Preliminary

02/20/2025

Technical Information Report

Camas PFAS Evaluation & Well 13 Treatment

February 20, 2025

PREPARED FOR:
City of Camas

CLIENT:
Carollo Engineers

Jurisdiction Project Number:
TBD

MacKay Sposito
Project Number: 18581.01.01

Prepared by:
Richard Prouse

MacKay Sposito

Vancouver Office
18405 SE Mill Plain Blvd, Suite 100 • Vancouver, WA 98683
360.695.3411 • info@mackaysposito.com

PRELIMINARY STORMWATER PLAN

TECHNICAL INFORMATION REPORT

Camas PFAS Evaluation & Well 13 Treatment

PROJECT NO. 18581.01.01

February 20, 2025

Designed by: Richard Prouse, P.E.

Reviewed by: Peter Tuck, P.E.

Mackay Sposito, Inc.
18405 SE Mill Plain Blvd., Suite 100
Vancouver, WA 98683
(360) 558-3971

REVISION	BY	DATE	COMMENTS

W:\18581 Camas PFAS\500 Design\501 Documents\Technical Files\Engineering\Preliminary\18581.eng.psr.title.docx

Table of Contents

Maps

General Location Map (Vicinity Map)
Elevation Contours
2021 Aerial Photography
Water, Sewer and Storm Systems (Wellhead Protection)
Water Systems
Soils Types
Environmental Constraints I (Floodplains and Shoreline Management)
Environmental Constraints II
Quarter Section Parcels

Technical Information Report

Section A – Project Overview 1
Section B – Minimum Requirements 4
Section C – Soils Evaluation 8
Section D – Source Control 10
Section E – Onsite Stormwater Management BMPs 12
Section F – Runoff Treatment Analysis and Design 14
Section G – Flow Control Analysis and Design 16
Section H – Wetlands Protection 19

Technical Appendices

Appendix A — Hydrologic Soil Groups in Clark County
Table A-3: Runoff Curve Numbers
Table 7: Estimated Physical and Chemical Properties of Soils
Isopluvial Maps from City of Camas Stormwater Design Manual

Appendix B — Figure 1.1: Flow Chart for Determining Stormwater Requirements
Figure 1.2: New Development Minimum Requirements Flow Chart

Appendix C — WWHM2012 Modeling

Appendix D — Geotechnical Engineering Report by Delve Underground dated June 2025.

Appendix E — Pre-developed Catchment Plan, Sheet 1 of 2
Developed Catchment Plan, Sheet 2 of 2

Tables

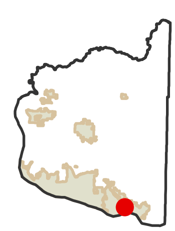
B1: Site Improvement Summary 5
B2: Additional Compliance Characteristics 7
B3: Applicable Minimum Requirements 7
F1: Effective Pollution Generating Surface Summary 15
G1: Land Use Areas for Pre-developed TDA 1 17
G2: Land Use Areas for Developed TDA 1 17

General Location

Account: 90928000, 91031000, 91034000
Owner: CITY OF CAMAS
Address: 616 NE 4TH AVE
C/S/Z: CAMAS, WA 98607

Printed on: June 13, 2024

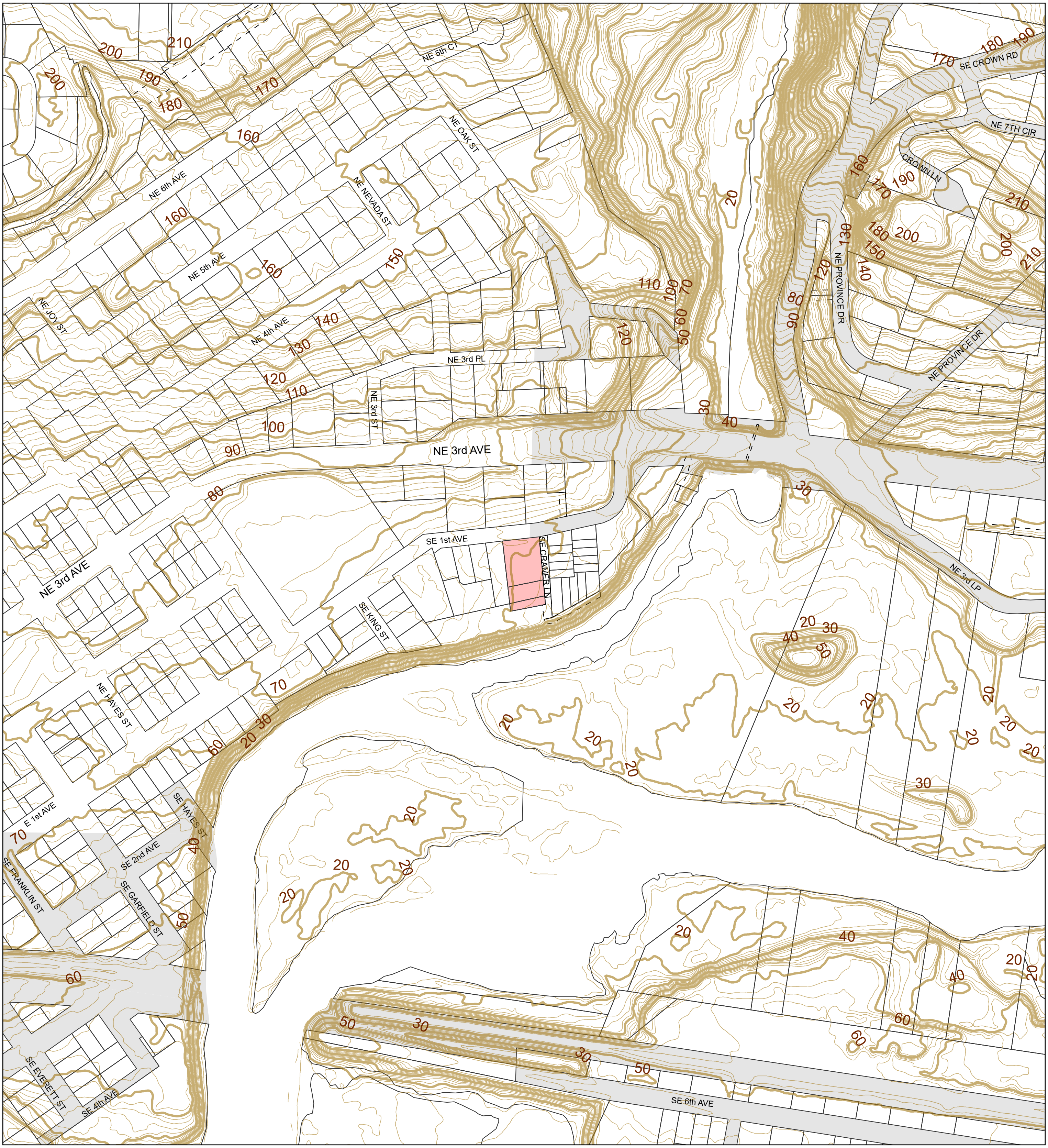
Location of Subject Property(s)



CLARK COUNTY, WASHINGTON
Geographic Information System

0 1,000 2,000
Feet

Information shown on this map was collected from several sources. Clark County accepts no responsibility for any inaccuracies that may be present.



Elevation Contours

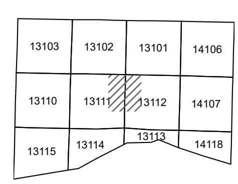
Printed on: June 13, 2024

Account: 90928000, 91031000, 91034000
Owner: CITY OF CAMAS
Address: 616 NE 4TH AVE
C/S/Z: CAMAS, WA 98607

CLARK COUNTY, WASHINGTON
Geographic Information System

0 200 400
Feet

Subject Property(s)
Public Road
Transportation or Major Utility Easement
10' Elevation Contours
2' Elevation Contours



Information shown on this map was collected from several sources. Clark County accepts no responsibility for any inaccuracies that may be present.

2021 Aerial Photography

Printed on: June 13, 2024

Account: 90928000, 91031000, 91034000
Owner: CITY OF CAMAS
Address: 616 NE 4TH AVE
C/S/Z: CAMAS, WA 98607

CLARK COUNTY, WASHINGTON
Geographic Information System

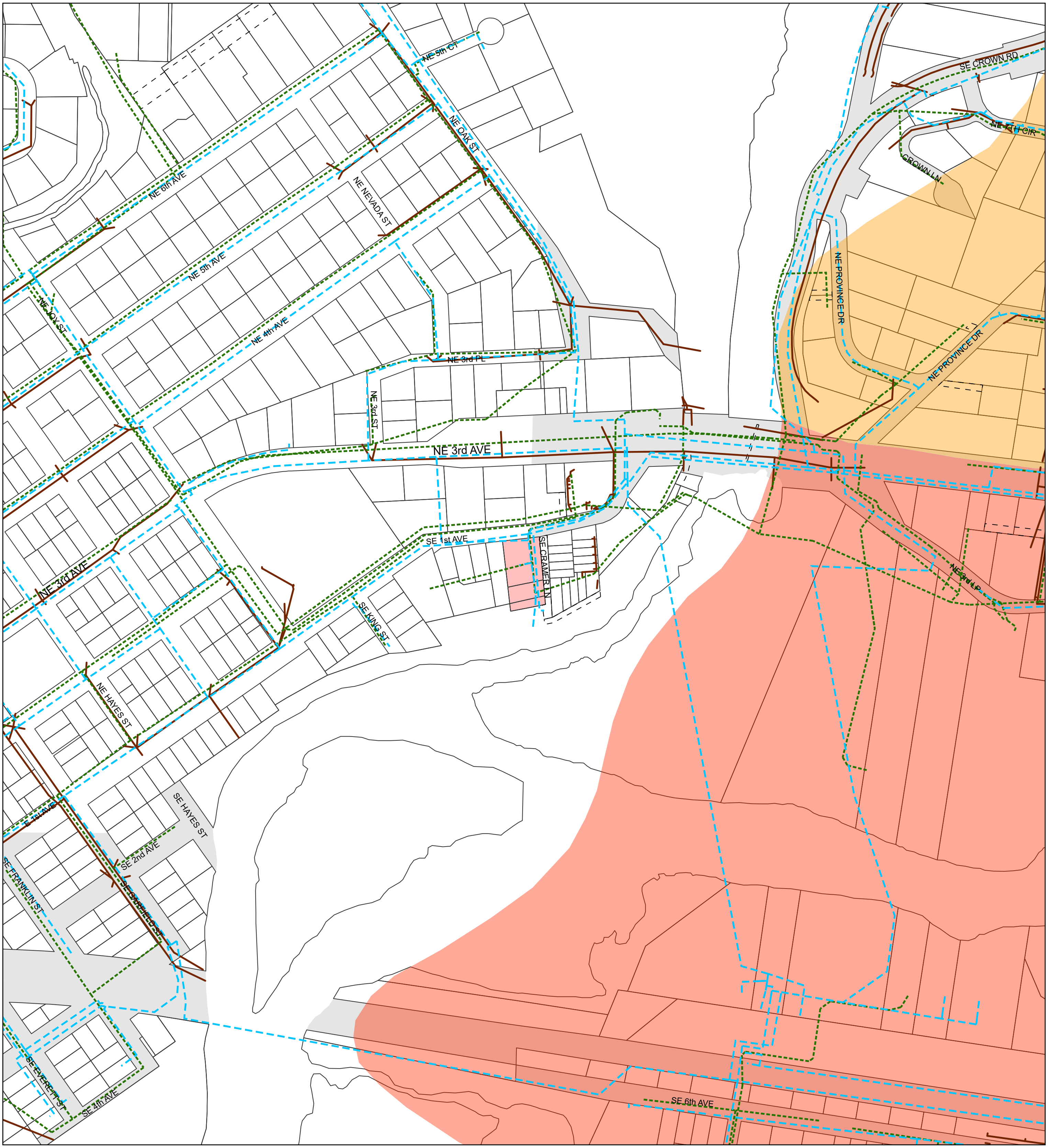
N

0 200 400
Feet

Subject Property(s)

13103	13102	13101	14106
13110	13111	13112	14107
13115	13114	13113	14118

Information shown on this map was collected from several sources. Clark County accepts no responsibility for any inaccuracies that may be present.



Water, Sewer, and Storm Systems

Printed on: June 13, 2024

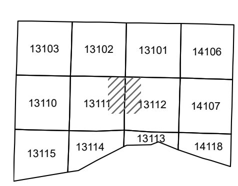
Account: 90928000, 91031000, 91034000
Owner: CITY OF CAMAS
Address: 616 NE 4TH AVE
C/S/Z: CAMAS, WA 98607

CLARK COUNTY, WASHINGTON
Geographic Information System

0 200 400
Feet

Information shown on this map was collected from several sources. Clark County accepts no responsibility for any inaccuracies that may be present.

- Subject Property(s)
- Public Road
- Transportation or Major Utility Easement
- 1-Year Wellhead ZOC
- 5-Year Wellhead ZOC
- 10-Year Wellhead ZOC
- Water Lines
- Sewer Lines
- Storm Water Lines
- Hydrants



Clark County, Washington
Geographic Information System

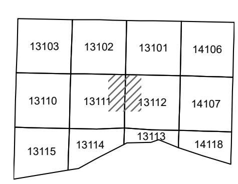
0 200 400
Feet

Information shown on this map was collected from several sources. Clark County accepts no responsibility for any inaccuracies that may be present.

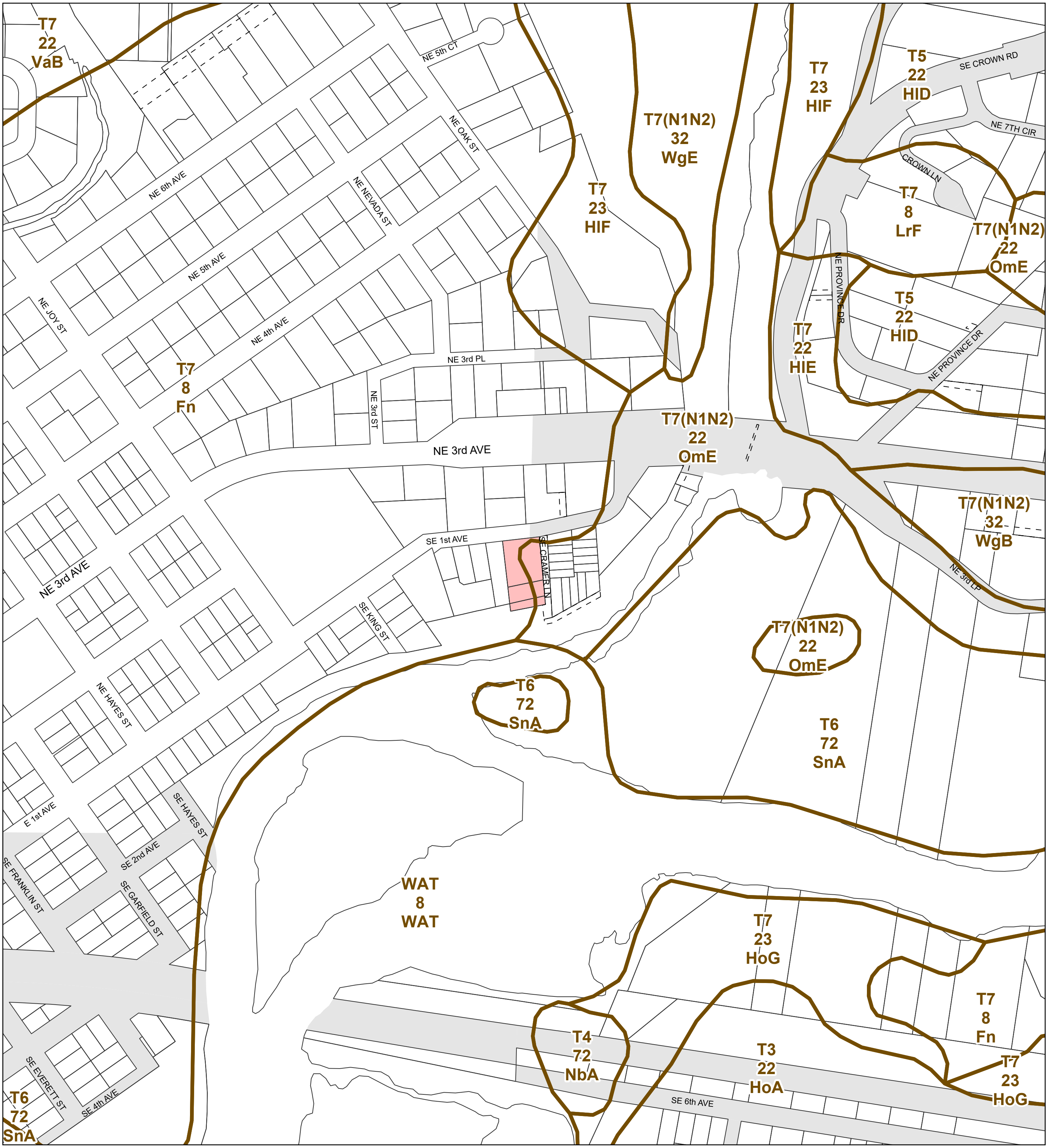
Water Systems

Printed on: June 13, 2024

Account: 90928000, 91031000, 91034000
Owner: CITY OF CAMAS
Address: 616 NE 4TH AVE
C/S/Z: CAMAS, WA 98607



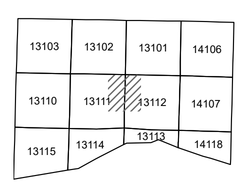
- Subject Parcel
- Public Road
- Water District Boundary
- Unknown Size Water Line
- < 10" Water LIne
- 10-20" Water Line
- > 20" Water Line
- No Flow Data Hydrant
- 0 - 499 GPM at 20 PSI
- 500 - 999 GPM at 20 PSI
- > 1000 - 1749 GPM at 20 PSI
- > 1750 GPM at 20 PSI
- Hydrant > 500' from parcel(s)



Soil Types

Printed on: June 13, 2024

Account: 90928000, 91031000, 91034000
Owner: CITY OF CAMAS
Address: 616 NE 4TH AVE
C/S/Z: CAMAS, WA 98607



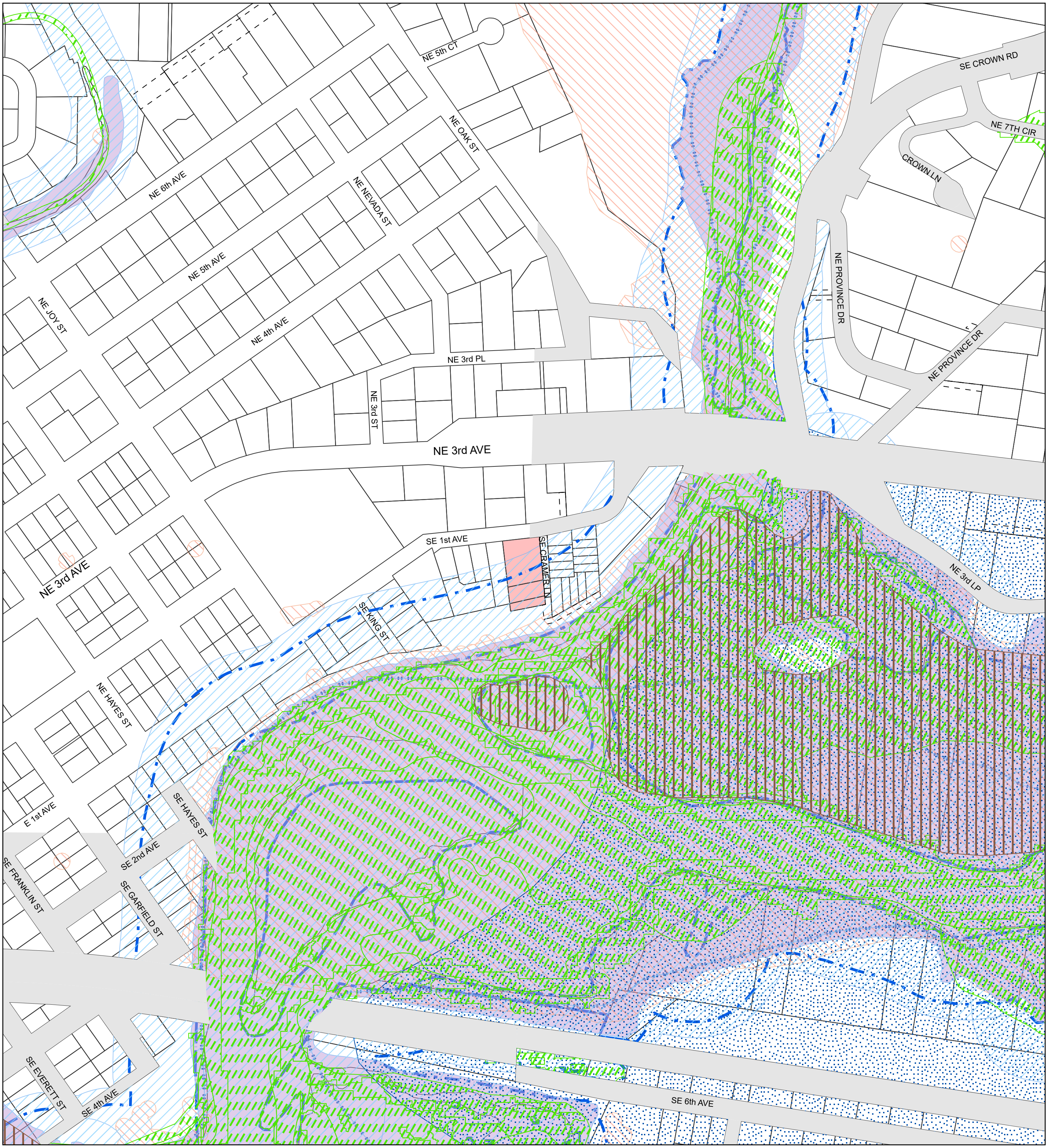
Clark County, Washington
Geographic Information System

N

0 200 400
Feet

- Subject Property(s)
- Public Road
- Transportation or Major Utility Easement
- Soil Type Boundary

Information shown on this map was collected from several sources. Clark County accepts no responsibility for any inaccuracies that may be present.



Environmental Constraints I

Printed on: June 13, 2024

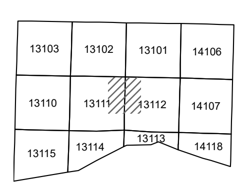
Account: 90928000, 91031000, 91034000
Owner: CITY OF CAMAS
Address: 616 NE 4TH AVE
C/S/Z: CAMAS, WA 98607

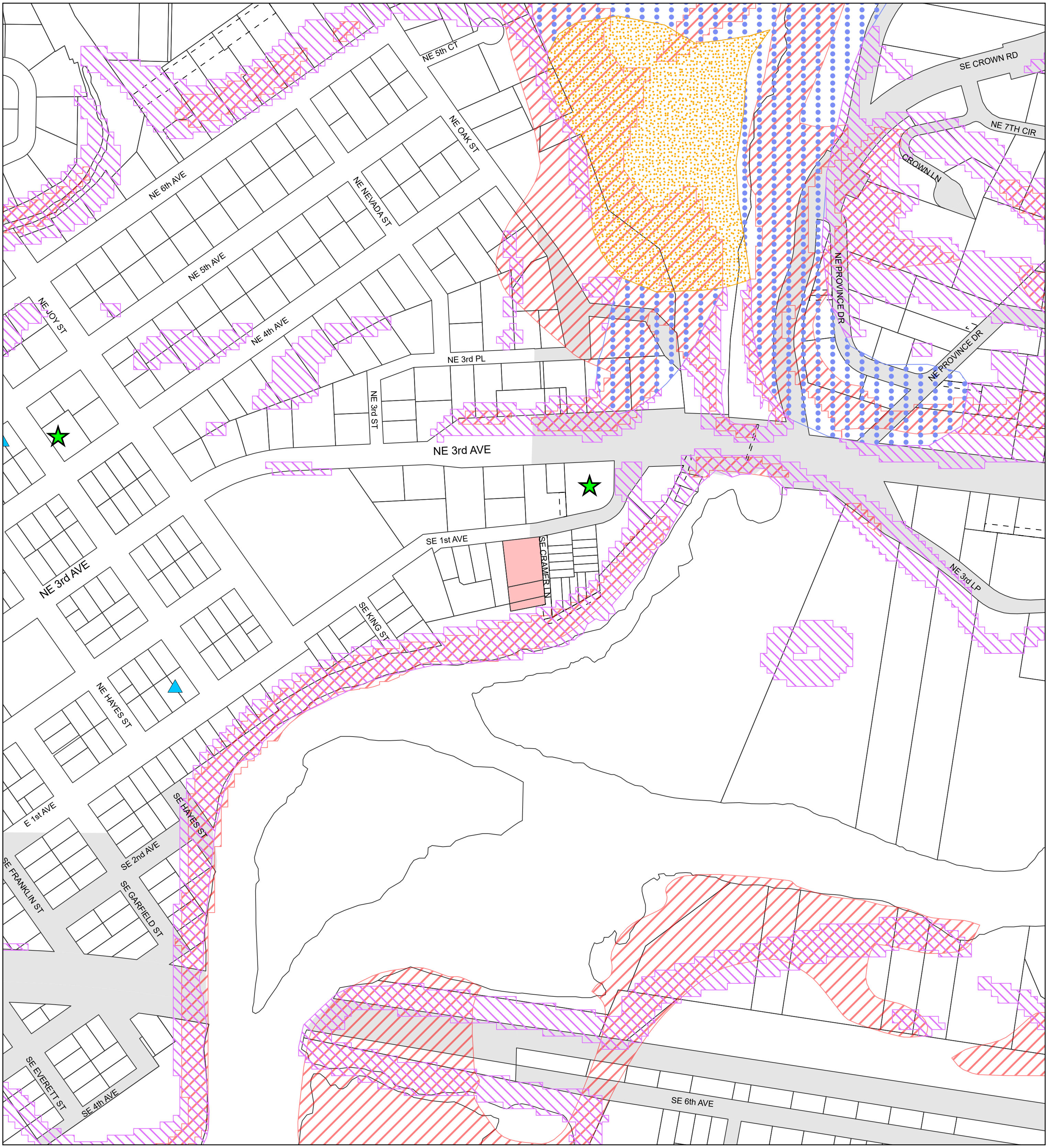
CLARK COUNTY, WASHINGTON
Geographic Information System

0 200 400 Feet

N

- Subject Property(s)
- Public Road
- Transportation or Major Utility Easement
- Hydric Soils
- Wetland Inventory
- CARA Category 1
- Riparian Habitat or Species Area
- Non-Riparian Habitat or Species Area
- 100 year Floodplains
- Floodway
- Shorelines
- Stream





Environmental Constraints II

Printed on: June 13, 2024

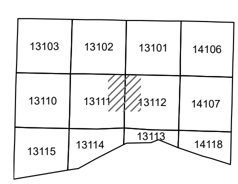
Account: 90928000, 91031000, 91034000
Owner: CITY OF CAMAS
Address: 616 NE 4TH AVE
C/S/Z: CAMAS, WA 98607

CLARK COUNTY, WASHINGTON
Geographic Information System

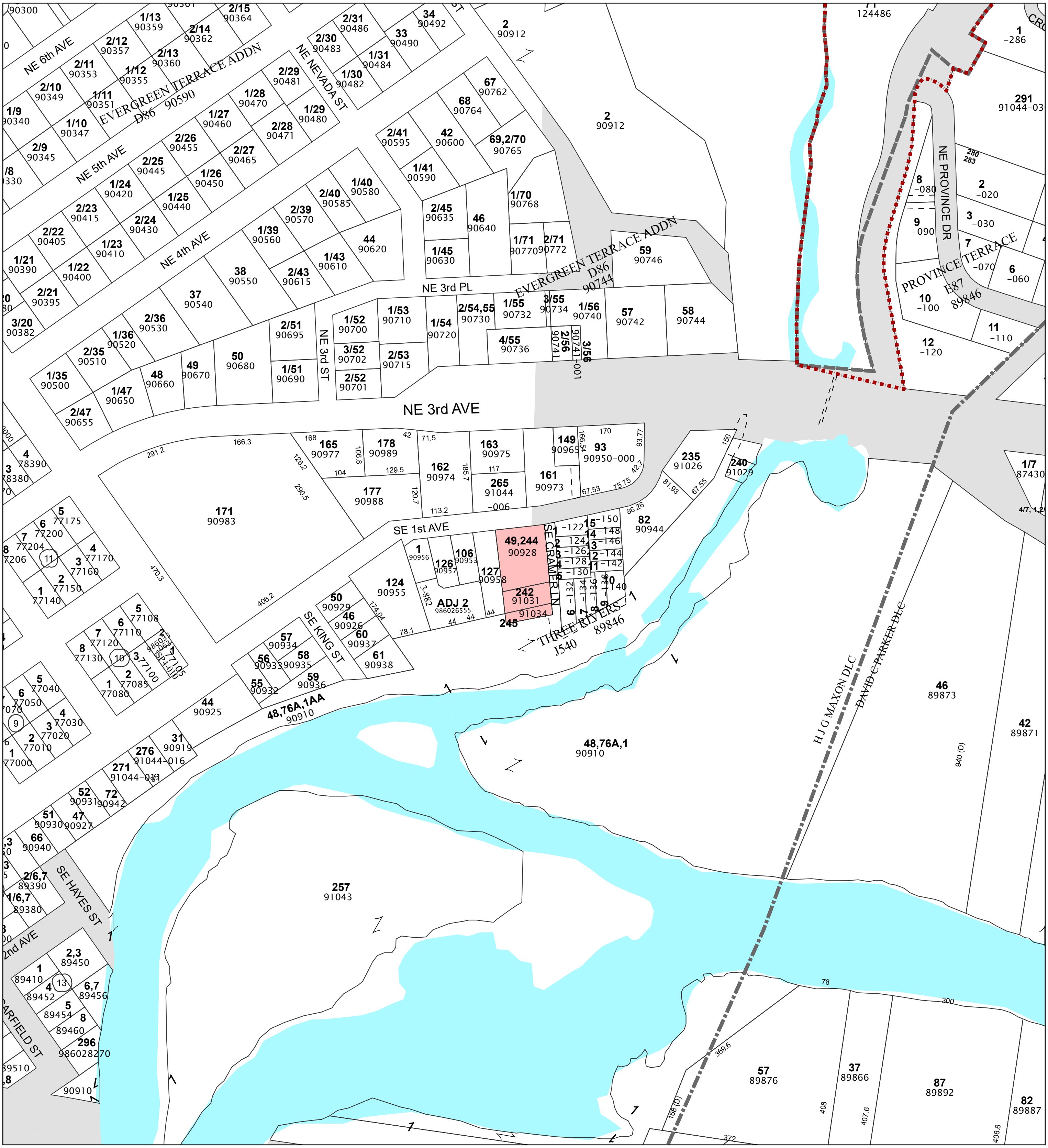
N

0 200 400
Feet

- Subject Property(s)
- Public Road
- Transportation or Major Utility Easement
- Slopes > 15%
- Potentially Unstable Slope
- Historic or Active Landslide
- Severe Erosion Hazard Area
- Forest Moratorium Area
- CCHR Historic Site
- NRHP Historic Site
- WSHR Historic Site
- WSHR Historic Barn
- INV Historic Site



Information shown on this map was collected from several sources. Clark County accepts no responsibility for any inaccuracies that may be present.



