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STORMWATER REPORT

TREATMENT AND DETENTION DESIGN

To
City of West Linn
Department of Engineering

For
Rosemont Subdivision
West Linn, Oregon

Prepared
August 28, 2013

Revised
September 10, 2013

Project Number
2130073.00

REGISTERED PROFESSIONAL ENGINEER
56660 PE
Ralph J. R. Henderson
OREGON
JULY 11, 2000
RALPH J. R. HENDERSON
EXPIRATION DATE: 6/30/15

MACKENZIE
Since 1960
RiverEast Center | 1515 SE Water Ave, Suite 100, Portland, OR 97214
PO Box 14310, Portland, OR 97293 | T 503.224.9560 | www.mcknze.com

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1. SITE AND SYSTEM DESCRIPTION

The proposed subdivision will divide the existing 1.86 AC property to create 7 residential lots and two access easements for private driveways. The proposed subdivision is located at 1485 Rosemont Road in West Linn, Oregon.

The city of West Linn follows the City of Portland Stormwater Management Manual (SWMM). For projects with less than 10,000 SF of new or redeveloped impervious area, the Simplified Approach may be used to size stormwater facilities (SWMM Section 2.2.1). However, in order to infiltrate up to the 100-year storm event, the Presumptive Approach was used.

Vegetated surface infiltration facilities are required on sites with a field infiltration rate of at least 2 in/hr. For sites with infiltration rates of less than 2 in/hr infiltration is allowed (SWMM Section 2.2.2). Infiltration testing was done near the proposed stormwater facility locations using the Encased Falling Head test method. All test locations had infiltration rates above 2in/hr, accept on lot 4, where the infiltration rate was 1.8 in/hr. A factor of safety of 3 was applied to the field infiltration rates to meet the SWMM requirements for Encased Falling Head infiltration tests (SWMM Appendix F.2).

In order to design so that all the facilities will infiltrate the 100-year design storm event and to address concerns about stormwater overflow, additional stormwater calculations were performed, beyond what is required by the simplified approach. Basins will be used to treat and infiltrate stormwater from impervious area on each residential lot. Swales along the sides of the driveways will manage stormwater from these paved areas. Water quality swales will be used to treat stormwater from the Rosemont Road half street improvements.

The City of Portland's Presumptive Approach Calculator (PAC) (SWMM Appendix C.3) was used to size the swales and basins for water quality. The PAC output is included in this report.

AutoCAD's Hydraflow Hydrographs Extension was used to size the basins for detention and infiltration. Hydraflow results show that each basin was sized to detain and infiltrate the 100-yr storm event, even on lot 4 where infiltration rates are just under 2 in/hr. This considerably upsized this facility.

Each new lot will be about 0.23 AC with an assumed impervious area of 4,400 sf per lot. Each access drive will be 16'-wide x 145'-long resulting in 2,000 sf of impervious area each. The half street improvements along Rosemont Road will result in 11,800 sf of impervious area. See the Table 1 below for a summary of the catchments for each stormwater facility.

The basin design has 12" of drain rock under the bottom of the basins. There is no rock under the side slopes of the basins.

Table 1: Catchment Summary

Contributing Basin	Stormwater Facility Type	Field Infiltration Rate (in/hr)	Design Infiltration Rate with Safety Factor of 3 (in/hr)	Contributing Impervious Area (SF)	Required Facility Bottom Area (rock area) (SF)	Facility Top Area (SF)
Lot 1	Basin	3.15	1.05	4,400	345	912
Lot 2	Basin	2.93	0.98	4,400	355	812
Lot 3	None	N/A	N/A	4,400	None	None
Lot 4	Basin	1.80	0.60	4,400	460	945
Lot 5	Basin	3.15	1.05	4,400	345	751
Lot 6	Basin	2.08	0.69	4,400	430	1116
Lot 7	Basin	2.08	0.69	4,400	430	1116
Access Drive 1	Swale	2.00	0.67	2,000	-	445
Access Drive 2	Swale	2.00	0.67	2,000	-	445
Rosemont Half Street	Swale	2.00	0.67	11,800	-	475

2. FACILITY DESIGN

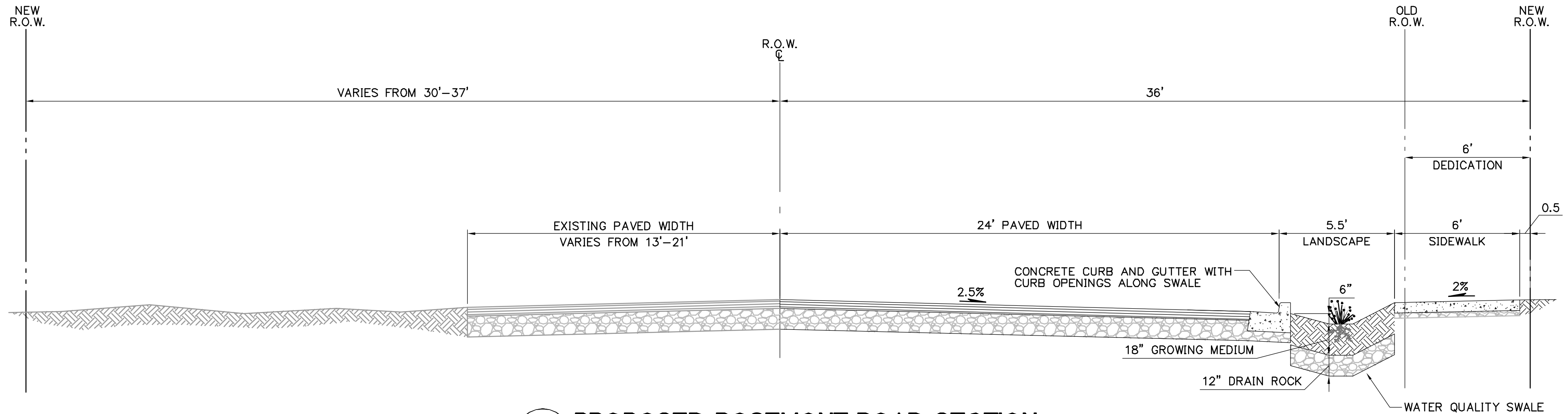
Basins have been sized for each new residential lot using the PAC and Hydraflow. The PAC was used to confirm that water quality requirements were being met. Hydraflow was used to the size the facility for detention and infiltration of the 100-yr storm. The basins will have 18" of growing medium over 12" of drain rock. There will be 12" of storage capacity above ground with 2" of freeboard.

The two 16'-wide driveways will sheet flow to an infiltration swale on one side. The swales will extend the full length of the driveway, which is larger than would be required using the Simplified Approach. The Simplified Approach applies a sizing factor of 0.09 to the impervious area or 2,000 SF*0.09=180 SF. The proposed swales are 450 SF, 150% more than required. The swales will have 18" of growing medium over 12" of drain rock. The swales will be 6"-deep and slope to match the driveways at no more than 6%.

Runoff from the Rosemont Road half street improvements will drain to 2 swales located between the curb and the sidewalk. Openings in the curb adjacent to the swales will allow water to drain into the swales. Stormwater is treated as it flows through the swales and infiltrates into the ground. Any excess water overflows through the curb breaks and flows to the next downstream inlet. Since the new impervious area along Rosemont exceeds 10,000 SF, the PAC was used to size the swales. The swales will have 18" of growing medium over 12" of drain rock. The swales will be 6"-deep and slope to match the roadway.


SEWER MANHOLE
RIM=631.95'
IE IN(W)=627.8'
IE OUT(E)=627.6'
FUTURE STORMWATER
INFILTRATION BASIN
SEE DETAIL 4/C6.0
430 SF BOTTOM
1,116 SF TOP
EXISTING 8" SANITARY SEWER @ 1.8%
SEWER MANHOLE
RIM=627.30'
IE IN(W)=621.9'
IE OUT(SE)=621.7'
FUTURE STORMWATER
INFILTRATION BASIN
SEE DETAIL 4/C6.0
345 SF BOTTOM
751 SF TOP
17'
17'
LOT 7
FUTURE STORMWATER
INFILTRATION BASIN
SEE DETAIL 4/C6.0
430 SF BOTTOM
1,116 SF TOP
LOT 5
8" CULVERT INLET
IE=603.2"
SEWER MANHOLE
RIM=605.26'
SEWER MANHOLE
RIM=605.99'
EXISTING 8" SANITARY SEWER
LOT 6
FUTURE STORMWATER
INFILTRATION BASIN
SEE DETAIL 4/C6.0
345 SF BOTTOM
912 SF TOP
FUTURE STORMWATER
INFILTRATION BASIN
SEE DETAIL 4/C6.0
355 SF BOTTOM
812 SF TOP
SEWER MANHOLE
RIM=629.96'
IE IN(NW)=620.9'
IE OUT(E)=620.7'
14'
20'
FUTURE STORMWATER
INFILTRATION SWALE
450 SF
FUTURE STORMWATER
INFILTRATION SWALE
450 SF
UNDERGROUND
ON NWN GA
LOT 1
LOT 2
LOT 3
EXISTING HOUSE
TO REMAIN
LOT 4
FUTURE STORMWATER
INFILTRATION BASIN
SEE DETAIL 4/C6.0
460 SF BOTTOM
945 SF TOP
5.05'
LINN LANE
EXISTING 16" CULVERT OUTFALL
OIL CAP/VENT
16" CULVERT OUTFALL
IE=615.6'
ROSEMONT ROAD
PUBLIC IMPROVEMENTS
WATER QUALITY SWALE
220 SF
PUBLIC IMPROVEMENTS
WATER QUALITY SWALE
255 SF
ACCESS EASEMENT 1
ACCESS EASEMENT 2
UNDERGROUND GAS BASED
ON NWN GAS MAP
TELECOM. MANHOLE
W/ UNDERGROUND
TELECOM. VAULT
STORM MANHOLE
RIM=634.57'
IE IN(E)=629.8'
IE OUT(S)=629.1'
IRELAND LANE
0
20
40
80

STORM PLAN



1 C6.0 PROPOSED ROSEMONT ROAD SECTION

N.T.S.

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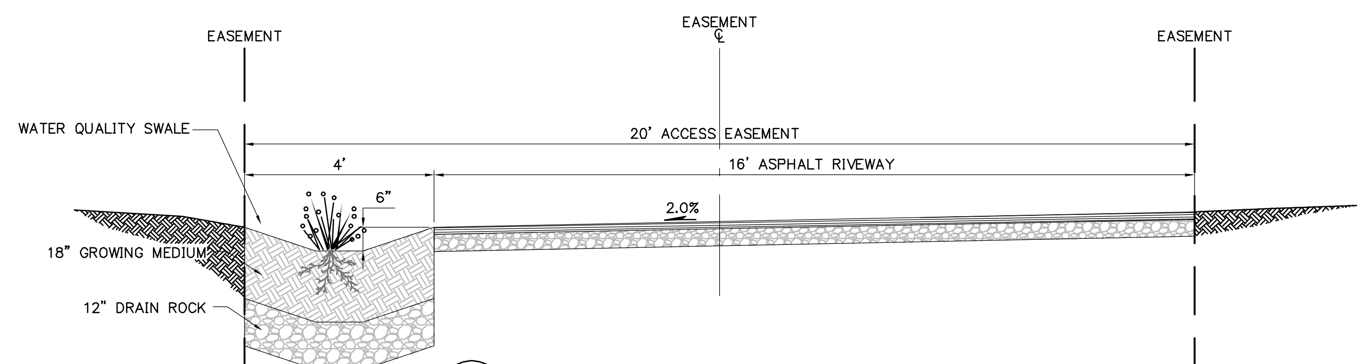

2 C6.0 ACCESS DRIVE 1 SECTION

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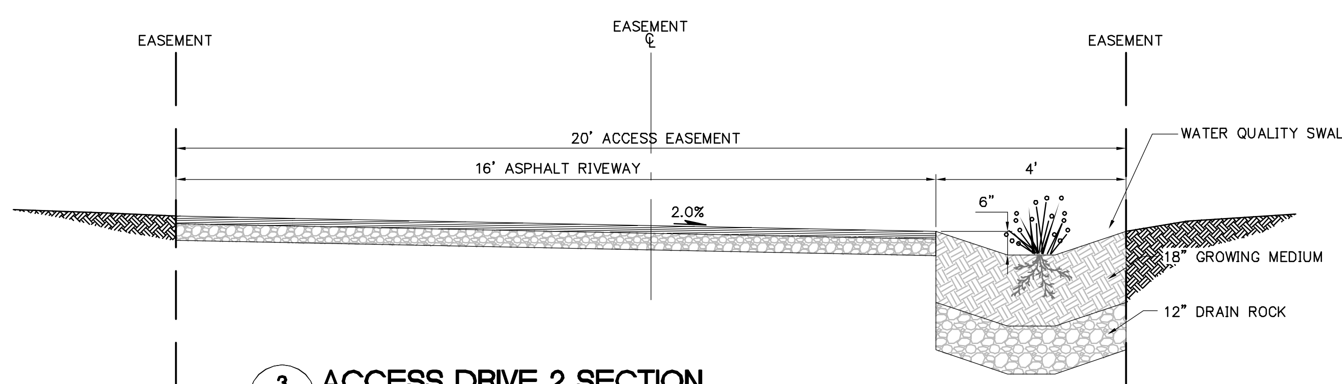

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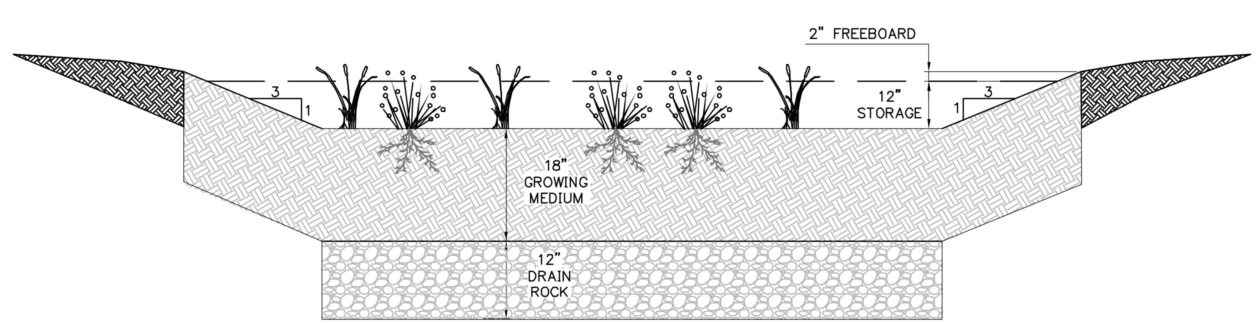


4 C6.0 INFILTRATION BASIN TYPICAL SECTION

1:1

Presumptive Approach Calculator ver. 1.2

Catchment Data

Catchment ID: **Lots 1&5**

Project Name:	**Rosemont Subdivision**
Project Address:	**1485 Rosemont Road**
	West Linn, OR
Designer:	**Megan Goplin**
Company:	**Mackenzie**

Date: **09/11/13**
Permit Number: **0**
Run Time 9/13/2013 7:32:42 AM

Drainage Catchment Information

Catchment ID	Lots 1&5	
	Catchment Area	
Impervious Area	4,400	SF
Impervious Area	0.10	ac
Impervious Area Curve Number, CN_{imp}	98	
Time of Concentration, Tc, minutes	5	min.

Site Soils & Infiltration Testing Data

Infiltration Testing Procedure:	Encased Falling Head	
Native Soil Field Tested Infiltration Rate (I_{test}):	2.1	in/hr
Bottom of Facility Meets Required Separation From High Groundwater Per BES SWMM Section 1.4:	Yes	

Field infiltration rate was manually adjusted down to model as safety factor of 3.

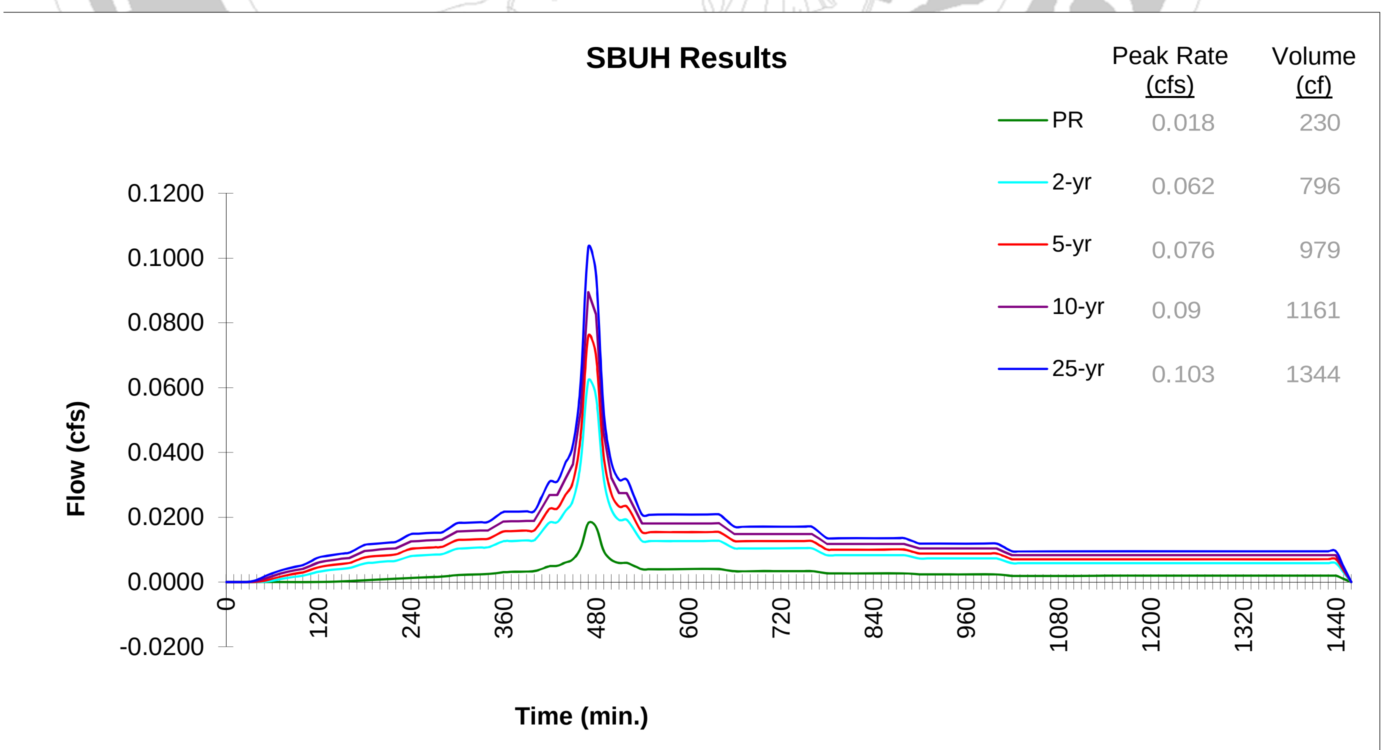
Correction Factor Component

CF_{test} (ranges from 1 to 3)	~~2~~ 3	

Design Infiltration Rates

I_{dsgn} for Native (I_{test} / CF_{test}):	1.05	in/hr
I_{dsgn} for Imported Growing Medium:	2.00	in/hr

Execute SBUH



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Presumptive Approach Calculator ver. 1.2

Catchment ID: Lots 1&5

Run Time 9/13/2013 7:32:42 AM

Project Name: **Rosemont Subdivision** **Catchment ID:** **Lots 1&5** **Date:** **9/11/2013**

Instructions:

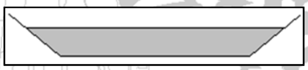
1. Identify which Stormwater Hierarchy Category the facility.
2. Select Facility Type.
3. Identify facility shape of surface facility to more accurately estimate surface volume, except for Swales and sloped planters that use the PAC Sloped Facility Worksheet to enter data.
4. Select type of facility configuration.
5. Complete data entry for all highlighted cells.

Catchment facility will meet Hierarchy Category: **1**

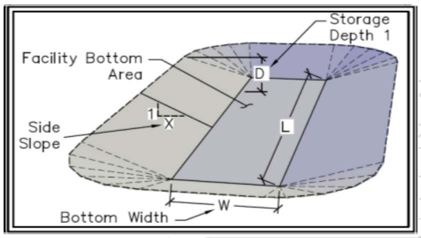
Goal Summary:

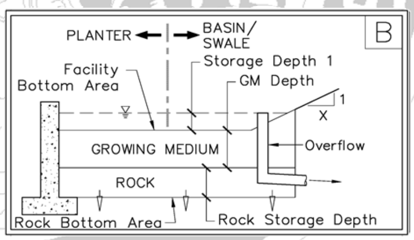
Hierarchy Category	SWMM Requirement	RESULTS box below needs to display…	
		Pollution Reduction as a	10-yr (aka disposal) as a
1	On-site infiltration with a surface infiltration facility.	PASS	PASS

Facility Type = Basin



Facility Shape: Rectangle/Square **Facility Configuration: B**





Calculation Guide
Max. Rock Stor. Bottom Area
813 SF

DATA FOR ABOVE GRADE STORAGE COMPONENT

Facility Bottom Area =	**345**	**sf**
Bottom Width =	**5.0**	**ft**
Facility Side Slope =	**3**	**to 1**
Storage Depth 1 =	**12**	**in**
Growing Medium Depth =	**18**	**in**
Freeboard Depth =	**2**	**in**
Surface Capacity at Depth 1 =	**579**	**cf**
Infiltration Area at 75% Depth1 =	**696**	**SF**
GM Design Infiltration Rate =	**2.00**	**in/hr**
Infiltration Capacity =	**0.032**	**cfs**

BELOW GRADE STORAGE

Rock Storage Bottom Area =	**345**	**sf**
Rock Storage Depth =	**12**	**in**
Rock Void Ratio =	**0.3**	
Rock Storage Capacity =	**104**	**cf**
Native Design Infiltration Rate =	**1.05**	**in/hr**
Infiltration Capacity =	**0.008**	**cfs**

RESULTS

		Overflow Volume		
Pollution Reduction	**PASS**	0 CF	**0%**	Surf. Cap. Used
			13%	Rock Cap. Used
10-yr	**PASS**	0 CF	**66%**	Surf. Cap. Used
			100%	Rock Cap. Used

Run PAC

FACILITY FACTS

Total Facility Area Including Freeboard =	**912 SF**
Sizing Ratio (Total Facility Area / Catchment Area) =	**0.207**

Presumptive Approach Calculator ver. 1.2

Catchment Data

Catchment ID: **Lot 2**

Project Name:	**Rosemont Subdivision**
Project Address:	**1485 Rosemont Road**
	West Linn, OR
Designer:	**Megan Goplin**
Company:	**Mackenzie**

Date: **09/11/13**
Permit Number: **0**
Run Time 9/11/2013 3:27:00 PM

Drainage Catchment Information

Catchment ID	Lot 2	
	Catchment Area	
Impervious Area	4,400	SF
Impervious Area	0.10	ac
Impervious Area Curve Number, CN_{imp}	98	
Time of Concentration, Tc, minutes	5	min.

Site Soils & Infiltration Testing Data

Infiltration Testing Procedure:	Encased Falling Head	
Native Soil Field Tested Infiltration Rate (I_{test}):	1.96	in/hr
Bottom of Facility Meets Required Separation From High Groundwater Per BES SWMM Section 1.4:	Yes	

Field infiltration rate was manually adjusted down to model as safety factor of 3.

Correction Factor Component

CF_{test} (ranges from 1 to 3)	~~2~~ 3	

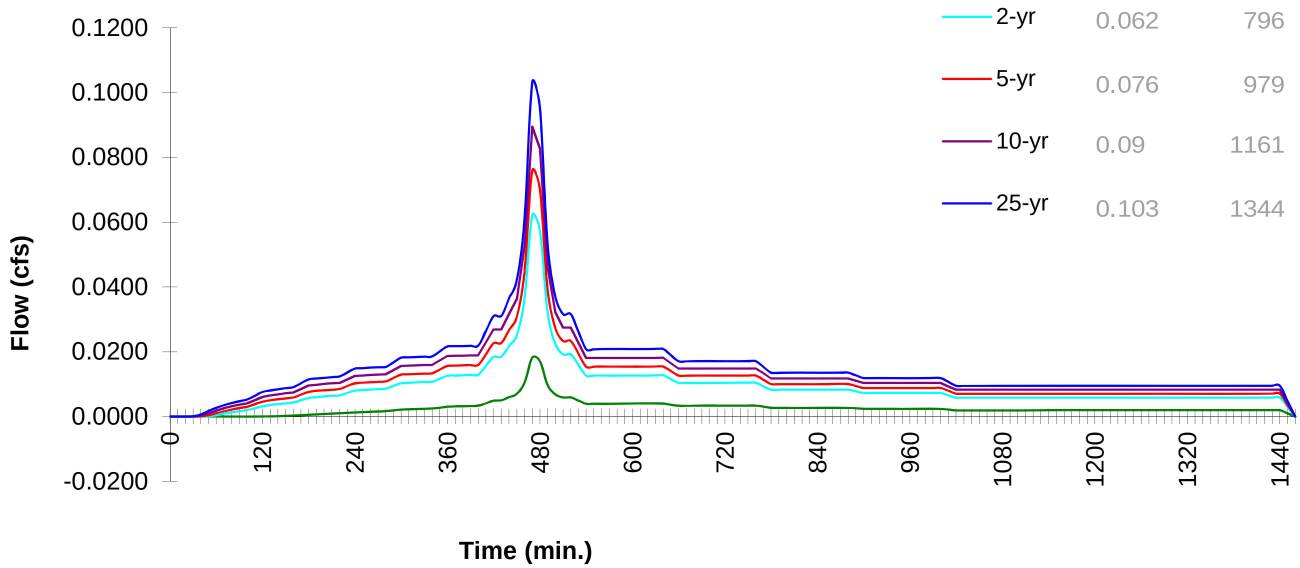
Design Infiltration Rates

I_{dsgn} for Native (I_{test} / CF_{test}):	0.98	in/hr
I_{dsgn} for Imported Growing Medium:	2.00	in/hr

Execute SBUH

SBUH Results

	Peak Rate (cfs)	Volume (cf)
PR	0.018	230
2-yr	0.062	796
5-yr	0.076	979
10-yr	0.09	1161
25-yr	0.103	1344



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Presumptive Approach Calculator ver. 1.2

Catchment ID: Lot 2

Run Time 9/11/2013 3:27:00 PM

Project Name: **Rosemont Subdivision** **Catchment ID:** **Lot 2** **Date:** **9/11/2013**

Instructions:

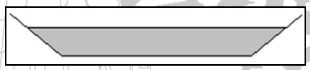
1. Identify which Stormwater Hierarchy Category the facility.
2. Select Facility Type.
3. Identify facility shape of surface facility to more accurately estimate surface volume, except for Swales and sloped planters that use the PAC Sloped Facility Worksheet to enter data.
4. Select type of facility configuration.
5. Complete data entry for all highlighted cells.

