
Exhibit D
Preliminary Stormwater
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EXHIBIT D

Preliminary Storm Drainage Design and Calculations For the Deer Meadows Subdivision

May, 2021

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RENEWAL DATE: 12/31/2022

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PURPOSE:

The purpose of this analysis is to:

- Describe existing and proposed site conditions.
- Provide detention calculations for the 2-yr, 5-yr, 10-yr, and 25-yr storm events.
- Provide water quality calculations.

PROJECT LOCATION AND DESCRIPTION:

The project site is located on the south side of the Mount Hood Highway in Sandy, Oregon. The site includes tax lots 900 and 1000. The +/- 15.91-acre site consists of grassy fields, and plentiful tree cover. The land is generally sloped to the north and west with an average slope of about 8%. A Vicinity Map and Site Layout (with proposed storm sewer layout) can be found in Appendix A.

PROPOSED IMPROVEMENTS

The proposed 32-lot Deer Meadows Subdivision project will consist of 29 single-family residential lots ranging from 5,500 SF to 32,189 SF. The project also includes a single split-zoned R-1/R-2 lot 7,076 SF in size, and a single R-2 lot 9,083 SF in size. The final lot is split zoned R-2/C-3 and is 320,409 SF in size. The split-zoned R-2/C-3 lot will be developed in the future under a design review process and will provide it's own stormwater detention/water quality system onsite. The site improvements will include streets, curbs, sidewalks, utilities, etc.

New storm sewer pipes, manholes, and catch basins will be installed to convey storm water to a public detention pond located in Tract C. A new water quality manhole will be installed downstream of the detention pond (See Site Layout – Appendix A).

The pond will be sized to detain the new public streets and the new homes to be built on lots 1 through 31. Lot 32 will provide lot-level detention and water quality systems at the time of future development. Lot 32 will drain through the detention pond, and the pond will be sized to accommodate these anticipated flows. The existing upland drainage on the site will be intercepted and flow through the new storm detention pond.

Upstream and downstream analyses will be performed as needed at the time of final engineering.

HYDROGRAPH PARAMETERS:

Rainfall
The rainfall distribution numbers below were taken from the City of Sandy Stormwater Website: https://www.ci.sandy.or.us/publicworks/page/stormwater

2 year, 24 hr. rainfall = 3.5"
5 year, 24 hr. rainfall = 4.5"
10 year, 24 hr. rainfall = 4.8"
25 year, 24 hr. rainfall = 5.5"

Soils
The soil data for this site is from *Soil Survey of Clackamas County, Oregon* published by the United Stated Department of Agriculture (USDA). The post-development soil is assumed to be the same as pre-development.

Soil Type: 15B, Cazadero silty clay loam. Hydrologic Group "C"
15C, Cazadero silty clay loam. Hydrologic Group "C"
24B, Cottrell silty clay loam. Hydrologic Group "C"

(See next section and Portland SWMM/Sewer and Drainage Facilities Design Manual for CN's)

Areas and Curve Numbers
Drainage basin areas were determined using a topographic map drafted in AutoCAD. See the Pre-Developed Plan and Developed Plan in Appendix A.

The impervious area for these post-developed basins includes the proposed roofs from lots 1 through 31, streets, sidewalks, driveways, and curbs and planters, as well as the un-developed condition of lot 32. See the following tables for a specific breakdown of these areas.

Pre-Development		
Areas	**CN**	**Reference**
Pervious (15.91 acres)	79	Portland SWMM Table A-8. Curve Numbers Type "C" Soils
Impervious (0.00 acres)	98	N/A
Post-Development		
Areas	**CN**	**Land Use Description**
Pervious (11.52 acres)*	76	Portland SDFDM Table 6-5 Non-composite Curve Numbers Lawns with Type "C" Soils, and Table A-8 as above.
Impervious (4.39 acres)**	98	Buildings, AC, Sidewalks, etc.

*Post-Developed Pervious CN: Weighted CN
Undeveloped Type C Soil 7.36 AC: CN = 79
Lawns Type C Soil 4.16 AC: CN = 70
[(7.36AC x 79) + (4.16AC x 70)] / (7.36 + 4.16) = 75.75 = **76.0**

**Refer to Water Quality Design Section for detailed area breakdown.

Time of Concentration
The times of concentrations (Tc), were assumed as follows.

Pre-development T_c= 30.0 minutes
Post-development T_c= 5.0 minutes

Hydrograph Modeling Results
Hydrographs for the site were determined using a spreadsheet based on the King County, Washington Hydrograph Program, version 4.21B, which uses the Santa Barbara Urban Hydrograph (SBUH) method.

DETENTION SIZING RESULTS:

The Post-Development flows were routed through a proposed 3-foot-deep detention pond. The 3-foot-deep detention pond has been designed so that the Post-Developed release rates for the entire site do not exceed the Pre-Developed rates for the 2-year, 5-year, 10-year, and 25-year storm events per the City of Sandy public Works Design Standards. See the Detention System Summary in Appendix B.

Hydrology Table			
Recurrence Interval (years)	**Pre-developed Flows (cfs)**	**Developed Flows (cfs)**	**Proposed Release Rates (cfs)**
2	3.84	7.46	3.73
5	6.37	11.21	6.09
10	7.17	12.39	7.17
25	9.09	15.21	9.09

The required storage volume is 20,016-cubic feet. This can be contained in a 3-foot-deep pond with a bottom area of 5,472 square feet.

Flow Control:

The flow control orifices were designed to release the Post-development Peak-Q's at or below the Pre-developed Peak-Q's.
(See the Detention System Summary - Appendix B)

Orifice Table		
Orifice	**Dia. (inches)**	**Height (feet)**
Bottom	10.72	0.00
Top	weir	weir

WATER QUALITY DESIGN:

CDS Storm Water Treatment Device

A CDS manhole by Contech Stormwater Solutions was designed for water quality for the site - see detail in Appendix B. The impervious area for the site includes AC pavement, sidewalks, and roofs. The impervious area is 4.39-acres.

Proposed asphalt, walks, etc.:	2.26 acres
Roof, Patio, Driveway*:	2.13 acres
Total Impervious Area:	4.39 acres

*40'x60' Building footprint:	2400SF
20'x20' Driveway:	400SF
2-10'x10' Patio:	200SF
Total:	3,000SF X 31 lots = 93,000SF

The flow (Q) from this runoff was calculated using the rational method (Q = CIA)

Where Q = flow (cfs)
C = runoff coefficient = 0.90 pavement and Roofs
I = Intensity = 0.2 inches per hour (Water Quality Design Storm)
A = Impervious Area = 4.39 Acres

Q = 0.90 X 0.2 X 4.39
Q = 0.79 cfs

A Contech Storm Water Treatment Device from the CDS line will be sized to treat the flow from impervious area at the time of final engineering.

CONCLUSIONS:

- The conveyance system for the proposed Deer Meadows Subdivision site has been sized to handle the peak 25-year, 24-hour storm.
- On-site detention has been designed to maintain existing downstream storm water runoff characteristics in accordance with the City of Sandy requirements.
- A CDS Storm Water Treatment Device will be used for water quality.

Appendix A

-Pre-Developed Plan
-Developed Plan

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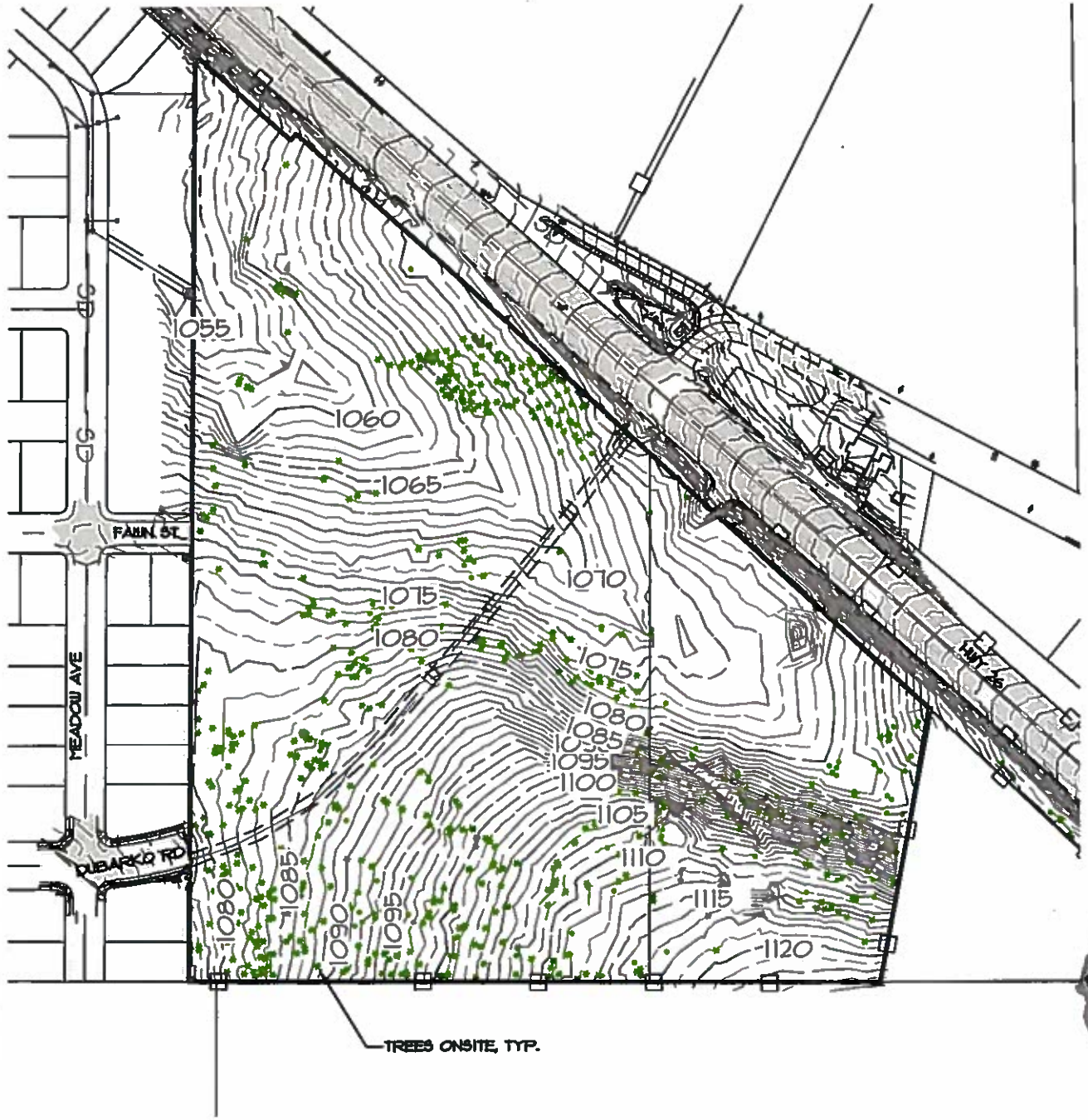
EXISTING CONDITIONS MAP



SCALE : 1" = 200'

0' 100' 200' 400'

REGISTERED PROFESSIONAL ENGINEER
49710
OREGON
JULY 21, 1998
RAY L. MOORE

RENEWAL DATE: 12/31/2022

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P.O. Box 955 Sandy, OR 97055
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19-035-Planning-B.dwg
DATE OF PLOT: 5/21/21