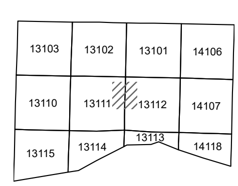
Quarter Section Parcels

Printed on: June 13, 2024

Account: 90928000, 91031000, 91034000
Owner: CITY OF CAMAS
Address: 616 NE 4TH AVE
C/S/Z: CAMAS, WA 98607

CLARK COUNTY, WASHINGTON
Geographic Information System

0 150 300
Feet



Subdivision Lines
Donation Land Claim
Section Quarters
City Boundaries
Subject Property(s)
Road Right of Way - Actual Road May not Exist
Transportation or Major Utility Easement

Information shown on this map was collected from several sources. Clark County accepts no responsibility for any inaccuracies that may be present.

Section A – Project Overview

1. **Describe the site location.**

   The City of Camas Well 13 PFAS Treatment Facility development site is approximately 0.5 acres in size and located at 1250 E. 1st Ave. Camas, Washington, which is southwest of the intersection of East 1st Avenue and East Cramer Lane. The property can be further described as tax lots #90928-000 and #91031-000 and is zoned Multi-family Residential (MF-18).

2. **Describe the topography, natural drainage patterns, vegetative ground cover, and presence of critical areas (CMC Title 16). Critical areas that receive runoff from the site shall be described to a minimum of ¼ mile away from the site boundary.**

   The project site slopes generally from northwest to southeast and varies in elevation between 62 ft. and 56 ft. The site is comprised of the existing City of Camas Well #13 Facility with associated buildings, sidewalks, driveways, generator slab, and landscape areas. There are two existing one-story CMU buildings, which are 1,730 square feet and 400 square feet in size, and the landscaping is mainly comprised of a grass surface with shrubs and bushes adjacent to E. 1st Ave.

3. **Identify and discuss existing onsite stormwater systems and their functions**

   Stormwater runoff from the site is captured in existing area drains and conveyed by pipe to a perforated pipe flow spreader outfall at the south end of the site. Runoff from the existing facility ultimately drains to the southern extent of Lacamas Creek and its confluence with the Washougal River, which is located south of the project site.

4. **Identify and discuss site parameters that influence stormwater system design.**

   Delve Underground has completed a Geotechnical Engineering Report for this development (see Appendix D). One soil boring (B-1) was completed on site to a depth of 51.5 feet below ground surface and one shallow boring to 6.5 feet depth was completed for purposes of infiltration testing. The tested infiltration rate in the shallow boring was determined to be very low, at 1.0 inches per hour. The onsite soil has been identified as Fill Land (Fn) and Olympic Stony Clay Loam (OmE). These soils are generally moist with low to non-existent infiltration capacity and are therefore not suitable for infiltration. Groundwater was not encountered during the shallow boring but is estimated to be near an elevation of 67.6 feet below ground surface based on nearby Water Well Reports maintained by the Washington State Department of Ecology. This is described in greater detail in Section C “Soils Evaluation” of this report.

5. **Describe drainage to and from adjacent properties.**

   All runoff from within the site drains generally in the southeast direction toward E. Cramer Lane located east of the site and ultimately to the southern extent of Lacamas Creek and its confluence with the Washougal River located south of the project site. The surrounding properties are developed and there does not appear to be runoff contributed to site from offsite sources.

6. Describe adjacent areas, including streams, lakes, wetland areas, residential areas, and roads that might be affected by the construction project.

The City of Camas Well 13 PFAS Treatment Facility is bordered on the north by E. 1st Ave., on the west by a one-story single-family home, on the east by E. Cramer Lane and a two-story apartment building, and on the south by the southern extent of Lacamas Creek and its confluence with the Washougal River.

7. Generally describe proposed site construction, size of improvements, and proposed methods of mitigating stormwater runoff quantity and quality impacts.

The City of Camas is proposing construction of a new facility that will include treatment for PFAS at the existing Well 13 site. The new treatment facility and associated improvements at the site are expected to include installing PFAS treatment equipment (ion exchange tanks and bag filters), adding a new generator, a building addition for a new electrical room, a building addition for a new chemical/well room for a proposed new well, and constructing a new driveway off E. 1st Ave. to accommodate a well pump crane truck. The construction is to be completed in two stages, with Stage 1 specifically consisting of construction of a new electrical room, a new generator pad, a new transformer pad with gravel access, two ion exchange tanks on a concrete pad, a covered bag filter pad and associated bag filters, a new driveway for a crane truck, and removal of the Well 4 building. Stage 2 is to specifically consist of installation of a new well, a new chemical/well building, and installation of four ion exchange tanks on two concrete pads.

- The site is 21,969.8 square feet (0.504 acres) in size and the proposed site areas can be summarized as follows:
- Existing Building to Remain = 1,710.6 square feet = 0.039 acres
- New Building (Stage 1) = 560.4 square feet = 0.013 acres
- New Building (Stage 2) = 1,475.0 square feet = 0.034 acres

- Asphalt Pavement to Remain = 478.4 square feet = 0.011 acres

- Concrete Slab to be Replaced = 593.0 square feet = 0.014 acres
- New Concrete Driveway (Stage 1) = 2,193.7 square feet = 0.050 acres
- New Concrete Slab (Stage 1) = 1,722.6 square feet = 0.040 acres
- New Concrete Driveway (Stage 2) = 131.0 square feet = 0.003 acres
- New Concrete Slab (Stage 2) = 1,190.0 square feet = 0.027 acres

- Sidewalk to Remain = 359.1 square feet = 0.008 acres
- New Sidewalk (Stage 1) = 328.4 square feet = 0.008 acres
- New Sidewalk (Stage 2) = 82.7 square feet = 0.002 acres
- New Sidewalk (Frontage) = 922.0 square feet = 0.021 acres

- New Gravel (Stage 1) = 389.0 square feet = 0.009 acres

- Landscape = 10,855.6 square feet = 0.249 acres

There is an existing storm sewer system that is comprised of area drains and storm sewer pipes that serve to convey stormwater from the site to an existing 50 foot long perforated pipe flow spreader outfall at the south end of the site. The existing storm sewer system is to remain in place and function as originally designed. Additional area drains and roof downspout connections may be added, but no further modifications to this system are proposed since the improvements associated with the project do not meet the thresholds required for treatment or flow control. This will be detailed in later sections of the report.

Section B – Minimum Requirements

1. **Describe the land-disturbing activity and document the applicable minimum requirements for the project site. Include the following information in table form: a) amount of existing impervious surface, b) new impervious surface, c) replaced impervious surface, d) native vegetation converted to lawn or landscaping, e) native vegetation converted to pasture, and f) total amount of land-disturbing activity in table format.**

   The entire site lies within the same Threshold Discharge Area (TDA1) and ultimately discharges to the southern extent of Lacamas Creek and its confluence with the Washougal River located south of the project site. New onsite land-disturbing activity will ultimately be approximately 0.46 acres.

   The 0.50 acre site is comprised of the existing City of Camas Well #13 Facility with associated existing buildings, sidewalks, driveways, generator slab, and landscape areas. There are two existing one-story CMU buildings, which are 1,730 square feet (0.040 acres) and 400 square feet (0.009 acres) in size, 478.5 square feet (0.011 acres) of existing pavement, 593.0 square feet (0.014 acres) of existing concrete slab, 359.1 square feet (0.008 acres) of existing sidewalk, and 18,828.6 square feet (0.432 acres) of landscape, which is mainly comprised of grass surface with shrubs and bushes adjacent to E. 1st Ave.

   The new treatment facility and associated improvements at the site are expected to include installing PFAS treatment equipment (ion exchange tanks and bag filters), adding a new generator, a building addition for a new electrical room, a building addition for a new chemical/well room for a proposed new well, and constructing a new driveway off E. 1st Ave. to accommodate a well pump crane truck. The construction is to be completed in two stages, with Stage 1 specifically consisting of construction of a new electrical room, a new generator pad, a new transformer pad with gravel access, two ion exchange tanks on a concrete pad, a covered bag filter pad and associated bag filters, a new driveway for a crane truck, and removal of the Well 4 building. Stage 2 is to specifically consist of installation of a new well, a new chemical/well building, and installation of four ion exchange tanks on two concrete pads. The proposed improvements include 1,710.6 square feet (0.039 acres) of existing building to remain in place, 560.4 square feet (0.013 acres) of new Stage 1 building, 1,475.0 square feet (0.034 acres) of new Stage 2 building, 478.5 square feet (0.011 acres of asphalt pavement to remain in place, 593.0 square feet (0.014 acres) concrete slab to be replaced, 2,193.7 square feet (0.050 acres) of new Stage 1 concrete driveway, 1,722.6 square feet (0.040 acres) of new Stage 1 concrete slab, 131 square feet (0.003 acres) of new Stage 2 concrete driveway, 1,190.0 square feet (0.027 acres) of new Stage 2 concrete slab, 359.1 square feet (0.008 acres) existing sidewalk to remain, 328.4 square feet (0.008 acres) new Stage 1 sidewalk, 82.7 square feet (0.002 acres) of new Stage 2 sidewalk, 922.0 square feet (0.021 acres) new offsite sidewalk along E. Cramer Lane, 389.0 square feet (0.009 acres) new Stage 1 gravel access, and 10,855.6 square feet (0.249 acres) of new landscape.

   Stages 1 and 2 of the development include an estimated 2,548.2 square feet (0.058 acres) of existing roof, pavement, and sidewalk that is to remain and be classified as "Existing Impervious Surface to Remain". There is 593.0 square feet (0.014 acres) of existing concrete slab to be replaced that is classified "Replaced Impervious Surface". There is 8,994.8 square feet (0.206 acres) of new roof, asphalt pavement, concrete driveway, concrete slab, gravel, and sidewalks that are all classified as "New Impervious Surface". The proposed development also includes 10,855.6 square feet (0.249 acres) of new landscaping that is replacing existing landscaping.

Per Figure 1.1 “Flow Chart for Determining Stormwater Requirements” from the City of Camas Stormwater Design Standards Manual, the development needs to apply the Minimum Requirements as outlined in Figure 1.2. This was determined because the project site will discharge stormwater directly into a Municipal Separate Storm Sewer System owned and operated by the City of Camas and there will be less than 1 acre of disturbance. Per Figure 1.2, since the site has less than 35% of existing impervious surface and the development will add more than 5,000 SF of new impervious surface, Minimum Requirements #1 through #9 will apply to the new impervious surfaces and the converted pervious surfaces.

- Refer to Fig. 1.1 and 1.2, included in Appendix B.

The following table summarizes the proposed site changes:

	TDA 1
Existing Impervious Surface (Acres)	0.072
New Impervious Surface (Acres)	0.206
Replaced Impervious Surface (Acres)	0.014
Existing Impervious Surface to Remain (Acres)	0.058
Existing landscaping converted to new landscaping (Acres)	0.249
Native vegetation converted to lawn or landscaping (Acres)	0.000
Native vegetation converted to pasture (Acres)	0.000
Total land-disturbing activity (Acres)	0.460

Table B1: Site Improvement Summary

2. **Provide a statement that confirms the minimum requirements that will apply to the development activity. For land-disturbing activities where minimum requirements 1 through 10 must be met include the following: a) Provide the amount of effective impervious area in each TDA, and document through an approved continuous runoff simulation model the increase in the 100-year flood frequency from pre-developed to developed conditions for each TDA, b) list the TDAs that must meet the runoff control requirements listed in Minimum Requirement 6, c) list the TDAs that must meet the flow control requirements listed in Minimum Requirement 7, and d) list the TDAs that must meet the wetlands protection requirements listed in Minimum Requirement 8.**

There is one TDA for both stages of this development and, as shown above, there is a total of 8,994.8 square feet (0.206 acres) of New Impervious Surface and 593.0 square feet

(0.014 acres) of Replaced Impervious Surface. As a result, the total New and Replaced Impervious Surface is 9,587.8 square feet (0.220 acres).

The 2,324.7 square feet (0.053 acres) of new concrete driveway is classified as Effective Pollution Generating Impervious Surface (PGIS).

Per Section I-3.4.6 “MR6: Runoff Treatment” of the Stormwater Management Manual for Western Washington, if a TDA meets any of the following thresholds, Runoff Treatment BMPs are required.

- TDAs that have a total of 5,000 square feet or more of Pollution Generating Impervious Surface (PGIS), or
- TDAs that have a total of 3/4 of an acre or more of Pollution Generating Pervious Surfaces (PGPS) – not including permeable pavements, and from which there will be a surface discharge in a natural or man-made conveyance system from the site.

The Effective Pollution Generating Impervious Surface (PGIS) in TDA 1 is 2,324.7 square feet, which is less than 5,000 square feet. The Pollution Generating Pervious Surface (PGPS) is 10,855.6 square feet (0.249 acres), which is less than 3/4 of an acre. From the information above, it is demonstrated that none of these treatment thresholds have been met and, therefore, Runoff Treatment BMPs are not required.

Per Section I-3.4.7 “MR7: Flow Control” of the Stormwater Management Manual for Western Washington, if a TDA meets any of the following thresholds, Flow Control BMPs are required.

- TDAs that have a total of 10,000 square feet or more of effective impervious surfaces, or
- TDAs that convert 3/4 acres or more of native vegetation, pasture, scrub/shrub, or unmaintained non-native vegetation to lawn or landscape, or convert 2.5 acres or more of native vegetation to pasture, and from which there is a surface discharge in a natural or man-made conveyance system from the TDA, or
- TDAs that through a combination of effective hard surfaces and converted vegetation areas cause a 0.15 cubic feet per second (cfs) or greater increase in the 100-year flow frequency as estimated using an approved continuous simulation model and 15-minute time steps.

The effective impervious surface in TDA 1 is 9,587.8 square feet, which is less than 10,000 square feet. TDA 1 converts 10,855.6 square feet (0.249 acres) existing landscape area to new landscape area, which is less than all of the landscape thresholds shown above. TDA 1 causes less than 0.15 cfs increase in the 100-year flow frequency as estimated using WWHM2012. The pre-developed and developed flows were calculated in WWHM2012 as follows:

Pre-developed 100 year flow (cfs) = 0.593691 cfs

Developed 100 year flow (cfs) = 0.615259 cfs

Developed flow – Pre-developed flow = 0.615259 cfs – 0.593691 cfs = 0.021568 cfs

0.021568 cfs < 0.15 cfs, therefore does not meet 100-year flow threshold.

From the information above, it is demonstrated that none of these flow control thresholds have been met and, therefore, Flow Control BMPs are not required.

- Refer to the WWHM2012 report for 100 year pre-developed and developed flows for TDA 1, included in Appendix C.

The following table summarizes the additional characteristics that determine compliance with Minimum Requirements 6, 7, and 8:

	TDA 1
Effective Pollution Generating Impervious Surface (PGIS) (Acres)	0.053
Effective Pollution Generating Pervious Surface (PGPS) (Acres)	0.249
Does the Large Water Body Exemption apply to this project?	No
Does the 100-year runoff increase by more than 0.15 cfs?	No
Does the project discharge directly or indirectly (through a conveyance system) into a wetland?	No

Table B2: Additional Compliance Characteristics

As a result of these surface cover characteristics, the following Minimum Requirements are triggered for this project per the City of Camas Stormwater Design Standards Manual:

	TDA1
Minimum Requirement 2 (Construction Stormwater Pollution Prevention)	Yes
Minimum Requirements 1, 3, 4, and 5 (Stormwater Site Plans, Source Control, Preservation of Natural Drainage Systems & Outfalls, Onsite Stormwater Management)	Yes
Minimum Requirement 6 (Runoff Treatment)	No
Minimum Requirement 7 (Flow Control)	No
Minimum Requirement 8 (Wetlands Protection)	No

Table B3: Applicable Minimum Requirements

Section C – Soils Evaluation

1. **Describe the site's suitability for stormwater infiltration for flow control, runoff treatment, and low impact development (LID) measures.**

   Delve Underground has completed a Geotechnical Engineering Report for this development (see Appendix D). One soil boring (B-1) was completed on site to a depth of 51.5 feet below ground surface and one shallow boring to 6.5 feet depth was completed for purposes of infiltration testing. The tested infiltration rate in the shallow boring was determined to be very low, at 1.0 inches per hour. The onsite soil has been identified as Fill Land (Fn) and Olympic Stony Clay Loam (OmE). These soils are generally moist with low to non-existent infiltration capacity and are therefore not suitable for infiltration. As a result, LID measures are not proposed for this development.

2. **Identify water table elevations, flow directions (where available), and data on seasonal water table fluctuations with minimum and maximum water table elevations where these may affect stormwater facilities.**

   Per the geotechnical report by Delve Underground, groundwater was not encountered during the shallow boring but is estimated to be near an elevation of 67.6 feet below ground surface based on nearby Water Well Reports. Water Well Reports maintained by the Washington State Department of Ecology cite a groundwater surface located 67.6 feet bgs at Louis Block Park in February 2006. Louis Block Park is located about 650 feet west of the Well 13 property and has a ground surface elevation approximately 10 feet higher than the subject property. Several Resource Protection Well Reports at a site located at NE 3rd Ave. and NE 3rd Place, about 500 feet northwest of the Well 13 property, did not indicate groundwater was encountered during hollow stem auger soil borings drilled between 15 and 20 feet below the ground surface in December 2013.

3. **Identify and describe soil parameters and design methods for use in hydrologic and hydraulic design of proposed facilities.**

   The Soil Survey of Clark County by the Soil Conservation Service shows the soil onsite is primarily Fill Land (Fn) with a relatively small area of Olympic Stony Clay Loam (OmE) along the east side of the site. (see Vicinity Maps section and Appendix A of this report). The soil properties are as follows:

   Fill Land (Fn)

   Classification: Hydrologic Group (In-situ) / SG4

   Permeability: (In-situ)

Curve Numbers:	Meadow/Pasture	CN=89
	Grass/Landscape:	CN=90
	Pavement/Sidewalk:	CN=98
	Roof:	CN=98

Olympic Stony Clay Loam (OmE)

Classification: Hydrologic Group B / SG3

Permeability: 0-44 in. depth, 0.2 to 0.63 in/hr
44-59 in. depth, 0.2 to 063 in/hr

Curve Numbers:	Meadow/Pasture	CN=78
	Grass/Landscape:	CN=80
	Pavement/Sidewalk:	CN=98
	Roof:	CN=98

A detailed list of the runoff curve numbers used in conveyance design is included in Appendix A. Conveyance design for the development is to be completed at time of final design. Runoff for conveyance design is to be estimated using the Santa Barbara Urban Hydrograph (SBUH) methodology. The following design storms are to be used in the hydrologic analysis:

2-year, 24-hour storm	2.8 inches of rainfall
10-year, 24-hour storm	3.9 inches of rainfall
100-year, 24-hour storm	5.2 inches of rainfall

- Isopluvial maps for the 2-year, 10-year, and 100-year storms are included in Appendix A.

4. Report findings of testing and analysis used to determine the infiltration rate.

One shallow boring to 6.5 feet depth was completed for purposes of infiltration testing. The tested infiltration rate in the shallow boring was determined to be very low, at 1.0 inches per hour. The onsite soil has been identified as Fill Land (Fn) and Olympic Stony Clay Loam (OmE). These soils are generally moist with low to non-existent infiltration capacity and are therefore not suitable for infiltration. As a result, LID measures are not proposed for this development.

5. Where unstable or complex soil conditions exist that may significantly affect the design of stormwater facilities, the responsible official may require a preliminary soils report that addresses stormwater design considerations arising from soil conditions. The preliminary soils report shall be prepared by a registered professional engineer proficient in geotechnical investigation and engineering or a registered soil scientist. The preliminary soils report shall include a soils map developed using the criteria set in the *NRCS National Soil Survey Handbook* (NRCS 2007) and the *SCS Soil Survey Manual* (SCS 1993), at a minimum scale of 1:5,000 (12.7 inch/mile).

Delve Underground has completed a Geotechnical Engineering Report for this development (see Appendix D). Additional information will be provided, if required.

Section D – Source Control

1. **If the development activity includes any of the activities listed in Section 2.2 of Volume IV of the *Stormwater Management Manual for Western Washington* (SMMWW), identify the source control BMPs to be used with the land-disturbing activity.**

The following Source Control BMPs apply to this project:

- BMPs for Landscaping and Lawn/Vegetation Management
    - Install engineered soil/landscape systems to improve the infiltration and regulation of stormwater in landscaped areas.
    - Do not dispose of collected vegetation into waterways or storm drainage systems.

- BMPs for Maintenance of Stormwater Drainage and Treatment Systems
    - Inspect and clean conveyance system and catch basins as needed, and determine whether improvements in O & M are needed.
    - Promptly repair any deterioration threatening the structural integrity of the facilities. These include replacement of clean-out gates, catch basin lids, and rock in dispersion trench.
    - Ensure that storm sewer capacities are not exceeded and that heavy sediment discharges to the sewer system are prevented.
    - Regularly remove debris and sludge from BMPs used for peak-rate control, treatment, etc. and discharge to sanitary sewer if approved by the sewer authority, or truck to a local or state government approved disposal site.
    - Clean catch basins when the depth of deposits reaches 60 percent of the sump depth as measured from the bottom of basin to invert of lowest pipe into or out of the basin. However, in no case should there be less than six inches clearance from the debris surface to the invert of the lowest pipe.
    - Clean woody debris in catch basins as frequently as needed to ensure proper operation of the catch basin.
    - Post warning signs; “Dump No Waste – Drains to Ground Water,” “Streams,” “Lakes,” or emboss on or adjacent to all storm drain inlets where practical.
    - Disposal of sediments and liquids must comply with “Recommendations for Management of Street Wastes” described in Appendix IV-G of Volume IV of the Stormwater Manual.

- BMPs for Urban Streets
    - For maximum Stormwater pollutant reductions on curbed streets and high volume parking lots use efficient vacuum sweepers.
    - For moderate stormwater pollutant reductions on curbed streets use regenerative air sweepers or tandem sweeping operations.
    - For minimal stormwater pollutant reductions on curbed streets use mechanical sweepers.
    - Conduct sweeping at optimal frequencies. Optimal frequencies are those scheduled sweeping intervals that produce the most cost-effective annual reduction of pollutants normally found in stormwater and can vary depending on land use, traffic volume and rainfall patterns.

- Disposal of street sweeping solids must comply with “Recommendations for Management of Street Wastes” described in Appendix IV-G of Volume IV of the Stormwater Manual.
- Inform citizens about eliminating yard debris, oil and other wastes in street gutters to reduce street pollutant sources.

Additional recommended BMPs can be found in Section 2.2 of Volume IV of the Stormwater Manual.

Section E – Onsite Stormwater Management BMPs

1. **On the preliminary development plan or other maps, show the site areas where on-site stormwater management BMPs will be effectively implemented. The plan must show the areas of retained native vegetation and required flow lengths and vegetated flow paths, as required for proper implementation of each onsite stormwater BMP. Arrows must show the stormwater flow path to each BMP.**

   There is an existing storm sewer system that is comprised of area drains and storm sewer pipes that serve to convey stormwater from the site to an existing 50 foot long perforated pipe flow spreader outfall at the south end of the site. The existing storm sewer system is to remain in place and function as originally designed. Additional area drains and roof downspout connections may be added, but no further modifications to this system are proposed since the improvements associated with the project do not meet the thresholds required for treatment or flow control (Refer to Section B of this report). As a result, no treatment or flow control BMPs are proposed as part of this development.

   - Refer to the Developed Catchment Plan in Appendix E.

2. **Identify and describe geotechnical studies or other information used to complete the analysis and design of each on-site stormwater BMP.**

   Delve Underground has completed a Geotechnical Engineering Report for this development (see Appendix D). One soil boring (B-1) was completed on site to a depth of 51.5 feet below ground surface and one shallow boring to 6.5 feet depth was completed for purposes of infiltration testing. The tested infiltration rate in the shallow boring was determined to be very low, at 1.0 inches per hour. The onsite soil has been identified as Fill Land (Fn) and Olympic Stony Clay Loam (OmE). These soils are generally moist with low to non-existent infiltration capacity and are therefore not suitable for infiltration. Groundwater was not encountered during the shallow boring but is estimated to be near an elevation of 67.6 feet below ground surface based on nearby Water Well Reports maintained by the Washington State Department of Ecology. This is described in greater detail in Section C “Soils Evaluation” of this report.

3. **Identify the criteria (and their source) used to complete analyses for each on-site stormwater BMP.**

   As demonstrated in Section B of this report, the improvements associated with the project do not meet the thresholds required for treatment or flow control. As a result, no treatment or flow control BMPs are proposed as part of this development.

4. **Describe how design criteria will be met for each proposed on-site stormwater management BMP.**

   As demonstrated in Section B of this report, the improvements associated with the project do not meet the thresholds required for treatment or flow control. As a result, no treatment or flow control BMPs are proposed as part of this development.

5. **Describe any on-site application of LID measures planned for the project. Provide a plan that shows the proposed location and approximate size of each LID facility.**

   Due to the low infiltration rate and poor soil conditions, infiltration LID measures are not applicable to this project.

6. **Identify and describe any assumptions used to complete the analysis.**

   As demonstrated in Section B of this report, the improvements associated with the project do not meet the thresholds required for treatment or flow control. As a result, no treatment or flow control BMPs are proposed as part of this development.

7. **Describe site suitability, including hydrologic soil groups, slopes, areas of native vegetation, and adequate location of each BMP.**

   As demonstrated in Section B of this report, the improvements associated with the project do not meet the thresholds required for treatment or flow control. As a result, no treatment or flow control BMPs are proposed as part of this development.

Section F – Runoff Treatment Analysis and Design

1. **Document the level of treatment required (basic, enhanced, phosphorus, oil/water separation) based on procedures in Vol. V, Chapter 2 of the SMMWW.**

   As demonstrated in Section B of this report, the improvements associated with the project do not meet the thresholds required for treatment. As a result, no treatment BMPs are proposed as part of this development.

2. **Provide background and description to support the selection of the treatment BMP being proposed. Include an analysis of initial implementation costs and long-term maitenance costs.**

   As demonstrated in Section B of this report, the improvements associated with the project do not meet the thresholds required for treatment. As a result, no treatment BMPs are proposed as part of this development.

3. **Identify geotechnical or soils studies or other information used to complete the analysis and design.**

   Delve Underground has completed a Geotechnical Engineering Report for this development (see Appendix D). One soil boring (B-1) was completed on site to a depth of 51.5 feet below ground surface and one shallow boring to 6.5 feet depth was completed for purposes of infiltration testing. The tested infiltration rate in the shallow boring was determined to be very low, at 1.0 inches per hour. The onsite soil has been identified as Fill Land (Fn) and Olympic Stony Clay Loam (OmE). These soils are generally moist with low to non-existent infiltration capacity and are therefore not suitable for infiltration. Groundwater was not encountered during the shallow boring but is estimated to be near an elevation of 67.6 feet below ground surface based on nearby Water Well Reports maintained by the Washington State Department of Ecology. This is described in greater detail in Section C "Soils Evaluation" of this report.