Catchment facility will meet Hierarchy Category: **1**

Goal Summary:

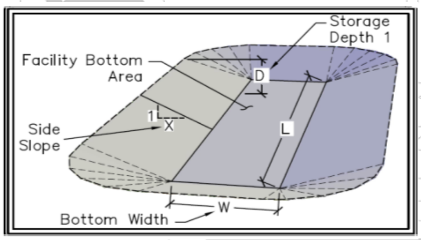
Hierarchy Category	SWMM Requirement	RESULTS box below needs to display…	
		Pollution Reduction as a	10-yr (aka disposal) as a
1	On-site infiltration with a surface infiltration facility.	PASS	PASS

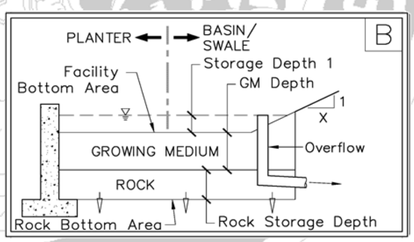
Facility Type = **Basin**



Facility Shape: **Rectangle/Square**

Facility Configuration: **B**





Calculation Guide
Max. Rock Stor. Bottom Area
835 SF

DATA FOR ABOVE GRADE STORAGE COMPONENT

Facility Bottom Area =	**355**	**sf**
Bottom Width =	**5.0**	**ft**
Facility Side Slope =	**3**	**to 1**
Storage Depth 1 =	**12**	**in**
Growing Medium Depth =	**18**	**in**
Freeboard Depth =	**2**	**in**
Surface Capacity at Depth 1 =	**595**	**cf**
Infiltration Area at 75% Depth1 =	**715**	**SF**
GM Design Infiltration Rate =	**2.00**	**in/hr**
Infiltration Capacity =	**0.033**	**cfs**

BELOW GRADE STORAGE

Rock Storage Bottom Area =	**355**	**sf**
Rock Storage Depth =	**12**	**in**
Rock Void Ratio =	**0.3**	
Rock Storage Capacity =	**107**	**cf**
Native Design Infiltration Rate =	**0.98**	**in/hr**
Infiltration Capacity =	**0.008**	**cfs**

RESULTS

		Overflow Volume		
Pollution Reduction	**PASS**	0 CF	**0%**	Surf. Cap. Used
			13%	Rock Cap. Used
10-yr	**PASS**	0 CF	**67%**	Surf. Cap. Used
			100%	Rock Cap. Used

Run PAC

FACILITY FACTS

Total Facility Area Including Freeboard = **936 SF**

Sizing Ratio (Total Facility Area / Catchment Area) = **0.213**

Presumptive Approach Calculator ver. 1.2

Catchment Data

Catchment ID:	Lot 4
Date:	09/11/13
Permit Number:	0
Run Time	9/11/2013 3:41:14 PM

Project Name:	**Rosemont Subdivision**
Project Address:	**1485 Rosemont Road**
	West Linn, OR
Designer:	**Megan Goplin**
Company:	**Mackenzie**

Drainage Catchment Information

Catchment ID	Lot 4	
	Catchment Area	
Impervious Area	4,400	SF
Impervious Area	0.10	ac
Impervious Area Curve Number, CN_{imp}	98	
Time of Concentration, Tc, minutes	5	min.

Site Soils & Infiltration Testing Data

Infiltration Testing Procedure:	Encased Falling Head	
Native Soil Field Tested Infiltration Rate (I_{test}):	1.2	in/hr
Bottom of Facility Meets Required Separation From High Groundwater Per BES SWMM Section 1.4:	Yes	

Field infiltration rate was manually adjusted down to model as safety factor of 3.

Correction Factor Component

CF_{test} (ranges from 1 to 3)	~~2~~ 3	

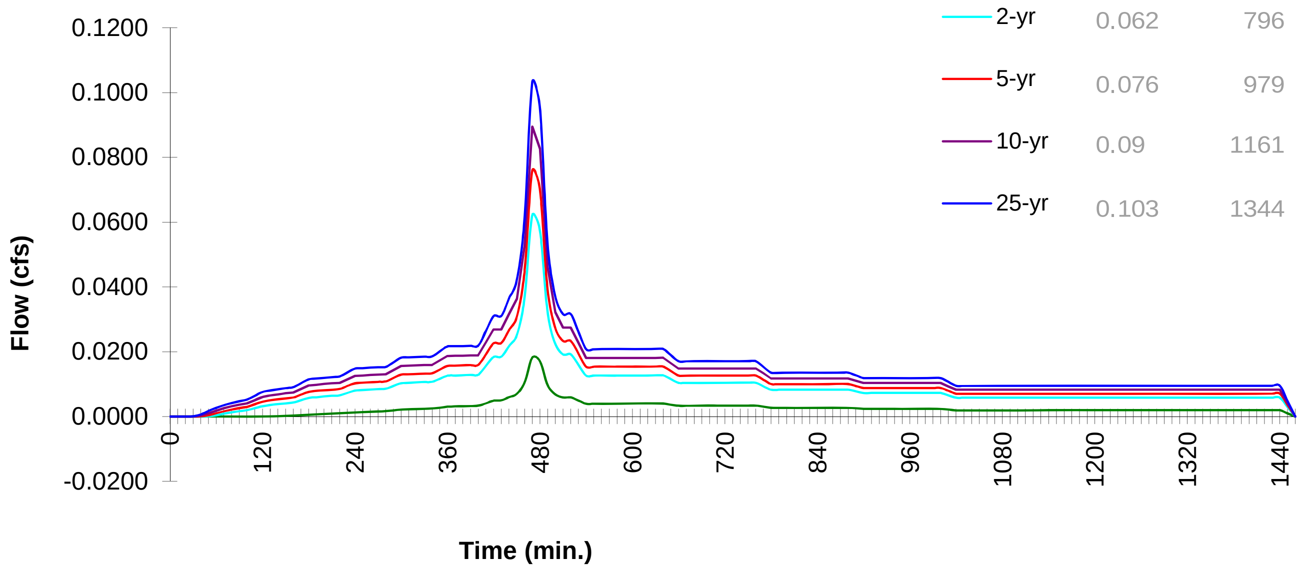
Design Infiltration Rates

I_{dsgn} for Native (I_{test} / CF_{test}):	0.60	in/hr
I_{dsgn} for Imported Growing Medium:	2.00	in/hr

Execute SBUH

SBUH Results

	Peak Rate (cfs)	Volume (cf)
PR	0.018	230
2-yr	0.062	796
5-yr	0.076	979
10-yr	0.09	1161
25-yr	0.103	1344



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Presumptive Approach Calculator ver. 1.2

Catchment ID: Lot 4

Run Time 9/11/2013 3:41:14 PM

Project Name: Rosemont Subdivision **Catchment ID:** Lot 4 **Date:** 9/11/2013

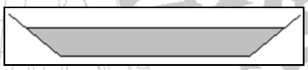
Instructions:
1. Identify which Stormwater Hierarchy Category the facility.
2. Select Facility Type.
3. Identify facility shape of surface facility to more accurately estimate surface volume, except for Swales and sloped planters that use the PAC Sloped Facility Worksheet to enter data.
4. Select type of facility configuration.
5. Complete data entry for all highlighted cells.

Catchment facility will meet Hierarchy Category: **1**

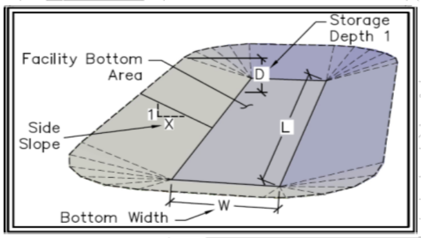
Goal Summary:

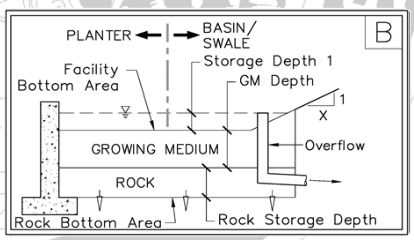
Hierarchy Category	SWMM Requirement	RESULTS box below needs to display…	
		Pollution Reduction as a	10-yr (aka disposal) as a
1	On-site infiltration with a surface infiltration facility.	PASS	PASS

Facility Type = Basin



Facility Shape: Rectangle/Square **Facility Configuration:** B





Calculation Guide
Max. Rock Stor. Bottom Area
1,066 SF

DATA FOR ABOVE GRADE STORAGE COMPONENT

Facility Bottom Area =	460	sf
Bottom Width =	5.0	ft
Facility Side Slope =	3	to 1
Storage Depth 1 =	12	in
Growing Medium Depth =	18	in
Freeboard Depth =	2	in
Surface Capacity at Depth 1 =	763	cf
Infiltration Area at 75% Depth1 =	914	SF
GM Design Infiltration Rate =	2.00	in/hr
Infiltration Capacity =	0.042	cfs

BELOW GRADE STORAGE

Rock Storage Bottom Area =	460	sf
Rock Storage Depth =	12	in
Rock Void Ratio =	0.3	
Rock Storage Capacity =	138	cf
Native Design Infiltration Rate =	0.60	in/hr
Infiltration Capacity =	0.006	cfs

RESULTS

		Overflow Volume		
Pollution Reduction	**PASS**	0 CF	**0%**	Surf. Cap. Used
			13%	Rock Cap. Used
10-yr	**PASS**	0 CF	**65%**	Surf. Cap. Used
			100%	Rock Cap. Used

Run PAC

FACILITY FACTS

Total Facility Area Including Freeboard = **1,188 SF**

Sizing Ratio (Total Facility Area / Catchment Area) = **0.270**

Presumptive Approach Calculator ver. 1.2

Catchment Data

Catchment ID: Lots 6&7

Project Name:	**Rosemont Subdivision**
Project Address:	**1485 Rosemont Road**
	West Linn, OR
Designer:	**Megan Goplin**
Company:	**Mackenzie**

Date: 09/11/13
Permit Number: 0
Run Time 9/13/2013 7:35:00 AM

Drainage Catchment Information

Catchment ID	Lots 6&7	
	Catchment Area	
Impervious Area	4,400	SF
Impervious Area	0.10	ac
Impervious Area Curve Number, CN_{imp}	98	
Time of Concentration, Tc, minutes	5	min.

Site Soils & Infiltration Testing Data

Infiltration Testing Procedure:	Encased Falling Head	
Native Soil Field Tested Infiltration Rate (I_{test}):	1.38	in/hr
Bottom of Facility Meets Required Separation From High Groundwater Per BES SWMM Section 1.4:	Yes	

Field infiltration rate was manually adjusted down to model as safety factor of 3.

Correction Factor Component

CF_{test} (ranges from 1 to 3)	~~2~~	3

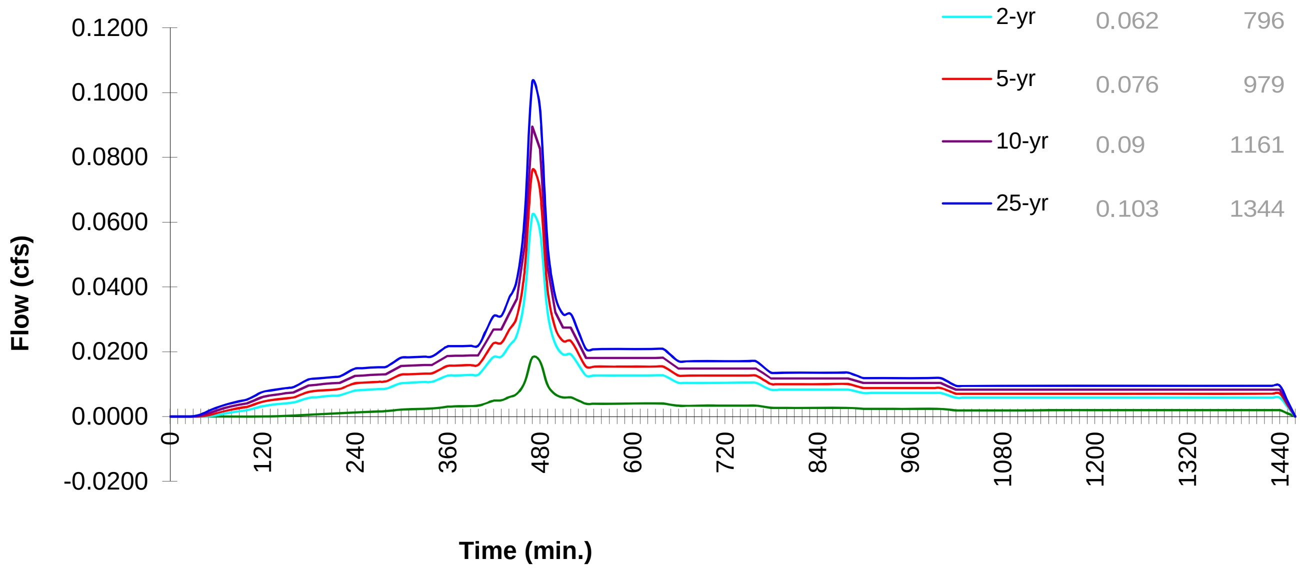
Design Infiltration Rates

I_{dsgn} for Native (I_{test} / CF_{test}):	0.69	in/hr
I_{dsgn} for Imported Growing Medium:	2.00	in/hr

Execute SBUH

SBUH Results

	Peak Rate (cfs)	Volume (cf)
PR	0.018	230
2-yr	0.062	796
5-yr	0.076	979
10-yr	0.09	1161
25-yr	0.103	1344



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Presumptive Approach Calculator ver. 1.2

Catchment ID: Lots 6&7

Run Time 9/13/2013 7:35:00 AM

Project Name: Rosemont Subdivision **Catchment ID:** Lots 6&7 **Date:** 9/11/2013

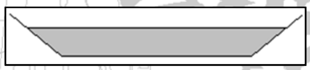
Instructions:
1. Identify which Stormwater Hierarchy Category the facility.
2. Select Facility Type.
3. Identify facility shape of surface facility to more accurately estimate surface volume, except for Swales and sloped planters that use the PAC Sloped Facility Worksheet to enter data.
4. Select type of facility configuration.
5. Complete data entry for all highlighted cells.

Catchment facility will meet Hierarchy Category: **1**

Goal Summary:

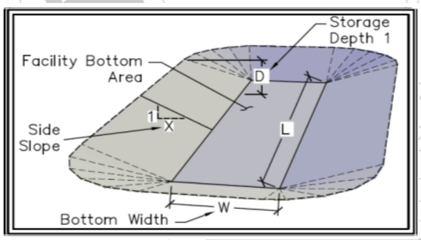
Hierarchy Category	SWMM Requirement	RESULTS box below needs to display…	
		Pollution Reduction as a	10-yr (aka disposal) as a
1	On-site infiltration with a surface infiltration facility.	PASS	PASS

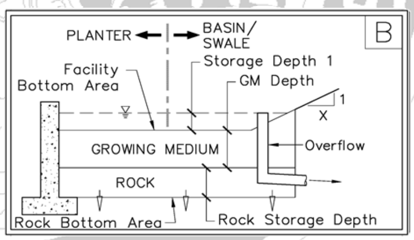
Facility Type = Basin



Facility Shape: Rectangle/Square

Facility Configuration: B





Calculation Guide
Max. Rock Stor. Bottom Area
1,000 SF

DATA FOR ABOVE GRADE STORAGE COMPONENT

Facility Bottom Area =	430	sf
Bottom Width =	5.0	ft
Facility Side Slope =	3	to 1
Storage Depth 1 =	12	in
Growing Medium Depth =	18	in
Freeboard Depth =	2	in
Surface Capacity at Depth 1 =	715	cf
Infiltration Area at 75% Depth1 =	857	SF
GM Design Infiltration Rate =	2.00	in/hr
Infiltration Capacity =	0.040	cfs

BELOW GRADE STORAGE

Rock Storage Bottom Area =	430	sf
Rock Storage Depth =	12	in
Rock Void Ratio =	0.3	
Rock Storage Capacity =	129	cf
Native Design Infiltration Rate =	0.69	in/hr
Infiltration Capacity =	0.007	cfs

RESULTS

		Overflow Volume		
Pollution Reduction	PASS	0 CF	0%	Surf. Cap. Used
			13%	Rock Cap. Used
10-yr	PASS	0 CF	66%	Surf. Cap. Used
			100%	Rock Cap. Used

Run PAC

FACILITY FACTS

Total Facility Area Including Freeboard = **1,116 SF**

Sizing Ratio (Total Facility Area / Catchment Area) = **0.254**

Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	15.2592	11.5000	0.8471	--------
3	0.0000	0.0000	0.0000	--------
5	25.3747	13.0000	0.9061	--------
10	25.8093	12.4000	0.8784	--------
25	36.8956	14.0000	0.9212	--------
50	48.4310	15.1000	0.9560	--------
100	34.2017	11.7000	0.8567	--------

File name: Newberg.IDF

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	1.42	1.13	0.95	0.82	0.72	0.65	0.59	0.54	0.50	0.47	0.44	0.41
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	1.85	1.48	1.24	1.07	0.94	0.84	0.76	0.70	0.64	0.59	0.55	0.52
10	2.10	1.68	1.41	1.22	1.07	0.96	0.87	0.80	0.74	0.68	0.64	0.60
25	2.45	1.98	1.66	1.43	1.26	1.13	1.02	0.94	0.86	0.80	0.75	0.70
50	2.75	2.22	1.87	1.61	1.42	1.27	1.15	1.05	0.97	0.89	0.83	0.78
100	3.07	2.45	2.05	1.77	1.56	1.40	1.27	1.16	1.08	1.00	0.94	0.88

Tc = time in minutes. Values may exceed 60.

Precip. file name: Newberg.pcp

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	0.00	2.20	0.00	3.00	3.20	3.80	4.30	4.45
SCS 6-Hr	0.00	1.10	0.00	1.30	1.60	1.80	1.80	1.95
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph description
1	SCS Runoff	0.006	2	482	175	------	------	------	Pre-Developed Lot
2	SCS Runoff	0.004	2	484	105	------	------	------	Pre-Developed Drive
3	SCS Runoff	0.048	2	470	671	------	------	------	Post-Developed Lot
4	SCS Runoff	0.024	2	470	336	------	------	------	Post-Developed Drive
5	Reservoir	0.000	2	300	0	3	100.64	103	RG Lot 1 & 5
6	Reservoir	0.000	2	262	0	3	100.64	108	RG Lot 2
7	Reservoir	0.000	2	244	0	3	100.66	143	RG Lot 4
8	Reservoir	0.000	2	284	0	3	100.65	132	RG Lot 6 & 7

STORMWATER-small-inf.gpw	Return Period: 2 Year	Friday, Sep 13, 2013

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph description
1	SCS Runoff	0.018	2	480	349	------	------	------	Pre-Developed Lot
2	SCS Runoff	0.011	2	482	200	------	------	------	Pre-Developed Drive
3	SCS Runoff	0.067	2	470	942	------	------	------	Post-Developed Lot
4	SCS Runoff	0.033	2	470	471	------	------	------	Post-Developed Drive
5	Reservoir	0.000	2	170	0	3	100.94	176	RG Lot 1 & 5
6	Reservoir	0.000	2	168	0	3	100.95	183	RG Lot 2
7	Reservoir	0.000	2	158	0	3	100.96	237	RG Lot 4
8	Reservoir	0.000	2	156	0	3	100.95	220	RG Lot 6 & 7

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph description
1	SCS Runoff	0.022	2	480	397	------	------	------	Pre-Developed Lot
2	SCS Runoff	0.013	2	482	227	------	------	------	Pre-Developed Drive
3	SCS Runoff	0.071	2	470	1,010	------	------	------	Post-Developed Lot
4	SCS Runoff	0.036	2	470	505	------	------	------	Post-Developed Drive
5	Reservoir	0.000	2	162	0	3	102.50	196	RG Lot 1 & 5
6	Reservoir	0.000	2	142	0	3	102.52	204	RG Lot 2
7	Reservoir	0.000	2	150	0	3	102.53	264	RG Lot 4
8	Reservoir	0.000	2	168	0	3	102.52	244	RG Lot 6 & 7

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph description
1	SCS Runoff	0.033	2	480	551	------	------	------	Pre-Developed Lot
2	SCS Runoff	0.019	2	480	310	------	------	------	Pre-Developed Drive
3	SCS Runoff	0.085	2	470	1,213	------	------	------	Post-Developed Lot
4	SCS Runoff	0.043	2	470	607	------	------	------	Post-Developed Drive
5	Reservoir	0.000	2	126	0	3	102.92	268	RG Lot 1 & 5
6	Reservoir	0.000	2	136	0	3	102.94	279	RG Lot 2
7	Reservoir	0.000	2	126	0	3	102.96	362	RG Lot 4
8	Reservoir	0.000	2	126	0	3	102.94	335	RG Lot 6 & 7

STORMWATER-small-inf.gpw	Return Period: 25 Year	Friday, Sep 13, 2013

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph description
1	SCS Runoff	0.046	2	480	730	------	------	------	Pre-Developed Lot
2	SCS Runoff	0.026	2	480	406	------	------	------	Pre-Developed Drive
3	SCS Runoff	0.100	2	470	1,434	------	------	------	Post-Developed Lot
4	SCS Runoff	0.050	2	470	717	------	------	------	Post-Developed Drive
5	Reservoir	0.000	2	104	0	3	103.46	360	RG Lot 1 & 5
6	Reservoir	0.000	2	100	0	3	103.49	376	RG Lot 2
7	Reservoir	0.000	2	120	0	3	103.49	485	RG Lot 4
8	Reservoir	0.000	2	106	0	3	103.47	450	RG Lot 6 & 7

Pond Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066 — Friday, Sep 13, 2013

Pond No. 1 - RG Lot 1 & 5

Pond Data

Trapezoid - Bottom L x W = 69.0 x 5.0 ft, Side slope = 3.00:1, Bottom elev. = 100.00 ft, Depth = 1.00 ft, Voids = 33.00%
Contours - User-defined contour areas. Average end area method used for volume calculation. Begining Elevation = 101.01 ft

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	100.00	345	0	0
0.10	100.10	390	12	12
0.20	100.20	435	14	26
0.30	100.30	481	15	41
0.40	100.40	528	17	58
0.50	100.50	576	18	76
0.60	100.60	624	20	96
0.70	100.70	673	21	117
0.80	100.80	723	23	140
0.90	100.90	774	25	165
1.00	101.00	825	26	191
1.01	101.01	00	4	195
2.50	102.50	00	0	195
3.50	103.50	345	173	368

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	Inactive	Inactive	Inactive	Inactive
Span (in)	= 6.00	1.10	1.50	0.00
No. Barrels	= 1	1	1	0
Invert El. (ft)	= 629.30	628.80	630.60	0.00
Length (ft)	= 10.00	10.00	10.00	0.00
Slope (%)	= 2.00	2.00	2.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	Yes	Yes	No

Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	Inactive	0.00	0.00	0.00
Crest El. (ft)	= 632.00	0.00	0.00	0.00
Weir Coeff.	= 3.33	3.33	3.33	3.33
Weir Type	= Riser	---	---	---
Multi-Stage	= Yes	No	No	No

Exfil.(in/hr) = 1.050 (by Contour)
TW Elev. (ft) = 0.00

Note: Culvert/Orifice outflows are analyzed under inlet (ic) and outlet (oc) control. Weir risers checked for orifice conditions (ic) and submergence (s).

Stage / Storage / Discharge Table

Stage ft	Storage cuft	Elevation ft	Clv A cfs	Clv B cfs	Clv C cfs	PrfRsr cfs	Wr A cfs	Wr B cfs	Wr C cfs	Wr D cfs	Exfil cfs	User cfs	Total cfs
0.00	0	100.00	0.00	0.00	0.00	---	0.00	---	---	---	0.000	---	0.000
0.10	12	100.10	0.00	0.00	0.00	---	0.00	---	---	---	0.009	---	0.009
0.20	26	100.20	0.00	0.00	0.00	---	0.00	---	---	---	0.011	---	0.011
0.30	41	100.30	0.00	0.00	0.00	---	0.00	---	---	---	0.012	---	0.012
0.40	58	100.40	0.00	0.00	0.00	---	0.00	---	---	---	0.013	---	0.013
0.50	76	100.50	0.00	0.00	0.00	---	0.00	---	---	---	0.014	---	0.014
0.60	96	100.60	0.00	0.00	0.00	---	0.00	---	---	---	0.015	---	0.015
0.70	117	100.70	0.00	0.00	0.00	---	0.00	---	---	---	0.016	---	0.016
0.80	140	100.80	0.00	0.00	0.00	---	0.00	---	---	---	0.018	---	0.018
0.90	165	100.90	0.00	0.00	0.00	---	0.00	---	---	---	0.019	---	0.019
1.00	191	101.00	0.00	0.00	0.00	---	0.00	---	---	---	0.020	---	0.020
1.01	195	101.01	0.00	0.00	0.00	---	0.00	---	---	---	0.020	---	0.020
2.50	195	102.50	0.00	0.00	0.00	---	0.00	---	---	---	0.020	---	0.020
3.50	368	103.50	0.00	0.00	0.00	---	0.00	---	---	---	0.020	---	0.020

Hydrograph Report

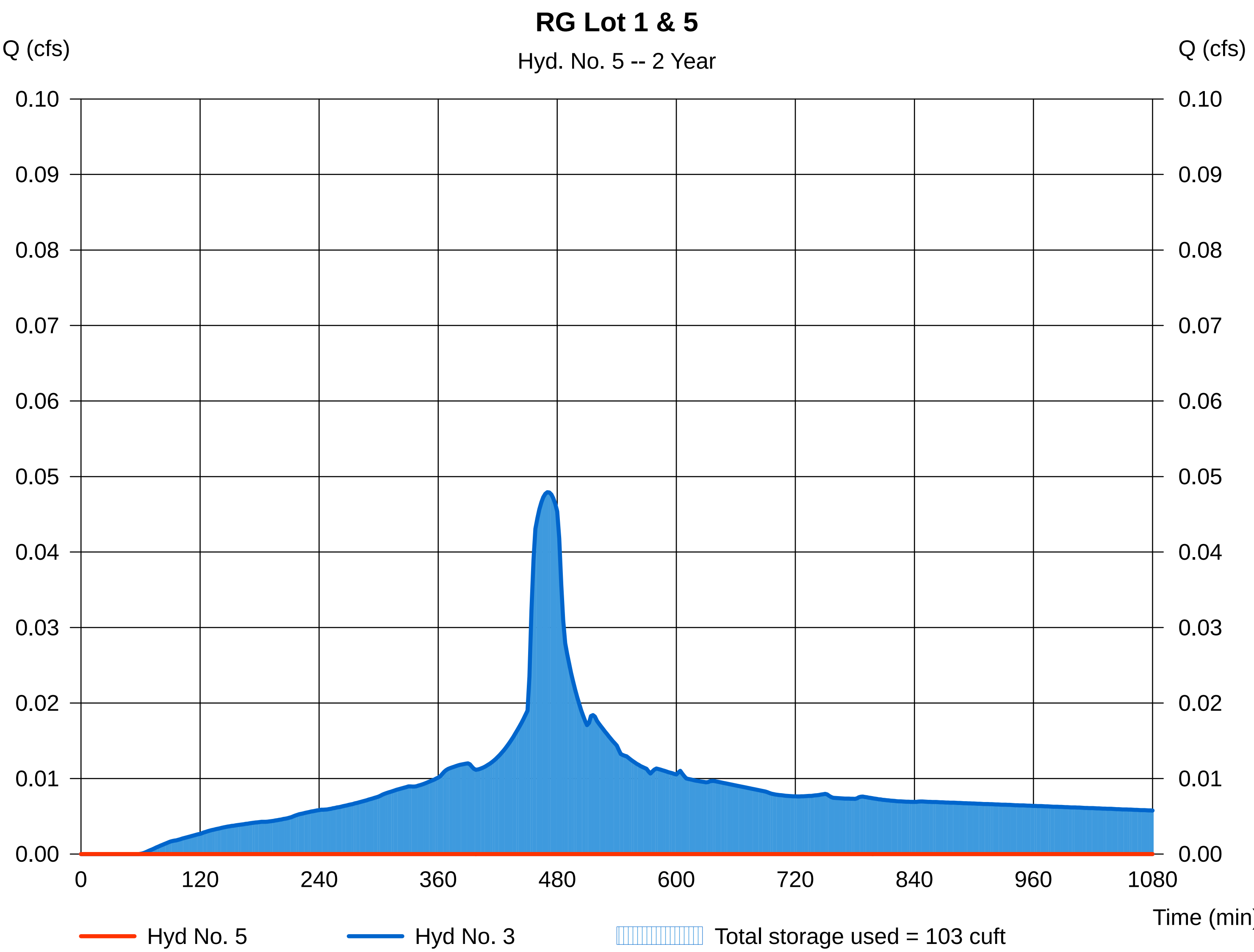
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066 Friday, Sep 13, 2013

Hyd. No. 5

RG Lot 1 & 5

Hydrograph type	= Reservoir	Peak discharge	= 0.000 cfs
Storm frequency	= 2 yrs	Time to peak	= 300 min
Time interval	= 2 min	Hyd. volume	= 0 cuft
Inflow hyd. No.	= 3 - Post-Developed Lot	Max. Elevation	= 100.64 ft
Reservoir name	= RG Lot 1 & 5	Max. Storage	= 103 cuft

Storage Indication method used. Exfiltration extracted from Outflow.



