TECHNICAL MEMORANDUM:

Design of IMPs for Hydromodification and Water Quality Purposes for The Hosking Ranch Development

Julian, San Diego County, California

Prepared for:

Masson & Associates Inc.
October 31, 2011



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Tory R. Walker, R.C.E. 45005

Joy R Walker

President





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Design OF IMPs for Hydromodification and Water Quality Purposes for The Hosking Ranch Development. Julian, CA.

TO: Dan Masson – Masson & Associates Inc.

200 East Washington Ave, Suite 200, Escondido, 92025.

FROM: Tory Walker PE, CFM, LEED GA

Luis Parra, PhD, PE, CPSWQ, ToR, DWRE

DATE: October 27, 2011

RE: Summary of IMP Design for Hydromodification and Water Quality Compliance

for the Hosking Ranch Development

INTRODUCTION

This technical memorandum summarizes the approach used to design 32 bio-retention cells for the proposed Hosking Ranch Development. The design will satisfy both hydromodification and water quality requirements, and is based on the sizing tables of the Final Hydromodification Management Plan (HMP) for San Diego County (March 25, 2011 version) as well as the water quality requirements established in the County of San Diego SUSMP. Bio-retention cells were chosen as the best Integrated Management Practice (IMP) option for the project, since they are one of the preferred treatment facilities in the SUSMP document (together with infiltration devices) and the predominant soil type C of the area is not conducive to design infiltration facilities. Although some of the drainage areas correspond to soils type B which could potentially be used for infiltration facilities, in order to standardize the design process of the 32 IMPs in this Tentative Plan submittal, bio-retention cells were chosen for all areas. Final design submittal could optimize the preliminary design made in this document in terms of analyzing the possibility to use continuous simulation for the largest IMPs to potentially reduce their size, optimize the location of IMPs, or analyze the possibility of replacing some bio-retention cells for infiltration facilities if available infiltration data in the future shows such an option as feasible.

As the contributing areas to the bio-retention cells display a varied combination of slopes and in some cases soil types, and as the contributing areas are mostly pervious for most cases, the size of the bio-retention will result in a linear combination of the sizing factors displayed in the HMP, where the assumptions on the design will be clearly explained in this memorandum. Also, depending on the size of the contributing area and the proportion of pervious areas, water quality size of the IMP may become larger than hydromodification size, and consequently both sizing procedures are carried out.

It must be pointed out that the Points of Compliance (POC) for hydromodification purposes will correspond to the discharge of the outlet structure into the natural first order streams. The discharge pipe will be extended until it daylights to the natural terrain, and as there is no MS4, each point will become a POC, meaning that there are 32 POCs in this project. General figures and locations of the IMP can be seen in Appendix 1.

IMP SIZE FOR HYDROMODIFICATION COMPLIANCE

The required size of an IMP for hydromodification compliance depends mainly on 4 factors: 1) the peak flow minimum threshold, which will be $0.1Q_2$ in this tentative map submittal as no evaluation of susceptibility of the receiving streams will be performed at this level; 2) the soil type of the area draining to the IMP which would be B or C (or both) according to the soil map displayed in the San Diego County Hydrology Manual; 3) the slope, which can be flat, moderate or steep (or a combination of any of those three), and 4) the rainfall station that is more representative of the project location, which in this case is Lake Wohlford. It is important to mention that a susceptibility analysis could be performed at a final design stage to see if medium or low susceptibility is found and a higher minimum threshold $(0.3Q_2 \text{ or } 0.5Q_2)$ can be used.

Returning to the discussion on the current tentative map submittal design, and from the detailed analysis of the 32 contributing areas in pre-development and post-development condition attached in the Appendix 2, it is clear that in many cases mitigation has to occur for a combination of areas and slopes. For example, in IMP-16, 0.39 acres of moderate slope become impervious areas and 0.96 acres of steep slope become impervious. Consequently, a linear combination of the sizing factors must be used to obtain the final size of the IMP. In this example, as the sizing factor for moderate slope, type C is 0.11, and for steep slope, soil type C is 0.09, the resulting IMP size would be $0.11 \times 0.39 + 0.09 \times 0.96 = 0.1293$ acres or 5632 sq-ft.

It is important to realize that a basic assumption is established here: areas that do not change from pre to post-development conditions (remaining pervious and with the same slope) do not affect the size of the IMP for hydromodification purposes as those areas do not suffer any alteration in its flow duration curve from pre-development to post-development conditions. Therefore, hydromodification factors will be applied to the portion of the area that changes to impervious in post-development conditions as the sizing tables only account for such a change. In case of changes of slope, a further explanation follows.

For some areas, development does not change the characteristics of the surface but does change the characteristics of the slope. For example, a portion of the moderate slope can become steep slope due to grading operations, even though both areas are actually pervious. However, a steep slope will generate more runoff than a moderate slope, and consequently will need a certain detention size which is not considered in the sizing tables of the HMP permit. As the sizing tables do not give sizing values when there is an increase in the slope that generates an increase in runoff, TRWE has assumed that the sizing factor of areas that increase slope is conservatively half of the sizing factor of those areas when they become impervious. For example, if the sizing factor of a moderate slope becoming impervious is 0.11 for soil Type C, then the sizing factor for a moderate slope becoming steep is 0.055 for soil Type C. To help explain this assumption, Appendix 3 shows two graphics of flow duration curves for a standard 10 acre lot. The first graphic shows flow duration curves for soil Type C under Lake Wohlford precipitation assuming flat, moderate, steep slopes and flat and moderate impervious slopes; the second graphic is similar, but for soil Type B. Clearly, the effect of imperviousness is much more important than the effect of slope, but an increment in slope generates an increment in discharge as observed. Those graphics were added to show how the consideration of an increased slope in this report affects the design despite the fact that the San Diego HMP document does not show it, and how

assuming a 50% sizing factor is conservative, as the flow duration curve difference between different slopes is less than between natural soil and impervious surfaces.

If the change in area is actually a reduction of slope, then the runoff in post-development conditions will have a tendency to reduce, as shown in Appendix 3. The attenuating effect of reducing the slope of an area will not be considered. For example, in IMP-24, 0.20 acres of steep slope, soil Type B in pre-development conditions become 0.20 acres of flat slope, soil Type B in post-development conditions. The reduction in runoff for such transformation is not included, as a conservative approach.

It is worth noting that the sizing tables do not consider the difference between flat slope impervious areas and moderate slope impervious areas, and both areas are included in the last version of the SDHM Model (8-15-2011 version). However, those differences are not very significant, as shown in Appendix 3.

Finally, 3 IMPs (23, 21, and 26) have contributing areas in both soil Type B and soil Type C. In this case, the size of the IMPs is a linear combination of the sizing areas for each soil and each slope. Sizing results are shown in Table 1. The reader is referred to design Excel tables on Appendix 2, where assumptions, sizing factors and detailed calculations are shown for all 32 IMPs. Notice that if the size of the IMP is a combination of 2 or more factors, the corresponding linear equation used to determine the size is explicitly shown in each IMP table-calculations.

Design of Lower Orifice Diameter and Riser Diameter: Discussion about Q_2 and Q_{10} .

Once the area of the IMP is known, the lower level orifice must be sized. This small orifice at the bottom of the bio-retention cell should be designed in such a way that it does not discharge more than 10% of Q_2 when the bio-retention cell voids are saturated. As the gravel at the bottom has a depth of 30", the orifice diameter should be selected in such a way that the discharge of the orifice under a hydraulic head of 30" is smaller than 10% of Q_2 . The additional head associated with the saturation of the amended soils will not be considered, per typical EPA recommendations for bio-retention design, due to the fact that energy losses per Darcy's equation are approximately equal to head gain (such approximation is not valid for the gravel, as the saturated hydraulic conductivity of the gravel is much larger than the saturated hydraulic conductivity of the amended soil).

In order to determine Q_2 and Q_{10} , the peak factors for soil Type C, and soil Type B for flat, moderate and steep slopes are used (both calculated with Wohlford data, see Appendix 4). Q_2 and Q_{10} are then a linear combination of those factors depending on the size of the areas in predevelopment conditions.

For example, in the complex scenario of IMP-26, there are 6 different areas in pre-development conditions: flat-B, flat-C, moderate-B, moderate-C, steep-B, and steep-C. Therefore, Q_2 and Q_{10} are a linear combination of the six sizing factors times the six respective areas. In the case of Q_2 :

 $Q_2 = 0.2037 \cdot 0.64 + 0.2317 \cdot 7.28 + 0.2791 \cdot 3.19 + 0.1443 \cdot 0.36 + 0.1928 \cdot 1.76 + 0.2389 \cdot 1.45 = 3.144 \ cfs.$

The application of the orifice equation as explained in the calculations of each IMP in Appendix 2 allows for the design of the lower orifice diameter. It should be pointed out that the size of the orifices was adjusted to increments of 1/8 of an inch for orifices larger than ½ inch and 1/16 of an inch for orifice smaller than ½ inch, as those are the typical increments that metallic plates can be drilled to be placed in the outlet structure for the French drain discharge.

Regarding the extreme event discharge, the upper level riser should be designed to discharge Q_{10} with 2 inches of head over the riser (or more when noted in Appendix 2 for risers that are exceedingly large). Q_{10} is calculated using the same methodology as Q_2 , but with the Q_{10} sizing factors. The diameter of the riser is then obtained knowing Q_{10} , the hydraulic head and using the weir equation (See calculations in Appendix 2). Overall results are shown in Table 1.

IMP SIZE FOR WATER QUALITY COMPLIANCE

The required area of a bio-retention cell for water quality purposes can be obtained by a detailed routing of the 85th percentile 24 hour storm event combined with the characteristics of the bio-retention cell, or can be established with the simple procedure explained in the SUSMP document, which can be summarized by the following equation:

$$A_{Bio} = 0.04 \cdot A_{IMPERV} + 0.004 A_{PERV} + 0.008 A_{PAVERS}$$
 (1)

where:

A_{Bio}: Area of bio-retention (sq-ft)

A_{IMPERV}: Impervious area draining to the bio-retention (roofs, concrete, asphalt, sq-ft).

A_{PERV}: Pervious areas draining to the bio-retention (includes landscape, natural areas, pervious concrete, porous asphalt, crushed aggregate areas, and amended and mulch soil areas, sq-ft).

A_{PAVERS}: Area of solid unit pavers on granular base draining to the bio-retention cell (sq-ft). This area is zero for all 32 bio-retention cells designed here.

It should be pointed out that equation (1) does not make a distinction from pervious areas with different slope or soil type, and therefore the contributing areas to each IMP are simply divided in two areas in this report when using equation (1): impervious areas and the remaining area (there are no solid pavers in this development which would use a different weighting factor). The IMP area needed for water quality purposes is shown in Table 1.

Modification of Dimensions if Water Quality Size is larger than Hydromodification Size

Even though the hydromodification sizing factor is larger than the water quality sizing factor for impervious surfaces, there is no hydromodification sizing factor for areas that do not change from pre- to post-development condition, but there is a small sizing factor for those pervious areas for water quality purposes, as the water from impervious areas mixes with water from pervious or natural areas before treatment. Therefore, there may be scenarios when the water quality area is larger than the hydromodification area because of the large amount of pervious areas draining to a given IMP that are affecting water quality size but not hydromodification size.

Of the 32 IMPs designed, the following seven have larger water quality size than hydromodification size: IMP-2, IMP-6, IMP-26, IMP-27, IMP-29, IMP-30, and IMP-31. In this case, the water quality area is increased to satisfy equation (1) and insure compliance. However, for water quality purposes, there is no volume requirements in the simplified approach followed by the San Diego County SUSMP: the area specified is large enough to infiltrate the peak flow produced by the intensity of 0.2 in/hr, and consequently only 18 inches of amended soil are required to give enough treatment for water quality purposes. Therefore, the depth of the gravel layer and the depth of the surface layer can be reduced in such a way that the water quality BMP has the volume needed for hydromodification purposes (volume is required for hydromodification purposes as the water is stored during the continuous simulation routing).

The typical dimensions of the gravel layer and surface layer below the invert of the riser are 30" and 10" respectively. Those dimensions can be reduced if the area of the IMP is increased to comply with water quality requirements. The depth of ponding for IMP-2, IMP-6, IMP-26, IMP-27, IMP-30 and IMP-31 was assumed as follows: 10 inches, 1.5 inches, 1.5 inches, 10 inches, 10 inches, 1.5 inches, and 10 inches respectively. Ponding depth was assumed to be either 10 inches to minimize gravel, or a minimum size of 1.5 inches to insure that at least 7.5 inches of gravel remain in the design. Gravel depth was calculated equaling the hydromodification volume of voids with the volume of the modified IMP assuming the new area, and calculating the corresponding gravel depth. Volumetric equation is displayed in Appendix 2.

DRYING TIME OF IMPs

In order to demonstrate that IMPs drain in less than 96 hours to avoid potential mosquito or vector problems, the drying time of the surface volume was calculated under the assumption of constant discharge through the low level orifice (saturated gravel and amended soil, and energy level equal to depth of gravel), according to equation 2:

$$T = \frac{V}{3600Q_{orif} + f \cdot A_{IMP} / 12}$$
 (2)

where:

T: drying time of the surface volume V in hours

V: surface volume in cu-ft, equal to the A_{IMP} times the depth from the invert of the riser to the surface of the bioretention

O_{orif}: discharge flow of the lower level orifice, in cfs

f: mean permeability, defined per page 4.20 of the HMP permit as 2·INFILT·INTFW, or equivalent to 0.15 in/hr for soils type C and 0.21 in/hr for soils type B.

A_{IMP}: area of the IMP (sq-ft).

Even though the use of a French drain is not needed for soils Type B, it is still recommended in this design to reduce the drying time of the bio-retentions cells in soil Type B. Drying time values are added in Table 1, and they are significantly smaller than 96 hours for all cases.

SUMMARY

The summary of the design characteristics is included in Table 1. All IMPs designed in this Tentative Map submittal satisfy both hydromodification and water quality compliance, per the simplified methodologies of the HMP and SUSMP permits respectively.

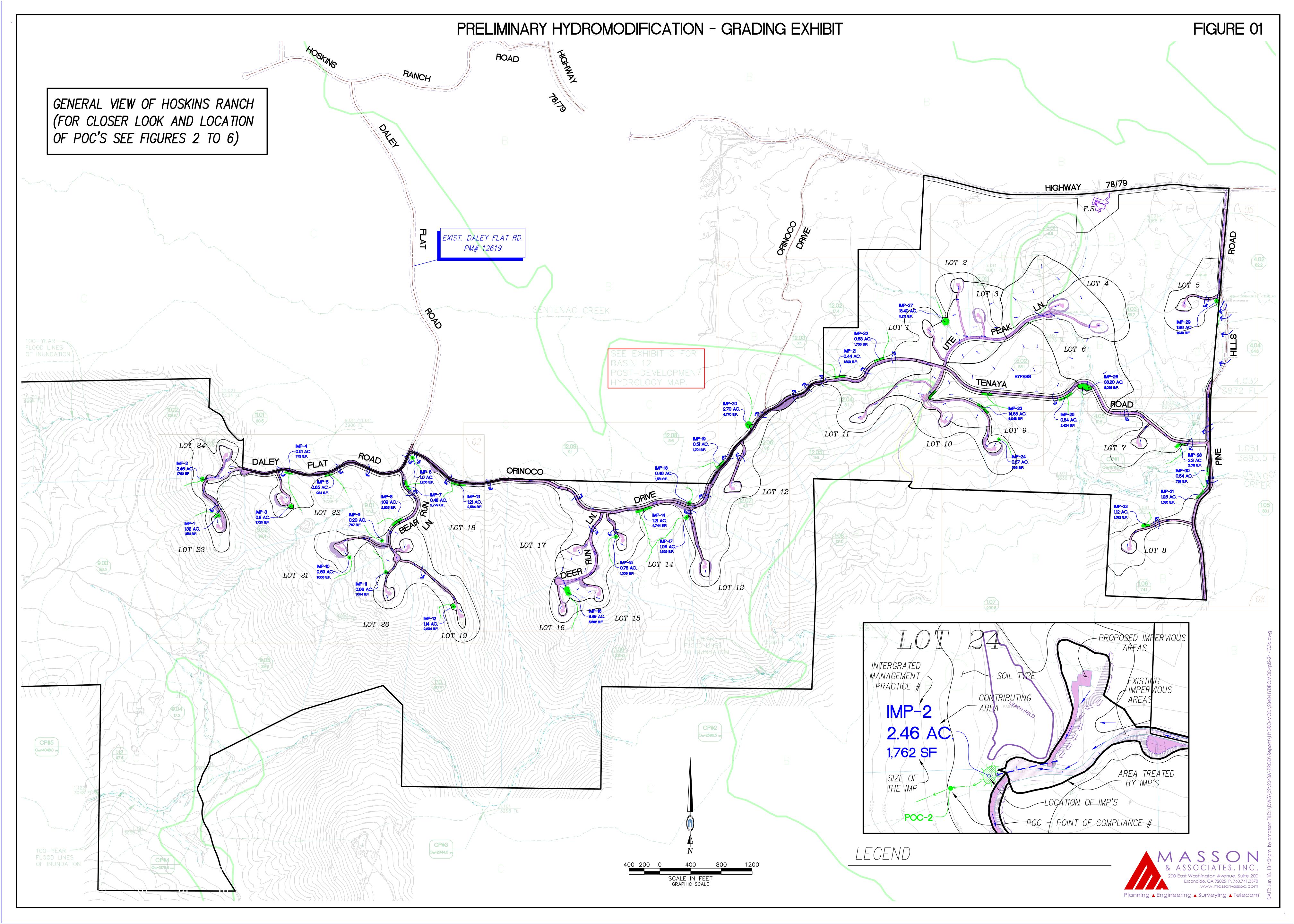
TABLE 1. Summary of IMPs Characteristics