4. **Identify the BMPs used in the design, and their sources.**

   As demonstrated in Section B of this report, the improvements associated with the project do not meet the thresholds required for treatment. As a result, no treatment BMPs are proposed as part of this development.

5. **Summarize the results of the runoff treatment design, and describe how the proposed design meets the requirements of CMC Chapter 14.02 and the Stormwater Manual.**

   As demonstrated in Section B of this report, the improvements associated with the project do not meet the thresholds required for treatment. As a result, no treatment BMPs are proposed as part of this development.

6. Provide a table that lists the amount of Pollution-Generating Pervious Surfaces (PGPS) and Pollution-Generating Impervious Surfaces (PGIS) for each Threshold Discharge Area (TDA).

The following table lists the areas of Pollution-Generating Pervious Surfaces (PGPS) and Pollution-Generating Impervious Surfaces (PGIS) for each Threshold Discharge Area (TDA):

	TDA 1
Effective Pollution Generating Impervious Surface (PGIS) (Acres)	0.053
Effective Pollution Generating Pervious Surface (PGPS) (Acres)	0.249

Table F1: Effective Pollution Generating Surface Summary

Section G – Flow Control Analysis and Design

1. **Identify the site's suitability for stormwater infiltration for flow control, including tested infiltration rates, logs of soil borings, and other information.**

   One shallow boring to 6.5 feet depth was completed for purposes of infiltration testing. The tested infiltration rate in the shallow boring was determined to be very low, at 1.0 inches per hour. The onsite soil has been identified as Fill Land (Fn) and Olympic Stony Clay Loam (OmE). These soils are generally moist with low to non-existent infiltration capacity and are therefore not suitable for infiltration.

2. **Identify and describe geotechnical or other studies used to complete the analysis and design.**

   Delve Underground has completed a Geotechnical Engineering Report for this development (see Appendix D). One soil boring (B-1) was completed on site to a depth of 51.5 feet below ground surface and one shallow boring to 6.5 feet depth was completed for purposes of infiltration testing. The tested infiltration rate in the shallow boring was determined to be very low, at 1.0 inches per hour. The onsite soil has been identified as Fill Land (Fn) and Olympic Stony Clay Loam (OmE). These soils are generally moist with low to non-existent infiltration capacity and are therefore not suitable for infiltration. Groundwater was not encountered during the shallow boring but is estimated to be near an elevation of 67.6 feet below ground surface based on nearby Water Well Reports maintained by the Washington State Department of Ecology. This is described in greater detail in Section C "Soils Evaluation" of this report.

3. **If infiltration cannot be utilized for flow control, provide the following additional information:**

   a. **Identify areas where flow control credits can be obtained for dispersion, LID, or other measures, per the requirements in the Stormwater Manual.**

      Due to the low infiltration rate and poor soil conditions, infiltration LID measures are not applicable to this project.

   b. **Provide the approximate sizing and location of flow control facilities for each TDA, per Volume III of the Stormwater Manual.**

      As demonstrated in Section B of this report, the improvements associated with the project do not meet the thresholds required for flow control. As a result, no flow control BMPs are proposed as part of this development.

   c. **Identify the criteria (and their sources) used to complete the analysis, including pre-developed and post-developed land use characteristics.**

      As demonstrated in Section B of this report, the improvements associated with the project do not meet the thresholds required for flow control. As a result, no flow control BMPs are proposed as part of this development. In order to demonstrate that the developed stormwater flows do not meet the 0.15 cfs threshold for the 100-year storm, the stormwater flows have been modeled based on the continuous storm in accordance with the requirements of the City of Camas Stormwater Design Standards Manual Section 4.02 and Volume III of the SMMWW. WWHM has been used for the continuous simulation model for this development.

A summary of the pre-developed and developed TDA 1 land use areas are shown in the tables below:

Pre-developed TDA 1:

Land Use	Description	Area (ac)
Pervious	SG4, Lawn, Flat	0.407
Impervious	Roof Tops / Flat	0.049
	Driveways / Flat	0.032
	Sidewalks / Flat	0.016

Table G1: Land Use Areas for Pre-developed TDA 1

Developed TDA 1:

Land Use	Description	Area (ac)
Pervious	SG4, Lawn, Flat	0.255
Impervious	Roof Tops / Flat	0.086
	Driveways / Flat	0.145
	Sidewalks / Flat	0.018

Table G2: Land Use Areas for Developed TDA 1

4. **For sites considered to be historical prairie, submit a project site report prepared by a wetland scientist or horticulturist experienced in identifying soils, plans, and other evidence associated with historic prairies to demonstrate the existence of historic prairie on the project site. Areas within Camas that were historically prairie include Fern and Lacamas prairies. Contact City staff for a map showing potential prairie locations.**

   This section does not apply.

5. **Complete a hydrologic analysis for existing and developed site conditions, in accordance with the requirements of Chapter 4 of this manual and Chapter 2, Volume III of the Stormwater Manual, using an approved continuous runoff simulation model. Compute existing and developed flow duration for all subbasins. Provide an output table from the continuous flow model.**

   As demonstrated in Section B of this report, the improvements associated with the project do not meet the thresholds required for flow control. As a result, no flow control BMPs are proposed as part of this development. Refer to Appendix C for a detailed WWHM hydraulic analysis of the pre-developed and developed site during the 2-, 10-, 50-, and 100-yr. continuous storm events.

6. **Include and reference all hydrologic computations, equations, graphs, and any other aids necessary to clearly show the methodology and results.**

   Refer to Appendix C for a detailed WWHM hydraulic analysis of the pre-developed and developed site during the 2-, 10-, 50-, and 100-yr. continuous storm events.

7. **Include all maps, exhibits, graphics, and references used to determine existing and developed site hydrology.**

   Refer to the Catchment Plans in Appendix E for catchment area locations and the specific locations of the stormwater facilities.

   Refer to the Maps section of this report.

Section H – Wetlands Protection

This section does not apply.

Technical Appendix

Appendix A	Hydrologic Soil Groups in Clark County Table A-3: Runoff Curve Numbers Table 7: Estimated Physical and Chemical Properties of Soils Isopluvial Maps from City of Camas Stormwater Design Manual
Appendix B	Figure 1.1: Flow Chart for Determining Stormwater Requirements Figure 1.2: New Development Minimum Requirements Flow Chart
Appendix C	WWHM2012 Modeling
Appendix D	Geotechnical Engineering Report by Delve Underground dated June 2025.
Appendix E	Pre-developed Catchment Plan, Sheet 1 of 2 Developed Catchment Plan, Sheet 2 of 2

Hydrologic Soil Groups for Soils in Clark County

U.S. Department of Agriculture

Soil Conservation Service

WATER FEATURES

Survey Area: CLARK COUNTY, WASHINGTON

Map Symbol	Soil Name	Hydrologic Group	Clark County WWHM Soils Group
BpB	BEAR PRARIE	B	2
BpC	BEAR PRARIE	B	2
CnB	CINEBAR	B	2
CnD	CINEBAR	B	2
CnE	CINEBAR	B	2
CnG	CINEBAR	B	2
CrE	CINEBAR	B	2
CrG	CINEBAR	B	2
CsF	CISPUS	B	2
CtA	CLOQUATO	B	2
CvA	COVE	D	4
CwA	COVE	D	4
DoB	DOLLAR	C	3
Fn	FILL LAND	In-situ	N/A
GeB	GEE	C	4

Map Symbol	Soil Name	Hydrologic Group	Clark County WWHM Soils Group
NbA	NEWBERG	B	2
NbB	NEWBERG	B	2
OdB	ODNE	D	4
OeD	OLEQUA	B	3
OeE	OLEQUA	B	3
OeF	OLEQUA	B	3
OhD	OLEQUA VARIANT	C	4
OhF	OLEQUA VARIANT	C	4
OlB	OLYMPIC	B	3
OlD	OLYMPIC	B	3
OlE	OLYMPIC	B	3
OlF	OLYMPIC	B	3
OmE	OLYMPIC	B	3
OmF	OLYMPIC	B	3
OpC	OLYMPIC VARIANT	C	3
OpE	OLYMPIC VARIANT	C	3
OpG	OLYMPIC VARIANT	C	3
OrC	OLYMPIC VARIANT	C	3
PhB	PILCHUCK	C	2
PoB	POWELL	C	3
PoD	POWELL	C	3
PoE	POWELL	C	3
PuA	PUYALLUP	B	2
Ra	RIVERWASH	D	N/A

Table A-3: Runoff Curve Numbers

LAND USE DESCRIPTION		CURVE NUMBERS BY HYDROLOGIC SOIL GROUP A	B	C	D
Cultivated land (1):	winter condition	86	91	94	95
Mountain open areas:	low growing brush and grasslands	74	82	89	92
Meadow or pastures:		65	78	85	89
Wood or forest land:	undisturbed	42	64	76	81
Wood or forest land:	young second growth or brush	55	72	81	86
Orchard:	with cover crop	81	88	92	94
Open spaces, lawns, parks, golf courses, cemeteries, landscaping:					
Good condition:	grass cover on over 75% of the area	68	80	86	90
Fair condition:	grass cover on 50-75% of the area	77	85	90	92
Gravel roads & parking lots:		76	85	89	91
Dirt roads & parking lots:		72	82	87	89
Impervious surfaces, pavement, roofs etc.		98	98	98	98
Open water bodies:		100	100	100	100
Single family residential (2):					
Dwelling Unit/Gross Acre	% Impervious (3)	Separate curve number shall be selected for pervious & impervious portions of the site or basin			
1.0 DU/GA	15				
1.5 DU/GA	20				
2.0 DU/GA	25				
2.5 DU/GA	30				
3.0 DU/GA	34				
3.5 DU/GA	38				
4.0 DU/GA	42				
4.5 DU/GA	46				
5.0 DU/GA	48				
5.5 DU/GA	50				
6.0 DU/GA	52				
6.5 DU/GA	54				
7.0 DU/GA	56				
PUD's, condos, apartments, commercial businesses & industrial areas	% impervious must be computed				

TABLE 7.—*Estimated physical and chemical properties of the soils*

Soil series and map symbols	Depth from surface	Classification: Dominant USDA texture	Classification: Unified	Classification: AASHO	Percentage passing sieve—: No. 4 (4.76 mm.)[1]	Percentage passing sieve—: No. 10 (2.0 mm.)	Percentage passing sieve—: No. 200 (0.074 mm.)	Permeability	Available water capacity	Reaction
	Inches							*Inches per hour*	*Inches per inch of soil*	*pH*
Bear Prairie: BpB, BpC.	0–51	Silt loam	CL	A–6	90–100	85–95	75–85	0.63–2.0	0.19–0.21	4.6–5.5
	51–75	Gravelly loam	ML	A–4	70–80	65–75	50–60	0.63–2.0	0.14–0.16	5.1–6.0
Cinebar: CnB, CnD, CnE, CnG.	0–65	Silt loam and loam.	ML	A–4	90–100	85–95	60–70	0.63–2.0	0.19–0.21	5.1–6.5
CrE, CrG.	0–60	Silt loam	CL	A–4	70–80	60–80	50–70	0.63–2.0	0.12–0.14	5.1–6.5
Cispus: CsF.	0–24	Gravelly sandy loam.	SM	A–2	70–80	65–75	20–30	2.0–6.3	0.08–0.10	5.6–6.5
	24–53	Very cobbly sand	SM	A–1	35–50	30–50	5–10	>20.0	0.03–0.05	5.6–6.5
Cloquato: CtA.	0–40	Silt loam	ML	A–4	--------	100	70–80	0.63–0.20	0.19–0.21	5.6–7.3
	40–72	Sandy loam and sand.	SM	A–2	100	95–100	15–30	>6.3	0.08–0.10	5.6–7.3
Cove: CvA.	0–36	Clay	CH	A–7	--------	100	70–80	<0.06	0.14–0.16	5.6–7.3
	36–54	Gravelly silty clay loam.	CL	A–7	65–75	60–70	50–60	0.06–0.20	0.15–0.17	5.6–7.3
Cove, thin solum: CwA.	0–14	Silty clay loam	CL	A–7	--------	100	85–95	0.06–0.20	0.19–0.21	4.5–6.0
	14–21	Clay	CH	A–7	--------	100	70–80	<0.06	0.14–0.16	5.6–7.3
	21–60	Silt loam	ML or CL	A–4 or A–6.	--------	100	65–75	0.06–0.20	0.19–0.21	6.6–7.3
Dollar: DoB.	0–32	Loam	ML	A–4	100	90–95	60–70	0.63–2.0	0.16–0.18	4.5–6.0
	32–60	Loam (fragipan)	ML or CL	A–4	100	95–100	60–70	<0.06	0.06–0.08	6.0
Fill land: Fn.	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Gee: GeB, GeD, GeE, GeF.	0–22	Silt loam	ML or CL	A–6	--------	100	70–85	0.63–2.0	0.19–0.21	5.1–6.0
	22–72	Silty clay loam	CL	A–6	--------	100	70–80	<0.06	0.06–0.08	5.1–6.0
Gumboot: GuB.	0–12	Silt loam	OL	A–7	90–95	85–95	75–85	0.63–2.0	0.19–0.21	4.5–7.3
	12–50	Gravelly silty clay loam, clay loam.	CL	A–6	90–100	85–95	65–75	0.06–0.2	0.19–0.21	6.1–7.3
	50–60	Very gravelly silty clay.	GC	A–7	40–50	35–50	25–35	<0.06	0.06–0.08	6.1–7.3
Hesson: HcB, HcD, HcE, HcF.	0–22	Clay loam	CL	A–7	85–95	85–95	65–75	0.63–2.0	0.19–0.21	4.5–6.0
	22–91	Clay	CH	A–7	85–90	85–90	75–85	0.2–0.63	0.14–0.16	4.5–6.0
HgB, HgD, HhE.	0–22	Gravelly clay loam.	SC	A–6	75–85	70–80	40–50	0.63–2.0	0.14–0.16	4.5–6.0
	22–91	Gravelly clay	CH	A–7	75–85	70–80	60–70	0.2–0.63	0.11–0.13	4.5–6.0
Hillsboro: HlA, HlB, HlC, HlD, HlE, HlF.	0–36	Loam	ML	A–4	--------	100	55–65	0.63–2.0	0.16–0.18	5.1–6.5
	36–62	Sandy loam and sand.	SM	A–1	95–100	95–100	15–25	2.0–6.3	0.10–0.12	5.6–7.3
HoA, HoB, HoC, HoD, HoE, HoG, HsB.	0–86	Silt loam (boulders on surface of HsB).	ML	A–4	--------	100	80–90	0.63–2.0	0.19–0.21	5.0–6.0

See footnotes at end of table.

TABLE 7.—*Estimated physical and chemical properties of the soils*—Continued

Soil series and map symbols	Depth from surface	Classification: Dominant USDA texture	Classification: Unified	Classification: AASHO	Percentage passing sieve—: No. 4 (4.76 mm.)[1]	Percentage passing sieve—: No. 10 (2.0 mm.)	Percentage passing sieve—: No. 200 (0.074 mm.)	Permeability	Available water capacity	Reaction
	Inches							*Inches per hour*	*Inches per inch of soil*	*pH*
Hockinson: HtA, HuB, HvA. For properties of the Dollar part of HvA, see Dollar series.	0–23	Loam	ML or CL	A–4	--------	100	55–65	0.63–2.0	0.16–0.18	5.1–6.0
	23–51	Fine sandy loam and loam.	SC or CL	A–4	--------	100	45–55	0.06–0.2	0.14–0.16	5.6–6.5
	51–74	Silt loam	ML	A–4	--------	100	60–70	0.2–0.63	0.19–0.21	5.6–6.5
Kinney: KeC, KeE, KeF, KnF.	0–60	Gravelly silt loam, gravelly silty clay loam, and gravelly clay loam.	ML	A–7	70–100	65–95	55–75	0.63–2.0	0.14–0.16	5.1–6.0
	60	Weathered igneous rock.								
Larchmount: LaE, LaG.	0–62	Cobbly silt loam and clay loam.	ML	A–4	[3] 55–75	50–70	35–50	0.63–2.0	0.12–0.14	4.5–6.5
	62	Fractured bedrock.								
LcG.	0–62	Silt loam and clay loam.	ML	A–4	[4] 30–55	25–50	15–35	0.63–2.0	0.08–0.10	4.5–6.5
	62	Fractured bedrock.								
L[illegible]: LgB, LgD, LgF, LlB.	0–33	Very gravelly loam.	GM	A–2	40–50	35–50	20–35	0.63–2.0	0.08–0.10	5.6–7.3
	33–70	Very gravelly coarse sandy loam.	GM	A–1	40–50	35–50	5–15	6.3–20.0	0.06–0.08	6.1–7.3
	70	Very gravelly loamy coarse sand.								
LrC, LrF.	0–14	Gravelly loam and gravelly clay loam.	SM	A–4	55–75	50–70	35–50	0.63–2.0	0.12–0.14	6.1–7.3
	14–35	Very gravelly clay loam (weakly cemented).	GC	A–2 or A–4	35–50	30–55	20–40	0.63–2.0	0.10–0.12	6.1–7.3
	35–60	Very gravelly clay loam.	GC	A–2	25–45	20–40	15–30	<0.06	0.04–0.06	6.1–7.3
McBee: McB, MeA.	0–65	Silty clay loam, clay.	CL	A–6	--------	100	80–90	0.63–2.0	0.19–0.21	5.6–6.0
MlA.	0–19	Silt loam and loam.	ML	A–4	90–95	85–95	50–60	0.63–2.0	0.17–0.19	6.1–7.3
	19–44	Gravelly fine sandy loam.	SM	A–4	75–90	70–85	35–50	0.63–2.0	0.10–0.12	6.1–7.3
	44–62	Very gravelly loamy sand.	GM	A–1	35–50	30–50	5–15	>20.0	0.04–0.06	6.1–7.3

See footnotes at end of table.

414–134—72——6

TABLE 7.—*Estimated physical and chemical properties of the soils*—Continued

Soil series and map symbols	Depth from surface	Classification: Dominant USDA texture	Classification: Unified	Classification: AASHO	Percentage passing sieve—: No. 4 (4.76 mm.) [1]	Percentage passing sieve—: No. 10 (2.0 mm.)	Percentage passing sieve—: No. 200 (0.074 mm.)	Permeability	Available water capacity	Reaction
	Inches							*Inches per hour*	*Inches per inch of soil*	*pH*
Minniece: MnA, MnD.	0–48	Silty clay and clay	CH	A–7	90–95	85–95	65–75	<0.06	0.06–0.08	6.1–7.8
	48	Basalt bedrock.								
MoA.	0–12	Silt loam	ML	A–4	100	95–100	65–75	0.63–2.0	0.19–0.21	6.1–6.5
	12–22	Silty clay	CH	A–7	95–100	95–100	80–90	0.06–0.2	0.12–0.14	6.1–6.5
	22–60	Very gravelly clay loam (weakly cemented).	GC	A–2	35–50	30–50	20–35	<0.06	0.03–0.05	5.6–6.5
Mossyrock: MsB.	0–23	Silt loam	OL or OH	A–5	95–100	95–100	50–60	0.63–2.0	0.19–0.21	6.1–6.5
	23–60	Silt loam	ML	A–5	100	95–100	55–65	0.63–2.0	0.19–0.21	6.6–7.3
	60–74	Loam	ML	A–4	100	95–100	70–80	0.63–2.0	0.16–0.18	6.1–7.3
Newberg: NbA, NbB.	0–7	Silt loam	ML	A–4	--------	100	70–80	0.63–2.0	0.19–0.21	5.6–6.5
	7–52	Fine sandy loam and sandy loam.	SM or ML	A–4	--------	100	40–55	2.0–6.3	0.13–0.15	6.1–7.3
	52–72	Sand	SM	A–1	--------	100	5–15	0.63–20.0	0.05–0.07	6.6–7.3
Odne: OdB.	0–50	Silt loam, silty clay loam, clay loam, and loam.	CL	A–4 or A–6	--------	100	75–85	<0.06	0.10–0.12	5.0–6.5
Olequa: OeD, OeE, OeF.	0–17	Silt loam	ML	A–7	--------	100	75–85	0.63–2.0	0.19–0.21	6.1–6.5
	17–90	Heavy silt loam and silty clay loam.	CL	A–7	--------	100	80–90	0.2–0.63	0.19–0.21	4.5–6.5
OhD, OhF.	0–32	Silty clay loam	CL	A–7	95–100	90–95	85–95	0.2–0.63	0.19–0.21	[illegible]–6.0
	32–82	Silty clay and clay	CH	A–7	95–100	90–95	85–95	<0.06	0.06–0.08	5.1–6.5
Olympic: OlB, OlD, OlE, OlF, OmE, OmF.	0–44	Clay loam and silty clay loam.	ML or CL	A–7	90–100	90–100	75–85	0.2–0.63	0.19–0.21	5.1–6.0
	44–59	Gravelly clay loam.	GC	A–4	75–90	70–85	35–50	0.2–0.63	0.10–0.12	4.5–5.5
	59	Fractured basalt.								
OpC, OpE, OpG, OrC.	0–30	Heavy clay loam and heavy silty clay loam.	ML or CL	A–7	90–95	90–95	75–85	0.2–0.63	0.19–0.21	5.1–6.0
	30	Fractured basalt.								
Pilchuck: PhB.	0–60	Fine sand	SM	A–3	95–100	90–100	5–10	6.3–20.0	0.05–0.07	6.1–7.3
Powell: PoB, PoD, PoE.	0–23	Silt loam	ML	A–4	--------	100	80–90	0.63–0.20	0.18–0.20	5.1–6.0
	23–63	Silt loam (fragipan).	ML	A–4	--------	100	80–90	0.06–0.20	0.06–0.08	5.1–6.0
Puyallup: PuA.	0–27	Stratified fine sandy loam, loam, and loamy sand.	SM	A–4	100	95–100	35–50	2.0–6.3	0.10–0.12	5.6–6.5
	27–60	Gravelly sand	SP or SW	A–1	70–90	65–85	0–5	6.3–20.0	0.04–0.06	6.6–7.3
Riverwash, sandy: Ra.	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Riverwash, cobbly: Rc.	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Rock land: Rk.	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Rough broken land: Ro.	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)

See footnotes at end of table.

TABLE 7.—*Estimated physical and chemical properties of the soils*—Continued

Soil series and map symbols	Depth from surface	Classification: Dominant USDA texture	Classification: Unified	Classification: AASHO	Percentage passing sieve—: No. 4 (4.76 mm.) [1]	Percentage passing sieve—: No. 10 (2.0 mm.)	Percentage passing sieve—: No. 200 (0.074 mm.)	Permeability	Available water capacity	Reaction
	Inches							*Inches per hour*	*Inches per inch of soil*	*pH*
Salkum: SaC.	0–8	Silty clay loam	CL	A–6	--------	100	80–90	0.2–0.63	0.19–0.21	4.5–6.5
	8–31	Heavy silty clay loam.	CH	A–7	--------	100	80–90	0.2–0.63	0.18–0.20	4.5–5.5
	31–55	Heavy silty clay loam.	CH	A–7	95–100	95–100	90–95	0.06–0.20	0.18–0.20	4.5–5.0
Sara: SlB, SlD, SlF.	0–10	Silt loam	CL	A–4	100	90–95	85–95	0.63–2.0	0.19–0.21	5.6–6.0
	10–70	Heavy silty clay loam and silty clay.	CL	A–6	100	95–100	85–95	<0.06	0.06–0.08	4.0–5.0
Sauvie: SmA, SmB, SpB.	0–63	Silty clay loam and silt loam.	CL	A–6 or A–7	--------	100	75–85	0.2–0.63	0.19–0.21	6.1–7.3
SnA.	0–36	Silty clay loam	CL	A–7	--------	100	75–85	0.2–0.63	0.19–0.21	6.1–6.5
	36–63	Fine sandy loam.	SM	A–4	--------	100	35–50	2.0–6.3	0.13–0.15	6.1–7.3
Semiahmoo: Sr.	0–40	Muck	Pt	(5)	(5)	(5)	(5)	0.63–2.0	>0.20	4.5–5.5
	40–120	Peat	Pt	(5)	(5)	(5)	(5)	0.63–2.0	>0.20	5.6–7.3
Su.	0–30	Muck	Pt	(5)	(5)	(5)	(5)	0.63–2.0	>0.20	4.5–5.5
	30–60	Stratified sand, silt, and clay.	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Sif[illegible]: SvA.	0–16	Gravelly loam	SM or GM	A–2	60–80	55–75	35–50	2.0–6.3	0.12–0.14	4.5–6.0
	16–60	Very gravelly loamy coarse sand and very gravelly coarse sand.	GP	A–1	40–60	15–30	0–5	>20.0	0.03–0.05	6.1–6.5
Tisch: ThA.	0–31	Silt loam	OL	A–7	--------	100	50–60	0.2–0.63	0.19–0.21	5.6–6.5
	31–45	Muck	Pt	(5)	(5)	(5)	(5)	0.63–2.0	>0.20	5.1–5.5
	45–53	Peat	Pt	(5)	(5)	(5)	(5)	0.63–2.0	>0.20	4.5–5.5
Vader: VaB, VaC.	0–30	Silt loam and loam	ML	A–4	95–100	95–100	50–60	2.0–6.3	0.16–0.18	5.6–6.5
	30	Sandstone bedrock.								
Washougal: WaA, WgB, WgE, WhF.	0–22	Gravelly loam	SM	A–4	55–90	50–85	35–50	0.63–2.0	0.12–0.14	4.5–5.5
	22–36	Very gravelly loam and very gravelly coarse sandy loam.	GM or SM	A–1	35–45	20–40	10–20	0.63–2.0	0.06–0.08	5.1–5.5
	36–60	Sand, gravel, and stones.	GP	A–1	25–35	20–30	0–5	>20.0	0.03–0.05	5.1–5.5
Wind River: WnB, WnD, WnG, WrB, WrF.	0–24	Coarse sandy loam.	SM	A–2	95–100	90–100	25–35	2.0–6.3	0.10–0.12	6.1–7.3
	24–62	Loamy coarse sand and coarse sand.	SM	A–2	95–100	95–100	15–35	6.3–20.0	0.06–0.08	6.6–7.3
Yacolt: YaA, YaC, YcB.	0–39	Gravelly loam	ML, SM	A–4	55–75	50–70	35–60	0.63–2.0	0.12–0.14	5.6–6.0
	[6] 39–61	Cobbly loam	SM, ML	A–4	55–75	50–70	35–55	0.63–2.0	0.12–0.14	5.6–6.0

[1] Includes material more than 3 inches in diameter.
[2] Soil material is too variable for reliable evaluation.
[3] 25 to 45 percent of the profile is cobblestones and stones by weighted average. This material was excluded from the classification.
[4] 45 to 70 percent of the profile is cobblestones and stones by weighted average. This material was excluded from the classification.
[5] Not applicable.
[6] 25 to 45 percent of this horizon is cobblestones and stones by weighted average. This material was excluded from the classification.

