temperatures due to relatively low heat demands, minimal safety concerns, ease of operation, and extensive track record of successful applications. However, thermophilic digesters allow higher solids and hydraulic loading rates, while providing increased volatile solids reduction and digester gas production. Thermophilic digestion also improves pathogen destruction rates and, when operated within specific parameters, is recognized by the EPA as a process capable of producing Class A biosolids.

However, there are several potential disadvantages to anerobic digestion, including higher energy requirements, poorer quality supernatant, more odorous solids during processing, and safety concerns regarding the warmer solids.

Air Quality permitting will be required for this process alternative as a result of the off gasses including methane and ammonia produced.

Reliability and Redundancy Criteria

If the digester is taken out of service for maintenance, alternative solids handling arrangements should be made.

Auxiliary Systems/System Integration

The primary concern with adding anaerobic digestion is that PWRF would be adding another biological treatment process. Although it would require constant upkeep and monitoring, managing the biosolids product would be fairly easy because it could be pumped directly to nearby fields.

Costing Basis

Capital costs include allowances for mechanical equipment, new liner and cover, installation, sitework, taxes, contractor markups, contingency, market adjustment factor, and project delivery fees. Capital costs are based on lining and covering the 8 MG pond, heat exchangers, solids recirculation pumps, hot water recirculation pumps, solids transfer pumps, and auxiliary digester equipment. The ROM capital cost for this alternative included in solids thickening is $32,354,000.

6.3 OTHER REQUIRED PROCESS IMPROVEMENTS

Regardless of the selected alternative, the headworks screens, primary clarifier, and storage facilities would need to be upgraded. Odor control upgrades are also recommended.

6.3.1 Headworks Screens

The existing screen capacity of 8.65 mgd is insufficient for Phase 2 flows. A third screen is required to provide sufficient capacity for the Phase 2 peak flow rate of 8.67 mgd. It is recommended that the screen be installed prior to Phase 1 for redundancy.

6.3.2 Primary Clarifier

A new 90-foot diameter primary clarifier is required to maintain the average surface loading below 1,000 gpm/sf and maximum below 1,500 gpm/sf. It is recommended that the clarifier be installed prior to Phase 1. The existing sedimentation basin is undersized for current summer flow rates and treatment performance is suffering as a result. TSS concentrations must be reduced to maintain the integrity of downstream equipment

6.3.3 Storage

The PWRF needs approximately 120 MG of total storage to accommodate existing processor flows from November 1 to March 31. With a 10% safety factor, this means that the PWRF needs a total of 199 MG of storage now. This is an additional 51 MG that is required before Phase 1. In order to store Phase 2 flows from November 1 to March 31 the PWRF will need 311 MG of total storage. A detailed evaluation of the site storage requirements is discussed in the Long-Term Alternatives section.

6.3.4 pH Adjustment

Recent data (March 27-April 4, 2018, 4 data points) indicated median pH values of 5.3 for the prescreen influent, 4.3 for the primary clarifier effluent, and 3.7 for the IPS effluent. This low pH has not been problematic to crop growth because the existing flow to the land treatment system is approximately 30% process water. The remaining 70% is fresh water from groundwater wells onsite. The large quantity of fresh water dilutes the process water and raises the pH. At Phase 2, this ratio will reverse, and process water will make up approximately 70% of the total water requirement, eliminating the dilution effect.

This drop in pH across the pretreatment system and in the 8 MG equalization basin, indicates volatile fatty acids (VFAs), as the likely most significant source of malodor, and are resulting from anoxic biological degradation of soluble organics in the wastewater from the processors.

pH adjustment must be added to the PWRF treatment train in order to maintain satisfactory crop yields and remain within permit limits. There are two options to cost-effectively maintaining an acceptable pH for land application of the wastewater:

- Biological treatment implemented in Phases 1 and 2 will eliminate VFAs and is expected to increase the pH of the IPS effluent to 7 or above. While not the primary intent of this system, elimination of VFAs will also mitigate odor during land treatment of treated wastewater. However, a malodorous condition will remain at the PWRF unless a pH greater than ~ 7 is maintained. This biological treatment will not affect the removal of nitrogen. Nitrogen removal is not required at Phase 2 in order to meet the land treatment system limits.
- Adding magnesium hydroxide (Mg(OH)2) to the primary clarifier influent to increase pH to minimize VFA volatilization. Adding Mg(OH)2 at processor discharge locations and at the PWRF will help to retard anoxic biological degradation in the conveyance piping to the PWRF and in the PWRF unit processes. However, Mg(OH)2 increases the FDS load on the land treatment system, which is highly likely to impact crop performance and permit compliance. The projected FDS (salts) loadings are already at the high end of the acceptability range.

6.4 PRE-TREATMENT ALTERNATIVES COMPARISON

Each alternative was evaluated based on key outcomes for the PWRF, as shown in Table 6-2. A new screen, primary clarifier, pH adjustment, and storage are required regardless of which treatment alternative is selected.

Converting the EQ basin into a clarifier does not meet pretreatment pH requirements on its own, and does not provide any additional benefits beyond the recommended new primary clarifier and pH adjustment. Therefore, is not a suitable alternative. The existing sedimentation basin should be replaced by a clarifier sized for Phase 2 flow and loading. Both ASB and SBR provide significant reductions in odors and raises the pH by eliminating VFAs. Both ASB and SBR alternatives meet all of the pretreatment requirements.

The advantages of an ASB include low energy and simplicity of operation compared to an SBR. Therefore, it is recommended that surface aerators be installed in the equalization basin with the goal of increasing the pH in addition to the clarifier, screen, and storage modifications previously discussed.

The advantages of Anaerobic Digestion include a reduction in solids handling. Anaerobic digestion reduces the mass of solids produced by wastewater treatment, which reduces solids hauling requirements. Biosolids are also a valuable fertilizer due to a preferable carbon, nitrogen, and phosphorus content. Digester gas produced during anaerobic digestion can be used as a source of renewable energy, reducing dependence on fossil fuels and offsetting emissions of fossil fuel-based greenhouse gases.

Anaerobic digestion is a biological process that stabilizes organic matter in the absence of oxygen. During this process, biodegradable organic matter is converted to methane (CH_4) and carbon dioxide (CO2). As a result, Air Quality permitting will be required to implement this treatment train. Further, nitrogen removal is limited to aerobic treatment processes. This treatment train is approximately 37% higher capital cost, compared to the ASB (aerobic) process discussed in for the PWRF.

Temperature is an important variable in anaerobic digester design because it influences biological kinetics. Anaerobic digestion processes are typically operated at temperatures in either the mesophilic (95 to 98 degrees F) range. However there are several disadvantages, including higher energy requirements, poorer quality supernatant, more odorous solids during processing, and safety concerns regarding the warmer solids.

Table 6-2: Treatment Alternatives Analysis Summary

System Criteria	Convert 35 MG EQ Pond To:			
	Clarifier	ASB	SBR	Anaerobic Digester
Meets Pretreatment Requirements		X	X	X
Odor Mitigation/Raise pH		X	X	X
Power Requirements	X	X		X
Solids Generation	X			
Simplicity of Operations	X	X		
Footprint	X	X	X	X

6.5 RECOMMENDED PRE-TREATMENT SYSTEM ALTERNATIVE

The recommended alternative is to upgrade the treatment capacity at the PWRF immediately with the installation of a new screen, clarifier, pH adjustment, and storage, sized for Phase 2. During the summer, the upgraded PWRF will treat process wastewater for BOD_5, TSS, and TN and discharge the treated water to the existing land treatment system. During the winter, the same treatment will occur, however, the treated water will be stored onsite until it can be discharged to the spray fields in the spring.

The recommended alternative consists of the following major elements:

- Third, identical rotary drum screen to be installed in the existing headworks building
- pH control downstream of the rotary drum screens
- 90-foot diameter circular primary clarifier
- Equalization using the existing 35 MG pond
- Surface Aerators in the 35 MG EQ pond
- 362 MG additional winter storage across multiple basins

The process flow diagram for the recommended system is presented in Figure 6-1. Other work elements include demolishing existing facilities, including the sedimentation basin, constructing surface access to new facilities including driveways, pavement, and fencing. After the project is completed, the PWRF will operate within its permit limits using the same land treatment acreage and the crop rotations outlined in Chapter 7. Foul odors will be minimized to ensure that the City is acting as a good neighbor to all industries and residents in the area.

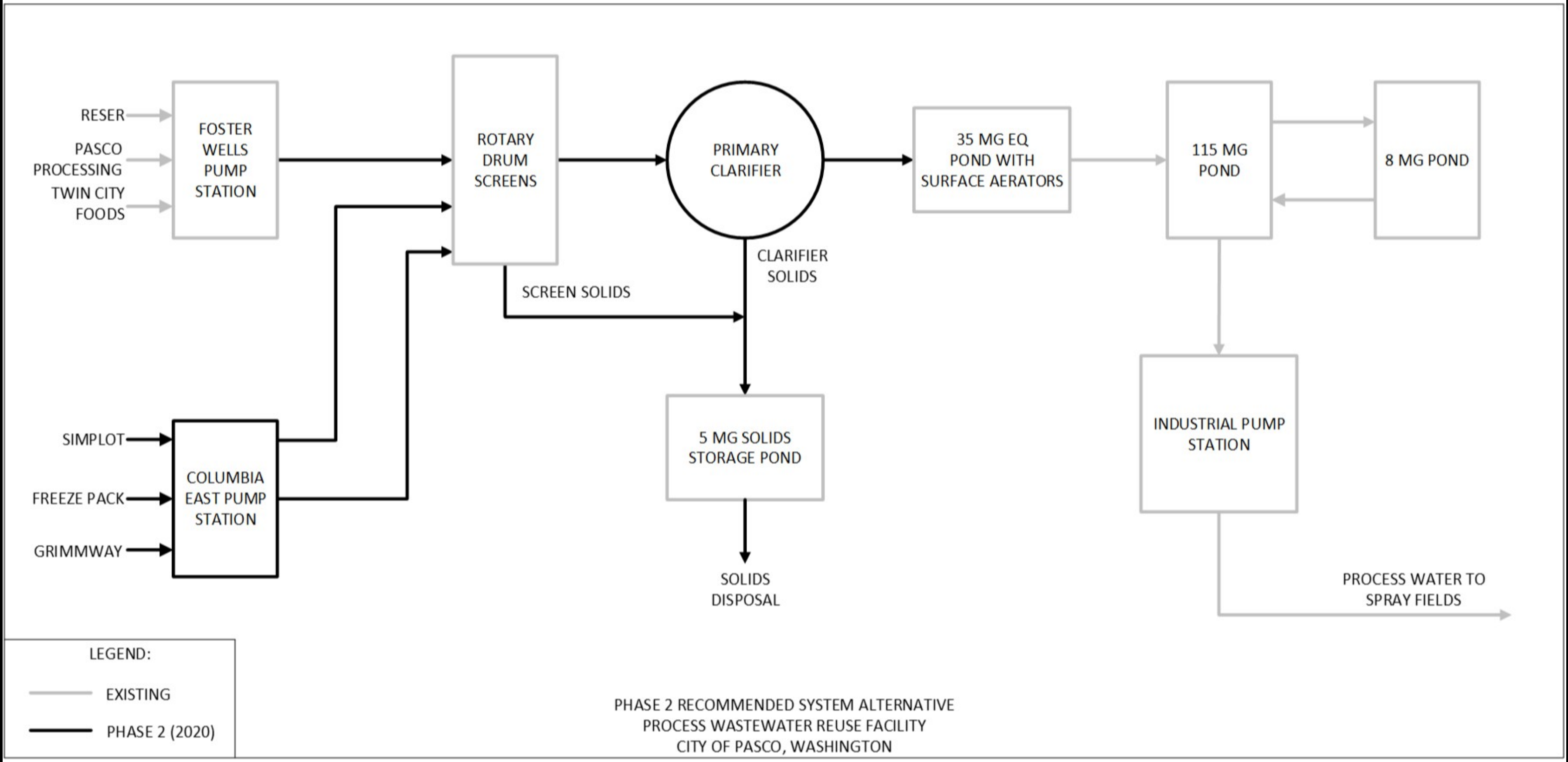


Figure 6-1	*Recommended System Alternative PFD*	17454.00
		06.2019

THIS PAGE IS INTENTIONALLY LEFT BLANK.

6.6 DESIGN CRITERIA SUMMARY

As previously noted, the recommended alternative was sized for the projected Phase 2 flows and loadings based on the capacity of the land treatment system as shown in Table 6-1 above. Operational changes made by individual processors before Phase 2 will impact sizing and potentially phasing of the recommended treatment system.

The Phase 2 flow and loading are presented in Table 6-3.

Table 6-3: Phase 2 Flow and Loading

Parameter	Summer	Winter
Total Volume (MG)	1,035	339
Max Flow (mgd)	9.02	4.44
Average Flow (mgd)	5.83	2.1
BOD_5 (mg/L)	890	561
BOD_5 (lbs/day)	43,274	9,826
TSS (mg/L)	570	1,124
TSS (lbs/day)	27,715	19,686
TN (mg/L)	54	49
TN (lb/day)	2,533	762

6.6.1 Project Elements

6.6.1.1 Rotary Drum Screens

A third 3,000 gpm rotary drum screen will be installed in the headworks building between the two existing screens. This will increase the capacity of the screens to 12.98 mgd which is sufficient for Phase 2 peak flow rate of 8.67 mgd. It is recommended to install the third screen immediately to provide redundancy in Phase 1 and allow for flexibility in cleaning the existing screens.

6.6.1.2 pH Adjustment

Mg(OH)2 will be available for injection downstream of the rotary drum screens to neutralize organic acids in the process wastewater and raise the pH. This will help to mitigate odors in the process facilities and storage and maintain the integrity of the crops. Mg(OH)2 is widely used in similar applications, because it is low cost, divalent, and the increased magnesium concentration does not upset downstream processes. Mg(OH)2 will minimize volatilization of VFAs and raise the pH but should be used secondarily to the ASB because Mg(OH)2 increases the FDS load to the land treatment system.

It is estimated that approximately 4 million pounds of Mg(OH)2 is required per year to raise the pH from 4.5 to 5.5 without additional fresh water dilution. Recent data suggests that the PWRF discharge pH could be as low as 3.5, meaning that nearly 9 million pounds of Mg(OH)2 would be required to reach a pH of 5.5.

The installation and use of an ASB to eliminate VFAs and raise the pH will offset the quantity of Mg(OH)2 required. The ASB design is discussed below under Secondary Treatment.

6.6.1.3 Primary Clarifier

A 90-foot diameter primary clarifier will be installed to replace the existing sedimentation basin. The clarifier is sized to maintain average surface loadings below 1,000 gpd/sf and peak day surface loadings below 1,500 gpd/sf. The clarifier is expected to reduce TSS to an average concentration less than 250 mg/L and maximum concentration of approximately 350 mg/L under peak conditions, as well as reducing BOD_5 and TN associated with the TSS.

Tables 6-4 and 6-5 show the clarifier influent and effluent flow and loadings for the summer and winter seasons, respectively.

Table 6-4: Summer Clarifier Performance

Parameter	Clarifier Influent		Clarifier Effluent	
	Average	Peak	Average	Peak
Average Flow (mgd)	5.63	8.67	5.63	8.67
BOD_5 (mg/L)	890	1,434	730	970
BOD_5 (lb/d)	41,742	67,272	34,234	70,203
TSS (mg/L)	570	1,397	250	367
TSS (lb/d)	26,747	65,535	11,730	26,550
TN (mg/L)	54	113	44	77
TN (lb/d)	2,533	5,288	2,071	5,545

Table 6-5: Winter Clarifier Performance

Parameter	Clarifier Influent		Clarifier Effluent	
	Average	Peak	Average	Peak
Average Flow (mgd)	1.87	1.87	1.87	1.87
BOD_5 (mg/L)	561	1,103	474	860
BOD_5 (lb/d)	8,756	17,214	7,392	13,425
TSS (mg/L)	1,124	2,795	250	367
TSS (lb/d)	17,540	43,615	3,901	5,727
TN (mg/L)	49	154	41	118
TN (lb/d)	762	2,396	638	1,845

6.6.1.4 Equalization Basin

Equalization will be provided downstream of the primary clarifier to prevent flow rate variability and surging in the secondary treatment system. During the evaluation of alternatives, the existing 8 MG equalization pond was proposed for future flow equalization and treatment. However, the existing 8 MG EQ pond is not large enough to equalize Phase 2 peak summer flows and will not provide sufficient retention time. Instead, it is recommended that the existing 35 MG pond be used for equalization at Phase 2 and beyond.

6.6.1.5 Secondary Treatment

Biological treatment is the recommended approach for removing VFAs, raising the pH and eliminating odors. Installation of surface aerators in the 35 MG equalization pond is strongly recommended. The ASB will operate at full capacity in the summer and 65% capacity in the winter to eliminate VFAs and reduce the quantity of Mg(OH)2 required to meet the discharge pH requirement of 5.5.

It is estimated that 20 75-hp high speed floating aerators are required to provide adequate aeration during peak summer conditions to meet the oxygen demand and provide a power density of approximately 44 hp/MG. During peak winter operation, 13 of the 20 aerators would be operated and the power density would be less than 30 hp/MG. Aerators would be brought on and offline as needed to handle average and low flow periods.

Preliminary calculations indicate that approximately 60 percent of the BOD_5 would be removed. TSS would increase by approximately 17 percent due to the conversion of soluble organics to biomass. Approximately 70 to 75 percent of the nitrogen would be removed with the synthesis of biomass.

The power density should be high enough to keep most of the solids suspended during summer operation. The biosolids produced by ASB operation would be deposited in the 115 MG storage basin. During the winter season, solids will likely deposit in the 35 MG pond. It is estimated that approximately 80 percent of these solids will settle in the storage basins to a consistency of 6 to 8 percent and approximately 25 to 35 percent of the solids will degrade over the winter with the release of some soluble BOD_5 and nitrogen.

The overall reduction in nitrogen is expected to be approximately 30 to 35 percent. The TSS concentration is expected to be less than 150 mg/L when the storage basins are pumped out in the summer.

6.6.1.6 Storage

The PWRF requires 311 MG of storage by Phase 2 to hold treated process water between November 1 and March 31. The 35 MG pond is no longer available for storage, since it is to be used for equalization. The 8 MG pond which was previously used for equalization is now available for storage. This necessitates the construction of 120 MG of storage. It is recommended that all storage be constructed immediately to handle future processors.

6.6.1.7 Solids Handling

Solids handling will include removal and disposal of larger particulate (screenings) with the existing rotary drum screens plus the addition of a 3rd identical screen, smaller settleable solids (silts and organics) will be removed from a new primary clarifier, floatable solids removed from surface skimmer in new primary clarifier, and excess biomass generated from the new Aerobic Stabilization Basin.

The screenings from the rotary drum screens will discharge into the existing conveyor and on to the functioning existing FKC screw press. The solids will be dewatered and collected in a large dumpster or truck bed to be hauled away for disposal either as cattle food or disposed of at the landfill site. Similarly, the floatable solids removed from the surface of the primary clarifier would be pumped to the FKC screw press for dewatering and disposal. All flow from the dewatering process will be pumped to the 35 MG aerated stabilization basin (ASB) for further treatment.

The remaining settleable solids and biomass collected from the primary clarifier and ASB will be piped and pumped to the existing solids storage pond where it will be stored awaiting final disposal.

Appendix H evaluated several other options for removal and dewatering of solids. These options are better suited for consideration in future phases of the PWRF, if needed.

Solids retention in the storage pond must be limited to prevent nuisance odor emissions. Frequency of solids removal and disposal will be refined with practice and will vary seasonally. Solids should not be left to accumulate in the storage pond more than 2 -3 days before disposal methods are implemented. It is anticipated that during summer operations approximately 15,000 lbs/day of total solids will be removed and require storage and disposal.

Final disposal includes solids removal, haul and disposal to a permitted disposal site such as the one located in Sunnyside, Washington. The City is currently removing all solids from the solids storage pond using this method of disposal.

6.7 ABILITY TO EXPAND

The facilities described in this technical memo are intended for operation at Phase 2. With the current crop rotations, biological treatment will be required beyond Phase 2 to reduce total nitrogen and BOD load to the land treatment system. Solids handling facilities will likely be required to dewater and/dispose of the solids produced in the biological treatment process.

Additional rotary drums screens and storage capacity will be required beyond Phase 2. Expansion of the headworks building to accommodate additional screens is not discussed in this facility plan. The location of future storage will depend on siting of the facilities required for Phase 2. A new, identical primary clarifier could be installed as additional capacity is required.

6.8 FURTHER EVALUATION

It is critical that reliable sampling and constituent analysis program continue to be conducted at the PWRF to verify the wasteload design criteria provided in this document. Additional sampling data throughout the PWRF treatment train will help optimize the design criteria and model accuracy for each unit process. Additional sampling data will be of critical importance to sizing and designing a biological treatment system after Phase 2.

THIS PAGE IS INTENTIONALLY LEFT BLANK.

CHAPTER 7
INDUSTRIAL RE-USE EVALUATION

7.1 TREATMENT TO INDUSTRIAL RE-USE STANDARDS

This evaluation assumes that wastewater received at the PWRF beyond Phase 2 flow and loading would receive additional biological pretreatment prior to either beneficial use or discharge to groundwater. Industrial Reuse Water, according to RCW 90.46.010(9), is defined as water that has been used for the purpose of industrial processing and has been adequately and reliably treated so that, as a result of that treatment, it is suitable for other uses. If adequately and reliably treated with the intent for groundwater recharge, then the treatment would need to meet groundwater criteria including requirements for anti and non-degradation of groundwater.

Treatment will entail physical, chemical, and biological treatment processes. The treatment processes that may be used for production of Industrial Reuse Water are shown in Figure 7-1.

7.2 LAND TREATMENT SITE CAPACITY

Chapter 1 defines agronomic capacity of the Land Treatment Site. While adequate to continue to treat current flow and loading from existing processors and with expanded pretreatment discussed in Chapter 6, the capacity to treat projected Phase 2 flow and loading. Phase 3 flow and loading and beyond will require significant reductions in BOD, Nitrogen, and salts in order to meet groundwater recharge requirements for the existing footprint or expand the PWRF Land Treatment Site.

Our analysis included review of several pretreatment process trains. The following pretreatment improvements were considered for treating Phase 3 flow and loading. Please note, pretreatment improvements must include both existing customers and future flows such as Lamb Weston, as all flows would be co-mingled at the PWRF.

- Additional pH buffering will be required to improve pretreatment and control odors at the PWRF. Likely this capital improvement will include the addition of magnesium hydroxide downstream to the drum screens to adjust influent pH prior to further biological treatment.
- A third drum screen will be required for coarse solids removal.
- Additional capacity will be required in the new primary clarifier, i.e., 100-foot diameter versus 90-foot diameter.
- Biological treatment to reduce BOD and Nitrogen loading.

- New solids handling facilities must be increased in size to accommodate the winter flow and load from Lamb Weston.
    - This option would require additional storage capacity added to the PWRF of 390 MG to store winter flows from Lamb Weston.
- The new Irrigation Pump station would be modified to increase pumping capacity to the land treatment system as a result of the added storage volumes and summer flows.

In summary, the impacts to the City's PWRF accepting Phase 3 flow and loading will exceed current pretreatment and land treatment capacities. The additional capital improvements above are needed including purchase of additional land adjacent to the existing PWRF to accommodate winter storage. The pretreatment process train requires the addition of biological pretreatment, incremental increase in size for the irrigation pump station, primary clarifier, solids handling, and pH conditioning. The capital cost for the improvements to produce Industrial Reuse Water was estimated at approximately $83.0M for Phase 3 flow and loading. This capital cost was found to be excessive and not affordable. No further work will be accomplished at this time for this alternative.

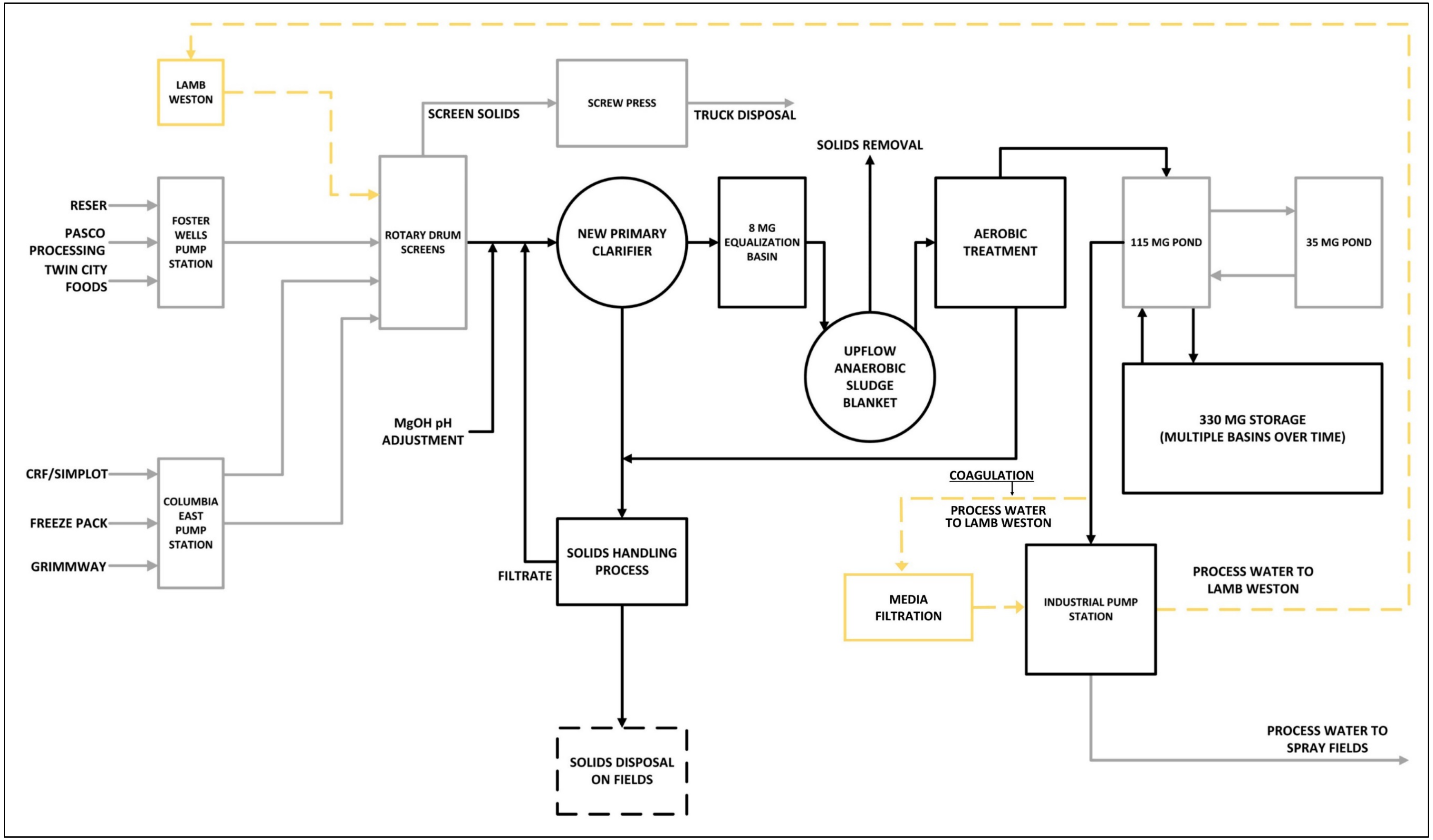


Figure 7-1	***Lamb Weston Option #2 Flow Diagram***	17454.00 05.11.2018

THIS PAGE IS INTENTIONALLY LEFT BLANK.