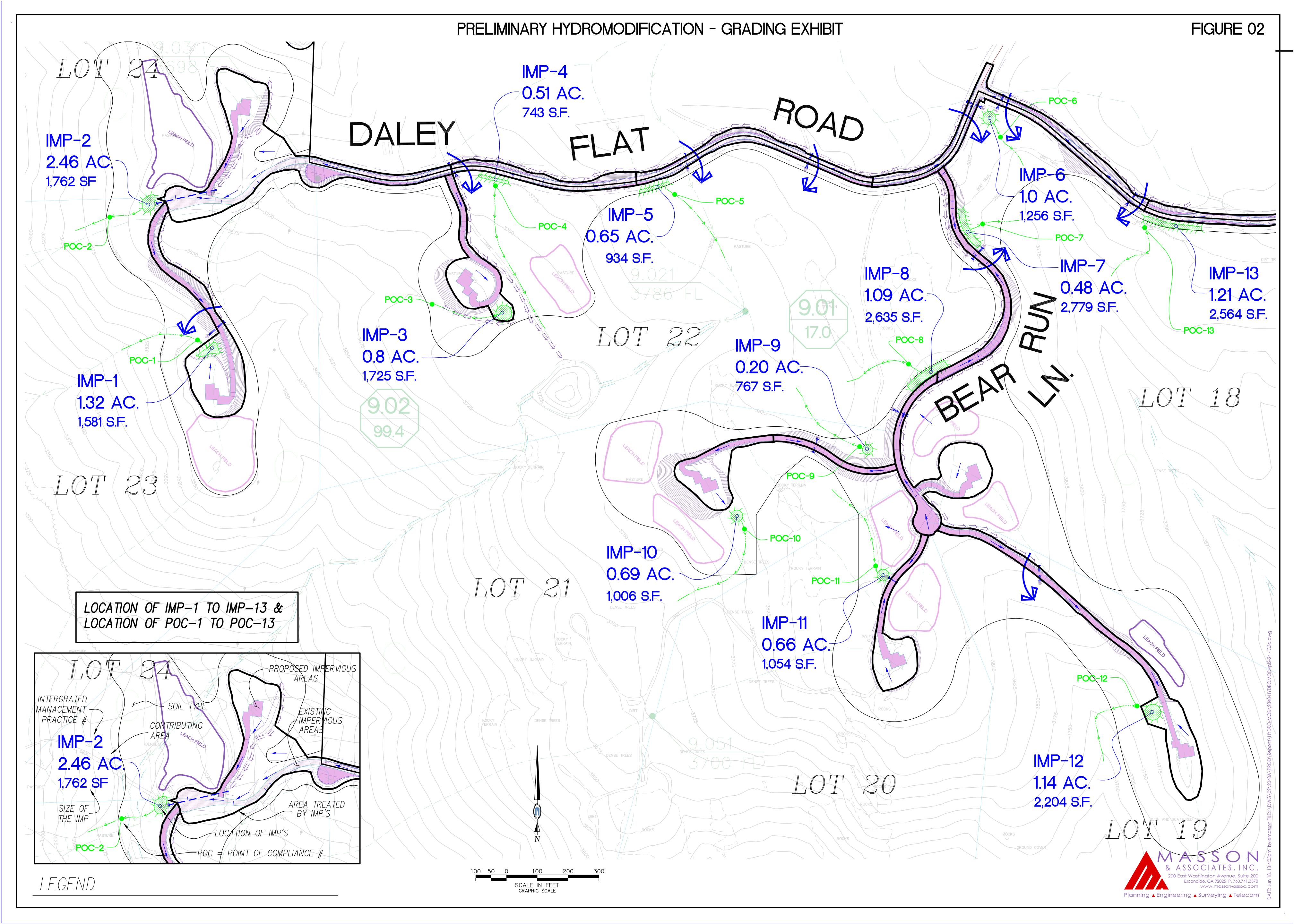
IMP#	Hydromod size (sq-ft)	WQ size (sq-ft)	IMP size (sq-ft)	D of low orifice (inches)	Riser Diam. (in)	Surface Ponding depth (in)	Top depth + free border (ft)	Depth of gravel layer (in)	Drying time (hr)
IMP1	1581	747	1581	3/4	12	10	1.5	30	12.6
IMP2	1485	1762	1762	1 1/4	24	10	1.5	18.5	5.7
IMP3	1725	704	1725	5/8	8	10	1.5	30	17.8
IMP4	743	622	743	5/8	6	10	1.5	30	9.1
IMP5	934	835	934	3/4	8	10	1.5	30	8.1
IMP6	527	1256	1256	7/8	12	1.5	1.0	9	1.2
IMP7	2779	920	2779	5/8	12	10	1.5	30	24.7
IMP8	2635	1052	2635	3/4	12	10	1.5	30	18.6
IMP9	767	286	767	5/16	6	10	1.5	30	26.2
IMP10	1006	450	1006	1/2	8	10	1.5	30	16.6
IMP11	1054	460	1054	1/2	6	10	1.5	30	17.2
IMP12	2204	920	2204	3/4	12	10	1.5	30	16.3
IMP13	2564	1544	2564	7/8	12	10	1.5	30	14.5
IMP14	4744	1669	4744	3/4	12	10	1.5	30	27.4
IMP15	1006	465	1006	5/8	8	10	1.5	30	11.7
IMP16	5632	3666	5632	2 3/8	30	10	2.0	30	5.2
IMP17	1629	718	1629	3/4	12	10	1.5	30	12.9
IMP18	1581	519	1581	1/2	6	10	1.5	30	22.9
IMP19	1701	559	1701	1/2	6	10	1.5	30	24.0
IMP20	4770	2274	4770	1 1/4	24	10	1.5	30	13.5
IMP21	1309	500	1309	7/16	6	10	1.5	30	21.0
IMP22	1703	784	1703	1/2	6	10	1.5	30	21.0
IMP23	6048	5098	6048	2 3/4	42	10	2.0	30	4.1
IMP24	566	465	566	5/8	8	10	1.5	30	6.8
IMP25	2424	1181	2424	1/2	8	10	1.5	30	25.2
IMP26	3363	8038	8038	4 1/2	60	1.5	1.5	9	0.3
IMP27	4310	5213	5213	2 3/4	42	10	2.0	17.5	3.6
IMP28	2518	2141	2518	1 1/8	24	10	1.5	30	8.9
IMP29	1849	1943	1943	1 1/8	24	10	1.5	26.5	7.2
IMP30	298	739	739	5/8	8	1.5	1.0	7.5	1.3
IMP31	1278	1580	1580	7/8	12	10	1.5	16	9.2
IMP32	1592	869	1592	5/8	12	10	1.5	30	15.3

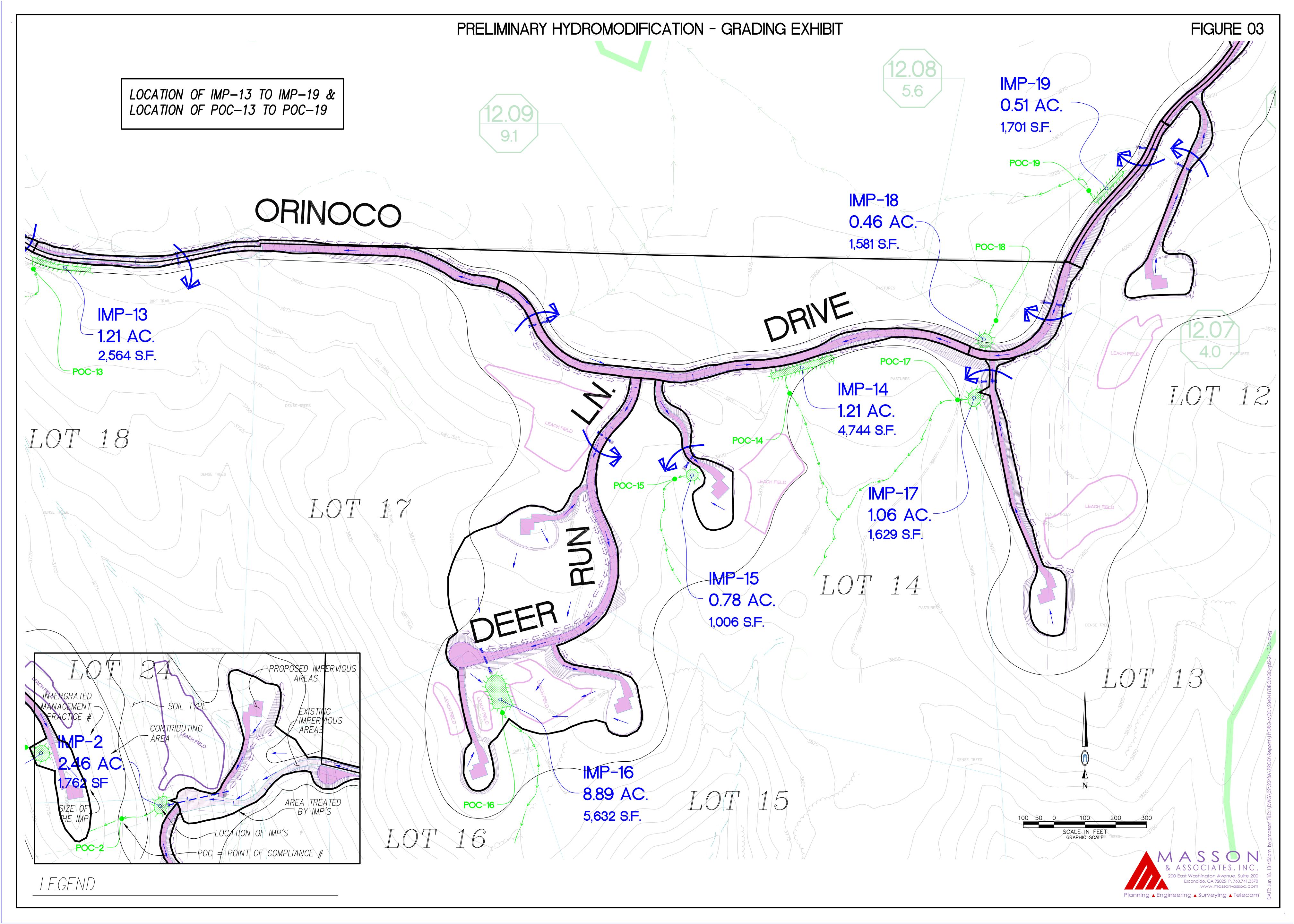
APPENDICES

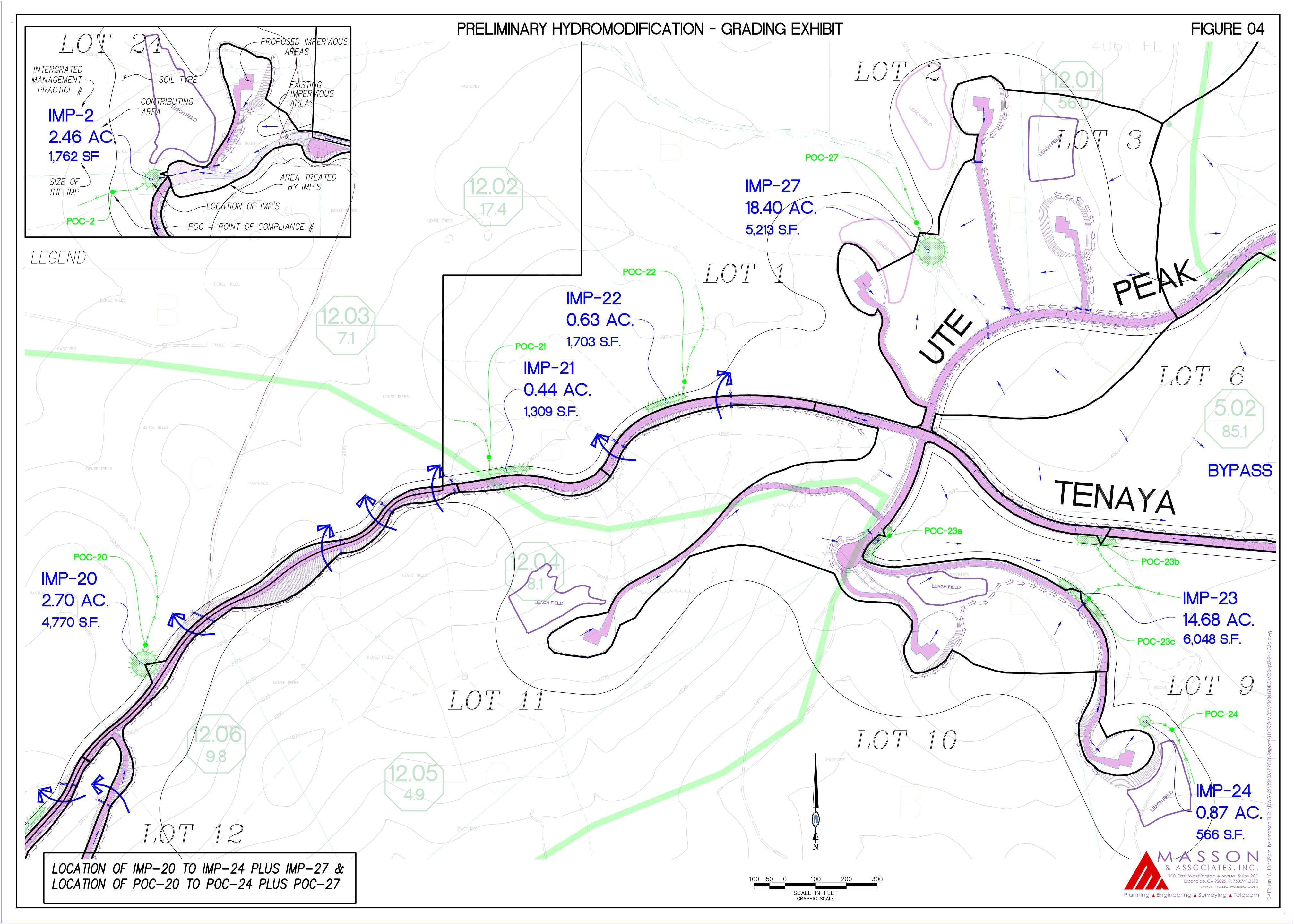
- 1. General Project Map, and detailed location of IMPs and POCs.
- 2. Excel Calculations from IMP-1 to IMP-32
- 3. Typical Flow duration curves with Lake Wohlford rainfall data for soil Type C and Type B under different combinations of slope and land use (pervious flat, pervious moderate, pervious steep, impervious flat and impervious moderate)
- 4. Typical SDHM peak flow values with Lake Wohlford rainfall data for soils Type C and B under different combinations of slope and land use (pervious flat, pervious moderate, pervious steep, impervious flat and impervious moderate)

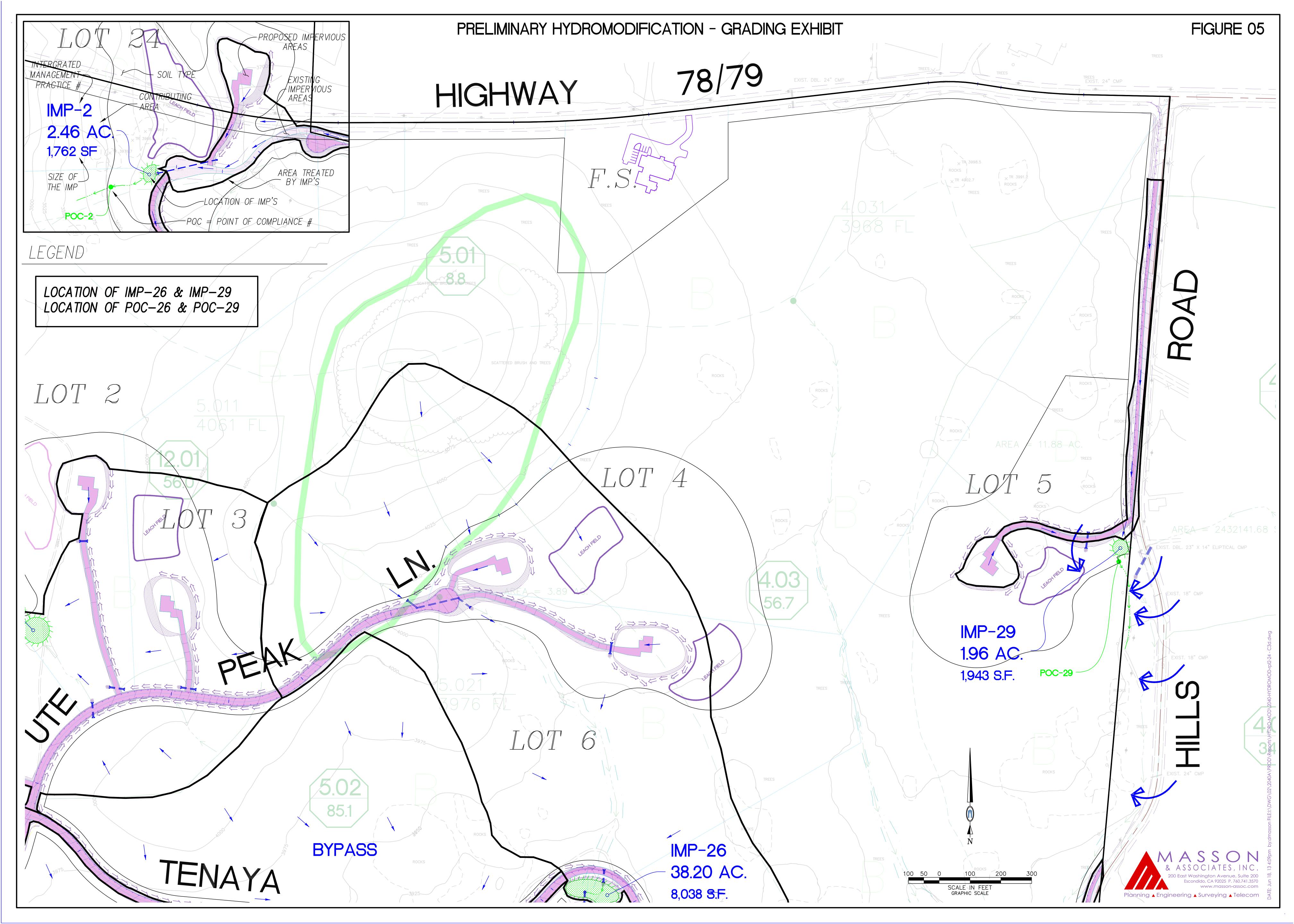
APPENDIX 1 General Project Map, and Detailed Location of IMPs and POCs