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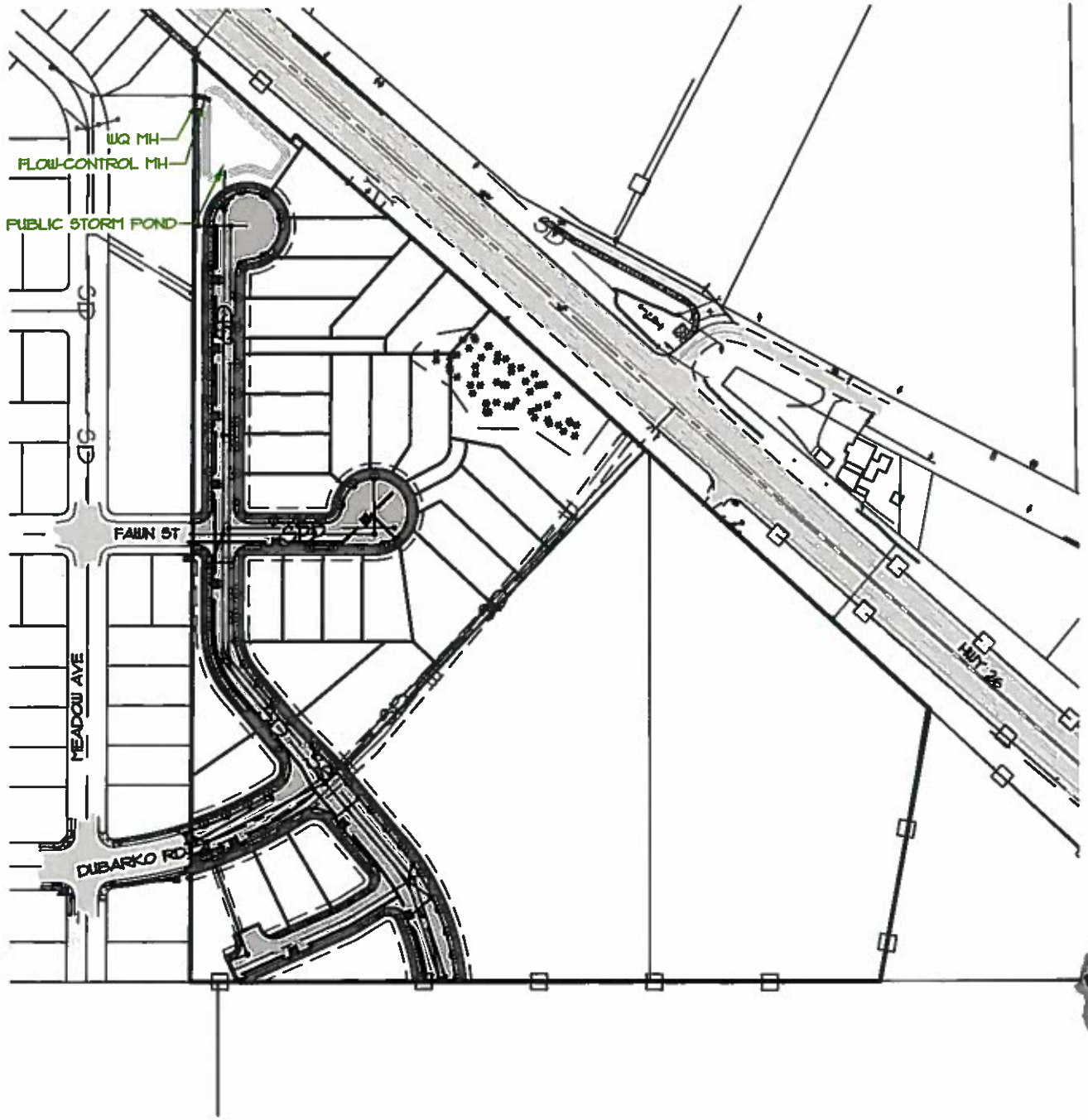
DEVELOPED CONDITIONS MAP



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All County
Est. 1990
Surveyors
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SCALE : 1" = 200'

0' 100' 200' 400'

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Appendix B

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Standard formulas used for the Time of Concentration Calculations

Overland Flow (max 300' total)

$$\frac{(0.42)[(Ns)(L)]^{0.8}}{(P_2)^{0.5}(S_0)^{0.4}}$$

Tc	= time of concentration for less than 300' of travel (minutes)
Ns	= sheet flow Manning's effective roughness coefficient
L	= flow length (ft)
P2	= 2-year, 24 hour rainfall (in)
So	= slope of hydraulic grade line (land slope, ft/ft)

Shallow Concentrated Flow (after initial 300')

$$T = \frac{L}{(60)(k\sqrt{S_0})}$$

T	= travel time for sheet flow (min)
L	= flow length (ft)
So	= slope of hydraulic grade line (land slope, ft/ft)
k	= time of concentration velocity factor (ft/s)

Flow in Swales

Q = (1.486/n) x A x R^2/3 x S^1/2 (Manning's Equation)

Tc	= time of concentration for gutter flow (minutes)
A	= area of flow (sf)
R	= hydraulic radius (ft)
Ls	= side slope
Q	= quantity of flow (ft^3/sec)
V	= average velocity of flow (ft/sec)
L	= length of flow
Ve	= vertical length of side slope
Ho	= horizontal length of side slope
Bw	= base width (in)
D	= depth (in)
S	= slope (ft/ft)
n	= Manning's n

Flow in gutters

$$V = \frac{1.12}{n}(S)^{0.5}(Sx)^{.67}(T)^{0.67}$$

Tc	= time of concentration for gutter flow (minutes)
V	= average velocity of flow (ft/sec)
Q	= quantity of flow (ft^3/sec)
S	= street longitudinal slope (ft/ft)
Sx	= street cross slope (ft/ft)
T	= total width of flow in the gutter (ft)
n	= sheet flow Manning's (pavement = 0.018)
L	= Length of flow (ft)

Flow in pipes

Mannings Equation

Tc	= time of concentration in pipe (minutes)
V	= calculated velocity pipe full (ft/sec)
Q	= quantity of flow (ft^3/sec)
n	= Manning's n
D	= pipe Diameter (in)
S	= slope (ft/ft)
L	= length of pipe

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COEFFICIENTS

Ns = = Manning's coefficient (sheet flow)
n values are for sheet flow only

Design Value	
0.011	Concrete or asphalt
0.010	Bare soil
0.020	Graveled surface
0.020	Bare clay - loam (eroded)
0.150	Grass (short prairie)
0.240	Grass (dense lawn)
0.410	Grass (bermuda)
0.400	Woods (light underbrush)
0.800	Woods (dense underbrush)

k = = time of concentration velocity factor (ft/s)

Design Value	
3	Forest with heavy ground cover and meadows (n=0.10)
5	Brushy ground with some trees (n=0.060)
8	Fallow or cultivation (n=0.040)
9	High grass (n=0.035)
11	Short grass, pasture or lawns (n=0.030)
13	Nearly bare ground (n=0.025)
27	Paved and gravel areas (n=0.012)

n = = Manning's coefficient (channel)

Design Value	
	CONSTRUCTED CHANNELS
	A. Earth, straight and uniform
0.018	Earth (straight and uniform)
0.025	Gravel (straight and uniform)
0.027	Grass (with weeds)
	B. Earth, winding and sluggish
0.025	Earth (no vegetation)
0.030	Grass (some weeds)
0.035	Dense weeds (deep channel)
0.030	Earth (rubble bottom and sides)
0.035	Stony bottom and weedy banks
0.040	Cobble bottom with clean sides
	C. Rock lined
0.035	Smooth and uniform
0.040	Jagged and irregular
	D. Channels not maintained (weeds and brush uncut)
0.050	Dense weeds (high as flow depth)
0.050	Clean bottom (brush on sides)
0.100	Dense brush (high stage)
0.200	Water quality swales (mowed regulary)
	NATURAL STREAMS
0.029	Clean (straight no pools)
0.035	Clean (straight no pools with weeds and stones)
0.039	Clean (winding pools)
0.042	Clean (winding pools weeds and stones)
0.052	Clean (winding pools weeds and large stones)
0.065	Weedy (sluggish with deep pools)
0.112	Very weedy (sluggish with deep pools)

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Project Name: Deer Meadows
Hydrograph Analysis Summary

Job # 19-035
Date: 5/28/2021

Rainfall (year)	Rainfall (inches)
2	3.50
5	4.50
10	4.80
25	5.50
100	0.00

Pre-Developed		
Pervious		
Area =	15.91	acres
CN =	79	na
Impervious		
Area =	0	acres
CN =	98	na
Tc =	30	min
Total A =	15.91	acres

Developed		
Pervious		
Area =	11.52	acres
CN =	78	na
Impervious		
Area =	4.39	acres
CN =	98	na
Tc =	5	min
Total A =	15.91	acres

Note: The hydrographs shown are based on the S.C.S. Type - 1A, 24 hour storm using the SBUH method based on the King County Model.