SECTION III
CONVEYANCE EVALUATION

CHAPTER 8
PWRF SERVICE AREA

8.1 SERVICE AREA CHARACTERISTICS

8.1.1 Service Area Boundary

The service area for the PWRF (Pasco Process Water Re-Use Facility) is made up of two areas, the Foster Wells Service Area and the Columbia East Service Area. These areas consist of existing and future food processors that will send their waste to individual pump stations that will pump the waste to the PWRF. The Foster Wells Service Area contains Pasco Processing, Inc.; Pasco Holding; Twin City Foods; and Reser's Fine Foods. The waste generated from these food processors will flow to the Foster Wells Pump Station which will then be pumped to the PWRF. It is unknown at this time the destination of the waste produced at Lamb Weston, Inc. and whether that waste will end at the PWRF. If it does, the flow may be pumped through its own forcemain. The Columbia East Service Area contains Simplot RDO, Grimmway, and Freeze Pack. The waste generated from these food processors will flow to the Future Regional Pump Station Site which will then be pumped to the PWRF.

THIS PAGE IS INTENTIONALLY LEFT BLANK.

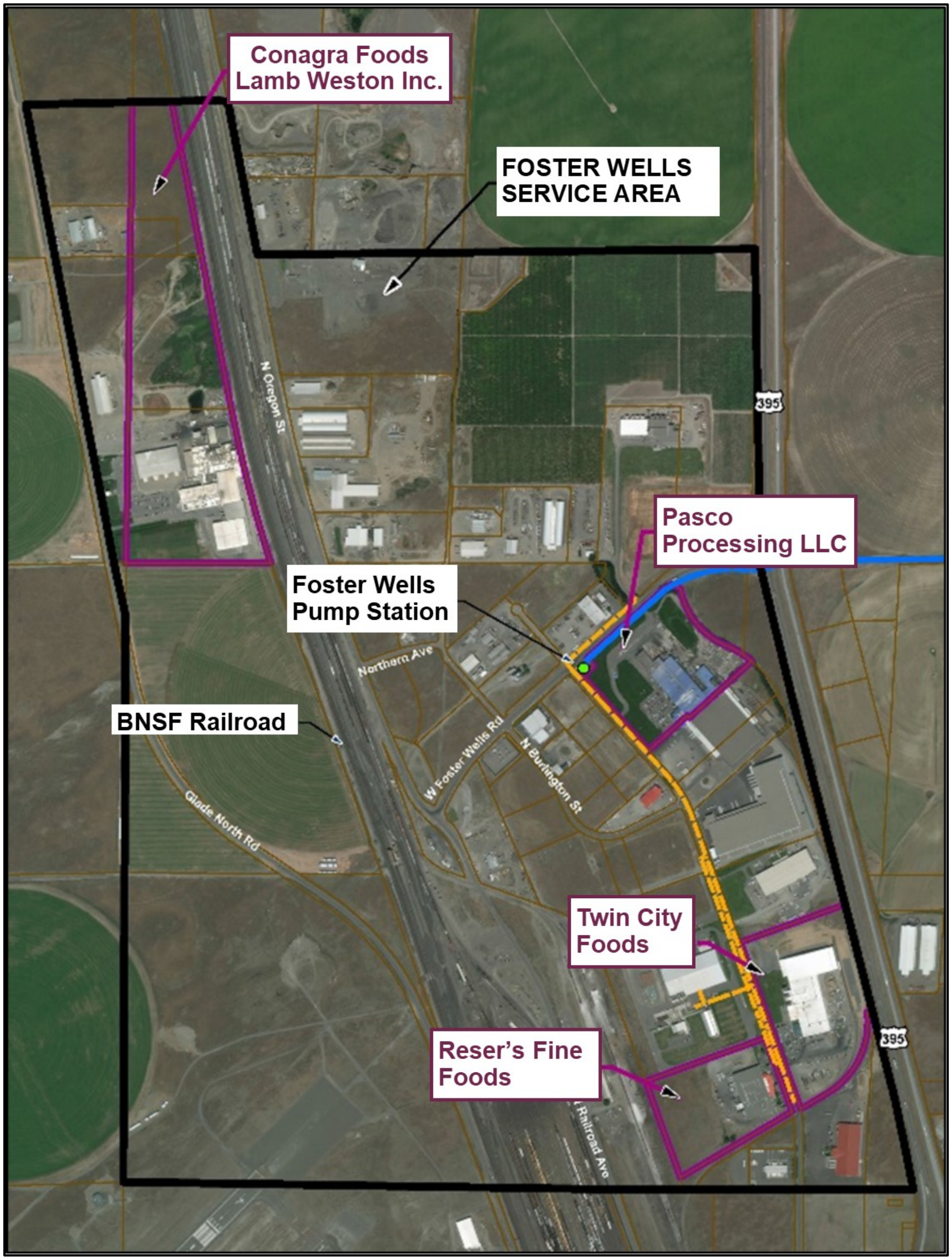


Figure 8-1	Foster Wells Service Area	17454.00
		11.28.2017

THIS PAGE IS INTENTIONALLY LEFT BLANK.

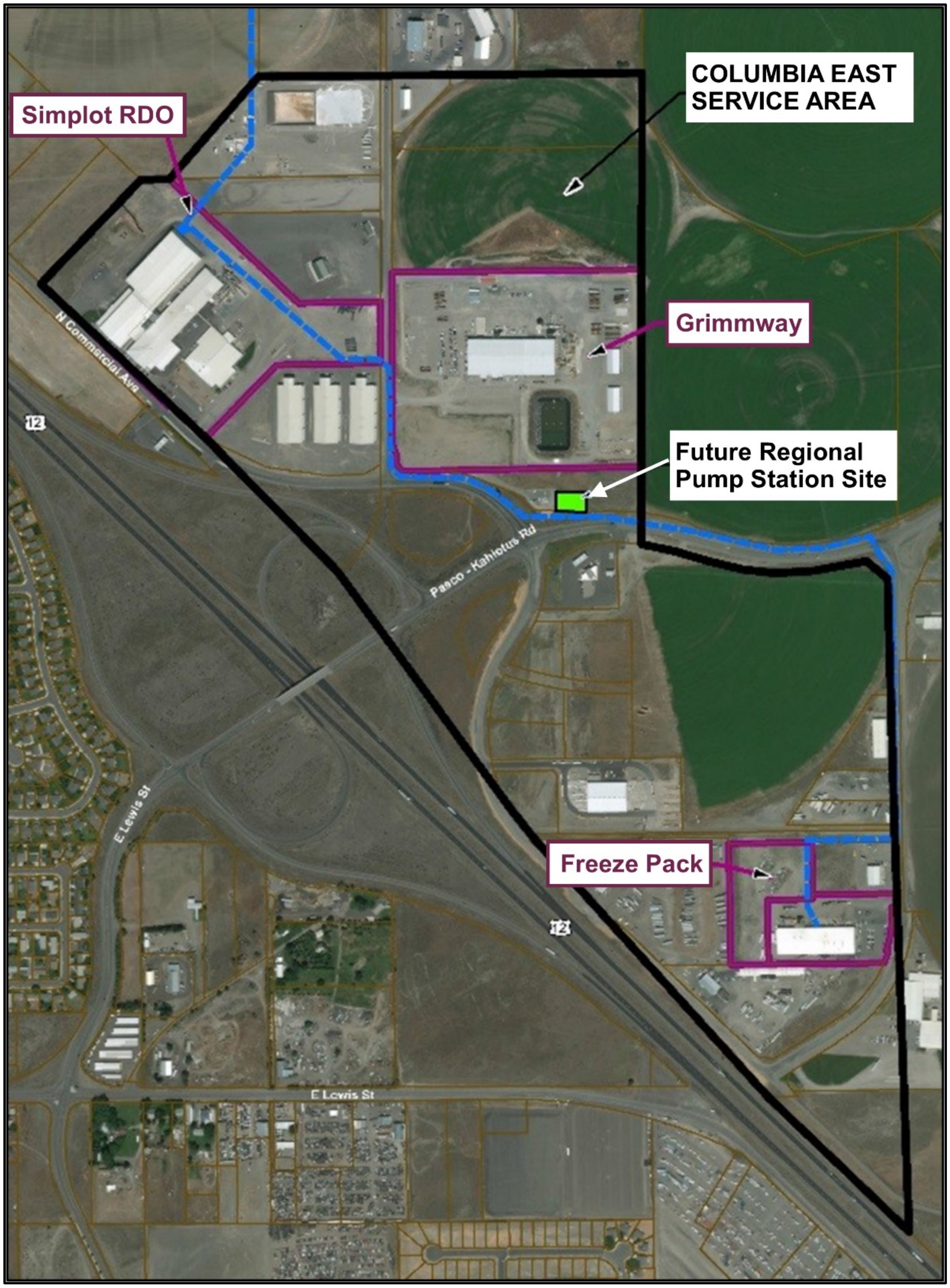


Figure 8-2	*Columbia East Service Area*	17454.00
		11.28.2017

THIS PAGE IS INTENTIONALLY LEFT BLANK.

8.2 ECONOMIC DATA

Pasco is one of the fastest growing communities in the state. From the census of 2010, there were 59,781 people. As of 2016, there were 70,560 people, making the average annual growth rate 3%, which is one of the highest in the state.

The current employment profile of the City of Pasco according to Census.gov is shown below in Table 8-1. This suggests that the current profile of the city has a diverse industry. The PRWF expansion will solidify the diverse employment profile of Pasco.

Table 8-1: Economic Profile

	Population	Percent of Population
Occupations		
Civilian employed population 16 years and over	31,519	
Management, business, science, and arts occupations:	7,134	22.6%
Service occupations:	6,074	19.3%
Sales and office occupations:	5,839	18.5%
Natural resources, construction, and maintenance occupations:	6,447	20.5%
Production, transportation, and material moving occupations:	6,025	19.1%
Industry		
Civilian employed population 16 years and over	31,519	
Agriculture, forestry, fishing and hunting, and mining	4067	13%
Construction	2026	6%
Manufacturing	3920	12%
Wholesale trade	1225	4%
Retail trade	2975	9%
Transportation and warehousing, and utilities	2174	7%
Information	243	1%
Finance and insurance, and real estate and rental and leasing	886	3%
Professional, scientific, and management, and administrative	3265	10%
Educational services, and health care and social assistance	5592	18%
Arts, entertainment, and recreation, food and accommodation	2933	9%
Other services, except public administration	1047	3%
Public administration	1168	4%

8.2.1 Economic Growth

The PWRF will bring in more jobs that will be spread out over the manufacturing, construction, agriculture, transportation and warehousing industries.

It would take an estimated three to five years to complete planning, engineering, and construction for the PWRF improvements. Once complete, additional capacity would be available for expansion of the current processing operations and new customers. It is estimated that expansion of current users could be up to 10 employees per each user for a total of 50 new jobs. A new processor would account for up to 50 employees. Thus, it could be possible for an estimated 50-100 new jobs.

8.3 CLIMATIC DATA

The climate of the immediate area is arid to semi-arid. The average annual precipitation is approximately 7.5 inches, varying from about 5 to 15 inches per year based on data from 1981 through 2010. The average monthly precipitation ranges from 0.22 inch in July to 1.13 inches in December. Snow may fall as early as October and may remain as late as April with a mean annual snowfall of 6.5 inches (Western Regional Climate Center, 2016).

The mean annual daily high temperature of the City is approximately 65.6 degrees Fahrenheit (°F). The temperature averages range from a maximum of 90.3°F in July to a minimum of 28.8°F in January.

Average annual evaporation as measured from a U.S. Weather Service Class A pan ranges from 50 to 70 inches (Hickerson-Jacobs, Inc., and Esvelt Environmental Engineering, 1990). The prevailing wind is generally out of the southwest.

8.4 WETLANDS

According to the U.S. Fish and Wildlife Service wetland mapper, there are no wetlands on the City's property. There is one wetland close to the eastern-most irrigation plot that is characterized as PEM1A, which breaks down as follows:

- P – Palustrine System
- EM – Emergent class
- 1 – Persistent subclass
- A – Temporary flooded water regime

Figure 8-10 shows the location of the wetland in relation to the PWRF and the application sites.

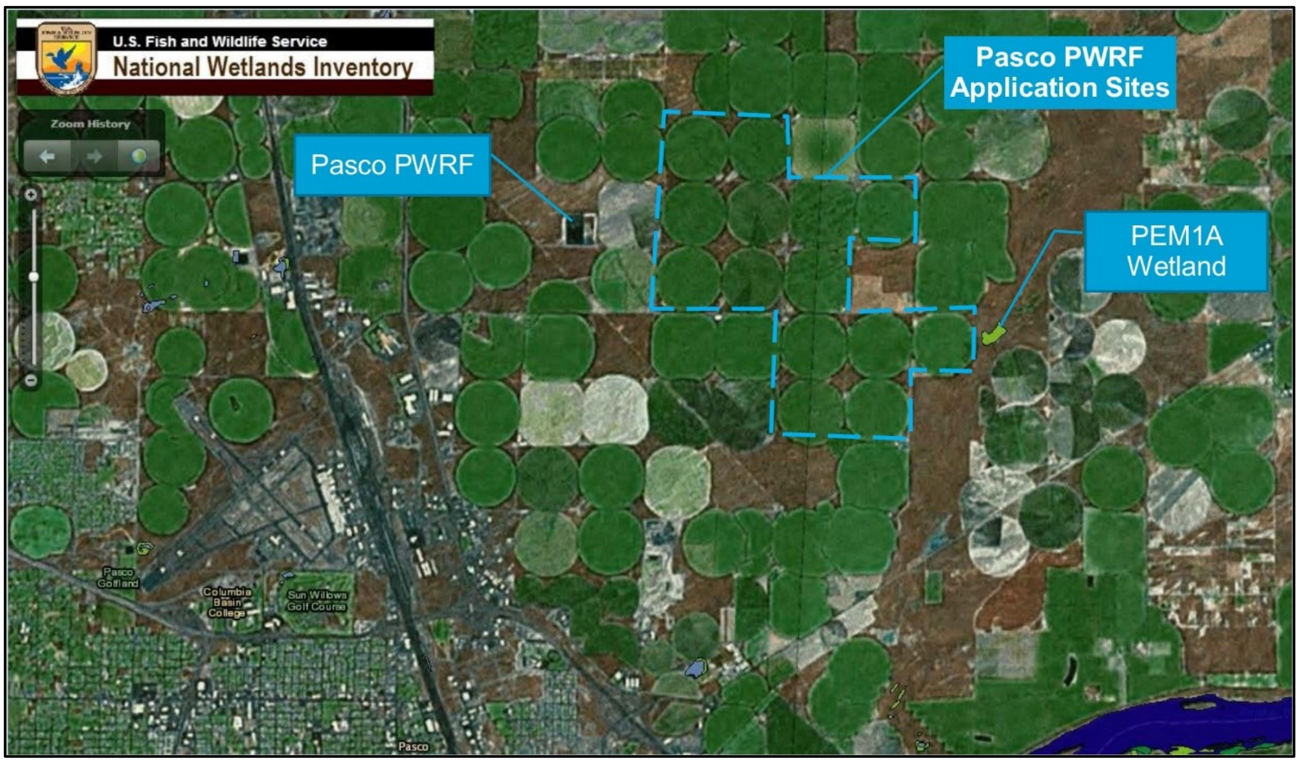


Figure 8-3	*Wetland Location*	17454.00
		11.28.2017

8.5 LAND USE

According to the Franklin County Planning and Building Department, the PWRF and application sites are zoned as agricultural production 20 (AP-20). This zone (Figure 8-11) is designed to maintain the agricultural economy of the county by reserving lands that are used for farming. Most of the land in this zone has access to irrigation water or is surrounded by lands with access.

The adjacent parcels to the PWRF and application sites are also zoned as AP-20. Shown in Figure 8-11, the gray parcels are a mixture of the following zones: Rural residential (RR-5) and general industrial district (I-2).

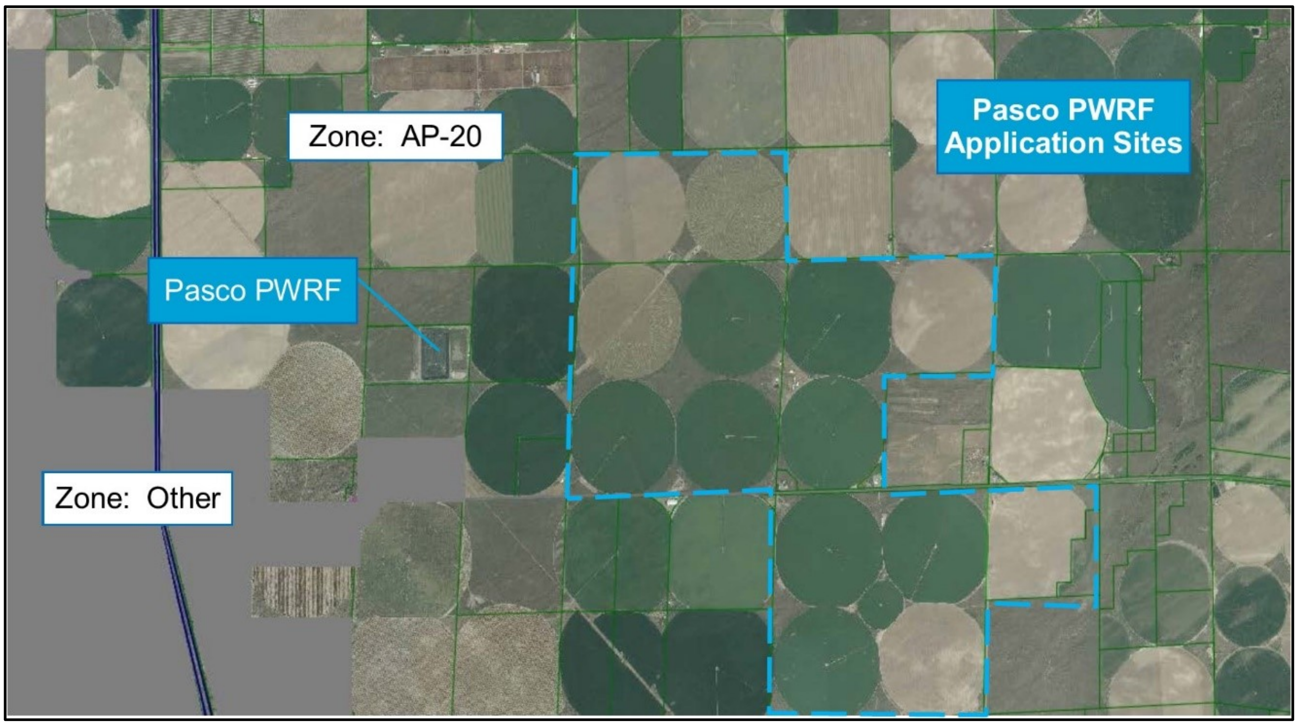


Figure 8-4	Parcel Zoning	17454.00
		11.28.2017

8.6 EXISTING WATER SYSTEMS

8.6.1 Municipal Water

The City's municipal water system is supplied from surface water withdrawals from the McNary Pool of the Columbia River. The existing distribution system consists of approximately 280 miles of watermain ranging in size from less than 6 inches in diameter up to 36 inches in diameter. The City did have four groundwater wells located in West Pasco off of Road 108 which served as an emergency backup supply. The City has obtained a transfer of water rights from the Port of Pasco, to the McNary Pool of the Columbia River, and had received a temporary transfer of water rights from wells located at the Industrial Wastewater Treatment Facility land application site to the Road 108 Wellfield that expired in June of 2004. The City of Pasco continues working towards obtaining additional water rights through all options available. The City's current storage system consists of three water storage reservoirs located throughout the service area in addition to the 0.485 million gallon clear well at the Butterfield Water Filtration Plant and the 1.62 million gallon clear well at the West Pasco Water Treatment Plant

8.6.2 Irrigation Water

The processed water produced from the PWRF is used for irrigation of the crop circles east of the PWRF. The City owns and maintains a separate irrigation system apart from domestic supply. To assure the crops circles are maintaining sufficient water, the City supplements the crop circles when needed through this separate irrigation supply water. The source of the City owned and maintained irrigation supply is through eleven irrigation wells and the water rights for these wells are shown in Table 8-3.

Table 8-2: Irrigation Wells Water Rights

Water Right No.	Permitted Right (Ac-ft)	Farm Circle Nos.
G3-24546P	609.6	C01
G3-25175P	520.0	C10
G3-20245P	2101.6	C06, C07, C08, C09
G3-20247P	2101.6	C02, C03, C04, C05
G3-22491P	1037.0	C11, ½ of C12
G3-22499P	744.0	C13
G3-23867P	116.0	½ of C12, C15
Total Area	**8229.8**	**–**

THIS PAGE IS INTENTIONALLY LEFT BLANK.

CHAPTER 9
FOSTER WELLS SERVICE AREA
CONVEYANCE CONDITIONS ASSESSMENT

9.1 GENERAL DESCRIPTION OF EXISTING FOSTER WELLS PUMP STATION

Food processing plants located in the Foster Wells Service Area generate a large volume of wastewater that must be treated by the City of Pasco. The Foster Wells Pump Station was designed and constructed in 1994/1995 to convey the wastewater flows generated from three nearby food processing plants: Pasco Processing LLC, Twin City Foods, and Reser's Fine Foods.

Two existing 24-inch gravity sewer mains convey incoming wastewater flows to the pump station upstream manhole and into a 36-inch sewer main into the wet well at a depth of 26.67 feet below grade. The wet well is 10 feet wide by 20 feet long with a depth of 34.17 feet, with four (4) vertical turbine can sewage pumps.

The existing two (2) smaller pumps with 100 Hp motors have a current pumping capacity of 1,800 gpm each at 195 feet TDH.

The existing two (2) larger pumps with 300 Hp motors have a current pumping capacity of 3,500 gpm each at 250 feet TDH. One of these larger pumps was recently rebuilt with a slightly larger pumping capacity of 3,890 gpm at 250.0 feet TDH with a 350 Hp motor.

Figure 9-1	Existing Foster Wells Pump Station	17454.00
		12.14.2017

Flows are pumped from the Foster Wells Pump Station to the City of Pasco's Industrial Reuse Facility, now called the Process Water Re-Use Facility (PWRF). Two forcemains (FM), one 16-inch FM and one 8-inch FM, both about 12,840 feet long, convey flow from this pump station to the PWRF. Due to the nature of the process wastewater being pumped, it has a tendency to become more anaerobic with the pH becoming more acidic with longer residency times in the forcemains. Operationally, so as to prevent wastewater in the forcemain pipelines from becoming septic, City crews plan to maintain continuous flow through both the 8-inch and 16-inch forcemains to minimize the residency times to both pipelines.

9.2 BACKGROUND – QUALITY OF WASTEWATER

The three food processers produce and discharge process wastewater. Wastewater flows from Pasco Processing and Twin City Foods are a combination of wastewater from cleaning and processing a variety of food crops, mostly carrots, corn, and onions, including washing, cooking, and packaging. Reser Fine Foods processes mainly potatoes.

Food processing operations for the three producers is somewhat seasonal. This means that the highest levels of wastewater generation will occur during harvest periods in the summer and fall. During off-season periods, waste generation can be a fraction of the high season flows.

Historically, since startup for this pump station, the incoming wastewater has had very high total suspended solids (TSS) in the range of 1,700 mg/l with lots of fine sand particles from washing carrots and potatoes that makes for aggressive wear on pipeline interior linings. Additionally, the nature of the food processors' wastewater coming to Foster Wells Pump Station has some partially cooked and fine cuttings from carrots containing relatively high sugar content for wastewater. Carrots accumulate and store two types of sugar, fructose and glucose, in their orange, edible roots. Fresh carrots are usually alkaline, but as the carrots are processed, the resulting wastewater generated becomes more acidic as the residency time increases. Regular recordings of the pH level of incoming wastewater to the Foster Wells Pump Station is in the range of 3.5 to 5.5. The resulting chemistry of low pH and high TSS has had devastating effects on the longevity of pump impellers and pipeline linings at the Foster Wells Pump Station and forcemains.

9.3 EXISTING PUMP STATION CONFIGURATION AND FINDINGS

9.3.1 Pump Components

The Foster Wells Pump Station as-built plan information for the pump piping mechanical is shown in Figure 9-2. The pump station capacity is comprised of four (4) vertical turbine can sewage pumps. Historically, the pumps see a lot of wear on the impellers and inside components due to low pH of the wastewater received from the food processors, mainly from the carrot industry, and the amount of fine sands and dirt washed off the raw vegetables being processed. Wastewater from processing carrots contains more of these types of solids. This creates wear on the pump components, requiring excessive maintenance and consistent pump rebuilds on a regular schedule at least every two years (see Appendix I for a listing of System Pump Repairs/Replacements).

Originally, all of the pumps (Pumps No. 1, 2, and 3) were the same size as the current smaller vertical turbine pumps (Pumps No. 1 and 2) and were configured as follows:

- 100 HP motors on pumps with design capacity of about 1,800 gpm at 195 feet TDH.

Pump No. 2 was rebuilt in 2017 with a new SST vertical turbine and can pump with the same configuration as follows:

- 100 HP motor on pump with design capacity of about 1,800 gpm at 195 feet TDH.

In 2009, Pump No. 3 was replaced with larger vertical turbine pumps; in 2010, a new Pump No. 4 was installed with the same configuration as Pump No. 3 with the following operational conditions:

- 300 HP motors on pumps with design capacity of about 3,500 gpm at 250 feet TDH.

In the summer of 2017, Pump No. 4 suffered a catastrophic failure of the pump base elbow and the pump base oil seal bonnet shearing off due to the high axial pressure exceeding the tensile strength of the compromised cast bronze. The pump base elbow eroded completely through and exploded out discharge pressure wastewater in the pumphouse, resulting in many items having to be replaced and/or repaired. Pump No. 4 is currently in the process of being rebuilt with a new SST vertical turbine can pump with the following operational conditions:

- 300 HP motor on pump with design capacity of 3,500 gpm at 250 feet TDH.

Pump No. 3 is currently in acceptable condition, but is scheduled to be rebuilt entirely next year with the same operating conditions as Pump No. 4 (300 Hp motor with design capacity of 3,500 gpm at 250 feet TDH).

The firm capacity of a pump station is defined as the capacity with the largest or one of the largest pumps being out of service. For the Foster Wells Pump Station the firm capacity equals the capacity of one large pump of 3,500 gpm and one small pump of 1,800 gpm for a total of 5,300 gpm. If both of the small pumps are running with one of the larger pumps it will exceed 150 psi, the discharge pressure rating of the forcemain pipelines.

9.3.2 Electrical Components

Pump No. 1 electrical components:

- Variable Frequency Drive (VFD) No. 1 for Pump No. 1: Condition from recent water damage from Pump No. 4 failure resulted in VFD No. 1 becoming saturated. Now dry and working, but is old and in need of replacement.
- Motor No. 1 was replaced in 2015 with new 100 Hp motor.

- Pump No. 1 Control Panel Switch Gear – still original panel from 1995. Switch gear most likely has been replaced since original installation.

Pump No. 2 electrical components:

- VFD No. 2 for Pump No. 2: A bit newer, but two to three years left of useful life before replacement is necessary.
- Motor No. 2 (100 Hp) – still original motor from 1995.
- Pump No. 2 Control Panel Switch Gear – still original panel from 1995. Switch gear most likely has been replaced since original installation.

Pump No. 3 electrical components:

- VFD No. 3 for Pump No. 3: Recently exploded from Pump No. 4 blowout failure and was replaced in Fall 2017.
- Motor No. 3 (300 Hp) – Rebuilt in February 2017.
- Pump No. 3 Control Panel Switch Gear – Installed in 2009 for new components for larger 300 Hp motor pump controls (located on north outside wall of pumphouse).

