CONCEPT
STORM
DRAINAGE REPORT

FOR

GRANDVIEW ADDITION

City of Spokane, Washington

December 30, 2024

2021-3017

Prepared by:

Whipple Consulting Engineers
21 S. Pines Road
Spokane Valley, WA
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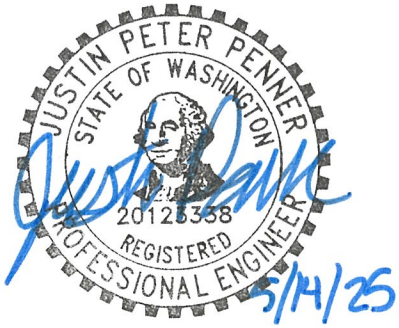
This report has been prepared by Whipple Consulting Engineers under the direction of the undersigned professional engineer whose seal and signature appears hereon:



Justin Penner, P.E.

INTRODUCTION:

The purpose of this drainage narrative is to identify drainage impacts resulting from the proposed development of Grandview Addition. This drainage narrative will determine the drainage infrastructure improvements that are necessary to control and treat the stormwater runoff from the project site. The report will demonstrate there is no negative impact to the adjacent properties with the proposed development. The proposed project lies within the City of Spokane and will be designed in accordance with the Spokane Regional Stormwater Manual (SRSM). As outlined in the SRSM, treatment methods will be based on equation 6-1d:, V=1815A.

NARRATIVE:

PROJECT DESCRIPTION:

The proposed project is a 96-lot subdivision located near Grandview Ave and H Street. There are six (6) new roads. The proposed development of the site will result in 96 new lots, driveways, extension of public streets, and associated onsite storm drainage facilities. The proposed and existing stormwater facilities will adequately collect, treat, and discharge the stormwater runoff from the proposed development

The subject property is located within the City of Spokane in a portion of the NE 1/4 of Section 26, T 25 N., R 42 E., W.M. The parcel numbers for the project are 25261.2606, 25261.2607, 25261.2901, 25261.2812, 25261.3001 thru 25261.3005, 25261.3101, 25261.3305, 25261.3301, 25261.3204, and 25261.3203. Please see the Vicinity Map attached in the Appendix.

GEOTECHNICAL INFORMATION:

Per a geotechnical report completed by Budinger and Associates dated 9/20/2021 the site is centered on a bluff of a remnant basalt lava plateau with steep sides eroded and undercut by glacial flood waters. Geologic mapping of this area shows Glacial Lake Missoula outburst flood deposits across but primarily along the lower reaches of middle Miocene Epoch Basalt lava belong to the Priest Rapids Member of the Wanapum Basalt, Columbia River Basalt Group.

Outflow rates were provided within the Geotech and ranged from a single depth drywell outflow rate of 0.3 cfs at TP-15 and the use of a gravel gallery elsewhere with a recommended outflow rate of 14cf/d/lf. See appendix for geotechnical recommendations.

PRE-DEVELOPMENT BASIN INFORMATION:

As shown on the pre-basin map the site consists of undeveloped land with abundant outcrop of rock and steep rock faces with accumulated talus. There are two benches above the overall plateau surface with a maximum relief of approximately 78 ft from the top of the benches towards 17th Ave. The site is currently covered with trees, field grass, weeds, etc. The site was divided into three (3) pre basins based on the contours of the existing site. The majority of the site drains both north and south gentler grades on the south and steeper grades on the north.

The offsite stormwater flow path to the north is generally directed towards H St where the stormwater sheet flows to the north and in the shallow ditch along H St before pooling and crossing 17th Ave to the north. From there the stormwater continues northwest where it is intersected by Interstate 90 stormwater facilities. The stormwater that flows offsite to the south is collected in various low points in the adjacent properties or pools in the unused F St right of way.

Table 1 – Pre-Development Project Site Basin Summary

	Total Basin Area (sf)	Impervious Area (sf)	Pervious Area (sf)
Pre-Basin A	478,351	0	478,351
Pre-Basin B	351,967	0	351,967
Pre-Basin C	140,622	0	140,622

POST-DEVELOPMENT BASIN INFORMATION:

The Post-Development stormwater was separated into four (4) major basins with additional subbasins to be developed in the design phase of the project.

The Basins were determined by the collection and discharge point for the stormwater. Due to the hillside nature of the project the stormwater will be collected via catch basin and pipe system.

Basins A and B utilized a pipe and catch basin system while Basin C and Basin D discharge offsite in the direction of the predeveloped condition.

While the SRSM requires analysis of the 10 and 25-year storm events, for this project due to its soils and hillside nature, we have provided bowstring calculations and pond sizing for the 100-year event for conservatism.

Table 2 – Post-Development Project Site Basin Summary

	Total Basin Area (sf)	Impervious Area (sf)	Pervious Area (sf)
Post A	391,802	224,410	62,728
Post B	343,290	200,320	216,492
Post C	124,055	21,935	116,585
Post D	108,776	18,480	110,530

Table 3 – Post-Development Project Site Pond Summary

	PGIS Area (sf)	(Method 1815A (ac)) Treatment Area/Volume (square feet/cubic feet)	
		Required	Provided
Post A	85,710	3,571	3,744
Post B	98,320	4,097	10,322
Post C	1,485	62	n/a
Post D	980	41	n/a

Refer to basin calculations in Appendix for areas and peak flows for all basins.

Operational Characteristics:

The stormwater for the Grandview Addition development will be collected in proposed catch basins and pipes that will discharge into storm drainage ponds. The drainage ponds in turn will discharge underground via drywell of gravel gallery.

The stormwater generated on Basin C and Basin D will continue to discharge in the post basin as in the pre basin. The area of Basin C and Basin D are reduced in area as a large portion of them will be developed and directed to the proposed roadways and directed to the stormwater ponds that are proposed within Basin A and B. There will be a short length of roadway in both Basin C and D that will drain offsite at the connection points of the projects. The stormwater from these portions of roads will be captured by the existing stormwater facilities that are offsite.

Methodology:

As required by the SRSM, the storm drainage facilities proposed for this site have been sized to attenuate the 10- and 25-year storm events using the Rational Method as outlined in Section 5.5 of the SRSM. It should be noted that due to the hillside nature of the project site, storage calculations have been completed using the 100-year storm event for conservatism. The peak flows and volumes for these storm events are shown in the calculations that are included within the Appendix of this report.

Water Quality Treatment:

The proposed storm drainage ponds have been designed to provide treatment volume based on Equation 6-1d (V=1815A) of the SRSM, as outlined in Section 6.7.1. Once the treated stormwater exceeds a height of 12 inches, it will spill into drywells, where it will be discharged underground. It is to be noted that the ponds are to be L.I.D. ponds.

Critical Areas:

Based on the Critical Area Maps provided by Spokane County, (DNR Streams, Fish and Wildlife, Wetlands, Geo-hazard Area and Critical Aquifer Resource Area), there are no critical areas onsite except steep slopes greater than 30% and the project site has a CARA susceptibility rating of high.

Results:

As shown in Table 3 within this report we have provided the required treatment volume for the improvements proposed for the development. Table 4 below shows the onsite pond/swale storage summary for the 100-year storm event.

Table 4 – Project Site Pond/Swale Storage Summary

	100-YR Storm	
	Required	Provided
Basin	Vol. (cf)	Vol. (cf)
Basin A	16,438s	18,087
Basin B	17,170	21,827
Basin C	n/a	n/a
Basin D	n/a	n/a

Perpetual Maintenance of Facilities:

This is a residential development with public roads as access. The surface maintenance of the ponds, pond structure maintenance, and pond replacement will be provided by the Homeowners Association while street structure maintenance and replacement are to be done by the City of Spokane. A maintenance plan will be provided to the owner if requested.

Offsite Easements:

There are no offsite easements required for this property.

Regional Facilities:

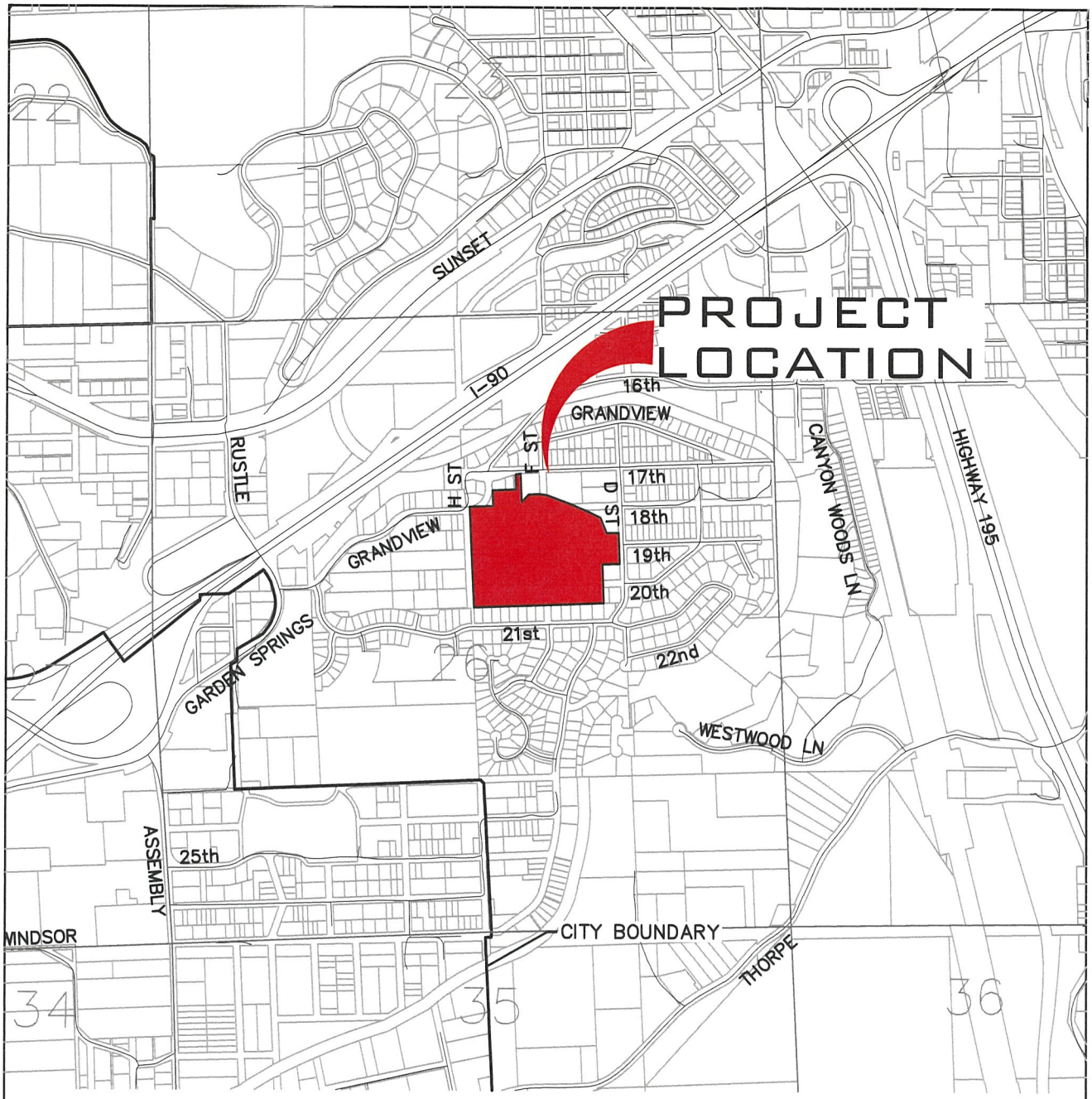
There are no known regional facilities that lie within the project site. However, the project does have offsite stormwater that will be passed the project site.