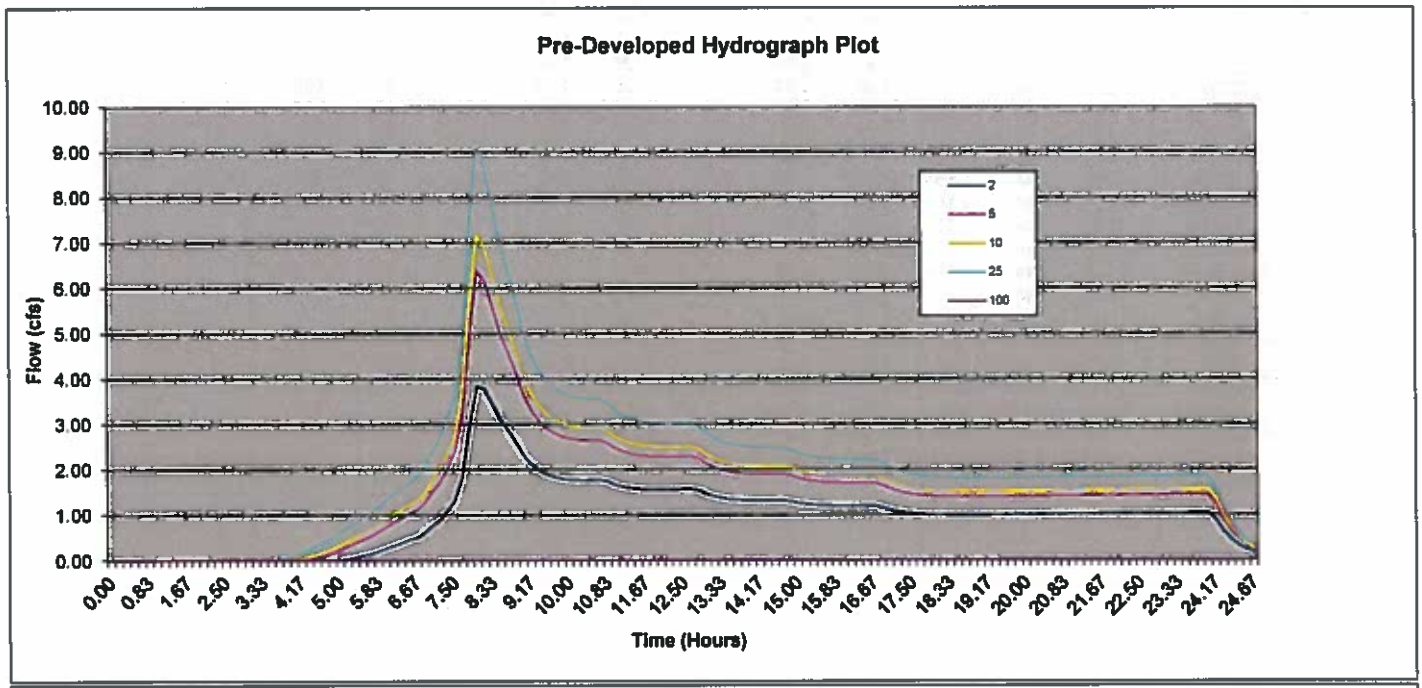
		Pre-Developed Hydrographs					Developed Hydrographs				
Year	==========>	2	5	10	25	100	2	5	10	25	100
Qpeak	cfs =>	3.84	6.37	7.17	9.09	0.00	7.46	11.21	12.39	15.21	0.00
Volume	cf =>	90,144	136,837	151,461	186,400	-	109,099	156,947	171,829	207,263	-
Tpeak	min =>	480	480	480	480	10	470	470	470	470	10
Tpeak	hr =>	8.00	8.00	8.00	8.00	0.17	7.83	7.83	7.83	7.83	0.17
Hydrograph Name=>		2	5	10	25	100	2	5	10	25	100
Time (min)	Time (hr)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.04	0.00
40	0.67	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.07	0.12	0.00
50	0.83	0.00	0.00	0.00	0.00	0.00	0.05	0.12	0.14	0.20	0.00
60	1.00	0.00	0.00	0.00	0.00	0.00	0.09	0.17	0.19	0.26	0.00
70	1.17	0.00	0.00	0.00	0.00	0.00	0.12	0.21	0.23	0.30	0.00
80	1.33	0.00	0.00	0.00	0.00	0.00	0.14	0.24	0.27	0.34	0.00
90	1.50	0.00	0.00	0.00	0.00	0.00	0.17	0.27	0.30	0.37	0.00
100	1.67	0.00	0.00	0.00	0.00	0.00	0.19	0.29	0.32	0.40	0.00
110	1.83	0.00	0.00	0.00	0.00	0.00	0.23	0.35	0.39	0.47	0.00
120	2.00	0.00	0.00	0.00	0.00	0.00	0.28	0.41	0.45	0.55	0.00
130	2.17	0.00	0.00	0.00	0.00	0.00	0.30	0.43	0.47	0.57	0.00
140	2.33	0.00	0.00	0.00	0.00	0.00	0.31	0.45	0.49	0.59	0.00
150	2.50	0.00	0.00	0.00	0.00	0.00	0.33	0.46	0.51	0.60	0.00
160	2.67	0.00	0.00	0.00	0.00	0.00	0.34	0.48	0.52	0.62	0.00
170	2.83	0.00	0.00	0.00	0.00	0.00	0.36	0.54	0.58	0.69	0.00
180	3.00	0.00	0.00	0.00	0.00	0.00	0.43	0.60	0.65	0.77	0.00
190	3.17	0.00	0.00	0.00	0.00	0.00	0.44	0.61	0.66	0.78	0.00
200	3.33	0.00	0.00	0.00	0.00	0.00	0.45	0.62	0.67	0.79	0.00
210	3.50	0.00	0.00	0.00	0.00	0.00	0.46	0.63	0.68	0.80	0.00
220	3.67	0.00	0.00	0.00	0.01	0.00	0.47	0.64	0.69	0.80	0.00
230	3.83	0.00	0.00	0.00	0.05	0.00	0.52	0.70	0.75	0.88	0.00
240	4.00	0.00	0.00	0.01	0.10	0.00	0.56	0.76	0.82	0.96	0.00
250	4.17	0.00	0.01	0.04	0.17	0.00	0.57	0.77	0.82	1.01	0.00
260	4.33	0.00	0.03	0.08	0.24	0.00	0.58	0.77	0.83	1.07	0.00
270	4.50	0.00	0.07	0.13	0.32	0.00	0.58	0.78	0.86	1.14	0.00
280	4.67	0.00	0.11	0.19	0.40	0.00	0.59	0.79	0.91	1.20	0.00
290	4.83	0.00	0.17	0.26	0.50	0.00	0.64	0.91	1.04	1.38	0.00
300	5.00	0.01	0.24	0.34	0.61	0.00	0.70	1.04	1.19	1.56	0.00
310	5.17	0.03	0.31	0.43	0.72	0.00	0.70	1.10	1.25	1.63	0.00
320	5.33	0.06	0.39	0.51	0.83	0.00	0.71	1.15	1.31	1.71	0.00
330	5.50	0.10	0.46	0.59	0.93	0.00	0.72	1.21	1.37	1.77	0.00
340	5.67	0.15	0.54	0.68	1.03	0.00	0.75	1.26	1.43	1.84	0.00
350	5.83	0.20	0.63	0.78	1.16	0.00	0.86	1.42	1.61	2.06	0.00
360	6.00	0.26	0.73	0.90	1.31	0.00	0.97	1.59	1.79	2.29	0.00
370	6.17	0.32	0.84	1.01	1.45	0.00	1.01	1.65	1.86	2.37	0.00
380	6.33	0.39	0.93	1.12	1.58	0.00	1.06	1.71	1.92	2.44	0.00
390	6.50	0.45	1.02	1.21	1.70	0.00	1.10	1.77	1.99	2.51	0.00
400	6.67	0.51	1.11	1.31	1.81	0.00	1.15	1.83	2.05	2.58	0.00
410	6.83	0.61	1.27	1.50	2.04	0.00	1.43	2.27	2.54	3.19	0.00
420	7.00	0.75	1.51	1.76	2.37	0.00	1.74	2.73	3.05	3.83	0.00
430	7.17	0.88	1.71	1.98	2.65	0.00	1.81	2.83	3.16	3.94	0.00
440	7.33	1.07	2.02	2.32	3.07	0.00	2.23	3.46	3.85	4.79	0.00
450	7.50	1.32	2.40	2.76	3.61	0.00	2.67	4.11	4.57	5.67	0.00
460	7.67	1.63	3.22	3.67	4.76	0.00	4.10	6.25	6.93	8.55	0.00
470	7.83	3.00	5.09	5.76	7.36	0.00	7.46	11.21	12.39	15.21	0.00
480	8.00	3.84	6.37	7.17	9.09	0.00	7.23	10.78	11.88	14.53	0.00
490	8.17	3.77	6.17	6.93	8.74	0.00	4.24	6.26	6.89	8.38	0.00
500	8.33	3.44	5.57	6.24	7.84	0.00	3.04	4.46	4.91	5.95	0.00
510	8.50	3.12	5.00	5.58	6.99	0.00	2.65	3.87	4.25	5.15	0.00
520	8.67	2.90	4.60	5.13	6.41	0.00	2.69	3.92	4.30	5.20	0.00

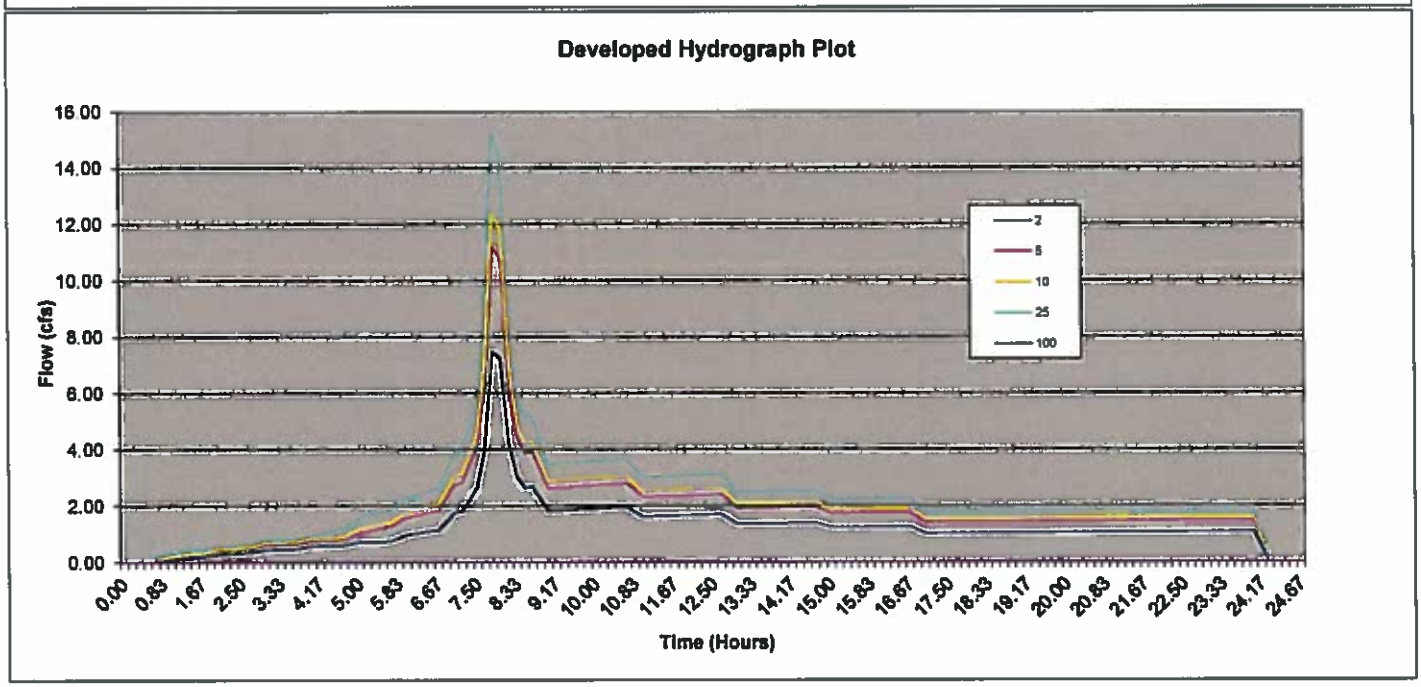
		Pre-Developed Hydrographs					Developed Hydrographs				
Year ==========>		2	5	10	25	100	2	5	10	25	100
Qpeak	cfs =>	3.84	6.37	7.17	9.09	0.00	7.46	11.21	12.39	15.21	0.00
Volume	cf =>	90,144	136,837	151,461	186,400	-	109,099	158,947	171,829	207,253	-
Tpeak	min =>	480	480	480	480	10	470	470	470	470	10
Tpeak	hr =>	8.00	8.00	8.00	8.00	0.17	7.83	7.83	7.83	7.83	0.17
Hydrograph Name=>		2	5	10	25	100	2	5	10	25	100
Time (min)	Time (hr)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)
530	8.83	2.64	4.15	4.63	5.76	0.00	2.25	3.28	3.60	4.35	0.00
540	9.00	2.34	3.66	4.08	5.06	0.00	1.81	2.63	2.88	3.47	0.00
550	9.17	2.14	3.32	3.69	4.57	0.00	1.82	2.64	2.90	3.50	0.00
560	9.33	1.99	3.08	3.42	4.22	0.00	1.84	2.66	2.92	3.52	0.00
570	9.50	1.90	2.92	3.24	3.98	0.00	1.86	2.68	2.94	3.54	0.00
580	9.67	1.84	2.81	3.11	3.82	0.00	1.87	2.70	2.95	3.56	0.00
590	9.83	1.80	2.74	3.03	3.71	0.00	1.89	2.72	2.97	3.58	0.00
600	10.00	1.78	2.69	2.97	3.64	0.00	1.90	2.73	2.99	3.59	0.00
610	10.17	1.77	2.66	2.94	3.59	0.00	1.92	2.75	3.01	3.61	0.00
620	10.33	1.76	2.65	2.92	3.57	0.00	1.93	2.77	3.02	3.63	0.00
630	10.50	1.77	2.65	2.92	3.55	0.00	1.94	2.78	3.04	3.65	0.00
640	10.67	1.77	2.65	2.92	3.55	0.00	1.96	2.80	3.06	3.66	0.00
650	10.83	1.74	2.59	2.85	3.46	0.00	1.79	2.56	2.79	3.34	0.00
660	11.00	1.67	2.48	2.72	3.31	0.00	1.62	2.31	2.52	3.02	0.00
670	11.17	1.62	2.40	2.64	3.20	0.00	1.63	2.32	2.53	3.03	0.00
680	11.33	1.59	2.35	2.58	3.13	0.00	1.64	2.33	2.54	3.04	0.00
690	11.50	1.57	2.32	2.55	3.08	0.00	1.65	2.34	2.55	3.05	0.00
700	11.67	1.56	2.30	2.52	3.05	0.00	1.66	2.35	2.56	3.06	0.00
710	11.83	1.56	2.29	2.51	3.03	0.00	1.66	2.36	2.57	3.07	0.00
720	12.00	1.55	2.28	2.50	3.02	0.00	1.67	2.37	2.58	3.08	0.00
730	12.17	1.56	2.28	2.50	3.02	0.00	1.68	2.38	2.59	3.09	0.00
740	12.33	1.56	2.28	2.50	3.02	0.00	1.69	2.39	2.60	3.10	0.00
750	12.50	1.57	2.29	2.51	3.02	0.00	1.69	2.39	2.61	3.11	0.00
760	12.67	1.57	2.29	2.51	3.03	0.00	1.70	2.40	2.62	3.12	0.00
770	12.83	1.53	2.23	2.45	2.94	0.00	1.53	2.16	2.35	2.80	0.00
780	13.00	1.46	2.12	2.32	2.79	0.00	1.36	1.91	2.08	2.48	0.00
790	13.17	1.41	2.04	2.24	2.69	0.00	1.36	1.92	2.09	2.49	0.00
800	13.33	1.37	1.99	2.18	2.62	0.00	1.37	1.92	2.09	2.49	0.00
810	13.50	1.35	1.95	2.14	2.57	0.00	1.37	1.93	2.10	2.50	0.00
820	13.67	1.33	1.93	2.11	2.53	0.00	1.38	1.93	2.10	2.50	0.00
830	13.83	1.32	1.91	2.09	2.51	0.00	1.38	1.94	2.11	2.51	0.00
840	14.00	1.32	1.90	2.08	2.49	0.00	1.38	1.94	2.11	2.51	0.00
850	14.17	1.32	1.90	2.07	2.49	0.00	1.39	1.95	2.12	2.52	0.00
860	14.33	1.32	1.90	2.07	2.48	0.00	1.39	1.95	2.12	2.52	0.00
870	14.50	1.32	1.89	2.07	2.48	0.00	1.40	1.96	2.13	2.53	0.00
880	14.67	1.32	1.90	2.07	2.48	0.00	1.40	1.96	2.13	2.53	0.00
890	14.83	1.30	1.87	2.04	2.44	0.00	1.32	1.84	2.00	2.38	0.00
900	15.00	1.26	1.81	1.98	2.36	0.00	1.24	1.73	1.88	2.23	0.00
910	15.17	1.24	1.77	1.94	2.31	0.00	1.24	1.73	1.88	2.23	0.00
920	15.33	1.22	1.75	1.91	2.28	0.00	1.24	1.73	1.88	2.23	0.00
930	15.50	1.21	1.73	1.89	2.26	0.00	1.24	1.74	1.89	2.24	0.00
940	15.67	1.20	1.72	1.87	2.24	0.00	1.25	1.74	1.89	2.24	0.00
950	15.83	1.20	1.71	1.87	2.23	0.00	1.25	1.74	1.89	2.24	0.00
960	16.00	1.20	1.71	1.86	2.22	0.00	1.25	1.75	1.90	2.25	0.00
970	16.17	1.20	1.71	1.86	2.22	0.00	1.26	1.75	1.90	2.25	0.00
980	16.33	1.20	1.71	1.86	2.22	0.00	1.26	1.75	1.90	2.25	0.00
990	16.50	1.20	1.71	1.86	2.22	0.00	1.26	1.76	1.91	2.26	0.00
1000	16.67	1.20	1.71	1.86	2.22	0.00	1.26	1.76	1.91	2.26	0.00
1010	16.83	1.17	1.66	1.81	2.16	0.00	1.14	1.59	1.72	2.04	0.00
1020	17.00	1.11	1.58	1.72	2.05	0.00	1.02	1.41	1.53	1.81	0.00
1030	17.17	1.07	1.52	1.66	1.97	0.00	1.02	1.41	1.53	1.81	0.00
1040	17.33	1.04	1.48	1.61	1.92	0.00	1.02	1.41	1.53	1.82	0.00
1050	17.50	1.03	1.45	1.58	1.88	0.00	1.02	1.42	1.54	1.82	0.00
1060	17.67	1.01	1.43	1.56	1.86	0.00	1.02	1.42	1.54	1.82	0.00
1070	17.83	1.00	1.42	1.55	1.84	0.00	1.02	1.42	1.54	1.82	0.00
1080	18.00	1.00	1.41	1.54	1.83	0.00	1.03	1.42	1.54	1.82	0.00
1090	18.17	0.99	1.40	1.53	1.82	0.00	1.03	1.42	1.54	1.82	0.00
1100	18.33	0.99	1.40	1.52	1.81	0.00	1.03	1.43	1.55	1.83	0.00
1110	18.50	0.99	1.40	1.52	1.81	0.00	1.03	1.43	1.55	1.83	0.00
1120	18.67	0.99	1.40	1.52	1.81	0.00	1.03	1.43	1.55	1.83	0.00
1130	18.83	0.99	1.40	1.52	1.81	0.00	1.03	1.43	1.55	1.83	0.00
1140	19.00	0.99	1.40	1.52	1.81	0.00	1.03	1.43	1.55	1.83	0.00
1150	19.17	0.99	1.40	1.52	1.81	0.00	1.04	1.43	1.55	1.83	0.00
1160	19.33	0.99	1.40	1.52	1.81	0.00	1.04	1.44	1.56	1.84	0.00
1170	19.50	1.00	1.40	1.52	1.81	0.00	1.04	1.44	1.56	1.84	0.00
1180	19.67	1.00	1.40	1.53	1.81	0.00	1.04	1.44	1.56	1.84	0.00
1190	19.83	1.00	1.41	1.53	1.81	0.00	1.04	1.44	1.56	1.84	0.00
1200	20.00	1.00	1.41	1.53	1.81	0.00	1.04	1.44	1.56	1.84	0.00
1210	20.17	1.00	1.41	1.53	1.82	0.00	1.05	1.44	1.56	1.84	0.00
1220	20.33	1.00	1.41	1.53	1.82	0.00	1.05	1.45	1.57	1.85	0.00
1230	20.50	1.01	1.41	1.53	1.82	0.00	1.05	1.45	1.57	1.85	0.00