Pump No. 4 electrical components:

- VFD No. 4 for Pump No. 4: Installed in 2010 with about five to eight years of useful life remaining before replacement is necessary (typically VFDs of this size last 12 to 15 years).
- Motor No. 4 (300 Hp) – Original motor from 2010.
- Pump No. 4 Control Panel Switch Gear – Original panel installed in 2010 (located on north outside wall of pumphouse).
- In the summer of 2017, Pump No. 4 suffered a catastrophic failure of the pump base elbow and the pump base oil seal bonnet sheared off due to the high axial pressure exceeding the tensile strength of the compromised cast bronze. The pump base elbow eroded completely through and exploded, expelling discharge pressure wastewater in the pumphouse, resulting in many items having to be replaced and/or repaired. Pump No. 4 is currently being rebuilt with a new SST vertical turbine can pump with a 300 HP motor on pump with design capacity of 3,500 gpm at 250 feet TDH.

Radio Communications Controls Cabinet:

- The radio control equipment had some recent repair problems addressed with the blowout of Pump No. 4 since it had suffered some water damage. Almost all of the radio control equipment in this cabinet has been restored and placed back into service. The auxiliary status equipment displays on the face of this communication controls cabinet have been destroyed by the recent water damage from the pump blowout and are in need of replacement.
- Pump Room Wall Heater Nos. 1 and 2: One of the wall heaters was destroyed during the recent pump blowout incident in the pump room and is in need of replacement. The other is still in good working condition.

Ceiling Lights:

- *The ceiling light fixtures over the area of Pump No. 4 were damaged and are in need of replacement.* The other existing ceiling lights are still in working order.

Exhaust Fans Air Handlers:

- Wet well exhaust fan system is in good condition with no problems identified.
- Pump Room exhaust fan is in good condition.

Auxiliary Power Generator:

- The Auxiliary Power Generator is a trailer-mounted Caterpillar diesel generator with quick connection plug in receptacle to the main ATS gear. This generator is in good working condition and has no issues in need of reporting.

9.3.3 Piping Mechanical Components

Upstream of the 36-inch sewer line entering the wet well is a pre-chamber vault where the incoming 36-inch sewer has a manual bar screen to protect debris from entering the wet well and damaging the pumps. This pre-chamber vault (with a width of 4 feet and length of 9 feet) is 18.62 feet deep and is accessed via fixed manhole steps leading down to a 4-foot-wide by 5-foot-long concrete floor directly above the end of the fixed bar screen. From this concrete floor above the bar screen it is 4’6” deep vertically at the bar screen to the bottom invert of this bar screen vault. The as-built drawings indicated the bar screen is made of carbon steel ¼” thick x 1¼” wide. This bar screen should be inspected for corrosion from being immersed in the wastewater for almost 22 years and is most likely in need of replacement with an SST bar screen. It is also recommended that the manhole steps be replaced with a fixed SST ladder with ladder safety tie-off device for fall prevention and ladder-up safety post at the top of the ladder.

The four pumps in the main pump room have two discharge manifolds; a newer 24-inch manifold connects to the two larger pumps via 24-inch x 12-inch wyes and 12-inch discharge lines to the larger pumps with 12-inch Cla-Val check valves and 12-inch DeZurick plug valves. Both the 12-inch check valves and 12-inch plug valves are noted to be in good condition and not showing signs of unusual internal wear. The newer 24-inch piping manifold appears to be painted steel piping and discussions with the plant operators indicate that internal corrosion may result on all piping that is not stainless steel. If this 24-inch manifold is steel and not stainless steel it may, in the future, also need to be replaced with SST.

The older original 12-inch manifold connects to the smaller pumps via 12-inch x 8-inch wyes with 8-inch discharge lines to the smaller pumps with 8-inch SST knife gate valves and 8-inch check valves. The original 8-inch discharge piping had 8-inch gate valves and 8-inch check valves that had been worn extensively in the past and were replaced in the last five years.

The 12-inch discharge manifold as it leaves the main pumphouse room discharges through the floor vertically down and extends away from the pumphouse to an outside flow meter vault that is 8’5” deep with the 12-inch piping downsizing to an 8-inch line into the vault. An 8-inch magnetic flow meter is located on this line in the vault with this line about 1-foot off the floor of the vault to the bottom of the 8-inch line. It was observed that this line in the vault was mostly submerged with water due to rainwater and drainage regularly draining into this vault, which can aggravate and degrade the flow meter capabilities. It is suspected that the original ductile iron piping below grade and into the flow meter vault has been severely corroded like others found at the pumphouse and is in need of replacement. It is recommended that the flow meter vault be abandoned and the 12-inch discharge manifold in the pumphouse be replaced with 12-inch 316 SST discharge manifold at same pump manifold elevation. It should then continue through the CMU south wall and over the area of the existing meter vault where a new 8-inch MAG meter located about 2 feet above existing grade to pipeline centerline would be installed. This proposed outside piping for the 12-inch and 8-inch meter area would be installed with insulation jackets for freeze protection. This piping from the new meter would then turn 90 degrees and extend vertically down to tie back onto the existing 8-inch piping near the manifold area valving where it connects to the existing 16-inch forcemain.

All miscellaneous smaller galvanized control piping (3/4”, 1”, and 2” diameter) on the discharge manifolds are showing signs of some corrosion and over time should be considered for replacement with SST piping when items are in need of repair.

The water lines flowing to the stuffing boxes and bearings for the pumps are copper with bronze valving and are in good condition.

9.3.4 Forcemain Components

The Foster Wells Pump Station has an existing 16-inch forcemain along with an existing 8-inch forcemain that extend from the pump station along Foster Wells Road and along the plant road going to the existing PWRF treatment facility. These pipelines are buried with a minimum of 4.5 feet of cover and are constructed of PVC C-900 pipe with ductile iron restrained fittings. The recent history of these forcemains has shown that the corrosive nature of the wastewater, with a low pH of almost 3.5 (acidic) and high total suspended solids (~1,700 mg/l of fine sands from the food processors’ washing of vegetable produce), causes the interior linings of the pipe fittings, where inherently there is more turbulence, to corrode through and fail. It has been concluded that where similar PVC or HDPE pipe bends are used in forcemain or pump station fittings, they are not showing the type of corrosion that ductile or steel fittings are enduring, most likely because PVC and HDPE can withstand the low pH and plastics can absorb the particle deflection energy without causing wear from the grit in the wastewater.

It is apparent that these ductile iron fittings on the forcemains will need to be dug up and replaced with either HDPE or PVC fittings with thrust restraint couplings. The smaller 8-inch diameter 22.4-degree, 45-degree, and 90-degree bend fittings are all easily available in C-900 PVC standard fittings and PVC C-900 repair couplings. The larger 16-inch forcemain fittings for bends will need to be replaced with HDPE fabricated fittings and SST repair couplings along with mechanical restraints like Mega-Lug or similar.

It is estimated that on both the 8-inch and 16-inch forcemains there are about 14 each 8-inch and 16-inch existing ductile iron fittings (mostly 45° bends) that will need to be replaced as described above. This does not take into account those bends and wyes that are in the manifold buried header piping adjacent to the east side of the Foster Wells Pump Station building. Currently, the City has not been able to find an as-built for the configuration of this adjacent buried piping for the manifold header connection from the original construction or from the more recent construction of the newer 24-inch manifold and how it ties into the existing 16-inch and 8-inch PVC C-900 forcemains.

The as-built for the Foster Wells PS forcemains (16" and 8" PVC C-900) indicates that those portions of the pipelines installed within the existing 30-inch and 24-inch steel casing pipes under Highway 395 were constructed of ductile iron within these casing pipes, rather than PVC C-900, consistent with the remainder of the forcemain. The ductile iron portion of the 8-inch pipe within the casing sleeve has already failed and been replaced with 8-inch HDPE DR11 pipe. The City should plan accordingly and also replace the existing 16-inch ductile iron pipe within the 30-inch casing pipe with 20-inch HDPE DR11 pipe to prevent another failure due to excessive pipe corrosion.

9.3.5 Structural Components

The Foster Wells Pump Station as-built plan information for the piping mechanical is shown in Figures 10-2 and 10-3. The building is constructed of cement masonry units with engineered wood trusses and metal sheeting roof. The building main pump room has inside dimensions of 24'8" x 24'8".

The electrical area of the station is located on one-half of the pump room plan and the pumps and mechanical piping are located on the other side of the room. The room is tightly laid out with little space for maintenance operations and may not meet current standards for clearance distance requirements around electrical control panels and for quick egress out of the room.

The ceiling of the pumphouse room suffered severe water damage when Pump No. 3 pump base corroded through and sprayed water throughout the room for four to five hours before it was noticed and shut down. This water damage to the ceiling affected about 50 percent of the ceiling area in the pump room. Most of the damaged gypsum wall board and batt insulation above this damaged area has been removed. Replacement of the damaged gypsum board ceiling and insulation with in-kind materials is one option; another is to replace the ceiling gypsum board entirely with a water/fire resistant cementitious wall geo-board with rigid insulation above the ceiling. This would prevent excessive damage from occurring if other pump/pipe components were to have catastrophic failures.

The wet well is laid out directly below half of the pump room to one side with the vertical can pumps near the eastern wall of the wet well. Access to the wet well below is via an outside grade access hatch (2’6” square) near the front of the pumphouse to the right of the entry doors into a 4-foot-square concrete manhole. The entry hatch to the wet well does not have manhole steps, but has a landing 12 feet below in this concrete square manhole accessible with a portable ladder. At the bottom of the manhole you can walk into the wet well chamber and climb down a fixed galvanized steel 8.7-foot ladder leading down into the wet well lower mezzanine level.

From this wet well mezzanine level (21.2 feet below the main floor of the pumphouse) one can stand on the concrete mezzanine platform measuring 7 feet x 7 feet and observe the four vertical can wastewater pumps and the incoming flows entering via the 36-inch diameter incoming sewer line.

9.4 WET WELL INSPECTION FINDINGS

The wet well was inspected by PACE along with the City on December 26, 2017, and the following is a summary of those findings:

1. There was little erosion/corrosion of the concrete surfaces in the wet well other than those faces that are constantly in close contact with streaming inflow of process wastewater.
2. The fixed galvanized ladder in the wet well leading down to the 7’x7’ concrete mezzanine platform from the access manhole vault was in good condition. The spring-loaded galvanized gate on this fixed ladder was still in operational order, but in need of being cleaned and coated with a protectant grease. The bolts on the ladder into the concrete appeared to have some corrosion that, based on the time they have already been there, may be a need to be replaced with stainless steel bolts and nuts within five years.
3. The galvanized handrail on the 7’x7’ concrete mezzanine platform was in good condition. The bolts at the base of the handrail were not visible and the strength of the handrail was still very good and not yet compromised. There was a layer of a very gooey grey scum buildup on the platform of 5 to 7 inches that needs to be cleaned by fire-hosing with water. This layer of scum prevented the bolts on the handrail bases from being visible, and based on the condition of other carbon steel metals that were visible, it is logical to believe that these bolts are corroded down to the point where they are in need of replacement.
4. The galvanized chain guardrail on the platform area was in fair condition, but the galvanized clasp on the end was severely corroded and in need of replacement. It is recommended that this galvanized chain be completely replace with stainless steel (SST) ¼-inch-diameter chain with a SST snap clasp.
5. The fixed galvanized ladder leading down from the mezzanine platform to the very bottom of the wet well floor slab at the pump suction intakes was hanging with only two bolts on the top of the ladder and was very flimsy. It is recommended that this ladder be removed and not replaced. If the City believes that this ladder is necessary, it is

recommended that it be replaced with a SST chain flexible hanging ladder to serve as an emergency exit.

6. The existing 3-inch galvanized wash water piping located within the wet well is problematic. Though the 3-inch galvanized piping is rarely used for washwater to clean up the wet well area, it has corroded the two 3-inch gate valves on the mezzanine wet well level to the point where these valves are no longer operable. This wash water piping comes from the existing 12-inch pump discharge manifold in order to use the process wastewater for cleanup of the wet well interior. The problem with the corrosive nature of this wastewater is that all fittings and piping corrode quickly. Although this wash water piping appears as though it has rarely been used for wash down purposes, it is now in an inoperable condition and has become obsolescent.

It is recommended instead to have a fire hydrant installed on the site close to the corner of the intersection and to utilize a portable water meter with an integral check valve and extend a fire hose from the new hydrant to wash down the interior of the wet well (at least on a bi-annual basis). This will provide a safe working environment for normal egress and ingress to the mezzanine level. The existing 3-inch galvanized piping in the pump room that comes off the end of the 12-inch wye blind flange to pump no. 4 should be disconnected, and instead the 3-inch galvanized piping should be routed over to penetrate the CMU wall for connecting to a manual hose connection fitting on the outside of the building. From this exterior point of connection a fire hose could be extended above ground to the new fire hydrant for wet well cleaning and flushing.

The wash water piping that extends from the mezzanine level to the lower pump intake level is completely useless and inoperable. It has not been used as intended to clean the trough of the wet well intake to the pumps. It is doubtful that it was ever used at all.

It is recommended that this 3-inch galvanized piping from the mezzanine level 3-inch tee on this piping be demolished and capped at the tee and new fittings installed to provide a 1-inch ball valve with 1-inch hose connection for wash down. A 1-inch hose connection should be configured to connect to to the existing 3-inch galvanized piping in the wet well by removing the old 3-inch gate valves and instead install a 3-inch by 1-inch reducer with 1-inch bronze ball valve (1/4 turn) with a 1-inch NST x 1-inch hose thread bushing for the 1-inch hose connection.

1. The electrical wiring from removed and/or obsolescent level sensor devices located on the wet well interior wall near the mezzanine entry ladder should be removed and the electrical junction box be capped to prevent additional corrosion.

2. The easterly wall wet well has some minor concrete surface corrosion associated in the area where a 4-inch floor drain in the ceiling above to the pump station floor drains water to the wet well. This superficial corrosion of the concrete wall surface is considered to be negligible. The larger pumps were installed in pump locations no. 3 and no. 4, and this retrofit had involved installing a ¼-inch-thick carbon steel 20-inch +/- pipe at the floor opening surrounded with a concrete floor base around this pump base flange. These ¼-inch-thick 20-inch-diameter pipe pump bases are showing some signs of corrosion, and it is recommended that the interior of these steel pipe faces be swabbed with grease

to slow down the corrosion of the pump base flange piping each time the pumps are pulled and replaced (bi-annual maintenance occurrence).

3. The 36-inch ductile iron influent pipe to the wet well shows some corrosion to the interior lining. There were no visible signs of the mortar lining left on the interior of this 36-inch influent pipe, but it does not appear to be a major concern at this time.
4. The bottom of the wet well floor area at the pump suction intake was explored with a 12-foot long fiberglass pole to see if there were signs of deposition on the floor suction intake flow area and it was observed that although there were 4 to 5 inches of solids buildup at the high points between the pump intakes, there were no signs of large depositions or problematic flow restrictions. Based on this observation, no significant amounts of deleterious materials have entered the wet well that have not been able to be pumped through the vertical turbine intakes and into the forcemains over the course of the last 22 years of operations.
5. OSHA requires that confined space entry signage be posted on the outside wall directly above the entrance manhole hatch. It is recommended that an O&M program of wet well cleaning on an annual basis be implemented for routine maintenance. If this were to be implemented, it is recommended that the entrance hatch to the wet well be equipped with a fixed stainless steel ladder with a ladder-up safety post for easy access entry into the wet well. Additionally, a fall protection netting device should be installed just below the access hatch door within the frame so as to prevent someone from falling while the access hatch door is open.
6. The access manhole to the influent screen chamber vault showed the following conditions:
    - The existing carbon steel influent screen bars have completely corroded through, and there appears to have been an attempt to remove the screen to prevent solids materials from clogging and causing back-up problems. This screen appears to not be required, since in the last two or three years no one can recall anyone ever entering either this pre-chamber screen vault to clean the screen or for other maintenance issues. Knowing this implies that screening maintenance was rarely, if ever, performed, and certainly cleaning the screen was done only on an emergency basis. Over the last number of years since the screen was attempted to have been removed, no significant amounts of deleterious materials have entered the wet well that have not been able to be pumped through the vertical turbine intakes and into the forcemains.
    - The fixed ladder into this influent screen chamber vault appears to be either galvanized or SST and was in good condition. All bolts, nuts, and washers for this fixed ladder were SST and showed no signs of corrosion.
    - The concrete interior walls and ceiling of the pre-chamber screen vault were in very good condition and showed no signs of corrosion or erosion damage.

- An existing float level rubber bulb and wiring that appeared obsolescent were hanging on the same wall as the entry ladder. If this level sensor is obsolescent it should be removed. *It is recommended that since screening is not a necessary operation for the current types of wastewater process flows from the current food processors that flow to this pump station, the corroded bar screen needs to be cut apart and removed from this vault and not replaced. Since a screen is not being used, there is no condition necessitating that a flow level sensor be located in this vault, and the existing float and associated wiring should be removed.*

THIS PAGE IS INTENTIONALLY LEFT BLANK.

CHAPTER 10
COLUMBIA EAST SERVICE AREA
CONVEYANCE CONDITIONS ASSESSMENT

10.1 PURPOSE

Food processing generates a large volume of wastewater that must be treated by the City of Pasco. Currently, in the area near Pasco-Kahlotus Road and Commercial Avenue, there are three food processors that generate a relatively large quantity of wastewater with no fecal matter, low biochemical oxygen demand (BOD), high levels total suspended solids (TSS), high levels of inorganic solids, and low pH. Some of this wastewater is currently transported to the City's Wastewater Treatment Plant (WWTP), while the remaining portion is pumped to the Process Water Re-Use Facility (PWRF). The amount and quality of wastewater being transported to the WWTP is substantial enough that it consumes a significant portion of WWTP capacity. As a remedy, the City will pump all process water from these three particular food processors to the PWRF. Benefits of this approach include reduced municipal WWTP loading.

10.2 BACKGROUND – QUALITY OF WASTEWATER

The three food processers include Columbia River Foods, Grimmway, and Freeze Pack. Columbia River Foods is currently not in operation at this time and is considering selling the facility. All three produce and discharge process wastewater. Columbia River Foods cleans, packages, and freezes several organic fruits and vegetables such as peas, corn, green beans, and carrots. Grimmway also cleans and packages carrots. Freeze Pack operations include washing, cooking, and packaging onions. Grimmway, in particular, is planning to increase operations over the next ten years, which will increase wastewater generation and BOD rates.

Food processing operations for the three producers are somewhat seasonal. This means that the highest levels of wastewater generation will occur during harvest periods in the summer and fall. During off-season periods, waste generation can be a fraction of the high season flows.

Currently, Grimmway discharges process wastewater to the municipal Kahlotus pump station near the intersection of Commercial Avenue and Kahlotus Road. The waste is then pumped to a gravity line southwest of US Hwy 395 that leads to the municipal WWTP. Freeze Pack discharges to Columbia River Foods. Columbia River Foods currently pumps their process wastewater through a 10-inch diameter forcemain directly to the City's PWRF to the north.

10.3 PRIOR STUDIES – QUANTITY OF WASTEWATER

The City retained the services of Murray, Smith, & Associates, Inc., (MSA) to prepare a Comprehensive Sewer Master Plan (Plan) and Capital Improvement Program (CIP) in May

2014. MSA analyzed and modeled the City's wastewater collection and treatment systems and identified system improvements. Although the study did not address this project in detail, it provides fundamental information that provides the basis for this project. Specifically, the master plan characterizes growing trends within the local food processing industry and the need for more capacity at the WWTP.

Section 2 of the MSA master plan, Future Conditions and Wastewater Flow Projections, states "the PWRF is currently close to capacity at a maximum flow of 10.3 MGD, and would require expansion for new food processors". It also states "a separate conveyance system would be required to accommodate additional food processors." (Table 12-3 Phase II Flow/Demand states a maximum projected flow of 4.5 MGD.)

CHAPTER 11
FOSTER WELLS SERVICE AREA
CONVEYANCE IMPROVEMENTS

11.1 SUMMARY OF NEEDED CAPITAL IMPROVEMENTS FOR FOSTER WELLS SERVICE AREA

11.1.1 Pump Components Summary

Pumps have already been identified as being in need of replacement in the Annual Operations and Maintenance budgets for the Foster Wells Pump Station, as one the smaller and one of the larger pumps are regularly rebuilt/replaced every other year.

11.1.2 Electrical Components Summary

- VFD No. 1 for Pump No. 1: Condition from recent water damage from Pump No. 4 failure resulted in VFD No. 1 becoming saturated. Now dry and working, but is old and in need of replacement.
- VFD No. 2 for Pump No. 2: A bit newer, but two to three years left of useful life before replacement is necessary.
- VFD No. 3 for Pump No. 3: OK, installed in 2010 with about five to eight years of useful life remaining before replacement is necessary (typically VFDs of this size last 12 to 15 years).
- In the summer of 2017, Pump No. 4 suffered a catastrophic failure of the pump base elbow and the pump base oil seal bonnet shearing off due to the high axial pressure exceeding the tensile strength of the compromised cast bronze. The pump base elbow eroded completely through and exploded out discharge pressure wastewater in the pumphouse, resulting in many items having to be replaced and/or repaired. Pump No. 4 is currently in the process of being rebuilt with a new SST vertical turbine can pump with a 300 HP motor on pump with design capacity of 3,500 gpm at 250 feet TDH.
- Radio Communications Controls Cabinet: The auxiliary status equipment displays on the face of this communications controls cabinet have all been destroyed by water damage from the recent pump blowout incident and are in need of replacement.
- Pump Room Wall Heater Nos. 1 and 2: One of the wall heaters was destroyed in the recent pump blowout incident in the pump room, and is in need of replacement.
- Ceiling Lights: The ceiling light fixtures over the area of Pump No. 4 were damaged and are in need of replacement.

- Wet well: The electrical wiring from removed and or obsolescent level sensor devices located on the wet well interior wall near the mezzanine entry ladder should be removed and the electrical junction box be capped to prevent additional corrosion.
- Bar Screen Pre-chamber Vault Manhole: An existing float level rubber bulb and wiring that appeared obsolescent were hanging on the same wall as the entry ladder. If this level sensor is obsolescent it should be removed.

11.1.3 Piping Mechanical Components Summary

- The existing flow meter vault should be abandoned and existing 12-inch discharge manifold replaced with a 12-inch 316 SST manifold at same elevation, continuing through the CMU south wall, and over the area of the existing meter vault where a new 8-inch MAG meter located above grade should be installed. This above-grade outside piping would be installed with insulation jackets for freeze protection. New SST piping from the new meter would bend down at 45-degrees and extend vertically down to tie back onto the existing 8-inch piping near the manifold area valving where it connects to the existing 16-inch forcemain.
- All miscellaneous smaller galvanized control piping (3/4”, 1”, and 2” diameter) on the discharge manifolds should be considered for replacement with SST piping.
- Install a fire hydrant on the site close to the corner of the intersection so as to be utilized for wet well wash down maintenance. When using this fire hydrant for wash down utilize a portable water meter with an integral check valve and extend a fire hose from a new hydrant to wash down the interior of the wet well.
- The existing 3-inch galvanized piping in the pump room that comes off the end of the 12-inch wye blind flange to pump no. 4 should be disconnected and instead route the 3-inch galvanized piping over to penetrate the CMU wall for connecting to a manual hose connection fitting on the outside of the building. From this exterior point of connection a fire hose could be extend over ground to the new fire hydrant for wet well cleaning and flushing.
- The washwater piping that extends from the mezzanine level to the lower pump intake level useless and inoperable. It is recommended that this 3-inch galvanized piping from the mezzanine level 3-inch tee on this piping be demolished and capped at the tee and new fittings installed for 1-inch ball valve and hose connection for wash down. Install a 3-inch by 1-inch reducer with 1-inch bronze ball valve (1/4-turn) with a 1-inch NST x 1-inch hose thread bushing for 1-inch hose connection.
- Replace bolts on the fixed galvanized ladder in the wet well leading down to the 7’x7’ concrete mezzanine platform from the access manhole vault ease with new SST bolts and washers due to excessive corrosion on the existing bolts.
- Replace bolts on the galvanized handrail bottom support bases in the wet well on the 7’x7’ concrete mezzanine platform with new SST bolts and washers due to excessive corrosion on the existing bolts.

- Remove the galvanized guard chains on the wet well mezzanine platform area handrails and replace it with stainless steel (SST) 1/4-inch-diameter chain with a SST snap clasp.
- Remove the existing galvanized ladder that leads down from wet well mezzanine level platform to the pump intake wet well bottom trough area.
- Remove the old deteriorated bar screen in the existing pre-chamber vault manhole upstream of the wet well that is partially demolished and still obstructs flow in the 36-inch diameter influent sewer line. This old bar screen needs to be cut into pieces and then removed from this pre-chamber vault manhole.
- For the wet well entry access hatch, it is recommended that a fixed stainless steel ladder with ladder up-safety post and integral fall prevention netting within the access hatch frame be installed along with signage outside and on the bottom of the access hatch that reads "WARNING Confined Space – Permit Required for Entry." See example signage as follows:

11.1.4 Forcemain Components Summary

Ductile iron fittings on the forcemains need to be dug up and replaced with either HDPE or PVC fittings with thrust restraint couplings. Smaller 8-inch-diameter 22.4-degree, 45-degree, and 90-degree bend fittings shall be replaced with C-900 PVC standard fittings and PVC C-900 repair couplings. Larger 16-inch forcemain fittings for bends shall be replaced with HDPE fabricated fittings and SST repair couplings along with mechanical restraints like Mega-Lug, or similar. It is estimated that on both the 8-inch and 16-inch forcemains there are about 14 each 8-inch and 16-inch existing ductile iron fittings (mostly 45-degree bends) that will need to be replaced as described above. This does not take into account those bends and wyes that are in the manifold buried header piping adjacent to the east side of the Foster Wells Pump Station building.

- The as-built for the Foster Wells Pump Station forcemains (16" and 8") indicates that those portions of the pipelines installed within the existing 30-inch and 24-inch steel casing pipes under Highway 395 were constructed of ductile iron within these casing pipes. An inspection of these pipe materials within the casing pipes should be conducted to verify if ductile iron pipe was used instead of PVC. If found to be ductile iron, these sections of pipelines within the casing pipes should be either lined with polyethylene or replaced with HDPE.

11.1.5 Structural Components Summary

- The inside walls and ceilings of the wet well should be inspected for corrosion damage. If corrosion damage is identified as being significant and in need of repairs, the repair methods will be identified and included in a revised summary herein. *(This work is currently scheduled for December 26 inspection of the wet well.)*
- The damaged ceiling areas of the pumphouse room need to be repaired with either new gypsum board or cementitious geo-board. Damaged insulation in the ceiling attic area needs to be replaced in-kind with batt insulation or upgraded to rigid insulation.

11.2 LAMB WESTON ASSESSMENT

The City of Pasco and Lamb Weston processing plant have been discussing options for winter storage and treatment for Lamb Weston's flows. As part of these discussions, the possibility of consolidating treatment operations under the City's management has been advanced. Under this scenario, Lamb Weston would no longer own and operate a Land Treatment system, and the City's PWRF would expand incrementally to accept the Lamb Weston process wastewater flows and provide treatment in accordance with Ecology regulations.

Three scenarios regarding the treatment of Lamb Weston's process water have been in discussion.

1. The City of Pasco treats all process wastewater from Lamb Weston's Facility and disposes of the wastewater according to the City's PWRF Permit.
2. The City of Pasco treats all the process wastewater from Lamb Weston's Facility to Washington State Ecology Reuse Water standards and returns the treated water back to the Lamb Weston Facility for utilization in Lamb Weston's production processes.
3. The City of Pasco stores process wastewater from the Lamb Weston Facility during the winter, provides necessary pre-treatment as required per the City's Washington State Discharge Permit No. ST0005369, and returns the pre-treated effluent back to the Lamb Weston Facility for further land application and treatment per Lamb Weston's Washington State Discharge Permit No. ST0005309.

