

**STORM WATER RUNOFF
Detention Volume Calculations**

for

**WOLF MOUNTAIN SKI RESORT
Patron Parking & Building Area
Including Proposed Building
Site Plan
Rev. 02/28/13
Liberty, UT**

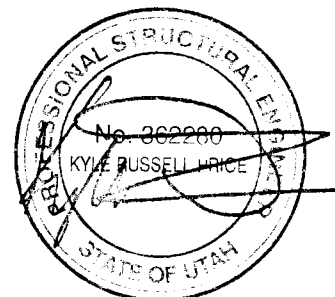
Criteria & Conclusions

**Return Period: 100 year
Duration: 24 hour
Max Storage Volume @ 12 hours
Allowable Runoff 0.1 cfs / acre
Orifice Diameter 3"
Total Required Storage 18,390 cu. ft.**

Report Date: 03/01/13



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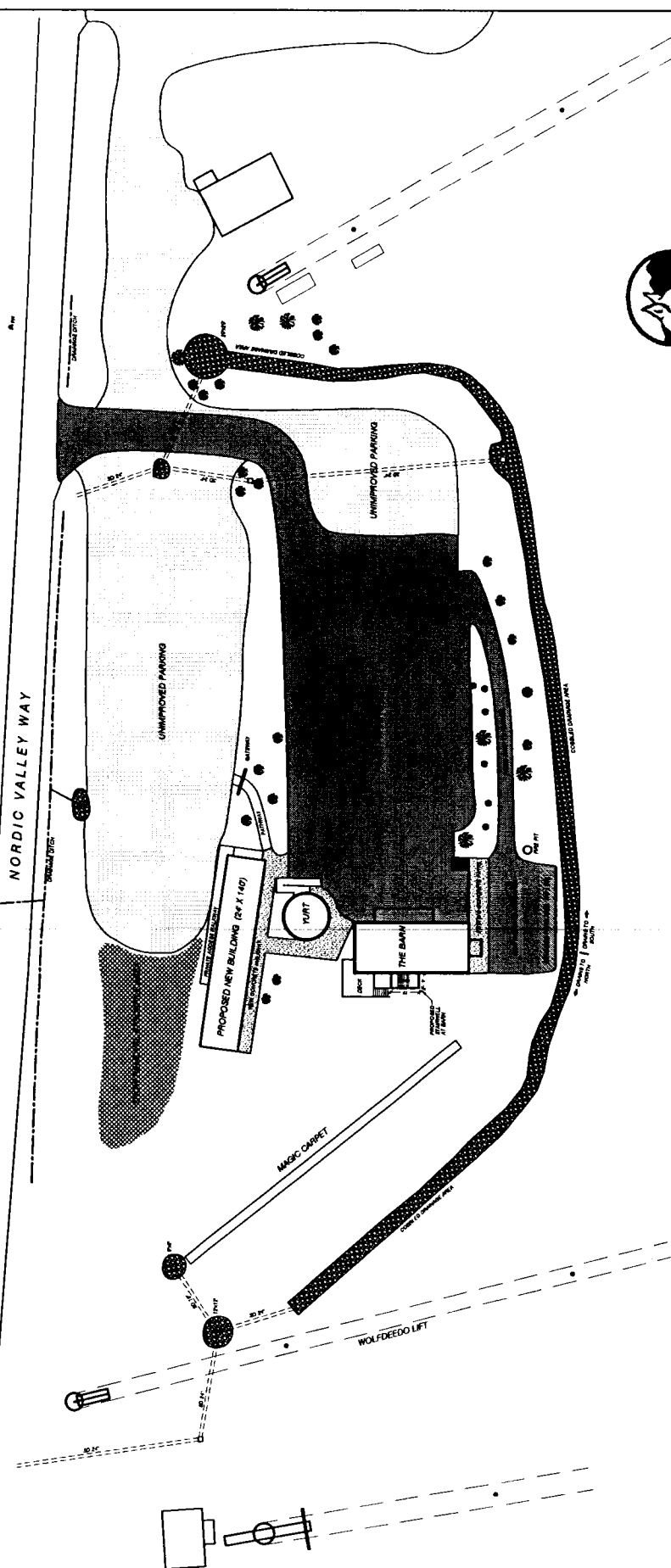