Figure A-2: 2-Year, 24-Hour Clark County Isopluvial Map

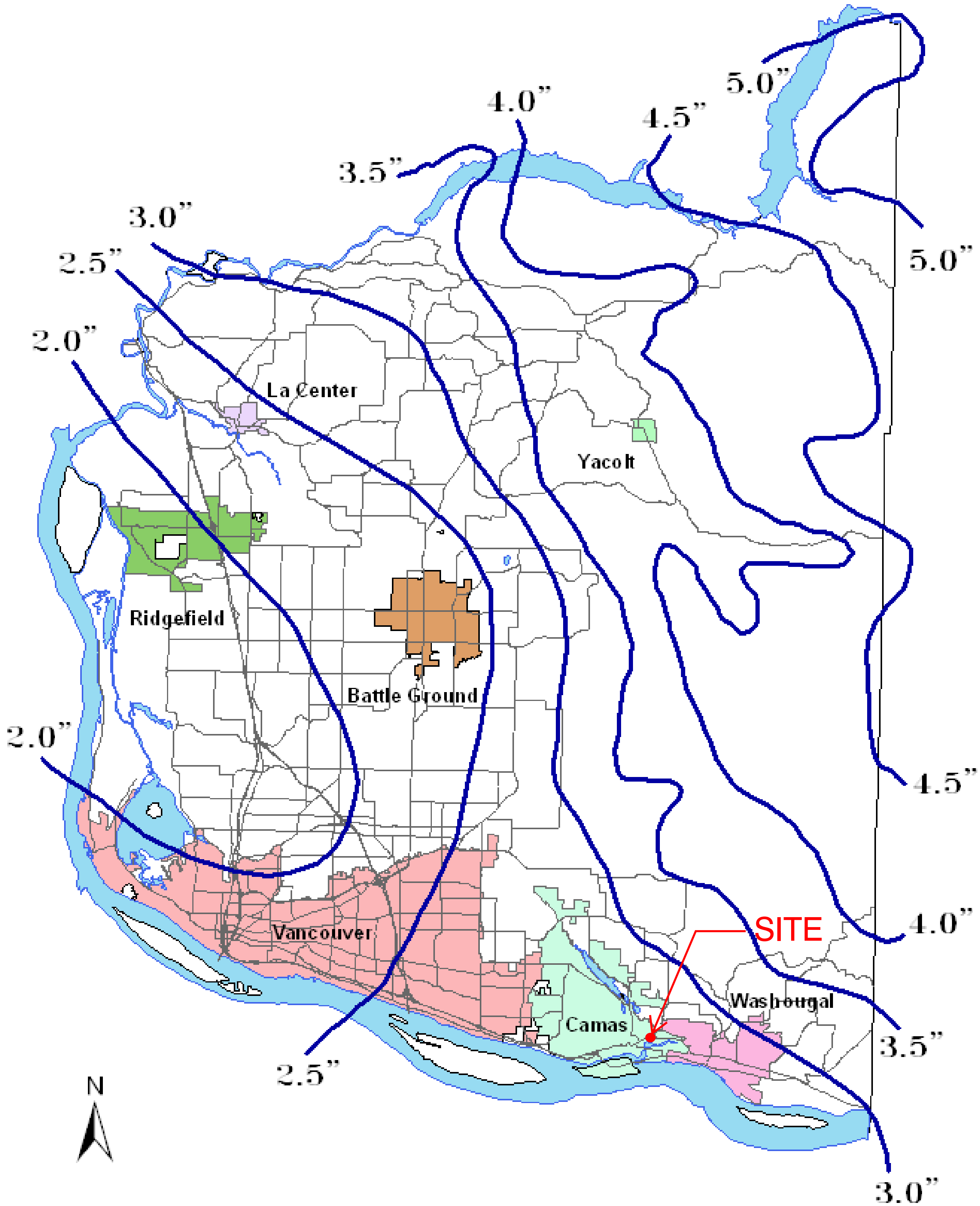


Figure A-3: 10-Year, 24-Hour Clark County Isopluvial Map

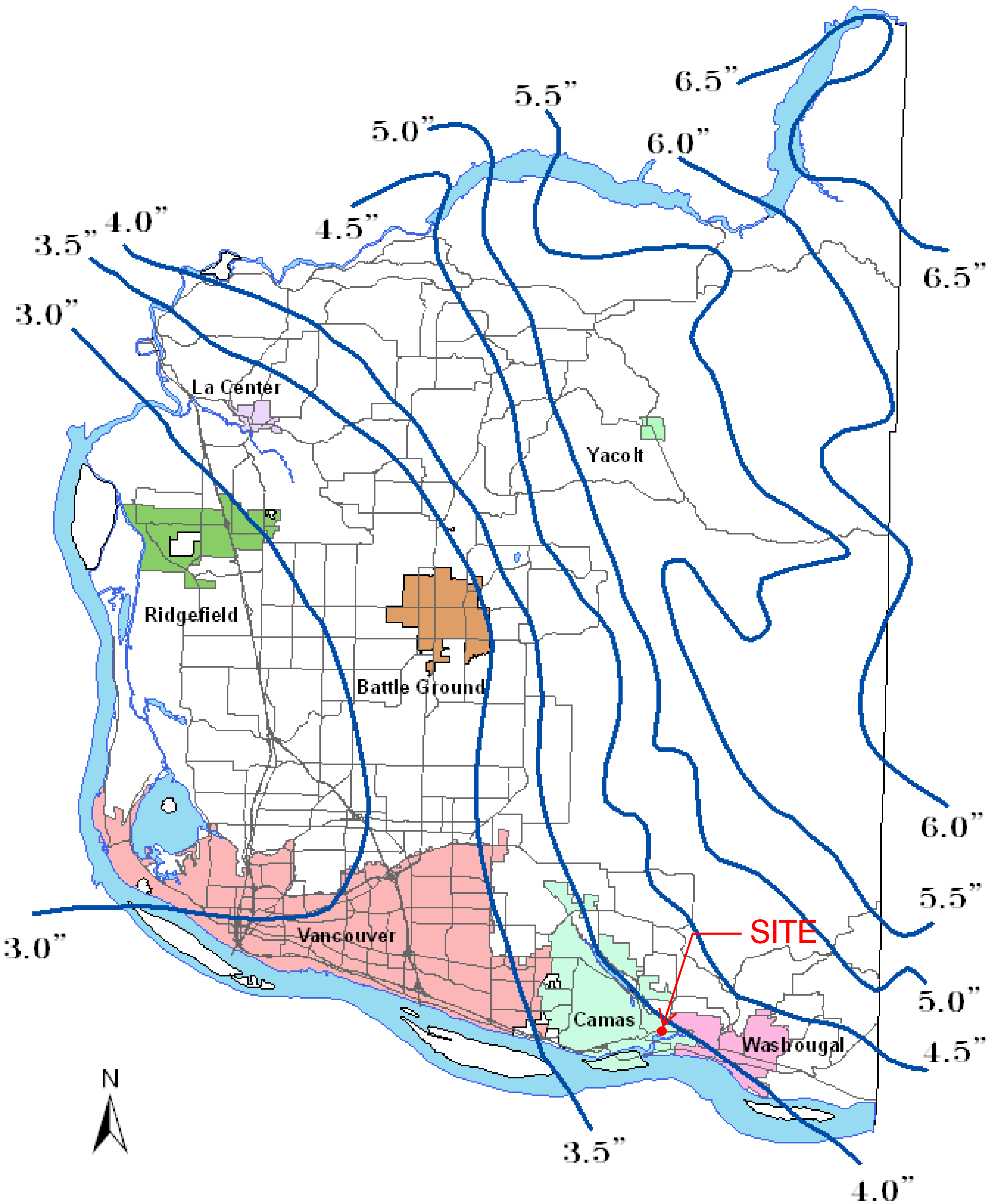
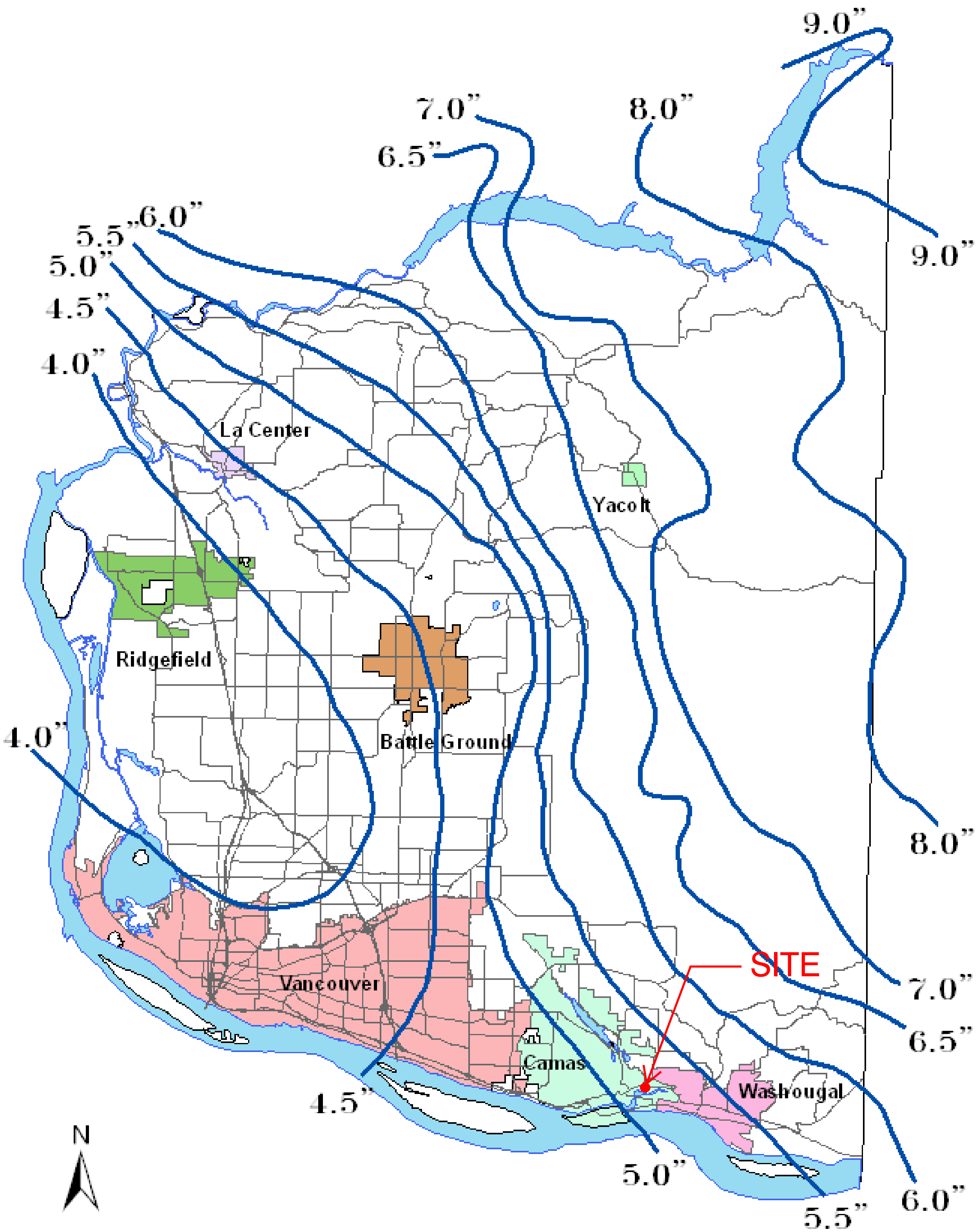


Figure A-5: 100-Year, 24-Hour Clark County Isopluvial Map



Chapter 1: General Requirements
Continued

Figure 1.1: Flow Chart for Determining Stormwater Requirements

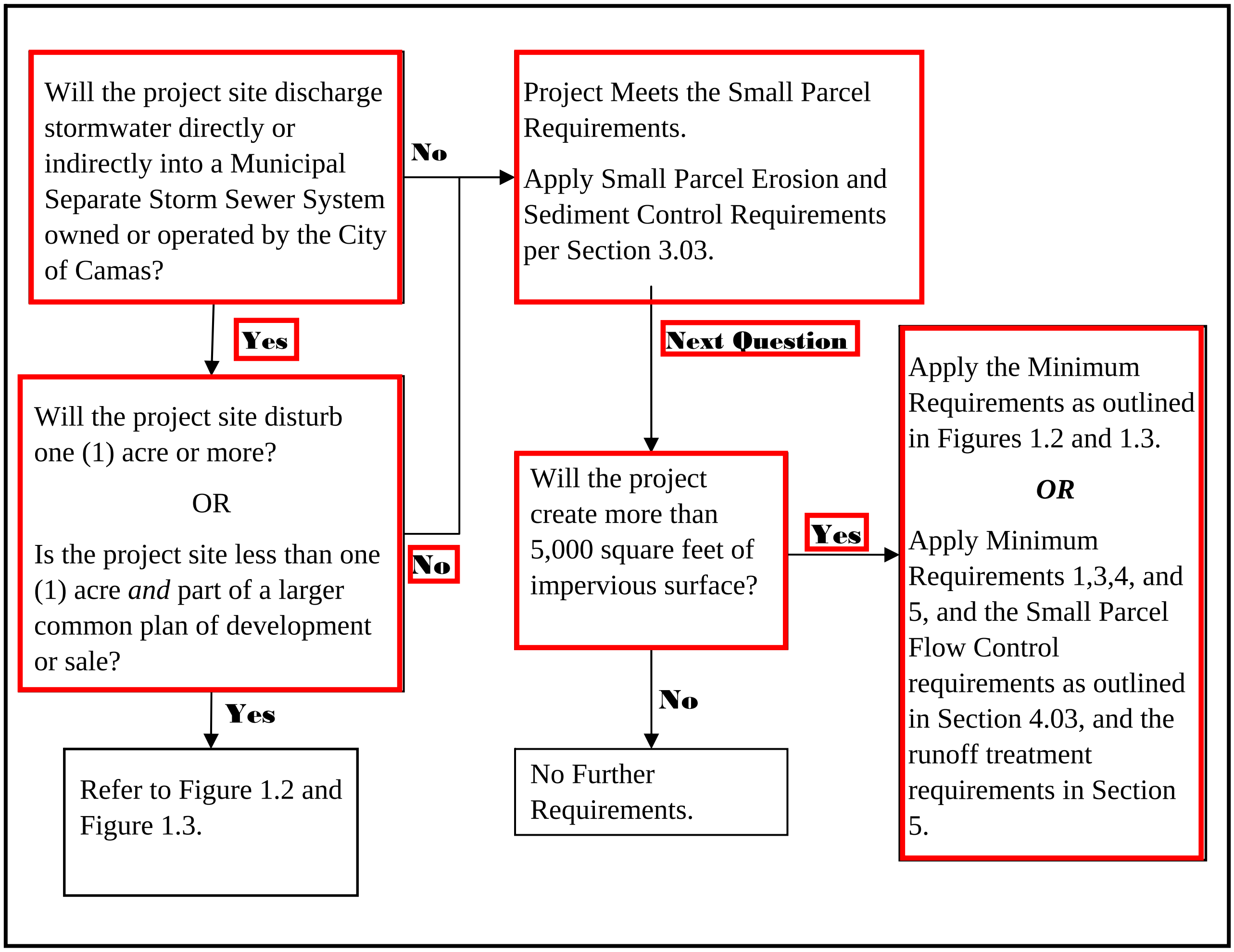
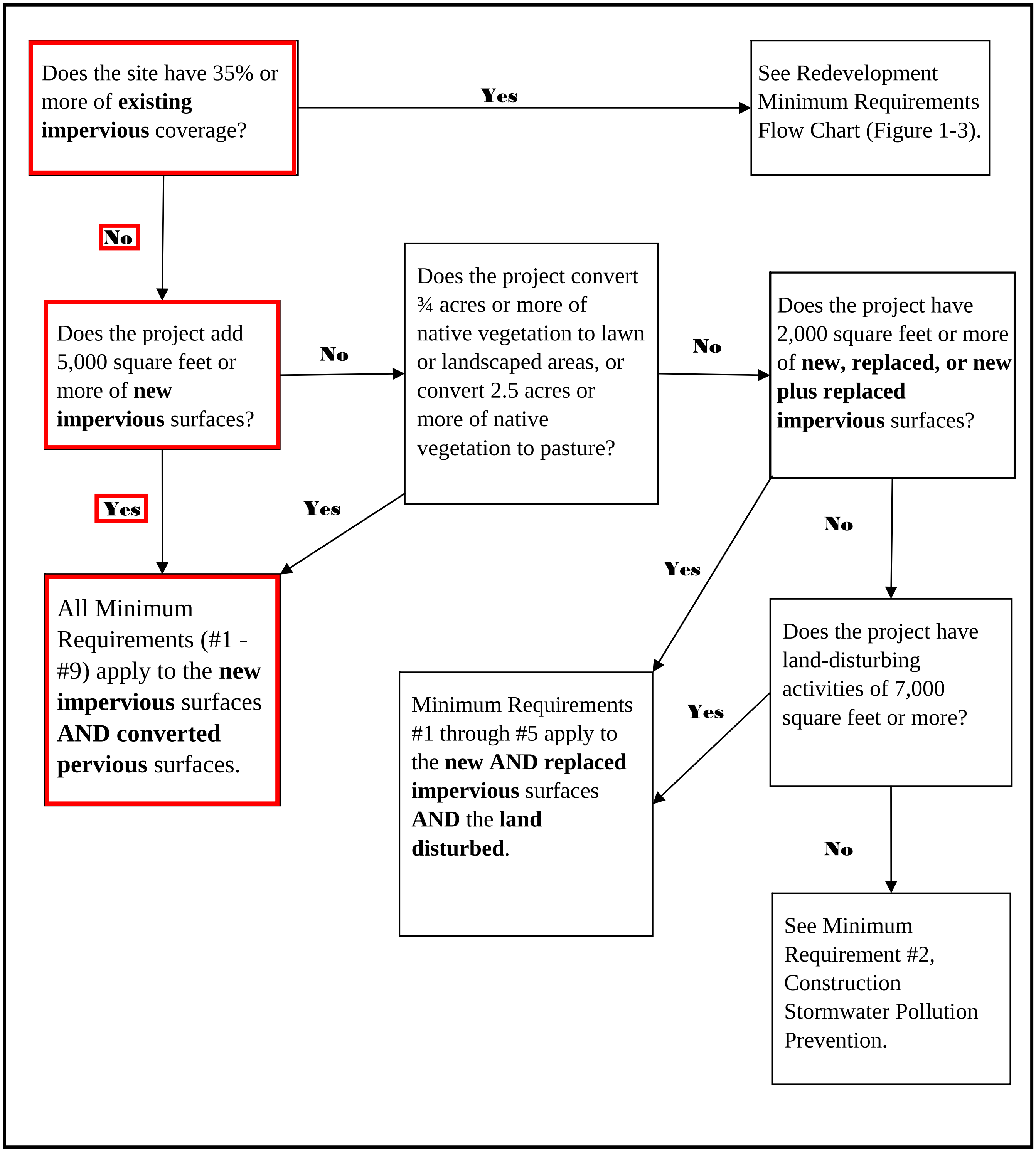


Figure 1.2: New Development Minimum Requirements Flow Chart



WWHM2012

PROJECT REPORT

General Model Information

WWHM2012 Project Name: 18581.e.Project Preliminary

Site Name:	Camas PFAS
Site Address:	1250 E 1st Ave.
City:	Camas
Report Date:	2/13/2025
Gage:	Troutdale
Data Start:	1948/10/01
Data End:	2008/09/30
Timestep:	15 Minute
Precip Scale:	1.370
Version Date:	2023/01/27
Version:	4.2.19

POC Thresholds

Low Flow Threshold for POC1:	50 Percent of the 2 Year
High Flow Threshold for POC1:	50 Year

Landuse Basin Data
Predeveloped Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
SG4, Lawn, Flat	0.407
Pervious Total	0.407
Impervious Land Use	acre
ROOF TOPS FLAT	0.049
DRIVEWAYS FLAT	0.032
SIDEWALKS FLAT	0.016
Impervious Total	0.097
Basin Total	0.504

Mitigated Land Use

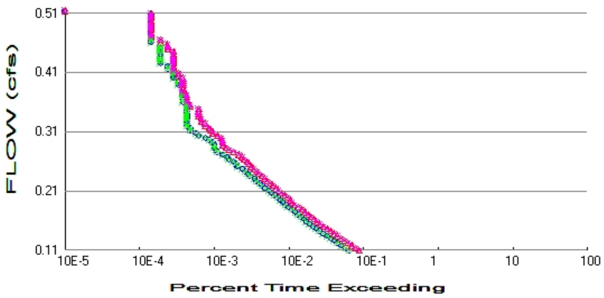
Basin 1

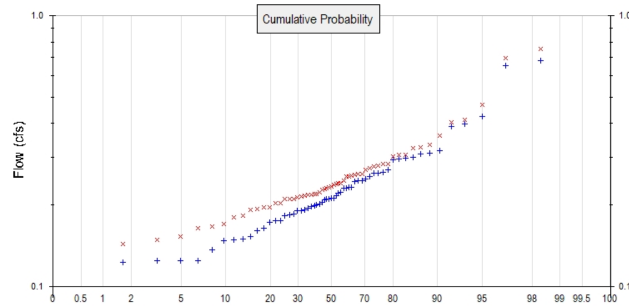
Bypass:	No
GroundWater:	No
Pervious Land Use	acre
SG4, Lawn, Flat	0.255
Pervious Total	0.255
Impervious Land Use	acre
ROOF TOPS FLAT	0.086
DRIVEWAYS FLAT	0.145
SIDEWALKS FLAT	0.018
Impervious Total	0.249
Basin Total	0.504

Routing Elements
Predeveloped Routing

Mitigated Routing

Analysis Results
POC 1





+ Predeveloped   x Mitigated

Predeveloped Landuse Totals for POC #1
Total Pervious Area: 0.407
Total Impervious Area: 0.097

Mitigated Landuse Totals for POC #1
Total Pervious Area: 0.255
Total Impervious Area: 0.249

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	**Flow(cfs)**
2 year	0.211428
5 year	0.292664
10 year	0.354376
25 year	0.441931
50 year	0.514498
100 year	0.593691

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	**Flow(cfs)**
2 year	0.234874
5 year	0.316021
10 year	0.377541
25 year	0.464647
50 year	0.536713
100 year	0.615259

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	**Predeveloped**	**Mitigated**
1949	0.175	0.223
1950	0.186	0.196
1951	0.201	0.210
1952	0.317	0.333
1953	0.205	0.218
1954	0.211	0.269
1955	0.153	0.164
1956	0.270	0.280
1957	0.191	0.196
1958	0.246	0.258

1959	0.125	0.144
1960	0.202	0.231
1961	0.211	0.219
1962	0.197	0.210
1963	0.216	0.237
1964	0.192	0.215
1965	0.209	0.219
1966	0.232	0.240
1967	0.199	0.217
1968	0.424	0.470
1969	0.293	0.360
1970	0.685	0.698
1971	0.147	0.214
1972	0.136	0.170
1973	0.221	0.228
1974	0.246	0.255
1975	0.210	0.220
1976	0.300	0.307
1977	0.124	0.153
1978	0.255	0.277
1979	0.263	0.283
1980	0.182	0.194
1981	0.232	0.241
1982	0.262	0.273
1983	0.298	0.302
1984	0.250	0.260
1985	0.184	0.229
1986	0.223	0.256
1987	0.175	0.191
1988	0.149	0.241
1989	0.231	0.255
1990	0.149	0.180
1991	0.244	0.260
1992	0.194	0.202
1993	0.399	0.412
1994	0.160	0.166
1995	0.212	0.234
1996	0.390	0.404
1997	0.309	0.325
1998	0.312	0.326
1999	0.164	0.182
2000	0.112	0.121
2001	0.124	0.148
2002	0.296	0.306
2003	0.231	0.245
2004	0.123	0.210
2005	0.173	0.233
2006	0.264	0.283
2007	0.190	0.204
2008	0.656	0.752

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	0.6848	0.7516
2	0.6565	0.6983
3	0.4236	0.4698
4	0.3991	0.4122

5	0.3899	0.4042
6	0.3172	0.3605
7	0.3117	0.3329
8	0.3085	0.3260
9	0.2996	0.3253
10	0.2982	0.3066
11	0.2958	0.3061
12	0.2930	0.3024
13	0.2703	0.2833
14	0.2636	0.2831
15	0.2625	0.2802
16	0.2619	0.2773
17	0.2552	0.2728
18	0.2502	0.2692
19	0.2461	0.2602
20	0.2461	0.2601
21	0.2437	0.2581
22	0.2320	0.2561
23	0.2316	0.2550
24	0.2310	0.2547
25	0.2307	0.2454
26	0.2230	0.2413
27	0.2209	0.2411
28	0.2164	0.2397
29	0.2123	0.2369
30	0.2111	0.2335
31	0.2106	0.2329
32	0.2098	0.2311
33	0.2091	0.2287
34	0.2051	0.2282
35	0.2016	0.2227
36	0.2008	0.2195
37	0.1990	0.2193
38	0.1970	0.2186
39	0.1940	0.2178
40	0.1918	0.2165
41	0.1905	0.2147
42	0.1903	0.2137
43	0.1857	0.2103
44	0.1844	0.2103
45	0.1822	0.2097
46	0.1753	0.2036
47	0.1747	0.2025
48	0.1726	0.1964
49	0.1638	0.1958
50	0.1604	0.1937
51	0.1531	0.1914
52	0.1494	0.1819
53	0.1491	0.1798
54	0.1472	0.1701
55	0.1361	0.1661
56	0.1248	0.1639
57	0.1244	0.1529
58	0.1241	0.1483
59	0.1227	0.1437
60	0.1117	0.1210

Duration Flows

The Duration Matching Failed

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.1057	1336	1842	137	Fail
0.1098	1206	1628	134	Fail
0.1140	1065	1463	137	Fail
0.1181	933	1276	136	Fail
0.1222	849	1159	136	Fail
0.1264	760	1037	136	Fail
0.1305	678	937	138	Fail
0.1346	597	846	141	Fail
0.1387	536	758	141	Fail
0.1429	488	682	139	Fail
0.1470	442	604	136	Fail
0.1511	396	544	137	Fail
0.1553	356	494	138	Fail
0.1594	332	451	135	Fail
0.1635	304	414	136	Fail
0.1677	278	380	136	Fail
0.1718	257	340	132	Fail
0.1759	230	315	136	Fail
0.1800	205	279	136	Fail
0.1842	188	245	130	Fail
0.1883	177	231	130	Fail
0.1924	162	217	133	Fail
0.1966	148	199	134	Fail
0.2007	132	183	138	Fail
0.2048	123	166	134	Fail
0.2089	112	152	135	Fail
0.2131	100	140	140	Fail
0.2172	91	128	140	Fail
0.2213	86	118	137	Fail
0.2255	77	107	138	Fail
0.2296	73	99	135	Fail
0.2337	63	91	144	Fail
0.2378	59	82	138	Fail
0.2420	54	78	144	Fail
0.2461	50	71	142	Fail
0.2502	43	65	151	Fail
0.2544	41	61	148	Fail
0.2585	38	58	152	Fail
0.2626	33	52	157	Fail
0.2668	31	50	161	Fail
0.2709	27	45	166	Fail
0.2750	23	38	165	Fail
0.2791	22	33	150	Fail
0.2833	21	30	142	Fail
0.2874	21	27	128	Fail
0.2915	20	27	135	Fail
0.2957	18	27	150	Fail
0.2998	16	26	162	Fail
0.3039	13	23	176	Fail
0.3080	12	20	166	Fail
0.3122	10	19	190	Fail
0.3163	10	18	180	Fail
0.3204	9	16	177	Fail
0.3246	9	16	177	Fail

0.3287	9	14	155	Fail
0.3328	9	14	155	Fail
0.3369	9	13	144	Fail
0.3411	9	13	144	Fail
0.3452	9	13	144	Fail
0.3493	9	13	144	Fail
0.3535	9	10	111	Fail
0.3576	9	10	111	Fail
0.3617	8	9	112	Fail
0.3658	8	9	112	Fail
0.3700	8	9	112	Fail
0.3741	8	9	112	Fail
0.3782	8	8	100	Pass
0.3824	8	8	100	Pass
0.3865	8	8	100	Pass
0.3906	7	8	114	Fail
0.3948	7	8	114	Fail
0.3989	7	8	114	Fail
0.4030	6	8	133	Fail
0.4071	6	7	116	Fail
0.4113	6	7	116	Fail
0.4154	6	6	100	Pass
0.4195	5	6	120	Fail
0.4237	5	6	120	Fail
0.4278	4	6	150	Fail
0.4319	4	6	150	Fail
0.4360	4	6	150	Fail
0.4402	4	6	150	Fail
0.4443	4	6	150	Fail
0.4484	4	6	150	Fail
0.4526	4	5	125	Fail
0.4567	4	5	125	Fail
0.4608	4	5	125	Fail
0.4649	3	4	133	Fail
0.4691	3	4	133	Fail
0.4732	3	3	100	Pass
0.4773	3	3	100	Pass
0.4815	3	3	100	Pass
0.4856	3	3	100	Pass
0.4897	3	3	100	Pass
0.4939	3	3	100	Pass
0.4980	3	3	100	Pass
0.5021	3	3	100	Pass
0.5062	3	3	100	Pass
0.5104	3	3	100	Pass
0.5145	3	3	100	Pass

The development has an increase in flow durations from 1/2 Predeveloped 2 year flow to the 2 year flow or more than a 10% increase from the 2 year to the 50 year flow.
The development has an increase in flow durations for more than 50% of the flows for the range of the duration analysis.

Water Quality

Water Quality BMP Flow and Volume for POC #1

On-line facility volume:	0 acre-feet
On-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.
Off-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.

LID Report

LID Technique	Used for Treatment ?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
Total Volume Infiltrated		0.00	0.00	0.00		0.00	0.00	0%	No Treat. Credit
Compliance with LID Standard 8% of 2-yr to 50% of 2-yr									Duration Analysis Result = Failed

Model Default Modifications

Total of 0 changes have been made.