CONCLUSION:

As required by the City of Spokane and the Spokane Regional Stormwater Manual, the onsite storm drainage facilities for this project will adequately collect, treat, and discharge stormwater runoff generated by the site during the 10-year storm event. Also, the storm drainage facilities will contain and discharge the 100-year storm. Therefore, this project will have no adverse impact to adjacent and/or downstream properties.

APPENDIX

VICINITY MAP



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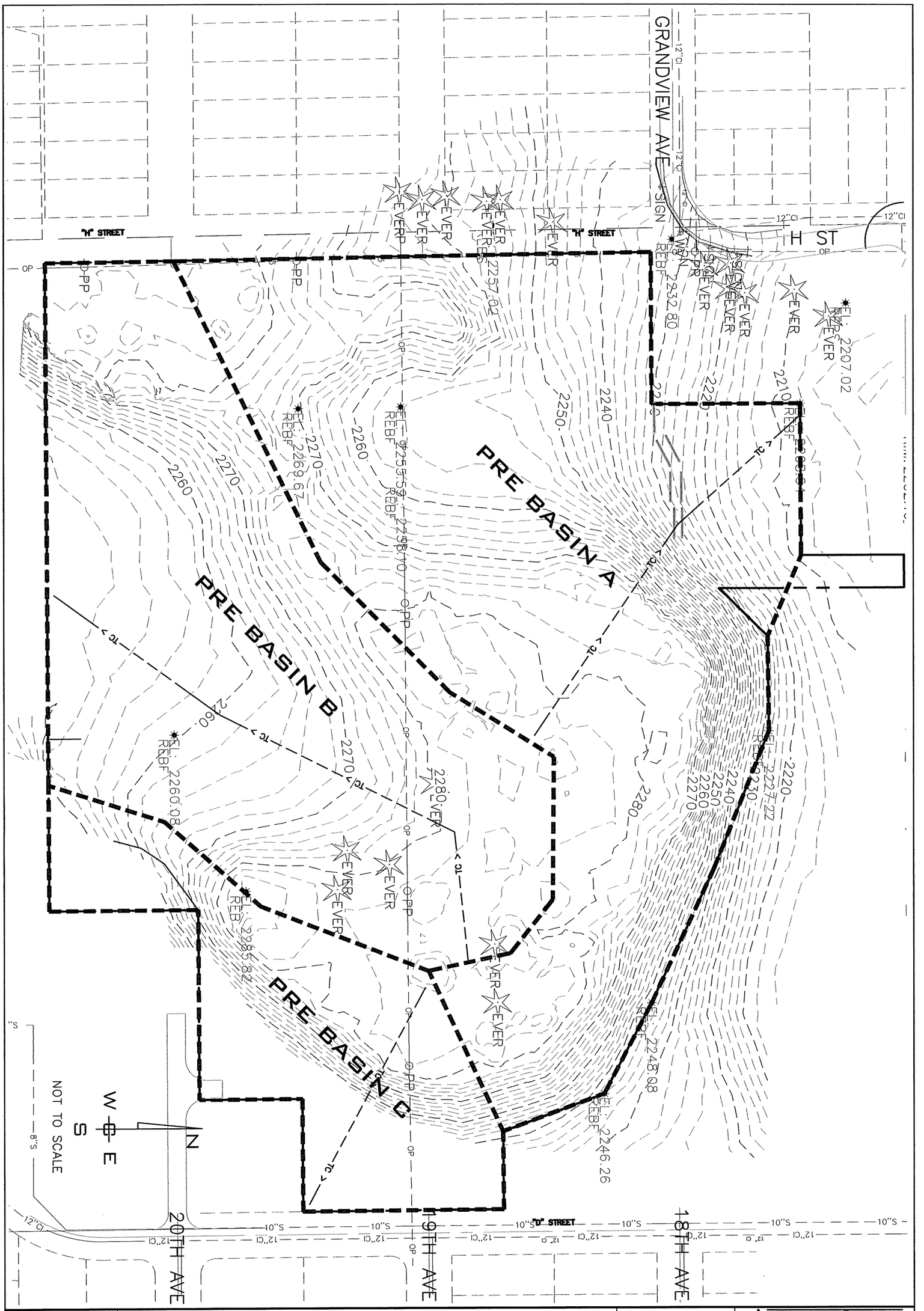
W E

S

NOT TO SCALE

PROJ #: 21-3017 DATE: 12/30/24 DRAWN: JPP APPROVED: JPP	DRAINAGE REPORT **GRAND VIEW ADDITION** GRANDVIEW AVE & H ST SPOKANE, WASHINGTON	WCE WHIPPLE CONSULTING ENGINEERS 21 SOUTH PINES RD SPOKANE VALLEY, WASHINGTON 99206 PH: 509-893-2617 FAX: 509-926-0227
FIGURE 1	VICINITY MAP	

BASIN MAPS



PRE-DEVELOPMENT BASIN MAP
GRANDVIEW ADDITION
GRANDVIEW AVE & H ST
SPOKANE , WASHINGTON

SHEET 1 OF 2

PROJ #: 21-3017
DATE: 12/30/24
DRAWN: JPP
APPROVED: JPP

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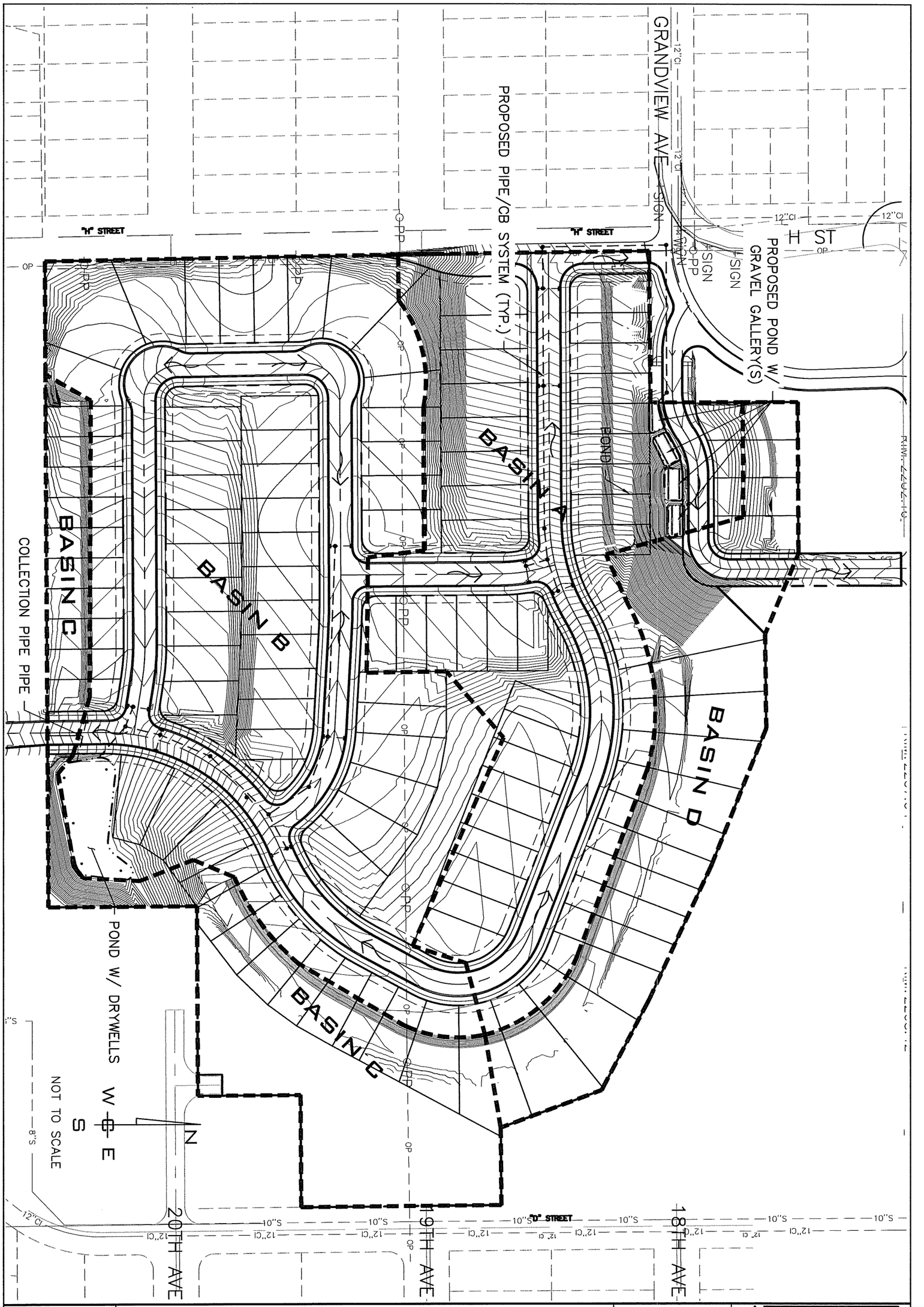