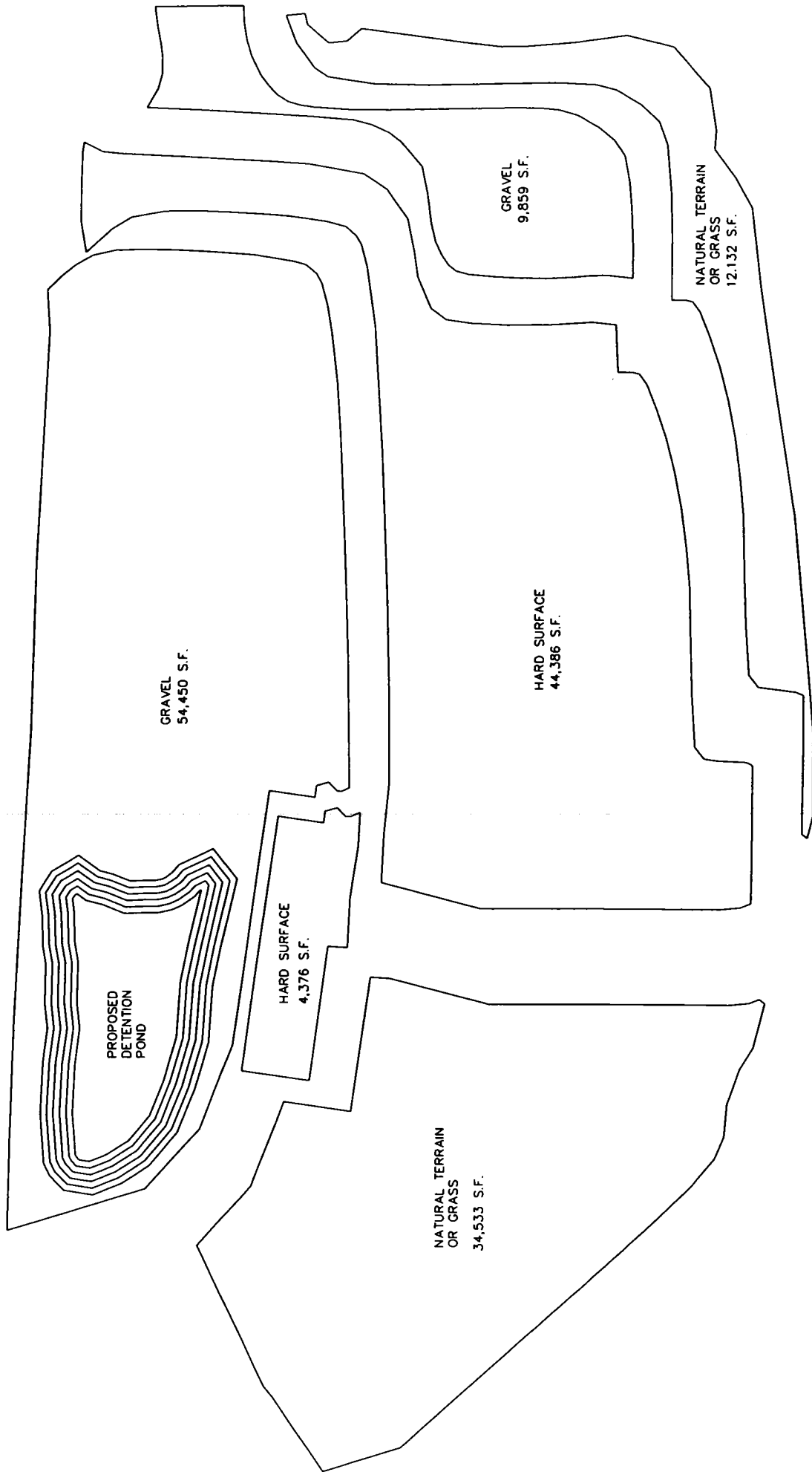
MAR 01 2013



Wolf Mountain

R E S O R T PROPOSED FACILITY EXPANSION AND IMPROVEMENTS





Wolf Mountain Patron Parking & Ski Building Area
Revision 03/01/13

Site Area Calculations

	Building	Parking Paved	Parking Gravel	Landscape
	4,376	44,388	64,309	46,665
Total	4,376	44,388	64,309	46,665
Acres	0.10	1.02	1.48	1.07
	(Sq. Ft.)	(Acres)		
Total Hard Surface	48,764	1.12		
Total Hard + Gravel	113,073	2.60		
Total All	159,738	3.67		
Grass Percentage	29.2%			