Hydrograph Report

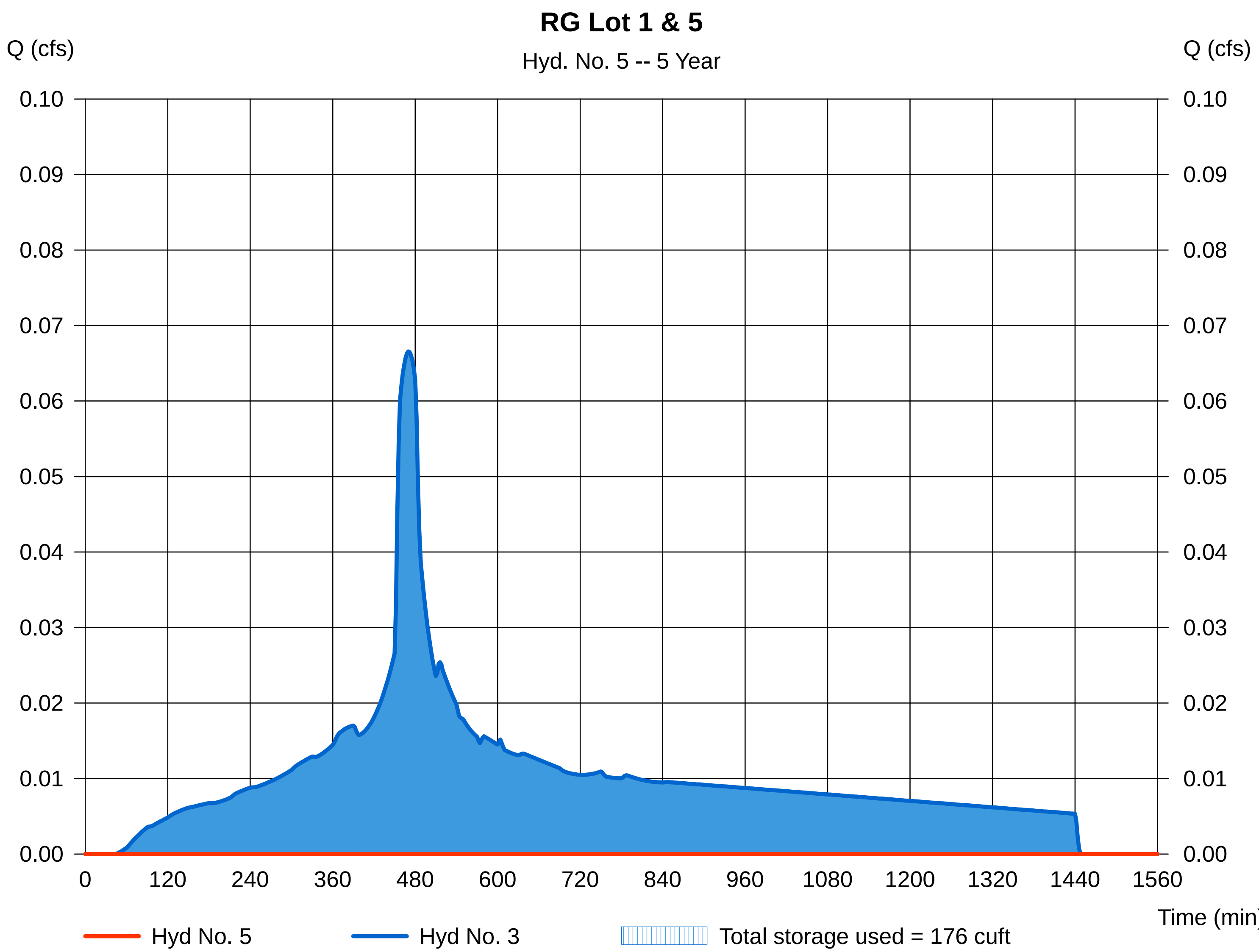
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066 — Friday, Sep 13, 2013

Hyd. No. 5

RG Lot 1 & 5

Hydrograph type	= Reservoir	Peak discharge	= 0.000 cfs
Storm frequency	= 5 yrs	Time to peak	= 170 min
Time interval	= 2 min	Hyd. volume	= 0 cuft
Inflow hyd. No.	= 3 - Post-Developed Lot	Max. Elevation	= 100.94 ft
Reservoir name	= RG Lot 1 & 5	Max. Storage	= 176 cuft

Storage Indication method used. Exfiltration extracted from Outflow.



Hydrograph Report

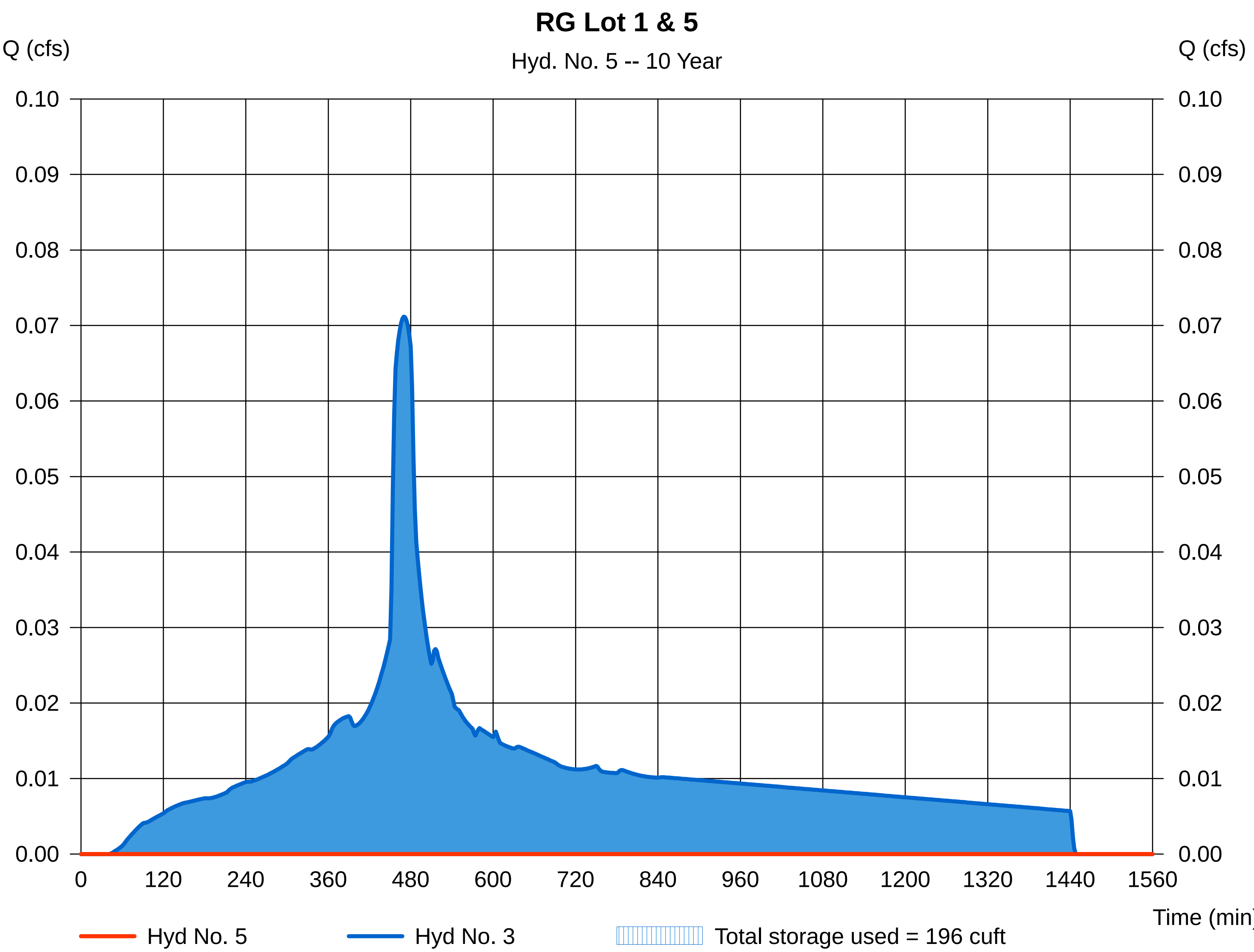
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066 — Friday, Sep 13, 2013

Hyd. No. 5

RG Lot 1 & 5

Hydrograph type	= Reservoir	Peak discharge	= 0.000 cfs
Storm frequency	= 10 yrs	Time to peak	= 162 min
Time interval	= 2 min	Hyd. volume	= 0 cuft
Inflow hyd. No.	= 3 - Post-Developed Lot	Max. Elevation	= 102.50 ft
Reservoir name	= RG Lot 1 & 5	Max. Storage	= 196 cuft

Storage Indication method used. Exfiltration extracted from Outflow.



Hydrograph Report

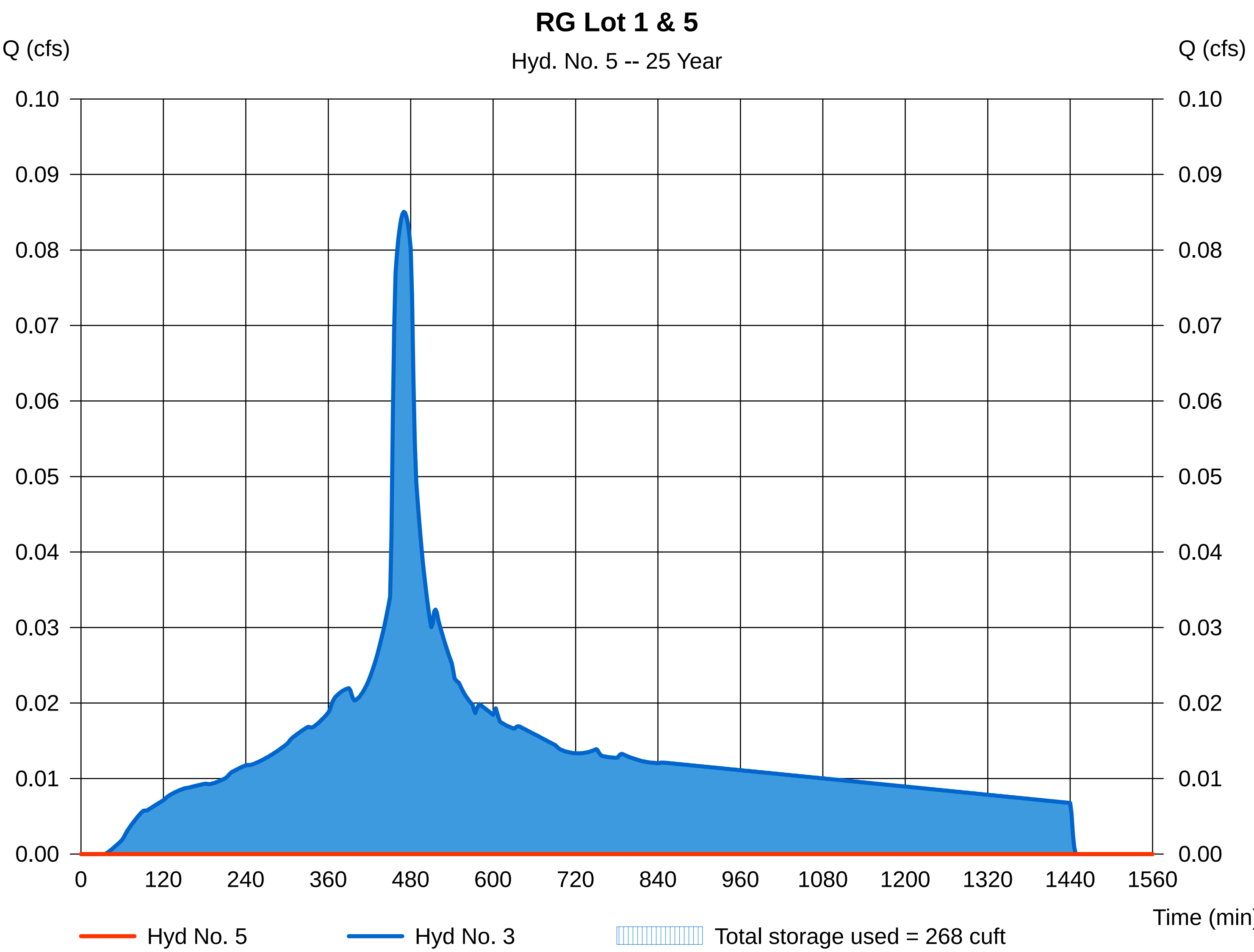
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066 Friday, Sep 13, 2013

Hyd. No. 5

RG Lot 1 & 5

Hydrograph type	= Reservoir	Peak discharge	= 0.000 cfs
Storm frequency	= 25 yrs	Time to peak	= 126 min
Time interval	= 2 min	Hyd. volume	= 0 cuft
Inflow hyd. No.	= 3 - Post-Developed Lot	Max. Elevation	= 102.92 ft
Reservoir name	= RG Lot 1 & 5	Max. Storage	= 268 cuft

Storage Indication method used. Exfiltration extracted from Outflow.



Hydrograph Report

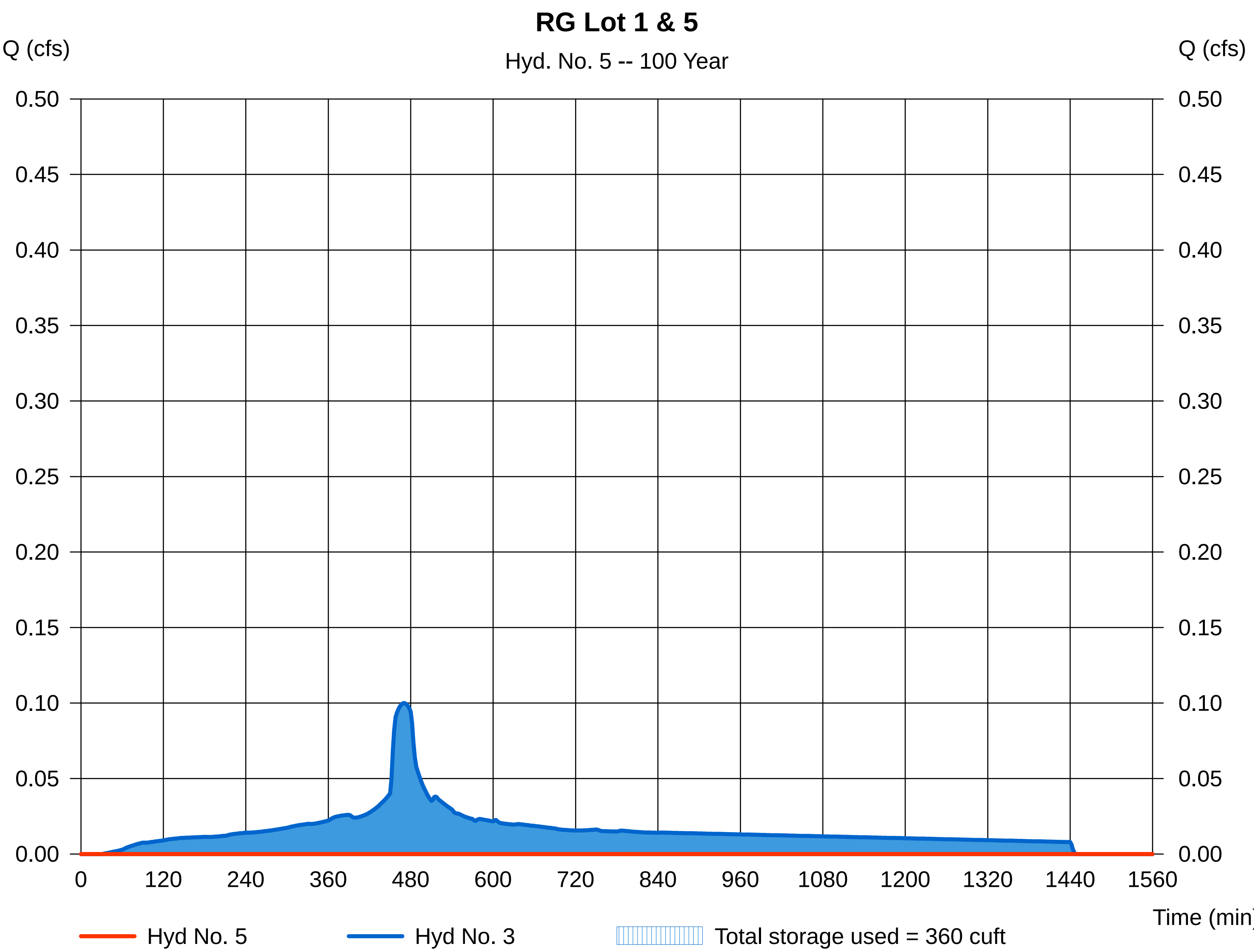
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066 Friday, Sep 13, 2013

Hyd. No. 5

RG Lot 1 & 5

Hydrograph type	= Reservoir	Peak discharge	= 0.000 cfs
Storm frequency	= 100 yrs	Time to peak	= 104 min
Time interval	= 2 min	Hyd. volume	= 0 cuft
Inflow hyd. No.	= 3 - Post-Developed Lot	Max. Elevation	= 103.46 ft
Reservoir name	= RG Lot 1 & 5	Max. Storage	= 360 cuft

Storage Indication method used. Exfiltration extracted from Outflow.



Pond Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066 Friday, Sep 13, 2013

Pond No. 2 - RG Lot 2

Pond Data

Trapezoid - Bottom L x W = 71.0 x 5.0 ft, Side slope = 3.00:1, Bottom elev. = 100.00 ft, Depth = 1.00 ft, Voids = 33.00%
Contours - User-defined contour areas. Average end area method used for volume calculation. Begining Elevation = 101.01 ft

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	100.00	355	0	0
0.10	100.10	401	12	12
0.20	100.20	448	14	26
0.30	100.30	495	16	42
0.40	100.40	543	17	59
0.50	100.50	592	19	78
0.60	100.60	642	20	98
0.70	100.70	692	22	120
0.80	100.80	743	24	144
0.90	100.90	795	25	169
1.00	101.00	847	27	196
1.01	101.01	00	4	201
2.50	102.50	00	0	201
3.50	103.50	355	178	378

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	Inactive	Inactive	Inactive	Inactive
Span (in)	= 6.00	1.10	1.50	0.00
No. Barrels	= 1	1	1	0
Invert El. (ft)	= 629.30	628.80	630.60	0.00
Length (ft)	= 10.00	10.00	10.00	0.00
Slope (%)	= 2.00	2.00	2.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	Yes	Yes	No

Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	Inactive	0.00	0.00	0.00
Crest El. (ft)	= 632.00	0.00	0.00	0.00
Weir Coeff.	= 3.33	3.33	3.33	3.33
Weir Type	= Riser	---	---	---
Multi-Stage	= Yes	No	No	No

Exfil.(in/hr) = 0.980 (by Contour)
TW Elev. (ft) = 0.00

Note: Culvert/Orifice outflows are analyzed under inlet (ic) and outlet (oc) control. Weir risers checked for orifice conditions (ic) and submergence (s).

Stage / Storage / Discharge Table

Stage ft	Storage cuft	Elevation ft	Clv A cfs	Clv B cfs	Clv C cfs	PrfRsr cfs	Wr A cfs	Wr B cfs	Wr C cfs	Wr D cfs	Exfil cfs	User cfs	Total cfs
0.00	0	100.00	0.00	0.00	0.00	---	0.00	---	---	---	0.000	---	0.000
0.10	12	100.10	0.00	0.00	0.00	---	0.00	---	---	---	0.009	---	0.009
0.20	26	100.20	0.00	0.00	0.00	---	0.00	---	---	---	0.010	---	0.010
0.30	42	100.30	0.00	0.00	0.00	---	0.00	---	---	---	0.011	---	0.011
0.40	59	100.40	0.00	0.00	0.00	---	0.00	---	---	---	0.012	---	0.012
0.50	78	100.50	0.00	0.00	0.00	---	0.00	---	---	---	0.013	---	0.013
0.60	98	100.60	0.00	0.00	0.00	---	0.00	---	---	---	0.015	---	0.015
0.70	120	100.70	0.00	0.00	0.00	---	0.00	---	---	---	0.016	---	0.016
0.80	144	100.80	0.00	0.00	0.00	---	0.00	---	---	---	0.017	---	0.017
0.90	169	100.90	0.00	0.00	0.00	---	0.00	---	---	---	0.018	---	0.018
1.00	196	101.00	0.00	0.00	0.00	---	0.00	---	---	---	0.019	---	0.019
1.01	201	101.01	0.00	0.00	0.00	---	0.00	---	---	---	0.019	---	0.019
2.50	201	102.50	0.00	0.00	0.00	---	0.00	---	---	---	0.019	---	0.019
3.50	378	103.50	0.00	0.00	0.00	---	0.00	---	---	---	0.019	---	0.019

Hydrograph Report

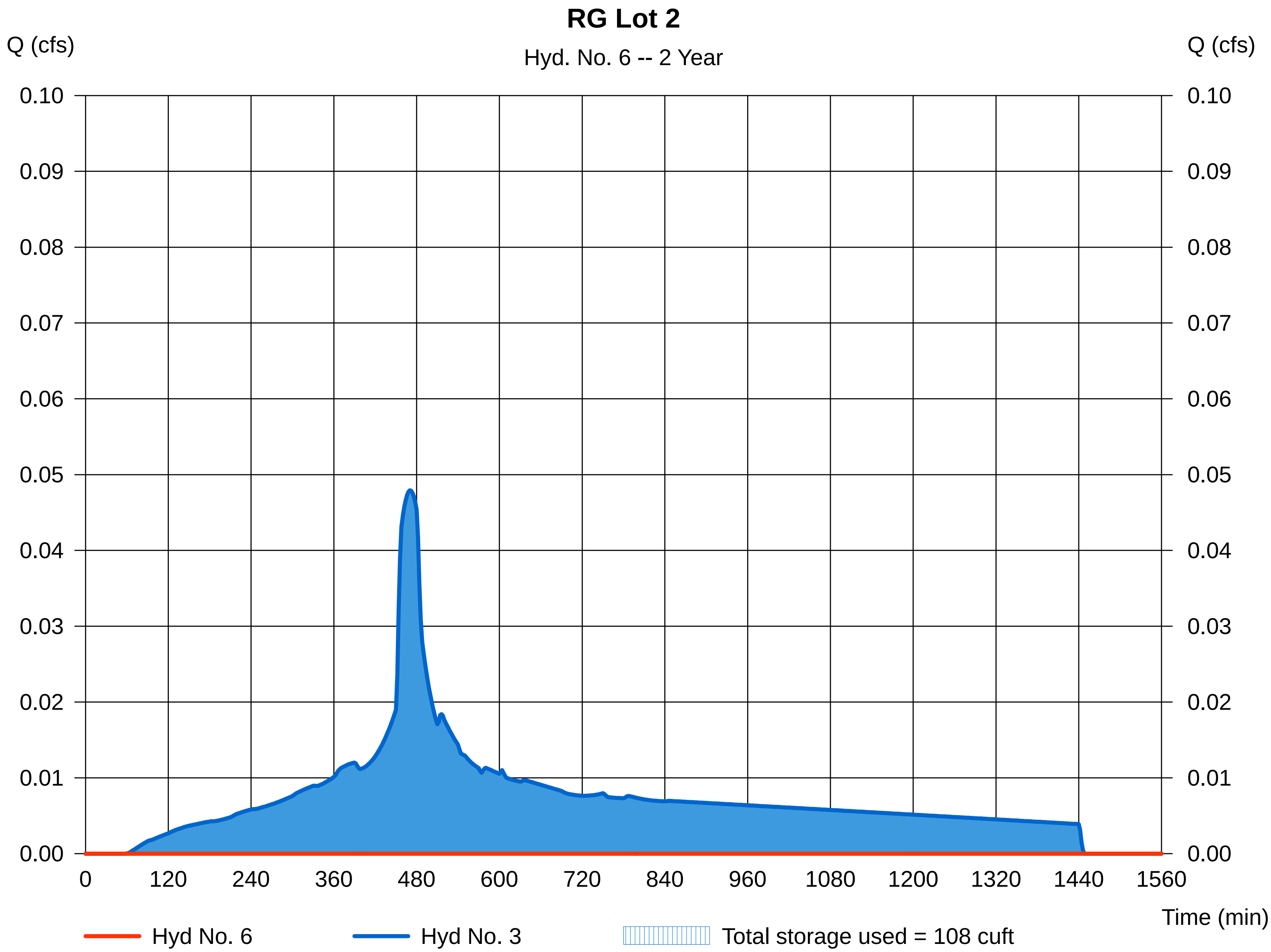
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066 — Friday, Sep 13, 2013

Hyd. No. 6

RG Lot 2

Hydrograph type	= Reservoir	Peak discharge	= 0.000 cfs
Storm frequency	= 2 yrs	Time to peak	= 262 min
Time interval	= 2 min	Hyd. volume	= 0 cuft
Inflow hyd. No.	= 3 - Post-Developed Lot	Max. Elevation	= 100.64 ft
Reservoir name	= RG Lot 2	Max. Storage	= 108 cuft

Storage Indication method used. Exfiltration extracted from Outflow.



Hydrograph Report

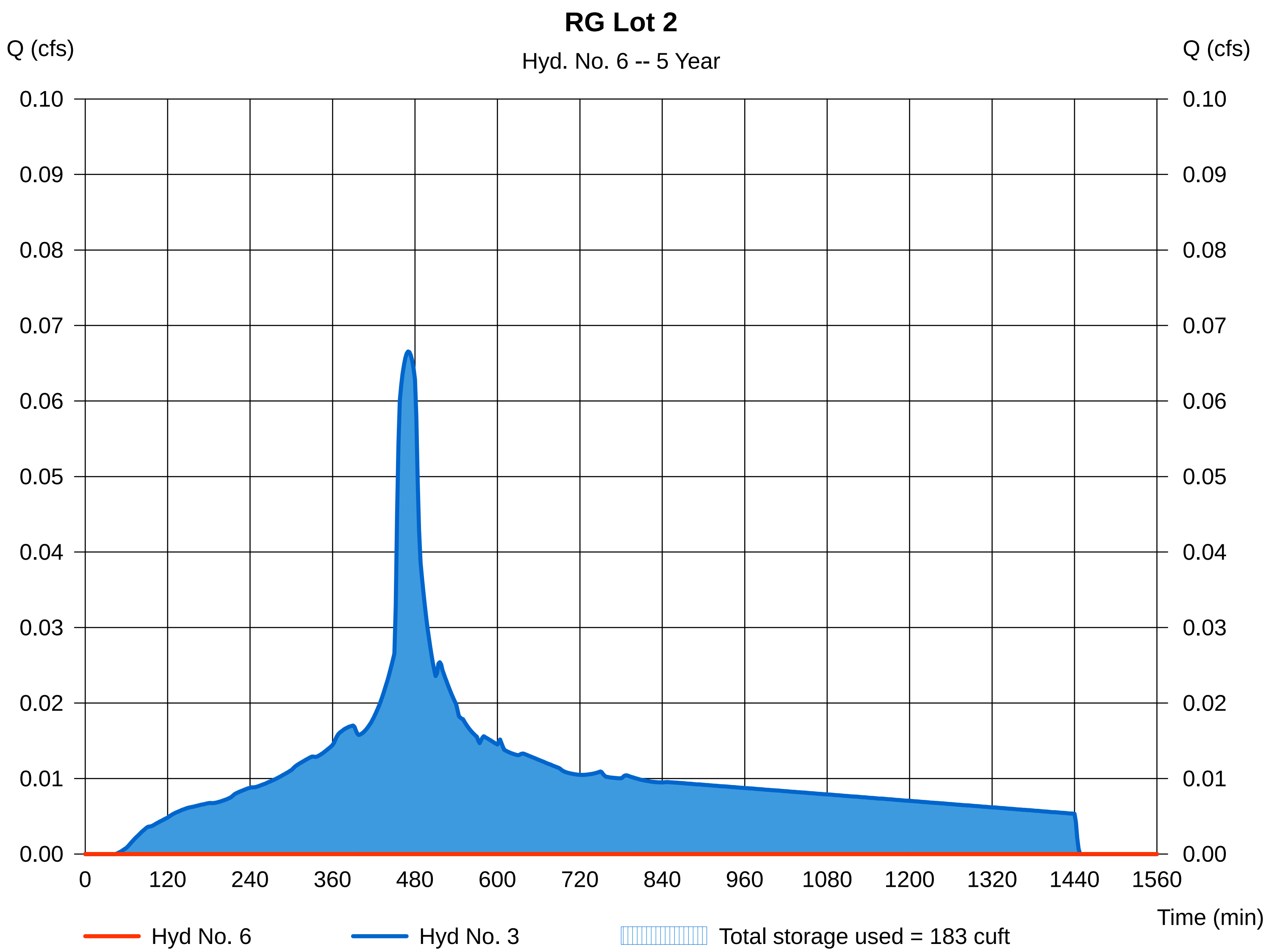
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066 Friday, Sep 13, 2013

Hyd. No. 6

RG Lot 2

Hydrograph type	= Reservoir	Peak discharge	= 0.000 cfs
Storm frequency	= 5 yrs	Time to peak	= 168 min
Time interval	= 2 min	Hyd. volume	= 0 cuft
Inflow hyd. No.	= 3 - Post-Developed Lot	Max. Elevation	= 100.95 ft
Reservoir name	= RG Lot 2	Max. Storage	= 183 cuft

Storage Indication method used. Exfiltration extracted from Outflow.