SHEET 2 OF 2

PRE-DEVELOPMENT BASIN MAP
GRANDVIEW ADDITION
GRANDVIEW AVE & H ST
SPOKANE , WASHINGTON

PROJ #: 21-3017
DATE: 12/30/24
DRAWN: JPP
APPROVED: JPP

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BASIN SUMMARY SHEET

Whipple Consulting Engineers

Basin Calculation Worksheet

Imp 0.9

Per 0.15

Intensities from SRSM eqn. 5-13, per Table 5-7, Assumes Tc = 5 min

I (2 yr) = 1.418 inches I (10 yr)= 2.619 inches NOTE:

I (25 yr) = 3.319 inches I (50 yr)= 3.843 inches

I (100 yr) = 4.381 inches

	WCE No.	Project Name
12/30/2024	21-3017	Grandview Addition
JPP		

SPOKANE COUNTY - SRSM - GRASSED PERCOLATION METHOD

Basin	Total	Access/Parking	Sidewalk	DV	Buildings	Total	Total	Weighted	PGIS	1815 A Pond	1815 A Pond	Q=CIA (cfs)				
	sf	/Street (sf)	sf	WY	sf	Impervious	Pervious	"C"	sf	Area (sf)	Vol (cf)	2 yr	10 yr	25 yr	50 yr	100 yr
Pre A	478,351	0	0	0	0	0	478,351	0.15	0	0	0	2.34	4.31	5.47	6.33	7.22
Pre B	351,967	0	0	0	0	0	351,967	0.15	0	0	0	1.72	3.17	4.02	4.66	5.31
Pre C	140,622	0	0	0	0	0	140,622	0.15	0	0	0	0.69	1.27	1.61	1.86	2.12
Pre Total	**970,940**	**0**	**0**	**0**	**0**	**0**	**970,940**	**0.15**	**0.00**	**0.00**	**0.00**	**4.74**	**8.76**	**11.10**	**12.85**	**14.65**
Post Onsite Flow																
Post A	287,138	61,710	18,700	24,000	120,000	224,410	62,728	0.74	85,710	7,143	3,571	6.88	12.71	16.11	18.65	21.26
Post B	416,812	67,320	20,400	31,000	81,600	200,320	216,492	0.51	98,320	8,193	4,097	6.93	12.79	16.21	18.77	21.40
Post C	138,520	1,485	450	0	20,000	21,935	116,585	0.27	1,485	124	62	1.21	2.24	2.84	3.28	3.74
Post D	129,010	480	1,500	500	16,000	18,480	110,530	0.26	980	82	41	1.08	2.00	2.53	2.93	3.34
Total	**971,480**	**130,995**	**41,050**	**55,500**	**237,600**	**465,145**	**506,335**	**0.51**	**186,495**	**15,541**	**7,771**	16.10	29.74	37.68	43.63	49.74

Driveway Area: 500sf

Roof Area: 2000sf

POND VOLUME & INFILTARTION

WHIPPLE CONSULTING ENGINEERS **Date: 12/30/2024**

POND VOLUME CALC SHEET

Project: 21-3017

Designer: JPP Grandview Addition

								Treatment					*Storage*
Basins	Ponds/ Swales	Bottom Area sf	Treatment Area (w/ Side Slopes)	Squared Side lf	Pond Bottom Elevation at Drywell	Pond Drywell Elevation	Pond Outlet Elevation (avg)	Conic Volume to Rim cf	Side Slope Volume cf	Total Volume to to Rim cf	Conic Volume to Inlet cf	Side Slope Volume cf	Total Volume to Inlet cf
A	A1	522	811	22.85	1000.00	1001.00	1003.00	522	137	659	1,566	1,234	2,800
	A2	830	1,194	28.81	1000.00	1001.00	1003.00	830	173	1,003	2,490	1,556	4,046
	A3	960	1,352	30.98	1000.00	1001.00	1003.00	960	186	1,146	2,880	1,673	4,553
	A4	770	1,121	27.75	1000.00	1001.00	1003.00	770	166	936	2,310	1,498	3,808
A TOTAL		**3,082**								**3,744**			**15,207**
B	**B**	**9,730**	**10,978**	**98.64**	**1000.00**	**1001.00**	**1002.00**	**9,730**	**592**	**10,322**	**19,460**	**2,367**	**21,827**

WHIPPLE CONSULTING ENGINEERS

GRAVEL GALLERY CALC SHEET

12/30/2024

21-3017 Grandview Addition
DESIGNER JPP

Porsity:	**0.3**
Infiltration Rate:	**14 cf/d/lf**
Convert gpd to cfs	**1.62E-04**

Note: infiltration rates per Budinger Geotechnical Report Dated December 1, 2021
14 gpd/lf of gallery

BASIN		Number of Galleries	Length	Width	Depth	Ground Water EL.	Gravel Gallery Bott. EL	Volume	Storage Volume	Outflow
			ft	ft	ft	ft	ft	cf	cf	cfs
A		7	40.00	3.00	3.00	-	1000.00	2,520	756	0.635

Storage Volume = Volume* Porosity
Sidewall Area= Perimeter*Depth
OutFlow = Sidewall Area+ Bottom Area * Infiltration Rate

Note: Outflow Assumes a Full Gallery

100-YEAR STORM EVENT BOWSTRING CALCULATIONS

PEAK FLOW CALCULATION
100-Year Design Storm

PROJECT: **21-3017**

BASIN: A

Tot. Area	287,138 SF	6.59 Acres	
Imp. Area	224,410 SF	C=	0.9
Perv. Area	62,728 SF	C=	0.15
Wt. C =	0.74	PGIS Area =	85,710

WCE Applicable Travel Time Ground Cover Coefficients			
Per Table 5-6 SRSM			
Type of Cover		K (ft/min)	
Short Pasture		420	
Nearly Bare Ground		600	
Small Roadside Ditch/ Grass		900	
Paved Area (use for parking lots)		1200	
Gutter - 4 inches deep		1500	
Gutter - 6 inches deep		2400	
Pipe - 12-inch PVC/DI		3000	
Pipe - 15/18-inch PVC/DI		3900	
Pipe - 24-inch PVC/DI		4700	

Reaches		
Reach 1	Offsite	also applicable for Pre-Developed Tc
Length	100.00	
K	420.00	
Slope (ft/ft)	0.0400	be sure this is decimal equivalent slope 0.0000
Travel Time	1.19	Minutes
Reach 2	Finished Lot from House to Street	
Length	100.00	
K	420.00	
Slope (ft/ft)	0.0300	be sure this is decimal equivalent slope 0.0000
Travel Time	1.37	Minutes
Reach 3	Gutter Flow to Inlet/Catch Basin	
Length	300.00	
K	2400.00	
Slope (ft/ft)	0.0300	be sure this is decimal equivalent slope 0.0000
Travel Time	0.72	Minutes
Reach 4	Pipe Flow 1	Pipe Reach One (only need one if no Dia change)
Length	1300.00	
K	3000.00	12-inch Pipe minimum
Slope (ft/ft)	0.1000	Average Slope for total pipe run
Travel Time	1.37	Minutes
Reach 5	Pipe Flow 2	Add additional pipe reacheds for other Dia
Length	0.00	
K	3900.00	15/18-inch Pipe
Slope (ft/ft)	0.1000	Average Slope for total pipe run
Travel Time	0.00	Minutes
Sum of Tc	4.66	Minutes
Tc for Analysis	5.00	Minutes

BOWSTRING METHOD
DETENTION BASIN DESIGN

PROJECT: 21-3017
BASIN: A
DESIGNER: JPP
DATE: 30-Dec-24

Time Increment (min)	10
Time of Conc. (min)	5.00
Outflow (cfs)	0.635
Design Year Flow T	100
Area (acres)	6.59
Impervious Area (sq ft)	224410
'C' Factor	0.74
Area * C	4.853
PGIS Area	85,710