Storm Runoff Totals (See attached Calculations)

Return Interval	100	(Years)				
Allowable Runoff	0.1	(cfs / Acre)				
Allowable Runoff Total	0.37	cfs				
Calculated Runoff Total	0.38	cfs				
Outlet Diameter	3	(in)				
Duration (min)	15	30	60	120	180	360
Storage Required (cu. ft.)	9887	13188	15964	17958	17658	17808
Duration (min)	720	1440				
Storage Required (cu. ft.)	18390	15052				



NOAA Atlas 14, Volume 1, Version 5

Location name: Eden, Utah, US*

Coordinates: 41.3100, -111.8640

Elevation: 5352 ft*

* source: Google Maps



POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic,
 Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel
 Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchon

NOAA, National Weather Service, Silver Spring, Maryland

[PF_tabular](#) | [PF_graphical](#) | [Maps_&_aerials](#)

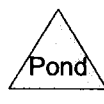
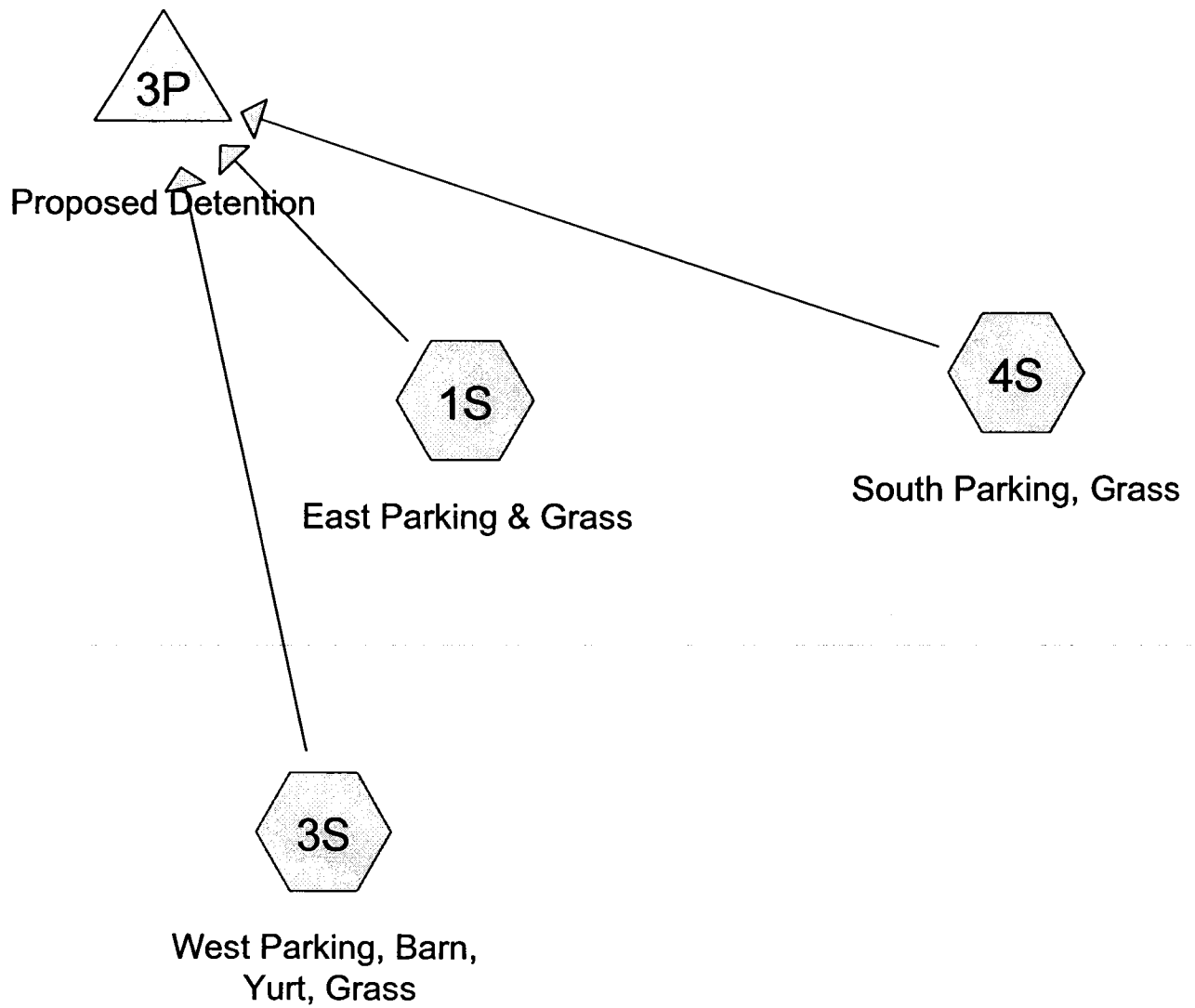
PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches/hour) ¹										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	2.00 (1.75-2.30)	2.53 (2.24-2.92)	3.42 (3.00-3.92)	4.22 (3.68-4.86)	5.50 (4.69-6.37)	6.66 (5.52-7.80)	8.05 (6.47-9.53)	9.68 (7.50-11.7)	12.4 (9.02-15.5)	14.9 (10.3-19.2)
10-min	1.52 (1.34-1.75)	1.93 (1.71-2.22)	2.60 (2.29-2.99)	3.22 (2.80-3.70)	4.19 (3.57-4.85)	5.07 (4.21-5.93)	6.13 (4.92-7.25)	7.37 (5.71-8.92)	9.41 (6.87-11.8)	11.3 (7.87-14.6)
15-min	1.26 (1.10-1.45)	1.59 (1.41-1.83)	2.15 (1.89-2.47)	2.66 (2.32-3.06)	3.46 (2.95-4.00)	4.19 (3.48-4.90)	5.06 (4.07-6.00)	6.09 (4.72-7.37)	7.78 (5.68-9.72)	9.37 (6.50-12.0)