Hydrograph Report

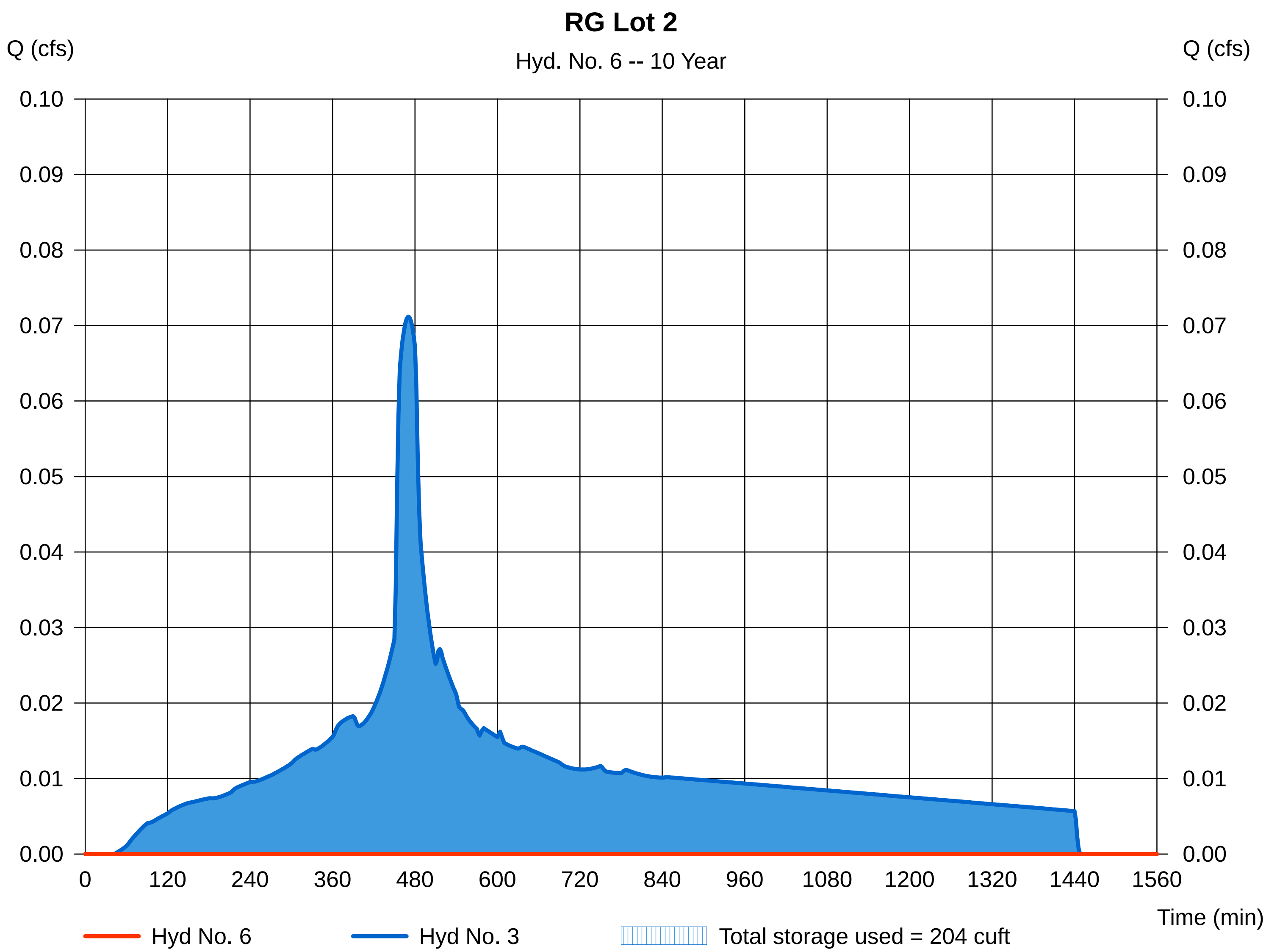
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066 Friday, Sep 13, 2013

Hyd. No. 6

RG Lot 2

Hydrograph type	= Reservoir	Peak discharge	= 0.000 cfs
Storm frequency	= 10 yrs	Time to peak	= 142 min
Time interval	= 2 min	Hyd. volume	= 0 cuft
Inflow hyd. No.	= 3 - Post-Developed Lot	Max. Elevation	= 102.52 ft
Reservoir name	= RG Lot 2	Max. Storage	= 204 cuft

Storage Indication method used. Exfiltration extracted from Outflow.



Hydrograph Report

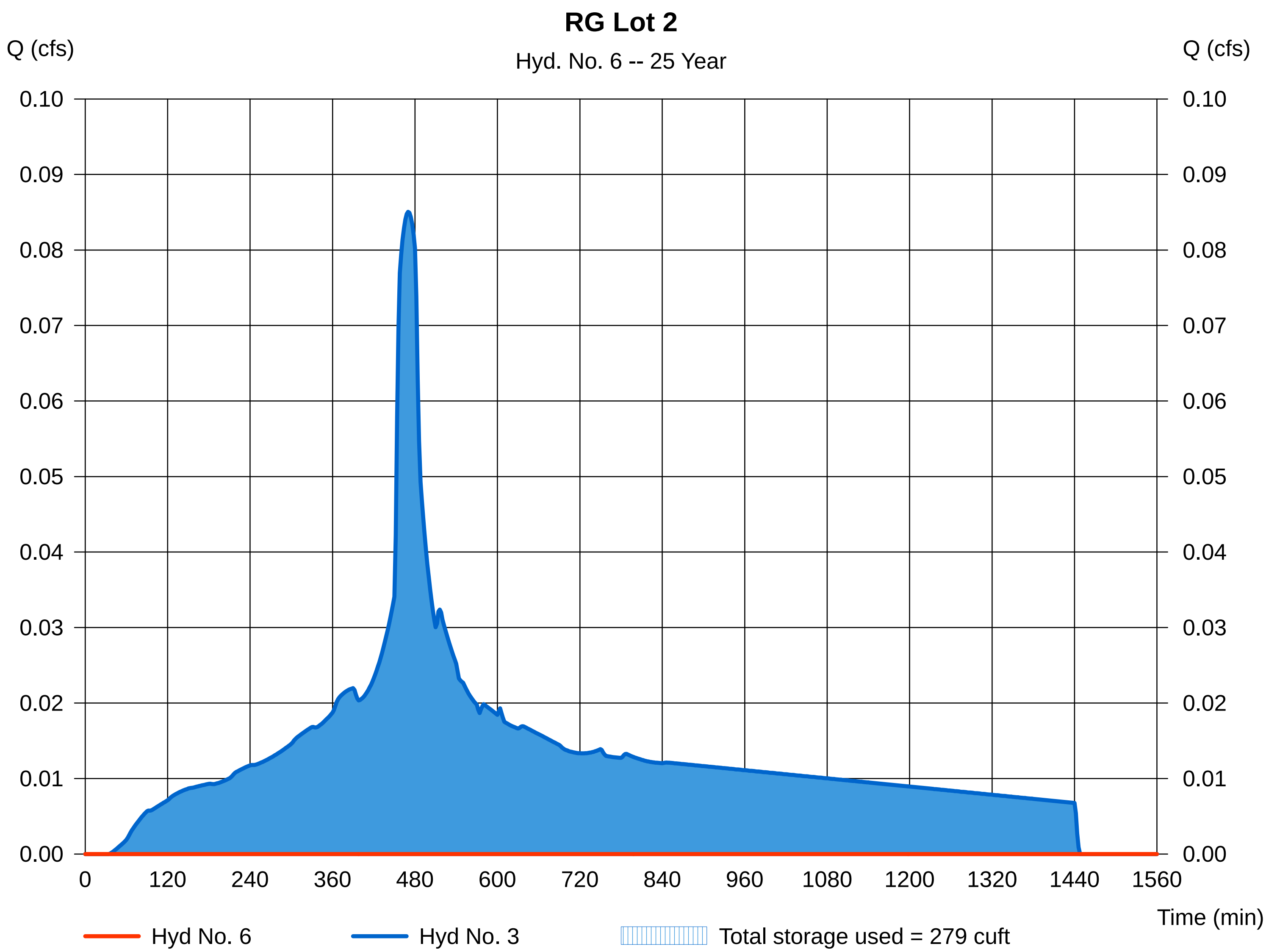
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066 — Friday, Sep 13, 2013

Hyd. No. 6

RG Lot 2

Hydrograph type	= Reservoir	Peak discharge	= 0.000 cfs
Storm frequency	= 25 yrs	Time to peak	= 136 min
Time interval	= 2 min	Hyd. volume	= 0 cuft
Inflow hyd. No.	= 3 - Post-Developed Lot	Max. Elevation	= 102.94 ft
Reservoir name	= RG Lot 2	Max. Storage	= 279 cuft

Storage Indication method used. Exfiltration extracted from Outflow.



Hydrograph Report

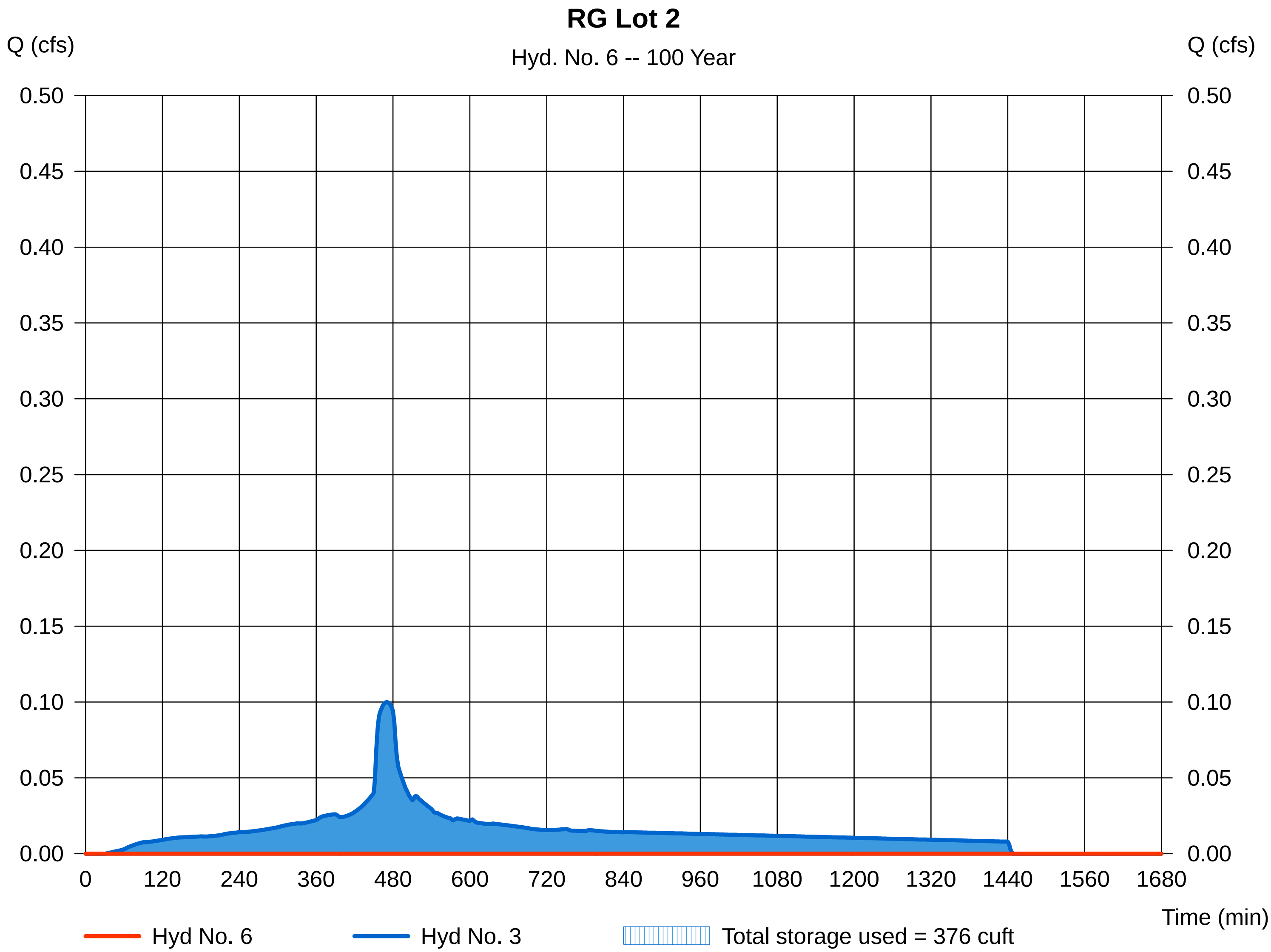
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066 Friday, Sep 13, 2013

Hyd. No. 6

RG Lot 2

Hydrograph type	= Reservoir	Peak discharge	= 0.000 cfs
Storm frequency	= 100 yrs	Time to peak	= 100 min
Time interval	= 2 min	Hyd. volume	= 0 cuft
Inflow hyd. No.	= 3 - Post-Developed Lot	Max. Elevation	= 103.49 ft
Reservoir name	= RG Lot 2	Max. Storage	= 376 cuft

Storage Indication method used. Exfiltration extracted from Outflow.



Pond Report

Pond No. 3 - RG Lot 4

Pond Data

Trapezoid - Bottom L x W = 92.0 x 5.0 ft, Side slope = 3.00:1, Bottom elev. = 100.00 ft, Depth = 1.00 ft, Voids = 33.00%
Contours - User-defined contour areas. Average end area method used for volume calculation. Begining Elevation = 101.01 ft

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	100.00	460	0	0
0.10	100.10	519	16	16
0.20	100.20	578	18	34
0.30	100.30	638	20	54
0.40	100.40	699	22	76
0.50	100.50	760	24	100
0.60	100.60	822	26	127
0.70	100.70	885	28	155
0.80	100.80	949	30	185
0.90	100.90	1,013	32	217
1.00	101.00	1,078	34	252
1.01	101.01	00	5	257
2.50	102.50	00	0	257
3.50	103.50	460	230	487

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	Inactive	Inactive	Inactive	Inactive
Span (in)	= 6.00	1.10	1.50	0.00
No. Barrels	= 1	1	1	0
Invert El. (ft)	= 629.30	628.80	630.60	0.00
Length (ft)	= 10.00	10.00	10.00	0.00
Slope (%)	= 2.00	2.00	2.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	Yes	Yes	No

Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	Inactive	0.00	0.00	0.00
Crest El. (ft)	= 632.00	0.00	0.00	0.00
Weir Coeff.	= 3.33	3.33	3.33	3.33
Weir Type	= Riser	---	---	---
Multi-Stage	= Yes	No	No	No

Exfil.(in/hr) = 0.600 (by Contour)
TW Elev. (ft) = 0.00

Note: Culvert/Orifice outflows are analyzed under inlet (ic) and outlet (oc) control. Weir risers checked for orifice conditions (ic) and submergence (s).

Stage / Storage / Discharge Table

Stage ft	Storage cuft	Elevation ft	Clv A cfs	Clv B cfs	Clv C cfs	PrfRsr cfs	Wr A cfs	Wr B cfs	Wr C cfs	Wr D cfs	Exfil cfs	User cfs	Total cfs
0.00	0	100.00	0.00	0.00	0.00	---	0.00	---	---	---	0.000	---	0.000
0.10	16	100.10	0.00	0.00	0.00	---	0.00	---	---	---	0.007	---	0.007
0.20	34	100.20	0.00	0.00	0.00	---	0.00	---	---	---	0.008	---	0.008
0.30	54	100.30	0.00	0.00	0.00	---	0.00	---	---	---	0.009	---	0.009
0.40	76	100.40	0.00	0.00	0.00	---	0.00	---	---	---	0.010	---	0.010
0.50	100	100.50	0.00	0.00	0.00	---	0.00	---	---	---	0.011	---	0.011
0.60	127	100.60	0.00	0.00	0.00	---	0.00	---	---	---	0.011	---	0.011
0.70	155	100.70	0.00	0.00	0.00	---	0.00	---	---	---	0.012	---	0.012
0.80	185	100.80	0.00	0.00	0.00	---	0.00	---	---	---	0.013	---	0.013
0.90	217	100.90	0.00	0.00	0.00	---	0.00	---	---	---	0.014	---	0.014
1.00	252	101.00	0.00	0.00	0.00	---	0.00	---	---	---	0.015	---	0.015
1.01	257	101.01	0.00	0.00	0.00	---	0.00	---	---	---	0.015	---	0.015
2.50	257	102.50	0.00	0.00	0.00	---	0.00	---	---	---	0.015	---	0.015
3.50	487	103.50	0.00	0.00	0.00	---	0.00	---	---	---	0.015	---	0.015

Hydrograph Report

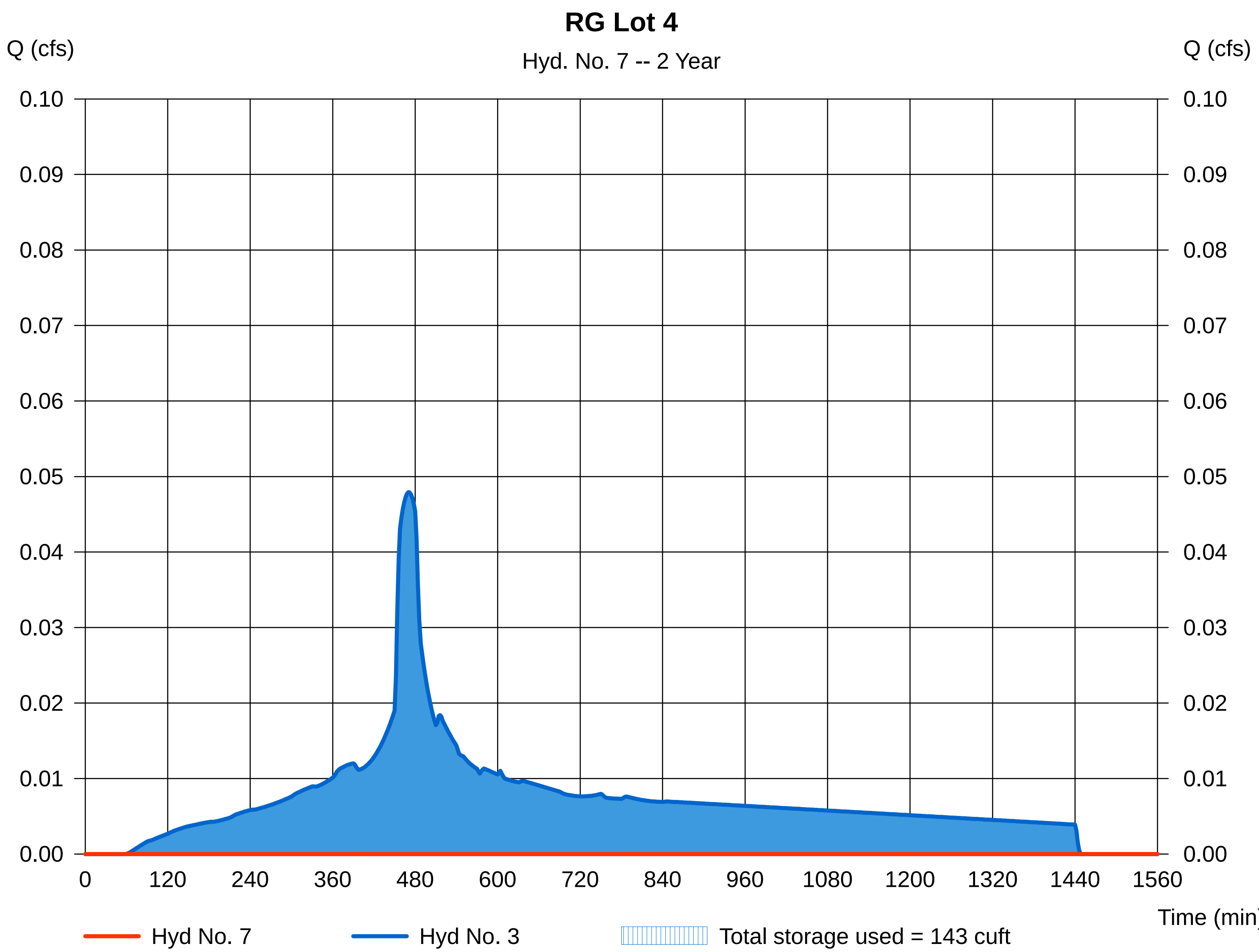
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066 Friday, Sep 13, 2013

Hyd. No. 7

RG Lot 4

Hydrograph type	= Reservoir	Peak discharge	= 0.000 cfs
Storm frequency	= 2 yrs	Time to peak	= 244 min
Time interval	= 2 min	Hyd. volume	= 0 cuft
Inflow hyd. No.	= 3 - Post-Developed Lot	Max. Elevation	= 100.66 ft
Reservoir name	= RG Lot 4	Max. Storage	= 143 cuft

Storage Indication method used. Exfiltration extracted from Outflow.



Hydrograph Report

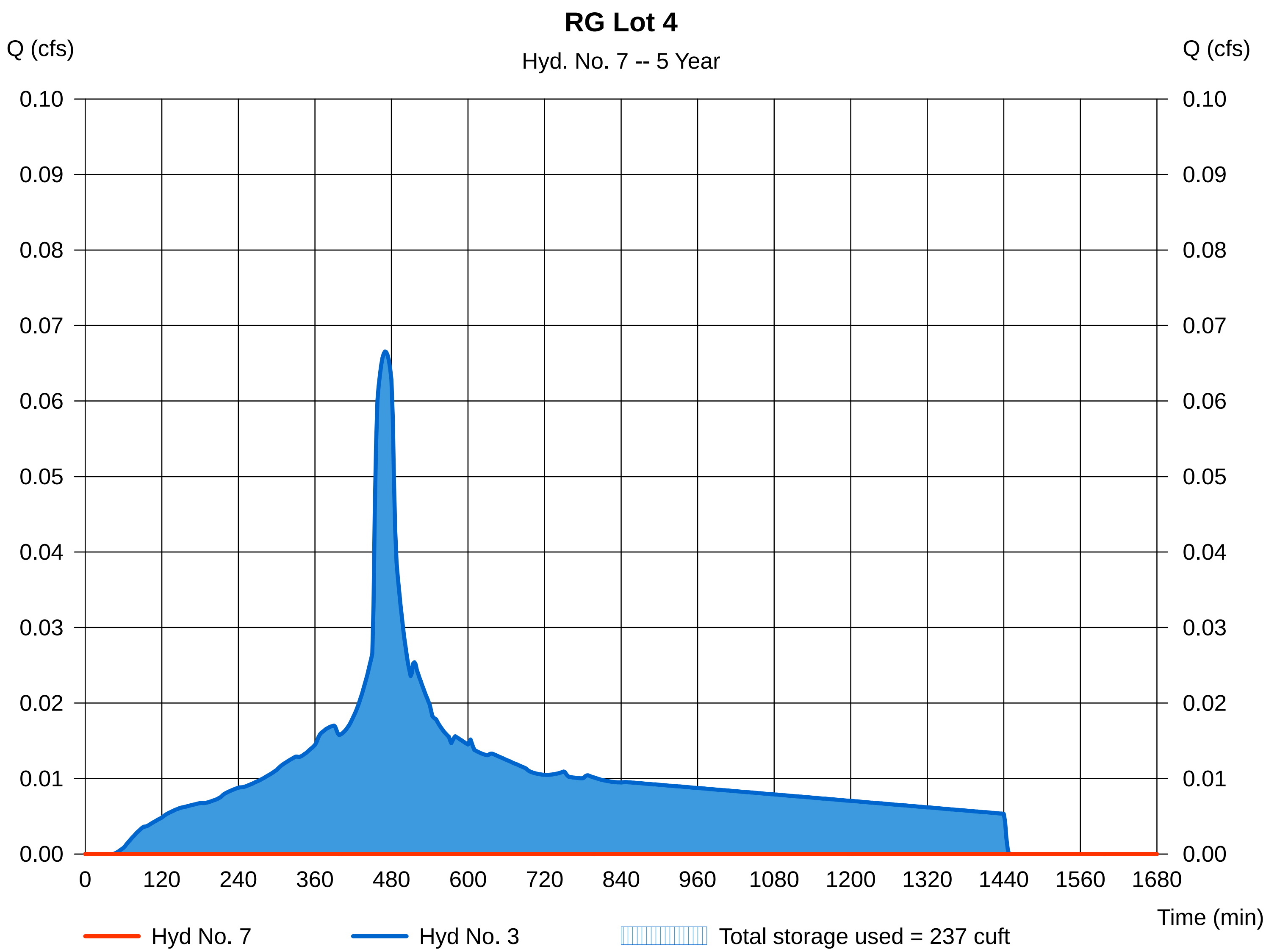
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066 — Friday, Sep 13, 2013

Hyd. No. 7

RG Lot 4

Hydrograph type	= Reservoir	Peak discharge	= 0.000 cfs
Storm frequency	= 5 yrs	Time to peak	= 158 min
Time interval	= 2 min	Hyd. volume	= 0 cuft
Inflow hyd. No.	= 3 - Post-Developed Lot	Max. Elevation	= 100.96 ft
Reservoir name	= RG Lot 4	Max. Storage	= 237 cuft

Storage Indication method used. Exfiltration extracted from Outflow.