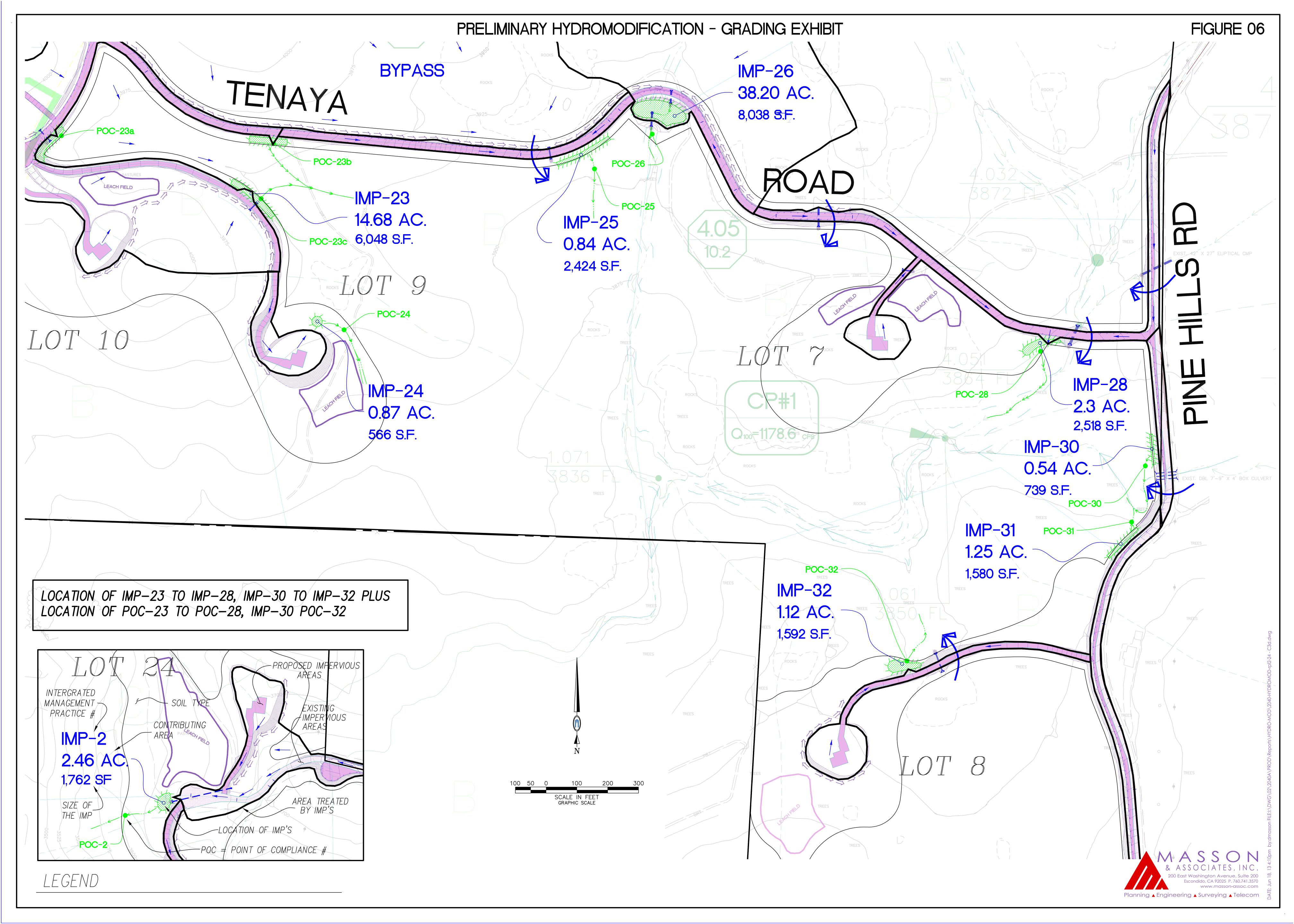












APPENDIX 2

EXCEL CALCULATIONS FROM IMP-1 TO IMP-32

Soil type: C

AREAS

Slope	Pre	Post
Flat		0.42
Moderate	1.32	0.16
Steep		0.41
Imperv.		0.33
TOTAL	1.32	1.32

Notes:

Soil transformation:

0.42 acres moderate slope become 0.42 acres flat slope

0.41 acres moderate slope become 0.41 acres steep slope

0.16 acres moderate slope remain unchanged

0.33 acres moderate slope become impervious

USE OF THE SIZING TABLE:

Asumptions:

- 1) 0.99 acres moderate in pre-development conditions is equivalent to 0.42 acres flat,
- 0.16 acres moderate and 0.41 acres steep in post-development conditions. (The weighted average slope in post development conditions is in the moderate range).
- 2) HMP mitigation has to occur only for the 0.33 acres of imperviousness, starting with
- 0.33 acres moderate slope in pre-development conditions.

SIZES:

Lake Wohlford Station, Soil Type C, 0.1Q2, medium slope, Table 7.1 of the HMP Document:

Area factor: 0.110 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0917 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12) Volume V_2 factor: 0.066 (equivalent of 18 inches of amended soil with porosity of 0.4 or 0.110 x 0.4 x 1.5)

DIMENSIONS:

Area: 1581 sq-ft (at the surface of bio-retention)

Ponding on top: 10 inches
Amended soil: 18 inches
gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 2 inches Low flow discharge cannot discharge more than 10% of Q_2 with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

Peak factor	Q_2 Q_{10}	Note:
(C, Wohlford)	(cfs/acre) (cfs/acre)	Q_2 and Q_{10} factors obtained with the
flat, grass	0.2037 0.4672	SDHM Program, version 8-15-11 for
moderate, grass	0.2317 0.4867	Wohlford station.
steep, grass	0.2791 0.5183	

 Q_2 : 0.306 cfs (0.2317 x 1.32) Q_{10} : 0.642 cfs (0.4867 x 1.32)

Diameter of the lower level orifice:

Using the orifice equation with $c_{\rm g}$ = 0.61: $0.1Q_2=0.25\pi D^2 c_g \sqrt{2g \left(H_{orif}-0.5D\right)}$ $H_{\rm orif}$, D : from the orifice equation with $c_{\rm g}$ = 0.61:

 D (inches)
 Discharge (cfs)

 0.75
 0.0236

 0.875
 0.0321

Solution: 3/4". (7/8" discharges more than 0.0306 cfs = $0.1Q_2$)

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

H (inches) L (ft) D_{riser} (inches) 2 3.05 11.6

Solution: riser must be at least 12" in diameter.

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

A_{IMP}: 747 sq-ft

As the area is smaller than for the HMP requirement, the HMP design is the dominant design.

DRYING TIME

The time to dry the top volume of the bio-retention is:

 $T = V/(3600 \cdot Q_{\text{orif}} + f \cdot A_{\text{IMP}}/12)$

V: volume of the 10" in the surface (cu-ft) = 1318 cu-ft
Q: discharge of the low orifice, cfs: 0.0236 cfs $A_{IMP}: Area of the IMP in sq-ft: 1581 sq-ft$ $f^{(1)}: infiltration of the bottom soil, in/hr: 0.15 in/hr$ T: Drying time: 12.6 hr

Soil type: C

AREAS

Slope	Pre	Post
Flat		0.42
Moderate	1.92	1.02
Steep		0.17
Imperv.	0.54	0.85
TOTAL	2.46	2.46

Notes:

Soil transformation:

0.42 acres moderate slope become 0.42 acres flat slope 0.17 acres moderate slope become 0.17 acres steep slope

1.02 acres moderate slope remain unchanged

0.54 acres impervious moderate remain unchanged

0.31 acres moderate slope become 0.31 acres impervious

USE OF THE SIZING TABLE:

Asumptions:

- 1) 1.61 acres moderate in pre-development conditions is equivalent to 0.42 acres flat,
- 1.02 acres moderate and 0.17 acres steep in post-development conditions. (The weighted average slope in post development conditions is in the moderate range).
- 2) HMP mitigation has to occur only for the 0.31 acres of imperviousness increment, starting with 0.31 acres moderate slope in pre-development conditions.

SIZES:

Lake Wohlford Station, Soil Type C, 0.1Q2, medium slope, Table 7.1 of the HMP Document:

Area factor: 0.110 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0917 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12)

Volume V_2 factor: 0.066 (equivalent of 18 inches of amended soil with porosity of 0.4 or 0.110 x 0.4 x 1.5)

DIMENSIONS:

Area: 1485 sq-ft (at the surface of bio-retention)

Ponding on top: 10 inches
Amended soil: 18 inches
gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 2 inches Low flow discharge cannot discharge more than 10% of Q_2 with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

Q_2	Q_{10}	Note:
(cfs/acre)	(cfs/acre)	\mathbf{Q}_{2} and \mathbf{Q}_{10} factors obtained with the
0.2037	0.4672	SDHM Program, version 8-15-11 for
0.2317	0.4867	Wohlford station.
0.2791	0.5183	
0.5051	0.7771	
	(cfs/acre) 0.2037 0.2317 0.2791	(cfs/acre) (cfs/acre) 0.2037 0.4672 0.2317 0.4867 0.2791 0.5183

 Q_2 : 0.718 cfs (0.2317 x 1.92+0.5051 x 0.54) Q_{10} : 1.354 cfs (0.4867 x 1.92+0.7771 x 0.54)

Diameter of the lower level orifice:

Using the orifice equation with $c_{\rm g}$ = 0.61: $0.1Q_2=0.25\pi D^2 c_g \sqrt{2g \left(H_{orif}-0.5D\right)}$ $H_{\rm orif}$, D : ft

D (inches)	Discharge (cfs)	
1 25	0.0653	

1.375

Solution: 1-1/4". (1.3/8" discharges more than 0.072 cfs = $0.1Q_2$)

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

H (inches) L (ft) D_{riser} (inches)

0.0789

2.03 6.28 24.0 Solution: riser must be approx. 24" in diameter.

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

A_{IMP}: **1762 sq-ft**

As the area is *larger* for than the HMP requirement, the WQ design is the dominant design.

MODIFICATION OF THE DIMENSIONS OF THE HMP DESIGN

In order to preserve the volume of the bio-retention, as the area is increasing, the storage depth will be reduced :

FINAL DIMENSIONS:

Area: 1762 sq-ft (at the surface of bio-retention)

Ponding on top: 10.0 inches (volume is more than need so gravel volume will reduce)

Amended soil: 18 inches (void volume is more than needed; gravel will reduce)

gravel at the bottom: 18.6 inches gravel depth to satisfy HMP volume calculated with eq. below

 $\{((30+18) \times 0.4 + 10) \times 1485 / 1762 - 18 \times 0.4 - 10\}/0.4$

DRYING TIME

The time to dry the top volume of the bio-retention is:

 $T = V/(3600 \cdot Q_{orif} + f \cdot A_{IMP}/12)$

V: volume of the 10" in the surface (cu-ft) = 1468 cu-ft
Q: discharge of the low orifice: 0.0653 cfs $A_{IMP}: Area of the IMP in sq-ft: 1762 sq-ft$ $f^{(1)}: infiltration of the bottom soil, in/hr: 0.15 in/hr$ T: Drying time: 5.7 hr

Soil type: C

AREAS

Slope	Pre	Post
Flat		0.30
Moderate	0.80	0.08
Steep		0.06
Imperv.		0.36
TOTAL	2 22	0.00

TOTAL 0.80 0.80

Notes:

Soil transformation:

0.30 acres moderate slope become 0.30 acres flat slope

0.06 acres moderate slope become 0.06 acres steep slope

0.08 acres moderate slope remain unchanged

0.36 acres moderate slope become impervious

USE OF THE SIZING TABLE:

Asumptions:

- 1) 0.44 acres moderate in pre-development conditions is equivalent to 0.30 acres flat, 0.08 acres moderate and 0.06 acres steep in post-development conditions. (The weighted average slope in post development conditions is in the flat moderate range).
- 2) HMP mitigation has to occur only for the 0.36 acres of imperviousness, starting with 0.36 acres moderate slope in pre-development conditions.

SIZES:

Lake Wohlford Station, Soil Type C, 0.1Q2, medium slope, Table 7.1 of the HMP Document:

Area factor: 0.110 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0917 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12) Volume V_2 factor: 0.066 (equivalent of 18 inches of amended soil with porosity of 0.4 or 0.110 x 0.4 x 1.5)

DIMENSIONS:

Area: 1725 sq-ft (at the surface of bio-retention)

Ponding on top: 10 inches
Amended soil: 18 inches
gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 2 inches Low flow discharge cannot discharge more than 10% of Q_2 with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

Peak factor	Q_2 Q_{10}	Note:
(C, Wohlford)	(cfs/acre) (cfs/acre)	${\rm Q}_2$ and ${\rm Q}_{10}$ factors obtained with the
flat, grass	0.2037 0.4672	SDHM Program, version 8-15-11 for
moderate, grass	0.2317 0.4867	Wohlford station.
steep, grass	0.2791 0.5183	

 Q_2 : 0.185 cfs (0.2317 x 0.80) Q_{10} : 0.389 cfs (0.4867 x 0.80)

Diameter of the lower level orifice:

Using the orifice equation with c_g = 0.61: $0.1Q_2 = 0.25\pi D^2 c_g \sqrt{2g \left(H_{orif} - 0.5D\right)}$ H_{orif} , D : ft

D (inches) Discharge (cfs)

0.625 0.0164

0.75 0.0236

Solution: 5/8". (3/4" discharges more than 0.0185 cfs = 0.1Q₂)

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

H (inches) L (ft) D_{riser} (inches)

2 1.85 7.1 Solution: riser must be at least 8" in diameter.

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

A_{IMP}: 704 sq-ft

As the area is smaller than for the HMP requirement, the HMP design is the dominant design.

DRYING TIME

The time to dry the top volume of the bio-retention is:

 $T = V/(3600 \cdot Q_{\text{orif}} + f \cdot A_{\text{IMP}}/12)$

V: volume of the 10" in the surface (cu-ft) = 1437 cu-ft Q: discharge of the low orifice: 0.0164 cfs A_{IMP} : Area of the IMP in sq-ft: 1725 sq-ft $f^{(1)}$: infiltration of the bottom soil, in/hr: 0.15 in/hr T: Drying time: 17.8 hr

Soil type: C

AREAS

Slope	Pre	Post
Flat		
Moderate	0.24	
Steep		0.17
Imperv.	0.27	0.34
TOTAL	0.51	0.51

Notes:

Soil transformation:

0.17 acres moderate slope become 0.17 acres steep slope0.27 acres impervious moderate remain unchanged

0.07 acres moderate slope become 0.07 acres impervious

USE OF THE SIZING TABLE:

Asumptions:

1) As there is no sizing value for moderate slopes becoming steep slopes, it is assumed that the sizing factor for the 0.17 acres whose slope increases is approximately and conservatively estimated as half of the sizing factor corresponding to impervious 2) HMP mitigation has to occur also for the 0.07 acres of imperviousness increase, starting with 0.07 acres moderate slope in pre-development conditions.

SIZES:

Lake Wohlford Station, Soil Type C, 0.1Q2, medium slope, Table 7.1 of the HMP Document:

Area factor: 0.110 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0917 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12) Volume V_2 factor: 0.066 (equivalent of 18 inches of amended soil with porosity of 0.4 or 0.110 x 0.4 x 1.5)

DIMENSIONS:

Area: **743 sq-ft** (at the surface of bio-retention)

Ponding on top: 10 inches (1): 43560*(0.110*0.07+0.110/2*0.17)

Amended soil: 18 inches gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 2 inches Low flow discharge cannot discharge more than 10% of Q_2 with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

Peak factor	Q_2	Q ₁₀	Note:
(C, Wohlford)	(cfs/acre) ((cfs/acre)	\mathbf{Q}_{2} and \mathbf{Q}_{10} factors obtained with the
flat, grass	0.2037	0.4672	SDHM Program, version 8-15-11 for
moderate, grass	0.2317	0.4867	Wohlford station.
steep, grass	0.2791	0.5183	
Impervious, moderate	0.5051	0.7771	

$$Q_2$$
: (0.5051 x 0.27 + 0.2317 x 0.24)
 Q_{10} : (0.7771 x 0.27 + 0.4867 x 0.24)

Diameter of the lower level orifice:

Using the orifice equation with
$$c_{\rm g}$$
 = 0.61: $0.1Q_2=0.25\pi D^2 c_g \sqrt{2g (H_{orif}-0.5D)}$ H_{orif}, D : f

D (inches)	Discharge (cfs)	
0.625	0.0164	Solution: $5/8$ ". (3/4" discharges more than 0.0192 cfs = 0.1Q ₂)
0.75	0.0236	

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

H (inches)	L (ft)	D _{riser} (inches)	
2	1.55	5.9	Solution: riser must be at least 6" in diameter.

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

As the area is smaller than for the HMP requirement, the HMP design is the dominant design.

DRYING TIME

The time to dry the top volume of the bio-retention is:

 $T = V/(3600 \cdot Q_{\text{orif}} + f \cdot A_{\text{IMP}}/12)$

V : volume of the 10" in the surface (cu-ft) = 619 cu-ft
Q: discharge of the low orifice: 0.0164 cfs $A_{IMP}: Area of the IMP in sq-ft: 743 sq-ft$ $f^{(1)}: infiltration of the bottom soil, in/hr: 0.15 in/hr$ T: Drying time: 9.1 hr

Soil type: C

AREAS

Slope	Pre	Post
Flat		
Moderate	0.29	
Steep		0.19
Imperv.	0.36	0.46
TOTAL	0.65	0.65

Notes:

Soil transformation:

- 0.19 acres moderate slope become 0.19 acres steep slope
- 0.36 acres impervious moderate remain unchanged
- 0.10 acres moderate slope become 0.10 acres impervious

USE OF THE SIZING TABLE:

Asumptions:

1) As there is no sizing value for moderate slopes becoming steep slopes, it is assumed that the sizing factor for the 0.19 acres whose slope increases is approximately and conservatively estimated as half of the sizing factor corresponding to impervious 2) HMP mitigation has to occur also for the 0.10 acres of imperviousness increase, starting with 0.10 acres moderate slope in pre-development conditions.