30-min	0.848 (0.744-0.974)	1.07 (0.952-1.23)	1.45 (1.27-1.66)	1.79 (1.56-2.06)	2.33 (1.99-2.70)	2.82 (2.34-3.30)	3.41 (2.74-4.04)	4.10 (3.18-4.96)	5.24 (3.82-6.54)	6.31 (4.38-8.11)
60-min	0.525 (0.461-0.603)	0.663 (0.589-0.764)	0.897 (0.788-1.03)	1.11 (0.966-1.27)	1.44 (1.23-1.67)	1.75 (1.45-2.04)	2.11 (1.69-2.50)	2.54 (1.97-3.07)	3.24 (2.37-4.05)	3.90 (2.71-5.02)
2-hr	0.346 (0.308-0.392)	0.432 (0.386-0.490)	0.556 (0.494-0.630)	0.672 (0.590-0.764)	0.862 (0.740-0.987)	1.03 (0.870-1.20)	1.24 (1.01-1.45)	1.48 (1.16-1.77)	1.87 (1.39-2.31)	2.23 (1.58-2.83)
3-hr	0.265 (0.239-0.296)	0.328 (0.297-0.367)	0.408 (0.365-0.456)	0.484 (0.430-0.542)	0.604 (0.527-0.683)	0.717 (0.614-0.818)	0.852 (0.712-0.988)	1.01 (0.819-1.19)	1.27 (0.978-1.54)	1.51 (1.12-1.90)
6-hr	0.186 (0.170-0.204)	0.227 (0.208-0.250)	0.273 (0.248-0.300)	0.315 (0.284-0.348)	0.377 (0.337-0.420)	0.430 (0.379-0.482)	0.489 (0.425-0.556)	0.556 (0.472-0.640)	0.689 (0.567-0.810)	0.810 (0.647-0.975)
12-hr	0.121 (0.111-0.133)	0.148 (0.136-0.164)	0.179 (0.163-0.197)	0.206 (0.186-0.227)	0.246 (0.220-0.274)	0.279 (0.247-0.314)	0.315 (0.274-0.359)	0.354 (0.301-0.408)	0.412 (0.341-0.486)	0.460 (0.370-0.553)
24-hr	0.082 (0.075-0.091)	0.101 (0.092-0.111)	0.121 (0.110-0.134)	0.138 (0.125-0.152)	0.161 (0.145-0.178)	0.179 (0.161-0.197)	0.198 (0.177-0.218)	0.217 (0.193-0.239)	0.242 (0.214-0.268)	0.262 (0.230-0.291)
2-day	0.050 (0.045-0.055)	0.061 (0.055-0.067)	0.073 (0.066-0.081)	0.083 (0.075-0.092)	0.097 (0.088-0.107)	0.108 (0.097-0.120)	0.119 (0.107-0.132)	0.131 (0.116-0.145)	0.146 (0.129-0.163)	0.158 (0.138-0.176)