Hydrograph Report

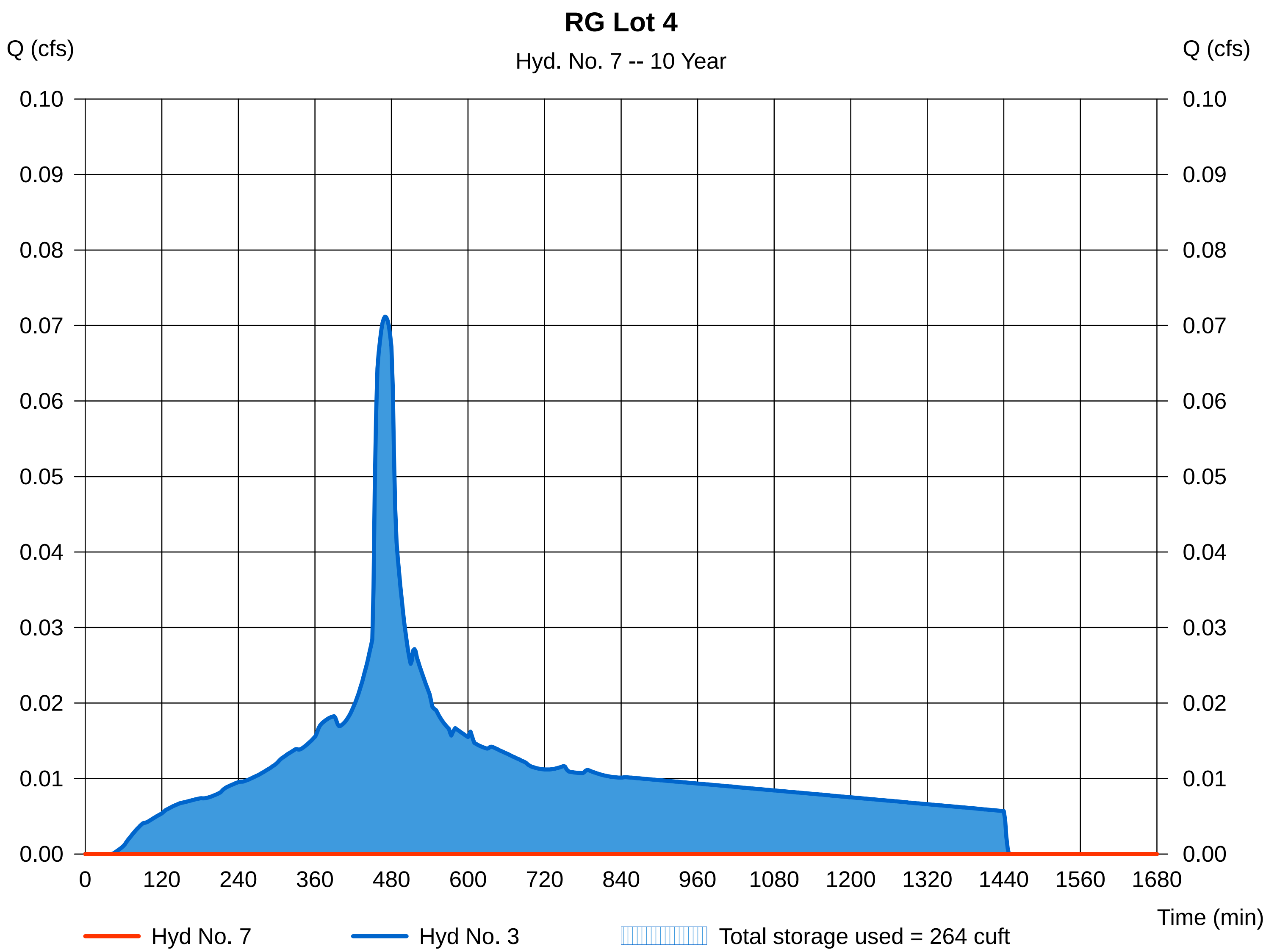
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066 Friday, Sep 13, 2013

Hyd. No. 7

RG Lot 4

Hydrograph type	= Reservoir	Peak discharge	= 0.000 cfs
Storm frequency	= 10 yrs	Time to peak	= 150 min
Time interval	= 2 min	Hyd. volume	= 0 cuft
Inflow hyd. No.	= 3 - Post-Developed Lot	Max. Elevation	= 102.53 ft
Reservoir name	= RG Lot 4	Max. Storage	= 264 cuft

Storage Indication method used. Exfiltration extracted from Outflow.



Hydrograph Report

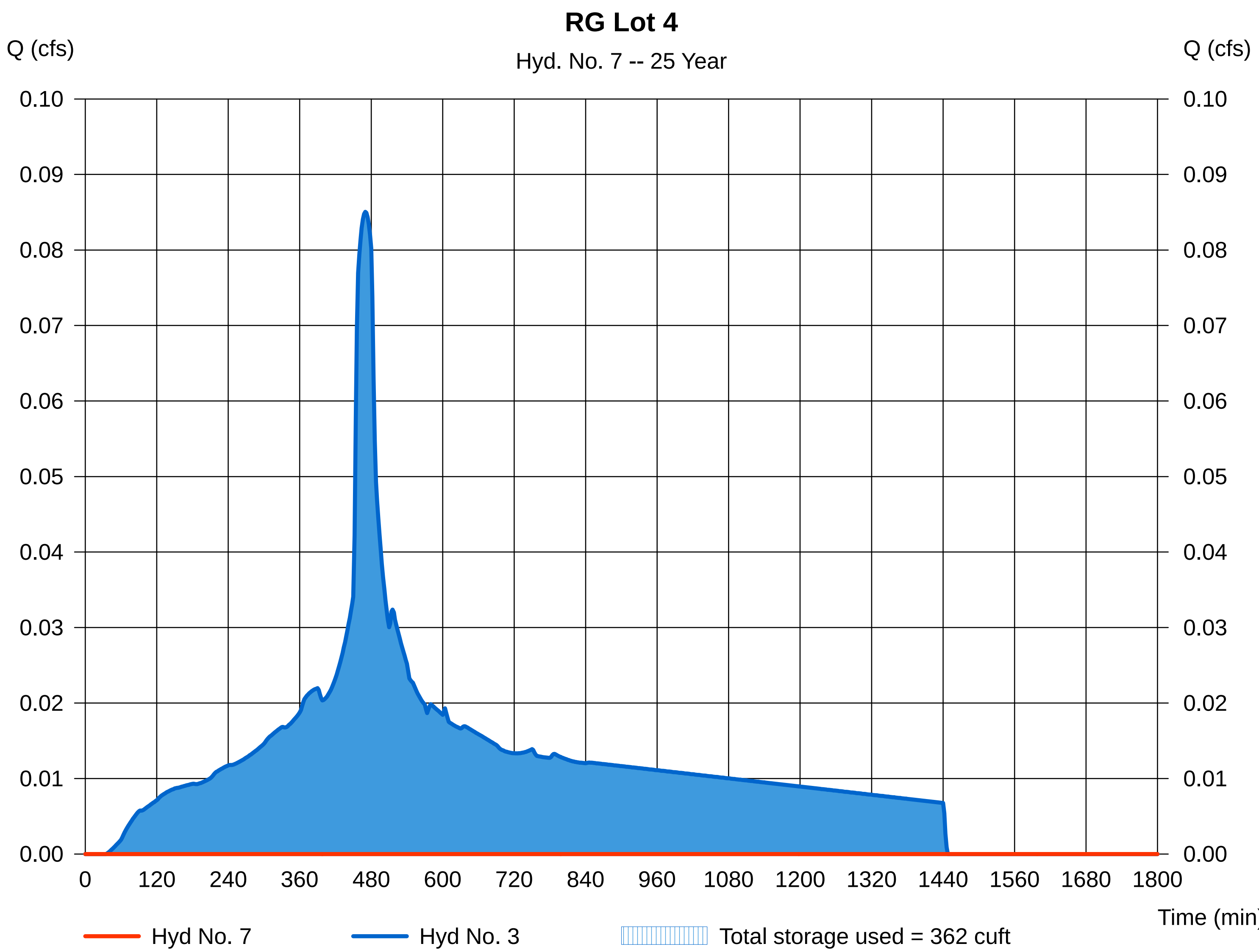
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066 — Friday, Sep 13, 2013

Hyd. No. 7

RG Lot 4

Hydrograph type	= Reservoir	Peak discharge	= 0.000 cfs
Storm frequency	= 25 yrs	Time to peak	= 126 min
Time interval	= 2 min	Hyd. volume	= 0 cuft
Inflow hyd. No.	= 3 - Post-Developed Lot	Max. Elevation	= 102.96 ft
Reservoir name	= RG Lot 4	Max. Storage	= 362 cuft

Storage Indication method used. Exfiltration extracted from Outflow.



Hydrograph Report

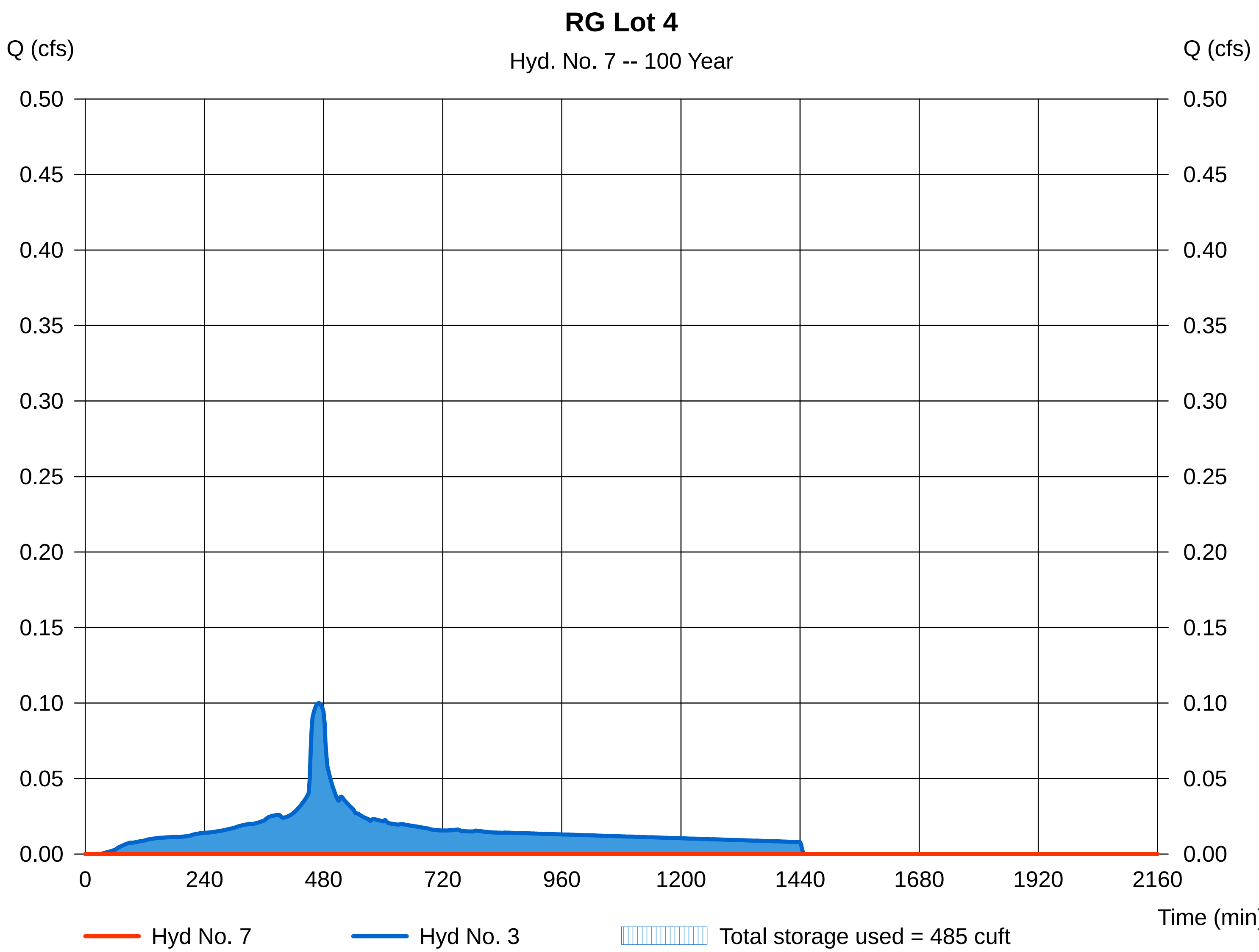
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066 Friday, Sep 13, 2013

Hyd. No. 7

RG Lot 4

Hydrograph type	= Reservoir	Peak discharge	= 0.000 cfs
Storm frequency	= 100 yrs	Time to peak	= 120 min
Time interval	= 2 min	Hyd. volume	= 0 cuft
Inflow hyd. No.	= 3 - Post-Developed Lot	Max. Elevation	= 103.49 ft
Reservoir name	= RG Lot 4	Max. Storage	= 485 cuft

Storage Indication method used. Exfiltration extracted from Outflow.



Pond No. 4 - RG Lot 6 & 7

Pond Data

Trapezoid - Bottom L x W = 86.0 x 5.0 ft, Side slope = 3.00:1, Bottom elev. = 100.00 ft, Depth = 1.00 ft, Voids = 33.00%
Contours - User-defined contour areas. Average end area method used for volume calculation. Begining Elevation = 101.01 ft

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	100.00	430	0	0
0.10	100.10	485	15	15
0.20	100.20	541	17	32
0.30	100.30	597	19	51
0.40	100.40	654	21	71
0.50	100.50	712	23	94
0.60	100.60	771	24	118
0.70	100.70	830	26	145
0.80	100.80	890	28	173
0.90	100.90	951	30	204
1.00	101.00	1,012	32	236
1.01	101.01	00	5	241
2.50	102.50	00	0	241
3.50	103.50	430	215	456

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	Inactive	Inactive	Inactive	Inactive
Span (in)	= 6.00	1.10	1.50	0.00
No. Barrels	= 1	1	1	0
Invert El. (ft)	= 629.30	628.80	630.60	0.00
Length (ft)	= 10.00	10.00	10.00	0.00
Slope (%)	= 2.00	2.00	2.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	Yes	Yes	No

Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	Inactive	0.00	0.00	0.00
Crest El. (ft)	= 632.00	0.00	0.00	0.00
Weir Coeff.	= 3.33	3.33	3.33	3.33
Weir Type	= Riser	---	---	---
Multi-Stage	= Yes	No	No	No

Exfil.(in/hr) = 0.690 (by Contour)
TW Elev. (ft) = 0.00

Note: Culvert/Orifice outflows are analyzed under inlet (ic) and outlet (oc) control. Weir risers checked for orifice conditions (ic) and submergence (s).

Stage / Storage / Discharge Table

Stage ft	Storage cuft	Elevation ft	Clv A cfs	Clv B cfs	Clv C cfs	PrfRsr cfs	Wr A cfs	Wr B cfs	Wr C cfs	Wr D cfs	Exfil cfs	User cfs	Total cfs
0.00	0	100.00	0.00	0.00	0.00	---	0.00	---	---	---	0.000	---	0.000
0.10	15	100.10	0.00	0.00	0.00	---	0.00	---	---	---	0.008	---	0.008
0.20	32	100.20	0.00	0.00	0.00	---	0.00	---	---	---	0.009	---	0.009
0.30	51	100.30	0.00	0.00	0.00	---	0.00	---	---	---	0.010	---	0.010
0.40	71	100.40	0.00	0.00	0.00	---	0.00	---	---	---	0.010	---	0.010
0.50	94	100.50	0.00	0.00	0.00	---	0.00	---	---	---	0.011	---	0.011
0.60	118	100.60	0.00	0.00	0.00	---	0.00	---	---	---	0.012	---	0.012
0.70	145	100.70	0.00	0.00	0.00	---	0.00	---	---	---	0.013	---	0.013
0.80	173	100.80	0.00	0.00	0.00	---	0.00	---	---	---	0.014	---	0.014
0.90	204	100.90	0.00	0.00	0.00	---	0.00	---	---	---	0.015	---	0.015
1.00	236	101.00	0.00	0.00	0.00	---	0.00	---	---	---	0.016	---	0.016
1.01	241	101.01	0.00	0.00	0.00	---	0.00	---	---	---	0.016	---	0.016
2.50	241	102.50	0.00	0.00	0.00	---	0.00	---	---	---	0.016	---	0.016
3.50	456	103.50	0.00	0.00	0.00	---	0.00	---	---	---	0.016	---	0.016

Hydrograph Report

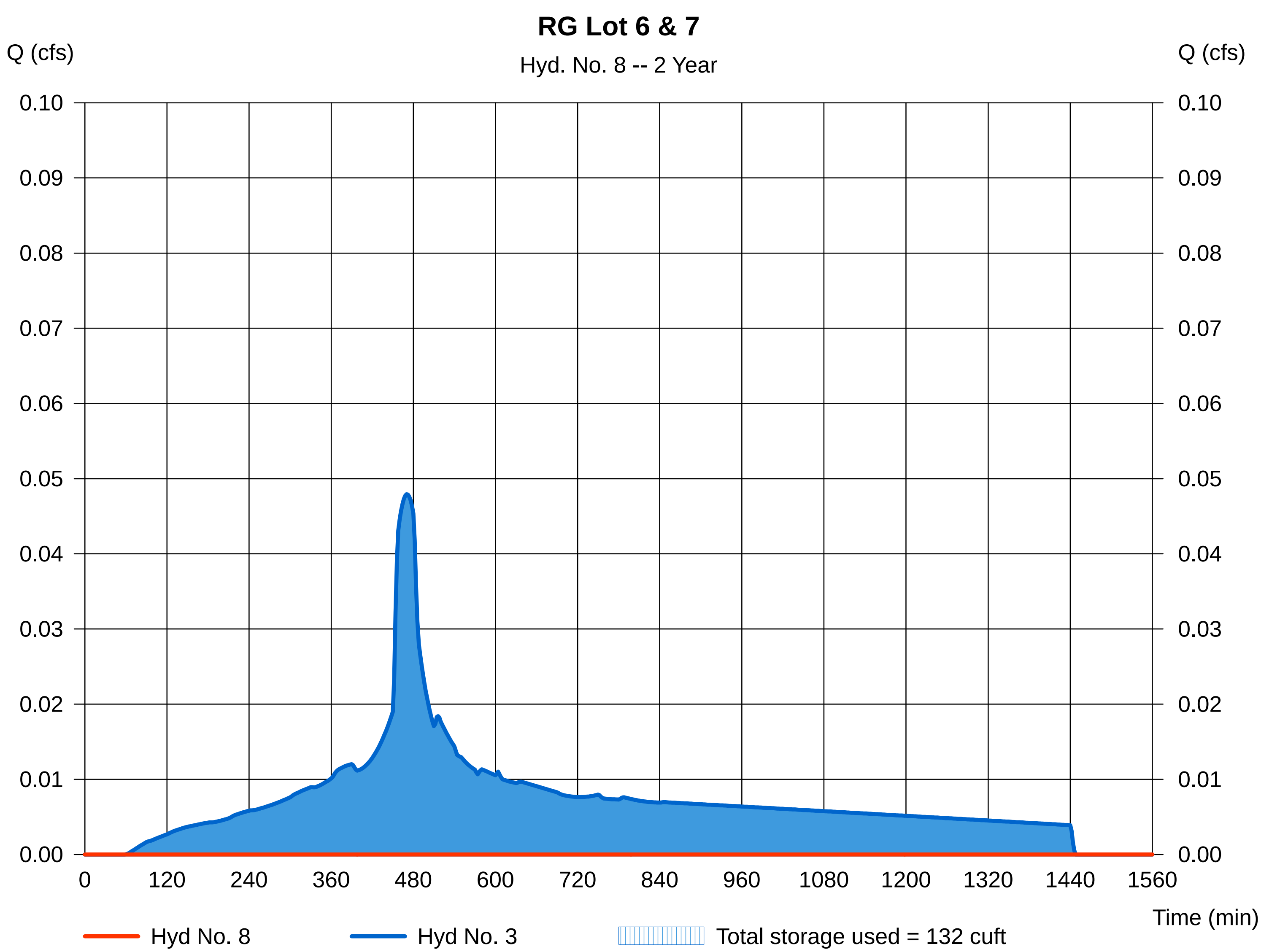
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066 Friday, Sep 13, 2013

Hyd. No. 8

RG Lot 6 & 7

Hydrograph type	= Reservoir	Peak discharge	= 0.000 cfs
Storm frequency	= 2 yrs	Time to peak	= 284 min
Time interval	= 2 min	Hyd. volume	= 0 cuft
Inflow hyd. No.	= 3 - Post-Developed Lot	Max. Elevation	= 100.65 ft
Reservoir name	= RG Lot 6 & 7	Max. Storage	= 132 cuft

Storage Indication method used. Exfiltration extracted from Outflow.



Hydrograph Report

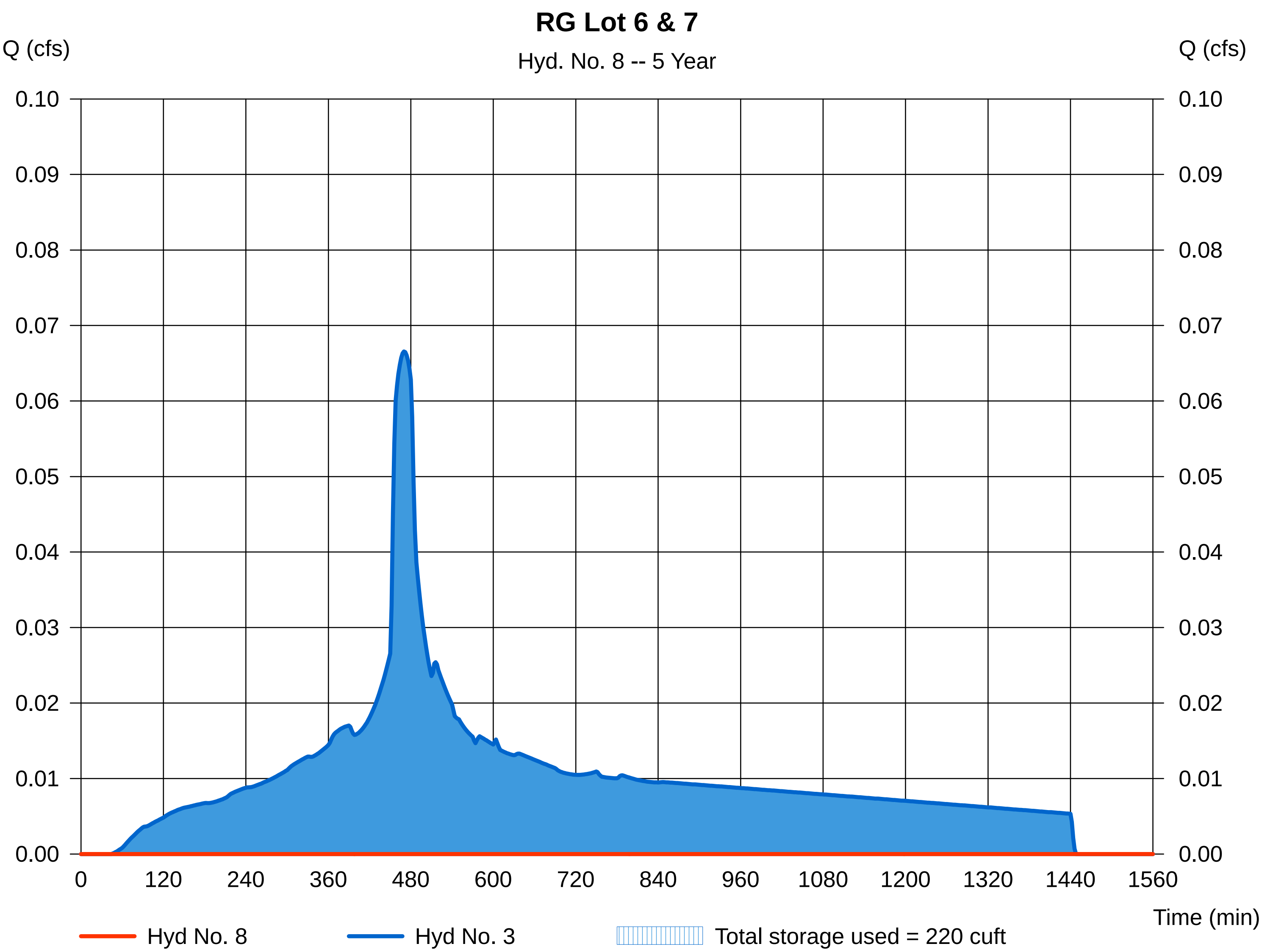
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066 | Friday, Sep 13, 2013

Hyd. No. 8

RG Lot 6 & 7

Hydrograph type	= Reservoir	Peak discharge	= 0.000 cfs
Storm frequency	= 5 yrs	Time to peak	= 156 min
Time interval	= 2 min	Hyd. volume	= 0 cuft
Inflow hyd. No.	= 3 - Post-Developed Lot	Max. Elevation	= 100.95 ft
Reservoir name	= RG Lot 6 & 7	Max. Storage	= 220 cuft

Storage Indication method used. Exfiltration extracted from Outflow.



Hydrograph Report

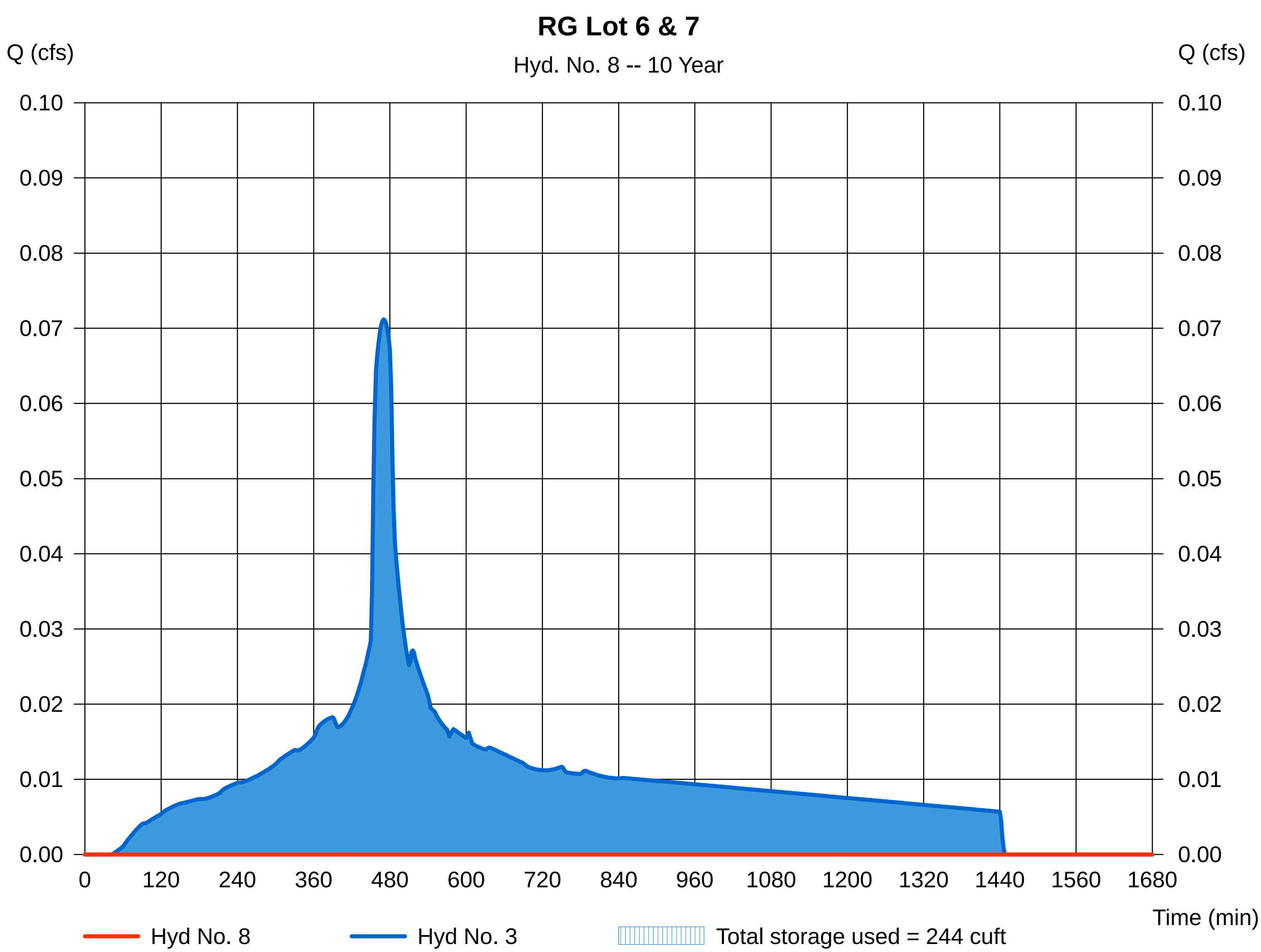
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066 — Friday, Sep 13, 2013

Hyd. No. 8

RG Lot 6 & 7

Hydrograph type	= Reservoir	Peak discharge	= 0.000 cfs
Storm frequency	= 10 yrs	Time to peak	= 168 min
Time interval	= 2 min	Hyd. volume	= 0 cuft
Inflow hyd. No.	= 3 - Post-Developed Lot	Max. Elevation	= 102.52 ft
Reservoir name	= RG Lot 6 & 7	Max. Storage	= 244 cuft

Storage Indication method used. Exfiltration extracted from Outflow.