SIZES:

Lake Wohlford Station, Soil Type C, 0.1Q2, medium slope, Table 7.1 of the HMP Document:

Area factor: 0.110 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0917 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12) Volume V_2 factor: 0.066 (equivalent of 18 inches of amended soil with porosity of 0.4 or 0.110 x 0.4 x 1.5)

DIMENSIONS:

Area: 934 sq-ft (1) (at the surface of bio-retention)

Ponding on top: 10 inches (1): 43560*(0.110*0.10+0.110/2*0.19)

Amended soil: 18 inches gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 2 inches Low flow discharge cannot discharge more than 10% of Q_2 with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

Peak factor	Q_2	Q ₁₀	Note:
(C, Wohlford)	(cfs/acre) ((cfs/acre)	\mathbf{Q}_{2} and \mathbf{Q}_{10} factors obtained with the
flat, grass	0.2037	0.4672	SDHM Program, version 8-15-11 for
moderate, grass	0.2317	0.4867	Wohlford station.
steep, grass	0.2791	0.5183	
Impervious, moderate	0.5051	0.7771	

$$Q_2$$
: 0.249 cfs $(0.5051 \times 0.36 + 0.2317 \times 0.29)$ Q_{10} : 0.421 cfs $(0.7771 \times 0.36 + 0.4867 \times 0.29)$

Diameter of the lower level orifice:

Using the orifice equation with
$$c_g$$
 = 0.61: $0.1Q_2 = 0.25\pi D^2 c_g \sqrt{2g(H_{orif} - 0.5D)}$ H_{orif} , D : ft

D (inches)	Discharge (cfs)
0.75	0.0236
0.875	0.0321

Solution:
$$3/4$$
". (7/8" discharges more than 0.0249 cfs = $0.1Q_2$)

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

As the area is smaller than for the HMP requirement, the HMP design is the dominant design.

DRYING TIME

The time to dry the top volume of the bio-retention is:

 $T = V/(3600 \cdot Q_{orif} + f \cdot A_{IMP}/12)$

V: volume of the 10" in the surface (cu-ft) = 779 cu-ft
Q: discharge of the low orifice: 0.0236 cfs $A_{IMP}: Area of the IMP in sq-ft: 934 sq-ft$ $f^{(1)}: infiltration of the bottom soil, in/hr: 0.15 in/hr$ T: Drying time: 8.1 hr

Soil type: C

AREAS

Slope	Pre	Post
Flat		
Moderate	0.42	0.31
Steep		
Imperv.	0.58	0.69
TOTAL	4.00	4.00

TOTAL 1.00 1.00

Notes:

Soil transformation:

0.31 acres moderate slope remain unchanged

0.58 acres moderate impervious remain unchanged

0.11 acres moderate slope become 0.11 acres impervious

USE OF THE SIZING TABLE:

Asumptions:

1) HMP mitigation has to occur only for the 0.11 acres of imperviousness, starting with 0.11 acres moderate slope in pre-development conditions.

SIZES:

Lake Wohlford Station, Soil Type C, 0.1Q2, medium slope, Table 7.1 of the HMP Document:

Area factor: 0.110 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0917 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12) Volume V_2 factor: 0.066 (equivalent of 18 inches of amended soil with porosity of 0.4 or 0.110 x 0.4 x 1.5)

DIMENSIONS:

Area: 527 sq-ft (at the surface of bio-retention)

Ponding on top: 10 inches
Amended soil: 18 inches
gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q₁₀ with an hydraulic head H of 2 inches

Low flow discharge cannot discharge more than 10% of Q₂ with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

 Q_2 and Q_{10} are determined by the factors associated with rainfall station, soil type and slope.

Peak factor	Q_2	Q_{10}	Note:
(C, Wohlford)	(cfs/acre)	(cfs/acre)	\mathbf{Q}_2 and \mathbf{Q}_{10} factors obtained with the
flat, grass	0.2037	0.4672	SDHM Program, version 8-15-11 for
moderate, grass	0.2317	0.4867	Wohlford station.
steep, grass	0.2791	0.5183	
Impervious, moderate	0.5051	0.7771	

 Q_2 : 0.390 cfs (0.2317 x 0.42 + 0.5051 x 0.58) Q_{10} : 0.655 cfs (0.4867 x 0.42 + 0.7771 x 0.58)

Diameter of the lower level orifice:

Using the orifice equation with c_g = 0.61:
$$0.1Q_2 = 0.25\pi D^2 c_g \sqrt{2g \left(H_{orif} - 0.5D\right)}$$
 H_{orif}, D : ft

D (inches) Discharge (cfs)

$$0.875$$
 0.0321 Solution: **7/8"**. (1" discharges more than 0.039 cfs = $0.1Q_2$)

 1 0.0419

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

As the area is *larger* than for the HMP requirement, the WQ design is the dominant design.

MODIFICATION OF THE DIMENSIONS OF THE HMP DESIGN

In order to preserve the volume of the bio-retention, as the area is increasing, the storage depth will be reduced :

FINAL DIMENSIONS:

Area:	1256 sq-ft	(at the surface of bio-retention)
Ponding on top:	1.5 inches	(volume is less than need but storage will compensate)
Amended soil:	18 inches	(void volume is more than needed; gravel will reduce)
gravel at the bottom:	8.9 inches	gravel depth to satisfy HMP volume calculated with eq. below
		$\{((30+18) \times 0.4 + 10) \times 527 / 1256 - 18 \times 0.4 - 1.5\}/0.4$

DRYING TIME

The time to dry the top volume of the bio-retention is:

$$T = V/(3600 \cdot Q_{orif} + f \cdot A_{IMP}/12)$$

V: volume of the 2" in the surface (cu-ft) = 157 cu-ft Q: discharge of the low orifice: 0.0321 cfs A_{IMP} : Area of the IMP in sq-ft: 1256 sq-ft $f^{(1)}$: infiltration of the bottom soil, in/hr: 0.15 in/hr T: Drying time: 1.2 hr

Soil type: C

AREAS

Slope	Pre	Post
Flat		
Moderate	0.96	0.28
Steep		0.20
Imperv.		0.48
TOTAL	0.96	0.96

Notes:

Soil transformation:

0.20 acres moderate slope become 0.20 acres steep slope

0.28 acres moderate remain the same

0.48 acres moderate slope become 0.48 acres impervious

USE OF THE SIZING TABLE:

Asumptions:

1) As there is no sizing value for moderate slopes becoming steep slopes, it is assumed that the sizing factor for the 0.20 acres whose slope increases is approximately and conservatively estimated as half of the sizing factor corresponding to impervious 2) HMP mitigation has to occur also for the 0.48 acres of imperviousness, starting with 0.48 acres moderate slope in pre-development conditions.

SIZES:

Lake Wohlford Station, Soil Type C, 0.1Q2, medium slope, Table 7.1 of the HMP Document:

Area factor: 0.110 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0917 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12) Volume V_2 factor: 0.066 (equivalent of 18 inches of amended soil with porosity of 0.4 or 0.110 x 0.4 x 1.5)

DIMENSIONS:

Area: 2779 sq-ft (1) (at the surface of bio-retention)

Ponding on top: 10 inches (1): 43560*(0.110*0.48+0.110/2*0.20)

Amended soil: 18 inches gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 2 inches Low flow discharge cannot discharge more than 10% of Q_2 with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

Peak factor	Q_2	Q ₁₀	Note:
(C, Wohlford)	(cfs/acre) ((cfs/acre)	\mathbf{Q}_{2} and \mathbf{Q}_{10} factors obtained with the
flat, grass	0.2037	0.4672	SDHM Program, version 8-15-11 for
moderate, grass	0.2317	0.4867	Wohlford station.
steep, grass	0.2791	0.5183	
Impervious, moderate	0.5051	0.7771	

$$Q_2$$
: 0.222 cfs (0.2317 x 0.96) Q_{10} : 0.467 cfs (0.4867 x 0.96)

Diameter of the lower level orifice:

Using the orifice equation with c_g = 0.61:
$$0.1Q_2 = 0.25\pi D^2 c_g \sqrt{2g \big(H_{orif} - 0.5D\big)} \qquad \text{H}_{\text{orif}} \text{, D : ft}$$

D (inches)	Discharge (cfs)	
0.625	0.0164		Solution:
0.75	0.0236		

Solution: 5/8". (3/4" discharges more than 0.0222 cfs = $0.1Q_2$)

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

As the area is smaller than for the HMP requirement, the HMP design is the dominant design.

DRYING TIME

The time to dry the top volume of the bio-retention is:

 $T = V/(3600 \cdot Q_{\text{orif}} + f \cdot A_{\text{IMP}}/12)$

V : volume of the 10" in the surface (cu-ft) = 2316 cu-ft Q: discharge of the low orifice: 0.0164 cfs $A_{\text{IMP}} : \text{Area of the IMP in sq-ft}: 2779 \text{ sq-ft}$ $f^{(1)} : \text{infiltration of the bottom soil, in/hr}: 0.15 \text{ in/hr}$ T : Drying time: 24.7 hr

Soil type: C

AREAS

Slope	Pre	Post
Flat		0.48
Moderate	1.09	
Steep		0.06
Imperv.		0.55
TOTAL	4.00	4.00

TOTAL 1.09 1.09

Notes:

Soil transformation:

0.48 acres moderate slope become 0.48 acres flat slope 0.06 acres moderate slope become 0.06 acres steep slope

0.55 acres moderate slope become impervious

USE OF THE SIZING TABLE:

Asumptions:

- 1) 0.54 acres moderate in pre-development conditions is equivalent to 0.48 acres flat, and 0.06 acres steep in post-development conditions, conservative assumption. (The weighted average slope in post development conditions is in the flat range range that has a smaller runoff).
- 2) HMP mitigation has to occur only for the 0.55 acres of imperviousness, starting with 0.55 acres moderate slope in pre-development conditions.

SIZES:

Lake Wohlford Station, Soil Type C, 0.1Q2, medium slope, Table 7.1 of the HMP Document:

Area factor: 0.110 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0917 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12) Volume V_2 factor: 0.066 (equivalent of 18 inches of amended soil with porosity of 0.4 or 0.110 x 0.4 x 1.5)

DIMENSIONS:

Area: 2635 sq-ft (at the surface of bio-retention)

Ponding on top: 10 inches
Amended soil: 18 inches
gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 2 inches Low flow discharge cannot discharge more than 10% of Q_2 with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

Peak factor	Q_2	Q_{10}	Note:
(C, Wohlford)	(cfs/acre)	(cfs/acre)	\mathbf{Q}_2 and \mathbf{Q}_{10} factors obtained with the
flat, grass	0.2037	0.4672	SDHM Program, version 8-15-11 for
moderate, grass	0.2317	0.4867	Wohlford station.
steep, grass	0.2791	0.5183	
Impervious, moderate	0.5051	0.7771	

$$Q_2$$
: 0.253 cfs (0.2317 x 1.09) Q_{10} : 0.531 cfs (0.4867 x 1.09)

Diameter of the lower level orifice:

Using the orifice equation with
$$c_g$$
 = 0.61: $0.1Q_2 = 0.25\pi D^2 c_g \sqrt{2g(H_{orif} - 0.5D)}$ H_{orif} , D : ft

D (inches)	Discharge (cfs)
0.75	0.0236
0.875	0.0321

Solution: 3/4". (7/8" discharges more than 0.0253 cfs = $0.1Q_2$)

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

As the area is smaller than for the HMP requirement, the HMP design is the dominant design.

DRYING TIME

The time to dry the top volume of the bio-retention is:

 $T = V/(3600 \cdot Q_{\text{orif}} + f \cdot A_{\text{IMP}}/12)$

V : volume of the 10" in the surface (cu-ft) = 2196 cu-ft Q: discharge of the low orifice: 0.0236 cfs A_{IMP} : Area of the IMP in sq-ft : 2635 sq-ft $f^{(1)}$: infiltration of the bottom soil, in/hr : 0.15 in/hr T : Drying time: 18.6 hr

Soil type: C

AREAS

_		
Slope	Pre	Post
Flat		0.04
Moderate	0.20	
Steep		
Imperv.		0.16
TOTAL	0.20	0.20

TOTAL 0.20 0.20

Notes:

Soil transformation:

0.04 acres moderate slope become 0.04 acres flat slope

0.16 acres moderate slope become impervious

USE OF THE SIZING TABLE:

Asumptions:

- 1) HMP mitigation has to occur only for the 0.16 acres of imperviousness, starting with 0.16 acres moderate slope in pre-development conditions.
- 2) The reduction in runoff from the transformation of 0.04 acres moderate slope predelopment into 0.04 acres pervious flat slope post-development is neglected.

SIZES:

Lake Wohlford Station, Soil Type C, 0.1Q2, medium slope, Table 7.1 of the HMP Document:

Area factor: 0.110 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0917 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12)

Volume V_2 factor: 0.066 (equivalent of 18 inches of amended soil with porosity of 0.4 or 0.110 x 0.4 x 1.5)

DIMENSIONS:

Area: **767 sq-ft** (at the surface of bio-retention)

Ponding on top: 10 inches
Amended soil: 18 inches
gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q₁₀ with an hydraulic head H of 2 inches

Low flow discharge cannot discharge more than 10% of Q₂ with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

Q_2	Q ₁₀	Note:
(cfs/acre)	(cfs/acre)	\mathbf{Q}_{2} and \mathbf{Q}_{10} factors obtained with the
0.2037	0.4672	SDHM Program, version 8-15-11 for
0.2317	0.4867	Wohlford station.
0.2791	0.5183	
0.5051	0.7771	
	(cfs/acre) 0.2037 0.2317 0.2791	(cfs/acre) (cfs/acre) 0.2037 0.4672 0.2317 0.4867 0.2791 0.5183

 Q_2 : 0.046 cfs (0.2317 x 0.20) Q_{10} : 0.097 cfs (0.4867 x 0.20)

Diameter of the lower level orifice:

Using the orifice equation with c_g = 0.61: $0.1Q_2 = 0.25\pi D^2 c_g \sqrt{2g(H_{orif} - 0.5D)}$ H_{orif} , D : ft

D (inches)	Discharge (cfs
0.3125	0.0041
0.375	0.0050

Solution: 5/16". (3/8" discharges more than 0.0046 cfs = $0.1Q_2$)

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

H (inches) L (ft) D_{riser} (inches) 2 0.46 1.8

1.8 Solution: riser must be at least 6" in diameter.

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

A_{IMP}: 286 sq-ft

As the area is smaller than for the HMP requirement, the HMP design is the dominant design.

DRYING TIME

The time to dry the top volume of the bio-retention is:

 $T = V/(3600 \cdot Q_{orif} + f \cdot A_{IMP}/12)$

V: volume of the 10" in the surface (cu-ft) = 639 cu-ft
Q: discharge of the low orifice: 0.0041 cfs $A_{IMP}: Area of the IMP in sq-ft: 767 sq-ft$ $f^{(1)}: infiltration of the bottom soil, in/hr: 0.15 in/hr$ T: Drying time: 26.2 hr

Soil type: C

AREAS

Slope	Pre	Post
Flat		0.29
Moderate	0.69	0.19
Steep		
Imperv.		0.21
TOTAL	0.69	0.69

Notes:

Soil transformation:

0.29 acres moderate slope become 0.29 acres flat slope

0.19 acres moderate slope remain unchanged

0.21 acres moderate slope become impervious

USE OF THE SIZING TABLE:

Asumptions:

- 1) HMP mitigation has to occur only for the 0.21 acres of imperviousness, starting with 0.21 acres moderate slope in pre-development conditions.
- 2) The reduction in runoff from the transformation of 0.48 acres moderate slope predelopment into 0.29 acres pervious flat slope post-development plus 0.19 acres pervious moderate slope is neglected as it is a conservative approximation.

SIZES:

Lake Wohlford Station, Soil Type C, 0.1Q2, medium slope, Table 7.1 of the HMP Document:

Area factor: 0.110 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0917 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12) Volume V_2 factor: 0.066 (equivalent of 18 inches of amended soil with porosity of 0.4 or 0.110 x 0.4 x 1.5)

DIMENSIONS:

Area: 1006 sq-ft (at the surface of bio-retention)

Ponding on top: 10 inches
Amended soil: 18 inches
gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q₁₀ with an hydraulic head H of 2 inches

Low flow discharge cannot discharge more than 10% of Q₂ with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

Peak factor	Q_2 Q_{10}	Note:
(C, Wohlford)	(cfs/acre) (cfs/ac	Q_2 and Q_{10} factors obtained with the
flat, grass	0.2037 0.4	SDHM Program, version 8-15-11 for
moderate, grass	0.2317 0.4	Wohlford station.
steep, grass	0.2791 0.5	183
Impervious, moderate	0.5051 0.7	771

 Q_2 : 0.160 cfs (0.2317 x 0.69) Q_{10} : 0.336 cfs (0.4867 x 0.69)

Diameter of the lower level orifice:

Using the orifice equation with $c_{\rm g}$ = 0.61: $0.1Q_2 = 0.25\pi D^2 c_g \sqrt{2g \left(H_{orif} - 0.5D\right)}$ $H_{\rm orif}$, D : from the orifice equation with $c_{\rm g}$ = 0.61:

D (inches) Discharge (cfs)

0.5 0.0105

0.625 0.0164

Solution: 1/2". (5/8" discharges more than 0.0160 cfs = 0.1Q₂)

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

H (inches) L (ft) D_{riser} (inches) 2 1.59 6.1

Solution: riser must be at least 8" in diameter.

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

A_{IMP}: 450 sq-ft

As the area is smaller than for the HMP requirement, the HMP design is the dominant design.

DRYING TIME

The time to dry the top volume of the bio-retention is:

 $T = V/(3600 \cdot Q_{orif} + f \cdot A_{IMP}/12)$

V : volume of the 10" in the surface (cu-ft) = 839 cu-ft
Q: discharge of the low orifice: 0.0105 cfs $A_{IMP}: Area of the IMP in sq-ft: 1006 sq-ft$ $f^{(1)}: infiltration of the bottom soil, in/hr: 0.15 in/hr$ T: Drying time: 16.6 hr

Soil type: C

AREAS

Slope	Pre	Post
Flat		0.44
Moderate	0.66	
Steep		
Imperv.		0.22
TOTAL	0.66	0.66

Notes:

Soil transformation:

0.44 acres moderate slope become 0.44 acres flat slope

0.22 acres moderate slope become impervious

USE OF THE SIZING TABLE:

Asumptions:

- 1) HMP mitigation has to occur only for the 0.22 acres of imperviousness, starting with 0.22 acres moderate slope in pre-development conditions.
- 2) The reduction in runoff from the transformation of 0.44 acres moderate slope predelopment into 0.44 acres pervious flat slope post-development is neglected as it is a conservative approximation.