3-day	0.037 (0.034-0.041)	0.046 (0.042-0.051)	0.055 (0.050-0.061)	0.063 (0.057-0.070)	0.074 (0.067-0.082)	0.083 (0.074-0.092)	0.092 (0.082-0.101)	0.101 (0.089-0.112)	0.113 (0.099-0.126)	0.123 (0.107-0.137)
4-day	0.031 (0.028-0.034)	0.039 (0.035-0.043)	0.047 (0.042-0.051)	0.053 (0.048-0.059)	0.063 (0.057-0.069)	0.070 (0.063-0.078)	0.078 (0.069-0.086)	0.086 (0.076-0.095)	0.097 (0.085-0.108)	0.105 (0.091-0.118)
7-day	0.022 (0.020-0.025)	0.028 (0.025-0.031)	0.033 (0.030-0.037)	0.038 (0.034-0.043)	0.045 (0.040-0.050)	0.050 (0.045-0.056)	0.055 (0.049-0.062)	0.061 (0.054-0.068)	0.068 (0.060-0.077)	0.074 (0.064-0.084)
10-day	0.018 (0.016-0.020)	0.022 (0.020-0.025)	0.027 (0.024-0.030)	0.030 (0.027-0.034)	0.035 (0.032-0.039)	0.039 (0.035-0.043)	0.042 (0.038-0.047)	0.046 (0.041-0.051)	0.051 (0.045-0.057)	0.055 (0.048-0.061)
20-day	0.012 (0.011-0.013)	0.015 (0.013-0.016)	0.018 (0.016-0.019)	0.020 (0.018-0.022)	0.022 (0.020-0.025)	0.025 (0.022-0.027)	0.027 (0.024-0.029)	0.028 (0.025-0.031)	0.031 (0.028-0.034)	0.033 (0.029-0.036)
30-day	0.010 (0.009-0.011)	0.012 (0.011-0.013)	0.014 (0.013-0.016)	0.016 (0.015-0.018)	0.018 (0.017-0.020)	0.020 (0.018-0.022)	0.021 (0.019-0.024)	0.023 (0.021-0.025)	0.025 (0.022-0.028)	0.026 (0.023-0.029)
45-day	0.008 (0.008-0.009)	0.010 (0.009-0.011)	0.012 (0.011-0.013)	0.013 (0.012-0.015)	0.015 (0.014-0.017)	0.017 (0.015-0.018)	0.018 (0.016-0.020)	0.019 (0.017-0.021)	0.021 (0.019-0.023)	0.022 (0.020-0.025)
60-day	0.007 (0.007-0.008)	0.009 (0.008-0.010)	0.010 (0.010-0.011)	0.012 (0.011-0.013)	0.013 (0.012-0.014)	0.014 (0.013-0.016)	0.015 (0.014-0.017)	0.017 (0.015-0.018)	0.018 (0.016-0.020)	0.019 (0.017-0.021)