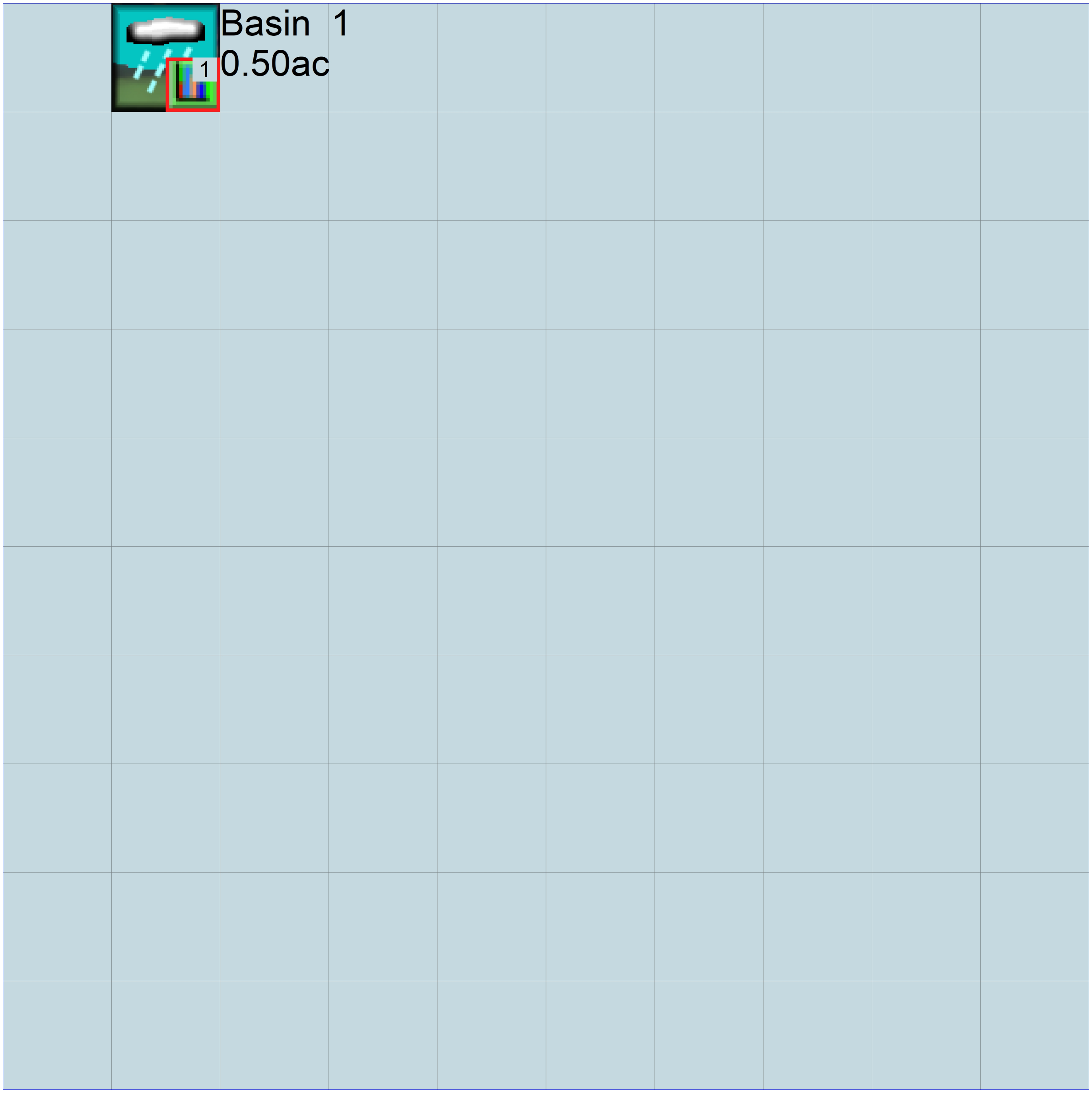
PERLND Changes

No PERLND changes have been made.

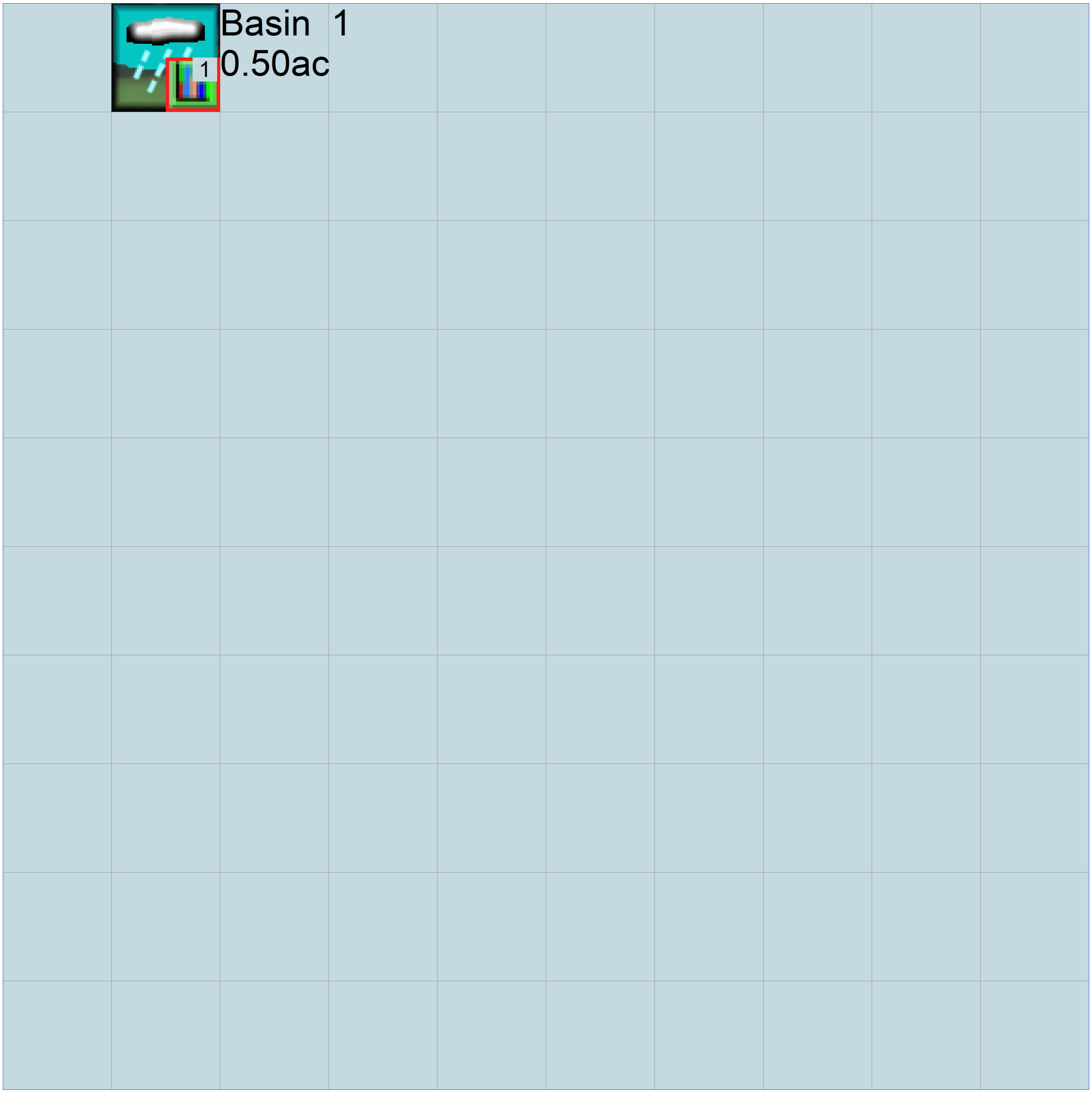
IMPLND Changes

No IMPLND changes have been made.

Appendix
Predeveloped Schematic



Mitigated Schematic



Predeveloped UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1948 10 01        END    2008 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                   UNIT SYSTEM     1
END GLOBAL

FILES
<File>  <Un#>   <-----------File Name------------------------------>***
<-ID->                                                             ***
WDM        26   18581.e.Project Preliminary.wdm
MESSU      25   Pre18581.e.Project Preliminary.MES
           27   Pre18581.e.Project Preliminary.L61
           28   Pre18581.e.Project Preliminary.L62
           30   POC18581.e.Project Preliminary1.dat
END FILES

OPN SEQUENCE
    INGRP              INDELT 00:15
      PERLND      34
      IMPLND       4
      IMPLND       5
      IMPLND       8
      COPY       501
      DISPLY       1
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        Basin  1                   MAX                      1    2   30    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
  501         1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
  END OPCODE
  PARM
    #    #         K ***
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                          User  t-series Engl Metr ***
                                          in  out          ***
   34      SG4, Lawn, Flat         1    1    1    1   27    0
  END GEN-INFO
  *** Section PWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
   34         0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ***************************** PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC  *********
```

```
   34         0    0    4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  PWAT-PARM1
    <PLS >  PWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
   34         0    0    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2         ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
   34             0         6      0.02       400      0.05         0      0.96
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
   34             0         0         3         2         0         0         0
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                               ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
   34           0.1       0.2      0.25         2       0.4      0.25
  END PWAT-PARM4

  PWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
              ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
    # -  # ***  CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
   34             0         0         0         0       2.5         1         0
  END PWAT-STATE1

END PERLND

IMPLND
  GEN-INFO
    <PLS ><-------Name------->   Unit-systems   Printer ***
    # -  #                     User  t-series Engl Metr ***
                                      in  out           ***
    4      ROOF TOPS/FLAT         1    1    1   27    0
    5      DRIVEWAYS/FLAT         1    1    1   27    0
    8      SIDEWALKS/FLAT         1    1    1   27    0
  END GEN-INFO
  *** Section IWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
    4         0    0    1    0    0    0
    5         0    0    1    0    0    0
    8         0    0    1    0    0    0
  END ACTIVITY

  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL    *********
    4         0    0    4    0    0    4    1    9
    5         0    0    4    0    0    0    1    9
    8         0    0    4    0    0    0    1    9
  END PRINT-INFO

  IWAT-PARM1
    <PLS >  IWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP  VRS  VNN RTLI     ***
    4         0    0    0    0    0
    5         0    0    0    0    0
    8         0    0    0    0    0
  END IWAT-PARM1
```

```
  IWAT-PARM2
    <PLS >      IWATER input info: Part 2         ***
    # -  # ***  LSUR     SLSUR      NSUR     RETSC
    4            400      0.01       0.1       0.1
    5            400      0.01       0.1       0.1
    8            400      0.01       0.1       0.1
  END IWAT-PARM2

  IWAT-PARM3
    <PLS >      IWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN
    4              0         0
    5              0         0
    8              0         0
  END IWAT-PARM3

  IWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
    # -  # ***  RETS      SURS
    4              0         0
    5              0         0
    8              0         0
  END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <-factor->     <Name>   #   Tbl#   ***
Basin  1***
PERLND  34                       0.407     COPY   501     12
PERLND  34                       0.407     COPY   501     13
IMPLND   4                       0.049     COPY   501     15
IMPLND   5                       0.032     COPY   501     15
IMPLND   8                       0.016     COPY   501     15

******Routing******
END SCHEMATIC

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
COPY   501 OUTPUT MEAN   1 1   48.4        DISPLY   1     INPUT  TIMSER 1



<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
END NETWORK

RCHRES
  GEN-INFO
    RCHRES       Name        Nexits   Unit Systems   Printer                 ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG            ***
                                         in  out                             ***
  END GEN-INFO
  *** Section RCHRES***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG ***
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ******************* PIVL  PYR
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR  *********
  END PRINT-INFO

  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                                      ***
```

```
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
            FG FG FG FG  possible  exit  *** possible  exit      possible  exit
             *  *  *  *    *  *  *  *  *       *  *  *  *  *        ***
  END HYDR-PARM1

  HYDR-PARM2
    # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50       ***
  <------><--------><--------><--------><--------><--------><-------->       ***
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                         ***
    # -  # ***   VOL     Initial  value  of COLIND     Initial  value  of OUTDGT
          *** ac-ft     for each possible exit       for each possible exit
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
  END HYDR-INIT
END RCHRES

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL    1.37           PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL    1.37           IMPLND   1 999 EXTNL  PREC
WDM      1 EVAP     ENGL    0.8            PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL    0.8            IMPLND   1 999 EXTNL  PETINP

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
COPY   501 OUTPUT MEAN   1 1     48.4      WDM    501 FLOW     ENGL      REPL
END EXT TARGETS

MASS-LINK
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>       <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                <Name> # #***
  MASS-LINK       12
PERLND     PWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   12

  MASS-LINK       13
PERLND     PWATER IFWO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   13

  MASS-LINK       15
IMPLND     IWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   15


END MASS-LINK

END RUN
```

Mitigated UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1948 10 01        END    2008 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                   UNIT SYSTEM     1
END GLOBAL

FILES
<File>  <Un#>   <-----------File Name------------------------------>***
<-ID->                                                              ***
WDM        26   18581.e.Project Preliminary.wdm
MESSU      25   Mit18581.e.Project Preliminary.MES
           27   Mit18581.e.Project Preliminary.L61
           28   Mit18581.e.Project Preliminary.L62
           30   POC18581.e.Project Preliminary1.dat
END FILES

OPN SEQUENCE
    INGRP              INDELT 00:15
      PERLND      34
      IMPLND       4
      IMPLND       5
      IMPLND       8
      COPY       501
      DISPLY       1
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        Basin  1                    MAX                    1    2   30    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
  501         1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
  END OPCODE
  PARM
    #    #         K ***
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                          User  t-series Engl Metr ***
                                         in  out            ***
   34      SG4, Lawn, Flat         1    1    1    1   27    0
  END GEN-INFO
  *** Section PWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
   34         0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ***************************** PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC  *********
```

```
  34         0    0    4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  PWAT-PARM1
    <PLS >  PWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
  34         0    0    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2         ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
  34              0         6      0.02       400      0.05         0      0.96
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
  34              0         0         3         2         0         0         0
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                                     ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
  34            0.1       0.2      0.25         2       0.4      0.25
  END PWAT-PARM4

  PWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
              ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
    # -  # ***  CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
  34              0         0         0         0       2.5         1         0
  END PWAT-STATE1

END PERLND

IMPLND
  GEN-INFO
    <PLS ><-------Name------->   Unit-systems   Printer ***
    # -  #                     User  t-series Engl Metr ***
                                     in  out            ***
    4      ROOF TOPS/FLAT         1    1    1   27    0
    5      DRIVEWAYS/FLAT         1    1    1   27    0
    8      SIDEWALKS/FLAT         1    1    1   27    0
  END GEN-INFO
  *** Section IWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
    4         0    0    1    0    0    0
    5         0    0    1    0    0    0
    8         0    0    1    0    0    0
  END ACTIVITY

  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL    *********
    4         0    0    4    0    0    4    1    9
    5         0    0    4    0    0    0    1    9
    8         0    0    4    0    0    0    1    9
  END PRINT-INFO

  IWAT-PARM1
    <PLS >  IWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP  VRS  VNN RTLI     ***
    4         0    0    0    0    0
    5         0    0    0    0    0
    8         0    0    0    0    0
  END IWAT-PARM1
```

```
  IWAT-PARM2
    <PLS >      IWATER input info: Part 2         ***
    # -  # ***  LSUR     SLSUR      NSUR     RETSC
    4            400      0.01       0.1       0.1
    5            400      0.01       0.1       0.1
    8            400      0.01       0.1       0.1
  END IWAT-PARM2

  IWAT-PARM3
    <PLS >      IWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN
    4              0         0
    5              0         0
    8              0         0
  END IWAT-PARM3

  IWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
    # -  # ***  RETS      SURS
    4              0         0
    5              0         0
    8              0         0
  END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <-factor->     <Name>   #   Tbl#   ***
Basin  1***
PERLND  34                       0.255     COPY   501     12
PERLND  34                       0.255     COPY   501     13
IMPLND   4                       0.086     COPY   501     15
IMPLND   5                       0.145     COPY   501     15
IMPLND   8                       0.018     COPY   501     15

******Routing******
END SCHEMATIC

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
COPY   501 OUTPUT MEAN   1 1   48.4        DISPLY   1     INPUT  TIMSER 1



<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
END NETWORK

RCHRES
  GEN-INFO
    RCHRES       Name        Nexits   Unit Systems   Printer                 ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG            ***
                                         in  out                             ***
  END GEN-INFO
  *** Section RCHRES***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG ***
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ****************** PIVL  PYR
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR  *********
  END PRINT-INFO

  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                                      ***
```

```
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
            FG FG FG FG  possible  exit  *** possible  exit      possible  exit
             *  *  *  *    *  *  *  *  *       *  *  *  *  *         ***
  END HYDR-PARM1

  HYDR-PARM2
    # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50       ***
  <------><--------><--------><--------><--------><--------><-------->       ***
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                         ***
    # -  # ***   VOL     Initial  value  of COLIND     Initial  value  of OUTDGT
          *** ac-ft     for each possible exit        for each possible exit
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
  END HYDR-INIT
END RCHRES

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL    1.37           PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL    1.37           IMPLND   1 999 EXTNL  PREC
WDM      1 EVAP     ENGL    0.8            PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL    0.8            IMPLND   1 999 EXTNL  PETINP

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
COPY     1 OUTPUT MEAN   1 1     48.4      WDM    701 FLOW     ENGL      REPL
COPY   501 OUTPUT MEAN   1 1     48.4      WDM    801 FLOW     ENGL      REPL
END EXT TARGETS

MASS-LINK
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>       <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                <Name> # #***
  MASS-LINK       12
PERLND     PWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   12

  MASS-LINK       13
PERLND     PWATER IFWO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   13

  MASS-LINK       15
IMPLND     IWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   15


END MASS-LINK

END RUN
```

Predeveloped HSPF Message File

Mitigated HSPF Message File

Disclaimer

Legal Notice

This program and accompanying documentation are provided 'as-is' without warranty of any kind. The entire risk regarding the performance and results of this program is assumed by End User. Clear Creek Solutions Inc. and the governmental licensee or sublicensees disclaim all warranties, either expressed or implied, including but not limited to implied warranties of program and accompanying documentation. In no event shall Clear Creek Solutions Inc. be liable for any damages whatsoever (including without limitation to damages for loss of business profits, loss of business information, business interruption, and the like) arising out of the use of, or inability to use this program even if Clear Creek Solutions Inc. or their authorized representatives have been advised of the possibility of such damages.

Clear Creek Solutions, Inc.
6200 Capitol Blvd. Ste F
Olympia, WA. 98501
Toll Free 1(866)943-0304
Local (360)943-0304

www.clearcreeksolutions.com

Camas Water System Well 13 PFAS Treatment Design

Geotechnical Engineering Report

March 2025

Final

Prepared for:

This page is intentionally left blank.

Document QA/QC Check Form

Project Number and Name:		6571.0				
Document Title:		Geotechnical Engineering Report				
Rev. No.	**Document Date**	**Description / Design Phase:**	**Geotechnical Engineering Report**			
0	6/4/2024	**Draft Submittal**	**Prepared by**	**Checked by**	**Technical Editor Review by**	**Approved by**
		Name	Jeremy Fissel, PE	Wolfe Lang, PE	Wolfe Lang, PE	Jeremy Fissel, PE
		Date	6/4/2024	6/4/2024	6/4/2024	6/4/2024
0	3/7/2025	**Final Submittal**	**Prepared by**	**Checked by**	**Technical Editor Review by**	**Approved by**
		Name	Jeremy Fissel, PE	Farid Sariosseiri, PE	Jeremy Fissel, PE	Farid Sariosseiri, PE
		Date	3/4/2025	3/5/2025	3/7/2025	3/7/2025

This page is intentionally left blank.

Table of Contents

1.0 Introduction 1

1.1 Background 1

1.2 Project Description 1

1.3 Purpose and Scope of Work 1

2.0 Geotechnical Investigation 2

2.1 Exploratory Boring 2

2.2 Laboratory Testing 3

2.3 Infiltration Testing 4

3.0 Site Conditions 5

3.1 Surface Conditions 5

3.2 Local Geology 5

3.3 Subsurface Conditions 6

3.3.1 Fill 6

3.3.2 Recent Alluvium 7

3.3.3 Coarse Grained Catastrophic Flood Deposits 7

3.4 Groundwater 7

3.5 Infiltration Testing Results 8

4.0 Seismic and Geologic Hazards Evaluation 9

4.1 Seismic Setting 9

4.1.1 Regional Seismicity 9

4.1.2 Cascadia Subduction Zone Seismic Sources 9

4.1.3 Shallow Crustal Source 10

4.2 Site Classification 11

4.3 Seismic Design Parameters 12

4.4 Seismic Sources and Hazard Deaggregation 13

4.5 Liquefaction and Lateral Spreading 13

4.6 Slope Stability 14

4.7 Flood Hazard 14
4.8 Other Hazards 14

5.0 Conclusions 15

6.0 Design Recommendations 15
6.1 Slab-on-Grade Foundations 15
6.1.1 Subgrade Preparation 16
6.2 Continuous, Strip, and Spread Footings 16
6.2.1 Subgrade Preparation 17
6.3 Lateral Earth Pressures on Embedded Walls 17

7.0 Construction Recommendations 18
7.1 Site Preparation 18
7.2 Backfill Materials and Compaction Criteria 18
7.2.1 Structural Fill 18
7.2.2 Embedded Wall Backfill 18
7.3 Separation Geotextiles 19
7.4 Temporary Shoring 19
7.5 Groundwater Control 19
7.6 Temporary Cuts 19
7.7 Wet Weather Construction 20

8.0 Closure 21

9.0 References 22

List of Tables

Table 4-1. USGS Class A Faults Within 20 km (12.5 miles) of the Project Site 11

Table 4-2. MCE Spectral Acceleration Parameters for Site Class D 12

Table 4-3. Deaggregation Results for 2,475-year Mean Source Event (MCE), PGA Period.......... 13

Table 6-1. Foundation Design Recommendations 17

List of Figures

Figure 1 Site Vicinity Map
Figure 2 Site Location Plan
Figure 3 Site Exploration Plan
Figure 4 Later Earth Pressures For Embedded Walls

Appendices

Appendix A Soil Boring Logs

Appendix B Laboratory Testing Results

Appendix C Water Well Reports

Distribution

To:	Jude D. Grounds, PE Carollo Engineers, Inc.
	Tyler Kane, PE Carollo Engineers, Inc
From:	Jeremy Fissel, PE Delve Underground
Prepared By:	Jeremy Fissel, PE Delve Underground
Reviewed By:	Bryan Duevel, PE Delve Underground

1.0 Introduction

1.1 Background

The City of Camas (City) is developing a strategy to address the public health concerns associated with per- and polyfluoroakyl substances (PFAS) in its drinking water. PFAS has been detected in groundwater at the City's Lower Washougal Wellfield (LWWF) and impacts the quality and quantity of its primary supply source. PFAS levels from LWWF Well 13 exceeds Washington State Action Levels (SAL), and other LWWF wells have yielded results that exceed the United States Environmental Protection Agency's (USEPA) proposed maximum contaminant levels (MCL).

The City developed a Water System Plan Addendum to advance the PFAS mitigation strategy. With this project, the City intends to 'fast track' the planning and implementation of wellfield development, treatment, funding, and an outreach approach that addresses the near-term water quality and quantity needs while establishing a sustainable and equitable approach for long-term PFAS mitigation.

1.2 Project Description

Carollo Engineers, Inc. (Carollo) has been contracted by the City for the Design, Planning, and Bidding efforts of the Project. Based on our communications with the City and Carollo, preliminary plans for the PFAS mitigation will include construction of a new facility that will include treatment for PFAS at the existing Well 13 site located at 1250 East 1st Avenue, Camas, Washington. Figures 1 and 2 show the general site location.

The new treatment facility and associated improvements at the site are expected to include new tanks, piping, increased supply capacities, and electrical upgrades at the site. A specific layout of the site improvements, including volume capacities, tank dimensions and elevations, and a hydraulic profile have not been developed during this preliminary design phase. As the project design phases continue, we should be provided an opportunity to review and possibly revise recommendations included in this report.

1.3 Purpose and Scope of Work

Carollo retained Delve Underground to evaluate the subsurface conditions and to provide preliminary geotechnical engineering design and construction recommendations for subsequent use by the design team in support of the Project. Specifically, our scope of work includes the following:

- *Geotechnical Visual Reconnaissance and Background Information Review*: Visit the site to evaluate existing and surrounding conditions and identify geologic hazards, if present.

Review available geologic publications to assess the subsurface conditions and potential geologic hazards.

- *Geotechnical Investigation*: Complete a geotechnical investigation at the Well 13 site consisting of one soil boring extending to a depth of 50 feet below ground surface. Our investigation included laboratory testing for the purpose of further defining the subsurface soils and for use in our geotechnical analyses. Infiltration testing was also performed at the site.
- *Geotechnical Analyses*:
  - Evaluate the Well 13 site for liquefaction potential, and liquefaction-induced effects such as seismic-induced settlements, lateral spreading, and potential reduction in bearing capacities.
  - Assess soil seismic profile (site classification) and site response parameters in accordance with the 2021 Washington State Building Code and the 2021 International Building Code. If the site is potentially liquefiable, the seismic profile will include those facilities with seismic periods less than 0.5 seconds.
  - Evaluate and provide recommendations for static and seismic soil bearing capacity, subgrade modulus, and total and differential settlement for potential foundations.
  - Recommendations and preliminary design criteria for the preferred foundation type, or preliminary ground improvement recommendations to mitigate potential site hazards or conditions.
  - Recommendations for shoring and dewatering of excavations.
  - Recommendations for site preparation, grading, drainage, and wet weather earthwork procedures.
  - Recommendations for engineered fill and compaction criteria for foundations, or ground improvement if deemed necessary.
- *Summarize the Above in this Geotechnical Engineering Report.*

2.0 Geotechnical Investigation

2.1 Exploratory Boring

The subsurface exploration was completed in the presence of a Delve Staff Engineer who directed the drilling operations, collected samples, and provided continuous observation and logging of the explorations. Soil materials were classified in the field in accordance with ASTM D2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedures). Sample depths, stratigraphy, groundwater occurrence, and soil characteristics were also recorded. The stratigraphic contacts indicated in the boring logs represent the approximate boundaries between soil types; actual transitions between soil units may be more gradual than shown. A log of the exploration is included in Appendix A.

To evaluate the subsurface conditions at the site, we completed one exploratory boring, B-1, advanced by Western States Soil Conservation (WSSC) of Hubbard, Oregon using a truck mounted CME 75 drill rig. The boring was advanced to a depth of 50 feet below ground surface (bgs) using mud rotary techniques. The approximate location of B-1 is shown in Figure 3.

Disturbed soil samples were obtained in our investigation. Split spoon samples were obtained in general accordance with ASTM D1586, "Standard Test Method for Standard Penetration Test (SPT) and Split Barrel Sampling of Soils." This procedure uses a 140-lb hammer dropped from a height of 30 inches to advance a 2-inch diameter split barrel sampler 18 inches. The number of hammer-blows for each 6 inches of penetration was recorded. The standard penetration resistance (designated as the "N-value") of the soil is the sum of the number of blows required for the final 12 inches of sampler penetration. The N-value is an indication of the relative density of granular soils and the relative consistency of cohesive soils. SPT N-values of 50 or more blows per 6 inches or less of penetration is defined as "refusal." Uncorrected, field-recorded N-values are presented in the boring log in Appendix A. An automatic hammer was used in our exploration. WSSC provided a Report of SPT hammer efficiencies (Shannon and Wilson 2023) which cite an energy transfer ratio (efficiency) of 90.6 and a Correction Factor of 1.51 for the automatic hammer used in our investigation.

Disturbed samples were also obtained using a 3-inch diameter, "Modified California" sampler. Blow counts to drive the sampler with the 140-lb hammer three 6-inch increments were recorded. The total number blows to drive the 3-inch sampler the final 12 inches were correlated to an N-value that would be obtained from the SPT method previously described using the Caltrans Geotechnical Manual Soil Correlations section (March 2021).

2.2 Laboratory Testing

Soil samples obtained from the exploration borings were re-examined and classified independently of field boring log descriptions to provide a quality control check of the field classifications. Representative soil samples were selected for laboratory testing. The laboratory testing program included the following tests:

- Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass (ASTM D2216);
- Standard Test Methods for Determining the Amount of Material Finer than 75-µm (No. 200) Sieve in Soils by Washing Amount of Material Finer than U.S. No. 200 Sieve (ASTM D1140);
- Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils (ASTM D4318);

- Standard Test Method for Particle-Size Analysis of Soils (ASTM D422, Mechanical Analysis Only).

Laboratory testing was performed by Breccia Geotechnical of Tigard, Oregon. Laboratory test results were used to characterize soil properties and refine soil classifications. The boring log in Appendix A includes the results for the laboratory index tests. The report provided by the testing laboratory is included in Appendix B.

2.3 Infiltration Testing

We performed infiltration testing at the Well 13 site. The testing was performed by a Delve Underground Staff Engineer in accordance with Section 6.6 of the Clark County Stormwater Manual (November 2009). The testing was done inside a 4.5-inch inside diameter (ID) hollow stem auger at an approximate depth of 6.25 feet bgs. The soil surface in contact with the hollow stem auger at the test depth were fine grained Missoula Flood Deposits.

Prior to testing, the soil was soaked for a four-hour period. Water levels inside the auger were observed in 15 and 30-minute intervals following the presoaking period. These observations continued over a period of 2 hours when consistent rates were observed. Our infiltration testing results are reported in Section 3.5.

After testing was complete, the auger was removed using the drill rig and the bored hole was backfilled with bentonite chips and the previously excavated soils.

3.0 Site Conditions

3.1 Surface Conditions

The address for the Well 13 property is 1250 East 1st Avenue in Camas, Washington. The property is rectangular, about 0.4 acres and located southwest of the intersection of East 1st Avenue and East Cramer Lane. The property is amongst a mostly residential community with a one-story single-family home located at the west and a two-story apartment building located at the east.

The property includes two existing structures, each is an above ground, one-story building constructed using Cement Masonry Units (CMUs). The structures were built in 1965 and 2007 and roughly have footprints of 400 and 1730 square feet, respectively, according to Clark County Property Maps (Clark County 2024).