SIZES:

Lake Wohlford Station, Soil Type C, 0.1Q2, medium slope, Table 7.1 of the HMP Document:

Area factor: 0.110 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0917 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12) Volume V_2 factor: 0.066 (equivalent of 18 inches of amended soil with porosity of 0.4 or 0.110 x 0.4 x 1.5)

DIMENSIONS:

Area: 1054 sq-ft (at the surface of bio-retention)

Ponding on top: 10 inches
Amended soil: 18 inches
gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q₁₀ with an hydraulic head H of 2 inches

Low flow discharge cannot discharge more than 10% of Q₂ with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

Peak factor	Q_2	Q_{10}	Note:
(C, Wohlford)	(cfs/acre)	(cfs/acre)	\mathbf{Q}_2 and \mathbf{Q}_{10} factors obtained with the
flat, grass	0.2037	0.4672	SDHM Program, version 8-15-11 for
moderate, grass	0.2317	0.4867	Wohlford station.
steep, grass	0.2791	0.5183	
Impervious, moderate	0.5051	0.7771	

 Q_2 : 0.153 cfs (0.2317 x 0.66) Q_{10} : 0.321 cfs (0.4867 x 0.66)

Diameter of the lower level orifice:

Using the orifice equation with c_g = 0.61: $0.1Q_2 = 0.25\pi D^2 c_g \sqrt{2g(H_{orif} - 0.5D)}$ H_{orif} , D : from the orifice equation with c_g = 0.61: $0.1Q_2 = 0.25\pi D^2 c_g \sqrt{2g(H_{orif} - 0.5D)}$

D (inches)	Discharge (cfs)
0.5	0.0105
0.625	0.0164

Solution: 1/2". (5/8" discharges more than 0.0153 cfs = $0.1Q_2$)

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

H (inches) L (ft) D_{riser} (inches) 2 1.52 5.8

Solution: riser must be at least 6" in diameter.

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

A_{IMP}: 460 sq-ft

As the area is smaller than for the HMP requirement, the HMP design is the dominant design.

DRYING TIME

The time to dry the top volume of the bio-retention is:

 $T = V/(3600 \cdot Q_{\text{orif}} + f \cdot A_{\text{IMP}}/12)$

V : volume of the 10" in the surface (cu-ft) = 878 cu-ft
Q: discharge of the low orifice: 0.0105 cfs $A_{IMP}: Area of the IMP in sq-ft: 1054 sq-ft$ $f^{(1)}: infiltration of the bottom soil, in/hr: 0.15 in/hr$ T: Drying time: 17.2 hr

Soil type: C

AREAS

Slope	Pre	Post
Flat		0.51
Moderate	1.14	
Steep		0.17
Imperv.		0.46
TOTAL	1 1 1	1 1 /

TOTAL 1.14 1.14

Notes:

Soil transformation:

0.51 acres moderate slope become 0.51 acres flat slope 0.17 acres moderate slope become 0.17 acres steep slope

0.46 acres moderate slope become impervious

USE OF THE SIZING TABLE:

Asumptions:

- 1) 0.68 acres moderate in pre-development conditions is equivalent to 0.51 acres flat slope and 0.17 acres steep slope in post-development conditions. (The weighted average slope in post development conditions is in the moderate range).
- 2) HMP mitigation has to occur only for the 0.46 acres of imperviousness, starting with 0.46 acres moderate slope in pre-development conditions.

SIZES:

Lake Wohlford Station, Soil Type C, 0.1Q2, medium slope, Table 7.1 of the HMP Document:

Area factor: **0.110** (Table 7.1, fraction of area that must become Bio-retention)

Volume V₁ factor: 0.0917 (equivalent of 10 inches of ponding on top of the bio-retention, or $0.110 \times 10/12$) Volume V₂ factor: 0.066 (equivalent of 18 inches of amended soil with porosity of 0.4 or 0.110 x 0.4 x 1.5)

DIMENSIONS:

(at the surface of bio-retention) 2204 sq-ft Area:

Ponding on top: 10 inches Amended soil: 18 inches gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q₁₀ with an hydraulic head H of 2 inches Low flow discharge cannot discharge more than 10% of Q₂ with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

Peak factor	Q_2	Q_{10}	Note:
(C, Wohlford)	(cfs/acre) (c	cfs/acre)	\mathbf{Q}_2 and \mathbf{Q}_{10} factors obtained with the
flat, grass	0.2037	0.4672	SDHM Program, version 8-15-11 for
moderate, grass	0.2317	0.4867	Wohlford station.
steep, grass	0.2791	0.5183	
Impervious, moderate	0.5051	0.7771	

$$Q_2$$
: 0.264 cfs (0.2317 x 1.14)
 Q_{10} : 0.555 cfs (0.4867 x 1.14)

Diameter of the lower level orifice:

Using the orifice equation with
$$c_{\rm g}$$
 = 0.61: $0.1Q_2=0.25\pi D^2 c_g \sqrt{2g \left(H_{orif}-0.5D\right)}$ $H_{\rm orif}$, D : ft

D (inches)	Discharge (cfs	5)
0.75	0.0236	
0.875	0.0321	

Solution: 3/4". (7/8" discharges more than 0.0264 cfs = $0.1Q_2$)

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

H (inches) L (ft) D_{riser} (inches)

2 2.63 10.0 Solution: riser must be at least 12" in diameter.

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

A_{IMP}: 920 sq-ft

As the area is smaller than for the HMP requirement, the HMP design is the dominant design.

DRYING TIME

The time to dry the top volume of the bio-retention is:

 $T = V/(3600 \cdot Q_{orif} + f \cdot A_{IMP}/12)$

V: volume of the 10" in the surface (cu-ft) = 1837 cu-ft Q: discharge of the low orifice: 0.0236 cfs A_{IMP} : Area of the IMP in sq-ft: 2204 sq-ft $f^{(1)}$: infiltration of the bottom soil, in/hr: 0.15 in/hr T: Drying time: 16.3 hr

Soil type: C

AREAS

Slope	Pre	Post
Flat		0.04
Moderate	0.80	0.09
Steep		0.23
Imperv.	0.41	0.85

TOTAL 1.21 1.21

Notes:

Soil transformation:

0.04 acres moderate slope become 0.04 acres flat slope 0.23 acres moderate slope become 0.23 acres steep slope

0.09 acres moderate slope remain unchanged

0.41 acres impervious moderate remain unchanged

0.44 acres moderate slope become 0.44 acres impervious

USE OF THE SIZING TABLE:

Asumptions:

- 1) 0.17 acres moderate in pre-development conditions is equivalent to 0.04 acres flat, 0.09 acres moderate and 0.04 acres steep in post-development conditions. (The weighted average slope in post development conditions is in the moderate range).
- 2) As there is no sizing value for mod. slopes becoming steep, it is conservatively assumed that the sizing factor for the remaining 0.19 acres whose slope increases from moderate to steep is approximately estimated as half of the sizing factor corresponding to impervious
- 3) HMP mitigation has to occur also for the 0.44 acres of imperviousness increase, starting with 0.44 acres moderate slope in pre-development conditions.

SIZES:

Lake Wohlford Station, Soil Type C, 0.1Q2, medium slope, Table 7.1 of the HMP Document:

Area factor: 0.110 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0917 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12) Volume V_2 factor: 0.066 (equivalent of 18 inches of amended soil with porosity of 0.4 or 0.110 x 0.4 x 1.5)

DIMENSIONS:

Area: **2564 sq-ft** (at the surface of bio-retention)

Ponding on top: 10 inches (1): 43560*(0.110*0.44+0.110/2*0.19)

Amended soil: 18 inches gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 2 inches Low flow discharge cannot discharge more than 10% of Q_2 with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

Peak factor	Q_2	Q ₁₀	Note:
(C, Wohlford)	(cfs/acre)	(cfs/acre)	$\mathbf{Q_2}$ and $\mathbf{Q_{10}}$ factors obtained with the
flat, grass	0.2037	0.4672	SDHM Program, version 8-15-11 for
moderate, grass	0.2317	0.4867	Wohlford station.
steep, grass	0.2791	0.5183	
Impervious, moderate	0.5051	0.7771	

 Q_2 : 0.392 cfs (0.2317 x 0.80+0.6935 x 0.41) Q_{10} : 0.708 cfs (0.4867 x 0.80+0.7771 x 0.41)

Diameter of the lower level orifice:

Using the orifice equation with c_g = 0.61:
$$0.1Q_2 = 0.25\pi D^2 c_g \sqrt{2g \big(H_{orif} - 0.5D\big)} \qquad \text{H}_{\text{orif}} \text{, D : ft}$$

D (inches)	Discharge (cf	
0.875	0.0321	Solution: 7/8". (1" discharges more than 0.039 cfs = 0.1Q
1	0.0419	

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

H (inches)	L (ft)	D _{riser} (inches)	
2.09	3.14	12.0	Solution: riser must be approx. 12" in diameter.

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

As the area is smaller than for the HMP requirement, the HMP design is the dominant design.

DRYING TIME

The time to dry the top volume of the bio-retention is:

$$T = V/(3600 \cdot Q_{\text{orif}} + f \cdot A_{\text{IMP}}/12)$$

V: volume of the 10" in the surface (cu-ft) = 2136 cu-ft Q: discharge of the low orifice: 0.0321 cfs A_{IMP} : Area of the IMP in sq-ft: 2564 sq-ft f⁽¹⁾: infiltration of the bottom soil, in/hr: 0.15 in/hr T: Drying time: 14.5 hr

Soil type: C

AREAS

Slope	Pre	Post
Flat		0.04
Moderate	1.21	0.08
Steep		0.16
Imperv.		0.93
	4 0 4	

TOTAL 1.21 1.21

Notes:

Soil transformation:

0.04 acres moderate slope become 0.04 acres flat slope

0.16 acres moderate slope become 0.16 acres steep slope

0.08 acres moderate slope remain unchanged

0.93 acres moderate slope become impervious

USE OF THE SIZING TABLE:

Asumptions:

- 1) 0.16 acres moderate in pre-development conditions is equivalent to 0.04 acres flat, 0.08 acres moderate and 0.04 acres steep in post-development conditions. (The weighted average slope in post development conditions is in the moderate range).
- 2) As there is no sizing value for mod. slopes becoming steep, it is conservatively assumed that the sizing factor for the remaining 0.12 acres whose slope increases from moderate to steep is approximately estimated as half of the sizing factor corresponding to impervious 2) HMP mitigation has to occur also for the 0.02 acres of imperviousness, starting with
- 3) HMP mitigation has to occur also for the 0.93 acres of imperviousness, starting with 0.93 acres moderate slope in pre-development conditions.

SIZES:

Lake Wohlford Station, Soil Type C, 0.1Q2, medium slope, Table 7.1 of the HMP Document:

Area factor: 0.110 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0917 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12)

Volume V_2 factor: 0.066 (equivalent of 18 inches of amended soil with porosity of 0.4 or 0.110 x 0.4 x 1.5)

DIMENSIONS:

Area: 4744 sq-ft (1) (at the surface of bio-retention)

Ponding on top: 10 inches (1): 43560*(0.110*0.93+0.110/2*0.12)

Amended soil: 18 inches gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 2 inches Low flow discharge cannot discharge more than 10% of Q_2 with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

Peak factor	Q_2 Q_{10}	Note:
(C, Wohlford)	(cfs/acre) (cfs/acre)	\mathbf{Q}_{2} and \mathbf{Q}_{10} factors obtained with the
flat, grass	0.2037 0.4672	SDHM Program, version 8-15-11 for
moderate, grass	0.2317 0.4867	Wohlford station.
steep, grass	0.2791 0.5183	

 Q_2 : 0.280 cfs (0.2317 x 1.21) Q_{10} : 0.589 cfs (0.4867 x 1.21)

Diameter of the lower level orifice:

Using the orifice equation with $c_{\rm g}$ = 0.61: $0.1Q_2=0.25\pi D^2 c_g \sqrt{2g \left(H_{orif}-0.5D\right)}$ $H_{\rm orif}$, D : ft

D (inches)	Discharge (cfs		
0.75	0.0236	Solution: $3/4$ ". (7/8" discharges more than 0.0280 cfs = 0.1Q ₂)	
0.875	0.0321		

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

H (inches)	L (ft)	D _{riser} (inches)	
2	2.79	10.7	Solution: riser must be at least 12" in diameter.

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

As the area is smaller than for the HMP requirement, the HMP design is the dominant design.

DRYING TIME

The time to dry the top volume of the bio-retention is:

 $T = V/(3600 \cdot Q_{orif} + f \cdot A_{IMP}/12)$

V : volume of the 10" in the surface (cu-ft) = 3953 cu-ft Q: discharge of the low orifice: 0.0236 cfs A_{IMP} : Area of the IMP in sq-ft : 4744 sq-ft $f^{(1)}$: infiltration of the bottom soil, in/hr : 0.15 in/hr T : Drying time: 27.4 hr

Soil type: C

AREAS

Slope	Pre	Post
Flat		0.43
Moderate	0.78	
Steep		0.14
Imperv.		0.21
TOTAL	0.70	0.70

TOTAL 0.78 0.78

Notes:

Soil transformation:

0.43 acres moderate slope become 0.43 acres flat slope

0.14 acres moderate slope become 0.14 acres steep slope

0.21 acres moderate slope become impervious

USE OF THE SIZING TABLE:

Asumptions:

- 1) 0.57 acres moderate in pre-development conditions is equivalent to 0.43 acres flat, and 0.14 acres steep in post-development conditions, conservative assumption. (The weighted average slope in post development conditions is in the flat range range that has a smaller runoff).
- 2) HMP mitigation has to occur only for the 0.21 acres of imperviousness, starting with
- 0.21 acres moderate slope in pre-development conditions.

SIZES:

Lake Wohlford Station, Soil Type C, 0.1Q2, medium slope, Table 7.1 of the HMP Document:

Area factor: 0.110 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0917 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12) Volume V_2 factor: 0.066 (equivalent of 18 inches of amended soil with porosity of 0.4 or 0.110 x 0.4 x 1.5)

DIMENSIONS:

Area: 1006 sq-ft (at the surface of bio-retention)

Ponding on top: 10 inches
Amended soil: 18 inches
gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 2 inches Low flow discharge cannot discharge more than 10% of Q_2 with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

Peak factor	Q_2	Q_{10}	Note:
(C, Wohlford)	(cfs/acre)	(cfs/acre)	\mathbf{Q}_2 and \mathbf{Q}_{10} factors obtained with the
flat, grass	0.2037	0.4672	SDHM Program, version 8-15-11 for
moderate, grass	0.2317	0.4867	Wohlford station.
steep, grass	0.2791	0.5183	
Impervious, moderate	0.5051	0.7771	

$$Q_2$$
: 0.181 cfs (0.2317 x 0.78)
 Q_{10} : 0.380 cfs (0.4867 x 0.78)

Diameter of the lower level orifice:

Using the orifice equation with
$$c_g$$
 = 0.61: $0.1Q_2 = 0.25\pi D^2 c_g \sqrt{2g(H_{orif} - 0.5D)}$ H_{orif} , D : fr

D (inches)	Discharge (cfs)
0.625	0.0164
0.75	0.0236

Solution: 5/8". (3/4" discharges more than 0.0181 cfs = $0.1Q_2$)

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

As the area is smaller than for the HMP requirement, the HMP design is the dominant design.

DRYING TIME

The time to dry the top volume of the bio-retention is:

 $T = V/(3600 \cdot Q_{\text{orif}} + f \cdot A_{\text{IMP}}/12)$

V: volume of the 10" in the surface (cu-ft) = 839 cu-ft
Q: discharge of the low orifice: 0.0164 cfs $A_{IMP}: Area of the IMP in sq-ft: 1006 sq-ft$ $f^{(1)}: infiltration of the bottom soil, in/hr: 0.15 in/hr$ T: Drying time: 11.7 hr

Soil type: C

AREAS

Slope	Pre	Post
Flat	0.26	1.02
Moderate	2.39	1.24
Steep	6.24	5.28
Imperv.	·	1.35

TOTAL 8.89 8.89

Notes:

Soil transformation:

0.76 acres moderate slope become 0.76 acres flat slope

0.26 acres flat, 1.24 acres moderate and 5.28 acres steep

remain unchanged

0.39 acres moderate slope become impervious

0.96 acres steep slope become impervious

USE OF THE SIZING TABLE:

Asumptions:

1) HMP mitigation has to occur for 0.39 acres of imperviousness starting as 0.39 acres of moderate slope, and 0.96 acres of imperviousness starting as 0.96 acres of steep slope.

2) The reduction in runoff from the transformation of 0.76 acres moderate slope pre-dev. into 0.76 acres pervious flat slope post-development is neglected.

SIZES:

Lake Wohlford Station, Soil Type C, 0.1Q2, moderate slope, Table 7.1 of the HMP Document:

Area factor: 0.110 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0917 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12) Volume V_2 factor: 0.066 (equivalent of 18 inches of amended soil with porosity of 0.4 or 0.110 x 0.4 x 1.5)

Lake Wohlford Station, Soil Type C, 0.1Q2, steep slope, Table 7.1 of the HMP Document:

Area factor: 0.090 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.075 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12) Volume V_2 factor: 0.054 (equivalent of 18 inches of amended soil with porosity of 0.4 or 0.110 x 0.4 x 1.5)

DIMENSIONS:

Amended soil: 18 inches gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 4 inches due to size of BMP. Low flow discharge cannot discharge more than 10% of Q_2 with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

Peak factor	Q_2	Q ₁₀	Note:
(C, Wohlford)	(cfs/acre)	(cfs/acre)	${\bf Q_2}$ and ${\bf Q_{10}}$ factors obtained with the
flat, grass	0.2037	0.4672	SDHM Program, version 8-15-11 for
moderate, grass	0.2317	0.4867	Wohlford station.
steep, grass	0.2791	0.5183	

Q_2 :	2.348 cfs	(0.2037 x 0.26 + 0.2317 x 2.39 + 0.2791 x 6.24)
Q ₁₀ :	4.519 cfs	(0.4672 x 0.26 + 0.4867 x 2.39 + 0.5183 x 6.24)

Diameter of the lower level orifice:

Using the orifice equation with c_g = 0.61: $0.1Q_2 = 0.25\pi D^2 c_g \sqrt{2g \left(H_{orif} - 0.5D\right)}$ H_{orif}, D : ft

D (inches)	Discharge (cfs)	
2.375	0.2334	Solution: 2-3/8". (2-1/2" discharges more than 0.235 cfs = $0.1Q_2$)
2.5	0.2583	•

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

H (inches)	L (ft)	D _{riser} (inches)	
4	7.57	28.9	Solution: riser must be at least 30" in diameter.

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

A_{IMP}: 3666 sq-ft

As the area is smaller than for the HMP requirement, the HMP design is the dominant design.