¹ Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).
 Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.
 Please refer to NOAA Atlas 14 document for more information.

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PF graphical



Drainage Diagram for Wolf Mountain

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Wolf Mountian

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Area Listing (all nodes)

<u>Area (acres)</u>	<u>C</u>	<u>Description (subcats)</u>
1.071	0.30	Grass Natural Terrain (3S,4S)
0.226	0.60	Grass Parking (4S)
1.250	0.60	Gravel Parking (1S)
1.019	0.90	Parking Hard Surface (3S)
0.100	0.90	Proposed Building (1S)
3.667		

Wolf Mountian*Liberty 100-Year Duration=720 min, Inten=0.31 in/hr*

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Time span=0.00-30.00 hrs, dt=0.01 hrs, 3001 points

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc

Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Subcatchment 1S: East Parking & Grass

Runoff Area=58,826 sf Runoff Depth=2.34"

Flow Length=200' Slope=0.0500 '/' Tc=8.3 min C=0.62 Runoff=0.27 cfs 0.264 af

Subcatchment 3S: West Parking, Barn, Yurt, Grass

Runoff Area=78,919 sf Runoff Depth=2.42"

Flow Length=300' Slope=0.0500 '/' Tc=11.4 min C=0.64 Runoff=0.37 cfs 0.365 af

Subcatchment 4S: South Parking, Grass

Runoff Area=21,991 sf Runoff Depth=1.63"

Flow Length=300' Slope=0.0500 '/' Tc=11.4 min C=0.43 Runoff=0.07 cfs 0.068 af

Pond 3P: Proposed Detention

Peak Elev=5,002.75' Storage=18,390 cf Inflow=0.70 cfs 0.697 af

Outflow=0.38 cfs 0.653 af

Total Runoff Area = 3.667 ac Runoff Volume = 0.697 af Average Runoff Depth = 2.28"**100.00% Pervious Area = 3.667 ac 0.00% Impervious Area = 0.000 ac**

Wolf Mountain

Liberty 100-Year Duration=720 min, Inten=0.31 in/hr

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Subcatchment 1S: East Parking & Grass

Runoff = 0.27 cfs @ 0.14 hrs, Volume= 0.264 af, Depth= 2.34"

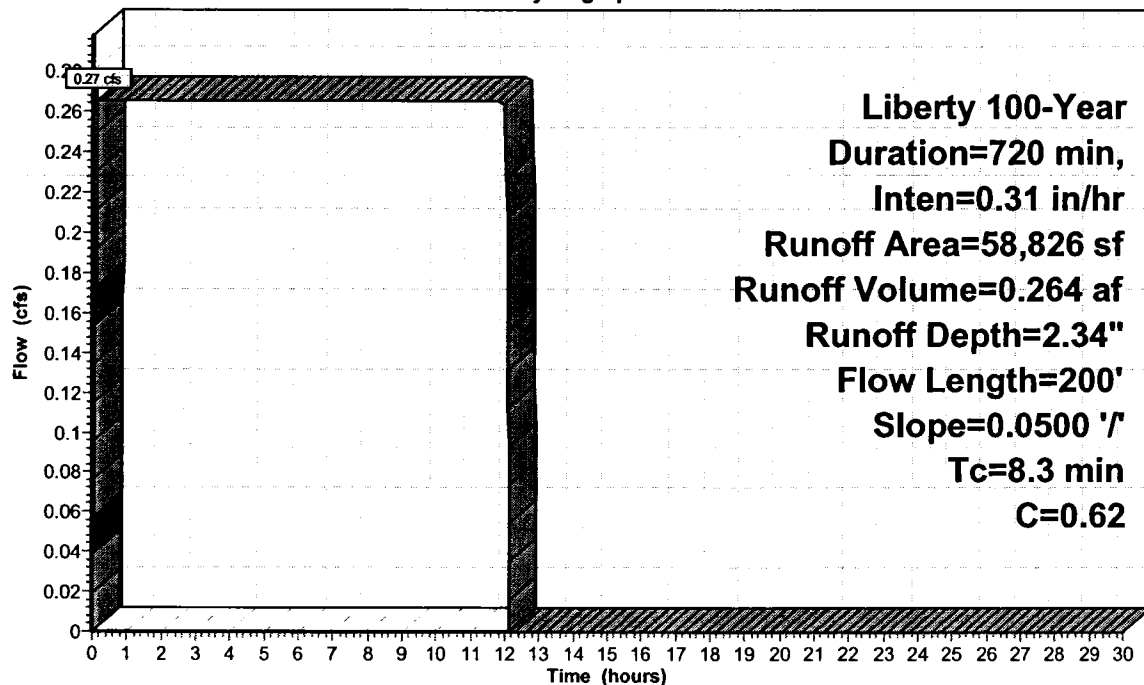
Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Liberty 100-Year Duration=720 min, Inten=0.31 in/hr

Area (sf)	C	Description
54,450	0.60	Gravel Parking
4,376	0.90	Proposed Building
58,826	0.62	Weighted Average
58,826	0.62	Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.3	200	0.0500	0.40		Sheet Flow, Sheet
Smooth surfaces n= 0.011 P2= 0.10"					

Subcatchment 1S: East Parking & Grass

Hydrograph



Wolf Mountain

Liberty 100-Year Duration=720 min, Inten=0.31 in/hr

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Subcatchment 3S: West Parking, Barn, Yurt, Grass

Runoff = 0.37 cfs @ 0.19 hrs, Volume= 0.365 af, Depth= 2.42"