Time (min)	Time Inc. (sec)	Intens. (in/hr)	Q Devel. (cfs)	Vol.In (cu ft)	Vol.Out (cu ft)	Storage (cu ft)	
5.00	300	4.38	21.26	8545	191	8355	
15	900	2.16	10.49	10509	572	9938	
25	1500	1.56	7.55	12098	953	11146	
35	2100	1.25	6.08	13394	1334	12061	
45	2700	1.07	5.18	14501	1715	12786	
55	3300	0.94	4.55	15474	2096	13379	
65	3900	0.84	4.09	16350	2477	13873	
75	4500	0.77	3.73	17148	2858	14291	
85	5100	0.71	3.44	17885	3239	14647	
95	5700	0.66	3.20	18571	3620	14952	
105	6300	0.62	3.00	19214	4001	15214	
115	6900	0.58	2.83	19821	4382	15440	
125	7500	0.55	2.68	20396	4763	15634	
135	8100	0.53	2.55	20944	5144	15800	
145	8700	0.50	2.44	21466	5525	15942	
155	9300	0.48	2.34	21967	5906	16062	
165	9900	0.46	2.24	22448	6287	16162	
175	10500	0.45	2.16	22911	6668	16244	
185	11100	0.43	2.09	23358	7049	16310	
195	11700	0.42	2.02	23790	7430	16361	
205	12300	0.40	1.95	24209	7811	16398	
215	12900	0.39	1.89	24614	8192	16423	
225	13500	0.38	1.84	25008	8573	16436	
235	14100	0.37	1.79	25391	8954	16438	<==
245	14700	0.36	1.74	25765	9335	16430	
255	15300	0.35	1.70	26128	9716	16413	
265	15900	0.34	1.65	26483	10097	16386	
275	16500	0.33	1.62	26829	10478	16352	
285	17100	0.33	1.58	27167	10859	16309	
295	17700	0.32	1.54	27498	11240	16259	
305	18300	0.31	1.51	27822	11621	16202	
315	18900	0.31	1.48	28140	12002	16138	
325	19500	0.30	1.45	28451	12383	16068	
335	20100	0.29	1.42	28756	12764	15992	
345	20700	0.29	1.40	29055	13145	15911	
355	21300	0.28	1.37	29425	13526	15900	
365	21900	0.28	1.35	29664	13907	15757	
375	22500	0.27	1.33	29978	14288	15691	
385	23100	0.27	1.33	30774	14669	16106	

Rainfall Intensity Coefficients for ***Spokane***
taken from Table 5-7 SRSM

M_{100} = 12.33
N_{100} = 0.643

Flow (weighted c)
Qwc= 21.26 cfs
Flow (time of concentration)
Qtc= 21.26 cfs

Time (min)	Time Inc. (sec)	Intens. (in/hr)	Q Devel (cfs)	Vol.In (cu ft)	Vol.Out (cu ft)	Storage (cu ft)
385						
395	23700	0.26	1.28	30415	15050	15366
405	24300	0.26	1.28	31182	15431	15751
415	24900	0.25	1.23	30735	15812	14924
425	25500	0.25	1.23	31473	16193	15280
435	26100	0.24	1.18	30939	16574	14365
445	26700	0.24	1.18	31647	16955	14693
455	27300	0.23	1.13	31026	17336	13691
465	27900	0.23	1.13	31706	17717	13989
475	28500	0.22	1.08	30997	18098	12899
485	29100	0.22	1.08	31647	18479	13169
495	29700	0.21	1.04	30851	18860	11992
505	30300	0.21	1.04	31472	19241	12232
515	30900	0.20	0.99	30589	19622	10968
525	31500	0.20	0.99	31181	20003	11179
535	32100	0.19	0.94	30211	20384	9827
545	32700	0.19	0.94	30773	20765	10009
555	33300	0.18	0.89	29715	21146	8570
565	33900	0.18	0.89	30249	21527	8723
575	34500	0.17	0.84	29104	21908	7196
585	35100	0.17	0.84	29609	22289	7320
595	35700	0.16	0.79	28376	22670	5706
605	36300	0.16	0.79	28852	23051	5801
615	36900	0.15	0.74	27532	23432	4100
625	37500	0.15	0.74	27978	23813	4165
635	38100	0.14	0.70	26571	24194	2377
645	38700	0.14	0.70	26988	24575	2413
655	39300	0.13	0.65	25493	24956	538
665	39900	0.13	0.65	25881	25337	545
675	40500	0.12	0.60	24299	25718	-1418
685	41100	0.12	0.60	24658	26099	-1440
695	41700	0.11	0.55	22989	26480	-3490
705	42300	0.11	0.55	23319	26861	-3541
715	42900	0.10	0.50	21562	27242	-5679
725	43500	0.10	0.50	21863	27623	-5759
735	44100	0.09	0.45	20019	28004	-7984
745	44700	0.09	0.45	20291	28385	-8094

"1815A" TREATMENT REQUIREMENTS		
Minimum "1815" Volume Required	3,571	cu ft
Provided Treatment Volume - Min.	3,744	cu ft
STORAGE REQ. - 100 YEAR DESIGN STORM		
Maximum Storage Required by Bowstring	16,438	cu ft
Provided Pond Storage Volume to Inlet - Min.	15,207	cu ft
Provided Drywell/Gallery Storage Volume	2,880	cu ft
Total Provided Volume	**18,087**	**cu ft**

PEAK FLOW CALCULATION — PROJECT: **21-3017**

100-Year Design Storm

BASIN: B

Tot. Area	416,812 SF	9.57 Acres	
Imp. Area	200,320 SF	C=	0.9
Perv. Area	216,492 SF	C=	0.15
Wt. C =	0.51	PGIS Area =	98,320

WCE Applicable Travel Time Ground Cover Coefficients		
Per Table 5-6 SRSM		
Type of Cover	K (ft/min)	
Short Pasture	420	
Nearly Bare Ground	600	
Small Roadside Ditch/ Grass	900	
Paved Area (use for parking lots)	1200	
Gutter - 4 inches deep	1500	
Gutter - 6 inches deep	2400	
Pipe - 12-inch PVC/DI	3000	
Pipe - 15/18-inch PVC/DI	3900	
Pipe - 24-inch PVC/DI	4700	

Reaches		
Reach 1	Offsite	also applicable for Pre-Developed Tc
Length	100.00	
K	420.00	
Slope (ft/ft)	0.0400	be sure this is decimal equivalent slope 0.0000
Travel Time	1.19	Minutes
Reach 2	Finished Lot from House to Street	
Length	100.00	
K	420.00	
Slope (ft/ft)	0.0300	be sure this is decimal equivalent slope 0.0000
Travel Time	1.37	Minutes
Reach 3	Gutter Flow to Inlet/Catch Basin	
Length	300.00	
K	2400.00	
Slope (ft/ft)	0.0300	be sure this is decimal equivalent slope 0.0000
Travel Time	0.72	Minutes
Reach 4	Pipe Flow 1	Pipe Reach One (only need one if no Dia change)
Length	1200.00	
K	3000.00	12-inch Pipe minimum
Slope (ft/ft)	0.0500	Average Slope for total pipe run
Travel Time	1.79	Minutes
Reach 5	Pipe Flow 2	Add additional pipe reacheds for other Dia
Length	1200.00	
K	3900.00	15/18-inch Pipe
Slope (ft/ft)	0.0500	Average Slope for total pipe run
Travel Time	1.38	Minutes
Sum of Tc	6.45	Minutes
Tc for Analysis	6.45	Minutes

BOWSTRING METHOD — PROJECT: 21-3017

DETENTION BASIN DESIGN — BASIN: B

DESIGNER: JPP

DATE: 30-Dec-24

Time Increment (min)	10
Time of Conc. (min)	6.45
Outflow (cfs)	0.600
Design Year Flow	100
Area (acres)	9.57
Impervious Area (sq ft)	200320
'C' Factor	0.51
Area * C	4.884
PGIS Area	98,320

Time (min)	Time Inc. (sec)	Intens. (in/hr)	Q Devel. (cfs)	Vol.In (cu ft)	Vol.Out (cu ft)	Storage (cu ft)	
6.45	387	3.72	18.16	9421	232	9188	
15	900	2.16	10.56	10891	540	10351	
25	1500	1.56	7.60	12403	900	11503	
35	2100	1.25	6.12	13663	1260	12403	
45	2700	1.07	5.21	14750	1620	13130	
55	3300	0.94	4.58	15711	1980	13731	
65	3900	0.84	4.11	16578	2340	14238	
75	4500	0.77	3.75	17371	2700	14671	
85	5100	0.71	3.46	18105	3060	15045	
95	5700	0.66	3.22	18788	3420	15368	
105	6300	0.62	3.02	19430	3780	15650	
115	6900	0.58	2.85	20035	4140	15895	
125	7500	0.55	2.70	20610	4500	16110	
135	8100	0.53	2.57	21157	4860	16297	
145	8700	0.50	2.45	21680	5220	16460	
155	9300	0.48	2.35	22181	5580	16601	
165	9900	0.46	2.26	22662	5940	16722	
175	10500	0.45	2.18	23126	6300	16826	
185	11100	0.43	2.10	23573	6660	16913	
195	11700	0.42	2.03	24006	7020	16986	
205	12300	0.40	1.96	24425	7380	17045	
215	12900	0.39	1.91	24832	7740	17092	
225	13500	0.38	1.85	25227	8100	17127	
235	14100	0.37	1.80	25611	8460	17151	
245	14700	0.36	1.75	25985	8820	17165	
255	15300	0.35	1.71	26350	9180	17170	<==
265	15900	0.34	1.67	26705	9540	17165	
275	16500	0.33	1.63	27053	9900	17153	
285	17100	0.33	1.59	27392	10260	17132	
295	17700	0.32	1.55	27725	10620	17105	
305	18300	0.31	1.52	28050	10980	17070	
315	18900	0.31	1.49	28368	11340	17028	
325	19500	0.30	1.46	28680	11700	16980	
335	20100	0.29	1.43	28986	12060	16926	
345	20700	0.29	1.41	29287	12420	16867	
355	21300	0.28	1.38	29659	12780	16879	
365	21900	0.28	1.36	29898	13140	16758	
375	22500	0.27	1.34	30214	13500	16714	
385	23100	0.27	1.34	31015	13860	17155	

Rainfall Intensity Coefficients for ***Spokane***

taken from Table 5-7 SRSM

M_{100} = 12.33

N_{100} = 0.643

Flow (weighted c)

Qwc= 21.40 cfs

Flow (time of concentration)