DRYING TIME

The time to dry the top volume of the bio-retention is:

 $T = V/(3600 \cdot Q_{orif} + f \cdot A_{IMP}/12)$

V : volume of the 10" in the surface (cu-ft) = 4694 cu-ft
Q: discharge of the low orifice: 0.2334 cfs $A_{IMP}: Area of the IMP in sq-ft: 5632 sq-ft$ $f^{(1)}: infiltration of the bottom soil, in/hr: 0.15 in/hr$ T: Drying time: 5.2 hr

Soil type: C

AREAS

Slope	Pre	Post
Flat		0.43
Moderate	1.06	0.04
Steep		0.25
Imperv.		0.34
	4 0 0	4.00

TOTAL 1.06 1.06

Notes:

Soil transformation:

0.43 acres moderate slope become 0.43 acres flat slope

0.25 acres moderate slope become 0.25 acres steep slope

0.04 acres moderate slope remain unchanged

0.34 acres moderate slope become 0.34 acres impervious

USE OF THE SIZING TABLE:

Asumptions:

- 1) 0.72 acres moderate in pre-development conditions is equivalent to 0.43 acres flat, 0.04 acres moderate and 0.25 acres steep in post-development conditions. (The weighted average slope in post development conditions is in the moderate range).
- 2) HMP mitigation has to occur only for the 0.34 acres of imperviousness, starting with 0.34 acres moderate slope in pre-development conditions.

SIZES:

Lake Wohlford Station, Soil Type C, 0.1Q2, medium slope, Table 7.1 of the HMP Document:

Area factor: 0.110 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0917 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12) Volume V_2 factor: 0.066 (equivalent of 18 inches of amended soil with porosity of 0.4 or 0.110 x 0.4 x 1.5)

DIMENSIONS:

Area: 1629 sq-ft (at the surface of bio-retention)

Ponding on top: 10 inches
Amended soil: 18 inches
gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 2 inches Low flow discharge cannot discharge more than 10% of Q_2 with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

Peak factor	Q_2	Q ₁₀	Note:
(C, Wohlford)	(cfs/acre) ((cfs/acre)	\mathbf{Q}_{2} and \mathbf{Q}_{10} factors obtained with the
flat, grass	0.2037	0.4672	SDHM Program, version 8-15-11 for
moderate, grass	0.2317	0.4867	Wohlford station.
steep, grass	0.2791	0.5183	
Impervious, moderate	0.5051	0.7771	

 Q_2 : 0.246 cfs (0.2317 x 1.06) Q_{10} : 0.516 cfs (0.4867 x 1.06)

Diameter of the lower level orifice:

Using the orifice equation with $c_{\rm g}$ = 0.61: $0.1Q_2=0.25\pi D^2 c_g \sqrt{2g \left(H_{orif}-0.5D\right)}$ $H_{\rm orif}$, D : from the orifice equation with $c_{\rm g}$ = 0.61:

D (inches)	Discharge (cfs)
0.75	0.0236
0.875	0.0321

Solution: 3/4". (7/8" discharges more than 0.0246 cfs = $0.1Q_2$)

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

H (inches) L (ft) D_{riser} (inches) 2 2.45 9.3

Solution: riser must be at least 12" in diameter.

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

A_{IMP}: 718 sq-ft

As the area is smaller than for the HMP requirement, the HMP design is the dominant design.

DRYING TIME

The time to dry the top volume of the bio-retention is:

 $T = V/(3600 \cdot Q_{\text{orif}} + f \cdot A_{\text{IMP}}/12)$

V : volume of the 10" in the surface (cu-ft) = 1358 cu-ft Q: discharge of the low orifice: 0.0236 cfs A_{IMP} : Area of the IMP in sq-ft : 1629 sq-ft $f^{(1)}$: infiltration of the bottom soil, in/hr : 0.15 in/hr T : Drying time: 12.9 hr

Soil type: C

AREAS

Slope	Pre	Post
Flat		0.03
Moderate	0.46	0.02
Steep		0.13
Imperv.		0.28

TOTAL 0.46 0.46

Notes:

Soil transformation:

0.03 acres moderate slope become 0.03 acres flat slope

0.13 acres moderate slope become 0.13 acres steep slope

0.02 acres moderate slope remain unchanged

0.28 acres moderate slope become 0.28 acres impervious

USE OF THE SIZING TABLE:

Asumptions:

- 1) 0.08 acres moderate in pre-development conditions is equivalent to 0.03 acres flat, 0.02 acres moderate and 0.03 acres steep in post-development conditions. (The weighted average slope in post development conditions is in the moderate range).
- 2) As there is no sizing value for mod. slopes becoming steep, it is conservatively assumed that the sizing factor for the remaining 0.10 acres whose slope increases from moderate to steep is approximately estimated as half of the sizing factor corresponding to impervious
- 3) HMP mitigation has to occur also for the 0.28 acres of imperviousness, starting with 0.28 acres moderate slope in pre-development conditions.

SIZES:

Lake Wohlford Station, Soil Type C, 0.1Q2, medium slope, Table 7.1 of the HMP Document:

Area factor: 0.110 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0917 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12) Volume V_2 factor: 0.066 (equivalent of 18 inches of amended soil with porosity of 0.4 or 0.110 x 0.4 x 1.5)

DIMENSIONS:

Area: 1581 sq-ft (1) (at the surface of bio-retention)

Ponding on top: 10 inches (1): 43560*(0.110*0.28+0.110/2*0.10)

Amended soil: 18 inches gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 2 inches Low flow discharge cannot discharge more than 10% of Q_2 with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

Peak factor	Q_2	Q ₁₀	Note:
(C, Wohlford)	(cfs/acre)	(cfs/acre)	$\mathbf{Q_2}$ and $\mathbf{Q_{10}}$ factors obtained with the
flat, grass	0.2037	0.4672	SDHM Program, version 8-15-11 for
moderate, grass	0.2317	0.4867	Wohlford station.
steep, grass	0.2791	0.5183	
Impervious, moderate	0.5051	0.7771	

 Q_2 : 0.107 cfs (0.2317 x 0.46) Q_{10} : 0.224 cfs (0.4867 x 0.46)

Diameter of the lower level orifice:

Using the orifice equation with c_g = 0.61: $0.1Q_2 = 0.25\pi D^2 c_g \sqrt{2g(H_{orif} - 0.5D)}$ H_{orif} , D : ft

D (inches)	Discharge (cfs)
0.5	0.0105	
0.625	0.0164	•

Solution: 1/2". (5/8" discharges more than 0.0107 cfs = 0.1Q₂)

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

H (inches)	L (ft)	D _{riser} (inches)	
2	1.06	4.1	Solution: riser must be at least 6" in diameter.

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

As the area is smaller than for the HMP requirement, the HMP design is the dominant design.

DRYING TIME

The time to dry the top volume of the bio-retention is:

$$T = V/(3600 \cdot Q_{orif} + f \cdot A_{IMP}/12)$$

V: volume of the 10" in the surface (cu-ft) = 1318 cu-ft Q: discharge of the low orifice: 0.0105 cfs A_{IMP} : Area of the IMP in sq-ft: 1581 sq-ft f⁽¹⁾: infiltration of the bottom soil, in/hr: 0.15 in/hr T: Drying time: 22.9 hr

Soil type: C

AREAS

Slope	Pre	Post
Flat		0.05
Moderate	0.51	
Steep		0.16
Imperv.		0.30
====:	0 = 1	^ - 4

TOTAL 0.51 0.51

Notes:

Soil transformation:

0.05 acres moderate slope become 0.05 acres flat slope

0.16 acres moderate slope become 0.16 acres steep slope

0.30 acres moderate slope become impervious:

USE OF THE SIZING TABLE:

Asumptions:

- 1) 0.10 acres moderate in pre-development conditions is equivalent to 0.05 acres flat, and 0.05 acres steep in post-development conditions. (The weighted average slope in post development conditions for this area is in the moderate range).
- 2) As there is no sizing value for mod. slopes becoming steep, it is conservatively assumed that the sizing factor for the remaining 0.11 acres whose slope increases from moderate to steep is approximately estimated as half of the sizing factor corresponding to impervious
- 3) HMP mitigation has to occur also for the 0.30 acres of imperviousness, starting with 0.30 acres moderate slope in pre-development conditions.

SIZES:

Lake Wohlford Station, Soil Type C, 0.1Q2, medium slope, Table 7.1 of the HMP Document:

Area factor: 0.110 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0917 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12) Volume V_2 factor: 0.066 (equivalent of 18 inches of amended soil with porosity of 0.4 or 0.110 x 0.4 x 1.5)

DIMENSIONS:

Area: 1701 sq-ft (1) (at the surface of bio-retention)

Ponding on top: 10 inches (1): 43560*(0.110*0.30+0.110/2*0.11)

Amended soil: 18 inches gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 2 inches Low flow discharge cannot discharge more than 10% of Q_2 with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

Peak factor	Q_2	Q ₁₀	Note:
(C, Wohlford)	(cfs/acre)	(cfs/acre)	\mathbf{Q}_{2} and \mathbf{Q}_{10} factors obtained with the
flat, grass	0.2037	0.4672	SDHM Program, version 8-15-11 for
moderate, grass	0.2317	0.4867	Wohlford station.
steep, grass	0.2791	0.5183	
Impervious, moderate	0.5051	0.7771	

 Q_2 : 0.118 cfs (0.2317 x 0.51) Q_{10} : 0.248 cfs (0.4867 x 0.51)

Diameter of the lower level orifice:

Using the orifice equation with $c_{\rm g}$ = 0.61: $0.1Q_2=0.25\pi D^2 c_g \sqrt{2g \left(H_{orif}-0.5D\right)}$ $H_{\rm orif}$, D : ft

D (inches)	Discharge (cfs)
0.5	0.0105	
0.625	0.0164	

Solution: 1/2". (5/8" discharges more than 0.0118 cfs = 0.1Q₂)

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

H (inches)	L (ft)	D _{riser} (inches)	
2	1.18	4.5	Solution: riser must be at least 6" in diameter.

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

A_{IMP}: 559 sq-ft

As the area is smaller than for the HMP requirement, the HMP design is the dominant design.

DRYING TIME

The time to dry the top volume of the bio-retention is:

 $T = V/(3600 \cdot Q_{orif} + f \cdot A_{IMP}/12)$

V: volume of the 10" in the surface (cu-ft) = 1418 cu-ft
Q: discharge of the low orifice: 0.0105 cfs $A_{IMP}: Area of the IMP in sq-ft: 1701 sq-ft$ $f^{(1)}: infiltration of the bottom soil, in/hr: 0.15 in/hr$ T: Drying time: 24.0 hr

Soil type: C

AREAS

Slope	Pre	Post
Flat	0.18	0.53
Moderate	0.73	0.08
Steep	1.79	0.94
Imperv.		1.15

TOTAL 2.70 2.70

Notes:

Soil transformation:

0.85 acres steep slope become 0.85 acres impervious

 $0.30\,\mathrm{acres}$ moderate slope become $0.30\,\mathrm{acres}$ impervious

0.35 acres moderate slope become 0.35 acres flat slope

0.18 acres flat slope, 0.08 acres moderate slope and 0.94 acres

steep slope do not change

USE OF THE SIZING TABLE:

Asumptions:

1) HMP mitigation has to occur for 0.30 acres of imperviousness starting as 0.30 acres of moderate slope, and 0.85 acres of imperviousness starting as 0.85 acres of steep slope.

2) The reduction in runoff from the transformation of 0.35 acres moderate slope pre-dev. into 0.35 acres pervious flat slope post-development is neglected.

SIZES:

Lake Wohlford Station, Soil Type C, 0.1Q2, medium slope, Table 7.1 of the HMP Document:

Area factor: 0.110 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0917 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12) Volume V_2 factor: 0.066 (equivalent of 18 inches of amended soil with porosity of 0.4 or 0.110 x 0.4 x 1.5)

Lake Wohlford Station, Soil Type C, 0.1Q2, steep slope, Table 7.1 of the HMP Document:

Area factor: 0.090 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.075 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12) Volume V_2 factor: 0.054 (equivalent of 18 inches of amended soil with porosity of 0.4 or 0.110 x 0.4 x 1.5)

DIMENSIONS:

Area: 4770 sq-ft (1) (at the surface of bio-retention)

Ponding on top: 10 inches (1): 43560*(0.090*0.85+0.11*0.30)

Amended soil: 18 inches gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 2 inches Low flow discharge cannot discharge more than 10% of Q_2 with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

Peak factor	Q_2	Q ₁₀	Note:
(C, Wohlford)	(cfs/acre)	(cfs/acre)	$\mathbf{Q_2}$ and $\mathbf{Q_{10}}$ factors obtained with the
flat, grass	0.2037	0.4672	SDHM Program, version 8-15-11 for
moderate, grass	0.2317	0.4867	Wohlford station.
steep, grass	0.2791	0.5183	
Impervious, moderate	0.5051	0.7771	

 Q_2 : 0.705 cfs (0.2037 x 0.18 + 0.2317 x 0.73 + 0.2791 x 1.79) Q_{10} : 1.367 cfs (0.4672 x 0.18 + 0.4867 x 0.73 + 0.5183 x 1.79)

Diameter of the lower level orifice:

Using the orifice equation with $c_{\rm g}$ = 0.61: $0.1Q_2 = 0.25\pi D^2 c_g \sqrt{2g \left(H_{orif} - 0.5D\right)}$ $H_{\rm orif}$, D : ft

D (inches)	Discharge (cfs
1.25	0.0653	
1.375	0.0789	-

Solution: 1-1/4". (1-3/8" discharges more than 0.0705 cfs = 0.1Q₂)

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

H (inches)	L (ft)	D _{riser} (inches)	
2.04	6.29	24.0	Solution: riser must be at least 24" in diameter.

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

As the area is smaller than for the HMP requirement, the HMP design is the dominant design.

DRYING TIME

The time to dry the top volume of the bio-retention is:

$$T = V/(3600 \cdot Q_{\text{orif}} + f \cdot A_{\text{IMP}}/12)$$

V : volume of the 10" in the surface (cu-ft) = 3975 cu-ft Q: discharge of the low orifice: 0.0653 cfs A_{IMP} : Area of the IMP in sq-ft : 4770 sq-ft $f^{(1)}$: infiltration of the bottom soil, in/hr : 0.15 in/hr T : Drying time: 13.5 hr

Soil type: B and C

AREAS

Notes on soil Transformation:

	Slope	Pre-B	Pre-C	Post-B	Post-C	0.10 acres moderate slope B become 0.10 acres steep slope B
	Flat					0.20 acres moderate slope B become 0.20 acres impervious B
	Moderate	0.34	0.10	0.04	0.01	0.02 acres moderate slope C become 0.02 acres steep slope C
	Steep			0.10	0.02	0.07 acres moderate slope C become 0.07 acres impervious C
	Imperv.			0.20	0.07	0.04 acres moderate slope B remain the same
•	TOTAL	0.34	0.10	0.34	0.10	0.01 acres moderate slope C remain the same

USE OF THE SIZING TABLE:

Asumptions:

- 1) Mitigation has to occur for 0.20 acres moderate slope soil C and 0.07 acres moderate slope soil B becoming impervious areas according to the sizing factors applied to the respective areas
- 2) As there is no sizing value for mod. slopes becoming steep, it is conservatively assumed that the sizing factor for the 0.10 acres moderate B becoming 0.10 steep B and the 0.02 acres moderate C becoming 0.02 acres steep C is equal to half of the sizing factor of those areas becoming impervious

SIZES:

Lake Wohlford Station, Soil Type C, 0.1Q2, medium slope, Table 7.1 of the HMP Document:

Area factor: 0.110 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0917 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12) Volume V_2 factor: 0.066 (equivalent of 18 inches of amended soil with porosity of 0.4 or 0.110 x 0.4 x 1.5)

Lake Wohlford Station, Soil Type B, 0.1Q2, medium slope, Table 7.1 of the HMP Document:

Area factor: 0.085 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0708 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12) Volume V_2 factor*: 0.051 (equivalent of 18 inches of amended soil with porosity of 0.4 or 0.110 x 0.4 x 1.5)

DIMENSIONS:

Area: 1309 sq-ft (1) (at the surface of bio-retention)

Ponding on top: 10 inches (1): 43560·(0.110·0.07+0.110/2·0.02+0.085·0.20+0.085/2·0.10)

Amended soil: 18 inches gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 2 inches Low flow discharge cannot discharge more than 10% of Q_2 with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

^{*:} volume factor is not shown for soils Type A and B but is needed in the permit as the tables were calculated with 30" of gravel

Peak factor	Q_2	Q ₁₀	Peak factor	Q_2	Q ₁₀
(C, Wohlford)	(cfs/acre)	(cfs/acre)	(B, Wohlford)	(cfs/acre)	(cfs/acre)
flat, grass	0.2037	0.4672	flat, grass	0.1443	0.4183
moderate, grass	0.2317	0.4867	moderate, grass	0.1928	0.4533
steep, grass	0.2791	0.5183	steep, grass	0.2389	0.4874
Impervious, moderate	0.5051	0.7771	Impervious, moderate	0.5051	0.7771

 $\begin{array}{lll} Q_2: & 0.089 \text{ cfs} & (0.2317 \times 0.10 + 0.1928 \times 0.34) & \text{Note: } Q_2 \text{ and } Q_{10} \text{ factors obtained with the SDHM} \\ Q_{10}: & 0.203 \text{ cfs} & (0.4867 \times 0.10 + 0.4533 \times 0.34) & \text{Program, version 8-15-11 for Wohlford station.} \end{array}$

Diameter of the lower level orifice:

Using the orifice equation with c_g = 0.61: $0.1Q_2 = 0.25\pi D^2 c_g \sqrt{2g(H_{orif} - 0.5D)}$ H_{orif} , D : fr

D (inches)	Discharge (cfs)
0.4375	0.0081
0.5	0.0105

Solution: **7/16**". (1/2)" discharges more than 0.0089 cfs = $0.1Q_2$)

Note: orifice not need due to soil type, but provided to reduce drying time.

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

H (inches) L (ft) D_{riser} (inches)

2 0.96 3.7 Solution: riser must be at least 6" in diameter.

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

A_{IMP}: 500 sq-ft

As the area is smaller than for the HMP requirement, the HMP design is the dominant design.