This general premise was developed in 2017 during discussions of funding for a capital improvement plan. This technical memorandum provides a detailed level of capital cost development for a number of elements. These include an analysis of a pump station and distribution system to accommodate Lamb Weston, additional land acquisition requirements, and all road and railroad crossing locations. For the new Lamb Weston lines proposed in this document, there is one BNSF crossing near the existing Foster Wells pump station and one under Highway 395, both proposed as boring underneath the road or railway and placing the forcemains in their own casing pipes.

Public right-of-way is intended to be used as much as possible, but a number of locations have been identified where there may need to be additional acquisitions. This is discussed in Section 4.0.

11.2.1 Summary

Three situations or options were examined prior to consideration for this pump station. These include:

1. A new Lamb Weston Pump Station and dedicated forcemain.
2. Upgrade the existing Foster Wells Pump Station to accept Lamb Weston flows.
3. Implement a manifold where flows from the Foster Wells Pump Station and the Lamb Weston Pump Station are combined into shared forcemains.

See plan Figures 11-1a – 11-1d for the proposed alignment for the Lamb Weston Forcemain pipeline.

In Option 2, all of the existing Foster Wells pumps would have to be replaced to accommodate the new peak flows brought in from Lamb Weston. It is also important to consider the inherent inefficiency of a new Lamb Weston Pump Station pumping the relatively short distance to Foster Wells pump station only to be pumped a second time to the PWRF. Due to these factors this option will involve significant cost and negligible benefit over the construction of a new pump station and line from Lamb Weston to the PWRF.

In Option 3, there are a number of complexities that cause issues in both design and implementation. Most notable is trying to manage the convergence of different head conditions. Combining different sized pumps with significantly varying elevations, while not impossible, is considered technically operationally infeasible for such significant flows.

While Options 2 and 3 are not mutually exclusive, they will not be discussed further in this memorandum due to a combination of complexity and anticipated higher costs.

Option 1 includes pumping the Lamb Weston wastewater from a new 8-foot-diameter triplex sewage pump station wet well and one 16-inch-diameter forcemain. See Figure 11-3 for the schematic layout for the proposed Lamb Weston Pump Station site.

11.2.2 Background – Quality of Wastewater

The Foster Wells service area currently includes Con Agra Foods Lamb Weston Inc., Pasco Processing LLC, Twin City Foods, and Reser's Fine Foods. All of these, with the exception Lamb Weston, are currently served by the Foster Wells Pump Station. Lamb Weston currently treats its process wastewater onsite near its existing facility.

The Foster Wells Pump station and associated forcemain lines are subject to a host of existing repairs and maintenance issues, but discussion of these will not be included in this memorandum. These will be discussed and evaluated in a separate report focused specifically on recommendations for existing facilities.

Food processing operations for the three producers are somewhat seasonal. This means that the highest levels of wastewater generation will occur during harvest periods in the summer and fall. During off-season periods, waste generation can be a fraction of the high season flows and typically are pumped to the PWRF for winter storage.

11.2.3 Prior Studies – Quantity Of Wastewater and Cost of Expansion

In addition to this plan, aspects of the demand and capacity of the existing PWRF were examined by CH2M Hill in April and July of 2016. Their scope of examination included storage considerations and an initial look at bringing Lamb Weston's process water into the industrial reclamation facility. Their conclusion was that costs for this new facility and storage could run from 13 million to 17.5 million dollars.

11.2.4 Governing Standards

General standards governing publicly owned and operated pump stations in the State of Washington are codified in the Criteria for Sewage Works Design by the Department of Ecology (Ecology), dated August 2008. The City does not have supplementary pump station design standards. This pump station will be based on a design for a proposed pump station at the Columbia East service area which itself was based on the recently constructed municipal Kahlotus Pump Station.

11.2.5 Existing Conditions

The project area for this pump station is located in the northern third of the Foster Wells Service area. Specifically, it is situated in the northeast corner of a parcel currently used for agricultural purposes. See Figure 11-4 for a view centered on the area showing the proposed Lamb Weston Pump Station site.

The Lamb Weston Facility currently treats its own wastewater onsite.

The pump station location is within an existing industrial area. The current site is located close to North Glade Road and is accessible from the existing asphalt or gravel in and around the existing Lamb Weston facility (see Figure 11-2). Vegetation is minimal and can be easily cleared. Existing grades are fairly mild and consistent, but tend to have a slight uphill slope from the West to the East. Elevations for the proposed pump station site begin in the west half at approximate elevation 410 and rise to elevation 412 in the east half of the property. Some very minor grading may be required to prepare a flat surface for the pump station area. FEMA has identified the proposed site as being above the 100-year flood.

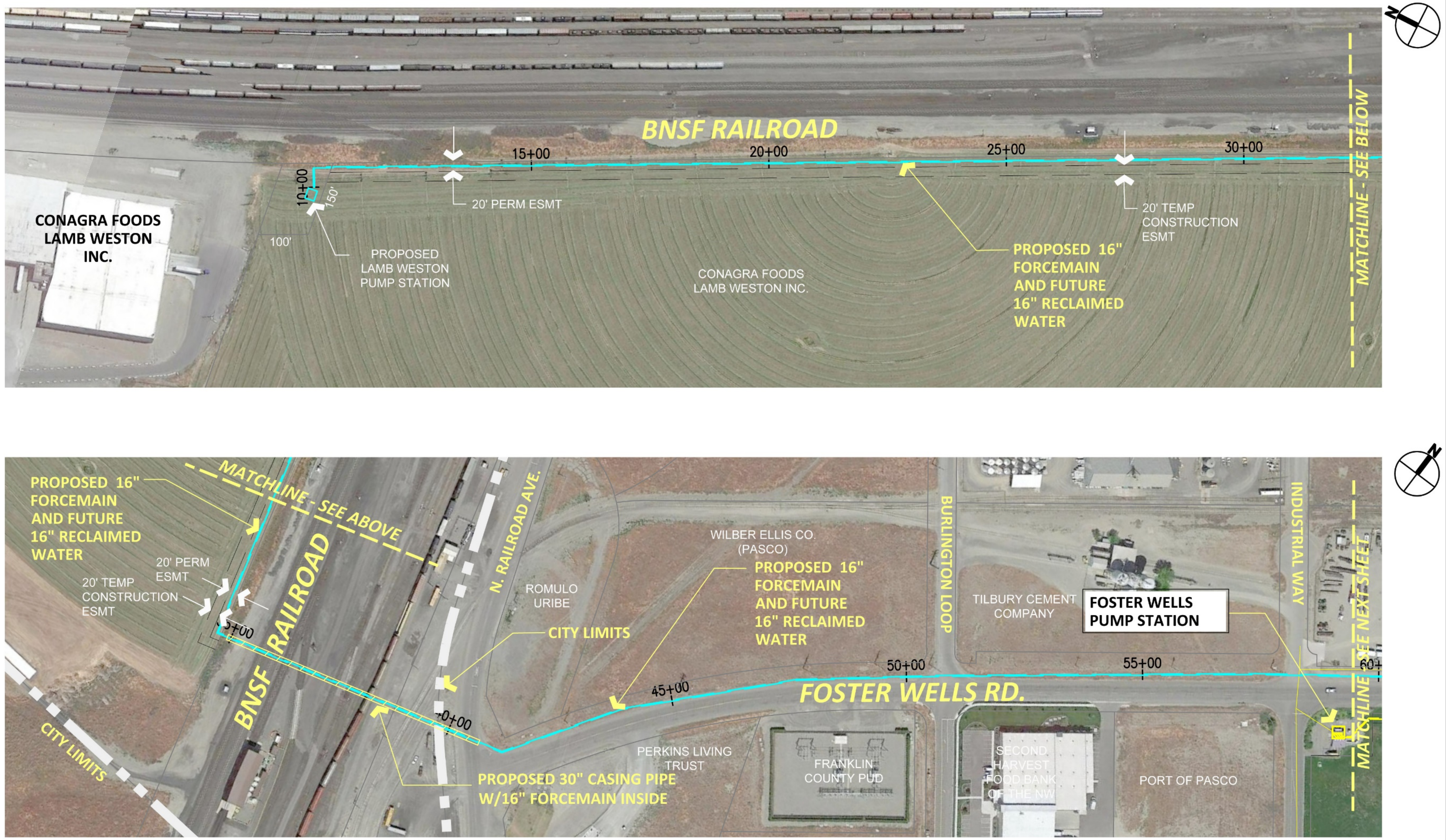


Figure 11-1a	Proposed Forcemains	17454.00
		12.14.2017

THIS PAGE IS INTENTIONALLY LEFT BLANK.

Figure 11-1b	*Proposed Forcemains*	17454.00
		12.14.2017

THIS PAGE IS INTENTIONALLY LEFT BLANK.

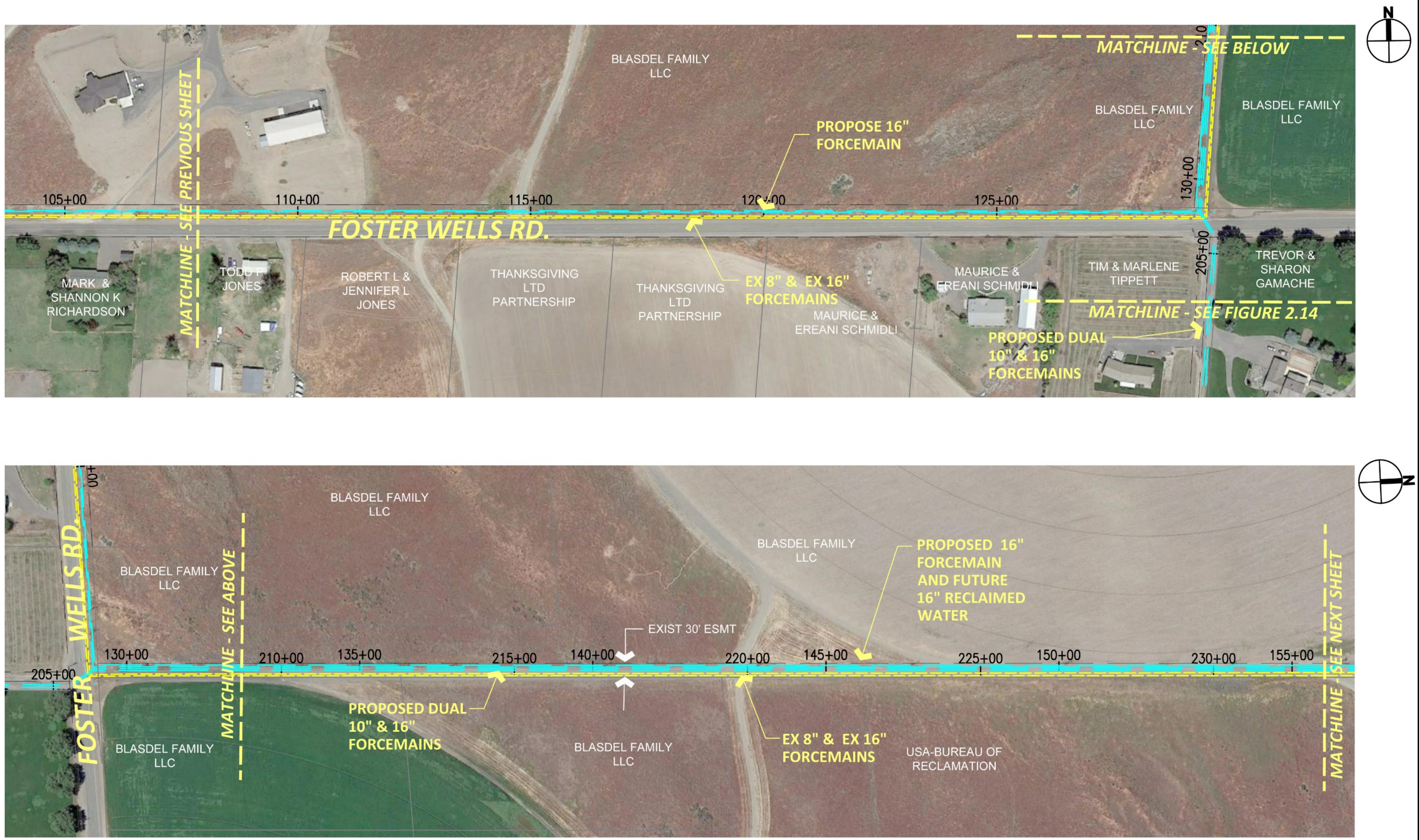


Figure 11-1c	Proposed Forcemains	17454.00
		12.14.2017

THIS PAGE IS INTENTIONALLY LEFT BLANK.

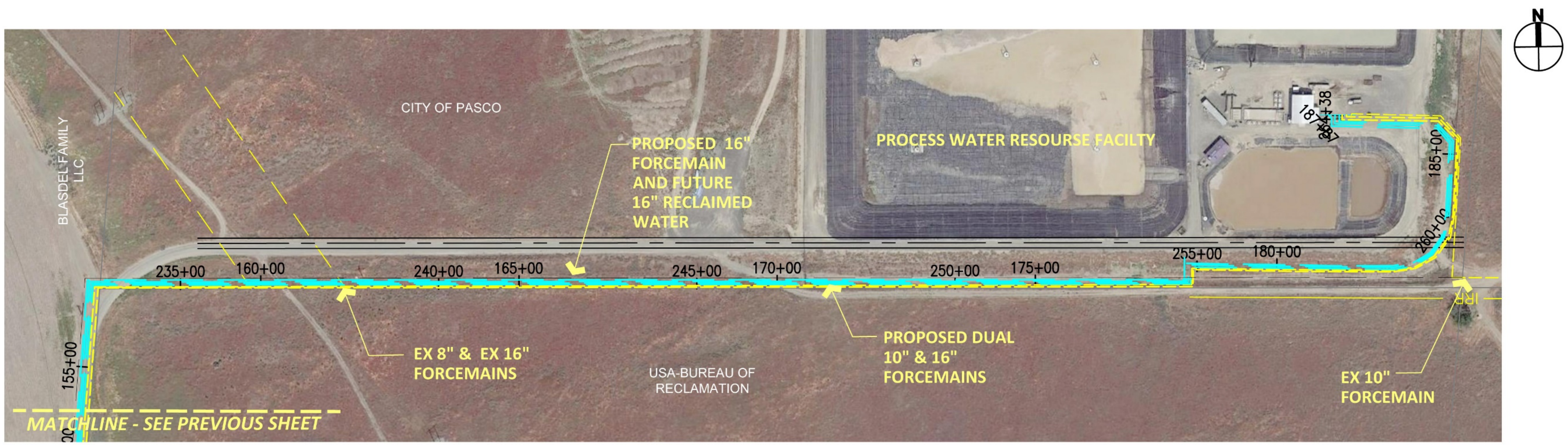


Figure 11-1d	Proposed Forcemains	17454.00
		12.14.2017

THIS PAGE IS INTENTIONALLY LEFT BLANK.

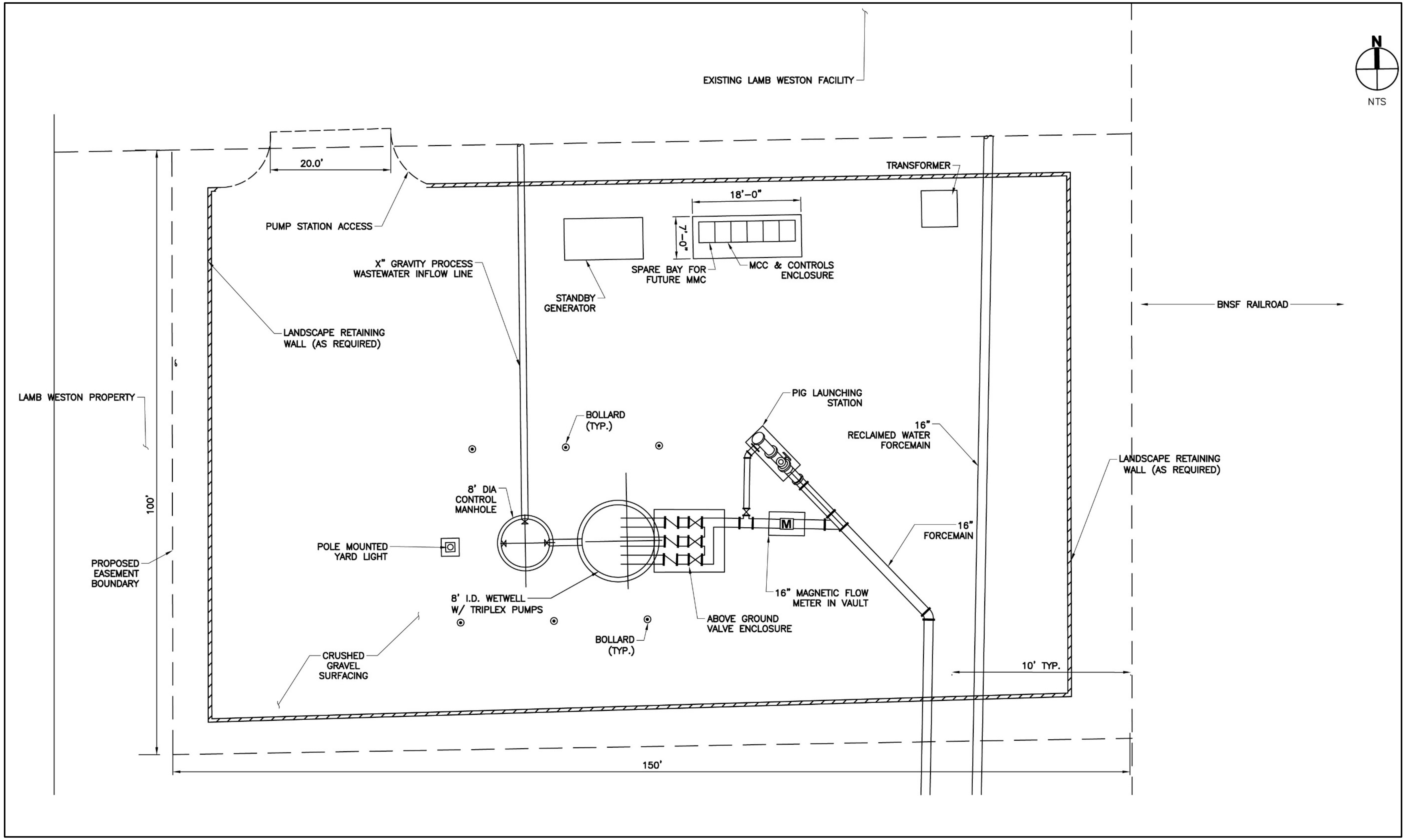


Figure 11-2	Lamb Weston Pump Station Schematic	17454.00
		12.14.2017

THIS PAGE IS INTENTIONALLY LEFT BLANK.

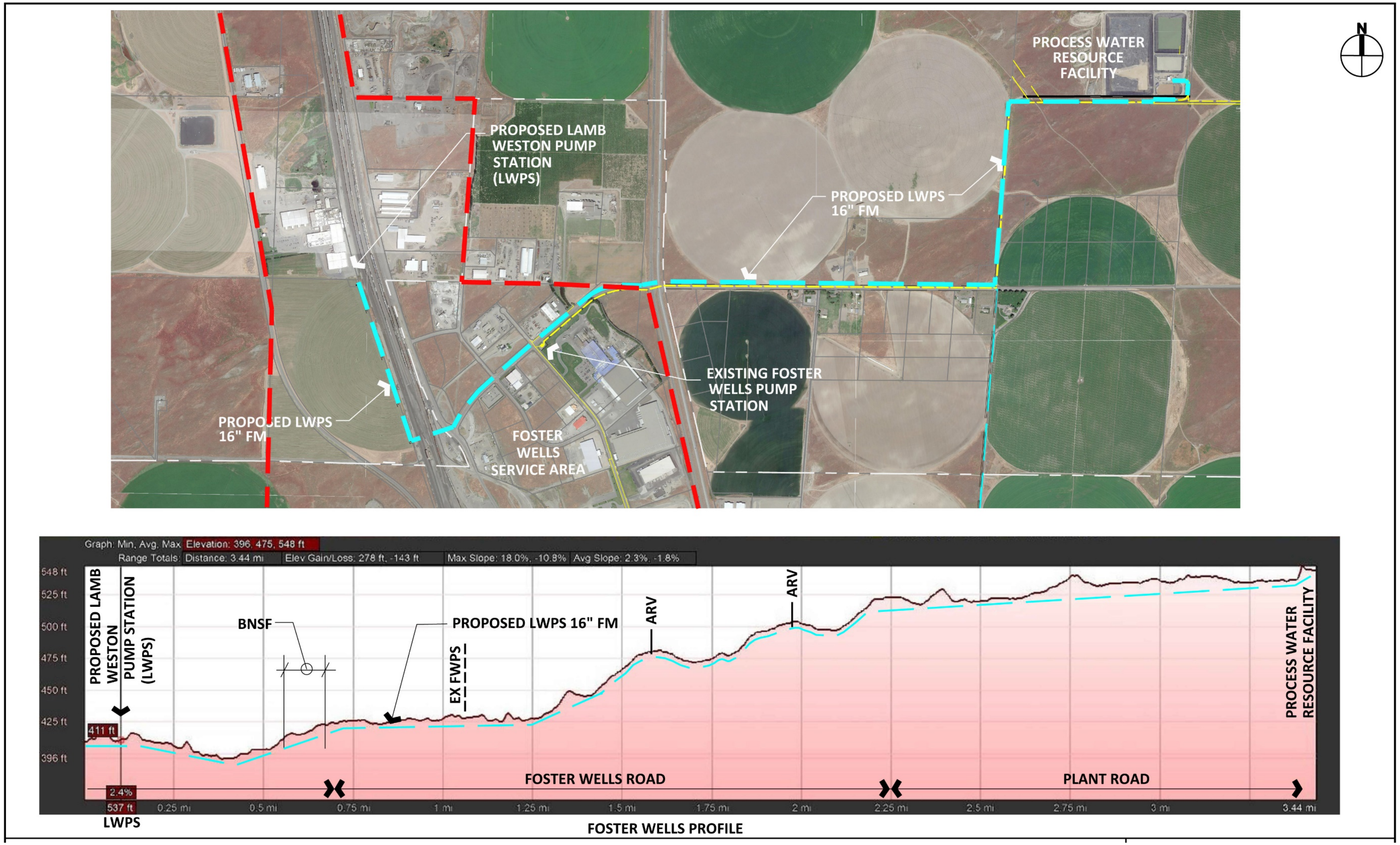


Figure 11-3	*Proposed Lamb Weston Pump Station Site*	17454.00
		12.14.2017

THIS PAGE IS INTENTIONALLY LEFT BLANK.

Figure 11-4	Proposed Lamb Weston Pump Station	17454.00
		12.14.2017

11.2.6 Existing Utilities

The site proposed for the future pump station does not currently serve any function other than land for farming. Due to the proximity to the Lamb Weston processing facility and the associated overhead power lines, the local PUD should be able to easily provide electrical power service to the new pumps and controls.

11.2.7 Soils

The soil conditions are generally uniform per the Natural Resources Conservation Service (NRCS) soils report. Most common is a loamy, fine sandy material to at least a 20-inch depth. Depths to restrictive rock and the water table are expected to be greater than 80 inches. The soil is considered to be well drained. A geotechnical investigation should be completed prior to final design to confirm soil conditions and existing groundwater elevation depth.

11.2.8 Forcemain Design

The forcemain for the proposed Lamb Weston Pump Station will be 16 inch diameter HDPE. One dedicated line has been sized as adequate for the peak expected flows created by the Lamb Weston facility.

In addition to the dedicated process sewage line, a line of identical material and size will be installed in parallel to transport treated process water back to the Lamb Weston facility.

Through the analysis of desired flows and velocities it was determined that a 16-inch-diameter forcemain would suit the peak flow needs of the Lamb Weston facility. The material for the forcemains was selected as HDPE in order to avoid some of the known issues with corrosion in lines currently running to the PWRF.

11.2.9 Alignment

The alignment for the proposed Lamb Weston forcemain was developed based on the one currently used for the existing Foster Wells forcemains. The exception to this is the initial section before crossing the BNSF railroad, the alignment over to the location of the proposed new forcemain, and the proposed reclaimed waterline reaching the existing Foster Wells Pump Station area and parallel to the existing forcemains (see Figures 11-1a – 11-1d).

11.2.10 Easements

A number of properties will require additional or amended easements in order to account for the new Lamb Weston forcemain and reclaimed water lines. These properties and their associated additional areas of easements are listed in Table 11-2 along with associated costs. Note that estimated easement costs may be subject to revision based on similar local project costs for easements and right-of-way acquisitions.

11.3 BASIS OF DESIGN

11.3.1 Hydraulics Design Parameters

The primary design parameters for sanitary lift stations are the peak hourly flow (PHF) expressed in gpm, and total dynamic head (TDH) expressed in feet of water. The PHF is typically estimated by applying a peaking factor (PF) to the average daily flow (ADF). The PF in turn can typically be estimated from sewer flow data or calculated using Ecology guidelines.

Pump station inflow is defined by the maximum expected future production by Lamb Weston.

In this case, however, the determination of these design parameters is somewhat non-traditional. Pump station inflow is defined by one distinct food processor as opposed to a basin of residential or commercial constituents. The peaking factor is applied to the maximum recorded daily flow (MDF) instead of the ADF. The MDF is more representative of consistent and sustained wastewater flows during periods of highest production. The pump station must be capable of processing those sustained high flows.

TDH is a function of the height the wastewater has be lifted, the distance it is pumped, the size/material/condition of the forcemain, and the flow velocity in the forcemain. Per Ecology standards and recommendations, sewer forcemains should be designed to keep velocities between 3.5 to 5.0 feet per second (fps) to limit solids settlement, thereby reducing maintenance costs. These recommendations, however, assume typical sanitary wastewater qualities with high solids content. For the Lamb Weston Regional Industrial Pump Station, the wastewater will only include food process water. Pre-treatment standards require that significant solids are removed prior to discharge from the facility. Also, some food processors utilize, or plan to utilize, equalization ponds that promote solids settlement. For these reasons, we believe that the minimum forcemain velocity can be approximately 3 fps. A maximum of velocity of 8 fps is recommended to keep friction head-loss and maximum pressures to an acceptable level.

11.3.2 Operational Design Parameters

11.3.2.1 Pump Station Site Location

The site location can greatly affect pump station design. Changes in elevation impact the total system head, the length/depth/size of the inflow sanitary lines, and inflow storage. The industrial pump station is proposed southeast of the existing Con Agra Foods building owned by Lamb Weston. This parcel is located on the west side of the BNSF railroad.

This location was selected due to its proximity to Lamb Weston’s facility. In addition, the parcel in question is already owned by Lamb Weston. The final placement of the pump station along the BNSF may change pending future considerations for nearby land use or regarding ease of construction for the gravity feed into the pump station. No additional locations have been explored at this point in time.

Elevations are largely flat at the proposed site. Through cursory examination, elevation appears to slope at about 1 to 2% to the west toward N. Glade Road. The required amount of grading is expected to be minor.

It is currently assumed that gravity flow to the pump station will be possible based on the relatively flat site. For the sake of the estimate for the new pump station, a conservative 18,100 linear feet for the length of gravity sewer was used. Given the nearby visible location of Lamb Weston's current onsite treatment facility, this appears to be reasonably close.

11.3.2.2 Design Flows

Design flows were considered with only the capacity for Lamb Weston in mind. These centered on an anticipated maximum day flow of 1,875 gpm (2.7 MGD). This is close to the midpoint of an average daily day flow of 1,530 gpm (2.2 MGD). Based upon flow records, a safety factor of 1.5 times average daily flow, or 2,310 gpm, will be used for pump station capacity.