Pre-Developed Hydrographs							Developed Hydrographs				
Year ==========>		2	5	10	25	100	2	5	10	25	100
Qpeak	cfs =>	3.84	6.37	7.17	9.09	0.00	7.46	11.21	12.39	15.21	0.00
Volume	cf =>	90,144	138,837	151,461	186,400	-	109,099	156,947	171,629	207,263	-
Tpeak	min =>	480	480	480	480	10	470	470	470	470	10
Tpeak	hr =>	8.00	8.00	8.00	8.00	0.17	7.83	7.83	7.83	7.83	0.17
Hydrograph Name=>		2	5	10	25	100	2	5	10	25	100
Time (min)	Time (hr)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)
1240	20.67	1.01	1.41	1.54	1.82	0.00	1.05	1.45	1.57	1.85	0.00
1250	20.83	1.01	1.42	1.54	1.82	0.00	1.05	1.45	1.57	1.85	0.00
1260	21.00	1.01	1.42	1.54	1.83	0.00	1.05	1.45	1.57	1.85	0.00
1270	21.17	1.01	1.42	1.54	1.83	0.00	1.05	1.45	1.57	1.85	0.00
1280	21.33	1.02	1.42	1.54	1.83	0.00	1.06	1.45	1.57	1.86	0.00
1290	21.50	1.02	1.42	1.55	1.83	0.00	1.06	1.46	1.58	1.86	0.00
1300	21.67	1.02	1.43	1.55	1.83	0.00	1.06	1.46	1.58	1.86	0.00
1310	21.83	1.02	1.43	1.55	1.83	0.00	1.06	1.46	1.58	1.86	0.00
1320	22.00	1.02	1.43	1.55	1.84	0.00	1.06	1.46	1.58	1.86	0.00
1330	22.17	1.02	1.43	1.55	1.84	0.00	1.06	1.46	1.58	1.86	0.00
1340	22.33	1.03	1.43	1.55	1.84	0.00	1.06	1.46	1.58	1.86	0.00
1350	22.50	1.03	1.43	1.56	1.84	0.00	1.07	1.46	1.58	1.87	0.00
1360	22.67	1.03	1.44	1.56	1.84	0.00	1.07	1.47	1.59	1.87	0.00
1370	22.83	1.03	1.44	1.56	1.84	0.00	1.07	1.47	1.59	1.87	0.00
1380	23.00	1.03	1.44	1.56	1.85	0.00	1.07	1.47	1.59	1.87	0.00
1390	23.17	1.03	1.44	1.56	1.85	0.00	1.07	1.47	1.59	1.87	0.00
1400	23.33	1.04	1.44	1.56	1.85	0.00	1.07	1.47	1.59	1.87	0.00
1410	23.50	1.04	1.44	1.57	1.85	0.00	1.07	1.47	1.59	1.87	0.00
1420	23.67	1.04	1.45	1.57	1.85	0.00	1.07	1.47	1.59	1.88	0.00
1430	23.83	1.04	1.45	1.57	1.85	0.00	1.08	1.48	1.60	1.88	0.00
1440	24.00	1.04	1.45	1.57	1.85	0.00	1.08	1.48	1.60	1.88	0.00
1450	24.17	0.89	1.24	1.35	1.59	0.00	0.54	0.74	0.80	0.94	0.00
1460	24.33	0.64	0.89	0.96	1.14	0.00	0.00	0.00	0.00	0.00	0.00
1470	24.50	0.46	0.63	0.69	0.81	0.00	0.00	0.00	0.00	0.00	0.00
1480	24.67	0.33	0.45	0.49	0.58	0.00	0.00	0.00	0.00	0.00	0.00
1490	24.67	0.23	0.32	0.35	0.41	0.00	0.00	0.00	0.00	0.00	0.00
1500	24.67	0.17	0.23	0.25	0.30	0.00	0.00	0.00	0.00	0.00	0.00

Pre-Developed Hydrographs						
Year	========>	2	5	10	25	100
Qpeak	cfs =>	3.84	6.37	7.17	9.09	0.00
Volume	cf =>	90,144	136,837	151,461	186,400	-
Tpeak	min =>	480	480	480	480	10
Tpeak	hr =>	8.00	8.00	8.00	8.00	0.17
Hydrograph Name=>		2	5	10	25	100
Time (min)	Time (hr)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)

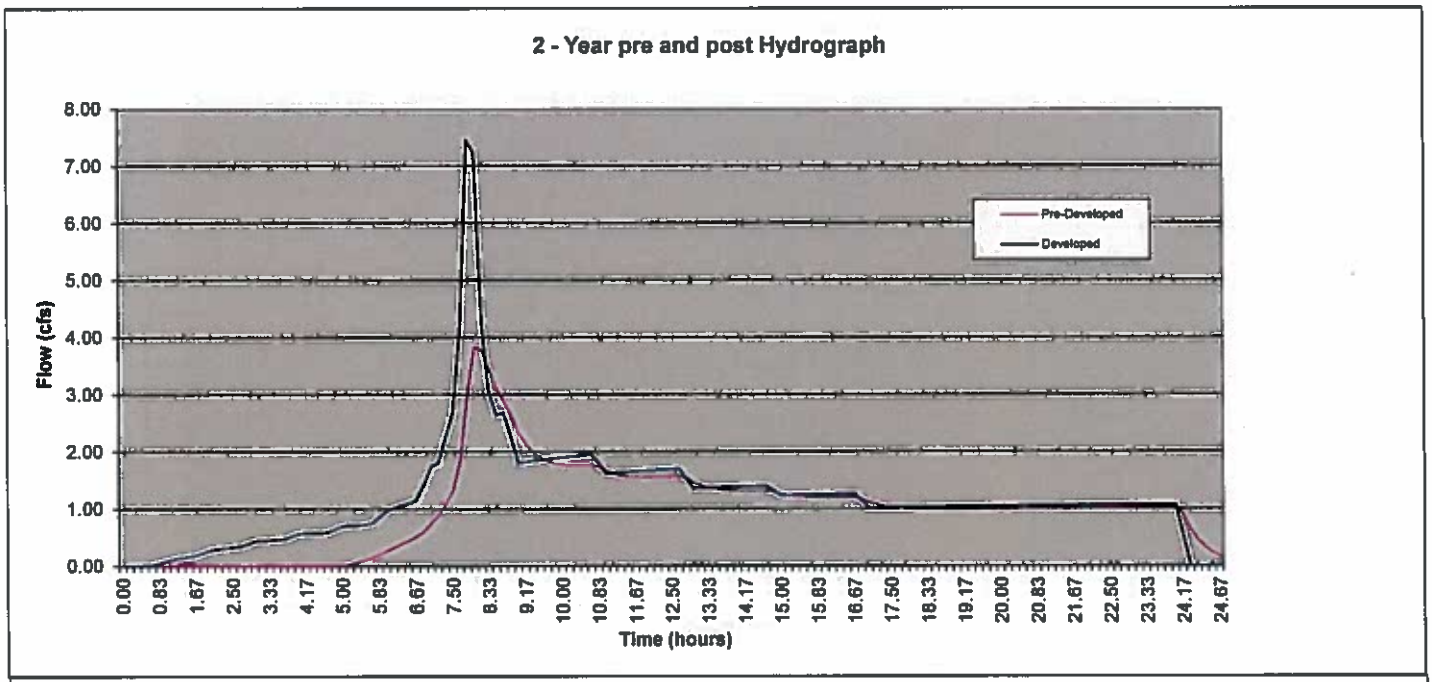
Developed Hydrographs				
2	5	10	25	100
7.46	11.21	12.39	15.21	0.00
109,099	158,947	171,829	207,263	-
470	470	470	470	10
7.83	7.83	7.83	7.83	0.17
2	5	10	25	100
Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)