DRYING TIME

The time to dry the top volume of the bio-retention is:

 $T = V/(3600 \cdot Q_{orif} + f \cdot A_{IMP}/12)$

V : volume of the 10" in the surface (cu-ft) = 1091 cu-ft Q: discharge of the low orifice: 0.0081 cfs A_{IMP} : Area of the IMP in sq-ft : 1309 sq-ft $f^{(1)}$: infiltration of the bottom soil, in/hr : 0.21 in/hr T : Drying time: 21.0 hr

Soil type: B

AREAS

Slope	Pre	Post
Flat		0.07
Moderate	0.63	
Steep		0.13
Imperv.		0.43
TOTAL	0.60	0.60

TOTAL 0.63 0.63

Notes:

Soil transformation:

0.07 acres moderate slope become 0.07 acres flat slope 0.13 acres moderate slope become 0.13 acres steep slope

0.43 acres moderate slope become impervious

USE OF THE SIZING TABLE:

Asumptions:

- 1) 0.14 acres moderate in pre-development conditions is equivalent to 0.07 acres flat, and 0.07 acres steep in post-development conditions. (The weighted average slope in post development conditions is in the moderate range).
- 2) As there is no sizing value for mod. slopes becoming steep, it is conservatively assumed that the sizing factor for the remaining 0.06 acres whose slope increases from moderate to steep is approximately estimated as half of the sizing factor corresponding to impervious 3) HMP mitigation has to occur also for the 0.43 acres of imperviousness, starting with
- 0.43 acres moderate slope in pre-development conditions.

SIZES:

Lake Wohlford Station, Soil Type B, 0.1Q2, moderate slope, Table 7.1 of the HMP Document:

Area factor: 0.085 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.07083 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12) Volume V_2 factor*: 0.051 (equivalent of 18 inches of amended soil with porosity of 0.4 or 0.110 x 0.4 x 1.5)

DIMENSIONS:

Area: 1703 sq-ft⁽¹⁾ (at the surface of bio-retention)

Ponding on top: 10 inches (1): $43560 \cdot (0.06 \times 0.085/2 + 0.43 \times 0.085)$

Amended soil: 18 inches gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 2 inches Low flow discharge cannot discharge more than 10% of Q_2 with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

^{*:} volume factor is not shown for soils Type A and B in Table 7.1 erroneously, but is needed in the design of the IMP as the tables were calculated with the HSPF model assuming 30" of gravel and no orifice, with discharge at the bottom due to infiltration

Peak factor	Q_2	Q ₁₀	Note:
(C, Wohlford)	(cfs/acre)	(cfs/acre)	\mathbf{Q}_{2} and \mathbf{Q}_{10} factors obtained with the
flat, grass	0.1443	0.4183	SDHM Program, version 8-15-11 for
moderate, grass	0.1928	0.4533	Wohlford station.
steep, grass	0.2389	0.4874	
Impervious, moderate	0.5051	0.7771	

 Q_2 : 0.121 cfs (0.1928 x 0.63) Q_{10} : 0.286 cfs (0.4533 x 0.63)

Diameter of the lower level orifice:

Using the orifice equation with c_g = 0.61: $0.1Q_2 = 0.25\pi D^2 c_g \sqrt{2g(H_{orif} - 0.5D)}$ H_{orif} , D : ft

D (inches)	Discharge (cfs)
0.5	0.0105	
0.625	0.0164	,

Solution: 1/2". (5/8" discharges more than 0.0121 cfs = $0.1Q_2$)

Note: orifice not need due to soil type, but provided to reduce drying time.

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter:

$$Q_{10} = K \cdot L \cdot H^{1.5}$$

H (inches)	L (ft)	D _{riser} (inches)
2	1.35	5.2

Solution: riser must be at least 6" in diameter.

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

A_{IMP}: 784 sq-ft

As the area is smaller than for the HMP requirement, the HMP design is the dominant design.

DRYING TIME

The time to dry the top volume of the bio-retention is:

 $T = V/(3600 \cdot Q_{\text{orif}} + f \cdot A_{\text{IMP}}/12)$

V: volume of the 10" in the surface (cu-ft) = 1419 cu-ft
Q: discharge of the low orifice: 0.0105 cfs $A_{IMP}: Area of the IMP in sq-ft: 1703 sq-ft$ $f^{(1)}: infiltration of the bottom soil, in/hr: 0.21 in/hr$ T: Drying time: 21.0 hr

Soil type: B and C

Notes on soil Transformation:

0.13 acres C steep become 0.13 acres C impervious 0.22 acres C moderate become 0.22 acres C impervious

AREAS

					<u> </u>
Slope	Pre-B	Pre-C	Post-B	Post-C	0.17 acres C moderate become 0.17 acres C flat
Flat	0.64	0.36	0.89	0.53	0.25 acres B steep become 0.25 acres B impervious
Moderate	7.28	1.76	6.01	1.37	1.02 acres B moderate become 1.02 acres B impervious
Steep	3.19	1.45	2.94	1.32	0.25 acres B moderate become 0.25 acres B flat
Imperv.			1.27	0.35	0.64 acres B flat, 6.01 acres B moderate, 2.94 acres B ster
TOTAL	11.11	3.57	11.11	3.57	O.36 acres C flat, 1.37 acres C moderate, and 1.32 acres C

0.36 acres C flat, 1.37 acres C moderate, and 1.32 acres C steep

do not change from pre to post-development

USE OF THE SIZING TABLE:

Asumptions:

1) Mitigation has to occur for the following 4 soils-slope combinations becoming impervious areas in post-dev: 0.13 acres C steep, 0.22 acres C moderate, 0.25 acres B steep and 1.02 acres B moderate

2) The reduction in runoff from the transformation of 0.17 acres soil C, moderate and 0.25 acres soil B moderate into 0.17 acres soil C flat and 0.25 acres soil B flat is neglected.

SIZES:

Lake Wohlford Station, Soil Type B, 0.1Q2, Table 7.1 of the HMP Document:

Area factor, moderate: 0.085 (Table 7.1, fraction of area that must become Bio-retention) Area factor, steep: 0.065 (Table 7.1, fraction of area that must become Bio-retention)

Lake Wohlford Station, Soil Type C, 0.1Q2, medium slope, Table 7.1 of the HMP Document:

Area factor, moderate: 0.110 (Table 7.1, fraction of area that must become Bio-retention) Area factor, steep: 0.090 (Table 7.1, fraction of area that must become Bio-retention)

DIMENSIONS:

6048 sq-ft (1) (at the surface of bio-retention) Area:

10 inches Ponding on top: (1): 43560·(0.065·0.25+0.085·1.02+0.090·0.13+0.11·0.22)

Amended soil: 18 inches gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 4 inches due to size of BMP. Low flow discharge cannot discharge more than 10% of Q₂ with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

Peak factor	Q_2	Q_{10}	Peak factor	Q_2	Q ₁₀
(C, Wohlford)	(cfs/acre) (cfs/acre)	(B , Wohlford)	(cfs/acre)	(cfs/acre)
flat, grass	0.2037	0.4672	flat, grass	0.1443	0.4183
moderate, grass	0.2317	0.4867	moderate, grass	0.1928	0.4533
steep, grass	0.2791	0.5183	steep, grass	0.2389	0.4874

 Q_2 : Note: Q_2 and Q_{10} factors obtained with the SDHM

Q₁₀: 6.899 cfs (6 coefficients x 6 areas) Program, version 8-15-11 for Wohlford station.

Diameter of the lower level orifice:

Using the orifice equation with c_g = 0.61: $0.1Q_2 = 0.25\pi D^2 c_g \sqrt{2g \left(H_{orif} - 0.5D\right)}$ H_{orif} , D : ft

D (inches)	Discharge (cfs
2.75	0.3119
2.875	0.3405

Solution: 2-3/4". (2-7/8" discharges more than 0.3144 cfs = $0.1Q_2$)

Note: orifice not need due to soil type, but provided to reduce drying time.

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

H (inches) L (ft) D_{riser} (inches)

4.13 11.01 42.0 Solution: riser must be at least 42" in diameter.

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

A_{IMP}: 5098 sq-ft

As the area is smaller than for the HMP requirement, the HMP design is the dominant design.

DRYING TIME

The time to dry the top volume of the bio-retention is:

 $T = V/(3600 \cdot Q_{orif} + f \cdot A_{IMP}/12)$

V: volume of the 10" in the surface (cu-ft) = 5040 cu-ft
Q: discharge of the low orifice: 0.312 cfs $A_{IMP}: Area of the IMP in sq-ft: 6048 sq-ft$ $f^{(1)}: infiltration of the bottom soil, in/hr: 0.21 in/hr$ T: Drying time: 4.1 hr

Soil type: B

AREAS

Slope	Pre	Post
Flat	0.01	0.21
Moderate	0.26	0.26
Steep	0.60	0.20
Imperv.		0.20

TOTAL 0.87 0.87

Notes:

Soil transformation:

0.20 acres steep slope become 0.20 acres flat slope

0.01 acres flat, 0.26 acres moderate and 0.20 acres steep

remain unchanged

0.20 acres steep slope become impervious

USE OF THE SIZING TABLE:

Asumptions:

- 1) HMP mitigation has to occur for the 0.20 acres of imperviousness, starting with
- 0.20 acres steep slope in pre-development conditions.
- 2) The reduction in runoff from the transformation of 0.20 acres steep slope pre-development into 0.20 acres pervious flat slope post-development is neglected.

SIZES:

Lake Wohlford Station, Soil Type B, 0.1Q2, steep slope, Table 7.1 of the HMP Document:

Area factor: 0.065 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0542 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12)

DIMENSIONS:

Area: 566 sq-ft (at the surface of bio-retention)

Ponding on top: 10 inches Amended soil: 18 inches gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q₁₀ with an hydraulic head H of 2 inches

Low flow discharge cannot discharge more than 10% of Q₂ with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

Peak factor	Q_2 Q_{10}	Note:
(B, Wohlford)	(cfs/acre) (cfs/acre)	Q_{2} and Q_{10} factors obtained with the
flat, grass	0.1443 0.4183	SDHM Program, version 8-15-11 for
moderate, grass	0.1928 0.4533	Wohlford station.
steep, grass	0.2389 0.4874	

$$Q_2$$
: 0.195 cfs (0.1443 x 0.01 + 0.1928 x 0.26 + 0.2389 x 0.60)

$$Q_{10}$$
: 0.414 cfs (0.4183 x 0.01 + 0.4533 x 0.26 + 0.4874 x 0.60)

Diameter of the lower level orifice:

Using the orifice equation with
$$c_g$$
 = 0.61: $0.1Q_2 = 0.25\pi D^2 c_g \sqrt{2g(H_{orif} - 0.5D)}$ H_{orif} , D : from the orifice equation with c_g = 0.61: $0.1Q_2 = 0.25\pi D^2 c_g \sqrt{2g(H_{orif} - 0.5D)}$

Solution:
$$5/8$$
". (3/4" discharges more than 0.0195 cfs = 0.1Q₂)

Note: orifice not need due to soil type, but provided to reduce drying time.

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter:
$$Q_{10} = K \cdot L \cdot H^{1.5}$$

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

As the area is smaller than for the HMP requirement, the HMP design is the dominant design.

DRYING TIME

The time to dry the top volume of the bio-retention is:

$$T = V/(3600 \cdot Q_{\text{orif}} + f \cdot A_{\text{IMP}}/12)$$

V : volume of the 10" in the surface (cu-ft) = 472 cu-ft
Q: discharge of the low orifice: 0.0164 cfs $A_{IMP}: Area of the IMP in sq-ft: 566 sq-ft$ $f^{(1)}: infiltration of the bottom soil, in/hr: 0.21 in/hr$ T: Drying time: 6.8 hr

Soil type: B

AREAS

Slope	Pre	Post
Flat	0.20	0.05
Moderate	0.50	0.05
Steep	0.14	0.08
Imperv.		0.66

TOTAL 0.84 0.84

Notes:

Soil transformation:

0.05 acres flat, 0.05 acres moderate and 0.08 acres steep

remain unchanged

0.15 acres flat slope become impervious

0.45 acres moderate slope become impervious

0.06 acres steep slope become impervious

USE OF THE SIZING TABLE:

Asumptions:

1) HMP mitigation has to occur for 0.15 acres of imperviousness starting as 0.15 acres of flat slope, 0.45 acres of imperviousness starting as 0.45 acres of moderate slope, and 0.06 acres of imperviousness starting as 0.06 acres of steep slope.

SIZES:

Lake Wohlford Station, Soil Type B, 0.1Q2, flat slope, Table 7.1 of the HMP Document:

Area factor: 0.090 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0750 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12)

Lake Wohlford Station, Soil Type B, 0.1Q2, medium slope, Table 7.1 of the HMP Document:

Area factor: 0.085 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0708 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12)

Lake Wohlford Station, Soil Type B, 0.1Q2, steep slope, Table 7.1 of the HMP Document:

Area factor: 0.065 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0542 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12)

DIMENSIONS:

Area: **2424 sq-ft** (at the surface of bio-retention)

Ponding on top: 10 inches (1): $43560 \times (0.09 \times 0.15 + 0.085 \times 0.45 + 0.065 \times 0.06)$

Amended soil: 18 inches gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 2 inches Low flow discharge cannot discharge more than 10% of Q_2 with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

Peak factor	Q_2	Q ₁₀	Note:
(B, Wohlford)	(cfs/acre)	(cfs/acre)	$\mathbf{Q_2}$ and $\mathbf{Q_{10}}$ factors obtained with the
flat, grass	0.1443	0.4183	SDHM Program, version 8-15-11 for
moderate, grass	0.1928	0.4533	Wohlford station.
steep, grass	0.2389	0.4874	

Q ₂ :	0.159 cfs	$(0.1443 \times 0.20 + 0.1928 \times 0.50 + 0.2389 \times 0.14)$
Q ₁₀ :	0.379 cfs	$(0.4183 \times 0.20 + 0.4533 \times 0.50 + 0.4874 \times 0.14)$

Diameter of the lower level orifice:

Using the orifice equation with $c_{\rm g}$ = 0.61: $0.1Q_2=0.25\pi D^2 c_g \sqrt{2g \left(H_{orif}-0.5D\right)}$ $H_{\rm orif}$, D : ft

D (inches) D	ischarge (cfs)	
0.5	0.0105	Solution: $1/2$ ". (5/8" discharges more than 0.0159 cfs = 0.1Q ₂)
0.625	0.0164	Note: orifice not need due to soil type, but provided to reduce drying time.

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

H (inches)	L (ft)	D _{riser} (inches)	
2	1.79	6.9	Solution: riser must be at least 8" in diameter.

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

As the area is smaller than for the HMP requirement, the HMP design is the dominant design.

DRYING TIME

The time to dry the top volume of the bio-retention is:

$$T = V/(3600 \cdot Q_{orif} + f \cdot A_{IMP}/12)$$

V : volume of the 10" in the surface (cu-ft) = 2020 cu-ft Q: discharge of the low orifice: 0.0105 cfs A_{IMP} : Area of the IMP in sq-ft : 2424 sq-ft $f^{(1)}$: infiltration of the bottom soil, in/hr : 0.21 in/hr T : Drying time: 25.2 hr

Soil type: B and C

Notes on soil Transformation:

0.01 acres C flat become 0.01 acres C impervious

AREAS 0.13 acres C moderate become 0.13 acres C impervious

Slope	Pre-B	Pre-C	Post-B	Post-C	0.02 acres C steep become 0.02 acres C impervious
Flat	3.60	0.19	4.83	0.18	0.06 acres B steep become 0.06 acres B impervious
Moderate	19.75	0.86	17.86	0.73	0.66 acres B moderate become 0.66 acres B impervious
Steep	4.86	8.95	4.80	8.93	1.23 acres B moderate become 1.23 acres B flat
Imperv.			0.72	0.16	3.60 acres B flat, 17.86 acres B moderate, 4.80 acres B steep,
TOTAL	28.21	10.00	28.21	10.00	0.18 acres C flat, 0.73 acres C moderate, and 8.93 acres C steep

do not change from pre to post-development

USE OF THE SIZING TABLE:

Asumptions:

1) Mitigation has to occur for the following 5 soils-slope combinations becoming impervious areas in post-dev: 0.01acres C flat, 0.13acres C mod, 0.02acres C steep, 0.66acres B mod and 0.06acres B steep

2) The reduction in runoff from the transformation of 1.23 acres soil B, moderate slope pre-dev. into 1.23 acres soil B pervious flat slope post-development is neglected.

SIZES:

Lake Wohlford Station, Soil Type B, 0.1Q2, Table 7.1 of the HMP Document:

Area factor, steep:

O.065 (Table 7.1, fraction of area that must become Bio-retention)

Area factor, moderate:

O.085 (Table 7.1, fraction of area that must become Bio-retention)

Lake Wohlford Station, Soil Type C, O.1Q2, Table 7.1 of the HMP Document:

Area factor, steep:

O.090 (Table 7.1, fraction of area that must become Bio-retention)

Area factor, moderate:

O.110 (Table 7.1, fraction of area that must become Bio-retention)

O.110 (Table 7.1, fraction of area that must become Bio-retention)

DIMENSIONS:

Area: 3363 sq-ft⁽¹⁾ (at the surface of bio-retention)

Ponding on top: 10 inches (1): 43560·(0.065x0.06+0.085x0.66+0.09x0.02+0.11x0.13+0.11x0.01)

Amended soil: 18 inches gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 6 inches due to size of BMP. Low flow discharge cannot discharge more than 10% of Q_2 with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

Peak factor	Q_2	Q_{10}	Peak factor	Q_2	Q_{10}
(C, Wohlford)	(cfs/acre)	(cfs/acre)	(B , Wohlford)	(cfs/acre)	(cfs/acre)
flat, grass	0.2037	0.4672	flat, grass	0.1443	0.4183
moderate, grass	0.2317	0.4867	moderate, grass	0.1928	0.4533
steep, grass	0.2791	0.5183	steep, grass	0.2389	0.4874

 Q_2 : Note: Q_2 and Q_{10} factors obtained with the SDHM

Q₁₀: 17.97 cfs (6 coefficients x 6 areas) Program, version 8-15-11 for Wohlford station.

Diameter of the lower level orifice:

0.9140

Using the orifice equation with c_g = 0.61: $0.1Q_2 = 0.25\pi D^2 c_g \sqrt{2g(H_{orif} - 0.5D)}$ H_{orif} , D : from the orifice equation with c_g = 0.61:

D (inches)	Discharge	(cfs)
		1

4.75

4.5 0).8222	Solution: $4-1/2$ ". $(4-3/4$ " discharges more than 0.822 cfs = $0.1Q_2$)

Note: orifice not need due to soil type, but provided to reduce drying time.