Hydrograph Report

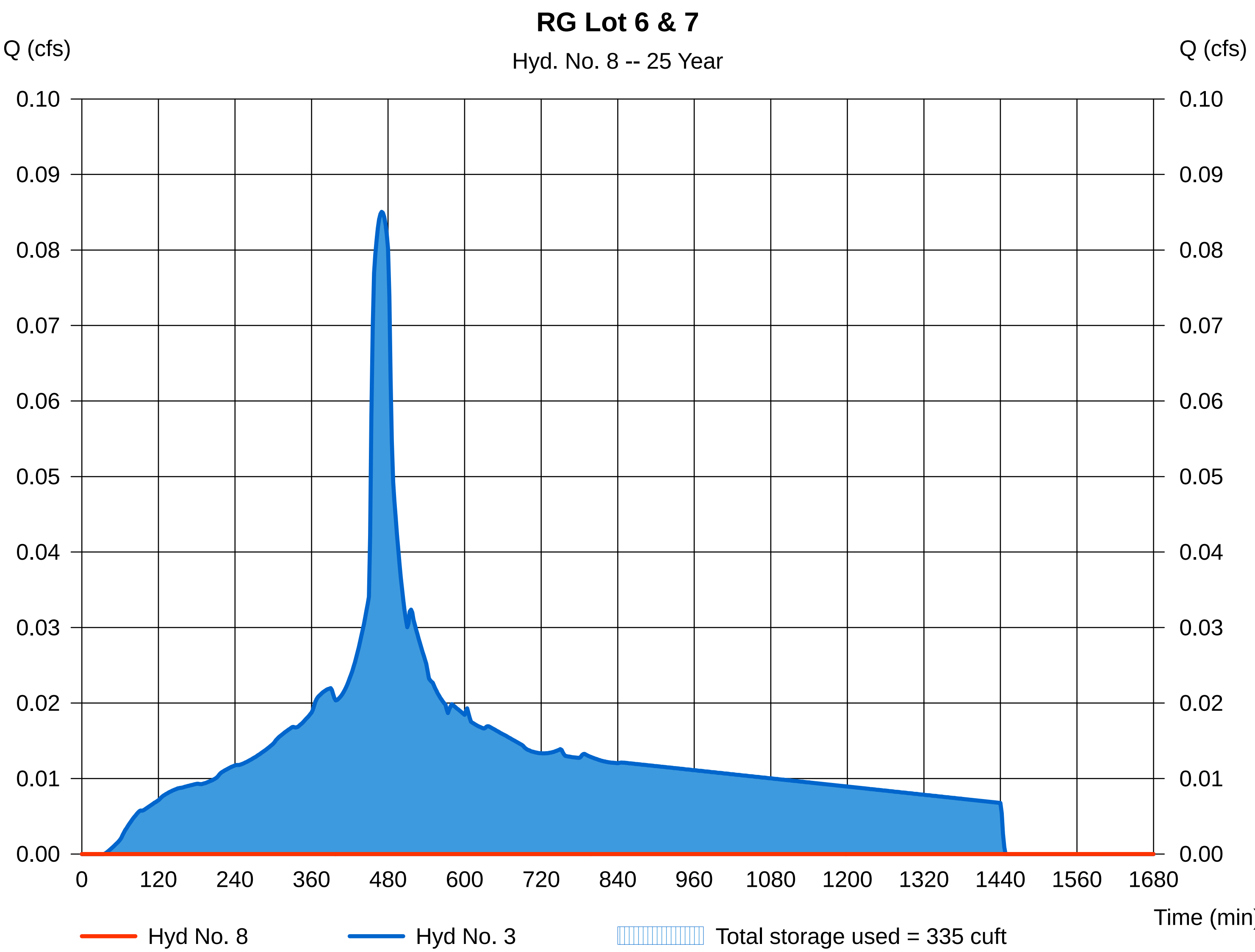
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066 Friday, Sep 13, 2013

Hyd. No. 8

RG Lot 6 & 7

Hydrograph type	= Reservoir	Peak discharge	= 0.000 cfs
Storm frequency	= 25 yrs	Time to peak	= 126 min
Time interval	= 2 min	Hyd. volume	= 0 cuft
Inflow hyd. No.	= 3 - Post-Developed Lot	Max. Elevation	= 102.94 ft
Reservoir name	= RG Lot 6 & 7	Max. Storage	= 335 cuft

Storage Indication method used. Exfiltration extracted from Outflow.



Hydrograph Report

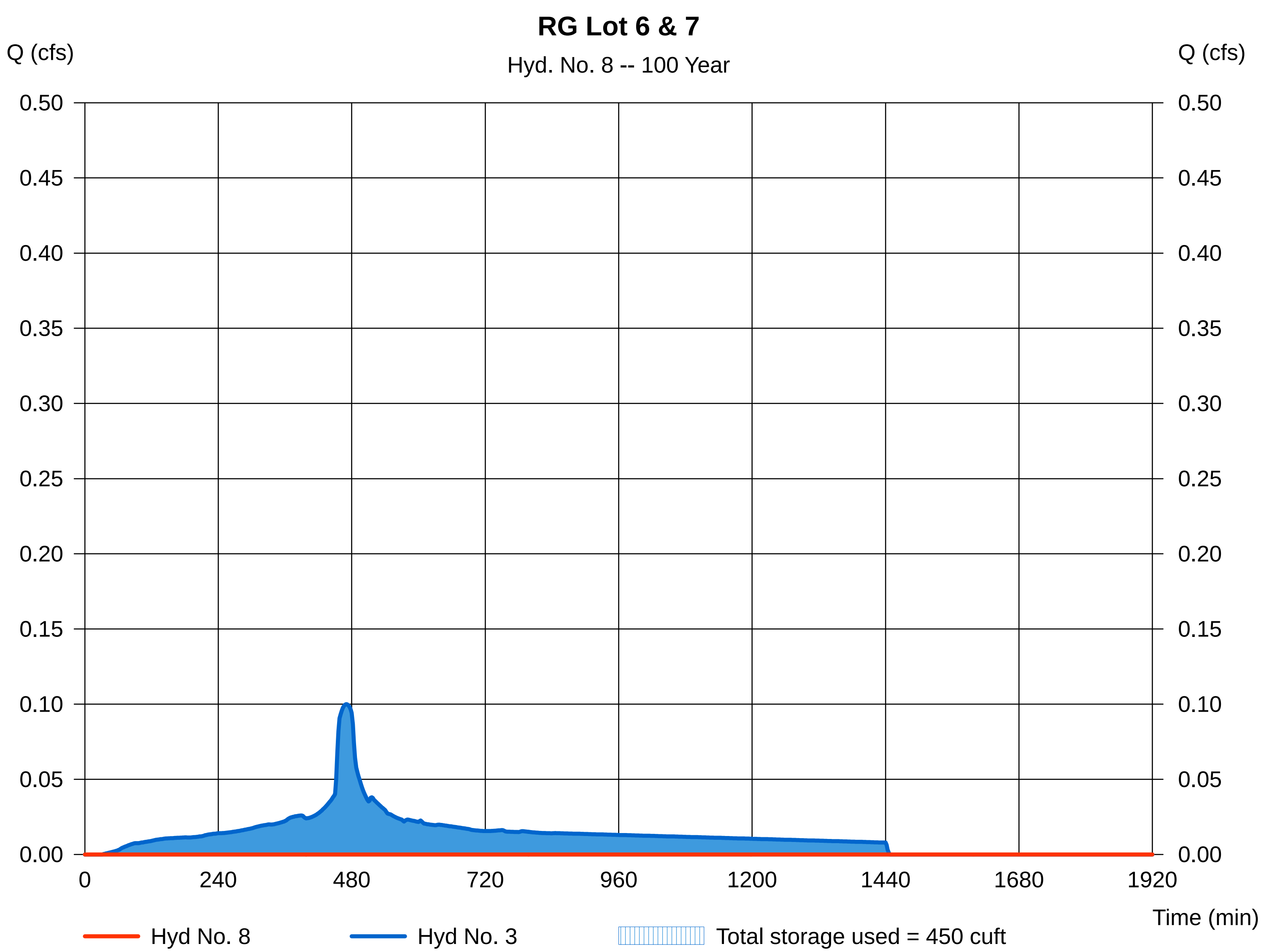
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066 | Friday, Sep 13, 2013

Hyd. No. 8

RG Lot 6 & 7

Hydrograph type	= Reservoir	Peak discharge	= 0.000 cfs
Storm frequency	= 100 yrs	Time to peak	= 106 min
Time interval	= 2 min	Hyd. volume	= 0 cuft
Inflow hyd. No.	= 3 - Post-Developed Lot	Max. Elevation	= 103.47 ft
Reservoir name	= RG Lot 6 & 7	Max. Storage	= 450 cuft

Storage Indication method used. Exfiltration extracted from Outflow.



ALASKA
CALIFORNIA
COLORADO
FLORIDA
MISSOURI
OREGON
WASHINGTON
WISCONSIN

August 29, 2013

Mr. Kelly Pyrch
1332 Stonehaven Drive
West Linn, Oregon 97068

**RE: REPORT OF GEOTECHNICAL ENGINEERING SERVICES
FOR THE PROPOSED 1485 ROSEMONT SUBDIVISION
WEST LINN, OREGON**

Dear Mr. Pyrch:

This letter presents our geotechnical subsurface data collection, design recommendations, and construction considerations supporting the design and construction of the roadway improvements, utility installations, and stormwater infiltration for the proposed 1485 Rosemont Subdivision. The site is located at 1485 Rosemont Road in West Linn, Oregon, as shown on Figure 1. Our services are being performed based on the Shannon & Wilson, Inc., proposal No. 24-2-04528-001 dated February 25, 2013.

Scope of Services

We performed the following geotechnical services in accordance with the scope of services specified in the agreement referenced above. In general, our services included the following:

- Exploring the subsurface conditions and collecting soil samples from four test pits;
- Performing infiltration tests in six locations along this portion of the alignment and providing raw field infiltration rate data for use in stormwater facility design;
- Conducting laboratory testing to characterize the subsurface material and to develop engineering parameters for evaluation;
- Performing geotechnical analyses including the development of earthquake design parameters and pavement recommendations;
- Providing recommendations for site preparation, grading, structural fill, and compaction criteria; and
- Providing this written report summarizing our explorations, data collection, geotechnical analyses, conclusions, and recommendations.

Results of the geotechnical analyses and our geotechnical recommendations for the location listed above are in the following sections.

Project Understanding

We understand that the site will be split into seven residential lots that have a total area of approximately 1.9 acres. Three stormwater quality and detention facilities, two residential access roads to Rosemont Road, and some proposed utilities will be included in this subdivision development. Individual lots and the associated development will be designed at a later date. Applicable design elements include site grading with cuts and fills, road construction, installation of pavements, and stormwater infiltration design. We have assumed that the facilities will be constructed in accordance with the applicable City of West Linn regulations.

In general, we understand that the roadway construction will require minor grading with cuts and fills less than 4 feet. We understand that the proposed infiltration facilities will consist of rain gardens on each proposed lot.

SUBSURFACE INVESTIGATION

Field Explorations

The site explorations consisted of shallow test pits at the locations shown on Figure 2. Test pits TP-1 through TP-4 were excavated on August 15, 2013, to depths between 8.5 and 9.5 feet. Test pits TP-5 through TP-7 were excavated on August 27, 2013, to depths between 7 and 8 feet. A Shannon &Wilson geologist was present during excavation to collect and log samples of soils and conduct infiltration testing. The test pits were excavated with backhoes provided and operated by Western States Soil Conservation (TP-1 through TP-4) and Scott Dahme (TP-5 through TP-7). Details of excavations and logs of soil samples are presented in Attachment A.

Test pits were loosely backfilled and tamped with the excavator bucket after each excavation. During construction, if the test pit excavations are in structural areas and if potential settlement is not acceptable, the material should be removed and re-compacted as structural fill.

Infiltration Testing

Infiltration testing was completed during the explorations at six locations in general accordance with the Encased Falling Head Method as described in Appendix F of the 2008 City of Portland Stormwater Management Manual (Appendix F). Tests were completed in a 6-inch-diameter standpipe embedded in the base of a test pit. The test areas were saturated prior to testing for 1 to 4 hours, depending on the test location. Two to three tests were completed at each location to confirm saturation and consistent rates.

Approximate infiltration test locations are shown on Figure 2, and results are provided in Attachment B. Infiltration rates discussed above and in Attachment B are raw, field-measured rates. Data should be evaluated, and the appropriate safety and design factors provided in the Portland Stormwater Management Manual should be applied to the field infiltration rates during design of the proposed facility.

Laboratory Testing

Soil samples obtained during field explorations were examined in the laboratory. Physical characteristics of the samples were noted, and field classifications were modified as necessary in accordance with the terminology presented in Attachment A, Figure A1. During the course of the examination, representative samples were selected for further testing. The soil-testing program included particle-size analyses and Atterberg Limits determinations. These tests are described in the following paragraphs. All test procedures were performed in general accordance to applicable ASTM International standards. The term “general accordance” means that certain local and common descriptive practices and methodologies have been followed.

Atterberg Limits Determinations

Atterberg Limits were determined for selected samples in accordance with ASTM D4318. This analysis yields index parameters of the soil that are useful in soil classification as well as in engineering analyses. Atterberg Limits tests include liquid and plastic limits. The results are plotted on Figure A8.

Grain-Size Analyses

Grain-size analyses were performed on selected samples of soil taken below three of the infiltration test locations in general accordance with ASTM D422, Standard Test Method for Particle-Size Analysis of Soils. Results of the grain-size analyses are plotted on grain-size distribution curves presented in Figure A9, Grain-Size Distribution.

SUBSURFACE CONDITIONS

Based on the materials encountered in test pits TP-1 through TP-7, the subsurface soils at the site have been grouped into four primary units: Fill, Colluvium, Residual Soil, and Decomposed Basalt. Interpretation of the subsurface conditions is based on data obtained from the test pits and regional information from published sources. The soil units are described as follows:

Fill

The fill was encountered in TP-2 on Lot 5 and consisted of medium stiff brown lean clay and silt with sand content (CL/ML). The fill had low to medium plasticity with few organics. The fill in TP-2 was 2 feet thick.

Colluvium

The colluvium at the site was present in all the test pits at the surface or underlying the fill and typically extended to depths between 4.5 and 6 feet below the ground surface. The colluvium consisted of stiff to very stiff, gray brown to red brown elastic silt (MH) with medium plasticity.

Residual Soil

The residual soil was encountered in all of the test pits underlying the colluvium layer and was between 1 and 5 feet thick. TP-1, TP-6, and TP-7 were terminated in this layer at depths between 7 and 9.5 feet below the ground surface (bgs). The residual soil consisted of very stiff to hard red-brown and gray elastic silt (MH) with medium plasticity.

Decomposed Basalt

Decomposed Columbia River Basalt was encountered below the residual soil in test pits TP-2 through TP-5 at depths between 6 and 8.4 feet bgs. This layer consists of very low to low strength, tan and red-brown fine grained basalt. Joints were closely spaced and rough planar with joint staining. The material was slightly to moderately vesicular.

These generalized geologic units were grouped based on engineering properties and their distribution in the subsurface. Variations in subsurface conditions may exist between the locations of the test pits. During our excavations, no groundwater was encountered seeping into the test pits.

SEISMIC DESIGN CONSIDERATIONS

In accordance with the site classification criteria set forth in the 2012 International Building Code (IBC), we recommend a Site Class D for the site based upon the borings explored on the site near the proposed retaining walls. The following paragraphs describe the required seismically related hazard evaluations on site.

Strong Ground Motions

The maximum considered earthquake (MCE) ground motions at the bedrock level of $S_S = 0.92$ g and $S_1 = 0.33$ g were obtained from the United States Geological Survey (USGS) Earthquake Hazards Program – 2002 interactive deaggregation website. Based on the site class and these values, the design earthquake spectral response coefficients are Fa = 1.13 and Fv = 1.74. The ground motions are based on a probabilistic hazard analysis performed by the USGS and the seismic site classification of the project site.

Fault Rupture

In the vicinity of the project site, the nearest mapped faults are as follows

- Oatfield fault, about 2.7 miles to the northeast
- Canby Molalla fault, about 3.4 miles to the southwest
- Portland Hills Fault, about 3.5 miles to the northeast
- Damascus-Tickle Creek fault, about 5.3 miles to the northeast
- East Bank fault, about 7.6 miles to the northeast

All five faults are designated as Class A by the USGE and are thought to have been active within the last 1.6 million years (Personius, 2002). Due to their mapped distance from the site, it is our opinion that the risk for fault rupture at the site is low.

Other Seismic Risks

Due to the shallow weathered bedrock at the site and the geography, it is our opinion that the risk for liquefaction and lateral spread at the site is minimal. Tsunmai and seiche are not a risk at the site.

CONCLUSIONS AND RECOMMENDATIONS

General

Based upon the subsurface conditions encountered in our explorations and information provided by Mr. Kelly Pyrch and Mackenzie, we have developed the following geotechnical engineering recommendations for the proposed subdivision development.

Pavement Recommendations

We are providing asphalt concrete (AC) pavement design for the two private, residential shared driveways that will provide access to Rosemont Road from each side of the proposed subdivision. The pavement was designed using the 2011 ODOT Pavement Design Guide (ODOT PDG) and the 1993 AASHTO Guide for Design of Pavement Structures procedures. For new pavement, ODOT PDG requires a minimum 20-year design life for AC. Subgrade preparation, pavement, base course materials, and installation should be completed in accordance with Oregon Standard Specifications for Construction (OSSC).

Traffic Analysis

We estimated the traffic volume to be 24 ADT (average daily traffic) with a design growth rate of 2 percent. No actual FHWA vehicle classes (based on number of axles) were obtained; therefore, the following vehicle breakdown was assumed, as shown in Table 1.

TABLE 1: ASSUMED SUMMARY OF PERCENTAGE OF VEHICLE CLASSES

Vehicle Type and Assumption	FHWA Vehicle Class	Percentage Vehicle of ADT
24 Passenger Cars a day (2-Axle)	1,2, or 3	99.94
5 Emergency Vehicles a year (4-Axle)	7	0.06

ODOT one-way truck conversion factors and lane distribution factors were used to estimate the design equivalent single-axle loads (ESALs). For a 20-year design life, the estimated design ESAL was 1,485.

Subgrade

The anticipated primary soil type exposed at pavement subgrade will be stiff to very stiff silt to clayey silt. We recommend that the subgrade be “proof-rolled” in the presence of a qualified geotechnical engineer or civil engineering representative to identify any soft or weak spots prior to the placement of pavement material. The subgrade should be prepared as described under "Geotechnical Construction Considerations." Soft or weak spots should be overexcavated and replaced with compacted granular material.

Asphalt Concrete Pavement Section Design Parameters

The following additional assumptions should be reviewed by the design team to evaluate their suitability for this project. Changes in the assumptions will affect the corresponding pavement section recommendations.

- Subgrade Resilient Modulus (M_R) = 5,000 psi
- Design Life: 20 years
- Standard Deviation = 0.49
- Loss of Serviceability = 1.7 (initial = 4.2, terminal = 2.5)
- Reliability = 75 percent
- Drainage Coefficient = 1.0 (good)

Recommended Asphalt Concrete Pavement Section

Based on these assumptions, we recommend that all AC pavements for the proposed driveways be constructed with the properties as presented in Table 2.

TABLE 2: RECOMMENDED AC PAVEMENT SECTION

Material	Thickness (in)	Material Requirements
AC	3	Level 2, ½-inch dense HMAC, PG 64-22
Base Rock	8	Dense graded base

Aggregate base material should meet Section 02630 of ODOT OSSC. The asphalt grade was selected based on Table J-2 of the 2011 ODOT PDG for urban highways with ESALs less than 1 million.

GEOTECHNICAL CONSTRUCTION CONSIDERATIONS

Site Preparation

Site preparation will include: (1) clearing, grubbing, and roadside cleanup, (2) removal of existing structures and underground utilities, and (3) subgrade preparation and excavation. Based on our explorations, the average depth of stripping will be approximately 6 inches to remove the topsoil and pavement; however, deeper excavations may be required locally.

After stripping and excavating to the proposed subgrade level, as required, the site should be proof-rolled with a fully loaded 10- to 12-yard dump truck, another suitably loaded rubber-tired construction vehicle, or self-propelled compaction equipment weighing at least 6 tons. Soils that are observed to rut or deflect excessively under the moving load, or are otherwise judged to be unsuitable, should be over-excavated and replaced with properly compacted fill. The proof-rolling and overexcavation activities should be witnessed by a representative of the geotechnical or civil engineer.

Subgrade areas should be cleanly cut to firm undisturbed soil. Proof-rolling of excavations is likely not appropriate during wet-weather grading in order to avoid disturbance of moisture-sensitive soils. Should construction take place during wet weather, we recommend that a representative of the geotechnical or civil engineer be present to observe the subgrade in order to evaluate whether additional preparation is indicated.

Cut-and-Fill Slopes

Unshored, temporary excavation slopes may be used where planned excavation limits will not undermine existing roadways and structures, interfere with other construction, or extend beyond construction limits. The stability of excavated slopes will depend on the following factors: (1) actual angle of slope, (2) the presence of groundwater; (3) the type and density of the soils; (4) the depth of excavation; (5) surcharge loading adjacent to the excavation, such as that from excavated material, existing facilities, or construction equipment; and (6) the weather and season of year. For planning purposes, we recommend that temporary slopes be excavated at no steeper than 1.5 horizontal to 1 vertical (1.5H:1V). Temporary cut slopes are typically the responsibility of the contractor and should comply with applicable local, state, and federal safety regulations, including the current OSHA Excavation and Trench Safety Standards. Permanent earth slopes should be cut to 2H:1V or flatter and protected from erosion.

If wetted by surface water, the slopes may be subject to erosion. Slope protection should be designed and properly installed, as appropriate, to reduce erosion effects.

Wet Weather Construction

Excavation and construction operations may expose the on-site silty surficial soils to inclement weather conditions. These soils can be easily disturbed when wet, and the stability of exposed soils may rapidly deteriorate due to a change in moisture content (i.e. wetting or drying) or the actions of heavy or repeated construction traffic. Accordingly, foundation and pavement area excavations should be adequately protected from the elements and from the actions of repetitive or heavy construction loadings.

Weathered Rock Excavation

Based on our explorations, weathered rock excavation may be required at the site depending on the proposed grading plans. Rock descriptions and depths where rock was encountered along the alignment are included in the discussion above and test pit logs included in Appendix A. In general, the weathered basalt was easily excavatable with conventional equipment.

Erosion Control

Erosion control work consists of furnishing, installing, maintaining, removing, and disposing of water sediments and erosion-control items in accordance with City Standard Specifications. Other erosion control items including seeding, fertilizing, and mulching construction areas should also be done in accordance with City requirements. Erosion control is typically the responsibility of the contractor during construction.

Structural Fill Material and Placement

On-site sand silt may be used for structural fill, provided that it meets these requirements, and topsoil, pavement, and cobbles larger than 6 inches are removed prior to placement. Structural fill material should meet the requirements in ODOT OSSC, Section 00330.12, and consist of relatively well-graded soils that are free of debris and organic matter and that can be compacted to the specified density. Typical structural fill materials include clean sand, gravel, washed rock, crushed rock, quarry spalls, well-graded mixtures of sand and gravel (commonly called “gravel borrow” or “pit-run”), and miscellaneous mixtures of silt, sand, and gravel. We recommend not using sand or rounded gravel as structural fill material. The maximum particle size should be restricted to 6 inches. If construction occurs during wet weather, fill materials should meet the requirements of ODOT OSSC, Section 00330.14, and contain less than 5 percent material passing the No. 200 sieve.

Structural fill should be placed in maximum lifts of 8 inches of loose material and should be compacted to within 2 percentage points of the optimum moisture content value in accordance with ASTM D1557 (modified proctor). If water must be added, it should be uniformly applied and thoroughly mixed into the soil or granular material by disking or scarifying. Each lift of the compacted fill should be tested by a representative of the geotechnical engineer prior to placement of subsequent lifts. Fill should extend horizontally outward from the exterior perimeter of the pavement at a distance equal to the height of the fill or 3 feet, whichever is greater, prior to sloping.

Drainage Considerations

Water should not be allowed to collect on prepared subgrade during construction. Positive site drainage should be maintained throughout construction activities. Overexcavated or graded excavated areas should be sloped to facilitate removal of any collected rainwater, perched groundwater, or surface runoff.

LIMITATIONS

The analyses, conclusions, and recommendations contained in this report are based upon site conditions as they presently exist and further assume that the test pits are representative of subsurface conditions throughout the site, i.e., the subsurface conditions everywhere are not significantly different from those disclosed by the field explorations.

If, during construction, subsurface conditions different from those encountered in the field explorations are observed or appear to be present beneath excavations, we should be advised at once so that we can review these conditions and reconsider our recommendations where necessary. If there is a substantial lapse of time between the submission of this report and start of work at the site, or if conditions have changed due to natural causes or construction operations at or adjacent to the site, it is recommended that this report be reviewed to determine the applicability of these conclusions and recommendations, considering the changed conditions and the elapsed time.

We recommend that Shannon & Wilson review the geotechnical portions of the construction plans and specifications, especially those parts that address embankments and earthwork, to determine if they are consistent with our recommendations.

This letter is prepared for the exclusive use of the Mr. Pyrch and Mackenzie and their design team for the design and construction of the proposed subdivision roadway and stormwater system construction. Unanticipated soil conditions are commonly encountered and cannot fully be determined by merely taking soil samples from geotechnical test pits. Such unexpected

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conditions frequently require that additional expenditures be made to attain properly constructed projects. This letter is not as a warranty of subsurface conditions described herein.

Please note that the scope of our services did not include any environmental assessment or evaluation regarding the presence or absence of hazardous or toxic materials in the soil, surface water, groundwater, or air, on or below or around the project site.

Sincerely,

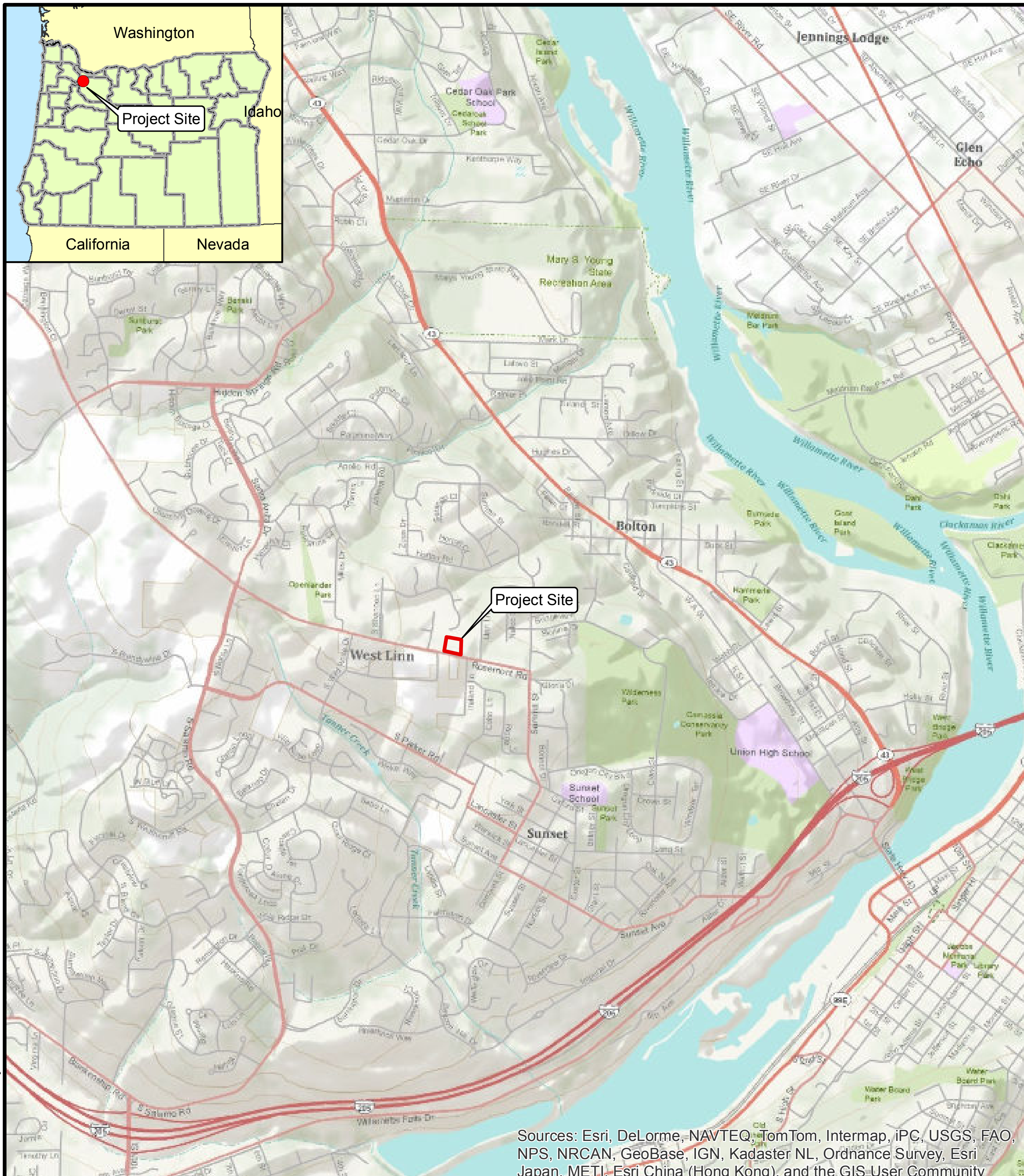
SHANNON & WILSON, INC.