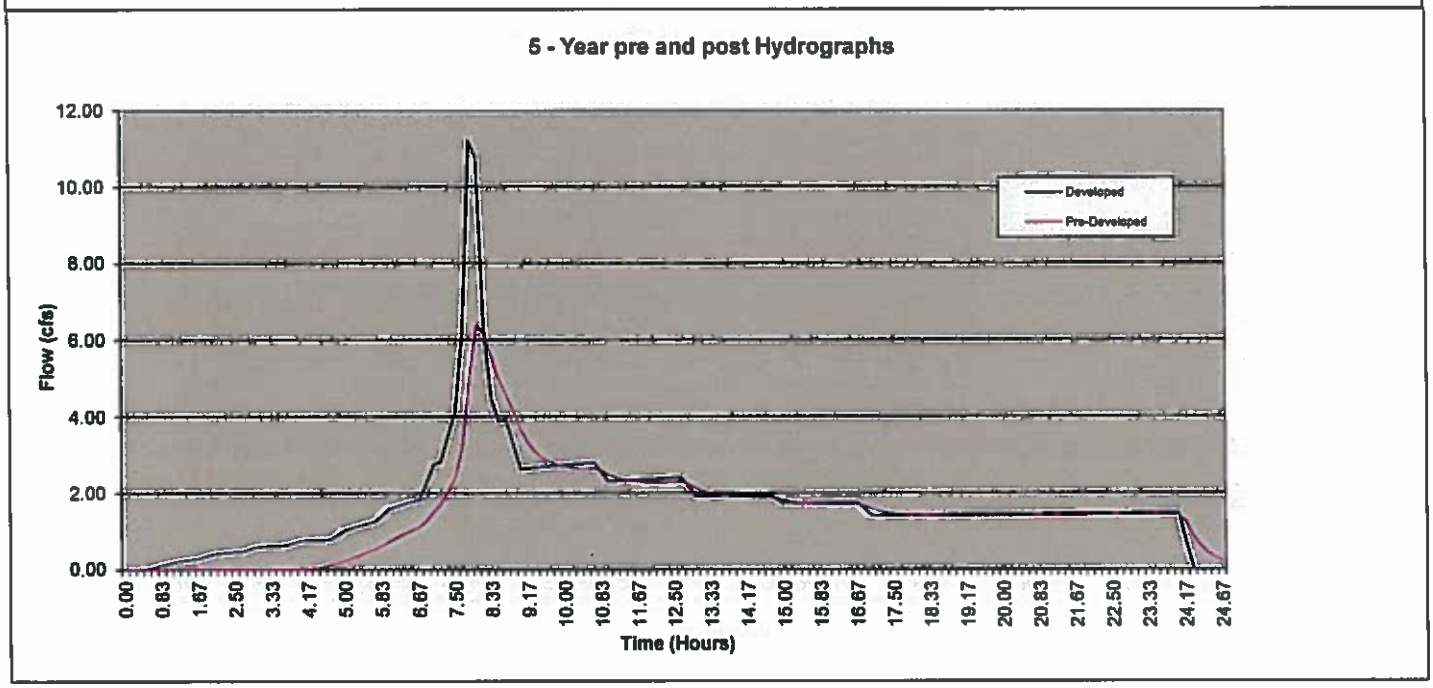




Pre-Developed Hydrographs						
Year	========>	2	5	10	25	100
Qpeak	cfs =>	3.84	6.37	7.17	9.09	0.00
Volume	cf =>	90,144	138,837	151,481	186,400	-
Tpeak	min =>	480	480	480	480	10
Tpeak	hr =>	8.00	8.00	8.00	8.00	0.17
Hydrograph Name=>		2	5	10	25	100
Time (min)	Time (hr)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)

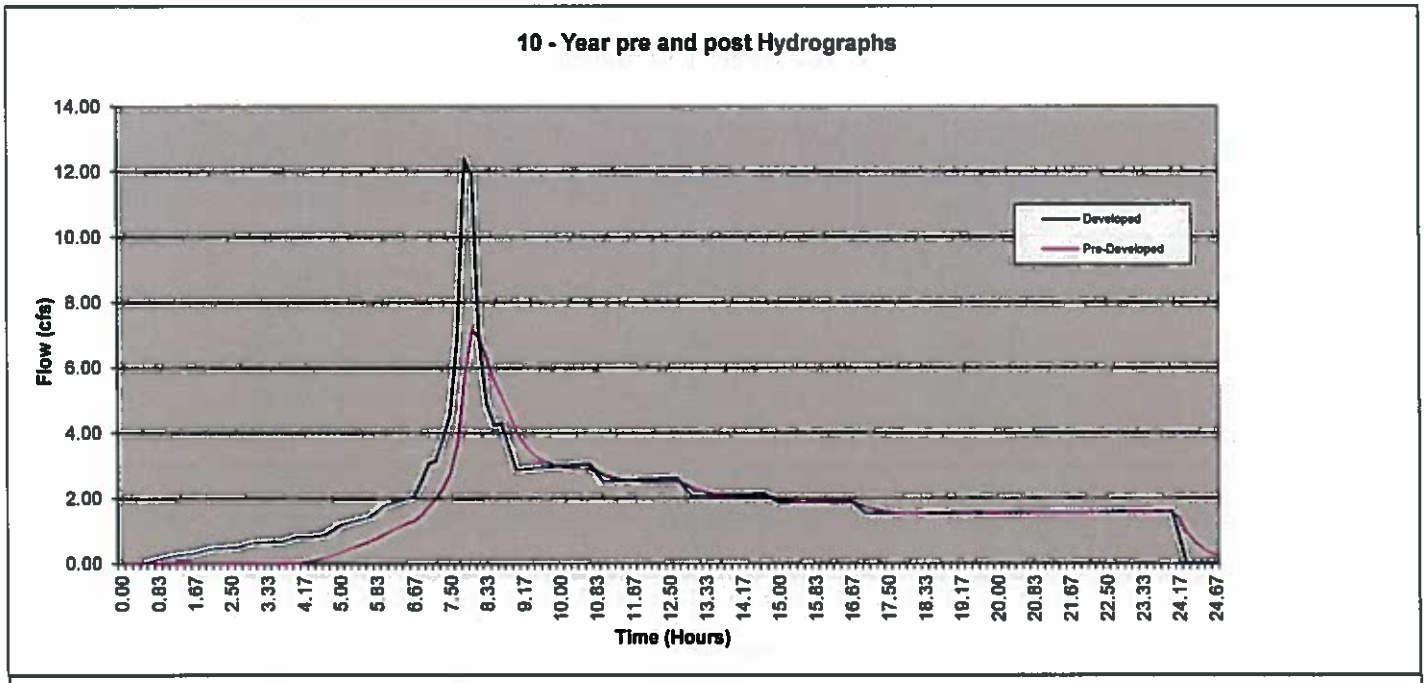
Developed Hydrographs				
2	5	10	25	100
7.46	11.21	12.39	15.21	0.00
109,099	158,947	171,829	207,263	-
470	470	470	470	10
7.83	7.83	7.83	7.83	0.17
2	5	10	25	100
Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)

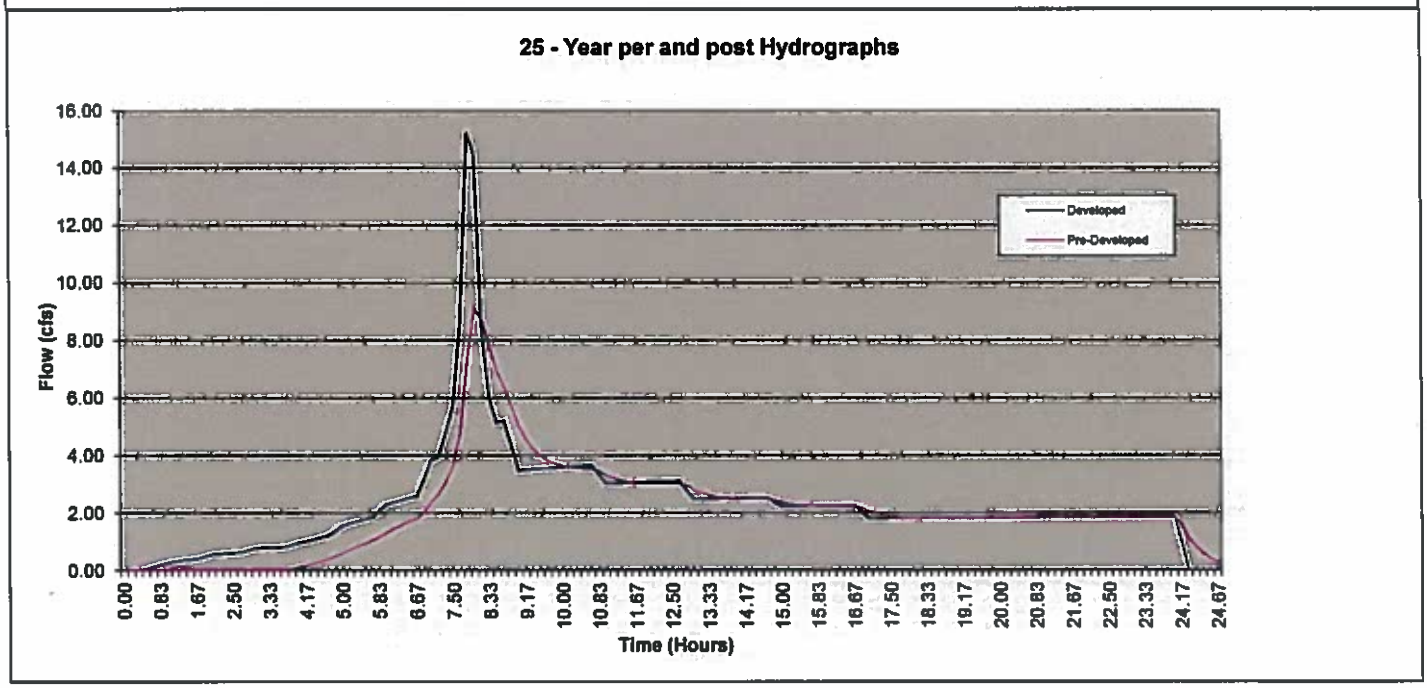




Pre-Developed Hydrographs						
Year	==========>	2	5	10	25	100
Qpeak	cfs =>	3.84	6.37	7.17	9.09	0.00
Volume	cf =>	90,144	138,837	151,461	188,400	-
Tpeak	min =>	480	480	480	480	10
Tpeak	hr =>	8.00	8.00	8.00	8.00	0.17
Hydrograph Name =>		2	5	10	25	100
Time (min)	Time (hr)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)