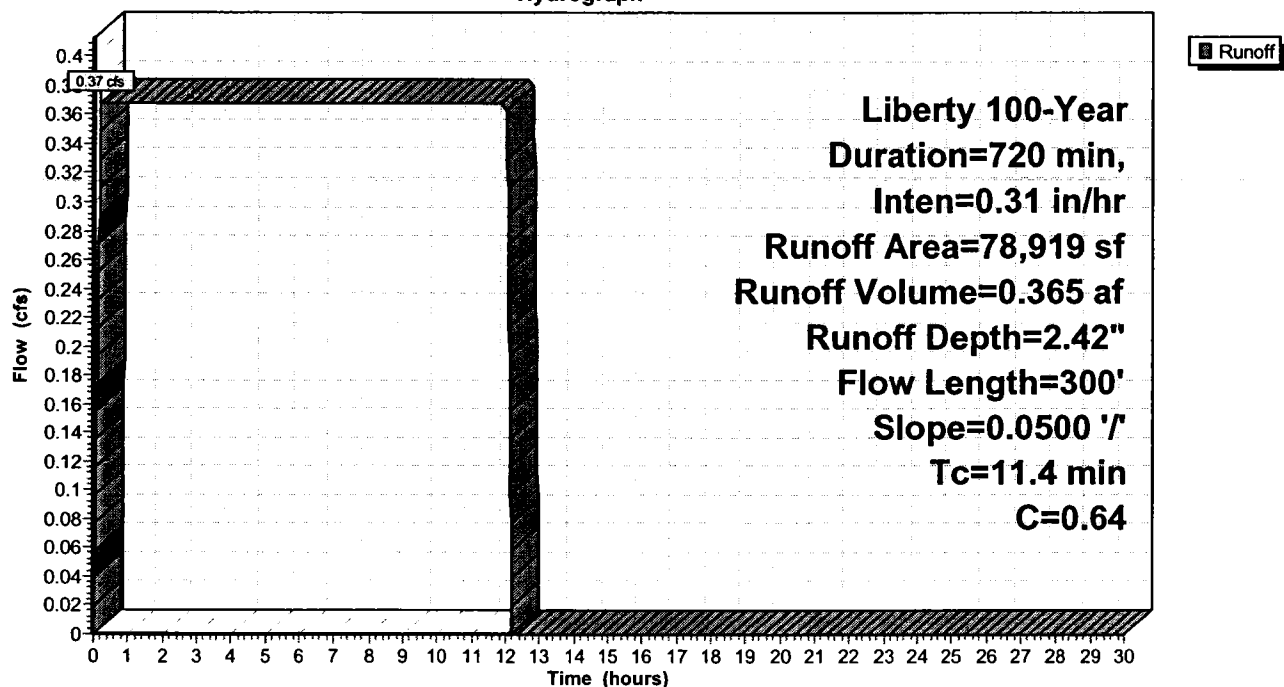
Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Liberty 100-Year Duration=720 min, Inten=0.31 in/hr

Area (sf)	C	Description
44,386	0.90	Parking Hard Surface
34,533	0.30	Grass Natural Terrain
78,919	0.64	Weighted Average
78,919	0.64	Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.4	300	0.0500	0.44		Sheet Flow, Sheet Smooth surfaces n= 0.011 P2= 0.10"