The Well 13 property is mostly level and includes an asphalt paved driveway accessing the larger structure from East Cramer Lane. The asphalt paved East Cramer Lane transitions to a gravel surface lane which crosses the adjacent property at the south. Otherwise, the ground surface surrounding each of the Well 13 facilities is grass-surfaced. The property is landscaped with shrubs and bushes adjacent to East 1st Avenue.

The southern extent of Lacamas Creek and its confluence with the Washougal River is about 100 feet south of the Well 13 site. Although not located on the subject property, there are steep banks trending down to Lacamas Creek on the order of 1 Horizontal : 1 Vertical (H:V). This ground slope is currently wooded with young and mature trees and thick underbrush. The ground surface elevation at the property is about 60 feet and slopes down to about 14 feet, the approximate water surface of Lacamas Creek.

3.2 Local Geology

The Well 13 site is located within the Portland Basin at the mouth of the Columbia River Gorge. A recently published geologic map of the Camas Quadrangle at a scale of 1:24,000 shows the Well 13 site is underlain by the gravel facies of cataclysmic floods referred to as the Missoula floods (Evarts and O'Connor, 2008). During the glacial periods of the late Pleistocene, several lakes developed behind ice dams at the margins of the continental glaciers in northeastern Washington, Idaho, and western Montana—the largest of which was Glacial Lake Missoula. Periodic failure of these ice dams caused a series of flood episodes on the Columbia River system. These massive floods scoured the Columbia River Gorge before spreading into the Portland Basin and through to the Willamette Valley. As the flood waters repeatedly entered the basin they cut flood channels, scoured the bedrock in areas, such as nearby Lacamas Lake, and left behind massive sediment deposits such as the gravel deposit near the mouth of the Washougal River in Camas (Burns and Coe, 2012). When the flood waters stopped, the water would flow from the Willamette Valley and other tributary valleys back into the Portland Basin leaving temporary lakes, where fine-grained sediments would settle, and the water would eventually drain to the ocean. The Missoula floods are believed to have occurred during a 2,000 to 3,000-year period between approximately 15,500 and 13,000 years before present (Waitt, et al., 2009; Allen, et al., 2009).

The Missoula-flood deposits-gravel facies (Qfg) are described by Evarts and O'Conner (2008) as "unconsolidated, gray, stratified, bouldery to cobbly gravel and sand." The gravel is texturally and compositionally variable. The unit includes local sand deposits that were likely deposited by smaller late-episode floods. The thickness of the unit at the Well 13 site is not known but a similar deposit to the west of the Camas Slough is estimated on the map cross-section to be around 100 feet thick. The bedrock adjacent to the site is mapped as Basaltic Andesite of Elkhorn Mountain.

Recent fine-grained alluvium derived from the Washougal River overbank deposits mantles the site.

3.3 Subsurface Conditions

The subsurface conditions at the Project site were explored with one geotechnical boring to 51.5 feet (B-1) in depth and one shallow boring to 6.5 feet (I-1) in depth for use with infiltration testing. We grouped the subsurface materials encountered into three based on their engineering properties, geologic origins, and their distribution in the subsurface: Fill, Recent Alluvium, and Coarse-Grained Catastrophic Flood Deposits. Variations in subsurface conditions may exist across the footprint of the Project. Contacts between the geotechnical units are approximate and may be more gradational than shown on the exploration log in Appendix A.

The following sections provide a discussion of soil unit characteristics, including a summary of soil index testing results and soil density/consistency for each unit based on data from the recent geotechnical exploration.

3.3.1 Fill

Fill was encountered from the surface in B-1 and I-1. At the surface, the soils were a clayey silt with fine to coarse sand, fine to coarse gravel, and rootlets from the surficial grasses, and was approximately 2 inches thick. Low plasticity silt (ML) with trace fine to coarse sand was present beneath this surficial layer. Although no particular manmade materials were observed in the auger cuttings (IT-1) or SPT samples (B-1), based on the general level site topography and inconsistent texture of the material, it is very likely that the fill soils at the site extend to about 18 inches below ground surface.

3.3.2 Recent Alluvium

Beneath the fill at about 18 inches bgs, we encountered similar fine-grained alluvial deposits comprised of silt (ML) with varying amounts of sand. The fine-grained alluvial deposits extended to about 5 feet bgs in B-1 and 6.5 feet bgs in I-1. Three SPT samples were obtained within this unit resulted in N-values of 1, 2, and 6 blows per foot, indicating very soft to medium stiff consistency.

Laboratory moisture content tests completed on the two samples within this unit resulted in 23 and 30 and 51 percent moisture. One fines content (ASTM D1140) was completed and resulted in 67% passing the No. 200 sieve, indicating a sandy silt (ML) soil classification per the Unified Soil Classification System (USCS, ASTM D2487).

3.3.3 Coarse Grained Catastrophic Flood Deposits

Gravel was encountered beneath the native fine-grained unit at a depth of approximately 5 feet bgs and extended to a depth of 50 feet bgs. The unit generally consisted of clayey gravel (GC), well graded gravel (GW), and poorly graded gravel (GP), each with varying amounts of sand. At the terminal depth of Boring B-1, 50 feet bgs, we encountered very dense, micaceous poorly graded sand (SP).

This consistency of this unit ranged from medium dense to very dense conditions and primarily gray to gray-brown in color.

A composite of the samples in boring B-1 at 10 and 12.5 feet bgs was tested for particle size analysis. A plot of the testing results is included in Appendix B. The results of this testing are summarized below:

- Coarse Gravel – 5 percent
- Fine Grave – 40 percent
- Coarse Sand – 26 percent
- Medium Sand – 13 percent
- Fine Sand – 5 percent
- Fines – 11 percent

3.4 Groundwater

Mud rotary drilling was used to drill soil boring B-1 for this project. The mud rotary method involves the circulation of drilling fluids; therefore, the presence or absence of groundwater could not be confidently determined. Groundwater was not encountered while advancing the infiltration test boring I-1 to about 6.5 feet bgs using hollow stem auger methods.

Water Well Reports maintained by the Washington State Department of Ecology cite a groundwater surface located 67.6 feet bgs at Louis Block Park in February 2006. Louis Block Park is located about 650 feet west of the Well 13 property and has a ground surface elevation approximately 10 feet higher than the subject property.

Several Resource Protection Well Reports at a site located at NE 3rd Avenue and NE 3rd Place, about 500 feet northwest of the Well 13 property, did not indicate groundwater was encountered during hollow stem auger soil borings drilled between 15 and 20 feet below the ground surface in December 2013.

The Water Well Reports referenced in this report section are provided in Appendix C.

Groundwater levels vary with precipitation, the time of year, and other factors. Generally, groundwater highs occur near the end of the wet season in late spring or early summer and groundwater lows occur near the end of the dry season in the early fall.

3.5 Infiltration Testing Results

We completed infiltration testing at one location at the site, shown as I-1 in Figure 2. The testing was performed inside a 4.25-inch (inside) diameter hollow stem auger at a depth of approximately 6.25 feet bgs. After presoaking for 4 hours, the testing was performed for a 2-hour period when consistent results were observed. The infiltration rate was 1.0 inch per hour. Per the Clark County Stormwater Manual (2006), the coefficient of permeability, k, was 0.0162 inches per hour for the auger borehole method.

4.0 Seismic and Geologic Hazards Evaluation

We performed a seismic hazards evaluation in general accordance with the 2021 Washington State Building Code (WSBC) which references the 2021 International Building Code (IBC) and ASCE's Minimum Design Loads and Associated Criteria for Buildings and Other Structures, 2017 Edition (ASCE/SEI 7-16). We evaluated the seismic hazards for the Maximum Considered Earthquake (MCE) having a 2 percent probability of exceedance in a 50-year period (2,475 year return period).

4.1 Seismic Setting

4.1.1 Regional Seismicity

The Pacific Northwest is a seismically active region. Earthquakes in the Pacific Northwest occur in response to active convergence of the Juan de Fuca oceanic plate and the North America continental plate. Stress builds within the colliding plates, resisted by friction at the contact between the plates. Periodically, the stress exceeds the friction and fault rupture occurs. Faulting can occur both between the plates (interplate) and within the plates (intraplate). In northwest Oregon, earthquakes can be generated from three primary sources:

- The Cascadia Subduction Zone (CSZ), which represents the interface between the subducting Juan de Fuca Plate and the overriding North American Plate;
- The CSZ intraslab within the deep subducted portion of the Juan de Fuca Plate; and
- Shallow intraplate crustal faults that form in the continental crust and accretionary wedge of sediments that accumulate along continental shelf and slope.

Background earthquakes not associated with known geologic structures, or on faults that do not exhibit surface expression or are not identified, are accounted for as grid sources in the seismic hazard analysis. Grid sources are used to account for seismic activity occurring in uncharacterized and unrecognized faults or seismic structures, and to include the effect of what has been described as a "floating earthquake."

The three primary sources above and the grid sources are included in the development of design ground motion parameters discussed in Section 4.3.

4.1.2 Cascadia Subduction Zone Seismic Sources

The CSZ extends from Vancouver Island to Northern California (about 754 km [469 mi]) and forms the boundary between the overriding North American plate and the subducting Juan de Fuca Plate. The interface and slab sources are associated with the CSZ and are described below:

- *Subduction Zone Megathrust Interface Source*: Large subduction zone (megathrust) earthquakes occur within the upper approximately 30 kilometers (18.6 mi) of the contact between the two plates (Pacific Northwest Seismic Network [PNSN], 2020). As the Juan de Fuca Plate subducts beneath the North American Plate through this zone, the plates are locked together by friction (PNSN, 2020). Stress slowly builds as the plates converge until the frictional resistance is exceeded and the plates rapidly slip past each other, resulting in a megathrust earthquake. The subduction zone dips between 9 and 11 degrees eastward and has a slip rate of less than 5 mm/year (Personius and Nelson, 2006). Geologic evidence indicates a recurrence interval for major subduction zone earthquakes of 250 to 650 years, with the last major event occurring in 1700 (Atwater et. al., 1995). The interface source generates earthquakes that range from 8 to 9.3 M on the interface between the Juan de Fuca and North American Plates. The 2021 WSBC

- *Subduction Zone Intraplate Source*: Below depths of approximately 30 kilometers, the plate interface does not appear to be locked by friction and the plates slowly slide past each other. The curvature of the subducted plate increases as the advancing edge moves east, creating extensional forces within the plate. Normal faulting occurs in response to these extensional forces. This region of maximum curvature and faulting of the subducting plate is where large intraplate (intraslab) earthquakes are expected and is located at approximate depths ranging from 30 to 60 kilometers (18.6–37.3 mi) (Geomatrix Consultants 1993, 1995; and Kirby et al., 2002). Intraplate earthquakes generally originate below depths of 30 kilometers and are typically less than M7.5 (Cascadia Region Earthquake Workshop, 2008).

4.1.3 Shallow Crustal Source

Crustal sources typically occur at depths ranging from approximately 14 to 40 kilometers (8.7–24.9 mi) below ground surface (Geomatrix Consultants, 1995). The US Geologic Survey (USGS) uses four class definitions to classify Quaternary-age faults (e.g., faults that have generated tectonic movement within the past 2.6 million years). These classes are defined as follows (Crone and Wheeler 2000):

- *Class A* – Geologic evidence demonstrates the existence of a Quaternary fault of tectonic origin, whether the fault is exposed for mapping or inferred from liquefaction or other deformational features.
- *Class B* – Geologic evidence demonstrates existence of a fault or suggests Quaternary deformation, but the fault may not extend deep enough to be a potential source of significant earthquakes, or the currently available geologic evidence is too strong to confidently assign the feature to Class C but not strong enough to assign it to Class A.
- *Class C* – Geologic evidence is insufficient to demonstrate (1) the existence of a tectonic fault or (2) a Quaternary slip or deformation associated with the feature.
- *Class D* – Geologic evidence demonstrates that the feature is not a tectonic fault or feature; this category includes features such as demonstrated joints or joint zones, landslides, erosional or fluvial scarps, or landforms resembling fault scarps, but of demonstrable non-tectonic origin.

The USGS online Interactive Quaternary Faults database (USGS, 2024) catalogs known, Class A crustal seismic sources. The Class A faults within 20 km of the site are presented in Table 4-1.

Table 4-1. USGS Class A Faults Within 20 km (12.5 miles) of the Project Site

USGS Fault ID.	Fault Name	Type of Fault	Slip Rate (mm/year)	Distance & Direction from Site
878	Grant Butte Fault	Normal	>0.2	11.0 km Southwest
879	Damascus-Tickle Creek Fault Zone	Right Lateral, Left Lateral, Reverse	>0.2	10.4 km South
880	Lacamas Lake Fault	Right Lateral, Normal	>0.2	0.6 km Northeast

Although not included in the USGS Fault and Fold Database, the northeast trending Prune Hill Fault and the northwest trending Blue Lake Fault about 4 km northwest and 4 km southwest of the site, respectively according to Evarts and O'Connor (2008).

The Washington State Department of Natural Resources (WSDNR) Division of Geology and Earth Resources (2024) identifies frequent seismic activity within the Saint Helens Fault Zone which southern extent is about 54 miles north of the site. The WSDNR Division of Geology and Earth Resources (2024) also archives historic seismic activity southwest of the Lacamas Lake Fault, about 0.5 km west of the Project site, with 6 noted events with Magnitude (M) 2.0 to 3.0 and two events between M 3.0 and 6.8.

The Pacific Northwest Seismic Network (PNSN) catalogs historic seismic events throughout the northwest. Within 5 km of the Project site the PNSN identifies more than 90 events between May 1988 and August 2022, with most occurring northwest of the site. The strongest event, M 2.8, occurred on September 7, 1996. These mapped locations of the events are bound by the Prune Hill Fault, Lacamas Lake Fault, and Blue Lake Fault previously described.

4.2 Site Classification

We assigned a seismic site class for the Project site following code-based procedures in Section 1613.2.2 of the Internation Building Code, which references the ASCE/SEI 7-16, Chapter 20 (2017). Site class is used to categorize common subsurface conditions into broad classes to which ground motion attenuation and amplification effects are assigned. Site classification is based on the weighted average of the shear wave velocity or Standard Penetration Test (SPT) blow counts (N-value) in the upper 100 feet of subsurface profile. Based on the SPT N-values in boring B-1, a Site Class D is appropriate for design purposes.

4.3 Seismic Design Parameters

The 2021 WSBC with its two amendments (WSBC 2023 and WSBC 2024) requires that spectral response accelerations be developed based on the ASCE 7-16 procedures. To develop spectral response accelerations, we used the online ASCE 7 Hazard Tool, which follows ASCE 7-16 and is based on the USGS 2014 National Seismic Hazard Mapping Project (NSHMP) developed for the Maximum Considered Earthquake (MCE) (Peterson et. al., 2014). The MCE consists of ground motions (accelerations) with a 2-percent probability of exceedance in 50 years (return period of 2,475 years). The mean earthquake magnitude and the mean site-to-source distance for the zero-second period of vibration (e.g., PGA) are 7.39 and 60.89 km, respectively, for the MCE. The recommended spectral acceleration parameters for use in structural design are provided in Table 4-2.

Table 4-2. MCE Spectral Acceleration Parameters for Site Class D

Parameter	0.2-Second Period	1-Second Period
Mapped MCE_R (Rock site)	S_S = 0.807g	S_1 = 0.350g
Site Coefficients	F_a = 1.177	F_v = 1.95
Site-Adjusted MCE_R	S_{MS} = 0.950g	S_{M1} = 0.682
Design MCE_R	S_{DS} = 0.633g	S_{D1} = 0.455
Mapped MCE PGA (Rock Site)	0.363g	
Site Coefficient F_{PGA}	1.237	
Site-adjusted MCE PGA_M	0.449g	

It is important to note that Section 11.4.8 of ASCE 7-16 requires a site-specific ground motion hazard analysis be performed on structures on Site Class D sites with a 1-second spectral response acceleration parameter (S_1) greater than 0.2g. However, Exception No. 2 in Section 11.4.8 states that a site-specific ground motion hazard analysis is not required at Site Class D site if the structure's fundamental period of vibration T is less than $1.5T_s$ and the seismic response coefficient C_s is used for design. We assume structures for the Project will be single story or below grade. Therefore, we anticipate the fundamental period of vibration T will be less than 0.5-second.

4.4 Seismic Sources and Hazard Deaggregation

We used the online USGS Unified Hazard Tool (USGS 2024b) to perform a deaggregation of the Uniform Hazard Spectrum at the site. Table 4-3 summarizes the results of the MCE hazard deaggregation for the zero-second period of vibration (e.g., PGA). The deaggregation data identify the earthquake sources, magnitudes, and site-to-source distances that contribute to the mean source event acceleration parameters summarized in Table 4-3 below.

Table 4-3. Deaggregation Results for 2,475-year Mean Source Event (MCE), PGA Period

Source	Moment Magnitude, M_W[1]	Site-to-Source Distance[2] (km)	% Contribution to Hazard
CSZ Interface	8.99	116.64	40.2
CSZ Intraslab	7.01	77.35	11.2
Crustal Faults[3]	6.04 to 6.33	7.81 to 12.94	48.6

Notes:

1. M_W values represent the mean value from each type of earthquake source.
2. Site-to-Source distances represent the mean value from each type of earthquake source.
3. Crustal faults source include gridded seismic sources that represent earthquakes that do not occur on known, mapped faults.

4.5 Liquefaction and Lateral Spreading

Liquefaction is the phenomenon whereby saturated cohesionless soils (e.g., sands, gravels, and non-plastic to low-plasticity silts) undergo significant strength loss and stiffness when subjected to vibration or large cyclic ground motions produced by earthquakes. Saturated granular and low-plasticity soils (i.e., gravels, sands, and silts) are most susceptible to liquefaction.

Because of the very dense gravelly conditions encountered, we conclude that the risk of liquefaction is very low at the site. This concurs with hazards maps provided by Washington State Department of Natural Resources Division of Geology and Earth Resources (Palmer et. al, 2004).

Lateral spreading is a liquefaction-related phenomenon that results in ground displacement during an earthquake and occurs in sloping ground or flat ground with free face (i.e., a creek bank or channel). Although these are steep creek banks to the south trending toward the south extent of Lacamas Creek, we consider the risk of lateral spreading low due to the lack of liquefiable soils encountered and the distance between the slope and the planned site improvements (which is more than 200 feet from the top of the nearest site slope).

4.6 Slope Stability

The Washington Geologic Information Portal (Washington DNR 2024) does not show any known landslides at the Project site. The nearest mapped landslide mass is about 1,200 feet north of the site along the banks of Lacamas Creek. This movement is reported to have occurred within the last 150 years and has a failure depth of 43 feet and a headscarp height of 50 feet. We confirmed these features by available LIDAR imagery.

A large slide mass is mapped about 1,800 feet west of the site along the steep slopes of Northwest 6th Avenue. This feature is reported to be fan material from a deep-seated slide mass with a failure depth of have a failure depth of 87 feet. This feature is located along the south slopes of Prune Hill bound at the north by Forest Home Road and is approximately 320 acres in size (Washington Geologic Portal, 2024).

The Well 13 site is relatively level. However, there are steep banks trending down to the confluence of Lacamas Creek and the Washougal River. These slopes are generally 1H:1V and wooded. During our site reconnaissance in April 2024, we did not observe clearly indicative signs of instability along this slope face, such as pistol butted tree trunks, surficial cracking, or soil raveling. Our review of available Lidar imagery (Washington Geologic Information Portal) confirms our observations. Although we do not interpret previous soil movement from Lidar imagery provided by WS DNR (Washington Geologic Information Portal 2024), the imagery could be interpreted to include erosional characteristics along the slope near the south terminus of East Cramer Lane.

In general, we anticipate that the risk of the creek bank failure and landslide affecting the proposed improvements is low.

4.7 Flood Hazard

The Federal Emergency Management Agency (FEMA) shows the site adjacent to Zone AE (Floodway) near the south banks to the Lacamas Creek (FEMA 2018). A flood water surface elevation is reported to be 35 feet at the site. The ground surface of the site is approximately between 50 and 60 feet.

4.8 Other Hazards

Other geologic and seismic hazards, including debris flows, fault rupture, and tsunamis/seiches are not considered risks to the project.

5.0 Conclusions

Based on the results of our geotechnical investigation, laboratory testing, seismic hazards evaluation, new site structures associated with the Project can be supported on shallow foundations, provided the recommendations in Section 6 are incorporated.

The layout, size, and elevations for new structures/facilities have not been established at this stage of the Project. At this preliminary stage of the Project, we assume the location of the site improvements will be in the north, undeveloped section of the property near East 1st Avenue.

There are two primary geotechnical-related considerations at the project site:

- *Soft Surficial Soils:* We encountered a 5- to 6.5-foot-thick mantle of very soft to soft fine-grained soils at the site that overlie dense gravely soil. Foundations bearing on the soft soils are highly likely to settle over time. Bearing surfaces of new foundations should be within the gravel stratum underlying these soft soils. Therefore, we recommend the foundation subgrade, if founded within the upper 5 feet, be overexcavated and replaced with structural fill.

- *Slope Setback*: The slopes down to the confluence of Lacamas Creek and the Washougal River are up to 1H:1V. Based on the dense gravelly subsurface conditions encountered, we do not expect new structures/facilities over 200 feet from the top of these slopes to be impacted from the potential slope erosion and instability conditions. However, we recommend a setback of at least 50 feet from the top of the slopes for any other possible project improvements. Stormwater generated by site improvements should be managed so that there is no discharge or open channel flow down these existing slopes and all stormwater management facilities should be setback the minimal distance recommended.

6.0 Design Recommendations

We are providing geotechnical design recommendations for the planning and layout of the site improvements that provide PFAS treatment at the site. We understand the new structure(s) will house and support tanks needed for the treatment processes. At this phase of the project, the layout, elevations, size, and of the new tanks and other equipment have not been established and our recommendations should be considered preliminary.

6.1 Slab-on-Grade Foundations

We recommend a modulus of subgrade reaction of 250 pounds per cubic inch (pci) for the design of concrete slab-on-grade foundations which will be supported on structural fills placed on native gravelly subgrade soils which should be prepared as recommended in Section 6.1.1

below. The recommended modulus of subgrade reaction represents the anticipated value, which would be obtained in a standard in situ plate test with a 1-foot square plate. Use of this subgrade modulus for design should include appropriate modifications based on dimensions as necessary.

We anticipate concrete slabs-on-grade will have a total static settlement up to ½ inch when designed in accordance with our recommendations. Differential settlement is expected to be one-half of this amount, or up to ¼-inch. We recommend allowing for an additional ½-inch total settlement and ¼-inch differential settlement under seismic conditions.

6.1.1 Subgrade Preparation

Subgrade soils supporting concrete slab foundations should consist of the native gravelly soils encountered beneath the surficial soft fine-grained soils about 5 to 6.5 feet bgs in our investigation. The subgrade should be excavated using a smooth bucket. After excavating to the proposed subgrade level, the subgrade surface should be observed by Delve Underground or their representative. Due to the soft surficial conditions at the site, we recommend assessing subgrade suitability by subgrade probing rather than proof rolling with a fully-loaded dump truck or equivalent. Soils that are observed to be unsuitable should be overexcavated and replaced with structural fill (see Section 7.2.1) at the direction of the Delve Underground Geotechnical Engineer, or their representative.

The exposed subgrade should be mechanically compacted to unyielding conditions and should be overlayed by a layer of separation geotextile (see section 7.3) prior to the placement of structural fill.

The structural fill should be capped by a 6-inch thick leveling coarse on which the slab-on-grade and footing foundations can be placed. The prepared subgrade, geotextile, and structural fill should extend a minimum of 2 feet outside the perimeter of the concrete slab.

6.2 Continuous, Strip, and Spread Footings

Although locations and depths of new structures are not shown at this phase of the design, those structures can be supported by shallow foundations, such as conventional strip, continuous, or spread footings bearing on the native gravelly soils. Preliminary recommendations for the design of shallow foundations are provided in Table 6-1.

Table 6-1. Foundation Design Recommendations

Parameter	Value
Net Allowable Bearing Pressure (psf)	2,500
Friction Coefficient, Pre-Cast Concrete Foundations	0.30
Friction Coefficient, Cast-in-Place Concrete Foundations	0.45
Passive Pressure (psf)	200D[1]

Note:

1. D: embedment depth; passive pressure value includes a factor of safety of 2.

The net allowable bearing pressure applies to the total of dead and long-term loads and may be increased by one-third when considering seismic loads. We recommend disregarding the effects of the upper 12 inches of soil in calculating passive resistance due to the likelihood of soil disturbance in this area.

Based on our analysis, the total static settlement is anticipated to be less than 1/2 inch. We estimate minimal total dynamic settlement, which will be about 0.1-inch. We estimate differential settlement to be up to one-half the total settlement under each condition.

6.2.1 Subgrade Preparation

The design parameters provided in Table 6-1 assume the foundations are bearing on prepared subgrade, as recommended in Section 6.1.1.

6.3 Lateral Earth Pressures on Embedded Walls

Below grade structures at the site can be designed to resist the lateral earth pressures provided in Figure 4.

7.0 Construction Recommendations

The following are preliminary recommendations intended for use during the construction phase. Once the Project design phase progresses, we can provide additional or revised recommendations based on the new information.

7.1 Site Preparation

All existing utilities should be identified prior to excavation. If applicable, demolition of any existing structures should include complete removal of all structural elements, including foundations, and concrete slabs. Abandoned buried utilities should similarly be removed or fully grouted.

7.2 Backfill Materials and Compaction Criteria

7.2.1 Structural Fill

Structural fill should be used under foundations and slabs. Structural fill should consist of imported, crushed rock conforming to Washington State Department of Transportation (WSDOT) 2025 Standard Specifications, M 41-10 (WSDOT 2025) Class B Gravel Backfill for Foundations, Section 9-03.12(1)B. Unless otherwise noted, structural fill below structures should be compacted to a minimum 95% of the maximum dry density determined by ASTM D698.

Structural fill placed within 5 feet around embedded walls should be compacted to no more than 95% of dry density determined by ASTM D698. The structural fill should be placed in maximum lifts of 8 inches of loose material. Each lift of structural fill should be tested prior to placement of subsequent lifts.

7.2.2 Embedded Wall Backfill

The walls of fully-embedded structures should be backfilled with free-draining granular materials the requirements of WSDOT 2025 Standard Specification, M 41-10 Section 9.03.12(2) for Gravel Backfill for Walls. The backfill placed within 3 feet of the wall for the structure should be compacted to not more than 92 percent of the maximum dry density per ASTM D698.

Large and heavy equipment, particularly compaction equipment, should not be allowed to operate near the walls during construction. The compaction equipment used within 3 feet of the wall should be hand compaction equipment, walk-behind, or self-propelled rollers with a limit static weight of less than 1,000 pounds. Loose lift thickness may need to be reduced where hand compaction equipment is used.

7.3 Separation Geotextiles

Separation geotextile placed on foundation subgrade should be installed over the prepared subgrade to prevent fines migration of the imported structural fill material into the prepared native gravel subgrade. The separation geotextile should be installed per the manufacturer's instructions. Separation geotextiles should meet the requirements for Separation Geotextile in Table 3 of WSDOT Standard Specification, M 41-10, Section 9-33.2(1).

7.4 Temporary Shoring

At this stage the locations, size and depths of the new Project structure are not known.

Selection of shoring systems and the safety of temporary excavation and cut slopes is solely the responsibility of the Contractor. The Contractor must submit an excavation and shoring plan to the Engineer prior to construction. The plan should show the design of the shoring, bracing, sloping, or other provisions to be made for worker protection from the hazard of caving ground for excavations over 4 feet in depth. The Contractor should be aware of, and familiar with, applicable local, state, and federal safety regulations, including the current Occupational Safety and Health Administration (OSHA) Excavation and Trench Safety Standards. The shoring plan must be prepared and stamped by a Professional Engineer in the State of Washington.

7.5 Groundwater Control

Static groundwater is not expected to be encountered within anticipated excavation depths (up to 10 feet). Therefore, we anticipate that any groundwater inflow to the excavation can be controlled using sumps.

7.6 Temporary Cuts

If cut slopes are required, maximum cut slope inclinations must be made in accordance with OSHA regulations. Based on the subsurface conditions encountered at the project site, an OSHA Type C soil type should be used in the upper 5 feet for temporary excavation layout. Below 5 feet, Type B soils can be used for the underlying gravelly conditions. For excavations up to 20 feet, ground cuts should not exceed 1H:1V in the site gravels and not exceed 1.5H:1V in the upper fine-grained silt soils.

Temporary slope recommendations do not consider site constraints such as groundwater, surcharge, or nearby structures. Temporary slopes should be evaluated on a case-by-case basis and incorporate groundwater conditions, soil classification, and site constraints. Cut slopes should be inspected and maintained as required by OSHA.

With time, the presence of seepage, and precipitation, temporary cut slope stability can be compromised. Therefore, temporary slopes kept open during construction should be protected from erosion by installing a surface water diversion ditch or berm at the top of the slope and covering the cut face with well-anchored plastic sheets. In addition, the Contractor should monitor the stability of the temporary cut slopes and adjust the construction schedule and slope inclination accordingly. Maintenance of safe working conditions, including temporary excavation stability, is the responsibility of the Contractor and all excavations must comply with current federal, state, and local requirements.