REGISTERED PROFESSIONAL ENGINEER
69452PE
OREGON
Nov. 14, 2006
ALLISON MARIE PYRCH
EXPIRES: 12/31/14

Allison M. Pyrch, PE, GE	Jerry L. Jacksha, PE, GE
Principal | Geotechnical Engineer	Senior Associate | Geotechnical Engineer

AMP/JLJ/amn

Encl: Figure 1 – Vicinity Map
Figure 2 – Plan of Explorations
Attachment A – Field Explorations and Laboratory Testing
Attachment B – Infiltration Testing Results
Attachment C - Important Information About Your Geotechnical/Environmental Report



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W E
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0 2,000 4,000
Feet

1485 Rosemont Subdivision
West Linn, Oregon

VICINITY MAP

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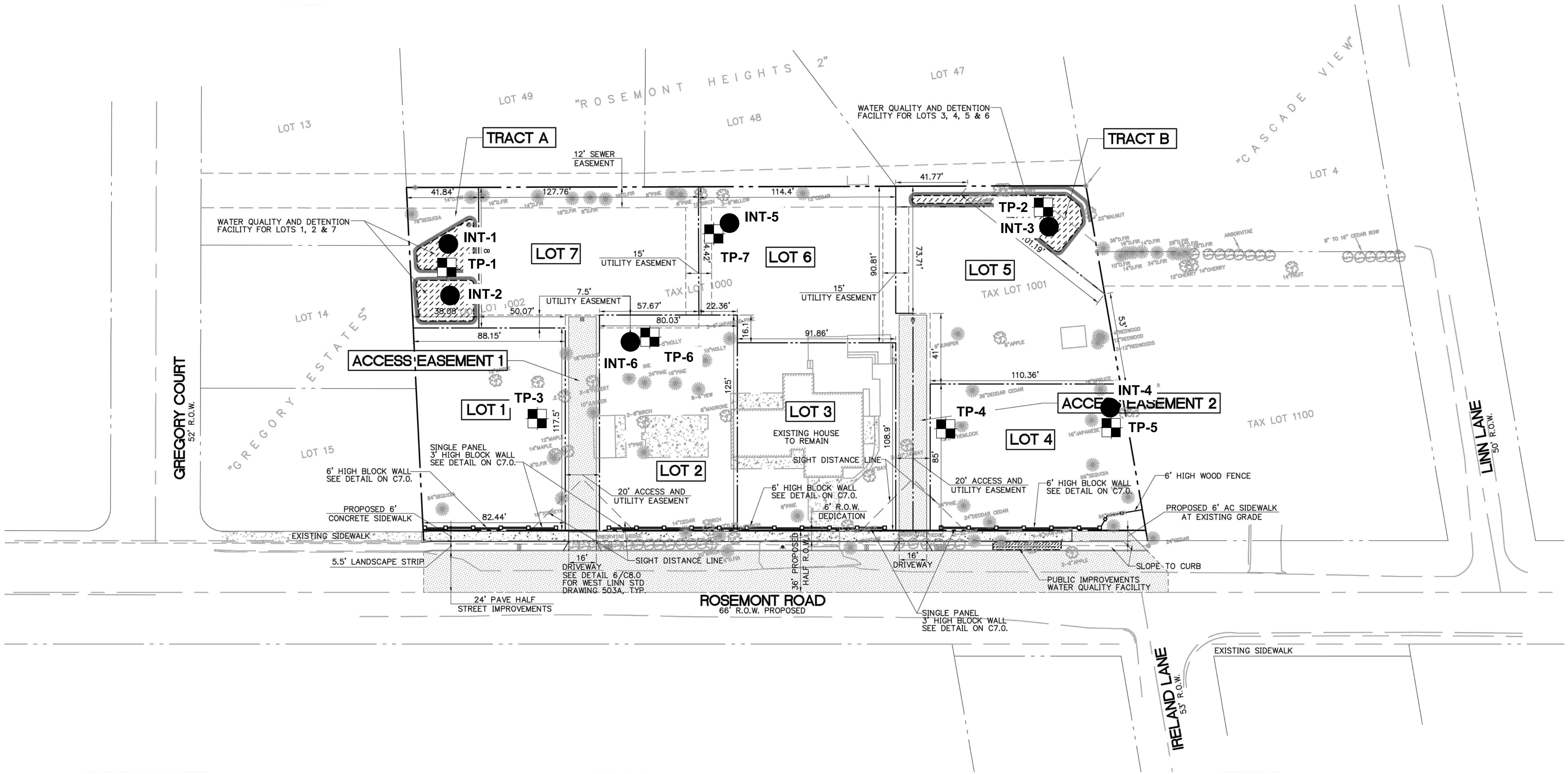
FIG. 1

Path: T:\Projects\24-1\3764_Rosemont\Avmxd\Vicinity.mxd 8/23/2013 ath



EXPLANATION

INT-1 ● Location and Designation of Infiltration Test

TP-1 Location and Designation of Test Pit

Reference: Base drawing provided by Group Mackenzie, entitled, "Tentative Subdivision Plan," dated May 23, 2013.

0 60 120

Scale in Feet

N

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West Linn, Oregon

PLAN OF EXPLORATIONS

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FIG. 2

File: I:\WIP\Projects\24-1 Portland\3700\3764 1485 Rosemont Subdivision\Graphics\CAD\24-1-03764-001-SP.dwg Date: 08-29-2013 Author: ath

ATTACHMENT A

FIELD EXPLORATIONS AND LABORATORY TESTING

TABLE OF CONTENTS

Figures

Shannon & Wilson, Inc. (S&W), uses a soil identification system modified from the Unified Soil Classification System (USCS). Elements of the USCS and other definitions are provided on this and the following pages. Soil descriptions are based on visual-manual procedures (ASTM D2488) and laboratory testing procedures (ASTM D2487), if performed.

S&W INORGANIC SOIL CONSTITUENT DEFINITIONS

CONSTITUENT[2]	FINE-GRAINED SOILS (50% or more fines)[1]	COARSE-GRAINED SOILS (less than 50% fines)[1]
Major	***Silt, Lean Clay, Elastic Silt,*** or ***Fat Clay***[3]	***Sand*** or ***Gravel***[4]
Modifying (Secondary) Precedes major constituent	30% or more coarse-grained: ***Sandy*** or ***Gravelly***[4]	More than 12% fine-grained: ***Silty*** or ***Clayey***[3]
Minor Follows major constituent	15% to 30% coarse-grained: ***with Sand*** or ***with Gravel***[4]	5% to 12% fine-grained: ***with Silt*** or ***with Clay***[3]
	30% or more total coarse-grained *and* lesser coarse-grained constituent is 15% or more: ***with Sand*** or ***with Gravel***[5]	15% or more of a second coarse-grained constituent: ***with Sand*** or ***with Gravel***[5]

[1]All percentages are by weight of total specimen passing a 3-inch sieve.
[2]The order of terms is: *Modifying Major with Minor*.
[3]Determined based on behavior.
[4]Determined based on which constituent comprises a larger percentage.
[5]Whichever is the lesser constituent.

MOISTURE CONTENT TERMS

Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, from below water table

STANDARD PENETRATION TEST (SPT) SPECIFICATIONS

Hammer:	140 pounds with a 30-inch free fall. Rope on 6- to 10-inch-diam. cathead 2-1/4 rope turns, > 100 rpm
Sampler:	10 to 30 inches long Shoe I.D. = 1.375 inches Barrel I.D. = 1.5 inches Barrel O.D. = 2 inches
N-Value:	Sum blow counts for second and third 6-inch increments. Refusal: 50 blows for 6 inches or less; 10 blows for 0 inches.

NOTE: Penetration resistances (N-values) shown on boring logs are as recorded in the field and have not been corrected for hammer efficiency, overburden, or other factors.

PARTICLE SIZE DEFINITIONS

DESCRIPTION	SIEVE NUMBER AND/OR APPROXIMATE SIZE
FINES	< #200 (0.075 mm = 0.003 in.)
SAND	
Fine	#200 to #40 (0.075 to 0.4 mm; 0.003 to 0.02 in.)
Medium	#40 to #10 (0.4 to 2 mm; 0.02 to 0.08 in.)
Coarse	#10 to #4 (2 to 4.75 mm; 0.08 to 0.187 in.)
GRAVEL	
Fine	#4 to 3/4 in. (4.75 to 19 mm; 0.187 to 0.75 in.)
Coarse	3/4 to 3 in. (19 to 76 mm)
COBBLES	3 to 12 in. (76 to 305 mm)
BOULDERS	> 12 in. (305 mm)

RELATIVE DENSITY / CONSISTENCY

COHESIONLESS SOILS		COHESIVE SOILS	
N, SPT, BLOWS/FT.	RELATIVE DENSITY	N, SPT, BLOWS/FT.	RELATIVE CONSISTENCY
< 4	Very loose	< 2	Very soft
4 - 10	Loose	2 - 4	Soft
10 - 30	Medium dense	4 - 8	Medium stiff
30 - 50	Dense	8 - 15	Stiff
> 50	Very dense	15 - 30	Very stiff
		> 30	Hard

WELL AND BACKFILL SYMBOLS

- Bentonite Cement Grout
- Bentonite Grout
- Bentonite Chips
- Silica Sand
- Perforated or Screened Casing
- Surface Cement Seal
- Asphalt or Cap
- Slough
- Inclinometer or Non-perforated Casing
- Vibrating Wire Piezometer

PERCENTAGES TERMS [1, 2]

Trace	< 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

[1]Gravel, sand, and fines estimated by mass. Other constituents, such as organics, cobbles, and boulders, estimated by volume.

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SOIL DESCRIPTION AND LOG KEY

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FIG. A1
Sheet 1 of 3

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)
(Modified From USACE Tech Memo 3-357, ASTM D2487, and ASTM D2488)

MAJOR DIVISIONS			GROUP/GRAPHIC SYMBOL	TYPICAL IDENTIFICATIONS
COARSE-GRAINED SOILS *(more than 50% retained on No. 200 sieve)*	Gravels *(more than 50% of coarse fraction retained on No. 4 sieve)*	Gravel *(less than 5% fines)*	GW	Well-Graded Gravel; Well-Graded Gravel with Sand
			GP	Poorly Graded Gravel; Poorly Graded Gravel with Sand
		Silty or Clayey Gravel *(more than 12% fines)*	GM	Silty Gravel; Silty Gravel with Sand
			GC	Clayey Gravel; Clayey Gravel with Sand
	Sands *(50% or more of coarse fraction passes the No. 4 sieve)*	Sand *(less than 5% fines)*	SW	Well-Graded Sand; Well-Graded Sand with Gravel
			SP	Poorly Graded Sand; Poorly Graded Sand with Gravel
		Silty or Clayey Sand *(more than 12% fines)*	SM	Silty Sand; Silty Sand with Gravel
			SC	Clayey Sand; Clayey Sand with Gravel
FINE-GRAINED SOILS *(50% or more passes the No. 200 sieve)*	Silts and Clays *(liquid limit less than 50)*	Inorganic	ML	Silt; Silt with Sand or Gravel; Sandy or Gravelly Silt
			CL	Lean Clay; Lean Clay with Sand or Gravel; Sandy or Gravelly Lean Clay
		Organic	OL	Organic Silt or Clay; Organic Silt or Clay with Sand or Gravel; Sandy or Gravelly Organic Silt or Clay
	Silts and Clays *(liquid limit 50 or more)*	Inorganic	MH	Elastic Silt; Elastic Silt with Sand or Gravel; Sandy or Gravelly Elastic Silt
			CH	Fat Clay; Fat Clay with Sand or Gravel; Sandy or Gravelly Fat Clay
		Organic	OH	Organic Silt or Clay; Organic Silt or Clay with Sand or Gravel; Sandy or Gravelly Organic Silt or Clay
HIGHLY-ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor		PT	Peat or other highly organic soils (see ASTM D4427)

NOTE: No. 4 size = 4.75 mm = 0.187 in.; No. 200 size = 0.075 mm = 0.003 in.

NOTES

1. Dual symbols *(symbols separated by a hyphen, i.e., SP-SM, Sand with Silt)* are used for soils with between 5% and 12% fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart. Graphics shown on the logs for these soil types are a combination of the two graphic symbols (e.g., SP and SM).

2. Borderline symbols *(symbols separated by a slash, i.e., CL/ML, Lean Clay to Silt; SP-SM/SM, Sand with Silt to Silty Sand)* indicate that the soil properties are close to the defining boundary between two groups.

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SOIL DESCRIPTION AND LOG KEY

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FIG. A1
Sheet 2 of 3

GRADATION TERMS

Poorly Graded	Narrow range of grain sizes present or, within the range of grain sizes present, one or more sizes are missing (Gap Graded). Meets criteria in ASTM D2487, if tested.
Well-Graded	Full range and even distribution of grain sizes present. Meets criteria in ASTM D2487, if tested.

CEMENTATION TERMS[1]

Weak	Crumbles or breaks with handling or slight finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

PLASTICITY[2]

DESCRIPTION	VISUAL-MANUAL CRITERIA	APPROX. PLASITICTY INDEX RANGE
Nonplastic	A 1/8-in. thread cannot be rolled at any water content.	< 4
Low	A thread can barely be rolled and a lump cannot be formed when drier than the plastic limit.	4 to 10
Medium	A thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. A lump crumbles when drier than the plastic limit.	10 to 20
High	It take considerable time rolling and kneading to reach the plastic limit. A thread can be rerolled several times after reaching the plastic limit. A lump can be formed without crumbling when drier than the plastic limit.	> 20

ADDITIONAL TERMS

Mottled	Irregular patches of different colors.
Bioturbated	Soil disturbance or mixing by plants or animals.
Diamict	Nonsorted sediment; sand and gravel in silt and/or clay matrix.
Cuttings	Material brought to surface by drilling.
Slough	Material that caved from sides of borehole.
Sheared	Disturbed texture, mix of strengths.

PARTICLE ANGULARITY AND SHAPE TERMS[1]

Angular	Sharp edges and unpolished planar surfaces.
Subangular	Similar to angular, but with rounded edges.
Subrounded	Nearly planar sides with well-rounded edges.
Rounded	Smoothly curved sides with no edges.
Flat	Width/thickness ratio > 3.
Elongated	Length/width ratio > 3.

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ACRONYMS AND ABBREVIATIONS

ATD	At Time of Drilling
Diam.	Diameter
Elev.	Elevation
ft.	Feet
FeO	Iron Oxide
gal.	Gallons
Horiz.	Horizontal
HSA	Hollow Stem Auger
I.D.	Inside Diameter
in.	Inches
lbs.	Pounds
MgO	Magnesium Oxide
mm	Millimeter
MnO	Manganese Oxide
NA	Not Applicable or Not Available
NP	Nonplastic
O.D.	Outside Diameter
OW	Observation Well
pcf	Pounds per Cubic Foot
PID	Photo-Ionization Detector
PMT	Pressuremeter Test
ppm	Parts per Million
psi	Pounds per Square Inch
PVC	Polyvinyl Chloride
rpm	Rotations per Minute
SPT	Standard Penetration Test
USCS	Unified Soil Classification System
q_u	Unconfined Compressive Strength
VWP	Vibrating Wire Piezometer
Vert.	Vertical
WOH	Weight of Hammer
WOR	Weight of Rods
Wt.	Weight

STRUCTURE TERMS[1]

Interbedded	Alternating layers of varying material or color with layers at least 1/4-inch thick; singular: bed.
Laminated	Alternating layers of varying material or color with layers less than 1/4-inch thick; singular: lamination.
Fissured	Breaks along definite planes or fractures with little resistance.
Slickensided	Fracture planes appear polished or glossy; sometimes striated.
Blocky	Cohesive soil that can be broken down into small angular lumps that resist further breakdown.
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay.
Homogeneous	Same color and appearance throughout.

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SOIL DESCRIPTION AND LOG KEY

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FIG. A1
Sheet 3 of 3

Total Depth:	*9.5 ft.*	Northing:	~	Drilling Method:		Hole Diam.:	~
Top Elevation:	~	Easting:	~	Drilling Company:	*Western States*	Rod Type:	~
Vert. Datum:		Station:	~	Drill Rig Equipment:	*backhoe*	Hammer Type:	~
Horiz. Datum:		Offset:	~	Other Comments:			

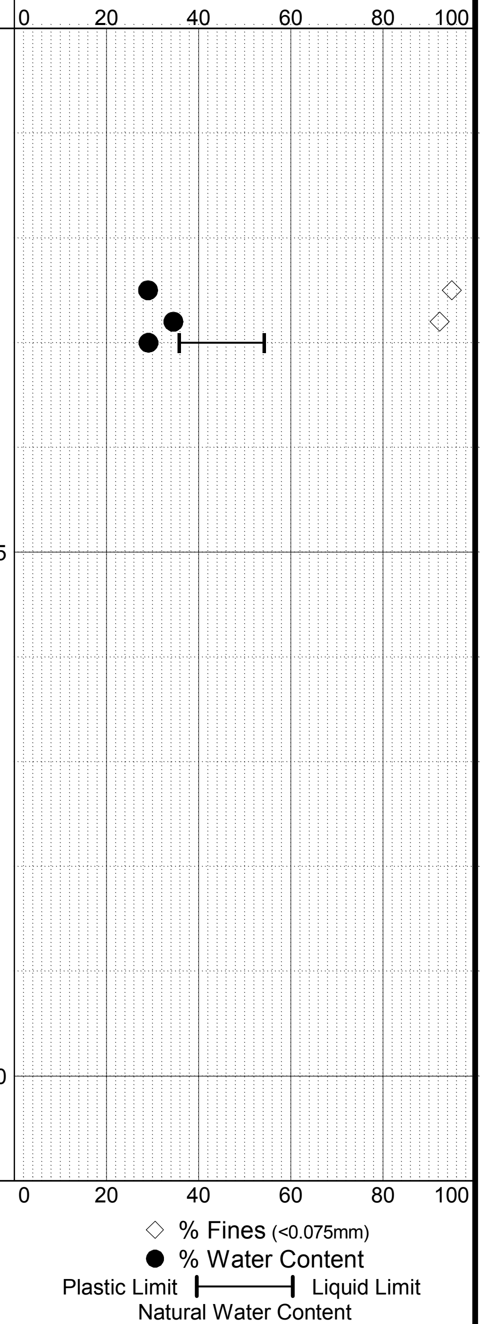
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

SOIL DESCRIPTION	*Elev.* Depth (ft.)	Symbol	Samples	Ground Water	Depth, ft.
Stiff to very stiff, gray-brown, *Elastic Silt (MH)*; moist; <10% fine to coarse, subrounded sand composed of decomposed basalt; medium plasticity; little to some organics in upper 1.0 ft. Grades to gray-yellow at 1.0 ft. Few rootlets from 1.0 to 2.0 ft. **COLLUVIUM**			S-1, S-2		
Very stiff, red-brown, *Elastic Silt (MH)*; moist; <10% fine sand; medium plasticity; relict joint surfaces with black staining. **RESIDUAL SOIL**	4.5		S-3, S-4	Not observed	5
Completed - August 15, 2013	9.5				10

PENETRATION RESISTANCE, N (blows/ft.)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



LEGEND

* Sample Not Recovered

G Grab Sample

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. Group symbol is based on visual-manual identification and selected lab testing.
4. The hole location and elevation should be considered approximate.

1485 Rosemont Subdivision
West Linn, Oregon

LOG OF TEST PIT TP-1

August 2013 24-1-03764-001

SHANNON & WILSON, INC.
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FIG. A2

REV 3

Log: AAH Rev: Typ: MAS

MASTER_LOG_E 24-1-03764.GPJ SHAN_WIL.GDT 8/28/13

Total Depth:	*9 ft.*	Northing:	~	Drilling Method:		Hole Diam.:	~
Top Elevation:	~	Easting:	~	Drilling Company:	*Western States*	Rod Type:	~
Vert. Datum:		Station:	~	Drill Rig Equipment:	*backhoe*	Hammer Type:	~
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

SOIL DESCRIPTION	*Elev.* Depth (ft.)	Symbol	Samples	Ground Water	Depth, ft.
Medium stiff, brown, *Lean Clay* to *Silt with Sand (CL/ML)*; dry to moist; fine to coarse, subrounded to subangular sand; low to medium plasticity; few to little organics. **FILL** Broken glass bottles at 1.8 ft.			S-1 (G)		
Stiff to very stiff, red-brown to yellow-brown, *Elastic Silt (MH)*; moist; <10% fine to coarse, subrounded sand; medium plasticity. **COLLUVIUM**	2.0		S-2 (G)	Not observed	
Very stiff, red-brown and gray mottled, *Elastic Silt (MH)*; moist; <10% fine sand; medium plasticity; remnant black joint staining. **RESIDUAL SOIL**	4.5		S-3 (G)		5
DECOMPOSED BASALT: very low strength (R1); dark gray with light gray vesicle infilling and red and white joint staining; slight to moderately vesicular; closely jointed. **DECOMPOSED COLUMBIA RIVER BASALT**	8.4		S-4 (G)		
Completed - August 15, 2013	9.0				10

PENETRATION RESISTANCE, N (blows/ft.)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ├──┤ Liquid Limit

Natural Water Content

LEGEND

* Sample Not Recovered

(G) Grab Sample

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. Group symbol is based on visual-manual identification and selected lab testing.
4. The hole location and elevation should be considered approximate.

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LOG OF TEST PIT TP-2

August 2013 24-1-03764-001

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FIG. A3

REV 3

MASTER_LOG_E 24-1-03764.GPJ SHAN_WIL.GDT 8/28/13 Log: AAH Rev: Typ: MAS

Total Depth:	8.5 ft.	Northing:	~	Drilling Method:		Hole Diam.:	~
Top Elevation:	~	Easting:	~	Drilling Company:	Western States	Rod Type:	~
Vert. Datum:		Station:	~	Drill Rig Equipment:	backhoe	Hammer Type:	~
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.*	Elev. Depth (ft.)	Symbol	Samples	Ground Water	Depth, ft.
Stiff to very stiff, gray-brown grading to red-brown, *Elastic Silt (MH)*; moist; <10% fine to coarse, rounded sand; medium plasticity; 10%-15% organics and roots from 0 to 1.5 ft. <5% rootlets from 1.5 to 4.0 ft. **COLLUVIUM**			S-1 G S-2 G	Not observed	5
Very stiff to hard, red-brown, *Elastic Silt (MH)*; moist; <10% fine to coarse, subrounded sand; medium plasticity; with remnant black joint staining and some light gray color. **RESIDUAL SOIL**	6.0		S-3 G		
DECOMPOSED BASALT: very low to low strength (R1-R2); light gray and red-brown; fine grained; closely spaced, rough, planar joints with black staining; highly weathered. **DECOMPOSED COLUMBIA RIVER BASALT**	8.0 8.5		S-4 G		10
Completed - August 15, 2013					

PENETRATION RESISTANCE, N (blows/ft.)
▲ Hammer Wt. & Drop: 140 lbs / 30 inches
0 20 40 60 80 100

Plastic Limit ├──┤ Liquid Limit
Natural Water Content

LEGEND
* Sample Not Recovered
G Grab Sample

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. Group symbol is based on visual-manual identification and selected lab testing.
4. The hole location and elevation should be considered approximate.

1485 Rosemont Subdivision
West Linn, Oregon

LOG OF TEST PIT TP-3

August 2013 24-1-03764-001

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FIG. A4

REV 3

MASTER_LOG_E 24-1-03764.GPJ SHAN_WIL.GDT 8/28/13 Log: AAH Rev: Typ: MAS

Total Depth:	9 ft.	Northing:	~	Drilling Method:		Hole Diam.:	~
Top Elevation:	~	Easting:	~	Drilling Company:	Western States	Rod Type:	~
Vert. Datum:		Station:	~	Drill Rig Equipment:	backhoe	Hammer Type:	~
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.*	*Elev.* Depth (ft.)	Symbol	Samples	Ground Water	Depth, ft.
Stiff to very stiff, red-brown, *Elastic Silt (MH)*; moist; <10% fine sand; medium plasticity; 15% organics and roots from 0 to 2.0 ft. **COLLUVIUM** 5%-10% rootlets from 2.0 to 4.0 ft.			S-1 (G) S-2 (G)	Not observed	
Very stiff, red-brown, *Elastic Silt with Cobbles and Boulders (MH)*; moist; ~30% cobbles and ~10% boulders up to 1.1 ft. diameter, subrounded, basaltic; medium plasticity; up to about medium high strength (R4). **RESIDUAL SOIL**	5.0				5
DECOMPOSED BASALT: very low to low strength (R1-R2); gray and red-brown; fine grained; closely spaced, rough, planar joints with black staining; highly weathered. **DECOMPOSED COLUMBIA RIVER BASALT**	6.0		S-3 (G) S-4 (G)		
Completed - August 15, 2013	9.0				10

PENETRATION RESISTANCE, N (blows/ft.)
▲ Hammer Wt. & Drop: 140 lbs / 30 inches

0 20 40 60 80 100

0 20 40 60 80 100

Plastic Limit ├──┤ Liquid Limit
Natural Water Content

LEGEND
* Sample Not Recovered
G Grab Sample

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. Group symbol is based on visual-manual identification and selected lab testing.
4. The hole location and elevation should be considered approximate.