Qtc= 18.16 cfs

Time (min)	Time Inc. (sec)	Intens. (in/hr)	Q Devel (cfs)	Vol.In (cu ft)	Vol.Out (cu ft)	Storage (cu ft)
385						
395	23700	0.26	1.29	30652	14220	16432
405	24300	0.26	1.29	31424	14580	16844
415	24900	0.25	1.24	30973	14940	16033
425	25500	0.25	1.24	31716	15300	16416
435	26100	0.24	1.19	31177	15660	15517
445	26700	0.24	1.19	31890	16020	15870
455	27300	0.23	1.14	31263	16380	14883
465	27900	0.23	1.14	31947	16740	15207
475	28500	0.22	1.09	31232	17100	14132
485	29100	0.22	1.09	31887	17460	14427
495	29700	0.21	1.04	31084	17820	13264
505	30300	0.21	1.04	31709	18180	13529
515	30900	0.20	0.99	30819	18540	12279
525	31500	0.20	0.99	31415	18900	12515
535	32100	0.19	0.94	30436	19260	11176
545	32700	0.19	0.94	31003	19620	11383
555	33300	0.18	0.90	29937	19980	9957
565	33900	0.18	0.90	30474	20340	10134
575	34500	0.17	0.85	29320	20700	8620
585	35100	0.17	0.85	29827	21060	8767
595	35700	0.16	0.80	28585	21420	7165
605	36300	0.16	0.80	29064	21780	7284
615	36900	0.15	0.75	27734	22140	5594
625	37500	0.15	0.75	28183	22500	5683
635	38100	0.14	0.70	26765	22860	3905
645	38700	0.14	0.70	27185	23220	3965
655	39300	0.13	0.65	25679	23580	2099
665	39900	0.13	0.65	26070	23940	2130
675	40500	0.12	0.60	24476	24300	176
685	41100	0.12	0.60	24838	24660	178
695	41700	0.11	0.55	23156	25020	-1864
705	42300	0.11	0.55	23488	25380	-1892
715	42900	0.10	0.50	21718	25740	-4022
725	43500	0.10	0.50	22021	26100	-4079
735	44100	0.09	0.46	20164	26460	-6296
745	44700	0.09	0.46	20437	26820	-6383

"1815A" TREATMENT REQUIREMENTS		
Minimum "1815A" Volume Required	4,097	cu ft
Provided Treatment Volume - Min.	10,322	cu ft
STORAGE REQ. - 100 YEAR DESIGN STORM		
Maximum Storage Required by Bowstring	17,170	cu ft
Provided Pond Storage Volume to Inlet - Min.	21,827	cu ft
Provided Drywell/Gallery Storage Volume	0	cu ft
Total Provided Volume	**21,827**	**cu ft**

GEOTECH REPORT

Budinger & Associates
Proudly serving the Inland Northwest for over 40 years

Geotechnical Engineering
Environmental Engineering
Construction Materials Testing
Subsurface Exploration
Special Inspection

TECHNICAL MEMORANDUM
To: Erin Hopkins, Toll Brothers, Inc.
From: David Lehn, LG, and John Finnegan, PE
Date:December 1, 2021
Project: S21702 Grandview 92-lot Development
Spokane, WA
Subject: Addendum 1 to Geotechnical Conditions Report
Results of Test Pit Infiltration Testing

JOHN EDWARD FINNEGAN STATE OF WASHINGTON 0033932 REGISTERED PROFESSIONAL ENGINEER 12/01/21

State of Washington Hydrogeologist 2145 Licensed Geologist John Edward Finnegan 12/01/21

This addendum to the Geotechnical Conditions Report (GCR) presents the results of field testing and analysis of infiltration potential at 3 locations. The target areas were delineated in an updated site plan provided by Whipple Consulting Engineers, dated August 25, 2021.

Scope

Infiltration tests were completed in accordance with the Test Pit Infiltration Method of the *Spokane Regional Stormwater Manual* (SRSM Appendix 4-C). Due to subsurface conditions observed in the initial field exploration, test pit infiltration tests were conducted in lieu of borings as outlined in Task 2 of proposal S21702, revised August 6, 2021. Limited depth of explorations and infiltration testing provide results suitable for single-depth drywell design.

We logged the subsurface conditions in 3 test pits prior to performing infiltration tests. A site plan with test locations, test pit logs, infiltration test results, and laboratory test results are presented in *Figures*.

Subsurface Conditions

Test Pit 14 (TP-14) was excavated at the proposed infiltration basin in the eastern portion of the site which is located west of D Street and approximately 160 feet south of 19th Avenue. Stratified colluvium consisting of clast-supported, angular basalt gravel and cobbles in a matrix of silt was encountered from 1 to 10 feet below ground surface (BGS). A lacustrine silt horizon was encountered beginning below 10 feet and extended to greater than 11 feet BGS.

TP-15 was excavated near the southeast corner of the site. Stratified colluvium, similar to that observed in TP-14, was encountered to 4 feet BGS. Below that, clean gravel with sand was encountered to greater than 9 feet BGS. Fines content (percent passing the US#200 sieve) for one representative sample tested was 1.1 percent (very low fines). The excavation was terminated due to excessive caving of the gravel and sand below the overlying silty soil. Infiltration was rapid with complete drawdown in less than 10 minutes.

TP-16 was excavated near the northwest corner of the site. It consisted of 1.5 feet of stratified colluvium overlying 3 feet of gravel with sand and cobbles. The sand within the gravel and cobbles was relatively clean, similar to TP-15. A 6-inch-thick stratum of volcanic ash was

encountered from 5 to 5.5 feet BGS. It was underlain by dense gravel with silt and sand that extended below the bottom of the test pit at 7 feet. Testing of one representative sample of the gravel with silt and sand sediments yielded a fines content of 8.4 percent. Excavation refusal occurred in the very dense gravel with silt and sand. Infiltration was moderately low at about 8 gallons per minute.

Table 1: Test Pit Infiltration Results

Test Pit ID	Q^1	H^2	$q_N{}^3$	$q_{ND}{}^4$	$H_D{}^5$	$q_A{}^6$	FS^7	$q_D{}^8$
TP-14	0.0038	4.5	0.00085	0.0040	6	0.024	NS[9]	NS
TP-15	0.056	2.2	0.026	0.065	6	0.39	1.4	0.28
TP-16	0.019	2.8	0.0068	0.018	6	0.11	2.1	0.051

1. Stabilized flow rate observed near the end of the constant-head portion of the test in cubic feet per second (cfs).
2. Level of water within the test pit in feet.
3. Normalized outflow rate of the test pit in cfs per foot.
4. Normalized outflow rate of the drywell in cfs per foot.
5. Maximum design drywell head in feet.
6. 'Actual' (calculated by SRSM method) outflow rate in cfs.
7. Factor of safety from the SRSM, Table 4C-1.
8. Calculated design drywell outflow rate in cfs.
9. Not suitable for drywell disposal per SRSM design criteria.

Conclusions and Recommendations

Drywells do not appear to be feasible in the vicinity of TP-14 (east portion of site) due to high fines content and low infiltration test rates. Gravel galleries may be feasible, but at very limited rates.

Good infiltration potential was encountered at TP-15. We recommend sizing single-depth drywells at a maximum outflow rate of 0.3 cfs within a 50-foot radius of TP-15.

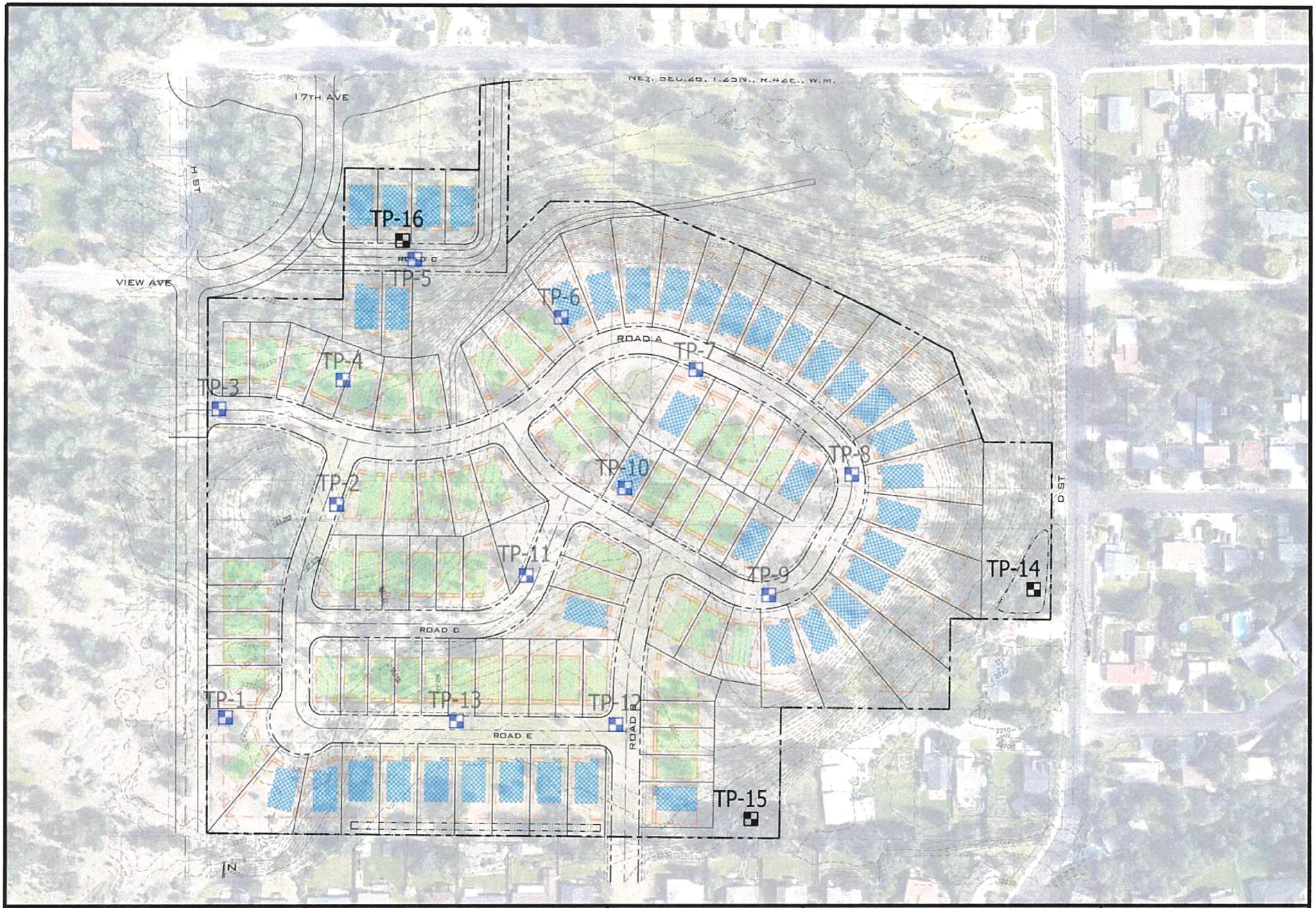
The volcanic ash stratum encountered in TP-16 represents a limiting layer and may render the use of single-depth drywells as infeasible. However, this area appears to be suitable for biofiltration utilizing a gallery approach with gravel trenches as follows:

- Perforated pipe in a 3-foot tall by 3-foot wide trench lined with filter fabric and filled with rounded drain rock. The pipe should be placed at least 12 inches below the biofiltration bottom.
- The recommended infiltration gallery discharge rate is 14 cubic feet per day per foot of trench length.
    - It is based on hydraulic conductivity, K, of 9.2 inches per hour (18.4 feet per day) from correlation with grain size distribution. A safety factor of 3.5 was applied to Darcy's equation $q = k \times i \times A$ with $i = 0.3$ due to low gradient (i) from mounding above the lower permeability limiting layer and $A = w + (2 \times h)$ where w and h are the gallery height and width, respectively.

Monitoring. We recommend installing and measuring water levels in a minimum of 3 monitoring wells near property lines in the downgradient direction from infiltration structures. The minimum recommended measurement frequency is 2 per year.

This report is subject to the limitations stated in the original report, to which it should be permanently affixed.

Attachments:
Figure A1-1: Site Plan
Figure A1-2: Guide to soil and rock descriptions
Figure A1, 3-14 to A1, 3-16: Infiltration Test Pit Logs
Figures A1, 4-1 to A1, 4-6: Infiltration Test Results
Figure A1-5: Laboratory Summary
Figure A1-6: Grain Size Distributions



TEST PIT LOCATION (TP-1)
TEST PIT INFILTRATION (TP-14)

N
SCALE: 1"=200'
0 100 200

BASE PLAN FROM WCE-08/25/21

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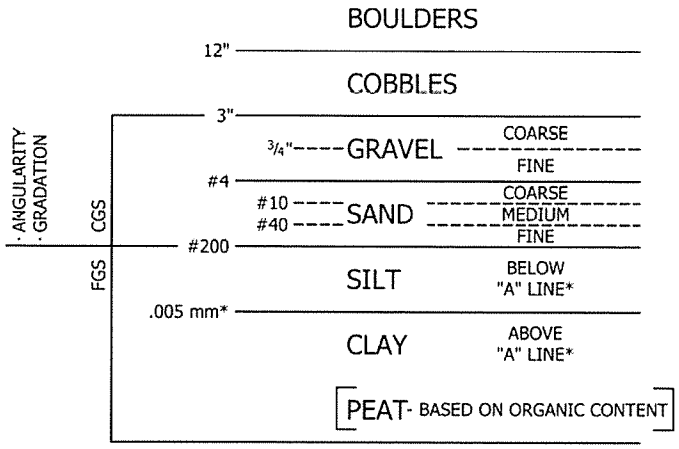
SITE PLAN	FIGURE A1-1
GRANDVIEW 92-LOT HOUSING DEVELOPMENT SPOKANE, WASHINGTON	PROJECT NUMBER S21702
	DATE: 11/2021

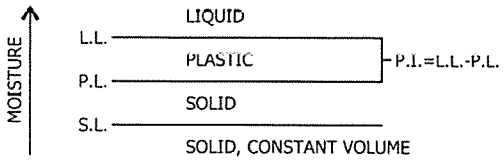
GUIDE TO SOIL & ROCK DESCRIPTIONS

SOIL CLASSIFICATION

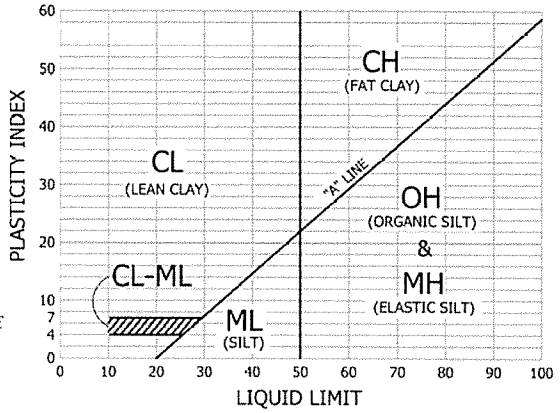


* *SEE PLASTICITY CHART*
CGS - COARSE GRAINED SOIL - MORE THAN 50% RETAINED ON A #200 SIEVE
FGS - FINE GRAINED SOIL - 50% MORE PASSES, #200 SIEVE
FINES - PORTION FINER THAN #200 SIEVE

ATTERBERG LIMITS



PLASTICITY CHART



NOTE - CHART APPLIES TO FGS AND MINUS #40 SIEVE FRACTION OF CGS

GUIDE TO SOIL DESCRIPTION MODIFIERS, MOISTURE, AND CONDITION PRESENTED ON LOGS

MODIFIER	ESTIMATED PERCENTAGE OF MATERIAL
SUFFIX "LY" OR "Y"	30% OR MORE FOR COARSE PARTS IN FGS GREATER THAN 12% FOR FINES IN CGS
WITH	15% - 29% FOR COARSE PARTS IN FGS 6% - 14% FOR FINES IN CGS

NOTE - VISUAL ESTIMATES OF MATERIAL PERCENTAGES TYPICALLY VARY 0 TO 10% FROM THOSE DETERMINED BY LABORATORY TESTING.

MOISTURE

DRY
MOIST
SATURATED OR WET

SOIL CONDITION

CGS:
- VERY LOOSE
- LOOSE
- MEDIUM DENSE
- DENSE
- VERY DENSE

FGS:
- VERY SOFT
- SOFT
- MEDIUM STIFF
- STIFF
- VERY STIFF
- HARD

SAMPLES

- STANDARD 2" PENETRATION TEST SAMPLER WITH BLOWS PER FOOT
- 3" SPLIT SPOON SAMPLER WITH BLOWS PER FOOT
- DRILL CUTTING SAMPLE
- BULK SAMPLE
- THIN-WALLED TUBE SAMPLE
- DIAMOND CORE RUN WITH % RECOVERY & ROCK QUALITY DESIGNATION
- 4" SPLIT SPOON SAMPLER WITH BLOWS PER FOOT
- R — REFUSAL OF SAMPLE (50+ BLOWS PER 6")

ROCK WEATHERING	ROCK CONDITION
FRESH	EXTREMELY WEAK
SLIGHTLY WEATHERED	VERY WEAK
MODERATELY WEATHERED	MODERATELY WEAK
HIGHLY WEATHERED	MODERATELY STRONG
COMPLETELY WEATHERED	STRONG
RESIDUAL SOIL	VERY STRONG

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FIGURE A1-2

TEST PIT 14

Date: 11-2-21
Excavator: B.Anderson
Equipment: CASE Extendahoe
Location: Infiltration 1
Surface: pine needles and grass

Elevation: 2215 ft
Logged by: D. Lehn
Size of hole: 2.5 x8

DEPTH	SAMPLES	MOISTURE, COLOR, CONDITION	DESCRIPTION	SOIL LOG
0		moist, dark brown, loose	SILT with Sand and Gravel and organics	
		dry, tan, medium dense	SILT with Sand, Gravel, and Cobbles, non-plastic (Colluvium)	
5			Stratified cobbles below 5 ft.	
10		dry, light gray, medium dense	SANDY SILT, stratified, blocky, lacustrine	
		no free groundwater observed	End of Excavation @ 11 ft	
15				
20				

TEST RESULTS

ATTERBERG LIMITS
PL — LL
WATER CONTENT ○

10 20 30 40 50 60 70 80 90

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TEST PIT LOGS **FIGURE A1, 3-14**

Project: Grandview 92-Lot Housing Development
Location: Spokane, WA
Number: S21702

TEST PIT 15

Date: 11-2-21
Excavator: B.Anderson
Equipment: CASE Extendahoe
Location: Infiltration 2
Surface: pine needles and grass

Elevation: 2225 ft
Logged by: D. Lehn
Size of hole: 2.5 x8

DEPTH	SAMPLES	MOISTURE, COLOR, CONDITION	DESCRIPTION	SOIL LOG
0		moist, dark brown, loose	SILT with Sand and Gravel and organics	
		dry, tan, medium dense	SILTY GRAVEL with Sand and Cobbles, coarse, subangular (Colluvium)	
5				
		moist, gray, medium dense	GRAVEL with Sand, fine, angular	
			Refusal due to excessive caving	
10		no free groundwater observed	End of Excavation @ 9 ft	
15				
20				

TEST RESULTS

ATTERBERG LIMITS
PL — LL
WATER CONTENT ○

10 20 30 40 50 60 70 80 90

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Spokane Valley, WA 99212

TEST PIT LOGS **FIGURE A1, 3-15**

Project: Grandview 92-Lot Housing Development
Location: Spokane, WA
Number: S21702

TEST PIT 16

Date: 11-2-21
Excavator: B.Anderson
Equipment: CASE Extendahoe
Location: Infiltration 3
Surface: pine needles and grass