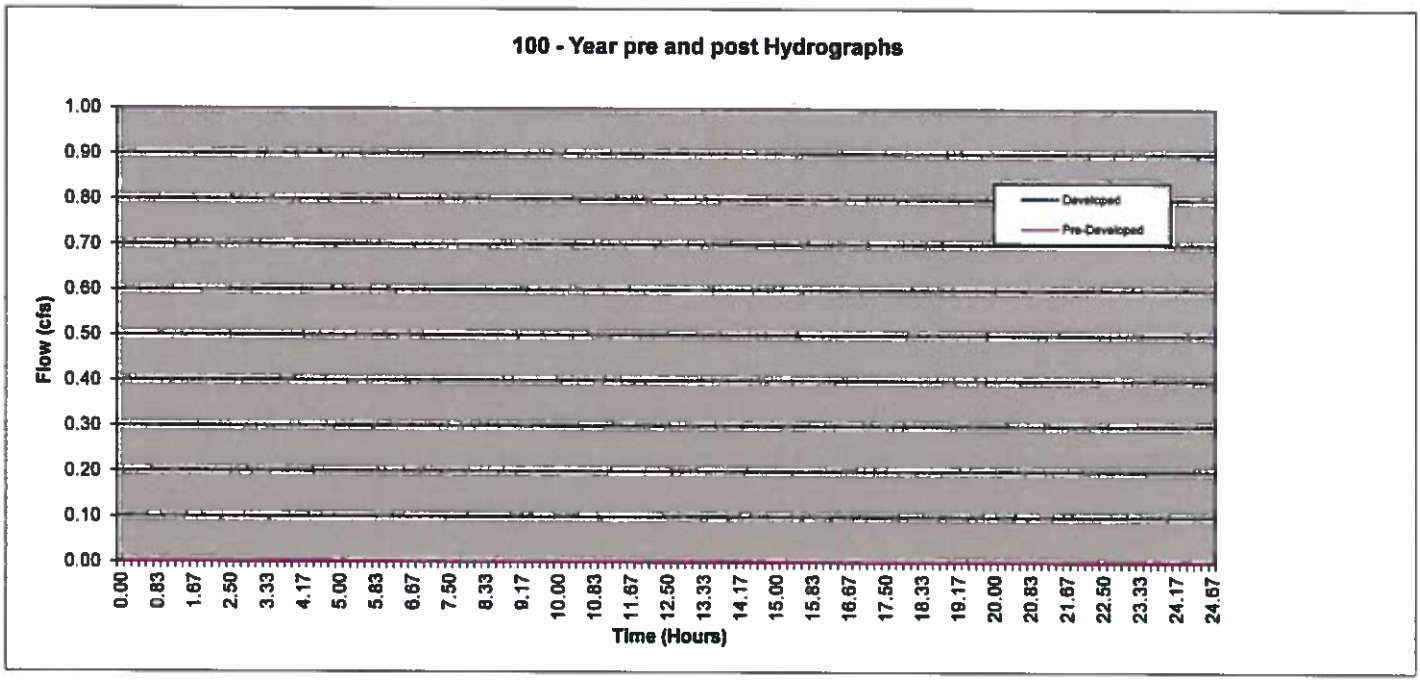
Developed Hydrographs				
2	5	10	25	100
7.46	11.21	12.39	15.21	0.00
109,099	156,947	171,829	207,263	-
470	470	470	470	10
7.83	7.83	7.83	7.83	0.17
2	5	10	25	100
Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)





Pre-Developed Hydrographs						
Year	========>	2	5	10	25	100
Qpeak	cfs =>	3.84	6.37	7.17	9.09	0.00
Volume	cf =>	90,144	138,837	151,461	186,400	-
Tpeak	min =>	480	480	480	480	10
Tpeak	hr =>	8.00	8.00	8.00	8.00	0.17
Hydrograph Name=>		2	5	10	25	100
Time (min)	Time (hr)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)

Developed Hydrographs				
2	5	10	25	100
7.46	11.21	12.39	15.21	0.00
109,099	156,947	171,829	207,283	-
470	470	470	470	10
7.83	7.83	7.83	7.83	0.17
2	5	10	25	100
Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)	Hyd (cfs)



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Project Name:	Deer Meadows
Detention System Summary	
Job #	19-035
Date:	5/28/2021

Note: The detention system design is based on the King County Model "Facility Design Routine".

1) Detention Facility Design Input:

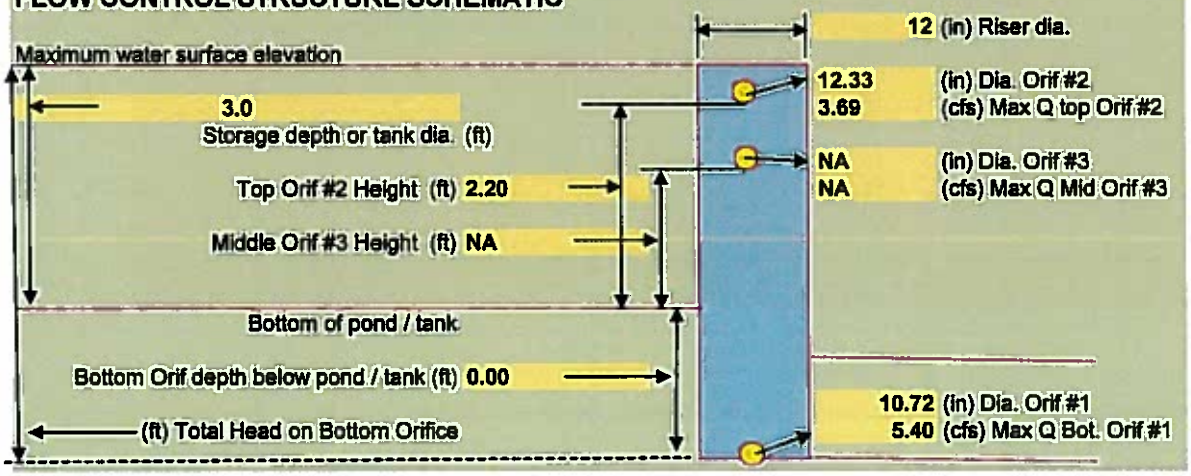
2) Type of facility:		DETENTION POND	
3) Pond side slopes:	3	to 1	
4) Pond storage depth:	3	ft (from bottom of pond to overflow)	
5) Vertical permeability	0	min/in	
6) Number of orifices:	2		
7) Riser dia. =>	12	in	
8) Orifice coefficient	0.62	(typically 0.62)	
9) IE - bottom orifice:	0	ft (distance below bottom of pond - Negative #)	
10) Max Q Bottom Orif. #1	5.40	cfs	
11) Top Orif #2 Height =	2.2	ft	
12) Max Q Mid Orif. #3	0.00	cfs	Orifice not being used
13) Mid Orif #3 Height =	0.00	ft	Orifice not being used

Detention Facility Design Results:

Performance year	Developed Inflow cfs	Pre-Developed Outflow cfs	Actual Outflow cfs	Peak Stage ft	Storage cf
100	0	0	0	0	-
25	15.21	9.09	9.09	3.00	20,016
10	12.39	7.17	7.17	2.50	16,021
5	11.21	6.37	6.09	2.31	14,602
2	7.46	3.84	3.73	1.43	8,474
			Required Storage ====		20,016

	Bottom Orif.	Middle Orif.	Top Orif.	Optional Weir Design
Total Q =	5.40	0.00	3.69	(for top orifice)
Head (ft) =	3.00	0.00	0.80	1.83 La (ft)
Dist. from bottom of pond (ft) =	0.00	NA	2.20	209.85 < deg.
Orif. Dia. (in) =	10.72	0.00	12.33	Must Use Weir

FLOW CONTROL STRUCTURE SCHEMATIC



Project Name:	Deer Meadows

Detention Facility Type

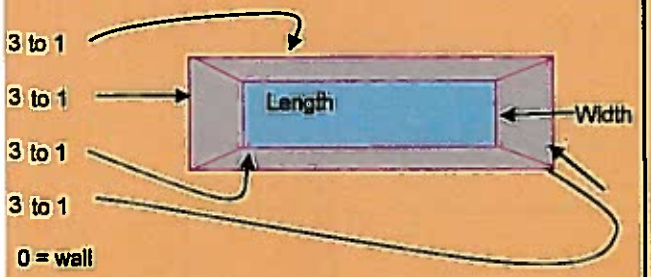
Job # 19-035
Date: 5/28/2021

Detention Facility Type:

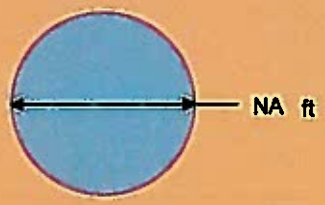
DETENTION POND

L =	72.5 ft
W =	72.5 ft
D =	3.0 ft
Pond Area =	5,259 sf

DETENTION POND



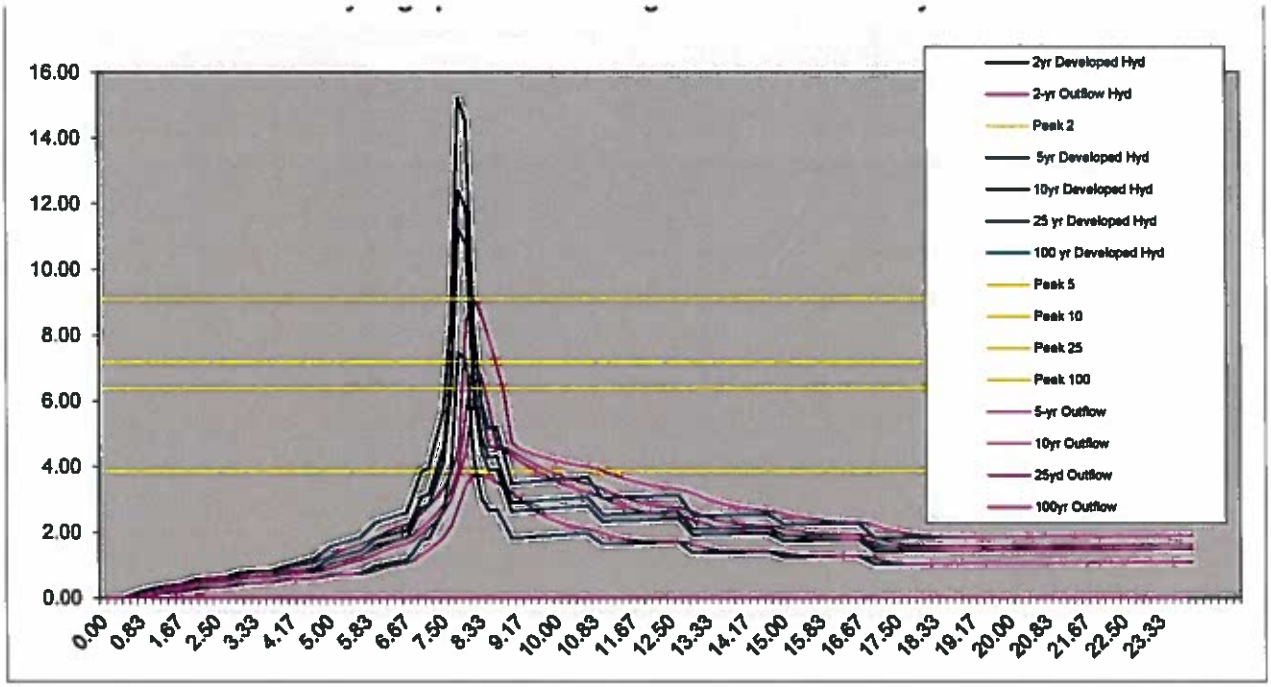
DETENTION TANK
NA

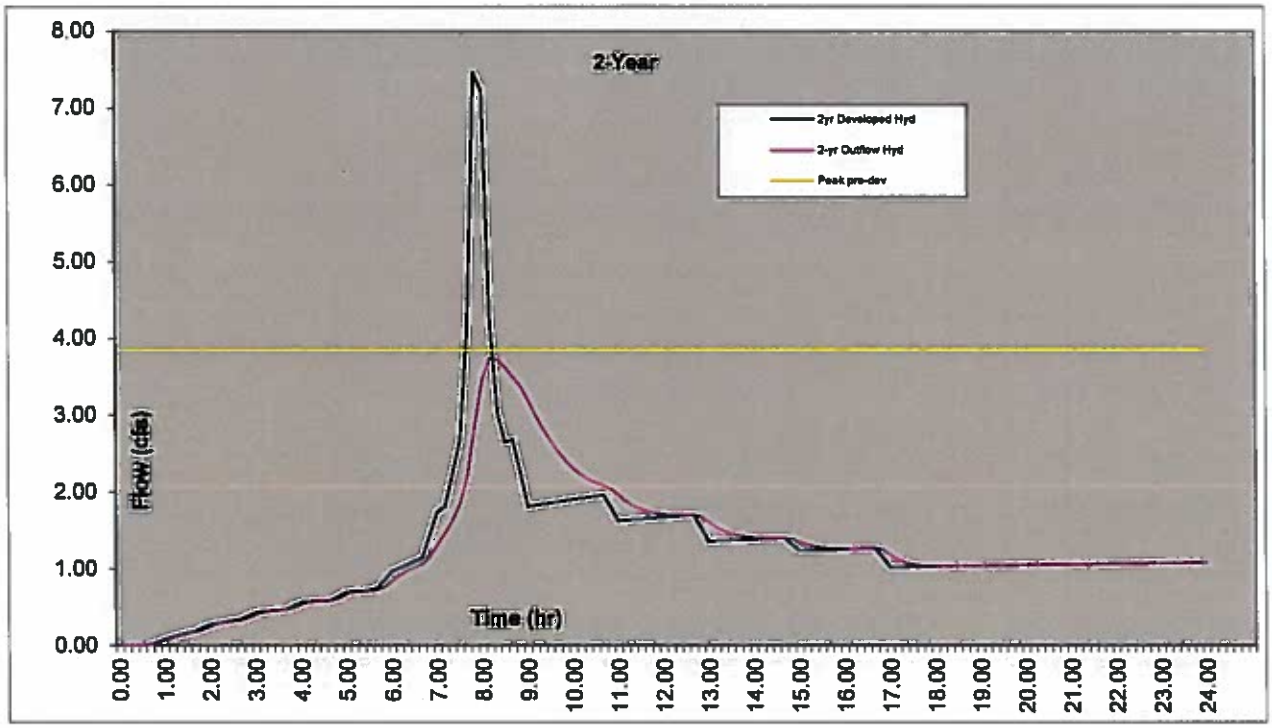


USER DEFINED POND
NA
Pond Geometry

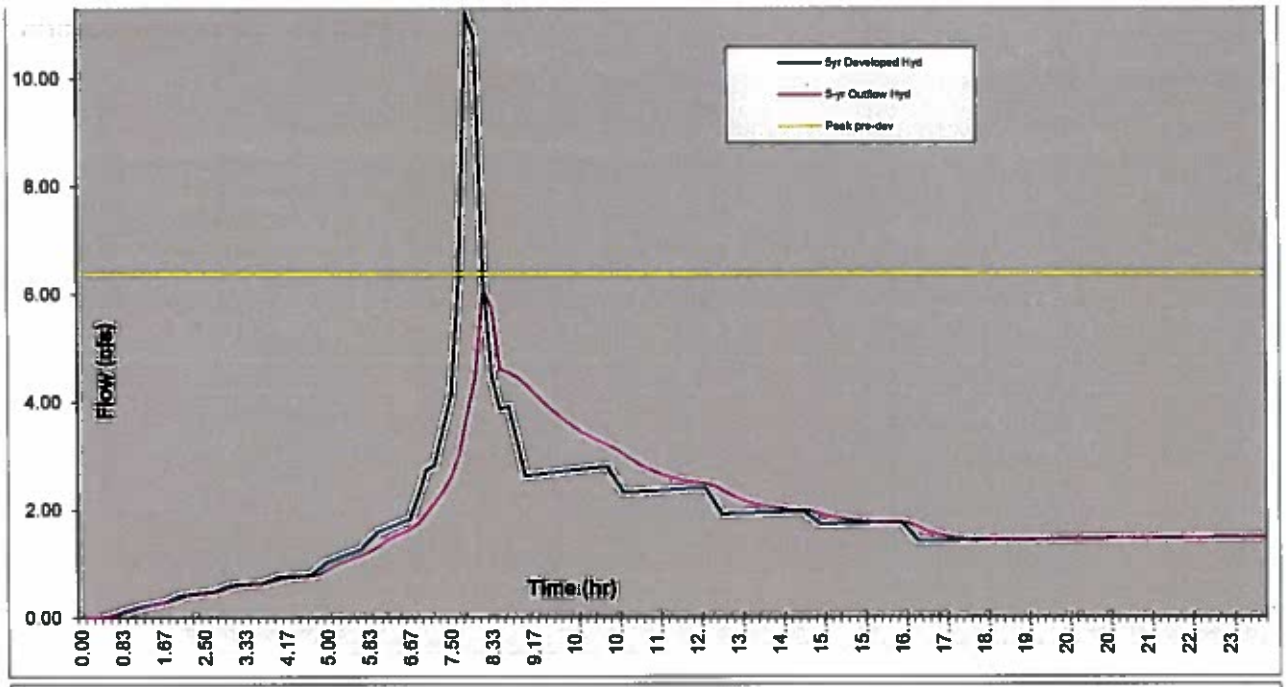
Stage (ft)	Area (sf)
0	NA
1	NA
2	NA
3	NA
4	NA
5	NA
6	NA
7	NA
8	NA
9	NA
10	NA
11	NA
12	NA
13	NA
14	NA
15	NA

All Storm Hydrographs Routed Through The Detention Facility


16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.00 0.83 1.67 2.50 3.33 4.17 5.00 5.83 6.67 7.50 8.33 9.17 10.00 10.83 11.67 12.50 13.33 14.17 15.00 15.83 16.67 17.50 18.33 19.17 20.00 20.83 21.67 22.50 23.33
2yr Developed Hyd
2-yr Outflow Hyd
Peak 2
5yr Developed Hyd
10yr Developed Hyd
25 yr Developed Hyd
100 yr Developed Hyd
Peak 5
Peak 10
Peak 25
Peak 100
5-yr Outflow
10yr Outflow
25yd Outflow
100yr Outflow


2-Year
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Flow (cfs)
Time (hr)
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00 15.00 16.00 17.00 18.00 19.00 20.00 21.00 22.00 23.00 24.00
2yr Developed Hyd
2-yr Outflow Hyd
Peak pre-dev


12.00
5-Year


5yr Developed Hyd
5-yr Outflow Hyd
Peak pre-dev
Flow (cfs)
Time (hr)
10.00
8.00
6.00
4.00
2.00
0.00
0.00
0.83
1.67
2.50
3.33
4.17
5.00
5.83
6.67
7.50
8.33
9.17
10.
10.
11.
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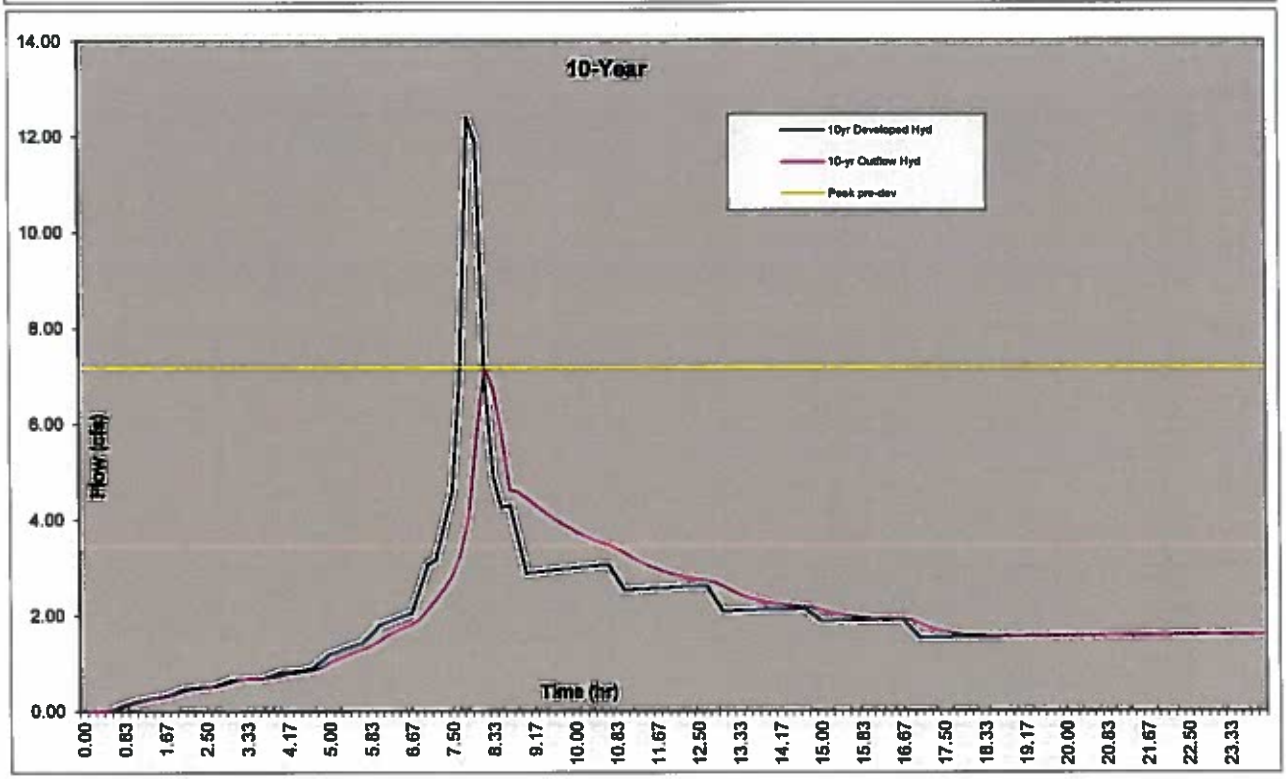
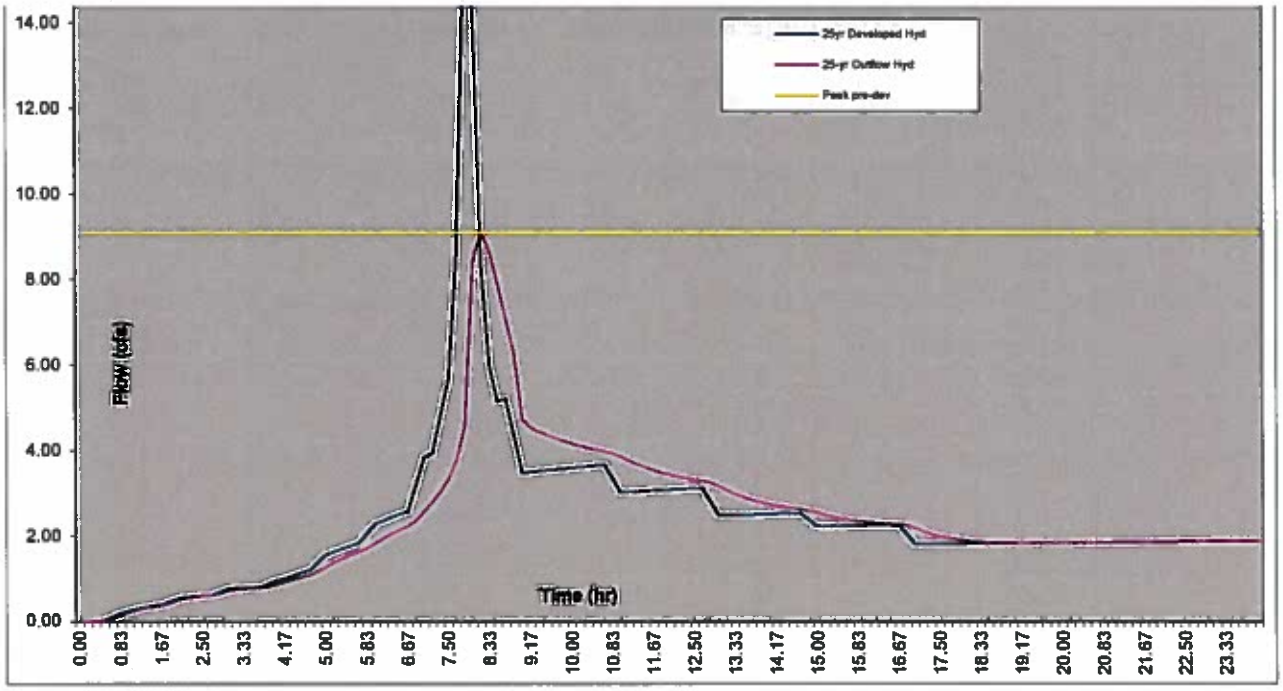

10-Year
10yr Developed Hyd
10-yr Outflow Hyd
Peak pre-dev
Flow (cfs)
Time (hr)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.00
0.83
1.67
2.50
3.33
4.17
5.00
5.83
6.67
7.50
8.33
9.17
10.00
10.83
11.67
12.50
13.33
14.17
15.00
15.83
16.67
17.50
18.33
19.17
20.00
20.83
21.67
22.50
23.33