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West Linn, Oregon

LOG OF TEST PIT TP-4

August 2013 24-1-03764-001

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FIG. A5

REV 3

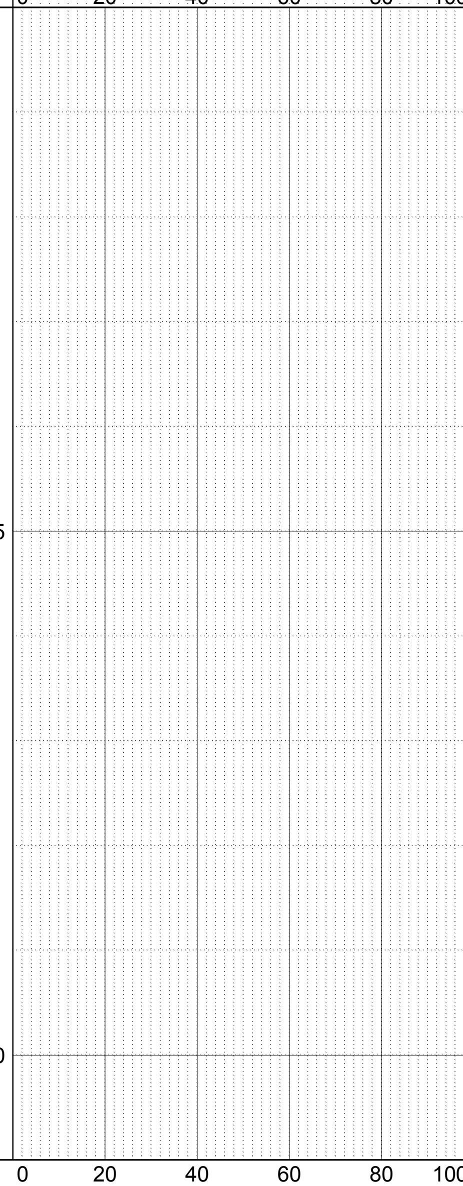
MASTER_LOG_E 24-1-03764.GPJ SHAN_WIL.GDT 8/28/13 Log: AAH Rev: Typ: MAS

Total Depth:	7 ft.	Northing:	~	Drilling Method:		Hole Diam.:	~
Top Elevation:	~	Easting:	~	Drilling Company:	*Owner's Sub*	Rod Type:	~
Vert. Datum:		Station:	~	Drill Rig Equipment:	*backhoe*	Hammer Type:	~
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

PENETRATION RESISTANCE, N (blows/ft.)
▲ Hammer Wt. & Drop: *140 lbs / 30 inches*

Soil Description	Elev. Depth (ft.)	Samples	Ground Water	Depth, ft.
Medium stiff to very stiff, red-brown, *Silt with Sand* to *Elastic Silt (ML/MH)*; dry to moist; fine, subangular sand; low to medium plasticity; little to some roots in upper 1.5 ft. <10% fine sand; few rootlets after 1.5 ft. **COLLUVIUM**		S-1 (G)	Not observed	
Very stiff, red-brown and gray, *Elastic Silt with Sand (MH)*; moist; fine to medium, subangular sand; medium plasticity; remnant black joint staining. 6- to 8-in.-diam. large cobbles at 6.0 ft. 3- to 8-in.-diam. small and large cobbles at 6.5 ft. **RESIDUAL SOIL**	5.0 6.5	S-2 (G)		5
DECOMPOSED BASALT: very low to low strength (R1-R2), tan and dark gray; closely spaced joints with black staining; highly weathered. **DECOMPOSED COLUMBIA RIVER BASALT**	7.0			
Completed - August 27, 2013				10



LEGEND
* Sample Not Recovered
G Grab Sample

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. Group symbol is based on visual-manual identification and selected lab testing.
4. The hole location and elevation should be considered approximate.

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West Linn, Oregon

LOG OF TEST PIT TP-5

August 2013 24-1-03764-001

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FIG. A6

REV 3

Typ: MAS Rev: Log: RAP

MASTER_LOG_E 24-1-03764.GPJ SHAN_WIL.GDT 8/28/13

Total Depth:	8 ft.	Northing:	~	Drilling Method:		Hole Diam.:	~
Top Elevation:	~	Easting:	~	Drilling Company:	Owner's Sub	Rod Type:	~
Vert. Datum:		Station:	~	Drill Rig Equipment:	backhoe	Hammer Type:	~
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

PENETRATION RESISTANCE, N (blows/ft.)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*

Soil Description	Elev. Depth (ft.)	Symbol	Samples	Ground Water	Depth, ft.
Medium stiff to stiff, brown to red-brown, *Silt* to *Elastic Silt (ML/MH)*; moist; <10% sand; low to medium plasticity; few roots and rootlets from 0 to 1.0 ft.; few to little black staining within large soil peds. Trace roots after 1.0 ft. **COLLUVIUM**			S-1 G	Not observed	
Stiff to very stiff, red-brown, red-yellow, and black, *Silt* to *Elastic Silt with Sand (ML/MH)*; moist; trace to few cobbles and boulders; ~10% to 15% subangular sand; medium plasticity; relict rock texture with black and orange staining. **RESIDUAL SOIL**	5.0		S-2 G		5
Completed - August 27, 2013	8.0				10

0 20 40 60 80 100

Log: RAP Rev: Typ: MAS

LEGEND

* Sample Not Recovered

G Grab Sample

Plastic Limit ├──┤ Liquid Limit

Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. Group symbol is based on visual-manual identification and selected lab testing.
4. The hole location and elevation should be considered approximate.

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West Linn, Oregon

LOG OF TEST PIT TP-6

August 2013 24-1-03764-001

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FIG. A7

MASTER_LOG_E 24-1-03764.GPJ SHAN_WIL.GDT 8/28/13

REV 3

Total Depth:	*7 ft.*	Northing:	~	Drilling Method:		Hole Diam.:	~
Top Elevation:	~	Easting:	~	Drilling Company:	*Owner's Sub*	Rod Type:	~
Vert. Datum:		Station:	~	Drill Rig Equipment:	*backhoe*	Hammer Type:	~
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

PENETRATION RESISTANCE, N (blows/ft.)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*

SOIL DESCRIPTION	Elev. Depth (ft.)	Symbol	Samples	Ground Water	Depth, ft.
Medium stiff to stiff, brown to red-brown, *Silt* to *Elastic Silt (ML/MH)*; moist; <10% fine, subangular sand; medium plasticity; trace roots. **COLLUVIUM**			S-1 G	Not observed	
Stiff to very stiff, red-brown and gray, *Elastic Silt (MH)*; moist; <10% fine, subangular sand; medium plasticity; residual rock texture with black and red staining. 1-ft.-diam. boulder at 5.0 ft. **RESIDUAL SOIL** Few to little cobbles after 6.0 ft.	4.5		S-2 G		5
Completed - August 27, 2013	7.0				10

0 20 40 60 80 100

Log: RAP Rev: Typ: MAS

LEGEND

* Sample Not Recovered

G Grab Sample

Plastic Limit ├──┤ Liquid Limit

Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. Group symbol is based on visual-manual identification and selected lab testing.
4. The hole location and elevation should be considered approximate.

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West Linn, Oregon

LOG OF TEST PIT TP-7

August 2013 24-1-03764-001

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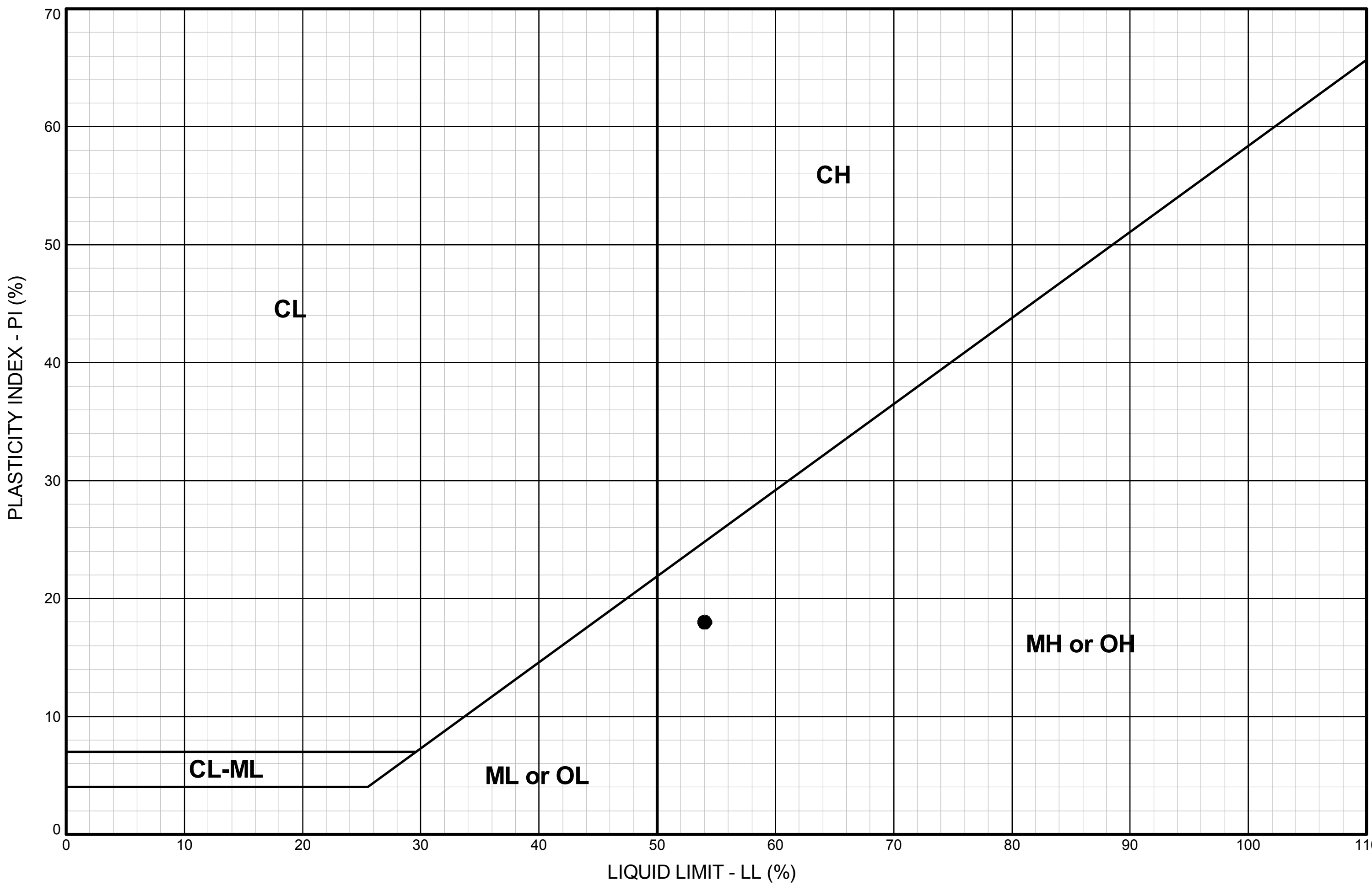
FIG. A8

MASTER_LOG_E 24-1-03764.GPJ SHAN_WIL.GDT 8/28/13

REV 3



NOTES

1) Atterberg limits tests were performed in general accordance with ASTM D4318 unless otherwise noted in the report.

2) Plasticity adjectives used in sample descriptions correspond to plasticity index as follows:
- Nonplastic (0 - 4%)
- Low Plasticity (>4 - 10%)
- Medium Plasticity (>10 - 20%)
- High Plasticity (>20 - 40%)
- Very High Plasticity (>40%)

BORING AND SAMPLE NO.	DEPTH (feet)	GROUP SYMBOL	SAMPLE DESCRIPTION	LL %	PL %	PI %	NAT. W.C. %	FINES %
● TP-1, S-2	3.0	MH	Elastic SILT, trace sand	54	36	18	29	

1485 Rosemont Subdivision
West Linn, Oregon

ATTERBERG LIMITS RESULTS

August 2013 24-1-03764-001

SHANNON & WILSON, INC.
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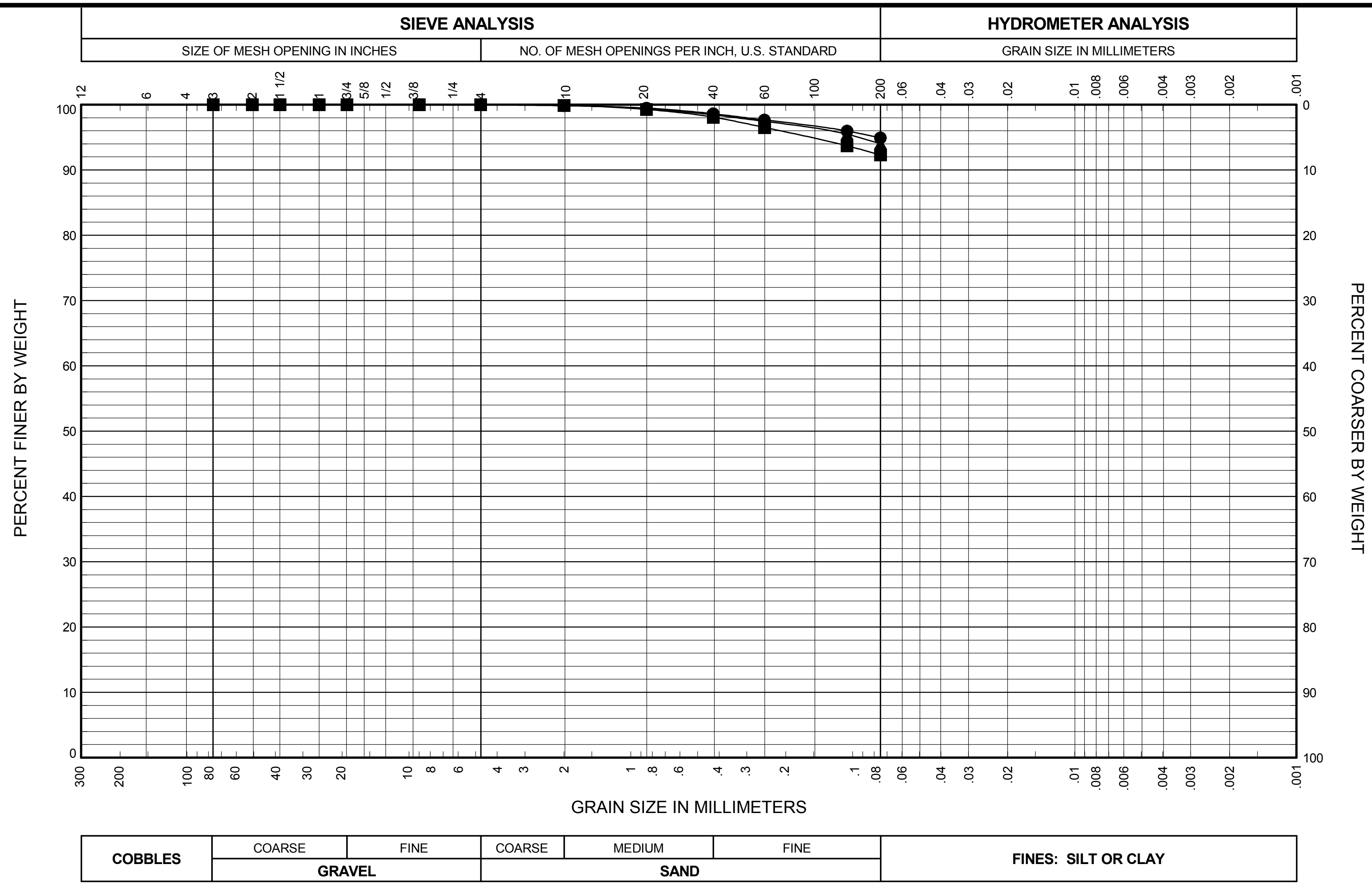
FIG. A9

ATT MAIN 24-1-03764.GPJ SHAN WIL.GDT 8/28/13

NOTES:
1) Sieve and hydrometer analyses were performed in general accordance with ASTM D422 unless otherwise noted in the report.
2) Particles retained on the 3-inch (76.2 mm) sieve are noted in the sample descriptions, but are not included in sieve analyses unless otherwise noted in the report.



BORING AND SAMPLE NO.	DEPTH (feet)	GROUP SYMBOL	SAMPLE DESCRIPTION	GRAVEL %	SAND %	FINES %	NAT. W.C. %	DRY DENSITY PCF
● TP-1,	2.5	MH	Elastic SILT, trace sand	0	5	95	29	
■ TP-1,	2.8	MH	Elastic SILT, trace sand	0	8	92	35	
▲ TP-2,	2.7	MH	Elastic SILT, trace sand	0	6	94	36	

1485 Rosemont Subdivision
West Linn, Oregon

GRAIN SIZE DISTRIBUTION

August 2013 24-1-03764-001

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FIG. A10

ATTACHMENT B

INFILTRATION TESTING RESULTS

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Location: 1485 Rosemont Road, West Linn, OR	Date: 8/15/2013 Job Number: 24-1-03764-001	Infiltration Test Number: Infiltration Test INT-1
Depth to bottom of hole: 2.5 ft	Dimension of casing: 0.5'	Test Method: Stand Pipe
Tester's Name: AMP Tester's Company: S&W		

Depth (feet):	Soil Texture:
2.5	Silt

Time	Time Interval (minutes)	Measurement (feet)	Head (feet)	Drop in Water Level (feet)	Infiltration rate (inches per hour)	Remarks
1203	--	0.70	1.00	--	--	Trial 1
1211	8	0.72	0.99	0.02	1.8	
1222	11	0.75	0.97	0.03	2.0	
1233	10	0.78	0.94	0.03	2.2	
1244	11	0.81	0.91	0.03	2.0	
1254	10	0.84	0.88	0.03	2.2	
1306	11	0.86	0.85	0.02	1.3	
1332	--	0.70	0.92	--		Trial 2
1405	33	0.78	0.96	0.08	1.7	
1444	39	0.87	0.88	0.09	1.7	
1506	--	0.69	0.92	--		Trial 3
1538	32	0.78	0.97	0.09	2.0	
1608	30	0.86	0.88	0.08	1.9	

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Location: 1485 Rosemont Road, West Linn, OR	Date: 8/15/2013 Job Number: 24-1-03764-001	Infiltration Test Number: Infiltration Test INT-2
Depth to bottom of hole: 2.8 ft	Dimension of casing: 0.5'	Test Method: Stand Pipe
Tester's Name: AMP Tester's Company: S&W		

Depth (feet):	Soil Texture:
2.8	Silt

Time	Time Interval (minutes)	Measurement (feet)	Head (feet)	Drop in Water Level (feet)	Infiltration rate (inches per hour)	Remarks
1159	--	1.34	1.00	--	--	Trial 1
1210	11	1.41	0.97	0.07	4.6	
1221	11	1.48	0.90	0.07	4.6	
1231	10	1.53	0.84	0.05	3.6	
1242	11	1.59	0.78	0.06	3.9	
1253	10	1.63	0.73	0.04	2.9	
1304	11	1.69	0.68	0.06	3.9	
1329	--	1.34	0.83	--		Trial 2
1401	32	1.50	0.92	0.16	3.6	
1441	40	1.66	0.76	0.16	2.9	
1507	--	1.34	0.84	--		Trial 3
1537	30	1.48	0.93	0.14	3.4	
1607	30	1.60	0.80	0.12	2.9	

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Location: 1485 Rosemont Road, West Linn, OR	Date: 8/15/2013 Job Number: 24-1-03764-001	Infiltration Test Number: Infiltration Test INT-3
Depth to bottom of hole: 2.7 ft	Dimension of casing: 0.5'	Test Method: Stand Pipe
Tester's Name: AMP Tester's Company: S&W		

Depth (feet):	Soil Texture:
2.7	Silt

Time	Time Interval (minutes)	Measurement (feet)	Head (feet)	Drop in Water Level (feet)	Infiltration rate (inches per hour)	Remarks
1228	--	0.72	1.00	--	--	Trial 1
1239	11	0.82	0.95	0.10	6.5	
1249	10	0.88	0.87	0.06	4.3	
1259	9	0.94	0.81	0.06	4.8	
1309	10	1.00	0.75	0.06	4.3	
1319	11	1.06	0.69	0.06	3.9	
1324	--	0.72	0.83	--	--	Trial 2
1358	35	0.93	0.90	0.21	4.3	
1435	37	1.11	0.70	0.18	3.5	
1455	--	0.71	0.81	--	--	Trial 3
1534	39	0.90	0.92	0.19	3.5	
1605	31	1.02	0.76	0.12	2.8	

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GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Location: 1485 Rosemont Road, West Linn, OR	Date: 8/27/2013 Job Number: 24-1-03764-001	Infiltration Test Number: Infiltration Test INT-4
Depth to bottom of hole: 2.8 ft	Dimension of casing: 0.5'	Test Method: Stand Pipe
Tester's Name: AMP Tester's Company: S&W		

Depth (feet):	Soil Texture:
2.8	Silt with sand

Time	Time Interval (minutes)	Measurement (feet)	Head (feet)	Drop in Water Level (feet)	Infiltration rate (inches per hour)	Remarks
1330	--	1.15	0.45	--	--	Trial 1
1341	11	1.19	0.41	0.04	2.6	
1353	12	1.23	0.37	0.04	2.4	
1359	6	1.24	0.36	0.01	1.2	
1409	10	1.28	0.32	0.04	2.9	
1418	9	1.32	0.28	0.04	3.2	
1426	8	1.34	0.26	0.02	1.8	
1428	--	1.14	0.46	--	--	Trial 2
1440	12	1.19	0.41	0.05	3.0	
1449	9	1.21	0.39	0.02	1.6	
1458	9	1.24	0.36	0.03	2.4	
1514	16	1.29	0.31	0.05	2.3	
1529	15	1.34	0.26	0.05	2.4	
1531	--	1.15	0.45	--	--	Trial 3
1545	14	1.19	0.41	0.04	2.1	
1552	15	1.22	0.38	0.03	1.4	
1607	15	1.26	0.34	0.04	1.9	

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Location: 1485 Rosemont Road, West Linn, OR	Date: 8/27/2013 Job Number: 24-1-03764-001	Infiltration Test Number: Infiltration Test INT-5
Depth to bottom of hole: 2.6 ft	Dimension of casing: 0.5'	Test Method: Stand Pipe
Tester's Name: AMP Tester's Company: S&W		

Depth (feet):	Soil Texture:
2.6	Silt

Time	Time Interval (minutes)	Measurement (feet)	Head (feet)	Drop in Water Level (feet)	Infiltration rate (inches per hour)	Remarks
1335	--	1.85	0.55	--	--	Trial 1
1345	10	1.88	0.52	0.03	2.2	
1355	10	1.92	0.48	0.04	2.9	
1403	8	1.92	0.48	0.00	0.0	
1412	9	1.96	0.44	0.04	3.2	
1422	10	1.99	0.41	0.03	2.2	
1431	9	2.01	0.39	0.02	1.6	
1434	--	1.84	0.56	--	--	Trial 2
1444	10	1.88	0.52	0.04	2.9	
1452	8	1.90	0.50	0.02	1.8	
1503	26	1.93	0.47	0.03	0.8	
1518	15	1.99	0.41	0.06	2.9	
1534	16	2.03	0.37	0.04	1.8	
1536	--	1.82	0.58	--	--	Trial 3
1548	12	1.85	0.55	0.03	1.8	
1557	9	1.89	0.51	0.04	3.2	
1612	20	1.94	0.46	0.05	1.8	
1616	4	1.95	0.45	0.01	1.8	
1636	20	2.00	0.40	0.05	1.8	

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Location: 1485 Rosemont Road, West Linn, OR	Date: 8/27/2013 Job Number: 24-1-03764-001	Infiltration Test Number: Infiltration Test INT-6
Depth to bottom of hole: 2.8 ft	Dimension of casing: 0.5'	Test Method: Stand Pipe
Tester's Name: AMP Tester's Company: S&W		

Depth (feet):	Soil Texture:
2.8	Silt

Time	Time Interval (minutes)	Measurement (feet)	Head (feet)	Drop in Water Level (feet)	Infiltration rate (inches per hour)	Remarks
1338	--	1.12	0.53	--	--	Trial 1
1347	9	1.15	0.50	0.03	2.4	
1357	10	1.21	0.44	0.06	4.3	
1404	7	1.25	0.40	0.04	4.1	
1414	10	1.29	0.36	0.04	2.9	
1423	9	1.32	0.33	0.03	2.4	
1436	13	1.37	0.28	0.05	2.8	
1437	--	1.22	0.43	--	--	Trial 2
1445	8	1.26	0.39	0.04	3.6	
1453	8	1.30	0.35	0.04	3.6	
1508	15	1.36	0.29	0.06	2.9	
1524	16	1.42	0.23	0.06	2.7	
1538	14	1.48	0.17	0.06	3.1	
1538	--	1.24	0.41	--	--	Trial 3
1549	11	1.29	0.36	0.05	3.3	
1558	9	1.32	0.33	0.03	2.4	
1619	21	1.41	0.24	0.09	3.1	

APPENDIX C

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL/ENVIRONMENTAL REPORT

Important Information About Your Geotechnical/Environmental Proposal

More construction problems are caused by site subsurface conditions than any other factor. The following suggestions and observations are offered to help you manage your risks.

HAVE REALISTIC EXPECTATIONS.

If you have never before dealt with geotechnical or environmental issues, you should recognize that site exploration identifies actual subsurface conditions at those points where samples are taken, at the time they are taken. The data derived are extrapolated by the consultant, who then applies judgment to render an opinion about overall subsurface conditions; their reaction to construction activity; appropriate design of foundations, slopes, impoundments, and recovery wells; and other construction and/or remediation elements. Even under optimal circumstances, actual conditions may differ from those inferred to exist, because no consultant, no matter how qualified, and no subsurface program, no matter how comprehensive, can reveal what is hidden by earth, rock, and time.

DEVELOP THE SUBSURFACE EXPLORATION PLAN WITH CARE.

The nature of subsurface explorations—the types, quantities, and locations of procedures used—in large measure determines the effectiveness of the geotechnical/environmental report and the design based upon it. The more comprehensive a subsurface exploration and testing program, the more information it provides to the consultant, helping reduce the risk of unanticipated conditions and the attendant risk of costly delays and disputes. Even the cost of subsurface construction may be lowered.

Developing a proper subsurface exploration plan is a basic element of geotechnical/environmental design, which should be accomplished jointly by the consultant and the client (or designated professional representatives). This helps the parties involved recognize mutual concerns and makes the client aware of the technical options available. Clients who develop a subsurface exploration plan without the involvement and concurrence of a consultant may be required to assume responsibility and liability for the plan's adequacy.

READ GENERAL CONDITIONS CAREFULLY.

Most consultants include standard general contract conditions in their proposals. One of the general conditions most commonly employed is to limit the consulting firm's liability. Known as a "risk allocation" or "limitation of liability," this approach helps prevent problems at the beginning and establishes a fair and reasonable framework for handling them, should they arise.

Various other elements of general conditions delineate your consultant's responsibilities. These are used to help eliminate confusion and misunderstandings, thereby helping all parties recognize who is responsible for different tasks. In all cases, read your consultant's general conditions carefully, and ask any questions you may have.

HAVE YOUR CONSULTANT WORK WITH OTHER DESIGN PROFESSIONALS.

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a consultant's report. To help avoid misinterpretations, retain your consultant to work with other project design professionals who are affected by the geotechnical/environmental report. This allows a consultant to explain report implications to design professionals affected by them, and to review their plans and specifications so that issues can be dealt with adequately. Although some other design professionals may be familiar with geotechnical/environmental concerns, none knows as much about them as a competent consultant.

OBTAIN CONSTRUCTION MONITORING SERVICES.

Most experienced clients also retain their consultant to serve during the construction phase of their projects. Involvement during the construction phase is particularly important because this permits the consultant to be on hand quickly to evaluate unanticipated conditions, to conduct additional tests if required, and when necessary, to recommend alternative solutions to problems. The consultant can also monitor the geotechnical/environmental work performed by contractors. It is essential to recognize that the construction recommendations included in a report are preliminary, because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site.

Because actual subsurface conditions can be discerned only during earthwork and/or drilling, design consultants need to observe those conditions in order to provide their recommendations. Only the consultant who prepares the report is fully familiar with the background information needed to determine whether or not the report's recommendations are valid. The consultant submitting the report cannot assume responsibility or liability for the adequacy of preliminary recommendations if another party is retained to observe construction.

REALIZE THAT ENVIRONMENTAL ISSUES MAY NOT HAVE BEEN ADDRESSED.

If you have requested only a geotechnical engineering proposal, it will not include services needed to evaluate the likelihood of contamination by hazardous materials or other pollutants. Given the liabilities involved, it is prudent practice to always have a site reviewed from an environmental viewpoint. A consultant cannot be responsible for failing to detect contaminants when the services needed to perform that function are not being provided.

ONE OF THE OBLIGATIONS OF YOUR CONSULTANT IS TO PROTECT THE SAFETY, PROPERTY, AND WELFARE OF THE PUBLIC.

A geotechnical/environmental investigation will sometimes disclose the existence of conditions that may endanger the safety, health, property, or welfare of the public. Your consultant may be obligated under rules of professional conduct, or statutory or common law, to notify you and others of these conditions.

RELY ON YOUR CONSULTANT FOR ADDITIONAL ASSISTANCE.

Your consulting firm is familiar with several techniques and approaches that can be used to help reduce risk exposure for all parties to a construction project, from design through construction. Ask your consultant not only about geotechnical and environmental issues, but others as well, to learn about approaches that may be of genuine benefit.

The preceding paragraphs are based on information provided by the
ASFE/Association of Engineering Firms Practicing in the Geosciences, Silver Spring, Maryland