7.7 Wet Weather Construction

Soil conditions should be evaluated in the field by the geotechnical engineer or their representative at the initial stage of site preparation to determine whether the recommendations within this section should be incorporated into construction. If earthwork is performed during extended periods of wet weather or in wet conditions, we recommend the following:

- Excavations should be protected from surface water runoff by placing sandbags or by other means to direct runoff of precipitation away from work areas and to prevent ponding of water in excavations.
- Plastic covers, sloping, ditching, sumps, dewatering, and other measures should be employed in work areas as necessary to permit timely completion of work. Bales of straw and/or geotextile silt fences should be used to control surface soil movement and erosion.
- Excavation or the removal of unsuitable soil should be followed promptly by placement and compaction of structural fill.

8.0 Closure

This report has been prepared for the exclusive use for Carollo Engineers for the PFAS Evaluation and Well 13 Treatment Design for the City of Camas, Washington. The data presented in this report is based on the subsurface conditions encountered during our site explorations and is intended to support the design of the proposed improvements. Delve Underground is not responsible for the interpretation of the data contained in this report by anyone; as such interpretations are dependent on each person's subjectivity.

In the performance of geotechnical work, specific information is obtained at specific locations at specific times, and geologic conditions can change over time. It should be acknowledged that variations in soil conditions may exist between exploration and exposed locations and this report does not necessarily reflect variations between different explorations. The nature and extent of variation may not become evident until construction. If, during construction, conditions observed or encountered differ from those disclosed by this report, Delve Underground should be advised at once so we can observe and review these conditions and reconsider our recommendations where necessary.

The geotechnical engineering evaluations and interpretations are completed within the limitations of Delve Underground's approved scope of work, schedule and budget. The services rendered by Delve Underground have been performed in a manner consistent with the level of care and skill ordinarily exercised by members of the profession currently practicing under similar conditions in the same area. The construction recommendations are considered preliminary and provided for planning purposes only. Delve Underground is not responsible for the use of this report in connection with anything other than the project at the location described above.

Delve Underground

Farid Sariosseiri, PE
Senior Engineer

Jeremy Fissel, PE
Associate Engineer

9.0 References

Allen, J.E., Burns, M., and Burns, S., 2009, Cataclysms on the Columbia, Ooligan Press.

ASCE, 2017. Minimum Design Loads and Associated Criteria for Buildings and Other Structures. American Society of Civil Engineers /SEI Standard 7-16.

Atwater, B.F., Nelson, A.R., Clague, J.J., Carver, G.A., Yamaguchi, D.K., Bobrowsky, P.T., Bourgeois, J., Darienzo, M.E., Grant, W.C., Hemphill-Haley, E., Kelsey, H.M., Jacoby, G.C., Nishenko, S.P., Palmer, S.P., Peterson, C.D., and Reinhart, M.A. 1995. Summary of Coastal Geologic Evidence for Past Great Earthquakes at the Cascadia Subduction Zone. Earthquake Spectra, 11(1): 1–18.

Burns, W. J., and D. E. Coe. 2012. "Missoula floods—Inundation extent and primary flood features in the Portland metropolitan area." Clark, Cowlitz, and Skamania Counties., Washington, and Clackamas, Columbia, Marion, Multnomah, Washington, and Yamhill Counties, Oregon: Oregon Department of Geology and Mineral Industries map IMS–36, scale 1, no. 8,200.

Caltrans. 2021. Geotechnical Manual – Soil Correlations. March 2021.

Cascadia Region Earthquake Workshop, 2008. Cascadia Deep Earthquakes. Washington Division of Geology and Earth Resources, Open File Report 2008-1.

Clark County. 2009. Stormwater Manual. November 2009.

Clark County. 2024. MapsOnline. https://gis.clark.wa.gov/mapsonline/index.cfm. Accessed April 26, 2024.

Crone, A.J., and R.L. Wheeler. 2000. Data for Quaternary Faults, Liquefaction Features, and Possible Tectonic Features in the Central and Eastern United States, East of the Rocky Mountain Front. USGS Open-File Report 00-0260. https://pubs.usgs.gov/of/2000/ofr-00-0260/.

Evarts, R.C., J.E. O’Connor, 2008. Geologic Map of the Camas Quadrangle, Clark County Washington, and Multnomah County, Oregon. U.S. Geologic Survey. Scientific Investigations Map SIM-3017. 2008.

FEMA, 2023. National Flood Hazard Layer (NFHL) Viewer, accessed September 2023 from FEMA website: https://www.fema.gov/flood-maps/national-flood-hazard-layer.

Geomatrix Consultants, 1993, Seismic margin Earthquake for the Trojan Site: Final Unpublished Report for Portland General Electric Trojan Nuclear Plant, Rainier, Oregon, May 1993.

Geomatrix Consultants, Inc., 1995. Seismic design mapping, State of Oregon: Technical report to Oregon Department of Transportation, Salem, Oregon, under Contract 11688, January 1995, unpaginated, 5 pls., scale 1:1,250,000.

Kirby, S.H., Wang, K., and Dunlop, S., 2002. The Cascadia Subduction Zone and Related Subduction Systems – Seismic Structure, Intraslab Earthquakes and Processes, and Earthquake Hazards: USGS Open-File Report 02-238, 182 pp., https://pub.usgs.gov/of/2002/0328/.

Personius, S.F., and Nelson, A.R., compilers. 2006. Fault number 781, Cascadia megathrust, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, https://earthquakes.usgs.gov/hazards/qfaults, accessed October 2023.

Pacific Northwest Seismic Network (PNSN), 2020. Pacific Northwest Earthquake Sources Overview, accessed May 2024, from PNSN web site, http://pnsn.org/outreach/earthquakesources/.

Peterson, M.D., Moschetti, M.P., Powers, P.M., Mueller, C.S., Haller, K.M., Frankel, A.D., Zeng, Yuehua, Rezaeian, Sanaz, Harmsen, S.C., Boyd, O.S., Field, Ned, Chen, Rui, Rukstales, K.S., Luco, Nico, Wheeler, R.L., Williams, R.A., and Olsen, A.H., 2014. Documentation for the 2014 update of the United States national seismic hazard maps: U.S. Geological Survey Open-File Report 2014–1091, 243 p., https://dx.doi.org/10.3133/ofr20141091.

Shannon & Wilson, 2023. Energy Measurement for Dynamic Penetrometers – Western States SPT Hammer Calibration Serives, Drill Rig 1, 2, 3, 4, 5, 8, 9, 10, 12, 13, 14. November 10, 2023.

U.S. Geological Survey (USGS). 2024. Quaternary Fault and Fold Database for the United States, accessed May 2024, https://www.usgs.gov/natural-hazards/earthquake-hazards/faults.

U.S. Geological Survey (USGS), 2024b. Unified Hazard Tool. Dynamic: Conterminous U.S. 2014 (update) (v4.2.0). Accessed May 2024, https://earthquake.usgs.gov/hazards/interactive/.

Waitt, R.B., Denlinger, R.P., and O'Connor, J.E., 2009, Many Monstrous Floods Down Channeled Scabland and Columbia Valley in O'Connor, J.E., Dorsey, R.J., and Madin, I.P., eds., Volcanoes to Vineyards: Geologic Field Trips through the Dynamic Landscape of the Pacific Northwest: Geological Society of America Field Guide 15, p. 775-844.

Washington Department of Natural Resources. 2024. Geologic Information Portal. Accessed April 2024. https://www.dnr.wa.gov/geologyportal.

Washington State Building Code. 2021. Based on 2021 International Building Code. Washington State Building Code Council. Olympia, Washington.

Washington State Building Code. 2023. Based on 2021 International Building Code - Adoption of and Amendments to the ICC/ANSI A117.1-2017. Washington State Building Code Council. First Edition. July 1, 2023.

Washington State Building Code. 2024. Based on 2021 International Building Code - Adoption of and Amendments to the ICC/ANSI A117.1-2017. Washington State Building Code Council. Second Edition. March 15, 2024.

Washington State Department of Transporation. 2025. Standard Specification for Road, Bridge, and Municipal Construction; M41-10. 2025.

DELVE underground

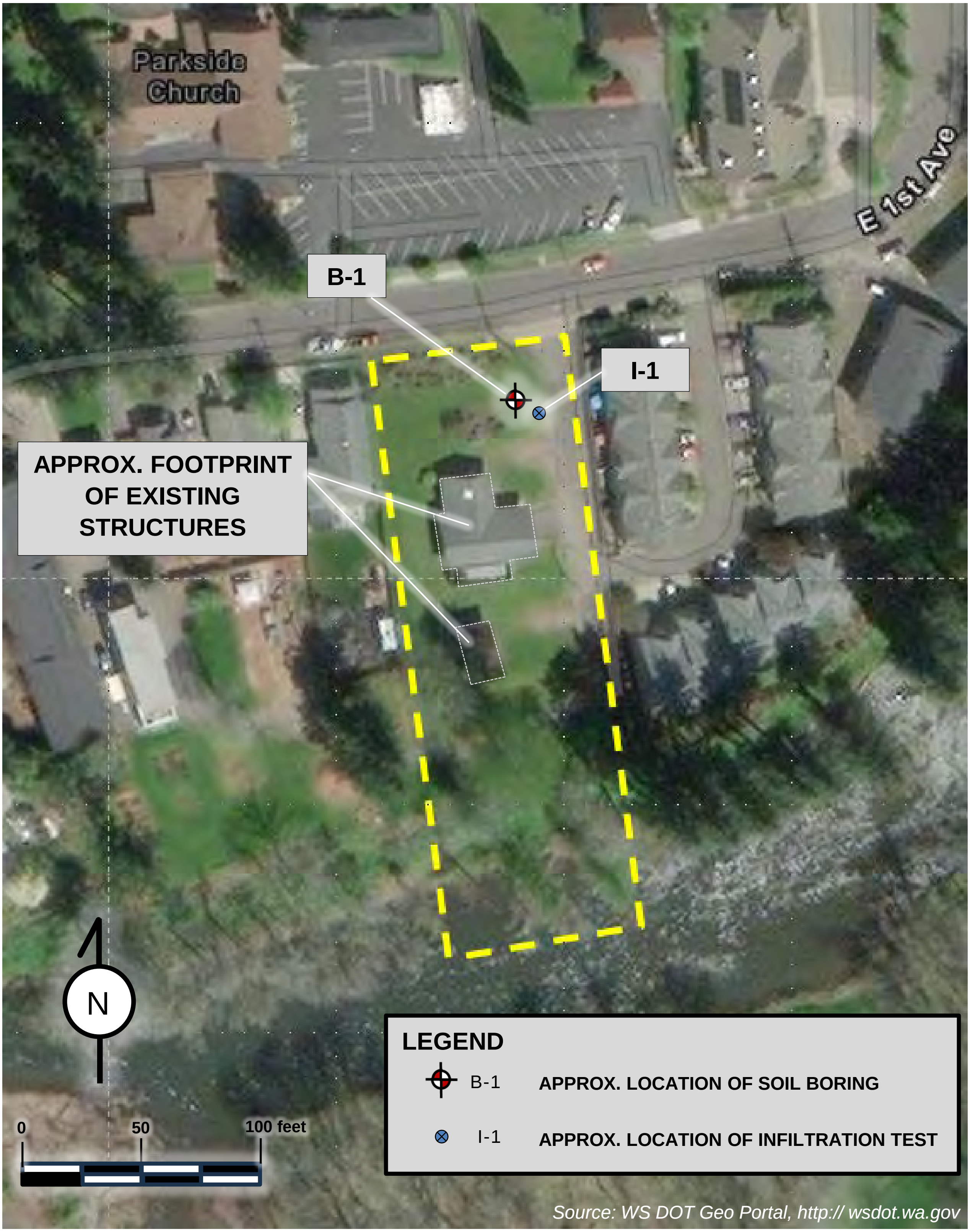
CAMAS WATER SYSTEM WELL 13 PFAS TREATMENT DESIGN

FIG 1

SITE VICINITY PLAN

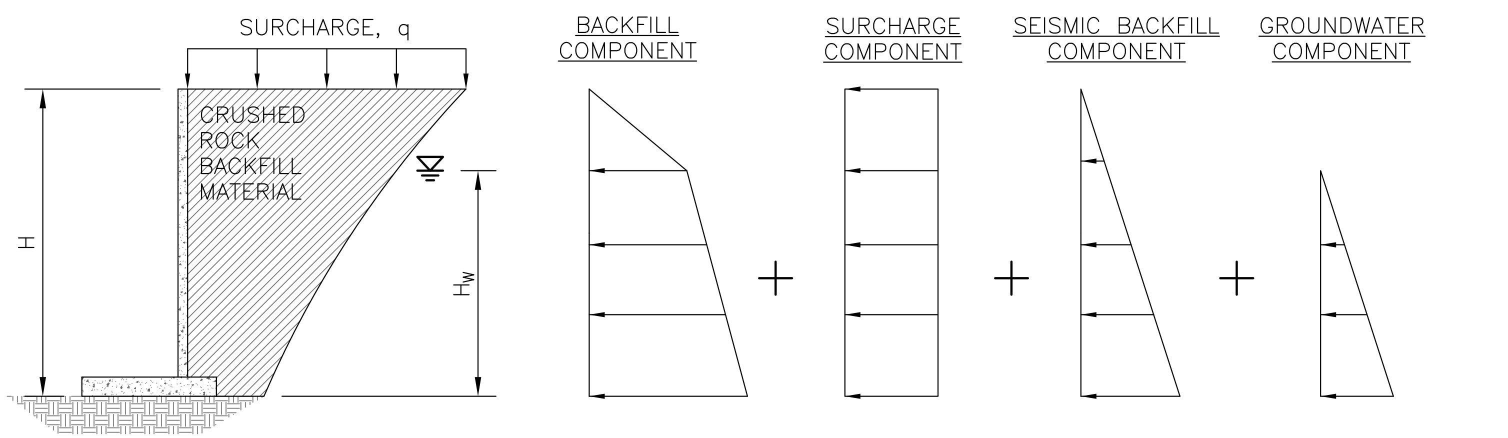
MARCH 2025

DELVE underground	CAMAS WATER SYSTEM WELL 13 PFAS TREATMENT DESIGN	FIG 2
	SITE LOCATION PLAN	MARCH 2025

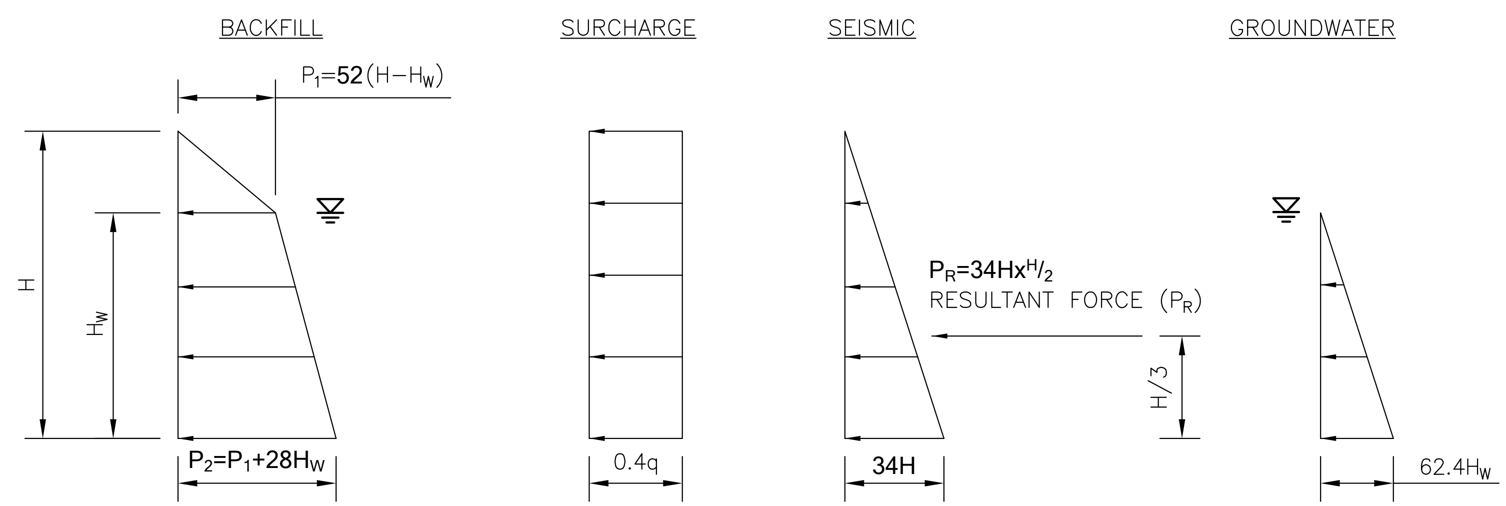


DELVE underground	CAMAS WATER SYSTEM WELL 13 PFAS TREATMENT DESIGN	FIG 3
	SITE EXPLORATION PLAN	MARCH 2025

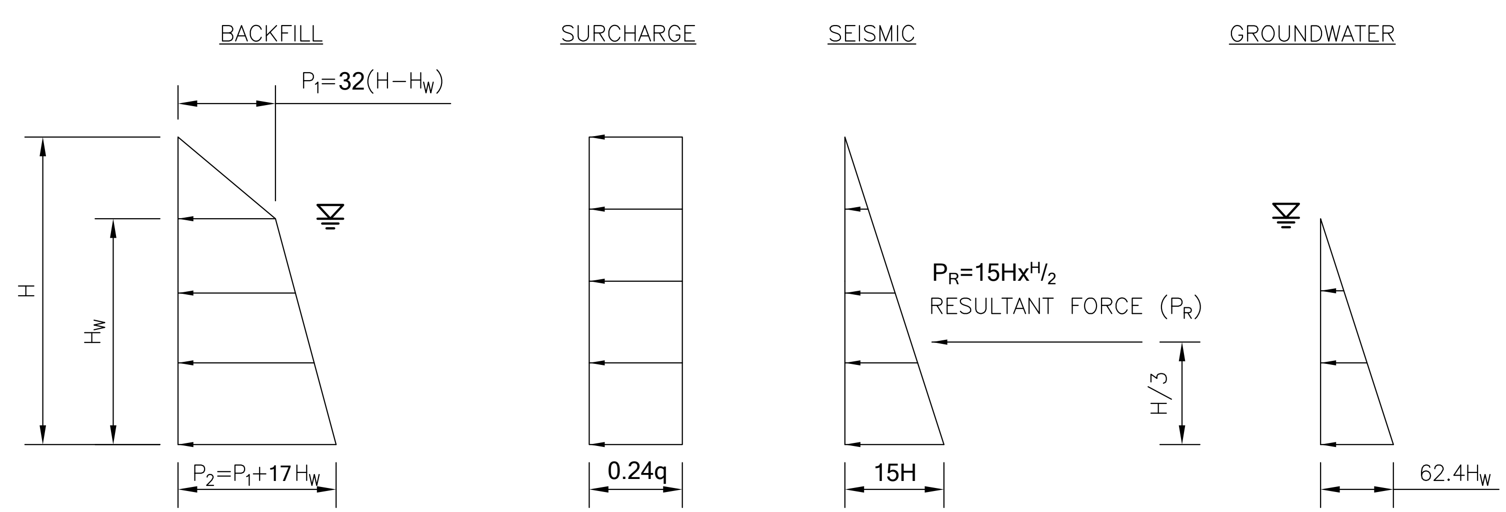
LATERAL EARTH PRESSURES ON EMBEDDED WALLS & STRUCTURES



RESTRAINED (NON–YIELDING) EMBEDDED WALLS & STRUCTURES



NON-RESTRAINED (YIELDING) EMBEDDED WALLS & STRUCTURES



NOTES:

1. UNITS ARE POUNDS PER SQUARE FOOT (PSF).
2. PRESSURES BASED ON WALL BACKFILL PER WSDOT 2024 STANDARD SPECIFICATIONS M41-10 SECTION 9.03.12(2)

DELVE underground

CITY OF CAMAS
WELL 13 PFAS TREATMENT DESIGN
GEOTECHNICAL ENGINEERING REPORT
LATERAL EARTH PRESSURES FOR EMBEDDED WALLS

FIG.4

MARCH 2025

Appendix A Soil Boring Logs

This page is intentionally left blank.

Project: Camas Water System WELL 13 PFAS Treatment Design
Project Location: Camas, Washington
Project Number: 6571.0

Log of Boring

B-1

Date(s) Drilled	05/01/2024	Client	Carollo Engineers	Final Depth	51.5 ft bgs
Coordinates	Lat. 45.58795°, Lon. -122.39343°	Geotechnical Consultant	Delve Underground	Method/ Rig Type	Mud Rotary CME 75
Surface Elevation	60.0 ft.	Drilling Contractor	Western States Soil Conservation, Inc.	Hole Diameter	4.78 in
Location	45 ft. South of sidewalk, ~12 ft off SE Cramer Rd.	Logged by/ Checked by	N. Lambing / A. Havekost	Hammer Type	140 lb / 30 in / Automatic

ELEV. (FT)	DEPTH (FT)	RECOVERY (%)	BLOW COUNTS	SAMPLE NUMBER	USCS	MATERIAL DESCRIPTION	REMARKS AND TESTS
	0–1.5				ML	Soft, moist, brown, SILT (ML); trace fine to coarse sand, low plasticity. **FILL**	
	1.5–5	67	0-0-1 (N=1)	S-01	ML	Very soft, moist, brown (SILT (ML); trace fine to coarse sand, trace mica. **RECENT ALLUVIUM**	
55	5–10	6	4-3-26 (N=29)	S-02	GW-GC	Medium dense, moist, brown fines, gray gravel, Well Graded GRAVEL with Clay (GW-GC); fine to coarse gravel, fine to coarse sand. **COARSE GRAINED CATASTROPHIC FLOOD DEPOSITS**	
		0	50/1" (Refusal)	S-00		*(7.5 ft. bgs) Refusal, no recovery at S-00*	
50	10–12.5	61	9-12-13 (N=25)	S-03	GC	Medium dense, moist, brown to gray, CLAYEY GRAVEL (GC); mostly coarse subrounded to subangular gravel, fine to coarse sand, medium plasticity fines.	
	12.5–15	56	18-27-27	S-04	GC	Dense, wet, brown fines and sand, gray gravel, red and red-brown clasts, CLAYEY GRAVEL (GC); fine to coarse gravel, fine to coarse sand, coarse sand/fine gravel red clasts, occassional charcoal, subrounded to angular gravel.	Modified California sampler for S-4., and S-6 through S-13. Hammer blow counts are as observed and uncorrected.
45	15–20	45	14-16-14 (N=30)	S-05	GP	Medium dense, gray, wet, well Poorly Graded GRAVEL (GP); fine to coarse sand, fine to coarse gravel, angular to subangular gravel.	(~17 ft. bgs) Drill rig chatter.
		56	13-16-17	S-06		*(17.5 ft bgs) Encountered red, coarse gravel-sized weak clasts.*	

NOTES: AL: Atterberg limits; N: Penetration resistance; MC: Moisture content; SA: Sieve analysis; LL/PL: Atterberg liquid/plastic limits
Location and Elevation Source:
Vertical Datum: USGS Camas Quadrangle 7.5 Min. Topo; NAD83 ; Coordinate System: WGS84

DELVE underground

Boring B-1

Project: Camas Water System WELL 13 PFAS Treatment Design
Project Location: Camas, Washington
Project Number: 6571.0

Log of Boring

B-1

Date(s) Drilled	05/01/2024	Client	Carollo Engineers	Final Depth	51.5 ft bgs
Coordinates	Lat. 45.58795°, Lon. -122.39343°	Geotechnical Consultant	Delve Underground	Method/ Rig Type	Mud Rotary CME 75
Surface Elevation	60.0 ft.	Drilling Contractor	Western States Soil Conservation, Inc.	Hole Diameter	4.78 in
Location	45 ft. South of sidewalk, ~12 ft off SE Cramer Rd.	Logged by/ Checked by	N. Lambing / A. Havekost	Hammer Type	140 lb / 30 in / Automatic

Column headings: ELEV. (FT) | WATER LEVEL | DEPTH (FT) | SAMPLE TYPE | RECOVERY (%) | BLOW COUNTS | SAMPLE NUMBER | ■ N (blows/ft) 10 20 30 40; ○ MC (%) — LL/PL 20 40 60 80 | USCS GRAPHIC | USCS | MATERIAL DESCRIPTION | REMARKS AND TESTS | BACKFILL/INSTALL.

Elev. (ft)	Depth (ft)	Recovery (%)	Blow Counts	Sample Number	USCS	Material Description	Remarks and Tests
	~20.5	67	19-37-49	S-07	GW	Very dense, wet, gray with light brown gravel fragments, Well Graded GRAVEL with Sand (GW); fine to coarse sand, fine to coarse gravel, angular (recently fractured) to subangular gravel, trace green-gray gravel. *(20 ft. bgs) Becomes very dense. Fine gravel clasts present.*	
	22						
	24						
35	~25	100	75/5"	S-08			
	26						
	28						
30	30	100	75/6"	S-09	GP	Very dense, moist, gray and gray brown with red clasts, Poorly Graded GRAVEL with Sand (GP); mostly fine subrounded to angular gravel, fine to coarse sand.	
	32						
	34						
25	~35	100	29-75/1"	S-10	GW	Very dense, moist, gray, Well Graded GRAVEL (GW); fine to coarse sand, fine to coarse gravel, subrounded to angular gravel, recently broken subrounded gravels present.	
	36						
	38						

Project: Camas Water System WELL 13 PFAS Treatment Design
Project Location: Camas, Washington
Project Number: 6571.0

Log of Boring
B-1

Date(s) Drilled	05/01/2024	Client	Carollo Engineers	Final Depth	51.5 ft bgs
Coordinates	Lat. 45.58795°, Lon. -122.39343°	Geotechnical Consultant	Delve Underground	Method/ Rig Type	Mud Rotary CME 75
Surface Elevation	60.0 ft.	Drilling Contractor	Western States Soil Conservation, Inc.	Hole Diameter	4.78 in
Location	45 ft. South of sidewalk, ~12 ft off SE Cramer Rd.	Logged by/ Checked by	N. Lambing / A. Havekost	Hammer Type	140 lb / 30 in / Automatic

ELEV. (FT)	WATER LEVEL DEPTH (FT)	SAMPLE TYPE	RECOVERY (%)	BLOW COUNTS	SAMPLE NUMBER	■ N (blows/ft) 10 20 30 40; ○ MC (%) — LL/PL 20 40 60 80	USCS GRAPHIC	USCS	MATERIAL DESCRIPTION	REMARKS AND TESTS	BACKFILL/INSTALL.
			67	40-75/12 "	S-11			GP	Very dense, wet, gray to brown, Poorly Graded GRAVEL (GP); fine to coarse sand, fine gravel, occasional coarse gravel.		
	42										
	44							GP	Very dense, moist-gray-brown, dark red, red-orange, and light gray, Poorly Graded GRAVEL with Sand (GP); mostly fine gravel, fine to coarse sand.		
15			67	43-75/12 "	S-12						
	46										
	48										
10	50		100	45-62-65	S-13			SP	Very dense, moist, gray and gray-brown, Poorly Graded SAND (SP); red, brown and light brown sand visible, micacous.		
	52									Borehole completed at 51.5 feet below ground surface (bgs).	
	54										
5											
	56										
	58										

DELVE underground

NOTES: AL: Atterberg limits; N: Penetration resistance; MC: Moisture content; SA: Sieve analysis; LL/PL: Atterberg liquid/plastic limits
Location and Elevation Source:
Vertical Datum: USGS Camas Quadrangle 7.5 Min. Topo; NAD83 ; Coordinate System: WGS84

Boring B-1

Project: Camas Water System WELL 13 PFAS Treatment Design
Project Location: Camas, Washington
Project Number: 6571.0

Log of Boring

I-1

Date(s) Drilled	05/01/2024	Client	Carollo Engineers	Final Depth	6.5 ft bgs
Coordinates	Lat. 45.58795°, Lon. -122.39343°	Geotechnical Consultant	Delve Underground	Method/ Rig Type	4.25" HSA CME 55
Surface Elevation	60.0 ft.	Drilling Contractor	Western States Soil Conservation, Inc.	Hole Diameter	6.00 in
Location	~35 ft. South of sidewalk, ~12 ft off SE Cramer Rd.	Logged by/ Checked by	N. Lambing / A. Havekost	Hammer Type	140 lb / 30 in / Automatic

ELEV. (FT)	WATER LEVEL	DEPTH (FT)	SAMPLE TYPE	RECOVERY (%)	BLOW COUNTS	SAMPLE NUMBER	■ N (blows/ft) 10 20 30 40 / ○ MC (%) —— LL/PL 20 40 60 80	USCS GRAPHIC	USCS	MATERIAL DESCRIPTION	REMARKS AND TESTS	BACKFILL/INSTALL.
		0–1.5							ML	Moist, brown SILT (ML), trace fine to coarse sand, low plasticity. **FILL**		
		1.5–5	Split spoon (3–4.5)	67	1-1-1 (N=2)	S-01			ML	Moist, brown SANDY SILT (ML); trace fine sand, low plasticity. **RECENT ALLUVIUM**		
55		5–6.5	Split spoon (5–6.5)	67	2-2-4 (N=6)	S-02			ML	Moist, brown SILT with SAND (ML); fine to coarse sand, low plasticity, coarse gravel fragment in shoe of split spoon		
		6.5								*Perform infiltration test. Pre-soak for 4 hours. Take two hours of measurements, adding additional water at each interval.*	Borehole completed at 6.5 feet below ground surface (bgs).	