11.3.3 Design Alternatives

No alternatives were analyzed in depth at this point in time. The major goal of this memorandum is to establish a baseline cost for the parties involved with future improvements to industrial wastewater infrastructure.

11.3.4 Wet well Design

The site location and elevation also impacts wastewater storage capacity in the case of pump failure. This total storage is important because it provides time for City crews to respond if there is a mechanical or electrical failure. For this reason, an 8-foot-diameter wet well is proposed to maximize storage within the pump station wet well. A backup generator is also proposed which will generally activate within 30 seconds of power failure. The gravity inflow lines also provide minimal emergency wastewater storage. For our purpose we will not include that storage. If more storage is desired, the diameter and depth of the wet well can be increased. A large diameter manhole can be installed adjacent to the proposed wet well to serve as an overflow storage structure, if necessary. An outlet pipe from the storage structure can gravity drain back to the wet well through a one-way Tideflex valve.

11.3.5 Key Performance Criteria

There is a small range of forcemain diameters that fall within the acceptable range of flow velocities. In order to make a preliminary forcemain diameter selection, the other variables listed must also be considered. Those key variables include TDH and associated system pressure, horsepower requirements, and forcemain residency time. The following is the recommended criteria for each variable:

- Flow velocities for each phase should fall within the range of 4 to 8 fps to prevent stagnation, solids settlement, and scouring.
- Standard operating pressures should not exceed 100 psi to limit stresses on system components. This allows for more standard and less expensive system components. Lower pressures are also safer for maintenance and repair operations.
- Limit pump sizes to no more than 200 hp. This reduces pump purchase, operating, maintenance, and replacement costs.
- Limit forcemain residency times to 180 minutes. This reduces the potential for stagnation or solids settlement.

Through initial examination it has been determined that a triplex pump station, with three 125 horsepower pumps, can accomplish this task reasonably well. Two 1,250 gpm pumps running in tandem will convey the firm, 2,500 gpm capacity with a third pump in reserve as a redundant backup, see Figure 11-3 for layout. This will exceed 2,310 gpm peak flow with any two pumps in operation.

Additional design applications to consider associated with the pump stations are as follows:

1. Ventilation: Ventilation must be provided within the wet well to provide an environment suitable for human occupancy. Ventilation purges the structure of odorous, toxic, and hazardous gases with outside fresh air. Ventilation must also manage flammable gases present in the wastewater to a level appropriate for the desired electrical equipment. The latest version of the NFPA Standard 820 requires ventilation at a rate of 12 air exchanges per hour to maintain a Class 1 Division 2 rating. The blower motor used to ventilate the wet well must be spark-proof so as not to create a spark while rotating. The Dayton Model #5C090 at 990 CFM is capable of meeting the 12 air exchanges based on a 12-foot-diameter, 20-foot-deep wet well.
2. Generator: The Department of Ecology recommends the installation of permanent engine generators for larger pump stations and permanent facilities. Automatic transfer switches provide for quick transitions to standby power when the primary power fails. Size of the generator should depend upon the requirements of starting and operating the pumps at peak possible load, and all ancillary equipment in the station. A diesel generator is recommended with the fuel stored in a "belly" tank located under the generator. The fuel storage should be sized to operate the pump station for a minimum of 24, and preferably 36, continuous hours. A weather-tight enclosed generator is sufficient. Stairs and landing may be required to access the maintenance doors for the generator.

3. Water: A single yard hydrant will be installed adjacent to the wet well. The pressurized potable water supply will be used to facilitate cleaning of the wet well and general site wash-down. An RPBA (reverse pressure backflow assembly) connection will be made at the point of connection to the City water system.
4. Telemetry: Telemetry will be included as part of the communication system for the pump station. Telemetry will allow the City operator(s) to monitor the various aspects of the operation of the pump station including, but not limited to, pumping volume, pump(s) operation status, wet well water level, etc. Telemetry will allow the operator to interface remotely with the pump station.
5. Wet well Lining: When the inside surface of the wet well is exposed to carbon dioxide and hydrogen sulfide gas carried in the wastewater, a complex, multiphase process of corrosion is set in motion. These acidic gases reduce the pH of the concrete from 12 to as low as 9. Sulfur oxidizing bacteria (SOB) attach to the surface as sulfates are produced. The acid attacking the concrete creates a layer of gypsum (calcium sulfate) that allows the microorganisms to reproduce, and more acid is created. Eventually the inside wall of the concrete wet well begins to fail.

   High-performance, chemical-resistant coatings are available to protect the interior of the wet well against deterioration by creating a protective barrier between the substrate and the waste flow. Coatings come in a variety of formulations with different functional characteristics and application requirements. For our installation an epoxy liner is recommended. Epoxy liners have long been favored by owners. In addition to their excellent chemical-resistant properties, they are strong and unaffected by wetness/humidity, making them ideal for applying to damp substrates. Epoxy liners are typically bonded directly to the substrate and may require the use of primer. They are spray-applied at dry film thicknesses of 60 to 250 mils.

6. Abrasion: Abrasion has been shown to greatly harm existing pump station forcemains currently operated by the City. Inorganics, such as dirt, found in the conveying wastewater erode the cement mortar lining commonly found in ductile iron pipe. Once this lining is removed, the abrasion caused by the inorganics slowly scours away the metal until failure occurs.

   History has shown that both Polyvinyl Chloride (PVC) and High Density Polyethylene (HDPE) pipe are minimally affected by scouring associated with conveying inorganics within a forcemain.

7. pH Corrosion: The City of Pasco generally placed the following pH discharge limits on Lamb Weston: Generally non-corrosive between 6.0 and 12.0.

   A pH below 7 is acidic; above 7 is alkaline. The further below or above 7 a solution is, the more acidic or alkaline it is. The scale is not linear – a drop from pH 8.2 to 8.1 indicates a 30 percent increase in acidity, or concentration of hydrogen ions; a drop from 8.1 to 7.9 indicates a 150 percent increase in acidity.

The pH level within the wet well will need to be monitored and maintained to not go below 8.0. Corrosion of any metal surfaces within the wet well will begin to occur at a pH below 8.0.

8. Odor: A common issue related to wastewater pump station operation is that of odor accumulation. Wastewater gas that has collected in the confined space of the wet well poses risks of toxicity, underground explosions, and damage to inlet and outlet lines. Methods for alleviating the dangers include aeration and the introduction of chemical additives such as sodium nitrate to elevate oxygen levels in the wet well. Scented products can also be used to ameliorate the more practical nuisance caused by excess wastewater gas.

   For our application, turning over the volume of wastewater within the wet well and not letting it accumulate for an excessive time will reduce the potential for nuisance odors. We also recommend installation of air meters to monitor dangerous gas accumulation in the wet well.

11.3.6 Electrical Considerations

Based on similar situations discussed with Franklin Public Utility District (FPUD), a pad-mounted utility transformer will be required for primary electrical service to the pump station. FPUD cannot guarantee service reliability, so a standby generator is recommended. An 800A service is required.

The pump control system will include a submersible pressure transducer for primary level control with redundant level control floats. A programmable logic controller (PLC) and operator interface terminal will be provided for station monitoring and operator control. A fiber-optic-based communication system will communicate status and alarms. An industrial grade uninterruptible power supply (UPS) will be provided to maintain power to the alarm/telemetry system. Outside lighting will be provided to illuminate the wet well area. A motor control center (MCC) will be used to house electrical equipment, motor controllers, and the PLC.

Other recommended elements of the new Lamb Weston Pump Station include the following:

1. Variable Frequency Drives (VFDs) to allow for pumping capacity adjustments if needed.
2. Spare pump and spare parts kit stored at City maintenance depot.
3. Consider influent pH ranges as it may impact pump coating specifications.
4. Recirculating (mixed-flush) valves on at least one pump to improve solids removal.
5. Above-ground frost-free insulated valve vault containing pump isolation, check valves, and flow meter.
6. Outdoor stainless steel NEMA 4X controls cabinet housing the Motor Controls Center (MCC), level controller, alarms, and telemetry equipment.

7. Water service including reduced pressure backflow preventer (RPBP) and non-freeze yard hydrant for wet well washdown.
8. Pole-mounted area light illuminating the wet well and valve vault areas.
9. Security equipment including lighting and CCTV cameras.
10. Set-aside area for corrosion control equipment if future conditions warrant it.

The following is a cost estimate for the electrical construction portion of the project:

Table 11-1: Electrical Construction Cost Estimate

Line No.	ITEM	QTY	UNIT	UNIT COST	TOTAL
	PUMP STATION ELECTRICAL				
1	PUD Line Extension and Transformer	1	LS	$ 25,000	$ 25,000
2	Standby Generator	1	EA	$ 93,000	$ 93,000
3	Meter-Main and Disconnect	1	EA	$ 3,000	$ 3,000
4	Manual Transfer Switch	1	EA	$ 2,000	$ 2,000
5	Gen Receptacles and Wiring	1	EA	$ 10,000	$ 10,000
6	Grounding	1	LS	$ 5,000	$ 5,000
7	Motor Control Center	1	LS	$ 100,000	$ 100,000
8	Telemetry Panel	1	LS	$ 25,000	$ 25,000
9	Programmable Logic Controller	1	EA	$ 10,000	$ 10,000
10	Electrical Cabinet	1	EA	$ 20,000	$ 20,000
11	Pump Disconnect Enclosure	1	LS	$ 15,000	$ 15,000
12	Float Switches	4	EA	$ 100	$ 400
13	Combustible Gas Detector	1	EA	$ 2,000	$ 2,000
14	Radio Tower	1	EA	$ 15,000	$ 15,000
15	Light Pole	1	EA	$ 3,000	$ 3,000
16	Conduit, Receptacles, Wire, Miscellaneous	1	LS	$ 20,000	$ 20,000
				Subtotal Pump Station Electrical	**$ 348,400**
				Subtotal Construction	$ 348,400
				Contingency (15%)	$ 52,260
				Washington State Sales Tax (8.6%)	$ 29,962
				Total Estimated Construction Cost	**$ 430,622**

11.3.7 Construction Cost

A construction cost estimate was prepared for the single option discussed thus far in this memorandum. As stated previously, the other alternatives or different conditions have currently been dismissed for their complexity and overall cost. This estimate can be seen in Table 11-1.

11.3.8 Operation and Maintenance Costs

The annual operation and maintenance costs were evaluated for this pump station. Typical costs include pump station and forcemain inspection, preventative maintenance, minor repair and servicing, major repair and equipment replacement, administration, and energy. Because not all of the food processors operate year-round, energy costs were compared for the period of one month during Phase II peak production. The same pump run times were assumed for each option at 16 hours per day. Table 11-2 illustrates the monthly power cost for the selected option based on an average Commercial rate of $.0591/kW-h.

Table 11-2: Peak Monthly Power Cost

Option Number	Description	Pumps	Monthly Power Cost
1	Single wet well – Single forcemain – Triplex (Two 125 HP Pumps Operating)	Three 125 HP (Ph. 2)	$3,305

11.3.9 Preferred Option

Overall we believe that a Triplex System is the best choice based on the given criteria.

With regard to wet well design, we found that an 8-foot-diameter wet well was suitable for the triplex system. An operational depth of 9 feet provides adequate operational volume and added wastewater storage. The total wet well depth is approximately 20 feet.

The following is a cost breakdown for the Lamb Weston Pump Station:

Table 11-3: Estimate of the Probable Cost of Construction Lamb Weston Pump Station

CITY OF PASCO	DATE: 12/8/2017	PROJECT NUMBER: 17454
Lamb Weston Industrial Pump Station Project	ESTIMATED BY: PACE	DESIGN STATUS: 15%

Line No.	ITEM	QTY	UNIT	UNIT COST	TOTAL
GENERAL					
1	Mobilization/Demobilization	1	LS	$ 175,000	$ 175,000
2	Testing and Commissioning	1	LS	$ 40,000	$ 40,000
3	Construction Surveying	1	LS	$ 20,000	$ 20,000
4	Temporary Erosion Controls	1	LS	$ 5,000	$ 5,000
5	Clearing and Grubbing	0.5	ACRE	$ 10,000	$ 5,000
				Subtotal General	**$ 233,023**
PUMP STATION SITE					
6	Pre-Cast Concrete Wet well 8' dia. x 20' deep	1	EA	$ 48,000	$ 48,000
7	Cast-in-Place Dry Pit Structure for Pumps & Valves – 20' x 24'	1	EA	$ 15,000	$ 65,300
8	Pre-Cast Inlet Manhole, 5' dia. by 10' deep	4	EA	$ 10,000	$ 40,000
9	Pre-Cast Meter Vault	1	EA	$ 12,000	$ 12,000
10	Landscape Block Retaining Wall – Less than 4' ht	1,000	SF	$ 25	$ 25,000
11	Chain Link Fence with Gate	360	LF	$ 25	$ 9,000
12	Site Grading including Gravel Borrow Backfill	750	SY	$ 10	$ 7,500
13	Crushed Gravel Surfacing	240	CY	$ 50	$ 12,000
14	Concrete Equipment Pads & Footings	10	CY	$ 250	$ 2,500
15	Bollards	6	EA	$ 1,000	$ 6,000
16	4" HMA Cl 1'2 PG 64-22	800	SY	$ 75	$ 60,000
17	18-inch PVC Gravity Sewer Pipe – Up to 10' Deep	1,800	LF	$ 125	$ 225,000
				Subtotal Pump Station Site	**$ 512,300**

Line No.	ITEM	QTY	UNIT	UNIT COST	TOTAL
PUMP STATION MECHANICAL					
18	Vertical Solid Handling Sewage Pumps (Submersible Type Motors for Dry Pit)	3	EA	$ 75,000	$ 225,000
19	Eccentric Plug Valve (3 ea –10" & 3 ea –12" Dia.)	6	EA	$ 6,000	$ 18,000
20	Swing Check Valve 10" Dia.	3	EA	$ 7,500	$ 22,500
21	2 -inch HDPE Water Line	400	LF	$ 30	$ 12,000
22	2" Water Service Connection	1	EA	$ 250	$ 250
23	Yard Hydrant	1	EA	$ 800	$ 800
24	1-inch RPBA	1	EA	$ 1,000	$ 1,000
25	Portable Davit Crane with Motor	1	LS	$ 8,000	$ 8,000
26	Pressure Gauges	3	EA	$ 600	$ 1,800
27	14-inch Magnetic Flow Meter	1	EA	$ 25,000	$ 25,000
28	Ultrasonic Level Indicator	1	EA	$ 5,000	$ 5,000
				Subtotal Pump Station Mechanical	**$ 319,350**
PUMP STATION ELECTRICAL					
29	PUD Line Extension and Transformer	1	LS	$ 25,000	$ 25,000
30	Standby Generator	1	EA	$ 93,000	$ 93,000
31	Meter-Main and Disconnect	1	EA	$ 3,000	$ 3,000
32	Manual Transfer Switch	1	EA	$ 2,000	$ 2,000
33	Gen Receptacles and Wiring	1	EA	$ 10,000	$ 10,000
34	Grounding	1	LS	$ 5,000	$ 5,000
35	Motor Control Center	1	LS	$ 100,000	$ 100,000
36	Telemetry Panel	1	LS	$ 25,000	$ 25,000
37	Programmable Logic Controller	1	EA	$ 10,000	$ 10,000
38	Electrical Cabinet	1	EA	$ 20,000	$ 20,000
39	Pump Disconnect Enclosure	1	LS	$ 15,000	$ 15,000
40	Float Switches	4	EA	$ 100	$ 400
41	Combustible Gas Detector	1	EA	$ 2,000	$ 2,000
42	Radio Controls and Antenna Tower	1	EA	$ 15,000	$ 15,000
43	Light Pole	1	EA	$ 3,000	$ 3,000
44	Conduit, Receptacles, Wire, Miscellaneous	1	LS	$ 20,000	$ 20,000
				Subtotal Pump Station Electrical	$ **$348,400**
				Subtotal Construction	$ 1,413,073
				Contingency (design engineering, const. admin., and permitting (40%)	$ 565,230
				Washington State Sales Tax (8.6%)	$ 121,524
				Total Estimated Construction Cost	**$ 2,099,827**

11.4 FORCEMAIN CONSTRUCTION COST

The construction cost (Table 11-4) for this aspect is separated due to the fact that it was created without prior knowledge of the current cost of materials. Prices are representative of current rates and can be subject to change for a variety of reasons. See Table 11-5 for associated easements.

Table 11-4: Estimate of the Probable Cost of Construction New 16-Inch-Diameter Forcemain and Return Line

CITY OF PASCO		DATE: 12/13/2017		PROJECT NUMBER: 17454	
Lamb Weston Industrial Pump Station Project		ESTIMATED BY: PACE		DESIGN STATUS: 15%	
Line No.	**ITEM**	**QTY**	**UNIT**	**UNIT COST**	**TOTAL**
1	Mobilization/Demobilization (8%)	1	LS	$ 520,800	$ 520,800
2	Testing and Commissioning	1	LS	$ 40,000.00	$ 40,000
3	Construction Surveying	1	LS	$ 30,000.00	$ 30,000
4	Temporary Erosion Controls	1	LS	$ 10,000.00	$ 10,000
5	Clearing and Grubbing	1.0	ACRE	$ 10,000.00	$ 9,711
6	Excavation incl. haul	30,489	CY	$ 21.00	$ 640,267
7	Forcemain 16” High Density Polyethylene (HDPE) Pipe	18,100	LF	$ 110.00	$ 1,991,000
8	Reclaimed 16” High Density Polyethylene (HDPE) Pipe	18,100	LF	$ 110.00	$ 1,991,000
9	30” Steel Casing Pipe	1,300	LF	$ 500.00	$ 650,000
10	Pavement Sawcutting	900	LF	$ 5.00	$ 4,500
11	Crushed Surfacing Base Course	154	CY	$ 22.00	$ 3,388
12	Crushed Surfacing Top Course	77	CY	$ 30.00	$ 2,310
13	4” HMA Cl 1’2 PG 64-22	690	SY	$ 75.00	$ 51,750
14	16" In-Line Plug Valve	3	EA	$ 5,500.00	$ 16,500
15	16" HDPE 45 Degree Sweep	31	EA	$ 2,700.00	$ 83,700
16	PWRF Screen Building Extension	1	LS	$ 105,000.00	$ 105,000
17	PWRF 36" Manifold and Appurtenances	1	LS	$ 100,000.00	$ 100,000
18	Air Release Valve Assembly	4	EA	$ 5,400.00	$ 21,600
				Subtotal	$ 6,271,526
	Contingency (design engineering, const. admin., and permitting (40%)				$ 2,508,610
				Washington State Sales Tax (8.6%)	$ 755,092
				Total Estimated Construction Cost	**$ 9,535,228**

11.4.1 Cost Summary

Combining the probable costs of construction for the forcemain and the pump station along with anticipated easement costs, PACE estimates that the proposed facilities required to convey the process water from Lamb Weston to the PWRF and for the 16-inch reclaimed waterline returning flow back to Lamb Weston is approximately $11,651,000.

THIS PAGE IS INTENTIONALLY LEFT BLANK.

Table 11-5: Right-of-Way and Easements

PROPERTY OWNER	PROPERTY ADDRESS	PARCEL NUMBER	TOTAL AREA (ACRES)	PERMANENT EASEMENT AREA (SF)	TEMPORARY CONSTRUCTION EASEMENT AREA (SF)	TOTAL 2018 MARKET VALUE ($)	EST. VALUE OF LAND ($/SF)	EST. COST PERMANENT EASEMENT ($ AT 15%)	EST COST TEMPORARY CONSTRUCTION EASEMENT ($ AT 5%)
Conagra Foods Lamb Weston Inc	960 Glade North Road, Pasco 99301	113110124	–	0	0	–	–	–	–
Conagra Foods Lamb Weston Inc	960 Glade North Road Pasco 99301	–	–	48,108.5	49,050.9	–	0.287	$2,111.64	$703.88
Pelican Fueling Inc	5207 N Railroad Avenue Pasco 99301	113120220	3.04	1,978.4	2,161.3	$106,600	0.805	$260.97	$86.99
Blasdel Family LLC	513 E Foster Wells Road Pasco 99301	113100037	558.10	0.0	35,710.0	$4,563,900	0.188	–	$335.19
Blasdel Family LLC	2001 E Foster Wells Road Pasco 99301	113100055	5.00	0.0	24,541.1	$25,000	0.115	–	$140.85
Blasdel Family LLC	513 E Foster Wells Road Pasco 99301	113100037	558.10	0.0	35,710.0	$4,563,900	0.188	–	$335.19
Total Cost of Permanent Easements =								**$2,372.61**	
Total Cost of Temporary Construction Easements =									**$1,602.11**

THIS PAGE IS INTENTIONALLY LEFT BLANK.

CHAPTER 12
COLUMBIA EAST SERVICE AREA
CONVEYANCE IMPROVEMENTS

12.1 PURPOSE

Food processing generates a large volume of wastewater that must be treated by the City of Pasco. Currently, in the area near Pasco-Kahlotus Road and Commercial Avenue, there are three food processors that generate a relatively large quantity of wastewater with no fecal matter, low biochemical oxygen demand (BOD), high levels total suspended solids (TSS), high levels of inorganic solids, and low Ph. Some of this wastewater is currently transported to the City's Wastewater Treatment Plant (WWTP), while the remaining portion is pumped to the Process Water Re-Use Facility (PWRF). The amount and quality of wastewater being transported to the WWTP is substantial enough that it consumes a significant portion of WWTP capacity. As a remedy, the City will pump all process water from these three particular food processors to the PWRF. Benefits of this approach include reduced municipal WWTP loading.

12.2 BACKGROUND – QUALITY OF WASTEWATER

The three food processers include Simplot RDO, Grimmway, and Freeze Pack. Simplot RDO is currently not in operation at this time and is considering selling the facility. All three produce and discharge process wastewater. Simplot RDO cleans, packages, and freezes several organic fruits and vegetables such as peas, corn, green beans, and carrots. Grimmway also cleans and packages carrots. Freeze Pack operations include washing, cooking, and packaging onions. Grimmway, in particular, is planning to increase operations over the next ten years, which will increase wastewater generation and BOD rates.

Food processing operations for the three producers are somewhat seasonal. This means that the highest levels of wastewater generation will occur during harvest periods in the summer and fall. During off-season periods, waste generation can be a fraction of the high season flows.

Currently, Grimmway discharges process wastewater to the municipal Kahlotus pump station near the intersection of Commercial Avenue and Kahlotus Road. The waste is then pumped to a gravity line southwest of US Hwy 395 that leads to the municipal WWTP. Freeze Pack discharges to Simplot RDO. Simplot RDO currently pumps their process wastewater through a 10-inch diameter forcemain directly to the City's PWRF to the north.

12.3 PRIOR STUDIES – QUANTITY OF WASTEWATER

The City retained the services of Murray, Smith, & Associates, Inc., (MSA) to prepare a Comprehensive Sewer Master Plan (Plan) and Capital Improvement Program (CIP) in May

2014. MSA analyzed and modeled the City's wastewater collection and treatment systems and identified system improvements. Although the study did not address this project in detail, it provides fundamental information that provides the basis for this project. Specifically, the master plan characterizes growing trends within the local food processing industry and the need for more capacity at the WWTP.

Section 2 of the MSA master plan, Future Conditions and Wastewater Flow Projections, states "the PWRF is currently close to capacity at a maximum flow of 10.3 MGD, and would require expansion for new food processors". It also states "a separate conveyance system would be required to accommodate additional food processors". (Table 12-3 Phase 2 Design Flows states a maximum projected flow of 4.5 MGD).

12.4 BERGERABAM FORCEMAIN ALIGNMENT STUDY

BergerABAM submitted to the City of Pasco a draft Alternative Evaluation Report titled "Kahlotus Highway Sewer Forcemain" dated September 2017. In the report BergerABAM evaluates four alternative routes for the sewer forcemain associated with the Columbia East Regional Industrial Pump Station. The findings of their study indicates that Alternatives B or D are the preferred routes to consider for final design.

12.5 GOVERNING STANDARDS

General standards guiding publicly owned and operated pump stations in the State of Washington are found in the Criteria for Sewage Works Design by the Department of Ecology (Ecology), dated August 2008. The City does not have supplementary pump station design standards.

12.6 EXISTING CONDITIONS

The project area for the pump station is located northeast of the City in the Columbia East Service Area. Specifically, it is located near the intersection of Commercial Avenue and Pasco-Kahlotus Road adjacent to the existing Kahlotus Pump Station. See Figure 12-1 below for a view of the existing Kahlotus Pump Station.

As part of the project scope, existing conditions were assessed at the project site. The pump station location is within an existing industrial area. The current site is located close to Pasco-Kahlotus Road and is accessible from an existing driveway for the Kahlotus Pump Station (see Figure 12-2 Kahlotus Pump Station Access). Vegetation is minimal and can be easily cleared. Existing grades vary but consist of moderate slopes. The grades slope uphill from the southwest to the northeast. Elevations for the proposed pump station property site begin in the southwest corner at approximate elevation 400 and rise to elevation 410 in the northeast corner of the property. Some grading will be required to prepare a flat surface for the pump station area. FEMA has identified the proposed site as being above the 100-year flood.

The City has contacted the land owner to discuss acquisition. Owner has expressed interest in negotiating acquisition.

Owner:	TSK Investments
Parcel #	113590031
Address:	801 N Commercial Ave, Pasco, WA. 99301
Land Code:	IRR Farm
Land Use:	Undeveloped
Acres:	3.79

Figure 12-1	***Existing Kahlotus Pump Station***	17454.00
		12.14.2017

Figure 12-2	*Kahlotus Pump Station Access*	17454.00
		12.14.2017

12.7 EXISTING UTILITIES

The recently constructed municipal Kahlotus Pump Station has similar utility demands as the proposed Columbia East Regional Industrial Pump Station. 480-V/3-ph power can be pulled from Dietrich Road and a water service connection is possible by tapping into the existing main located in Commercial Avenue.

12.8 SOILS

The soil conditions are generally uniform per the Natural Resources Conservation Service (NRCS) soils report. Most common is a silty or sandy loam material to at least a 60-inch depth. Depths to restrictive rock and the water table are expected to be greater than 80 inches. The soil is considered to be well drained. A geotechnical investigation should be completed prior to final design to confirm soil conditions and existing groundwater elevation depth.

12.9 BASIS OF DESIGN

12.9.1 Hydraulics Design Parameters

The primary design parameters for sanitary lift stations are the peak hourly flow (PHF) expressed in gpm, and total dynamic head (TDH) expressed in feet of water. The PHF is typically estimated by applying a peaking factor (PF) to the average daily flow (ADF). The PF in turn can typically be estimated from sewer flow data or calculated using Ecology guidelines.

In this case, however, the determination of these design parameters is somewhat non-traditional. Pump station inflow is defined by three distinct food processors as opposed to a basin of residential or commercial constituents. The peaking factor is applied to the maximum recorded daily flow (MDF) instead of the ADF. The MDF is more representative of consistent and sustained wastewater flows during periods of highest production. The pump station must be capable of processing those sustained high flows.

TDH is a function of the height the wastewater has to be lifted, the distance it is pumped, the size/material/condition of the forcemain, and the flow velocity in the forcemain. Per Ecology standards and recommendations, sewer forcemains should be designed to keep velocities between 3.5 to 5.0 feet per second (fps) to limit solids settlement, thereby reducing maintenance costs. These recommendations, however, assume typical sanitary wastewater qualities with high solids content. For the Columbia East Regional Industrial Pump Station, the wastewater will only include food process water. Pre-treatment standards require that significant solids are removed prior to discharge from the facility. Also, some food processors utilize, or plan to utilize, equalization ponds that promote solids settlement. For these reasons, we believe that the minimum forcemain velocity can be approximately 3 fps. A maximum of velocity of 8 fps is recommended to keep friction head-loss and maximum pressures to an acceptable level.