Subcatchment 3S: West Parking, Barn, Yurt, Grass

Hydrograph



Wolf Mountain

Liberty 100-Year Duration=720 min, Inten=0.31 in/hr

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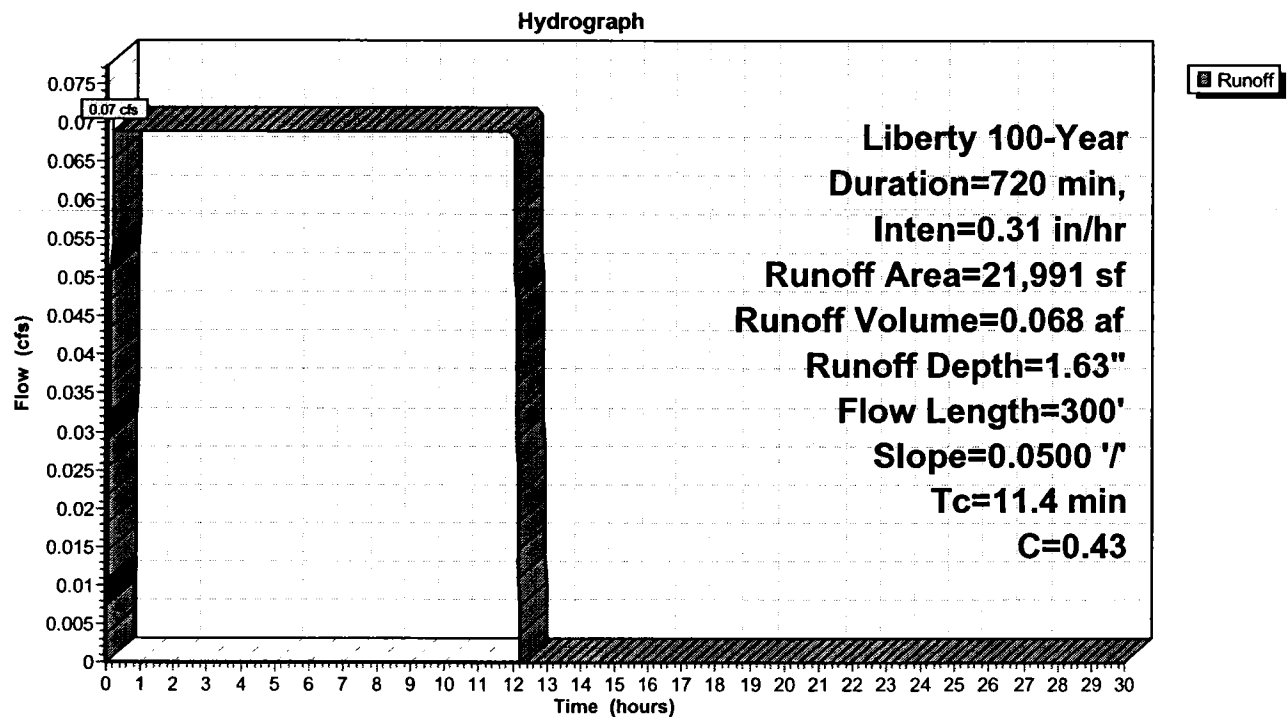
Subcatchment 4S: South Parking, Grass

Runoff = 0.07 cfs @ 0.19 hrs, Volume= 0.068 af, Depth= 1.63"

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Liberty 100-Year Duration=720 min, Inten=0.31 in/hr

Area (sf)	C	Description
9,859	0.60	Grass Parking
12,132	0.30	Grass Natural Terrain
21,991	0.43	Weighted Average
21,991	0.43	Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.4	300	0.0500	0.44		Sheet Flow, Sheet Smooth surfaces n= 0.011 P2= 0.10"

Subcatchment 4S: South Parking, Grass

Wolf Mountian

Liberty 100-Year Duration=720 min, Inten=0.31 in/hr

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Pond 3P: Proposed Detention

Inflow Area = 3.667 ac, Inflow Depth = 2.28" for 100-Year event
 Inflow = 0.70 cfs @ 0.19 hrs, Volume= 0.697 af
 Outflow = 0.38 cfs @ 12.08 hrs, Volume= 0.653 af, Atten= 46%, Lag= 713.1 min
 Primary = 0.38 cfs @ 12.08 hrs, Volume= 0.653 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
 Peak Elev= 5,002.75' @ 12.08 hrs Surf.Area= 8,204 sf Storage= 18,390 cf

Plug-Flow detention time=515.2 min calculated for 0.653 af (94% of inflow)
 Center-of-Mass det. time=492.4 min (857.5 - 365.1)

Volume	Invert	Avail.Storage	Storage Description
#1	5,000.00'	39,816 cf	Custom Stage Data (Prismatic) Listed below

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
5,000.00	5,150	0	0
5,001.00	6,200	5,675	5,675
5,002.00	7,317	6,759	12,434
5,003.00	8,494	7,906	20,339
5,004.00	9,714	9,104	29,443
5,005.00	11,031	10,373	39,816

Device	Routing	Invert	Outlet Devices
#1	Primary	5,000.00'	3.0" Vert. Orifice/Grate C= 0.600

Primary OutFlow Max=0.38 cfs @ 12.08 hrs HW=5,002.75' (Free Discharge)
 ↑1=Orifice/Grate (Orifice Controls 0.38 cfs @ 7.81 fps)

Pond 3P: Proposed Detention