Elevation: 2210 ft
Logged by: D. Lehn
Size of hole: 2.5 x8

DEPTH	SAMPLES	MOISTURE, COLOR, CONDITION	DESCRIPTION	SOIL LOG
0		moist, dark brown, loose	SILT with Sand and Gravel and organics	
		dry, tan, medium dense	GRAVEL with Silt, Sand, and Cobbles, coarse, subangular (Colluvium)	
5		moist, tan, medium dense	GRAVEL with Sand and Cobbles, coarse, subangular, alluvial	
		moist, white, medium dense	SILT (volcanic ash)	
		moist, white, very dense	GRAVEL with Silt and Sand, coarse to fine, subangular, alluvial	
10		no free groundwater observed	End of Excavation @ 7 ft Excavation refusal on very dense gravel with silt and sand	
15				
20				

TEST RESULTS

ATTERBERG LIMITS
PL — LL
WATER CONTENT ○

10 20 30 40 50 60 70 80 90

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Spokane Valley, WA 99212

TEST PIT LOGS **FIGURE A1, 3-16**

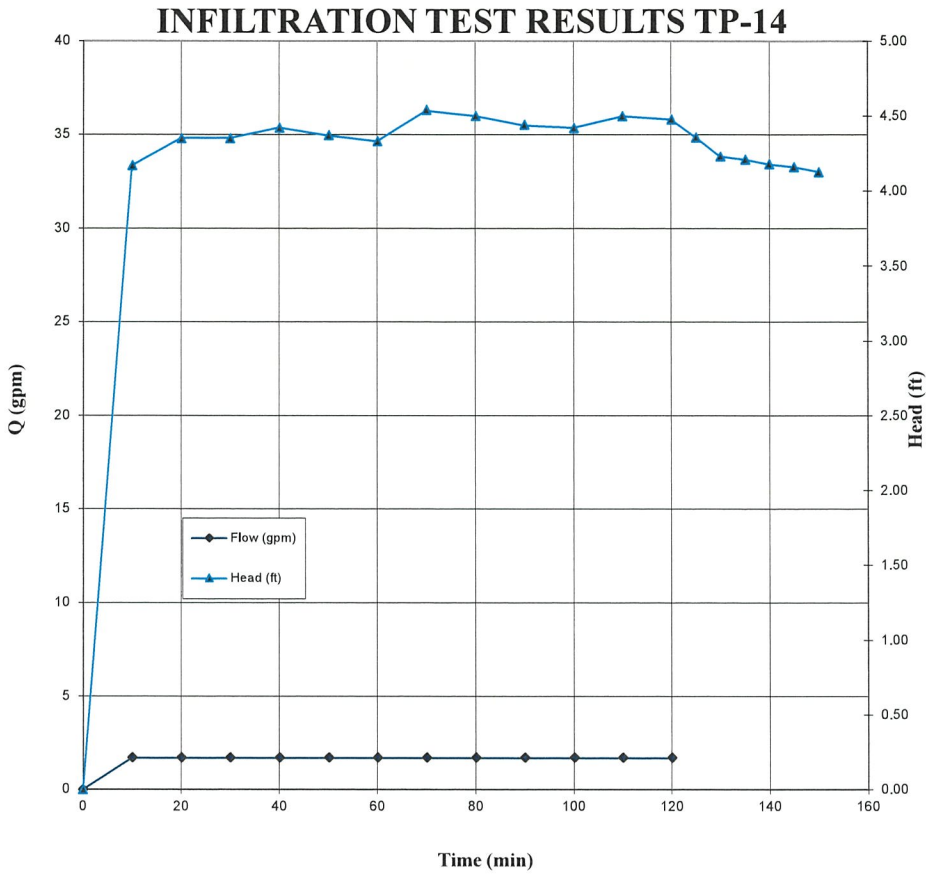
Project: Grandview 92-Lot Housing Development
Location: Spokane, WA
Number: S21702

Infiltration Test Results

TP-14

Total Depth (ft) 11.00

Date/Time	Time (min)	meter 1 (gal)	Cumulative Volume (gal)	Rate (gpm)	Head
11/2/2021 10:20	0	3971827	0	0	0.00
11/2/2021 10:30	10	3971844	17	1.7	4.17
11/2/2021 10:40	20	3971861	34	1.7	4.35
11/2/2021 10:50	30	3971878	51	1.7	4.35
11/2/2021 11:00	40	3971895	68	1.7	4.42
11/2/2021 11:10	50	3971912	85	1.7	4.37
11/2/2021 11:20	60	3971929	102	1.7	4.33
11/2/2021 11:30	70	3971945	118	1.7	4.54
11/2/2021 11:40	80	3971962	135	1.7	4.50
11/2/2021 11:50	90	3971979	152	1.7	4.44
11/2/2021 12:00	100	3971996	169	1.7	4.42
11/2/2021 12:10	110	3972013	186	1.7	4.50
11/2/2021 12:20	120	3972030	203	1.7	4.48
11/2/2021 12:25	125				4.36
11/2/2021 12:30	130				4.23
11/2/2021 12:35	135				4.21
11/2/2021 12:40	140				4.18
11/2/2021 12:45	145				4.16
11/2/2021 12:50	150				4.13

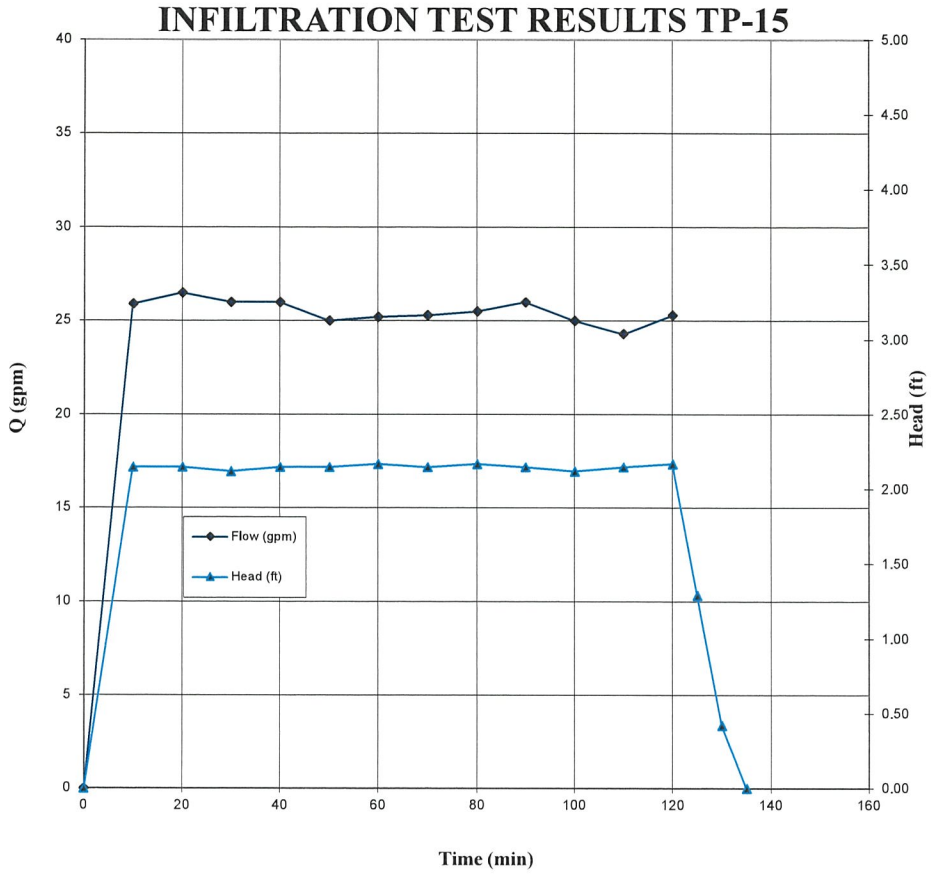

INFILTRATION TEST RESULTS TP-14
Q (gpm)
Head (ft)
Time (min)
Flow (gpm)
Head (ft)
0
5
10
15
20
25
30
35
40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
0
20
40
60
80
100
120
140
160

Infiltration Test Results

TP-15

Total Depth (ft) 8.00

Date/Time	Time (min)	meter 1 (gal)	Cumulative Volume (gal)	Rate (gpm)	Head
11/2/2021 14:00	0	3972586.0	0	0	0.00
11/2/2021 14:10	10	3972845.0	259	25.9	2.15
11/2/2021 14:20	20	3973110.0	524	26.5	2.15
11/2/2021 14:30	30	3973370.0	784	26.0	2.12
11/2/2021 14:40	40	3973630.0	1044	26.0	2.15
11/2/2021 14:50	50	3973880.0	1294	25.0	2.15
11/2/2021 15:00	60	3974132.0	1546	25.2	2.17
11/2/2021 15:10	70	3974385.0	1799	25.3	2.15
11/2/2021 15:20	80	3974640.0	2054	25.5	2.17
11/2/2021 15:30	90	3974900.0	2314	26.0	2.15
11/2/2021 15:40	100	3975150.0	2564	25.0	2.12
11/2/2021 15:50	110	3975393.0	2807	24.3	2.15
11/2/2021 16:00	120	3975646.0	3060	25.3	2.17
11/2/2021 16:05	125				1.29
11/2/2021 16:10	130				0.42
11/2/2021 16:15	135				0.00