12.9.2 Operational Design Parameters

12.9.2.1 Pump Station Site Location

The site location can have a significant influence on pump station design. Changes in elevation impact the total system head, the length/depth/size of the inflow sanitary lines, and inflow storage. The industrial pump station is proposed adjacent to and directly east of the Municipal Kahlotus Pump Station. See Figure 12-3.

The City has explored possible alternatives to this site. However, due to centralized location, current access to the site, and willingness of the landowner, this is the preferred location for the new regional pump station. The current site represents a low spot within the area, but not within any flood zones, which is advantageous for the accommodation of gravity inflow lines. This, however, also poses some risk for ponding or flooding in the case of pump station failure or severe weather. Risk mitigation measures can include onsite backup power generation, wet well and gravity inlet line storage, and site grading/drainage design.

Elevations of the proposed site generally increase to the north and northeast approximately 10 feet. The site will need to be regraded to match the existing elevation of the Municipal Kahlotus Pump Station. To match the existing elevation the site will either require retaining walls or cutbacks in the higher elevations. Matching elevations will simplify access to the sites.

Based on a conceptual review of the current site location, and the geographic relationship to the food processors, gravity flow to the pump station is possible assuming an unobstructed route and slope. The average grade from the respective processors ranges from 0.0035 to 0.004. Based on design flow projections and minimum pipe slope requirements, Simplot RDO and Grimmway would require a minimum 12-inch-diameter gravity inflow line, and Freeze Pack would pump via a dedicated forcemain. See Table 12-1 for a summary of each processor.

Table 12-1: Theoretical Processor Inflow Wastewater Lines

Source	Length	Slope	Flow	Pipe Dia.
	lf	rise/run	gpm	in
Grimmway *	100	0.0040	978	12
Simplot RDO	2,838	0.0070	1,075	12
Freeze Pack**	150	Pumped	139	8

* Intercept Grimmway flow at Municipal Kahlotus Pump Station inlet manhole and divert to new Columbia East Regional Industrial Station.
**Intercept 8” forcemain in Pasco-Kahlotus Road and redirect flow to Columbia East Pump Station.

Filling in the site to raise the existing grade elevation would prevent the possibility of ponding. Several dynamics would change if the pump station were to be located in a higher elevation area. Risks associated with ponding or flooding would be reduced. The total static head would be reduced, but with little overall impact to the design. The elevation gain complicates the ability of the processors to connect to the pump station with gravity flow. Fundamentally, the slope of the gravity inflow line flattens and, therefore, necessitates larger diameter lines to meet gravity flow standards. Based on a conceptual review, and the assumption of a deeper wet well connection to increase slopes, gravity line slopes would then range from 0.001 for Grimmway and Freeze Pack, to 0.0035 for Simplot RDO. This results in a 12-inch inflow line for Simplot RDO, 12-inch diameter line for Grimmway, and 8-inch line for Freeze Pack. Pumping would likely be the better option for Grimmway and Freeze Pack due to the high cost for large diameter pipe construction.

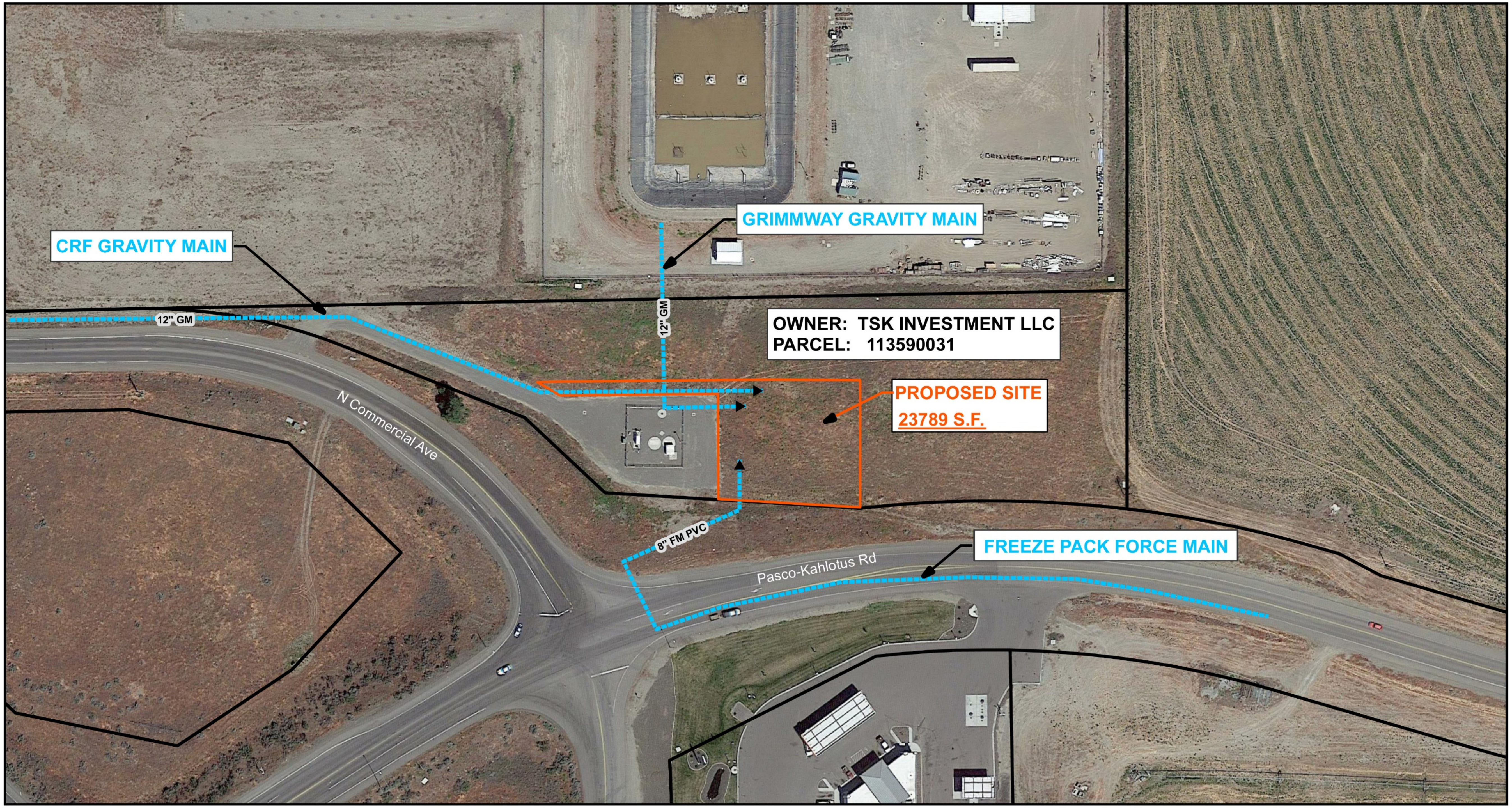


Figure 12-3	*Proposed Site Aerial*	17454.00 11.28.2017

THIS PAGE IS INTENTIONALLY LEFT BLANK.

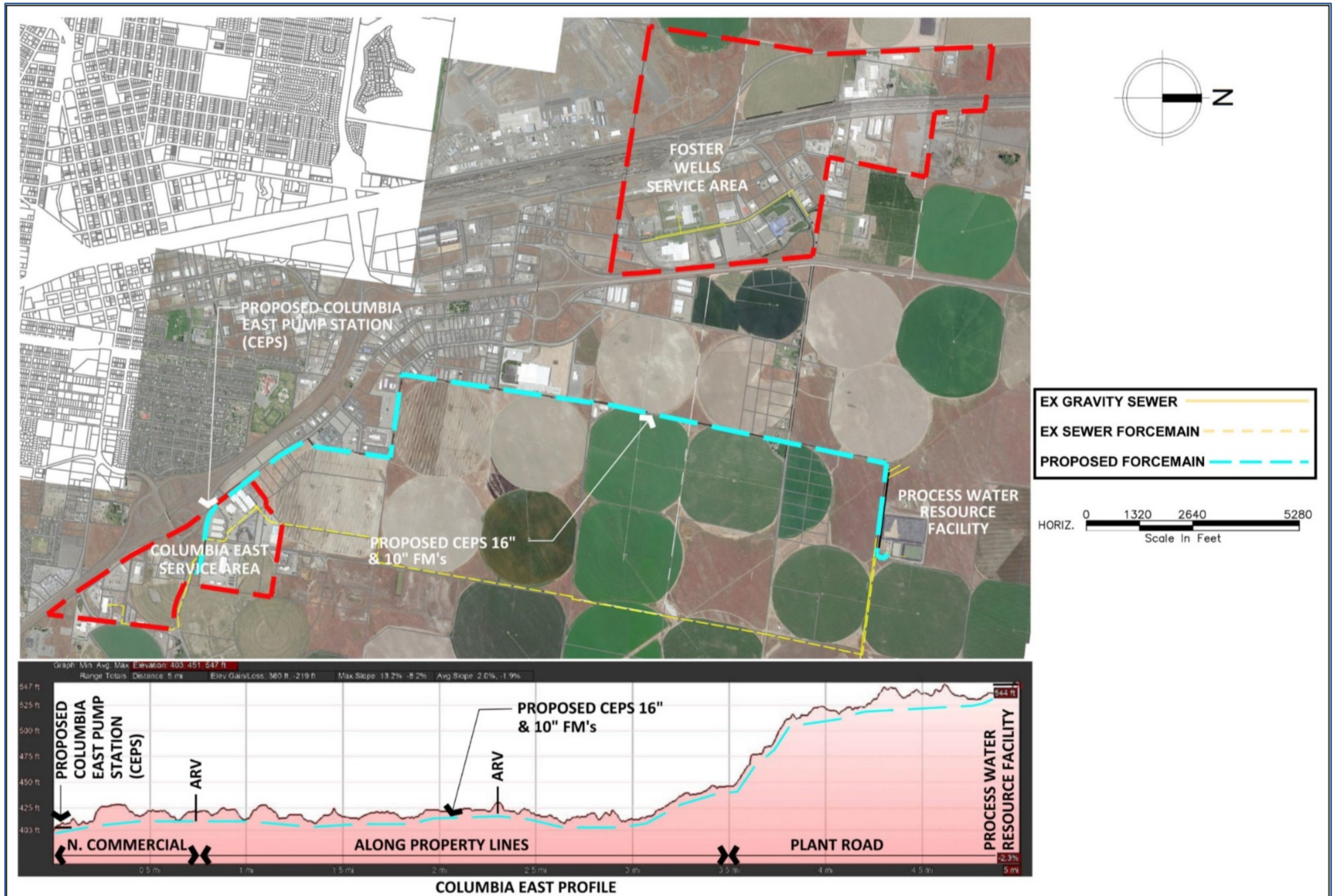


Figure 12-4	***Proposed Forcemains***	17454.00
		11.28.2017

THIS PAGE IS INTENTIONALLY LEFT BLANK.

12.9.2.2 Design Flows

Because the pump station influent stems from three distinct food processors, determination of design flows is specific to each processor. The design flows must be determined based on historical flows and any relevant information that may impact future flows. The City was able to provide wastewater flow records for Simplot RDO and Grimmway, and water use records from Freeze Pack. The City also interviewed each food processor with regard to future operations.

Table 12-2 represents a summary of the flow/demand data provided by the City for Grimmway, Simplot RDO, and Freeze Pack. From this data set, the ADF (Average Daily Flows) and MDF (Maximum Daily Flows) were identified. The MDF represents the maximum recorded daily flow from that same period. It is important to note that because Freeze Pack only had monthly water consumption data, the MDF represents the averaged flow from the month with the highest water use. Also, because the data is based on water consumption, it also includes ancillary water use that goes to the sanitary collection system.

A PF (Peaking Factor) is applied to the MDF to derive the peak hourly flows (PHF) for each phase. In general, the applied peaking factors are small relative to typical sanitary wastewater systems. This is because each of the food processors is expected to provide a controlled and consistent discharge. For Grimmway, a PF of 1.15 is applied to the recorded MDF. The 1.15 peaking factor provides a modest buffer above their MDF. Since the MDF for Grimmway flows are below permitted limits, this analysis will use the permitted maximum flow for MDF.

The greater PF compensates for the greater degree of uncertainty with regard to their MDF. Overall, the total PHF for Phase 1 is 2,174 gpm.

Table 12-2: Flow/Demand (Phase I)

Source	Average Daily Flows (ADF)		Maximum Daily Flows (MDF)		Peak Flow*	
	gpm	gpd	gpm	gpd	gpm	gpd
Simplot RDO	644	927,372	935	995,767	1,075	1,146,240
Freeze Pack	49	70,405	120	133,283	139	154,000
Grimmway	602	867,879	833	1,177,495	960	1,353,600
Total	**1,295**	**1,865,656**	**1,888**	**2,306,545**	**2,174**	**2,653,840**

*Safety Factor = 1.15
Peak Flow = Max. Day x 1.15

Table 12-3: Flow/Demand (Phase 2 Future)

Source	Average Daily Flows (ADF)		Maximum Daily Flows (MDF)		Peak Flow*	
	gpm	gpd	gpm	gpd	gpm	gpd
Simplot RDO	644	927,372	935	995,767	1,075	1,146,240
Freeze Pack	49	70,405	120	133,283	139	154,000
Grimmway	602	867,879	833	1,177,495	960	1,353,600
Future Processor	1,260	1,814,400	1,736	2,500,000	1,997	2,825,000
Total	**2,555**	**3,680,056**	**3,624**	**4,806,545**	**4,171**	**5,478,840**

*Safety Factor = 1.15
Peak Flow = Max. Day x 1.15

Peaking factors are unchanged based on the previous justification. Projected flows for Simplot RDO and Freeze Pack are unchanged. The recommended Phase 2 design flow is 4,171 gpm. Overall, the design flows of 2,174 gpm for Phase 1 and 4,171 gpm for Phase 2 are believed to be conservative based on the information provided.

12.9.3 Design Alternatives

As is common with many pump station projects, the flows will vary over time, often growing in phases or with commercial growth. This presents challenges with regard to pump station capital costs, operations, and efficiency. For Columbia East Regional Industrial Pump Station, there are two distinct phases.

Phase 1: Inlet flow from Grimmway, Freeze Pack, and Simplot RDO

Phase 2: Grimmway, Simplot RDO, Freeze Pack, and the addition of a high flow Future Processor

For this alternatives analysis, we used Alternative D as the preferred alignment for the Columbia East Pump Station as defined in the Kahlotus Highway Sewer Forcemain Alignment Study, dated September 2017, prepared by BergerABAM. The Total Dynamic head (TDH) is based on a forcemain length at 25,957 lf. The vertical lift from Columbia East Regional Industrial Pump Station to the PWRF is 120 feet. Therefore, 120 feet has been added to the calculated TDH shown in Tables 13-4 and 13-5. The four approaches considered include the following:

1. Install a single wet well and a duplex pumping system sized for Phase 2 ultimate Peak Hour Flow of 4,171 gpm. Initially install two pumps to convey Phase 1 Peak Hour Flow of 2,174 gpm. These pumps would later be replaced with the larger Phase 2 pumps of 4,171 gpm. Provide two forcemains (one for each phase) to reduce residence time.

2. Install a single wet well and triplex pumping system sized for Phase 2 ultimate Peak Hour Flow of 4,171 gpm. Initially two pumps will be installed for Phase 1; one pump at 2,174 gpm and a second pump at 4,171 gpm. A second 4,171 gpm pump will be installed for Phase 2 ultimate Peak Hour Flow of 4,171 gpm. Provide two forcemains (one for each phase) to reduce residence time.
3. Install dual wet wells with dual forcemains and quadruplex pumps. Initially install two pumps to convey Phase 1 Peak Hour Flow of 2,174 gpm in one wet well. For Phase 2, install the larger Phase 2 pumps of 4,171 gpm within the second wet well. Provide two forcemains (one for each phase) to reduce residence time.
4. Install a wet well/dry pit with a centrifugal duplex pumping system sized for Phase 2 ultimate Peak Hour Flow of 4,171 gpm. Initially two pumps will be installed for Phase 1; each pump at 2,174 gpm. Phase 2 capacity would be achieved by replacing Phase I pumps with new 4,171 gpm pumps.. Provide two forcemains (one for each phase) to reduce residence time. In order to evaluate the merits of the alternatives, each was analyzed with regard to wet well operating volume, forcemain diameter, forcemain velocity, forcemain residency time, total dynamic head (TDH), pump size, and pump cycling times. Of these variables, the forcemain diameter has the most impact on pump station sizing and construction cost. The forcemain diameter directly impacts the resulting TDH, and essentially controls pump sizing.

12.9.4 Wet Well Design

The site location and elevation also impacts wastewater storage capacity in the case of pump failure. This total storage is important because it provides time for City crews to respond if there is a mechanical or electrical failure. For this reason, a 12-foot-diameter or 8-foot x 20-foot wet well is proposed to maximize storage within the pump station wet well. A backup generator is also proposed which will generally activate within 30 seconds of power failure. Also, with the proposed 9 feet of operational depth, the both wet well operational storage volumes are approximately 7,500 to 8,000 gallons (gal). At ultimate flows this provides a range 3.2 to 6.2 minutes of storage. The gravity inflow lines also provide minimal emergency wastewater storage. For our purpose we will not include that storage. If more storage is desired, the dimensions and depth of the wet wells can be increased. Also, a large diameter manhole can be installed adjacent to the proposed wet wells to serve as an overflow storage structure. An outlet pipe from the storage structure can gravity drain back to the wet well through a one-way Tideflex valve.

<u>For Option 1</u>, a single wet well and duplex pumps with two forcemains, one forcemain will be designed for Phase 1 (2,174 gpm) and the second forcemain designed for Phase 2 (4,171 gpm). Both forcemains will be installed at the same time. Table 12-4 illustrates the impact of the forcemain diameters on pump station performance. Forcemain diameters that result in acceptable velocities (4 to 8 fps +/-) have been highlighted in orange. As shown, the possible forcemain diameters for Phase 1 that meet the approximate velocity are 8 and 10 inches. As shown, the possible forcemain diameters

for Phase 2 velocity are 16, 18, and 20 inches. However, instead of abandoning the Phase 1 forcemain and conveying the entire Phase 2 Peak Hour Flow through the larger diameter Phase 2 forcemain, it is recommended that the Phase 1 forcemain remain in service, thus reducing the size of the Phase 2 forcemain. Therefore, Phase 2 Peak Hour Flows will be conveyed through two forcemains. Because this represents a single wet well duplex system, these results do not change from Phase 1 to Phase 2. The key difference between the phases is the pump cycling frequency. During Phase 1, cycling is expected to be approximately six times per hour during peak operations.

Table 12-4: Option 1 (Ph. 1) – Single Wet Well, Duplex Pumps (2,174 gpm)

Forcemain Diameter	Forcemain Velocity	Total Dynamic Head (TDH)	Horsepower (BPH)	Forcemain Residency
in	ft/sec	ft	hp	min
8	6.9	778	216	63
10	4.4	342	95	98
12	3.1	212	59	140
14	2.3	163	45	188
16	1.7	143	40	254
18	1.4	133	37	309

Table 12-5: Option 1 (Ph. 2) – Single Wet Well, Duplex Pumps (4,171 gpm)

Forcemain Diameter	Forcemain Velocity	Total Dynamic Head (TDH)	Horsepower (BPH)	Forcemain Residency
in	ft/sec	ft	hp	min
12	11.8	1,208	1,278	37
14	8.7	634	670	50
16	6.7	388	410	65
18	5.3	271	287	82
20	4.3	211	223	101
24	2.7	157	166	160
30	1.9	133	141	228

For Option 2, single wet well and triplex pumps, the pump station has the ability to phase the pumping rate based on the number of pumps installed. See Figure 12-4. Phase 1 would include installation of two pumps in a duplex operation to convey Phase 1 Peak Hour Flow of 2,174 gpm, in which one pump alone would discharge the design flow. For Phase 1, one pump shall be sized at 2,174 gpm and the second 4,171 gpm. The 2,174 gpm pump will be the lead pump. For Phase 2, the additional third pump would be installed for ultimate Peak Hour Flow of 4,171 gpm and two pumps would act in parallel to discharge the design flow. Therefore, the additional third pump would also be sized at 4,171 gpm. The Phase 1 flow can be met with one pump down. When the third pump is installed, the Phase 2 flow can be met when either the 2,174 gpm or second 4,171 gpm pump is down. Based on acceptable forcemain velocities for Phase 1, the possible forcemain diameters are 8 and 10 inches (see Table 12-6). For Phase 2, the possible forcemain diameters are 16, 18, and 20 inches (see Table 12-7). However, instead of abandoning the Phase 1 forcemain and conveying the entire Phase 2 Peak Hour Flow through the larger diameter Phase 2 forcemain, it is recommended that the Phase 1 forcemain remain in service, thus reducing the size of the Phase 2 forcemain. Therefore, Phase 2 Peak Hour Flows will be conveyed through two forcemains.

Table 12-6: Option 2 – Phase 1, Single Wet Well, Triplex Pumps (2,174 gpm)

Forcemain Diameter	Forcemain Velocity	Total Dynamic Head (TDH)	Horsepower (BPH)	Forcemain Residency
in	ft/sec	ft	hp	min
8	6.9	778	216	63
10	4.4	342	95	98
12	3.1	212	59	140
14	2.3	163	45	188
16	1.7	143	40	254
18	1.4	133	37	309

Table 12-7: Option 2 – Phase 2, Single Wet Well, Triplex Pumps (4,171 gpm)

Forcemain Diameter	Forcemain Velocity	Total Dynamic Head (TDH)	Horsepower (BPH)	Forcemain Residency
in	ft/sec	ft	hp	min
12	11.8	1,208	1,281	37
14	8.7	634	674	50
16	6.7	388	412	65
18	5.3	271	287	82
20	4.3	211	224	101
24	2.7	157	167	160
30	1.9	133	141	228

For Option 3, dual wet well and dual pumping systems (four pumps total), pumping rates will also be phased along with the design flows. During Phase 1, only one duplex pumping system is active. Phase 2 would require installation of the second set of duplex pumps in the second wet well. The two wet wells would then act in parallel. Two forcemains will need to be installed because a single forcemain is not possible based on velocity requirements. This option requires that all four pumps are equally sized. This allows for the two wet wells to pump in parallel without complications from differential pressures.

With regard to pump station performance for Option 3, the results match those shown in Tables 13-6 and 13-7 for Option 2. The primary difference with Option 3 is that the dual wet well system provides more wet well operational volume and an additional backup pump. A pipe can be connected between each wet well to allow for equalization between the wet wells.

For Option 4, Install a wet well/dry pit with a centrifugal duplex pumping system sized for Phase 2 ultimate Peak Hour Flow of 4,171 gpm. Initially two pumps will be installed for Phase 1; each pump at 2,174 gpm. Phase 2 capacity would be achieved by replacing Phase I pumps with new 4,171 gpm pumps.. Provide two forcemains (one for each phase) to reduce residence time. In order to evaluate the merits of the alternatives, each was analyzed with regard to wet well operating volume, forcemain diameter, forcemain velocity, forcemain residency time, total dynamic head (TDH), pump size, and pump cycling times. Of these variables, the forcemain diameter has the most impact on pump station sizing and construction cost. The forcemain diameter directly impacts the resulting TDH, and essentially controls pump sizing.

See Figure 12-3 for proposed site plan and lift station schematic.

See the construction cost estimates for all options summarized in Table 12-8.

12.9.5 Key Performance Criteria

As highlighted in Tables 13-4 through 13-7, there is a small range of forcemain diameters that fall within the acceptable range of flow velocities. In order to make a preliminary forcemain diameter selection, the other variables listed must also be considered. Those key variables include TDH and associated system pressure, horsepower requirements, and forcemain residency time. The following is the recommended criteria for each variable:

- Flow velocities for each phase should fall within the range of 4 to 8 fps to prevent stagnation, solids settlement, and scouring.
- Standard operating pressures should not exceed 100 psi to limit stresses on system components. This allows for more standard and less expensive system components. Lower pressures are also safer for maintenance and repair operations.
- Limit pump sizes to approximately 300 hp. This reduces pump purchase, maintenance, and replacement costs.
- Limit forcemain residency times to 180 minutes. This reduces the potential for stagnation or solids settlement.

For Options 1, 2, 3 and 4, a 10-inch-diameter forcemain for Phase 1 meets the above criteria. For Phase 2 a 16-inch diameter forcemain, working in conjunction with the 10-inch diameter forcemain, most closely meets the above criteria. Based on these results, it is recommended that 10-inch and 16-inch diameter forcemains be installed.

During Phase 2 Peak Hour Flow of 4,171 gpm, the flow will be conveyed as follows:

- 939 gpm through the 10-inch forcemain with a velocity of 3.8 fps with friction of 160’ pipe loss + 120’ vertical = 280 TDH.
- 3,232 gpm through the 16-inch forcemain with a velocity of 5.2 fps with friction of 160’ pipe loss + 120’ vertical = 280 TDH.

Additional design applications to consider associated with the pump stations are as follows:

1. <u>Ventilation</u>: Ventilation must be provided within the wet well to provide an environment suitable for human occupancy. Ventilation purges the structure of odorous, toxic, and hazardous gases with outside fresh air. Ventilation must also manage flammable gases present in the wastewater to a level appropriate for the desired electrical equipment. The latest version of the NFPA Standard 820 requires ventilation at a rate of 12 air-exchanges per hour to maintain a Class 1 Division 2 rating. The blower motor used to ventilate the wet well must be spark-proof so as not to create a spark while rotating. The Dayton Model #5C090 at 990 CFM is capable of meeting the 12 air exchanges based on a 12-foot-diameter, 20-foot-deep wet well.

2. Generator: The Department of Ecology recommends the installation of permanent engine generators for larger pump stations and permanent facilities. Automatic transfer switches provide for quick transitions to standby power when the primary power fails. Size of the generator should depend upon the requirements of starting and operating the pumps at peak possible load, and all ancillary equipment in the station. A diesel generator is recommended with the fuel stored in a "belly" tank located under the generator. The fuel storage should be sized to operate the pump station a minimum of 24, and preferably 36, continuous hours. A weather-tight enclosed generator is sufficient. Stairs and landing may be required to access the maintenance doors for the generator.
3. Water: A single yard hydrant will be installed adjacent to the wet well. The pressurized potable water supply will be used to facilitate cleaning of the wet well and general site washdown. A second yard hydrant will be installed for general hosing down of the site. An RPBA (reverse pressure backflow assembly) connection will be made at the point of connection to the City water system.
4. Telemetry: Telemetry will be included as part of the communication system for the pump station. Telemetry will allow the City operator(s) to monitor the various aspects of the operation of the pump station including, but not limited to; pumping volume, pump(s) operation status, wet well water level, etc. Telemetry will allow the operator to interface remotely with the pump station.
5. Wet well Lining: When the inside surface of the wet well is exposed to carbon dioxide and hydrogen sulfide gas carried in the wastewater, along with low pH levels, a complex, multi-phase process of corrosion is set in motion. These acidic gases reduce the pH of the concrete from 12 to as low as 9. Sulfur oxidizing bacteria (SOB) attach to the surface as sulfates are produced. The acid attacking the concrete creates a layer of gypsum (calcium sulfate) that allows the microorganisms to reproduce, and more acid is created. Eventually the inside wall of the concrete wet well begins to fail.
6. High-performance, chemical-resistant coatings are available to protect the interior of the wet well against deterioration by creating a protective barrier between the substrate and the waste flow. Coatings come in a variety of formulations with different functional characteristics and application requirements. For our installation an epoxy liner is recommended. Epoxy liners have long been favored by owners. In addition to their excellent chemical-resistant properties, they are strong and unaffected by wetness/humidity, making them ideal for applying to damp substrates. Epoxy liners are typically bonded directly to the substrate and may require the use of primer. They are spray-applied at dry film thicknesses of 60 to 250 mils.
7. Abrasion: Abrasion has been shown to greatly harm existing pump station forcemains currently operated by the City. Inorganics, such as dirt, found in the conveying wastewater eat away at the cement mortar lining commonly found in

ductile iron pipe. Once this lining is removed, the abrasion caused by the inorganics slowly scours away the metal until failure occurs.