Depth scale: 2, 4, 6, 8, 10, 12, 14, 16, 18. Elevation scale: 55, 50, 45.

DELVE underground

NOTES: AL: Atterberg limits; N: Penetration resistance; MC: Moisture content; SA: Sieve analysis; LL/PL: Atterberg liquid/plastic limits
Location and Elevation Source:
Vertical Datum: USGS Camas Quadrangle 7.5 Min. Topo; NAD83 ; Coordinate System: WGS84

Boring I-1

Appendix B Laboratory Testing Results

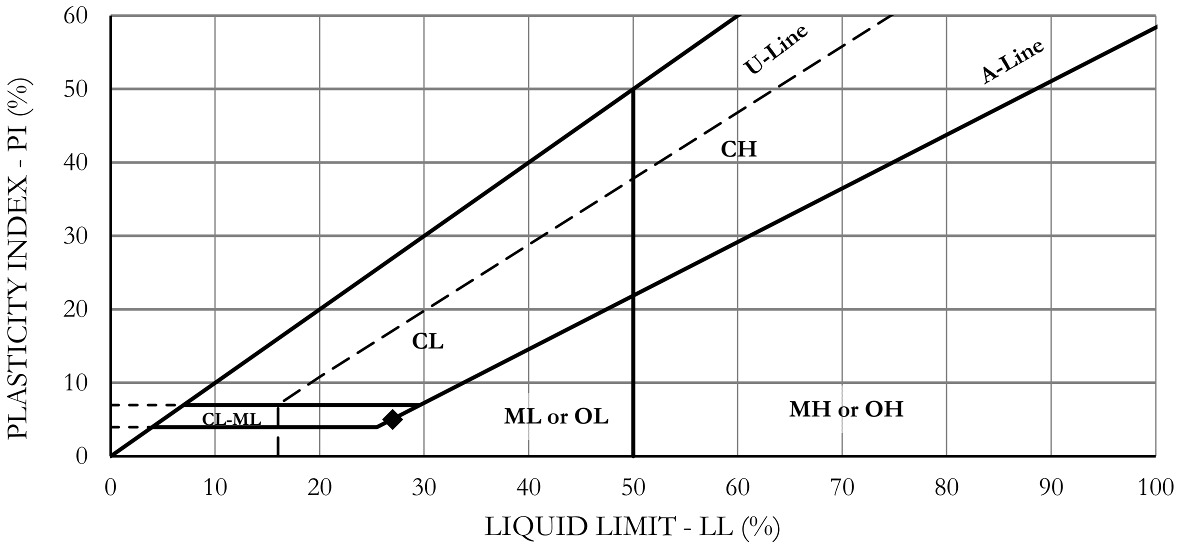
This page is intentionally left blank.

Breccia Geotechnical Testing, LLC.	Percent Fines (ASTM D1140)

Client:	Delve Underground	By:	FS
Project Name:	Camas Water System PFAS Evaluation	Date:	5/24/2024
Project Number:	6571.0		

Exploration ID	I-1					
Samples ID	S-2					
Samples Depth (ft.)	5					
Moisture Content (%)	30.3					
Percent Fines (%)	66.6					

ATTERBERG LIMITS TEST RESULTS (ASTM D4318)



	Boring ID	Sample ID	Depth (feet)	Moisture Content (%)	Atterberg Limits			%Pass #200	USCS
					LL	PL	PI		
◆	I-1	S-1	2.5	22.6	27	22	5	--	ML

Remarks

Project: Camas Water System PFAS Evaluation
Project No.: 6571.0
Location: Camas, WA

Breccia Geotechnical Testing, LLC.
Brecciageolab@gmail.com
Tel: 971-246-1324

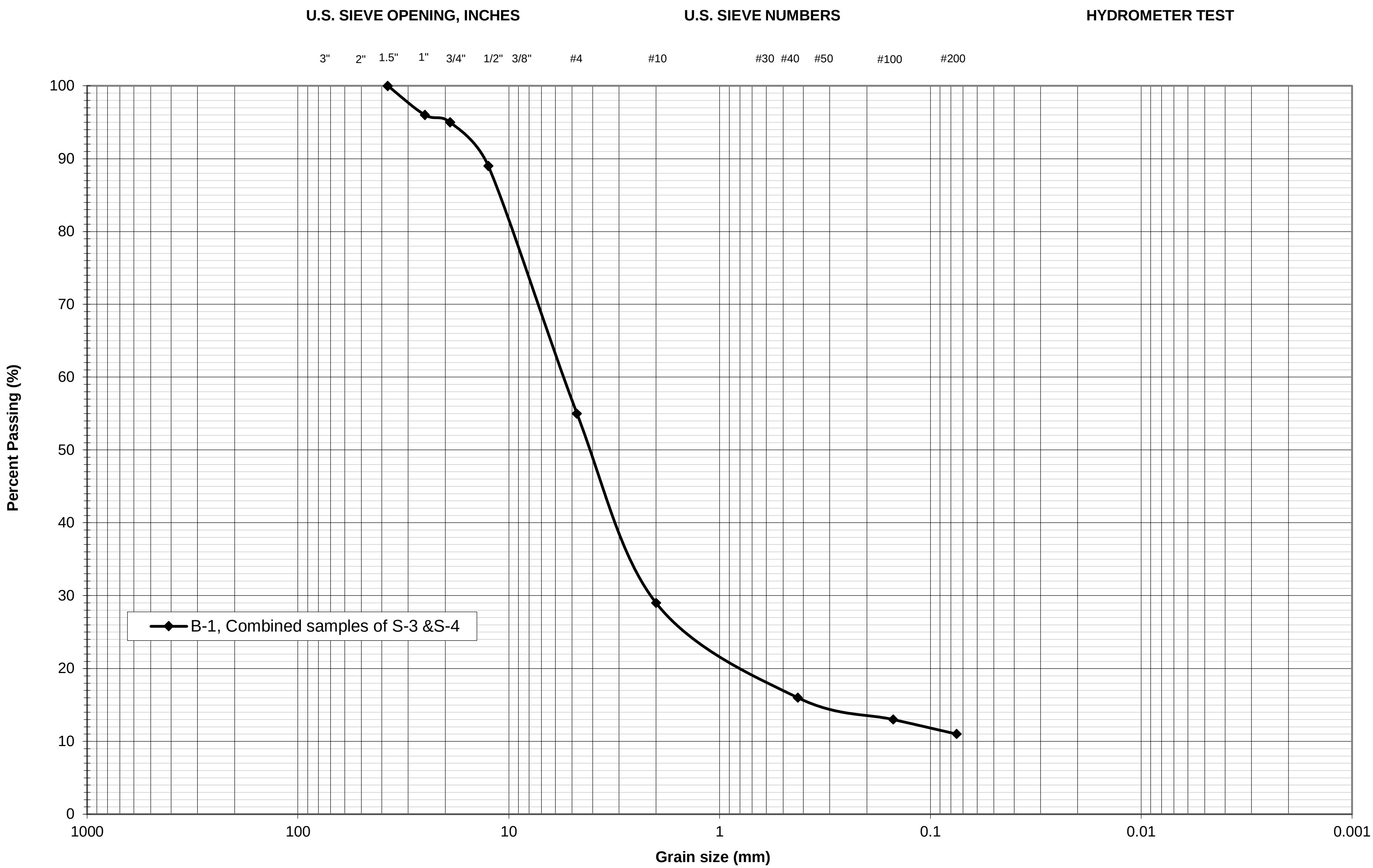
Breccia Geotechnical Testing, LLC.	**Particle-Size Analysis of Soils (ASTM D422) -** ***Mechanical Analysis without Hydrometer Test***

Client:	Delve Underground	By:	FS
Project Name:	Camas Water System PFAS Evaluation	Date:	5/24/2024
Project Number:	6571.0		

Exploration ID	B-1					
Samples ID	S-3&S-4					
Samples Depth (ft.)	10&12.5					
Sieve Size	Percent Passing					
1-1/2"	100					
1"	96					
3/4"	95					
1/2"	89					
No. 4	55					
No. 10	29					
No. 40	16					
No. 100	13					
No. 200	11					

% Coarse Gravel	5.0					
% Fine Gravel	40.0					
% Coarse Sand	26.0					
% Medium Sand	13.0					
% Fine Sand	5.0					
% Fines	11.0					

Note: Samples prepared by washing over No. 200 sieve



U.S. SIEVE OPENING, INCHES
U.S. SIEVE NUMBERS
HYDROMETER TEST
3"
2"
1.5"
1"
3/4"
1/2"
3/8"
#4
#10
#30
#40
#50
#100
#200
100
90
80
70
60
50
40
30
20
10
0
Percent Passing (%)
B-1, Combined samples of S-3 &S-4
1000
100
10
1
0.1
0.01
0.001
Grain size (mm)

Appendix C Water Well Reports

This page is intentionally left blank.

File Original with Department of Ecology
Second Copy - Owner's Copy
Third Copy - Driller's Copy 193881

WATER WELL REPORT

STATE OF WASHINGTON

Notice of Intent W241453
UNIQUE WELL I.D. # ALL-996
Water Right Permit No. ____

(1) OWNER: Name City of Camas Address PO Box 1055, Camas, WA 98607

(2) LOCATION OF WELL: County Clark SE 1/4 NE 1/4 Sec 11 T 1 N.R. 3E WM

(2a) STREET ADDRESS OF WELL: (or nearest address) Louis Block Park - NE 1st Ave

TAX PARCEL NO.: 090988-000

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

(4) TYPE OF WORK: Owner's number of well (if more than one) TW-1
☒ New Well ☐ Deepened ☐ Reconditioned ☐ Decommission
Method: ☐ Dug ☐ Bored ☒ Cable ☐ Driven ☐ Rotary ☐ Jetted

(5) DIMENSIONS: Diameter of well 8 inches
Drilled 138 feet. Depth of completed well 138 ft.

(6) CONSTRUCTION DETAILS
Casing Installed:
☒ Welded 8" Diam. from +2 ft. to 138 ft.
☐ Liner installed ____" Diam. from ____ ft. to ____ ft.
☐ Threaded ____" Diam. from ____ ft. to ____ ft.

Perforations: ☒ Yes ☐ No
Type of perforator used Mills Knife
SIZE of perforations 1/4" in. by 4" in.
60 perforations from 95 ft. to 110 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? 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 70 ft.
Static level 61.6 ft. below top of well Date 2/8/06
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 ____ 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 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
Brown silty Sand & Clay	0	10
Brown siltbound Sand, Gravel and Boulders	10	29
Brown siltbound Sand, Gravel and Cobbles	29	40
Brown siltbound Sand & Gravel	40	49
Brown very silty Sand and Gravel	49	58
Brown silty Sand & Gravel	58	80
Brown Sand & Gravel w/minor cobbles and siltbound interbeds	80	92
Brown Sand & Gravel	92	111
Brown fine Sand	111	120
Brown silty to very silty fine Sand	120	132
Tan Clay	132	136
Reddish-brown clay and Rockfrags. (weathered bedrock)	136	138

RECEIVED FEB 11 2003 Washington State Department of Ecology
RECEIVED APR 17 2006 Washington State Department of Ecology

Work Started 10/26/2005 Completed 2/15/2005

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 Randy Holt License No. 1099 (Licensed Driller/Engineer)
Trainee Name ____ License No. ____
Drilling Company Holt Drilling / Boart Longyear
(Signed) [signature] License No. 1099 (Licensed Driller/Engineer)
Address Po Box 1890 Milton WA 98354
Contractor's Registration No. BOARTLC055PZ Date 4/04/06

(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.

Please print, sign and return to the Department of Ecology

RESOURCE PROTECTION WELL REPORT

CURRENT Notice of Intent No. RE09349

(SUBMIT ONE WELL REPORT PER WELL INSTALLED)

Construction/Decommission *("x" in box)*
☒ Construction
☐ Decommission

ORIGINAL INSTALLATION Notice of Intent Number:

Consulting Firm

Unique Ecology Well IDTag No. BCM274

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 Last, First Name) Dennis, James

Driller/Engineer /Trainee Signature James Dennis

Driller or Trainee License No. 3145

If trainee, licensed driller's Signature and License Number:

Type of Well *("x" in box)*
☒ Resource Protection
☐ Geotech Soil Boring

499829

Property Owner City of Camas

Site Address NE 3rd Ave + NE 3rd Pl

City Camas County Clark

Location SE 1/4-1/4 NE 1/4 Sec 11 Twn 1N R 3E

EWM ☒ or WWM ☐

Lat/Long (s, t, r still REQUIRED) Lat Deg ___ Min ___ Sec ___
Long Deg ___ Min ___ Sec ___

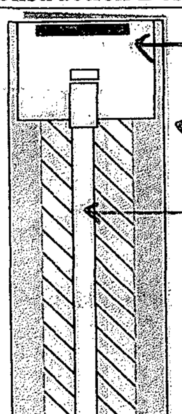
Tax Parcel No.

Cased or Uncased Diameter 5" Static Level none

Work/Decommission Start Date 12/6/13

Work/Decommission Completed Date 12/6/13

Construction Design



Well Data

MONUMENT/VAULT Below Ground
From 0 To 1

BORE HOLE
Diameter 5" From 0 To 20

CASING
Dia. 1" From ☐ 0 To 10
Gauge 580 Wld Thrd
Material ◯ Steel ✓ Plastic ☐ ☒

LINER
Dia. ___ From ☐ ___ To ___
Gauge ___ Wld Thrd
Material ◯ Steel ◯ Plastic ☐ ☐

SEAL
From 1 To 9
Material Bent Chips
Amount 23 Grout weight ___

SCREEN
(Casing)/Liner ___ Material PVC
Diameter 1" From 10 To 20
Slot Size .010

FILTER
Material Silica Sand Size of pack 10/20
From 9 To 20

Formation Description

Cibbles 0-3'
Sandy Silt/Gravels 3-7'
Boulders 7-9'
Cobbles 9-20'

RECEIVED
DEC 23 2013
WA State Department of Ecology (SWRO)

SCALE: 1"= ___ PAGE ___ OF ___

Please print, sign and return to the Department of Ecology

RESOURCE PROTECTION WELL REPORT

CURRENT Notice of Intent No. SE50012

(SUBMIT ONE WELL REPORT PER WELL INSTALLED)

Construction/Decommission *("x" in box)*
☒ Construction
☐ Decommission

ORIGINAL INSTALLATION Notice of Intent Number:

Consulting Firm

Unique Ecology Well IDTag No.

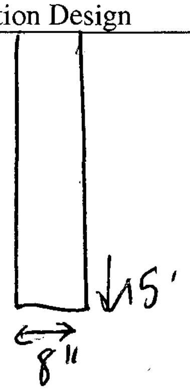
WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee
Name (Print Last, First Name) Dennis, James
Driller/Engineer /Trainee Signature James Dennis
Driller or Trainee License No. 3145

If trainee, licensed driller's Signature and License Number:

Type of Well *("x in box)* 499848
☐ Resource Protection
☒ Geotech Soil Boring

Property Owner City of Camas
Site Address NE 3rd Ave & NE 3rd Pl
City Camas County Clark
Location SE1/4-1/4 NE1/4 Sec 11 Twn 1N R 3E
EWM ☒ or WWM ☐
Lat/Long (s, t, r still REQUIRED) Lat Deg ___ Min ___ Sec ___
Long Deg ___ Min ___ Sec ___
Tax Parcel No.
Cased or Uncased Diameter 8" Static Level None
Work/Decommission Start Date 12/05/2013
Work/Decommission Completed Date 12/05/2013

Construction Design	Well Data	Formation Description
	Drilled (1) 15' hollow stem auger boring for geotechnical purposes.	Asphalt 0-6" Sand 6"-15'

Please print, sign and return to the Department of Ecology

RESOURCE PROTECTION WELL REPORT

CURRENT Notice of Intent No. AE24763

(SUBMIT ONE WELL REPORT PER WELL INSTALLED)

Construction/Decommission *("x" in box)*
☐ Construction
☒ Decommission

Type of Well *("x in box)*
☐ Resource Protection
☒ Geotech Soil Boring

499849

ORIGINAL INSTALLATION Notice of Intent Number: SE50012

Consulting Firm ______

Unique Ecology Well IDTag No. ______

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 Last, First Name) Dennis, James
Driller/Engineer /Trainee Signature James Dennis
Driller or Trainee License No. 3145

If trainee, licensed driller's Signature and License Number:

Property Owner City of Camas

Site Address NE 3rd Ave & NE 3rd Pl

City Camas County Clark

Location SE1/4-1/4 NE1/4 Sec 11 Twn 1N R 3E

EWM ☒ or WWM ☐

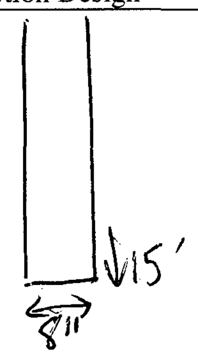
Lat/Long (s, t, r still REQUIRED) Lat Deg ______ Min ______ Sec ______
Long Deg ______ Min ______ Sec ______

Tax Parcel No. ______

Cased or Uncased Diameter 8" Static Level None

Work/Decommission Start Date 12/05/2013

Work/Decommission Completed Date 12/05/2013

Construction Design	Well Data	Formation Description
	Decommissioned (1) 15' hollow stem auger boring using (6) 50lb sack bentonite chips 15-2', gravel 2-6", Asphalt 6"-0'	Asphalt 0-6" Sand 6"-15' Boring decommssioned as described under well data. RECEIVED DEC 23 2013 WA State Department of Ecology (SWRO)

SCALE: 1"= 10 PAGE ____ OF 8

Please print, sign and return to the Department of Ecology

RESOURCE PROTECTION WELL REPORT

CURRENT Notice of Intent No. AE24763

(SUBMIT ONE WELL REPORT PER WELL INSTALLED)

Construction/Decommission *("x" in box)*

☐ Construction
☒ Decommission

ORIGINAL INSTALLATION Notice of Intent Number: SE50012

Consulting Firm

Unique Ecology Well IDTag No.

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 Last, First Name) Dennis, James

Driller/Engineer /Trainee Signature James Dennis

Driller or Trainee License No. 3145

If trainee, licensed driller's Signature and License Number:

Type of Well *("x in box)*

☐ Resource Protection
☒ Geotech Soil Boring

499853

Property Owner City of Camas

Site Address NE 3rd Ave & NE 3rd Pl

City Camas County Clark

Location SE1/4-1/4 NE1/4 Sec 11 Twn 1N R 3E

EWM ☒ or WWM ☐

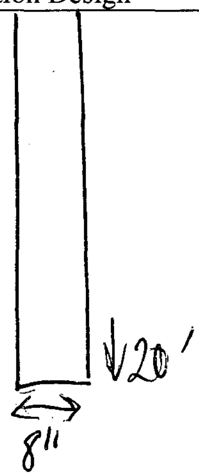
Lat/Long (s, t, r still REQUIRED) Lat Deg ___ Min ___ Sec ___ Long Deg ___ Min ___ Sec ___

Tax Parcel No.

Cased or Uncased Diameter 8" Static Level None

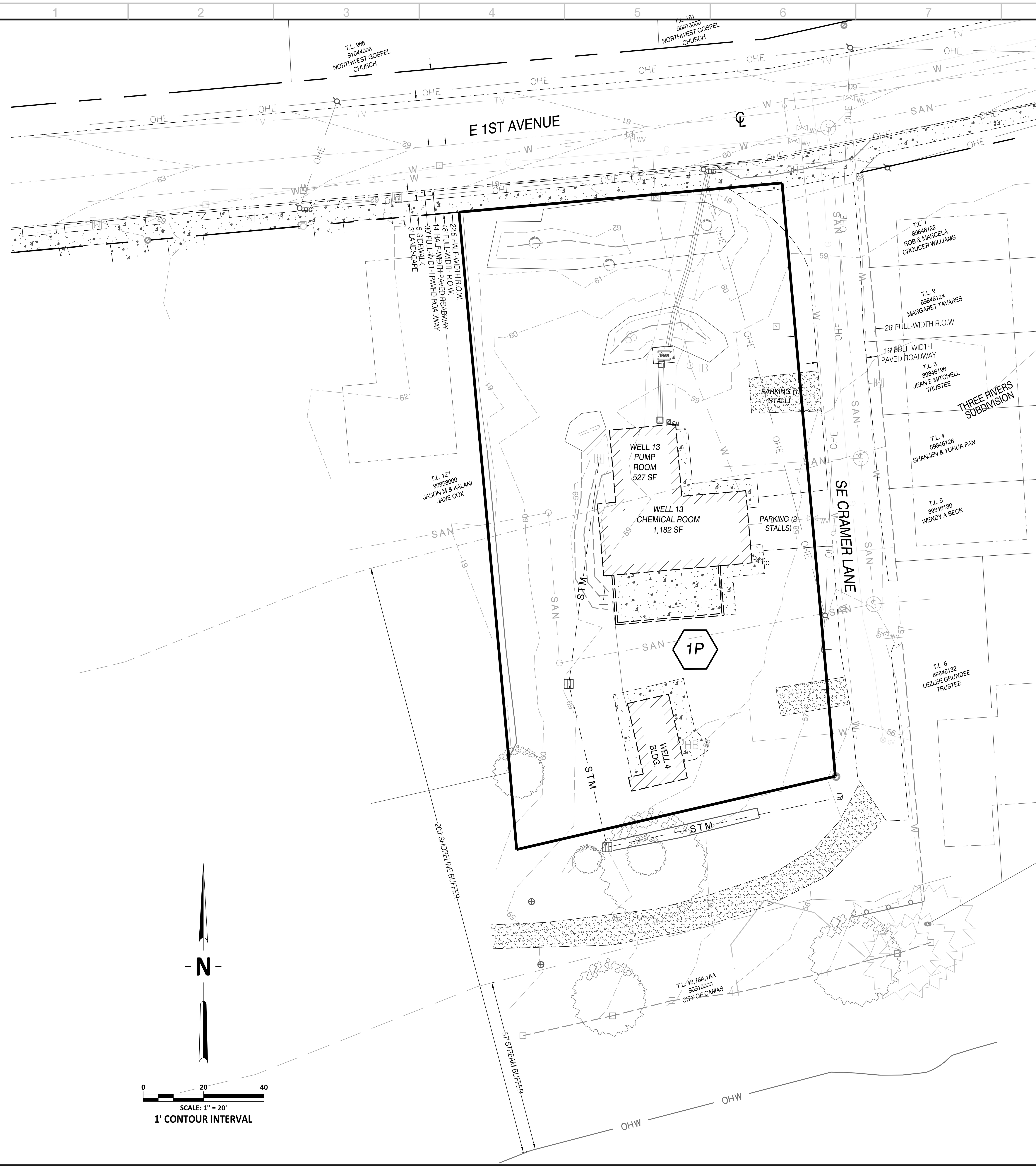
Work/Decommission Start Date 12/05/2013

Work/Decommission Completed Date 12/05/2013

Construction Design	Well Data	Formation Description
	Decommissioned (1) 20' hollow stem auger boring using (8) 50lb sack bentonite chips 20-2', gravel 2-6", Asphalt 6"-0'	Asphalt 0-1' Gravel 1-1.5' Sand 1.5-20' Boring decommssioned as described under well data.

RECEIVED
DEC 23 2013
WA State Department of Ecology (SWRO)

SCALE: 1"= 10 PAGE ____ OF 8



REV	DATE	BY	DESCRIPTION

INTERMEDIATE DESIGN SUBMITTAL
NOT FOR CONSTRUCTION

DESIGNED
DRAWN
CHECKED
DATE DECEMBER 2024

RICHARD WILLIAM ROUSE, STATE OF WASHINGTON, 43703, REGISTERED PROFESSIONAL ENGINEER
02/20/2025

MacKay Sposito

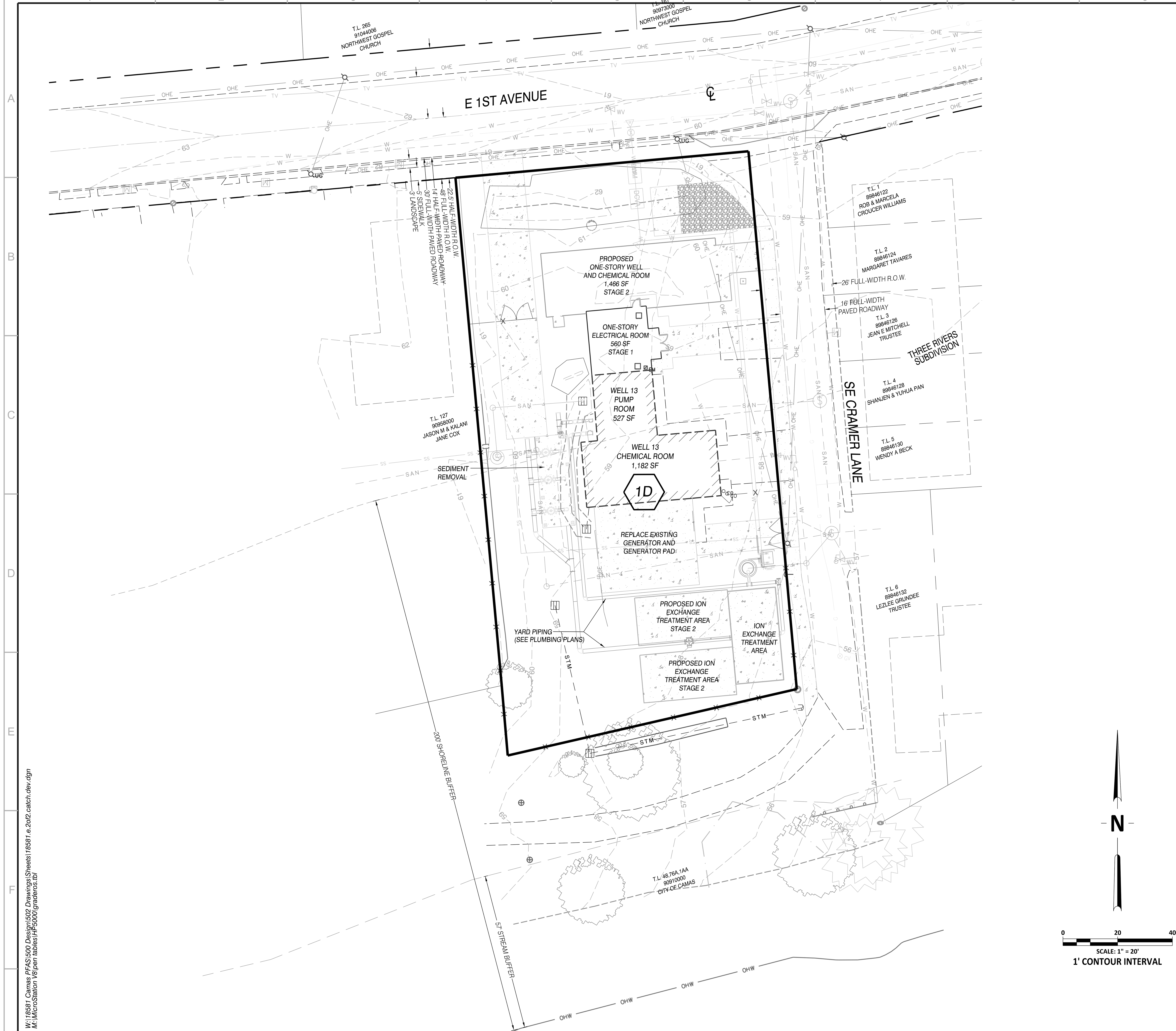
carollo®

City of Camas WASHINGTON

CITY OF CAMAS
CAMAS PFAS EVALUATION & WELL 13 TREATMENT
PRE-DEVELOPED CATCHMENT PLAN

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 203101
DRAWING NO.
SHEET NO. 1 OF 2



REV	DATE	BY	DESCRIPTION
			INTERMEDIATE DESIGN SUBMITTAL NOT FOR CONSTRUCTION

DESIGNED

DRAWN

CHECKED

DATE

DECEMBER 2024

RICHARD WILLIAM ROUSE, STATE OF WASHINGTON, 43703 REGISTERED PROFESSIONAL ENGINEER

02/20/2025

MacKay Sposito

carollo

City of Camas WASHINGTON

CITY OF CAMAS

CAMAS PFAS EVALUATION & WELL 13 TREATMENT

DEVELOPED CATCHMENT PLAN

VERIFY SCALES

BAR IS ONE INCH ON ORIGINAL DRAWING

0 1"

IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 203101

DRAWING NO.

SHEET NO. 2 OF 2