16.00
25-Year


25yr Developed Hyd
25-yr Outflow Hyd
Peak pre-dev
Flow (cfs)
Time (hr)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.00
0.83
1.67
2.50
3.33
4.17
5.00
5.83
6.67
7.50
8.33
9.17
10.00
10.83
11.67
12.50
13.33
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20.00
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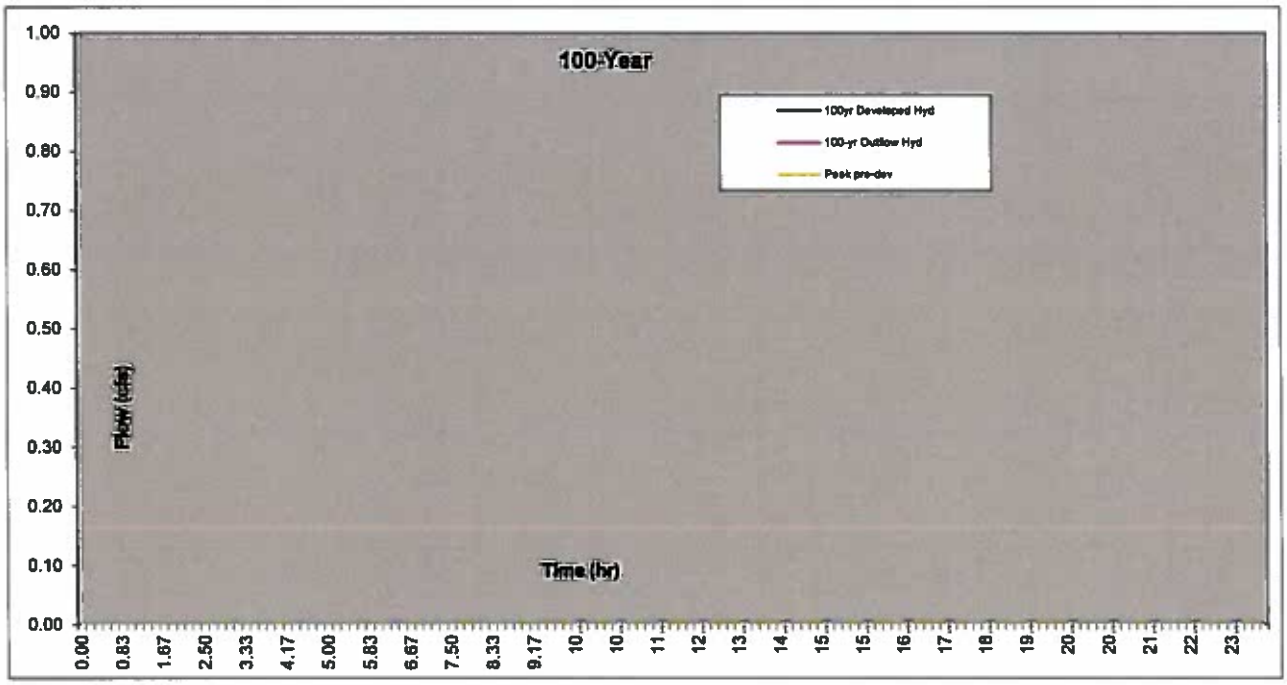
21.67
22.50
23.33


100-Year
100yr Developed Hyd
100-yr Outflow Hyd
Peak pre-dev
Flow (cfs)
Time (hr)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

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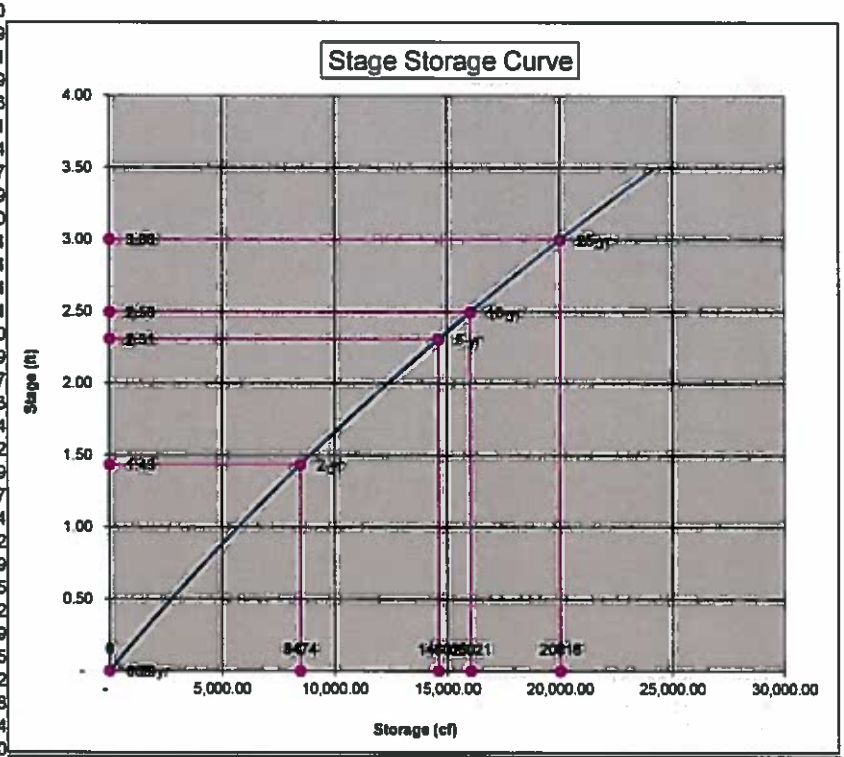
Project Name: Deer Meadows

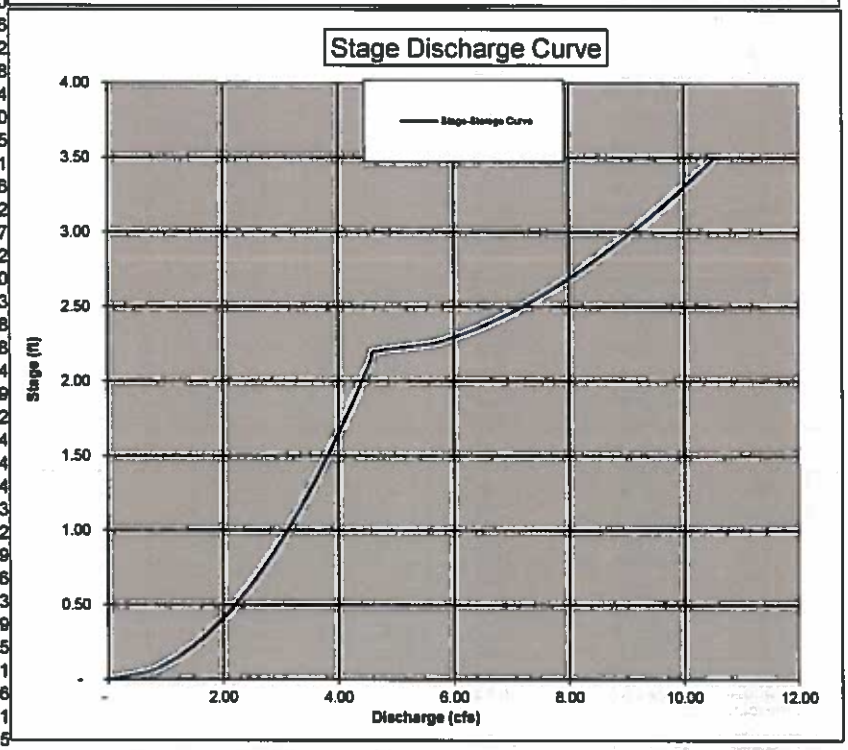
Stage Storage Summary

Job # 19-035

Date: 5/28/2021

Stage ft	Storage cf	Discharge cfs
-	-	-
0.05	264.02	0.70
0.10	530.23	0.99
0.15	798.64	1.21
0.20	1,069.24	1.39
0.25	1,342.06	1.56
0.30	1,617.09	1.71
0.35	1,894.36	1.84
0.40	2,173.86	1.97
0.45	2,455.62	2.09
0.50	2,739.63	2.20
0.55	3,025.90	2.31
0.60	3,314.45	2.41
0.65	3,605.28	2.51
0.70	3,898.41	2.61
0.75	4,193.83	2.70
0.80	4,491.57	2.79
0.85	4,791.62	2.87
0.90	5,094.01	2.96
0.95	5,398.73	3.04
1.00	5,705.80	3.12
1.05	6,015.23	3.19
1.10	6,327.01	3.27
1.15	6,641.18	3.34
1.20	6,957.72	3.42
1.25	7,276.66	3.49
1.30	7,597.99	3.55
1.35	7,921.74	3.62
1.40	8,247.91	3.69
1.45	8,576.50	3.75
1.50	8,907.53	3.82
1.55	9,241.00	3.88
1.60	9,576.93	3.94
1.65	9,915.32	4.00
1.70	10,256.19	4.06
1.75	10,599.53	4.12
1.80	10,945.37	4.18
1.85	11,293.71	4.24
1.90	11,644.55	4.30
1.95	11,997.92	4.35
2.00	12,353.80	4.41
2.05	12,712.23	4.46
2.10	13,073.20	4.52
2.15	13,436.72	4.57
2.20	13,802.81	4.62
2.25	14,171.46	5.60
2.30	14,542.70	6.03
2.35	14,916.53	6.38
2.40	15,292.95	6.68
2.45	15,671.98	6.94
2.50	16,053.63	7.19
2.55	16,437.91	7.42
2.60	16,824.82	7.64
2.65	17,214.37	7.84
2.70	17,606.57	8.04
2.75	18,001.44	8.23
2.80	18,398.98	8.42
2.85	18,799.19	8.59
2.90	19,202.10	8.76
2.95	19,607.70	8.93
3.00	20,016.01	9.09
3.05	20,427.03	9.25
3.10	20,840.78	9.41
3.15	21,257.27	9.56
3.20	21,676.49	9.71
3.25	22,098.47	9.85





Stage ft	Storage cf	Discharge cfs
3.30	22,523.21	9.99
3.35	22,950.71	10.13
3.40	23,381.00	10.27
3.45	23,814.07	10.41
3.50	24,249.94	10.54
3.50	24,249.94	10.54
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Stage ft	Storage cf	Discharge cfs
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Stage ft	Storage cf	Discharge cfs
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3.50	24,249.94	10.54
3.50	24,249.94	10.54
3.50	24,249.94	10.54
3.50	24,249.94	10.54
3.50	24,249.94	10.54
3.50	24,249.94	10.54

Project Name: Deer Meadows
Rectangular, Sharp Crested Weir Calculations

Job # 19-035
Date: 5/28/2021

Weir Equation: $Q = C(L-0.2H)H^{3/2}$

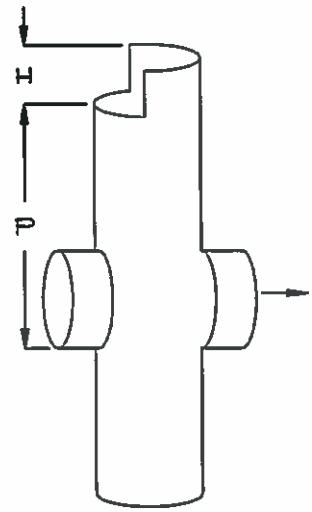
Q	= Flow over weir (cfs)
C	= 3.27 + 0.40 H/P (ft)
L	= Adjusted length of weir (La - 0.1H x 2) this is to account for side constraints
La	= Actual length of weir along pipes interior circumference (ft)
H	= Distance from bottom of weir to maximum head (ft)
P	= Distance from bottom of weir to outfall invert elevation (ft)
D	= Inside riser pipe diameter (in)
<	= Angle of opening for weir

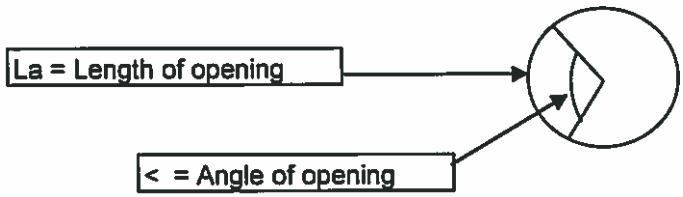
Given:

Q	3.69	cfs
H	0.80	ft
P	2.20	ft
D	12	in

Find:

C	3.42	ft
L	1.67	ft
La	**1.83**	**ft**
<	**210**	**degrees**





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