8. History has shown that both Polyvinyl Chloride (PVC) and High Density Polyethylene (HDPE) pipe are minimally effected by scouring associated with conveying inorganics within a forcemain.

9. <u>pH Corrosion</u>: The City of Pasco placed the following pH discharge limits on Grimmway, Freeze Pack, and Simplot RDO:

Company	Minimum pH	Maximum pH
Grimmway	5.0 Standard Units	9.0 Standard Units
Freeze Pack	5.0 Standard Units	9.0 Standard Units
Simplot RDO	5.0 Standard Units	12.0 Standard Units

A pH below 7 is acidic; above 7 is alkaline. The more below or above 7 a solution is, the more acidic or alkaline it is. The scale is not linear – a drop from pH 8.2 to 8.1 indicates a 30 percent increase in acidity, or concentration of hydrogen ions; a drop from 8.1 to 7.9 indicates a 150 percent increase in acidity. The pH level within the wet well will need to be monitored and maintained to not go below 8.0. Corrosion of any metal surfaces within the wet well will begin to occur at a pH below 8.0.

10. <u>Odor</u>: A common issue related to wastewater pump station operation is that of odor accumulation. Wastewater gas that has collected in the confined space of the wet well poses risks of toxicity, underground explosions, and damage to inlet and outlet lines. Methods for alleviating the dangers include aeration and the introduction of chemical additives such as sodium nitrate to elevate oxygen levels in the wet well. Scented products can also be used to ameliorate the more practical nuisance caused by excess wastewater gas.

    For our application, turning over the volume of wastewater within the wet well and not letting it accumulate for an excessive time will reduce the potential for nuisance odors.

11. <u>Oil/Water Separator</u>: An oil/water separator will be installed prior to the wet well and after the grit removal manhole. The oil/water separator will separate oils and suspended solids from the wastewater effluent prior to entering the wet well. The installation will greatly eliminate oil build up within the wet well thus reducing maintenance. Oils and solids can more easily be removed in the oil/water separator than in the deeper wet well.

12. <u>Oxygen Injection</u>: Oxygen injection equipment can be installed to assist in maintaining higher pH levels within the effluent. Companies such as BlueinGreen will be contacted to assist in engineering a system to best fit this projects parameters.

13. Forcemain Material: It is recommended that both forcemains be manufactured out of HDPE with shaved inner beads or C-900 PVC, with custom fittings made of equal material. Where HDPE or C-900 fittings are not manufactureable all other fittings must come with an epoxy or powder coated interior. No bends greater than 45 degrees should be used on the forcemain.
14. Valves: Valves shall be as recommended by the City; stainless steel gates or Dezurik plug valves. Check valves shall be Series 41 (Series 40 has been replaced) as manufactured by AVK International. All valves shall come with interior epoxy coatings from the factory.
15. Lubrication: An automatic lubrication system is recommended where applicable.

12.9.6 Electrical Considerations

Based on preliminary discussions with Franklin Public Utility District (FPUD), a pad-mounted utility transformer will be required for primary electrical service to the pump station. There are two options for power service. The first is to provide a pad-mounted transformer at the project site from an existing FPUD vault northwest of the project site. The second option is to upgrade the adjacent Kahlotus Pump Station transformer and provide service from there. The first option is higher cost, but will not have any impact to the Kahlotus Pump Station operations. FPUD cannot guarantee service reliability, so a standby generator is recommended. An 800A service is required.

The pump control system will include a submersible pressure transducer for primary level control with redundant level control floats. A programmable logic controller (PLC) and operator interface terminal will be provided for station monitoring and operator control. A fiber-optic-based communication system will communicate status and alarms. An industrial grade uninterruptible power supply (UPS) will be provided to maintain power to the alarm/telemetry system. Outside lighting will be provided to illuminate the wet well area. A motor control center (MCC) will be used to house electrical equipment, motor controllers, and the PLC.

Other recommended elements of the new Columbia East Regional Industrial Lift Station include the following:

1. Variable Frequency Drives (VFDs) to allow for pumping capacity adjustments if needed.
2. Spare pump and spare parts kit stored at City maintenance depot.
3. Consider influent pH ranges as it may impact pump coating specifications.
4. Recirculating (mixed-flush) valves on at least one pump to improve solids removal.
5. Above-ground frost free insulated valve vault containing pump isolation, check valves, and flow meter.

6. Outdoor stainless steel NEMA 4X controls cabinet housing the Motor Controls Center (MCC), level controller, alarms, and telemetry equipment.
7. Water service including reduced pressure backflow preventer (RPBP) and non-freeze yard hydrant for wet well washdown.
8. Pole-mounted area light illuminating the wet well and valve vault areas.
9. Security equipment including lighting and CCTV cameras are recommended. Cameras can assist Operators with exact-time remote viewing.
10. Set-aside area for corrosion control equipment if future conditions warrant it.

12.9.7 Construction Cost

Construction cost estimates were prepared for each option and summarized in Table 12-8. In all cases, the cost of the forcemain has not been included in the Total Construction Estimate. Option 2, the triplex pumping system, has the lowest estimated construction cost.

Table 12-8: Construction Cost Comparison

Option Number	Description	Pumps	Total Construction Estimate
Option 1	Single wet well – Duplex	Two 96 HP (Ph. I) Two 287 HP (Ph. II)	$2,250,967
Option 2	Single wet well – Triplex	One 96 HP (Ph. I) One 287 HP (Ph. I) One 96 HP (Ph. II) Two 287 HP (Ph. II)	$2,063,875
Option 3	Dual wet well – Quadruplex	Two 96 HP (Ph. I) Two 287 HP (Ph. II)	$2,368,577
Option 4	Wet well/Dry Pit – Duplex	Two 96 HP (Ph. I) Two 287 HP (Ph. II)	$2,548,600

12.9.8 Operation and Maintenance Costs

The annual operation and maintenance costs were evaluated for Options 1 through 4. Typical costs include pump station and forcemain inspection, preventative maintenance, minor repair and servicing, major repair and equipment replacement, administration, and energy. Energy costs represent the greatest difference between the options. Because not all of the food processors operate year-round, energy costs were compared for the period of one month during Phase 2 peak production. The same pump run times were assumed for each option at 16 hours per day. Table 12-9 illustrates the monthly power cost for each option, based on an average Commercial rate of $.0591/kW-h. For Options 2, 3, and 4 it was assumed the 96 Hp pump will operate 8 hours and one of the two 287 Hp pump will operate 8 hours. Option 2, 3, and 4 represents the least comparative power cost based on the current pump selections.

Table 12-9: Peak Monthly Power Cost

Option Number	Description	Pumps	Monthly Power Cost
Option 1	Single wet well – Duel forcemain – Duplex (Single 287 HP Pump Operating)	Two 287 HP (Ph. 2)	$6,070
Option 2	Single wet well – Duel forcemain – Triplex (8 hrs 96 HP-8 hrs 287 HP Operating)	One 96 HP (Ph. 2) Two 287 HP (Ph. 2)	$4,042
Option 3	Dual wet well – Duel forcemain – (2) Duplex (Single 287 HP Pump Operating)	Two 96 HP (Ph. 2) Two 287 HP (Ph. 2)	$4,042
Option 4	Wet well/Dry Pit – Duel forcemain – Duplex (8 hrs 96 HP-8 hrs 287 HP Operating)	Two 96 HP (Ph. 2) Two 287 HP (Ph. 2)	$4,042

There are some minor differences with regard to the other operation and maintenance costs. Option 1 will require slightly less servicing than the others because there are fewer pumps and equipment; however, pump maintenance and replacement costs will be higher. Option 3 requires servicing for an additional wet well and associated controls. Option 4 provides an improved factor of safety for the Operators. They can inspect the pumps without the inherent risk of operating around on open wet well. Pumps can be inspected at more frequent intervals and more readily conduct preventive and corrective maintenance. Down time of equipment will also be reduced. Non-submersible pumps can more easily accept automatic lubrication systems.

12.9.9 Summary of Wet well Alternatives and Costs

The advantages and disadvantages of each alternative have been summarized below:

- **Option 1: Duplex System –** This is not the least expensive option (capital cost), but it is within 7 percent of Option 2. This option has a monthly energy cost of approximately $6,070 per month. The pump station design is less complicated.
- The primary disadvantage of the duplex system is the initial purchase of two smaller Phase 1 pumps to be replaced with two larger Phase 2 pumps, along with retrofitting the electrical controls associated with the larger horsepower pumps.
- **Option 2: Triplex System –** The primary advantage is the comparatively low construction cost. This option has a monthly energy cost of approximately $4,042 per month. Furthermore, the three-pump configuration allows the third pump to be purchased and installed at a later time (future needs) when flows dictate the need. This may be particularly advantageous because the Phase 2 design flows reflect projections as opposed to certainties.
- **Option 3: Dual Wet well (2) Duplex System –** The primary advantages of the dual wet well system is the pumping redundancy. By having four pumps, there are always two serving as backup during Phase 2. The dual wet wells can also

provide more wastewater storage volume, which can provide greater time for response in the case of pump failure. Finally, installation of the Phase 2 set of duplex pumps can be deferred until needed.

This option has the highest construction cost estimate of the three viable options. Maintenance costs are higher because of the additional wet well and associated equipment.

- **Option 4: Wet well/Dry Pit Duplex System –** The primary advantage of Option 4 is the greater factor of safety this option provides to the maintenance workers compared with Options 1, 2 and 3. This option would be desired by the Operations Department. This option does have the highest initial construction cost. However, maintenance cost for a dry pit system is typically less than a submersible wet well system. This option has a monthly energy cost of approximately $4,042 per month. Furthermore, the three-pump configuration allows the third pump to be purchased and installed at a later time (future needs) when flows dictate the need. This may be particularly advantageous because the Phase 2 design flows reflect projections as opposed to certainties.

The following is a cost breakdown for Option 4:

Table 12-10: Estimate of the Probable Cost of Construction

CITY OF PASCO Columbia East Regional Industrial Pump Station Project Option 4 – Wet well/Dry Pit Pumps	DATE: 1/15/2018 ESTIMATED BY: PACE	PROJECT NUMBER: 17454 DESIGN STATUS: 15%

Line No.	ITEM	QTY	UNIT	UNIT COST	TOTAL
	GENERAL				
1	Mobilization/Demobilization	1	LS	$175,000	$175,000
2	Testing and Commissioning	1	LS	$40,000	$40,000
3	Construction Surveying	1	LS	$20,000	$20,000
4	Temporary Erosion Controls	1	LS	$5,000	$5,000
5	Clearing and Grubbing	0.5	ACRE	$10,000	$5,000
	Subtotal General				**$245,000**
	PUMP STATION SITE				
6	Cast In-Place Wet well/Dry Pit	1	EA	$325,000	$325,000
7	Pre-Cast Inlet Manhole, 8' dia. by 10' deep	1	EA	$15,000	$15,000
8	Landscape Block Retaining Wall – Less than 4' ht	1,000	SF	$25	$25,000
9	Chain Link Fence with Gate	250	LF	$25	$6,250
10	Site Grading including Gravel Borrow Backfill	750	SY	$10	$7,500
11	Crushed Gravel Surfacing	240	CY	$50	$12,000
12	Concrete Equipment Pads & Footings	10	CY	$250	$2,500
13	Bollards	5	EA	$1,000	$5,000

Line No.	ITEM	QTY	UNIT	UNIT COST	TOTAL
14	4” HMA Cl 1’2 PG 64-22	2,643	SY	$75	198,225
15	24-inch PVC Gravity Sewer Pipe – Up to 10’ Deep	100	LF	$150	$15,000
Subtotal Pump Station Site					**$611,475**
	PUMP STATION MECHANICAL				
16	Guild Vertical Split Case Pumps	3	EA	$95,000	$285,000
17	HVAC	1	LS	$7,500	$7,500
18	Mechanical	1	LS	$10,000	$10,000
19	Eccentric Plug Valve	3	EA	$5,000	$15,000
20	Swing Check Valve	3	EA	$7,500	$22,500
21	1-inch Copper Water Line	150	LF	$25	$3,750
22	1” Water Service Connection	1	EA	$250	$250
23	Yard Hydrant	2	EA	$500	$1,000
24	1-inch RPBA	1	EA	$1,000	$1,000
25	Portable Davit Crane with Motor	1	LS	$8,000	$8,000
26	Pressure Gauges	2	EA	$600	$1,200
27	Magnetic Flow Meter	2	EA	$25,000	$50,000
28	Ultrasonic Level Indicator	1	EA	$5,000	$5,000
Subtotal Pump Station Mechanical					**$410,200**

Line No.	ITEM	QTY	UNIT	UNIT COST	TOTAL
	PUMP STATION ELECTRICAL				
29	PUD Line Extension and Transformer	1	LS	$25,000	$25,000
30	Standby Generator	1	EA	$93,000	$93,000
31	Meter-Main and Disconnect	1	EA	$3,000	$3,000
32	Manual Transfer Switch	1	EA	$2,000	$2,000
33	Gen Receptacles and Wiring	1	EA	$10,000	$10,000
34	Grounding	1	LS	$5,000	$5,000
35	Motor Control Center	1	LS	$200,000	$200,000
36	Telemetry Panel	1	LS	$25,000	$25,000
37	Programmable Logic Controller	1	EA	$10,000	$10,000
38	Electrical Cabinet	1	EA	$20,000	$20,000
39	Pump Disconnect Enclosure	1	LS	$15,000	$15,000
40	Float Switches	4	EA	$100	$400
41	Combustible Gas Detector	1	EA	$2,000	$2,000
42	Radio Tower	1	EA	$15,000	$15,000
43	Light Pole	1	EA	$3,000	$3,000
44	Conduit, Receptacles, Wire, Miscellaneous	1	LS	$20,000	$20,000
Subtotal Pump Station Electrical					**$448,400**
Subtotal Construction					$1,715,075
Contingency (design engineering, const. admin., and permitting (40%)					$686,030
Washington State Sales Tax (8.6%)					$147,496
Total Estimated Construction Cost					**$2,548,600**

12.10 PREFERRED OPTION

Overall we believe that Option 4 Wet well/Dry Pit Duplex System is the best choice based on the given criteria. The safety of the maintenance workers outweighs the small cost difference. Also, preventive maintenance cost will be less. In addition, it will allow for phasing of the pumping capacity. The third pump can be installed when needed. Replacement of pumps, valving and piping is more accessible which makes them easier to physically manage.

12.11 SUMMARY

Four options were considered for the pump station design. Those options include:

1. Duplex Pump System
2. Triplex Pump System
3. Dual Wet well, Dual Forcemain, and Quadruplex Pump System
4. Wet well/Dry Pit Duplex Pump System

The evaluation included consideration of key pump station performance criteria such as forcemain velocity, system pressure, pump sizing, and wastewater residency time. Other key evaluation factors included Operators safety, ease of maintenance, capital construction costs, operational power costs, phasing adaptability and Operators preferred station.

Overall we found that Option 4, the Duplex Pump System, with two parallel forcemains, is the best choice based on the given criteria. This option represents the lowest maintenance cost, safest alternative for the Operators, ease of maintenance and is the preferred choice of City staff. It also provides a simple way to transition from Phase 1 to Phase 2 through the installation of the third dry pump. Also, if Phase 2 design flows are not realized in the near future, then the smaller duplex pumps will be more appropriately sized as compared to the larger duplex pumps.

Therefore, it is our recommendation the pumping of the food processing wastewater be by means of a new cast-in-place wet well/dry pit duplex sewage pump station and two parallel forcemains, two 16-inch-diameter pipes. See Figure 12-5 for the preferred Option #4 schematic.

THIS PAGE IS INTENTIONALLY LEFT BLANK.

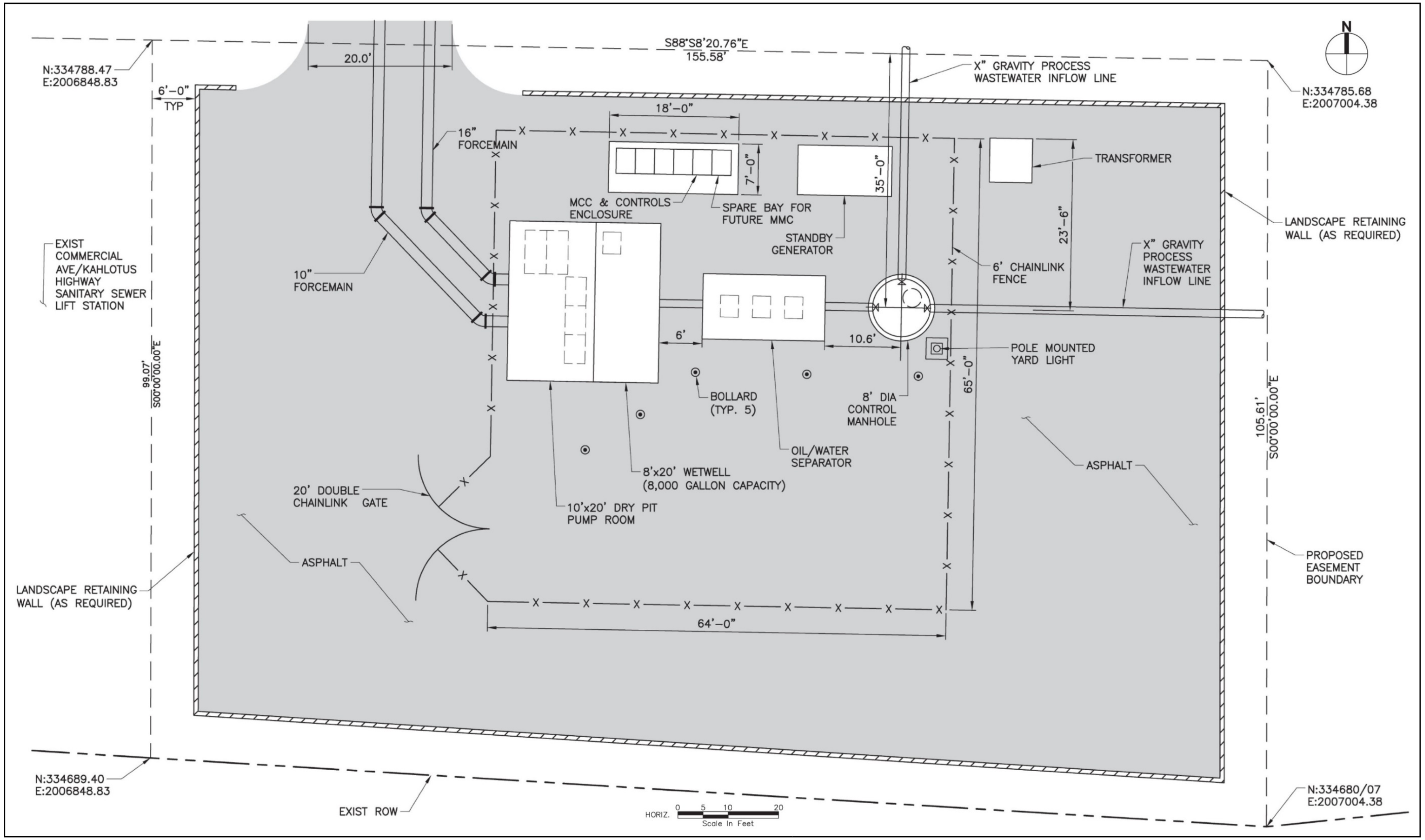


Figure 12-5	Proposed Design	17454.00
		12.14.2017

THIS PAGE IS INTENTIONALLY LEFT BLANK.

SECTION IV
FINANCIAL ASSESSMENT

CHAPTER 13
CAPITAL IMPROVEMENT PLAN

13.1 INTRODUCTION

The basis for the development of the proposed pretreatment system is presented in this chapter. It includes rough order of magnitude (ROM) capital and operations and maintenance (O&M) cost evaluations. Capital costs were compiled via a combination of vendor quotations and proprietary parametric estimating models. Table 13-1 shows the markups applied to the construction and equipment costs, as specified. Maintenance costs were assumed to be 5% of the equipment capital cost per year. Electricity costs for motor operation were assumed to be \$0.11/kWh. All costs are presented in 2018 dollars.

Table 13-1: Cost Estimate Markups

Markup	Percentage	Applied To
Overall Site Work	20%	Equipment Cost
Mechanical Work	15%	Equipment Cost
Electrical and Control	20%	Equipment Cost
Mobilization/Demobilization	10%	Equipment Cost
Contractor Overhead & Profit/Insurance	15%	Equipment Cost
Construction Change Order Allowance	10%	Equipment Cost
Tax	8.6%	Construction Cost
Contingency	40%	Construction Cost
Engineering, Testing, Contract Administration, Legal	27%	Construction Cost

13.2 HEADWORKS AND PRIMARY TREATMENT

A third 3,000 gpm rotary drum screen will be installed in the headworks building between the two existing screens. This screen will be identical to the existing screens and will increase the total rated capacity to 12.98 mgd.

A 90-foot diameter primary clarifier will be installed to replace the existing sedimentation basin. The clarifier is sized to maintain average surface loadings below 1,000 gpd/sf and peak day surface loadings below 1,500 gpd/sf. The clarifier is expected to reduce TSS to an average concentration less than 250 mg/L and maximum concentration of approximately 350 mg/L under peak conditions, as well as reducing BOD_5 and TN associated with the TSS. The ROM construction cost for the new screen, clarifier and sludge pumps is \$5,461,000. The annual O&M cost is estimated to be \$274,000.

13.3 pH CONTROL

Both magnesium hydroxide (Mg(OH)2) and aeration will be used to control pH, depending on the season, and the capacity for salts at the land treatment system. The chemical and electricity costs for pH control will vary accordingly. It is anticipated that the City will monitor salts concentrations and adjust treatment as necessary.

pH adjustment will be provided downstream of the clarifier to neutralize organic acids and reduce odors. The ROM cost for metering pumps, piping, and Mg(OH)2 storage is $520,000. The annual cost of maintenance is $26,000. The annual cost of chemical to raise the pH from 4.5 to 5.5 is $1,112,000. This cost assumes that no aeration is used.

Surface aerators will be installed in the 35 MG pond, allowing it to function as an aerated stabilization basin (ASB). The ASB will metabolize organic acids, increasing both alkalinity and pH and will provide equalization prior to discharge during the irrigation season. Twenty 75-hp aerators will provide sufficient aeration and keep suspended solids from settling in the basin during summer operation. The ROM cost for the aerators is $5,077,000. The estimated annual cost of maintenance and electricity is $794,000. This cost assumes that no Mg(OH)2 is used.

13.4 SOLIDS HANDLING

The City is pursuing land application of primary solids (PS) and ASB solids independently of this evaluation. PS include screened and clarified solids. Solids generated in the ASB will likely carry over to storage and settle out. They should be removed manually, similar to current annual basin cleaning.

It is envisioned that the City will dispose of solids directly to the fields to be land applied as directed by the Washington State Department of Ecology (Ecology) and Washington State Department of Health (DOH). If the City is allowed to directly land apply the solids, they will be stored in the existing 5 MG pond and trucked to the fields for land application. The ROM capital cost of sludge pumps is $761,800. The O&M cost electricity for motors, and system maintenance. The estimated annual O&M cost is $132,000.

13.5 STORAGE

The PWRF requires 170 MG of new storage by Phase 2 to hold treated process water for five months, between November 1 and March 31. This storage volume will be constructed immediately, with an estimated total cost of $14,500,000. Maintenance costs associated with storage basins includes cleaning and solids removal. These costs are best estimated by the City according to current maintenance procedures for their existing storage.

13.6 SCHEDULE OF IMPROVEMENTS

The headworks, primary treatment, pH control, and storage facilities are required in the near term and are independent of future processors connecting to the PWRF. It is recommended that all modifications be made immediately to provide system redundancy and capacity through Phase 2.

13.7 CONCLUSION

The capital improvement plan for the PWRF presents the recommended system alternative which achieves the following objectives:

- Maintains discharge quality below the land treatment system limits
- Maintains service to existing processors
- Plans for expansion and phasing of improvements
- Mitigates odors across the site, and provides adequate winter storage

The recommended system alternative includes headworks screens, primary treatment, pH control, solids handling, and storage. The design criteria for the system alternative are summarized in Table 13-2.

Table 13-2: Design Criteria Summary

Treatment Facility	Criteria and Sizing Value
Headworks Screen	
Quantity	1
Flow Rate	3,000 gpm
Primary Clarifier	
Material of Construction	Concrete
Configuration	Circular
Diameter	90 ft
Average Surface Loading	1,000 gpd/sf
Peak Surface Loading	1,500 gpd/sf
Average Effluent TSS Concentration	250 mg/L
Peak Effluent TSS Concentration	350 mg/L
pH Adjustment	
Target pH	5.5
Mg(OH)2 Addition	11,000 lbs/day
35 MG EQ Pond Aerators	
Aerator Quantity	20
Motor Horsepower	75 hp
Solids Handling	
Conveyance Piping	4,700 lf
Sludge Pump Quantity	2
Sludge Pump Flow Rate	200 gpm
Storage	
New Volume Required	170 MG
Total Storage Volume	311 MG

The total cost of the facility, sized to treat Phase 2 summer peak loads to below the land treatment system limits, is presented in Table 13-3. The O&M costs are presented in Table 13-4.