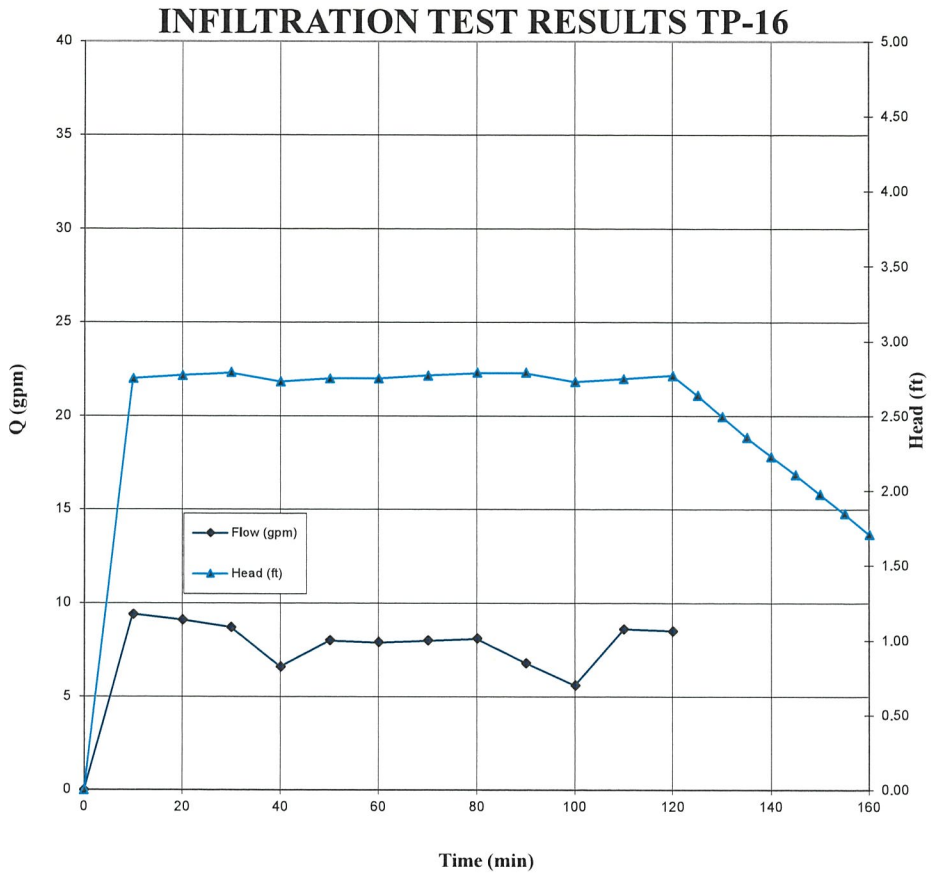

INFILTRATION TEST RESULTS TP-15
Q (gpm)
Head (ft)
Time (min)
Flow (gpm)
Head (ft)
0
5
10
15
20
25
30
35
40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
0
20
40
60
80
100
120
140
160

Infiltration Test Results

TP-16

Total Depth (ft) 6.70

Date/Time	Time (min)	meter 1 (gal)	Cumulative Volume (gal)	Rate (gpm)	Head
11/3/2021 8:50	0	3976334	0	0	0.00
11/3/2021 9:00	10	3976428	94	9.4	2.75
11/3/2021 9:10	20	3976519	185	9.1	2.77
11/3/2021 9:20	30	3976606	272	8.7	2.79
11/3/2021 9:30	40	3976672	338	6.6	2.73
11/3/2021 9:40	50	3976752	418	8.0	2.75
11/3/2021 9:50	60	3976831	497	7.9	2.75
11/3/2021 10:00	70	3976911	577	8.0	2.77
11/3/2021 10:10	80	3976992	658	8.1	2.79
11/3/2021 10:20	90	3977060	726	6.8	2.79
11/3/2021 10:30	100	3977116	782	5.6	2.73
11/3/2021 10:40	110	3977202	868	8.6	2.75
11/3/2021 10:50	120	3977287	953	8.5	2.77
11/3/2021 10:55	125				2.64
11/3/2021 11:00	130				2.50
11/3/2021 11:05	135				2.36
11/3/2021 11:10	140				2.23
11/3/2021 11:15	145				2.11
11/3/2021 11:20	150				1.98
11/3/2021 11:25	155				1.85
11/3/2021 11:30	160				1.71


INFILTRATION TEST RESULTS TP-16
Q (gpm)
Head (ft)
Time (min)
Flow (gpm)
Head (ft)
0
5
10
15
20
25
30
35
40
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
0
20
40
60
80
100
120
140
160

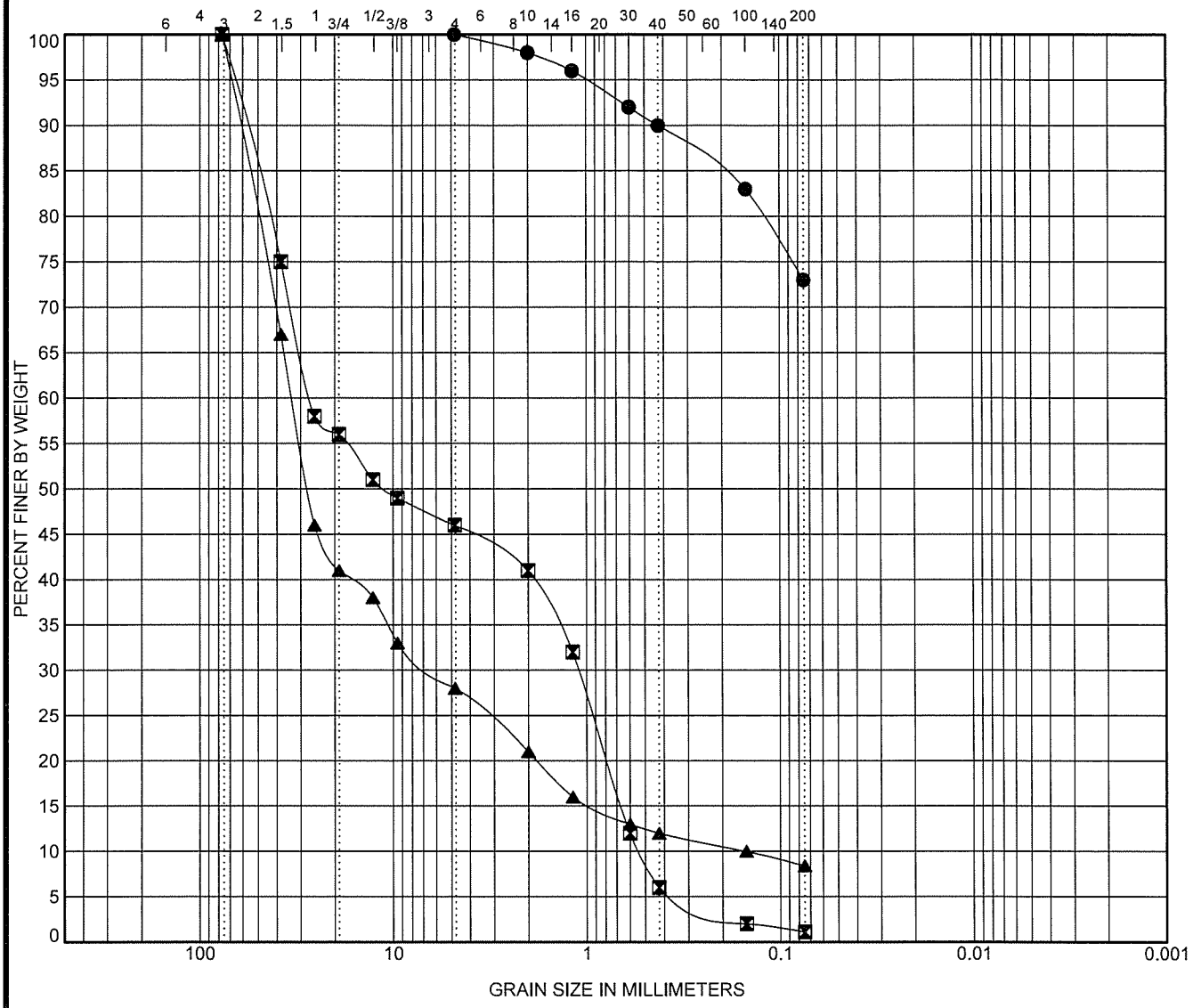
SOIL MECHANICS

LABORATORY SUMMARY

		Units	Test Methods	[illegible]	[illegible]	[illegible]
LABORATORY NUMBER				[illegible]	[illegible]	[illegible]
TEST PIT NUMBER				TP-14	TP-15	TP-16
DEPTH	TOP	feet		9	8	6
	BOTTOM	feet		10	9	7
MOISTURE CONTENT		%	ASTM D2216	8.2	2.3	7.5
PLASTICITY INDEX		%	ASTM D4318	NP		NP
UNIFIED CLASSIFICATION			ASTM D2487	ML	GP	GP-GM
SIEVE ANALYSIS			ASTM D6913			
	3"				100	100
	1 1/2"				75	67
S	1"	%			58	46
I	3/4"				56	41
E	1/2"	P			51	38
V	3/8"	A			49	33
E	#4	S		100	46	28
	#10	S		98	41	21
S	#16	I		96	32	16
I	#30	N		92	12	13
Z	#40	G		90	6	12
E	#100			83	2	10
	#200			73	1.1	8.4

*NP= Non Plastic

FIGURE A1- 5



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification			Classification	LL	PL	PI	Cc	Cu
●	14	9.0	SILT with SAND(ML)	NP	NP	NP		
⊠	15	7.0	POORLY GRADED GRAVEL with SAND(GP)	NP	NP	NP	0.09	49.79
▲	16	6.0	POORLY GRADED GRAVEL with SILT and SAND(GP-GM)	NP	NP	NP	7.98	221.50

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	14	9.0	4.8				0.0	27.0	73.0	
⊠	15	7.0	76.8	26.633	1.103	0.535	53.2	44.8	1.1	
▲	16	6.0	76.8	33.225	6.307	0.15	71.0	19.5	8.4	

Budinger & Associates
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Spokane Valley, WA 99212

GRAIN SIZE DISTRIBUTION RESULTS

Project: Grandview 92-Lot Housing Development

Location: Spokane, WA

Number: S21702

FIGURE A1-6

US_GRAIN SIZE_S21702.GPJ_BUDINGER.GDT_11/15/21