Table 13-3: Capital Cost Summary – Phase 2

Facility	Cost ($)
Screen and Clarifier	$ 5,461,000
pH Adjustment	$ 520,000
EQ Basin Aerators	$ 5,077,000
Solids Handling	$ 761,800
Storage	$ 7,336,000
Total Capital Cost	**19,155,800**

Table 13-4: O&M Cost Summary – Phase 2

Facility	Cost ($/yr)
Screen and Clarifier	$ 274,000
pH Adjustment	$ 1,112,000
EQ Basin Aerators	$ 794,000
Solids Handling	$ 132,000
Storage	City to provide
Total O&M Cost	**$ 2,312,000**

CITY OF PASCO PWRF
CAPITAL IMPROVEMENTS PROGRAM
Revision #2

No.	Description	Category/Need	Cost	Schedule	Customer							Functions of PWRF Service				
					City	Pasco Processing	Twin City Foods	Reser's Fine Foods	Freeze Pack	Simplot	Grimmway	Flow	BOD	Nitrogen	TSS	pH
FOSTER WELLS SERVICE AREA (Collection/Conveyance)																
FW-1	ATS Replacement	O&M Existing	$467,000.00	**2019**		x	x	x				100%				
FW-2	Odor Control Improvements Foster Wells PS	O&M Existing	$150,000.00	**2019**		x	x	x				50%	25%			25%
FW-3	Forcemain Replacement Foster Wells	O&M Existing	$4,420,000.00	**2019**		x	x	x				100%				
		Subtotal:	**$5,037,000.00**													
COLUMBIA EAST SERVICE AREA (Collection/Conveyance)																
CE-1	Columbia East Pump Station and Forcemain includes right-of-way	Additional Capacity (G+S+FP)	$9,211,000.00	**2019-2020**					x	x	x	100%				
CE-2	Grimmway Discharge Modifications	Additional Capacity	$30,000.00	**2020**							x	100%				
CE-3	Simplot Discharge to Columbia East PS Gravity Sewer	Additional Capacity	$301,000.00	**2020**						x		100%				
CE-4	Freeze Pack Discharge Modifications	Additional Capacity	$45,000.00	**2020**					x			100%				
		Subtotal:	**$9,587,000.00**													
PWRF PRE-TREATMENT IMPROVEMENTS (Treatment)																
	Pretreatment Improvements Phase 1 and 2															
PWRF-1	Irrigation Pump Station	O&M Existing	$4,272,000.00	**2019**		x	x	x	x	x	x	100%				
	IPS Influent Piping	O&M Existing	$2,015,000.00	**2019**		x	x	x	x	x	x	100%				
PWRF-2	35 MG EQ Basin Aerators	Capacity	$5,338,000.00	**2020**		x	x	x	x	x	x	25%	50%		25%	
PWRF-3	Install Third Drum Screen & New primary Clarifier (90 ft. Dia.)	Capacity	$5,462,000.00	**2020**		x	x	x	x	x	x	50%			50%	
PWRF-4	pH Control Equipment	Capacity	$584,000.00	**2020**		x	x	x	**x**	**x**	**x**	50%				50%
PWRF-5	Solids Handling	Capacity	$761,800.00	**2020**		x	x	x	**x**	**x**	**x**				100%	
PWRF-6	120 MG New Storage	Capacity	$7,573,000.00	**2020**		x	x	x	**x**	**x**	**x**	100%				
PWRF-7	New Office/Lab Building (42' x 48' CMU/metal roof)	Capacity	$670,000.00	**2023**		x	x	x	**x**	**x**	**x**	20%	20%	20%	20%	20%
PWRF-8	Existing 115 Pond Modifications and New Liner	O&M Existing	$2,592,000.00	**2026**		x	x	x	**x**	**x**	**x**	100%				
		Phase 1 & 2 Subtotal:	**$29,267,800.00**													
PWRF-10	**Future Pre-treatment Process Phase 3**															
	Biological Treatment (SBR + UASB)	Capacity	$36,078,000.00	**2040**								**10%**	40%	40%	10%	
	390 MG New Storage	Capacity	$33,800,000.00	**2040**								**100%**				
		Phase 3 Subtotal:	**$69,878,000.00**													
PWRF-5	**Expand Pretreatment Process Phase 4**	TBD	TBD	2050												
PWRF-6	**Expand Pretreatment Improvements Phase 5**	TBD	TBD	2050												
LAND TREATMENT SYSTEM IMPROVEMENTS					**City**	**Pasco Processing**	**Twin City Foods**	**Reser's Fine Foods**	**Freeze Pack**	**Simplot**	**Grimmway**	**Flow**	**BOD**	**Nitrogen**	**TSS**	**pH**
LT-1	Triple-Beam Towers (100% City)	O&M Existing	$50,000.00	ASAP	x											
LT-2	Install Variable Frequency Drive on Well #4 (100% City)	Capacity	$50,000.00	2019	x											
LT-3	Replace Well #6 (100% City)	O&M Existing	$75,000.00	2019	x											
LT-4	Replace Well #8 (100% City)	O&M Existing	$75,000.00	2020	x											
LT-5	Replace Circle 7 Pivot (70% City - 30% Processors)	O&M Existing	$125,000.00	2019	x	x	x	x	x	x	x	**50%**	**25%**	**25%**		
LT-6	Replace Circle 5 Pivot (70% City - 30% Processors)	O&M Existing	$125,000.00	2022	x	x	x	x	x	x	x	**50%**	**25%**	**25%**		
		Subtotal:	**$500,000.00**													

CHAPTER 14
FINANCIAL ANALYSIS

14.1 INTRODUCTION

In 2017 the City of Pasco contracted with PACE Engineers (PACE) to complete a Capital Facilities Plan/Engineering Report for the City's Process Water Reuse Facility (PWRF). Part of the report includes a multi-year financial analysis that establishes the annual revenue needs required for long term financial viability of the facility, development of a capital funding plan to support the financial impacts related to the completion of the capital projects identified in this PWRF Plan, and a cost allocation approach that equitably assigns costs to customers being served by the PWRF.

The following discussion will summarize the methodology, assumptions, and results of this analysis.

14.2 METHODOLOGY

14.2.1 Revenue Requirement

The first step of the multi-year financial analysis is to determine the overall revenue needed to fund all existing and future financial obligations of the PWRF. The analysis is developed by completing an operating forecast that identifies future annual operating costs and a capital funding plan that defines a strategy for funding the capital improvement needs of the PWRF. Financial obligations may include but are not limited to the following:

- Operating and maintenance costs, additional staffing needs, enhanced programs and/or initiatives
- Existing and future debt service
- Capital costs associated with Phase II of the PWRF
- Capital funding strategy for Phase II considering available funding sources, other outside funding available and identification of the need for future debt issuance
- Depreciation funding
- Minimum fund balance needs
- Debt service coverage minimums

14.2.1.1 Operating Expense Forecast

The 2018 budget formed the baseline for this forecast. The following list highlights some of the key assumptions used in the development of the PWRF operating forecast for cost allocation purposes.

- General Cost Inflation. 1.69 percent per year (based on the 10 year average CPI)
- Construction Cost Inflation. 3.03 percent per year (based on the 10 year average CCI)
- Labor Cost Inflation. 1.65 percent per year (based on the 10 year average CPI – June to June)
- Benefit Cost Inflation. 2.28 percent per year (based on the 10 year average employment cost index)
- Additional O&M Expenses. While the 2018 budgeted expenses were used as the basis to forecast future expenses, the following incremental expenses were added to the study period driven by the future capital improvements, as defined in Table 13-4:
  - One New Plant Ops FTE – $75,000 fully loaded salary and benefits
  - Chemical Supplies – increased by $1,112,000 annually
  - Electricity – increased by $1,200,000 annually

14.2.1.2 Capital Costs

The capital costs involved in the plan include costs through Phase 2 improvements. Capital is planned to take place over a nine-year time period (2019 to 2027), with the majority of the costs in the latter years. Total costs are $51.1 million ($2018), increasing when escalated to the year of construction.

14.2.1.3 Debt Service

- **Existing Debt**. Existing debt service averages just shy of $1.0 million annually. The PWRF currently has five outstanding debt issues:
  - Four revenue bonds with annual payments ranging from $697,000 to $1.03 million
  - One HAEIFIC loan that begins repayment in 2018 for a ten-year term at $174,630 annually.
- **New Debt**. In order to fund the total Phase 2 improvements identified in the capital facilities plan, new debt is assumed in two separate issuances totaling $29.6 million. The new debt issuance results in new debt service

payments reaching a peak of 12.0 million annually by 2026. New debt is assumed to be revenue bonds with a 25-year term, 5 percent interest and 1 percent issuance cost.

14.2.1.4 Depreciation Funding

Depreciation funding is a way to ensure system integrity through reinvestment in the system. This funding is meant to cash fund a portion of repair and replacement of system infrastructure on an ongoing basis. For the purpose of this analysis, depreciation funding will be held at current levels due to the significant capital expenses discussed in the capital facilities plan. The City may want to address the level of capital funded through rates in the future, once Phase II capital improvements have been completed.

- **Current Depreciation Levels**. Cost allocations will include a level of depreciation funding at 2019 levels. This results in depreciation funding of $705,083 annually.

14.2.1.5 Fund Balance

Operating reserves are designed to provide a liquidity cushion to ensure that adequate cash working capital will be maintained to deal with significant cash balance fluctuations, such as seasonal fluctuations in billings and receipts, unanticipated cash expenses, or lower than expected revenue collections. Target funding levels for an operating reserve are generally expressed as a certain number of days of O&M expenses, with the minimum requirement varying with the expected revenue volatility. The City's current goal is to maintain a minimum balance in the Operating Fund equal to 60 days of O&M expenses for working capital.

14.2.1.6 Debt Coverage Minimums

The coverage test is based on a commitment made by the City when issuing revenue bonds and some other forms of long-term debt. For the purposes of this analysis, revenue bond debt is assumed for any needed debt issuance. As a security condition of issuance, the City would be required per covenant to agree that the revenue bond debt would have a higher priority for payment (a senior lien) compared to most other expenditures; the only outlays with a higher lien are O&M expenses. Debt service coverage is expressed as a multiplier of the annual revenue bond debt service payment. For example, a 1.0 coverage factor would imply that no additional cushion is required. A 1.25 coverage factor means revenue must be sufficient to pay O&M expenses, annual revenue bond debt service payments, and an additional 25 percent of annual revenue bond debt service payments. The excess cash flow derived from the added coverage, if any, can be used for any purpose, including funding capital projects. Targeting a higher coverage factor can help the City achieve a better credit rating and provide lower interest rates for future debt issues. Debt service stays above the 1.25 minimum for the review period.

14.2.1.7 Summary of Revenue Requirement

The financial forecast, or revenue requirement analysis, forecasts the amount of annual revenue that must be generated by user rates. The analysis incorporates O&M expenses, debt service payments, rate-funded capital needs, and any other identified expenses related to operations. In addition to annual operating costs, the revenue needs also include debt covenant requirements and specific fiscal policies and financial goals of the City.

Bringing together all elements discussed above results in the overall revenue requirement for the PWRF once Phase II construction is completed. Each element in total is summarized in the following table.

Table 14-1: Summary of Revenue Requirement (Current Depreciation Levels)

Revenue Requirement	Phase II Completion
Cash Operating Expenses	$ 4,647,997
Existing Debt Service	$ 1,021,692
New Debt Service and Coverage Requirements	$ 13,898,225
Depreciation Funding	$ 705,083
Total	**$ 20,272,997**

14.2.2 Customer Cost Allocations

Once the overall revenue level is determined, the cost allocation analysis is performed. This analysis determines the equitable recovery of costs from customers according to unique demands each customer places on the system. There are three fundamental steps to allocating the annual revenue requirement to customers and developing the final rates – 1) allocate utility assets and total utility costs by function, 2) develop customer-specific allocation factors, and 3) allocate costs to each customer.

14.2.2.1 Allocation of Utility Assets by Function

The PWRF assets in service were reviewed to identify what infrastructure assets are in use and relate to providing service. This allocation assigns value and costs to functional categories based on documented system requirements, including engineering criteria, (e.g., flow, strength components, etc.) based on the relationship of each class of asset and their function in the system. Assets are allocated to the functions of service according to known or assumed cost “causation.” The functions of service to which the PWRF assets were allocated are discussed below.

- **Customer**. These are the costs associated with establishing, maintaining, and servicing PWRF customers and tend to include administrative, billing, and customer service costs. These costs are generally uniform by customer regardless of individual flow and/or strength characteristics.
- **Flow**. These costs are related to actual wastewater volume processed within the system in a year.
- **Strength**. These costs reflect strength of influent processed. Strength is tracked by the following three parameters:
  - **Nitrogen** – measurement of nitrogen loading requiring treatment before water reuse
  - **Total Suspended Solids (TSS)** – measurement of the amount of particles suspended in water that will not pass through a filter and thus require treatment
  - **Biochemical Oxygen Demand (BOD)** – measurement of the organic strength of the influent flow

Table 14-2: PWRF Functional Plant (Assets) in Service

Plant in Service	Total Costs	FUNCTIONS OF PWRF SERVICE					TOTAL	ALLOCATION BASIS
		Customer	Flow	Nitrogen	TSS	BOD		
Existing								
Treatment	$ 4,127,912	10.00%	40.00%	15.00%	30.00%	5.00%	100.00%	Treatment
Collection/Conveyance	$ 525,543	10.00%	45.00%	0.00%	45.00%	0.00%	100.00%	Pumping
Pretreatment	$ 11,889,284	10.00%	40.00%	15.00%	30.00%	5.00%	100.00%	Treatment
Future								
Treatment	$ 75,000	10.00%	40.00%	15.00%	30.00%	5.00%	100.00%	Treatment
Collection/Conveyance	$ 26,978,000	10.00%	45.00%	0.00%	45.00%	0.00%	100.00%	Pumping
Pretreatment	$ 105,869,209	10.00%	40.00%	15.00%	30.00%	5.00%	100.00%	Treatment
Total Utility Plant	$ 148,464,948	$ 14,846,495	$ 60,711,156	$ 18,294,211	$ 48,515,016	$ 6,098,070	$ 148,464,948	
PWRF Service Functions		10.00%	40.89%	12.32%	32.68%	4.11%	100.00%	
Allocation of “As All Others”		$ –	$ –	$ –	$ –	$ –	$ –	
TOTAL **Allocation Percentages**	**$ 148,464,948**	**$ 14,846,495** **10.00%**	**$ 56,444,917** **40.89%**	**$ 44,823,128** **12.32%**	**$ 44,823,128** **32.68%**	**$ 5,777,293** **4.11%**	**$ 138,187,948** **100.00%**	

The allocation basis (shown in Table 14-2) used for the major functions of service are as follows:

- **Treatment assets** are allocated 10 percent to customer, 40 percent to flow, 15 percent to nitrogen, 30 percent to TSS, and 5 percent to BOD.
- **Collection/Conveyance assets** are allocated 10 percent to customer, 45 percent to flow, and 45 percent to TSS. Collection and conveyance assets have a strength component due to the sand and grit present with solid loadings. A high concentration of inorganics within the TSS loading is very abrasive as it is pumped through the forcemain. The abrasive characteristics deteriorate metal piping and pumping equipment to the point of failure.
- **Pretreatment assets** are allocated 10 percent to customer, 40 percent to flow, 15 percent to nitrogen, 30 percent to TSS, and 5 percent to BOD.

All asset functional allocations were based on the engineer's analysis of system design criteria. The result of the functional asset allocation is 10.00 percent allocated to customer, 40.89 percent to flow, 12.32 percent to nitrogen, 32.68 percent to TSS, and 4.11 percent to BOD. This resulting asset allocation is referred to as the "plant-in-service" allocation and is used to allocate annual costs if the cost supports the total system.

14.2.2.2 Allocation of Utility Costs by Function

The annual test period costs were also grouped by function. The process required assigning each budget line item account to PWRF functions. The following summarizes the key cost allocation assumptions:

- **Utility Admin Salaries and Benefits** – All personnel expenses related to administration were allocated 100 percent to the customer function.
- **Electricity** – Allocated 100 percent to flow.
- **Pre-Treatment Expenses** – All expenses related to pre-treatment were allocated based on the pre-treatment allocation shown in Table 14-2 – 10 percent to customer, 40 percent to flow, 15 percent to nitrogen, 30 percent to TSS, and 5 percent to BOD.
- **All Other O&M Expenses** – The remaining O&M expenses were allocated based on the "plant-in-service" allocation, 10.00 percent allocated to customer, 40.89 percent to flow, 12.32 percent to nitrogen, 32.68 percent to TSS, and 4.11 percent to BOD.
- **Existing Debt Service** – Allocated as all customer.
- **New Debt Service** – Allocated as all customer.
- **Depreciation Funding** – Allocated as all customer.

The cost allocation indicates that the majority of system expenses relate to the customer component, followed by managing annual flow requirements and treatment of TSS. Figure 14-1 provides a summary of the functional cost allocation for the system expenses.

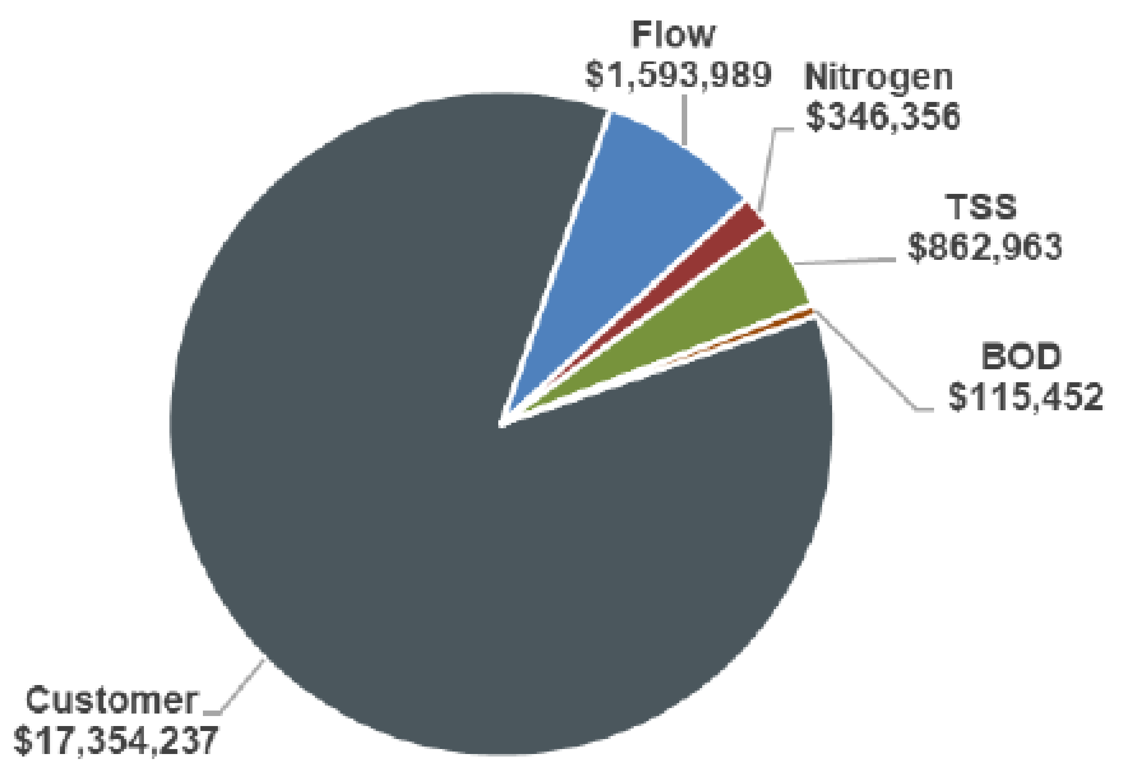


Figure 14-1	PWRF Functional Cost Allocation Summary	17454.05
		Rev. 06.26.2019

14.2.2.3 PWRF Customers

The current PWRF serves five customers. The Phase II expansion projects will allow for one new customer to be served by the facility. Both existing and future customers are included for cost allocation purposes and are identified as follows:

- Reser – existing customer
- Pasco Processing – existing customer
- TCF – existing customer
- Freeze Pack – existing customer
- Simplot – existing customer
- Grimmway – future customer

The main objective of this analysis was to determine an equitable split of costs associated with the operation, maintenance and capital expenditures associated with the PWRF.

14.2.2.4 Allocation Factors

Once the customers were defined, functional cost pools (shown in Table 14-3) were then allocated to these customers based on the service characteristics and facility requirements of each customer. Allocation factors were developed that identified customer characteristics including overall flow entering the wastewater system, capital cost distributions, and the unique strength parameters of each customer. The allocation factors are intended to equitably allocate total functional cost pools to customers based on service characteristics and facility requirements. For this study, the PWRF costs were allocated based on the following:

- **Customer – Operating**. Customer Portion of O&M Expenses: Allocated equally to each customer.
- **Customer – Existing Debt Service**: Allocated based on the current existing debt split applied by the City.
- **Customer – New Debt Service**: Each capital project was allocated to customers based on the function of the PWRF service the project addresses (i.e., flow, TSS, BOD, etc.) as well as whether each project will be utilized to provide service. The majority of the total future capital program of $54.5 million is assumed to be debt financed. The total capital cost pool for each customer provides the allocation factor for new annual debt service.
- **Depreciation Funding**: Allocated based on max design flow.
- **Flow**. Costs are allocated based on design criteria for maximum flow.
- **Nitrogen**. Costs are allocated based on the design criteria for lbs./year of Total Nitrogen.
- **TSS**. Costs are allocated based on the design criteria for lbs./year of TSS.
- **BOD**. Costs are allocated based on the design criteria for lbs./year of BOD.

Permit limits were primarily used to determine design criteria. Where information was not available on the permits, three years of individual Discharge Monitoring Report history from the processors was used to supplement the design criteria.

Table 14-3 summarizes the allocation factors used for each customer evaluated in this analysis.

Table 14-3: PWRF Customer Allocation Factors

Processor	Customer # of Accounts	Existing Debt Current Split	New Debt % of Future Capital	Depreciation Max Flow Design	Flow Max Flow Design	Nitrogen Design Lbs/Day	TSS Design Lbs/Year	BOD Design Lbs/Year
Reser	1	$ 210,167	$ 752,143	176	176	83,331	1,435,511	1,502,926
Pasco Processing	1	$ 353,165	$ 2,177,345	857	857	191,900	3,513,254	1,588,965
TCF	1	$ 149,536	613,559	466	466	158,214	525,559	1,289,336
Freeze Pack	1	–	234,039	58	58	19,610	294,440	127,395
Simplot	1	$ 308,824	$ 1,365,710	324	324	57,546	1,317,794	3,317,575
Grimmway	1	–	1,295,710	767	767	67,202	1,471,120	1,688,740
Lamb Weston	1	–	$ 6,975,958	986	986	870,613	1,674,255	15,063,205
Total	**6**	**$ 1,021,692**	**$ 4,129,965**	**2,648**	**2,648**	**577,803**	**8,557,678**	**9,514,937**

Customer	Customer Allocation	Existing Debt Service	New Debt Service	Depreciation Funding	Flow	Nitrogen	TSS	BOD
Reser	14.3%	20.6%	5.4%	5.5%	5.5%	5.8%	15.7%	6.4%
Pasco Processing	14.3%	34.6%	15.7%	26.9%	26.9%	13.4%	38.3%	6.8%
TCF	14.3%	14.6%	8.6%	14.6%	14.6%	11.1%	5.7%	5.5%
Freeze Pack	14.3%	0.0%	1.7%	1.8%	1.8%	1.4%	3.2%	0.5%
Simplot	14.3%	30.2%	9.8%	10.2%	10.2%	4.0%	14.4%	14.1%
Grimmway	14.3%	0.0%	8.6%	10.0%	10.0%	3.3%	4.5%	2.5%
Lamb Weston	14.3%	0.0%	50.2%	30.9%	30.9%	60.9%	18.3%	64.1%
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Table 14-4: PWRF Cost Allocations

Processor	Customer Costs	Existing Debt Service	Future Debt Service	Depreciation Funding	Flow	Nitrogen	TSS	BOD	Total
Reser	$ 247,034	$ 210,167	$ 752,143	$ 38,938	$ 88,027	$ 20,203	$ 135,074	$ 7,389	$ 1,498,975
Pasco Processing	$ 247,034	$ 353,165	$ 2,177,345	$ 189,600	$ 428,631	$ 46,525	$ 330,577	$ 7,812	$ 3,780,691
TCF	$ 247,034	$ 149,536	$ 1,201,304	$ 103,097	$ 233,072	$ 38,358	$ 49,452	$ 6,339	$ 2,028,192
Freeze Pack	$ 247,034	–	$ 234,039	$ 12,832	$ 29,009	$ 4,754	$ 27,705	$ 626	$ 555,999
Simplot	$ 247,034	$ 308,824	$ 1,365,710	$ 71,681	$ 162,050	$ 13,952	$ 157,538	$ 16,311	$ 2,309,559
Grimmway	$ 247,034	–	$ 1,191,725	$ 70,796	$ 160,049	$ 11,488	$ 38,620	$ 2,912	$ 1,722,624
Lamb Weston	$ 247,034	–	$ 6,975,958	$ 218,140	$ 493,151	$ 211,075	$ 157,538	$ 74,061	$ 8,376,957
Total	**$ 1,729,237**	**$ 1,021,692**	**$13,898,225**	**$ 705,083**	**$ 1,593,989**	**$ 346,356**	**$ 862,963**	**$ 115,452**	**$ 20,272,997**

The cost allocations are calculated by multiplying the functional cost pools by the allocation factor distribution percentages. Ultimately, this element of the analysis defines the total annual revenue that should be generated from each customer, in order to achieve cost based recovery from rates.

14.2.2.5 PWRF Cost Allocation Results

Table 14-4 provides a summary of the PWRF cost allocations to each customer, by functional category.

It should be noted that a cost allocation study is a snapshot in time and because costs fluctuate each year, the total costs to each customer will also fluctuate. The total cost allocation represents the anticipated cost responsibility to each customer after all Phase II projects are completed. The allocations provided outline the basis for which annual costs will be spread each year.

14.2.3 UNIT COSTS

The principal objective of any rate design is to implement rate structures that collect the appropriate level of revenue as outlined by the revenue requirement and to collect such revenue based on the customer allocations derived from the cost allocation analysis. The basis for rate design is a calculation of unit costs of design criteria capacity. Three unit cost calculations were discussed for the PWRF:

- All Fixed Rates: no variable component included, all customers pay a flat fee that varies by customer.
- All Variable Rates: Rates are variable by customer based on actual flow to the reuse facility. Unit costs are calculated based on design criteria flow.
- Fixed and Variable Rates: A portion of the revenue collected through a variable component (flow); the remainder collected through a fixed fee.

Tables 14-5a, 14-6, and 14-7 provide the results of each different rate design option.

Table 14-5a: PWRF Rate Design Options – All Fixed Charges

Class	Per Month	Annual Total
Reser	$ 124,915	$ 1,498,975
Pasco Processing	$ 315,058	$ 3,780,691
TCF	$ 169,016	$ 2,028,192
Freeze Pack	$ 46,333	$ 555,999
Simplot	$ 192,463	$ 2,309,559
Grimmway	$ 143,552	$ 1,722,624
Lamb Weston	$ 698,080	$ 8,376,957
Total	**$ 1,689,416**	**$ 20,272,997**

Table 14-5b: PWRF Rate Design Options – Fixed/Variable (Variable Flow)

Class	Fixed Per Month	Design Avg. Flow (MGY)	Variable per MG	Annual Total
Reser	$ 117,579	$ 87.00	$ 1,012	$ 1,498,975
Pasco Processing	$ 279,338	$ 380.00	$ 1,128	$ 3,780,691
TCF	$ 149,593	$ 261.00	$ 893	$ 2,028,192
Freeze Pack	$ 43,916	$ 30.00	$ 967	$ 555,999
Simplot	$ 178,959	$ 172.0	$ 942	$ 2,309,559
Grimmway	$ 130,215	$ 185.00	$ 865	$ 1,722,624
Lamb Weston	$ 656,984	$ 803.00	$ 614	$ 8,376,957
Total	**$ 1,556,584**	**$ 1,918.00**	**$ 831**	**$ 20,272,997**

Table 14-5c: PWRF Rate Design Options – All Variable

Class	Design Avg. Flow (MGY)	Variable per MG	Annual Total
Reser	87.00	$ 17,230	$ 1,498,975
Pasco Processing	380.00	$ 9,949	$ 3,780,691
TCF	261.00	$ 7,771	$ 2,028,192
Freeze Pack	30.00	$ 18,533	$ 555,999
Simplot	172.00	$ 13,428	$ 2,309,559
Grimmway	185.00	$ 9,311	$ 1,722,624
Lamb Weston	803.00	$ 10,432	$ 8,376,957
Total	**1,918.00**	**$ 10,570**	**$ 20,272,997**

Each unit cost calculation will allow the utility to collect the same total level of revenue from each customer. It should be noted that regardless of the rate design option decided upon, the City will estimate the rates to be charged each year based on forecasted expenses. Once the year has ended, a true-up calculation will be made to ensure that each customer pays their equitable share of costs and that all expenses of the PWRF are recovered by the City. Final rate designs will be negotiated in future agreements for services with the City.

14.3 SUMMARY

The analysis described above concludes the cost allocation analysis for the Pasco Process Water Reuse Facility. Costs are forecast to increase as the facility undergoes $158 million in capital improvements over the next nine years. These improvements are necessary to repair/replace existing infrastructure and upgrade/expand capacity for future customers. The costs shown above represent the annual costs once all Phase 2 construction is completed. As mentioned previously, costs shown in this report are a snapshot in time; the City will need to perform annual updates to the forecast of costs to determine future year cost allocations for each customer. A year-end true-up will ensure equitable cost recovery and long-term PWRF operating and financial sustainability.

THIS PAGE IS INTENTIONALLY LEFT BLANK.