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

H (inches) L (ft) D_{riser} (inches)

6.17 15.71 60.0 Solution: riser must be at least 60" in diameter.

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

As the area is *larger* than for the HMP requirement, the BMP area is used for design.

MODIFICATION OF THE DIMENSIONS OF THE HMP DESIGN

In order to preserve the volume of the bio-retention, as the area is increasing, the storage depth will be reduced :

FINAL DIMENSIONS:

Area:

8038 sq-ft

(at the surface of bio-retention)

Ponding on top:

1.5 inches

(volume is more than need so gravel volume will reduce)

Amended soil:

gravel at the bottom:

8.8 inches

gravel depth to satisfy HMP volume calculated with eq. below

{((30+18) x 0.4 + 10) x 3363 / 8038 - 18 x 0.4 - 1.5}/0.4

DRYING TIME

The time to dry the top volume of the bio-retention is:

$$T = V/(3600 \cdot Q_{\text{orif}} + f \cdot A_{\text{IMP}}/12)$$

V: volume of the 10" in the surface (cu-ft) = 1005 cu-ft
Q: discharge of the low orifice: 0.8222 cfs $A_{IMP}: Area of the IMP in sq-ft: 1206 sq-ft$ $f^{(1)}: infiltration of the bottom soil, in/hr: 0.21 in/hr$ T: Drying time: 0.3 hr

Soil type: B

AREAS

Slope	Pre	Post
Flat	2.79	2.16
Moderate	11.69	11.69
Steep	3.92	3.27
Imperv.		1.28

TOTAL 18.40 18.40

Notes:

Soil transformation:

2.16 acres flat, 11.69 acres moderate and 3.27 acres steep remain unchanged

0.63 acres flat slope become impervious

0.65 acres steep slope become impervious

USE OF THE SIZING TABLE:

Asumptions:

1) HMP mitigation has to occur for 0.63 acres of imperviousness starting as 0.63 acres of flat slope, and 0.65 acres of imperviousness starting as 0.65 acres of steep slope.

SIZES:

Lake Wohlford Station, Soil Type B, 0.1Q2, flat slope, Table 7.1 of the HMP Document:

Area factor: 0.090 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0750 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12)

Lake Wohlford Station, Soil Type B, 0.1Q2, steep slope, Table 7.1 of the HMP Document:

Area factor: 0.065 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0542 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12)

DIMENSIONS:

Area: $4310 \text{ sq-ft}^{(1)}$ (at the surface of bio-retention) Ponding on top: 10 inches (1): $43560 \times (0.09 \times 0.63 + 0.065 \times 0.65)$

Amended soil: 18 inches gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 5 inches due to size of BMP. Low flow discharge cannot discharge more than 10% of Q_2 with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

Peak factor	Q_2 Q_{10}	Note:
(B, Wohlford)	(cfs/acre) (cfs/acre)	\mathbf{Q}_{2} and \mathbf{Q}_{10} factors obtained with the
flat, grass	0.1443 0.4183	SDHM Program, version 8-15-11 for
moderate, grass	0.1928 0.4533	Wohlford station.
steep, grass	0.2389 0.4874	

Q₂:
$$3.593 \text{ cfs}$$
 $(0.1443 \times 2.79 + 0.1928 \times 11.69 + 0.2389 \times 3.92)$
Q₁₀: 8.377 cfs $(0.4183 \times 2.79 + 0.4533 \times 11.69 + 0.4874 \times 3.92)$

Diameter of the lower level orifice:

Using the orifice equation with c_g = 0.61: $0.1Q_2 = 0.25\pi D^2 c_g \sqrt{2g \left(H_{orif} - 0.5D\right)}$ H_{orif} , D : ft

D (inches)	Discharge (cfs)	
2.75	0.3119	
3	0.3703	

Solution: **2.75**". (3" discharges more than 0.3593 cfs = $0.1Q_2$)

Note: orifice not need due to soil type, but provided to reduce drying time.

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

H (inches) L (ft) D_{riser} (inches) 5 10.05 38.4

Solution: riser must be at least 42" in diameter.

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

A_{IMP}: **5213** sq-ft

As the area is *larger* than for the HMP requirement, the BMP area is used for design.

MODIFICATION OF THE DIMENSIONS OF THE HMP DESIGN

In order to preserve the volume of the bio-retention, as the area is increasing, the storage depth will be reduced :

FINAL DIMENSIONS:

DRYING TIME

The time to dry the top volume of the bio-retention is:

 $T = V/(3600 \cdot Q_{\text{orif}} + f \cdot A_{\text{IMP}}/12)$

V: volume of the 10" in the surface (cu-ft) = 4344 cu-ft
Q: discharge of the low orifice: 0.312 cfs $A_{IMP}: Area of the IMP in sq-ft: 5213 sq-ft$ $f^{(1)}: infiltration of the bottom soil, in/hr: 0.21 in/hr$ T: Drying time: 3.6 hr

Soil type: B

AREAS

Slope	Pre	Post	
Flat	0.28	0.97	
Moderate	1.06	0.08	
Steep	0.65	0.14	
Imperv.	0.31	1.11	

TOTAL 2.30 2.30

Notes:

Soil transformation:

0.69 acres moderate slope become 0.69 acres flat slope 0.28 acres flat, 0.08 acres moderate, 0.14 acres steep and 0.31 acres impervious remain unchanged 0.51 acres steep slope become impervious 0.29 acres moderate slope become impervious

USE OF THE SIZING TABLE:

Asumptions:

1) HMP mitigation has to occur for 0.29 acres of imperviousness starting as 0.29 acres of moderate slope, and 0.51 acres of imperviousness starting as 0.51 acres of steep slope.

2) The reduction in runoff from the transformation of 0.69 acres moderate slope pre-dev. into 0.69 acres pervious flat slope post-development is neglected.

SIZES:

Lake Wohlford Station, Soil Type B, 0.1Q2, steep slope, Table 7.1 of the HMP Document:

Area factor: 0.065 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0542 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12)

Lake Wohlford Station, Soil Type B, 0.1Q2, moderate slope, Table 7.1 of the HMP Document:

Area factor: 0.085 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0708 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12)

DIMENSIONS:

Area: 2518 sq-ft (1) (at the surface of bio-retention)

Ponding on top: 10 inches (1): $43560 \times (0.51 \times 0.065 + 0.29 \times 0.085)$

Amended soil: 18 inches gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 2 inches Low flow discharge cannot discharge more than 10% of Q_2 with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

Peak factor	Q_2	Q_{10}	Note:
(B, Wohlford)	(cfs/acre)	(cfs/acre)	\mathbf{Q}_2 and \mathbf{Q}_{10} factors obtained with the
flat, grass	0.1443	0.4183	SDHM Program, version 8-15-11 for
moderate, grass	0.1928	0.4533	Wohlford station.
steep, grass	0.2389	0.4874	
Impervious, moderate	0.5051	0.7771	

 Q_2 : 0.557 cfs $(0.1443 \times 0.28 + 0.1928 \times 1.06 + 0.2389 \times 0.65 + 0.5051 \times 0.31)$ Q_{10} : 1.155 cfs $(0.4183 \times 0.28 + 0.4533 \times 1.06 + 0.4874 \times 0.65 + 0.7771 \times 0.31)$

Diameter of the lower level orifice:

Using the orifice equation with c_g = 0.61: $0.1Q_2 = 0.25\pi D^2 c_g \sqrt{2g(H_{orif} - 0.5D)}$ H_{orif} , D : ft

(inches)	Discharge (cfs)
1.125	0.0529
1 25	0.0653

Solution: **1-1/8**". (1-1/4" discharges more than 0.0557 cfs = 0.1Q₂)

Note: orifice not need due to soil type, but provided to reduce drying time.

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

H (inches)	L (ft)	D _{riser} (inches)	
2	5.48	20.9	Solution: riser must be at least 24" in diameter.

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

A_{IMP}: 2141 sq-ft

As the area is smaller than for the HMP requirement, the HMP design is the dominant design.

DRYING TIME

The time to dry the top volume of the bio-retention is:

 $T = V/(3600 \cdot Q_{\text{orif}} + f \cdot A_{\text{IMP}}/12)$

V : volume of the 10" in the surface (cu-ft) = 2098 cu-ft Q: discharge of the low orifice: 0.0529 cfs A_{IMP} : Area of the IMP in sq-ft : 2518 sq-ft $f^{(1)}$: infiltration of the bottom soil, in/hr : 0.21 in/hr T : Drying time: 8.9 hr

Soil type: B

AREAS

Slope	Pre	Post
Flat	0.22	0.65
Moderate	0.95	0.12
Steep	0.31	0.18
Imperv.	0.49	1.02
	4 0-	4 0-

TOTAL 1.97 1.97

Notes:

Soil transformation:

0.43 acres moderate slope become 0.43 acres flat slope
0.22 acres flat, 0.12 acres moderate, 0.18 acres steep
and 0.49 acres impervious remain unchanged
0.13 acres steep slope become impervious
0.40 acres moderate slope become impervious

USE OF THE SIZING TABLE:

Asumptions:

1) HMP mitigation has to occur for 0.40 acres of imperviousness starting as 0.40 acres of moderate slope, and 0.13 acres of imperviousness starting as 0.13 acres of steep slope.

2) The reduction in runoff from the transformation of 0.43 acres moderate slope pre-dev. into 0.43 acres pervious flat slope post-development is neglected.

SIZES:

Lake Wohlford Station, Soil Type B, 0.1Q2, steep slope, Table 7.1 of the HMP Document:

Area factor: 0.065 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0542 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12)

Lake Wohlford Station, Soil Type B, 0.1Q2, moderate slope, Table 7.1 of the HMP Document:

Area factor: 0.085 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0708 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12)

DIMENSIONS:

Amended soil: 18 inches gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 2 inches Low flow discharge cannot discharge more than 10% of Q_2 with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

 Q_2 and Q_{10} are determined by the factors associated with rainfall station, soil type and slope.

Peak factor	Q_2	Q ₁₀	Note:
(B, Wohlford)	(cfs/acre)	(cfs/acre)	\mathbf{Q}_{2} and \mathbf{Q}_{10} factors obtained with the
flat, grass	0.1443	0.4183	SDHM Program, version 8-15-11 for
moderate, grass	0.1928	0.4533	Wohlford station.
steep, grass	0.2389	0.4874	
Impervious, moderate	0.5051	0.7771	

 Q_2 : 0.536 cfs $(0.1443 \times 0.22 + 0.1928 \times 0.95 + 0.2389 \times 0.31 + 0.5051 \times 0.49)$

1.055 cfs Q_{10} : $(0.4183 \times 0.22 + 0.4533 \times 0.95 + 0.4874 \times 0.31 + 0.7771 \times 0.49)$

Diameter of the lower level orifice:

Using the orifice equation with $c_g = 0.61$: $0.1Q_2 = 0.25\pi D^2 c_g \sqrt{2g(H_{orif} - 0.5D)}$

 $536 \text{ cfs} = 0.1Q_2$

D (inches) Discharge (cfs)

 	<u> </u>	·
1.125	0.0529	Solution: 1-1/8 ". (1-1/4" discharges more than 0.0536 cfs = 0
1.25	0.0653	Note: orifice not need due to soil type, but provided to reduce drying time.

Diameter of upper level riser:

 $Q_{10} = K \cdot L \cdot H^{1.5}$ Using the weir eq. with K=3.1, H (ft), and L = perimeter:

D_{riser} (inches) H (inches) L (ft)

> 2 19.1 Solution: riser must be at least 24" in diameter. 5.00

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

1943 sq-ft A_{IMP}:

As the area is *larger* than for the HMP requirement, the BMP area is used for design.

MODIFICATION OF THE DIMENSIONS OF THE HMP DESIGN

In order to preserve the volume of the bio-retention, as the area is increasing, the storage depth will be reduced:

FINAL DIMENSIONS:

(at the surface of bio-retention) Area: 1943 sq-ft Ponding on top: 10.0 inches (volume is more than need so gravel volume will reduce) 18 inches Amended soil: (void volume is more than needed; gravel will reduce) gravel at the bottom: 26.5 inches gravel depth to satisfy HMP volume calculated with eq. below $\{((30+18) \times 0.4 + 10) \times 1849 / 1943 - 18 \times 0.4 - 10\}/0.4$

DRYING TIME

The time to dry the top volume of the bio-retention is:

 $T = V/(3600 \cdot Q_{orif} + f \cdot A_{IMP}/12)$

V: volume of the 10" in the surface (cu-ft) = 1619 cu-ft Q: discharge of the low orifice: 0.053 cfs A_{IMP}: Area of the IMP in sq-ft: 1943 sq-ft f (1): infiltration of the bottom soil, in/hr: 0.21 in/hr T: Drying time: 7.2 hr

Soil type: B

AREAS

Slope	Pre	Post
Flat	0.06	0.07
Moderate	0.11	0.05
Steep	0.06	0.02
Imperv.	0.32	0.41
TOTAL	0.55	0.55

Notes:

Soil transformation:

0.01 acres moderate slope become 0.01 acres flat slope
0.06 acres flat, 0.05 acres moderate, 0.02 acres steep
and 0.32 acres impervious remain unchanged
0.04 acres steep slope become impervious
0.05 acres moderate slope become impervious

USE OF THE SIZING TABLE:

Asumptions:

1) HMP mitigation has to occur for 0.05 acres of imperviousness starting as 0.05 acres of moderate slope, and 0.04 acres of imperviousness starting as 0.04 acres of steep slope.

2) The reduction in runoff from the transformation of 0.01 acres moderate slope pre-dev. into 0.01 acres pervious flat slope post-development is neglected.

SIZES:

Lake Wohlford Station, Soil Type B, 0.1Q2, steep slope, Table 7.1 of the HMP Document:

Area factor: 0.065 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0542 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12)

Lake Wohlford Station, Soil Type B, 0.1Q2, moderate slope, Table 7.1 of the HMP Document:

Area factor: 0.085 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0708 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12)

DIMENSIONS:

Area: 298 sq-ft $^{(1)}$ (at the surface of bio-retention) Ponding on top: 10 inches $(1): 43560 \times (0.04 \times 0.065 + 0.05 \times 0.085)$

Amended soil: 18 inches gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 2 inches Low flow discharge cannot discharge more than 10% of Q_2 with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

 Q_2 and Q_{10} are determined by the factors associated with rainfall station, soil type and slope.

Peak factor	Q_2	Q ₁₀	Note:
(B, Wohlford)	(cfs/acre) ((cfs/acre)	\mathbf{Q}_2 and \mathbf{Q}_{10} factors obtained with the
flat, grass	0.1443	0.4183	SDHM Program, version 8-15-11 for
moderate, grass	0.1928	0.4533	Wohlford station.
steep, grass	0.2389	0.4874	
Impervious, moderate	0.5051	0.7771	

Q_2 :	0.206 cfs	(0.1443 x 0.06 + 0.1928 x 0.11 + 0.2389 x 0.06 + 0.5051 x 0.32)
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$$Q_{10}$$
: 0.353 cfs (0.4183 x 0.06 + 0.4533 x 0.11 + 0.4874 x 0.06 + 0.7771 x 0.32)

Diameter of the lower level orifice:

Using the orifice equation with
$$c_g$$
 = 0.61: $0.1Q_2 = 0.25\pi D^2 c_g \sqrt{2g(H_{orif} - 0.5D)}$ H_{orif} , D : from the orifice equation with c_g = 0.61: $0.1Q_2 = 0.25\pi D^2 c_g \sqrt{2g(H_{orif} - 0.5D)}$

D (inches)	Discharge	<u>(</u> cfs)

0.625	0.0164
0.75	0.0236

Solution: 5/8". (3/4" discharges more than 0.0206 cfs = $0.1Q_2$)

Note: orifice not need due to soil type, but provided to reduce drying time.

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

2 1.67 6.4

Solution: riser must be at least 8" in diameter.

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

A_{IMP}:

739 sq-ft

As the area is *larger* than for the HMP requirement, the BMP area is used for design.

MODIFICATION OF THE DIMENSIONS OF THE HMP DESIGN

In order to preserve the volume of the bio-retention, as the area is increasing, the storage depth will be reduced :

FINAL DIMENSIONS:

Area:	739 sq-ft	(at the surface of bio-retention)
Ponding on top:	1.5 inches	(volume is less than need so gravel volume will compensate)
Amended soil:	18 inches	(void volume is more than needed; gravel will reduce)
gravel at the bottom:	7.7 inches	gravel depth to satisfy HMP volume calculated with eq. below
		{((30+18) x 0.4 + 10)x 298 / 739 - 18 x 0.4 - 1.5}/0.4

DRYING TIME

The time to dry the top volume of the bio-retention is:

 $T = V/(3600 \cdot Q_{orif} + f \cdot A_{IMP}/12)$

V: volume of the 10" in the surface (cu-ft) = 92 cu-ft
Q: discharge of the low orifice: 0.0164 cfs $A_{IMP}: Area of the IMP in sq-ft: 739 sq-ft$ $f^{(1)}: infiltration of the bottom soil, in/hr: 0.21 in/hr$ T: Drying time: 1.3 hr

Soil type: B

AREAS

Slope	Pre	Post
Flat	0.43	0.14
Moderate	0.21	0.21
Steep	0.07	0.02
Imperv.	0.53	0.87
TOTAL	1.24	1.24

Notes:

Soil transformation:

0.14 acres flat, 0.21 acres moderate, 0.02 acres steep and 0.53 acres impervious remain unchanged0.05 acres steep slope become impervious0.29 acres flat slope become impervious

USE OF THE SIZING TABLE:

Asumptions:

1) HMP mitigation has to occur for 0.29 acres of imperviousness starting as 0.29 acres of flat slope, and 0.05 acres of imperviousness starting as 0.05 acres of steep slope.

SIZES:

Lake Wohlford Station, Soil Type B, 0.1Q2, steep slope, Table 7.1 of the HMP Document:

Area factor: 0.065 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0542 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12)

Lake Wohlford Station, Soil Type B, 0.1Q2, flat slope, Table 7.1 of the HMP Document:

Area factor: 0.090 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.075 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12)

DIMENSIONS:

Area: 1278 sq-ft $^{(1)}$ (at the surface of bio-retention) Ponding on top: 10 inches (1): 43560 x (0.05 x 0.065 + 0.29 x 0.09)

Amended soil: 18 inches gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 2 inches Low flow discharge cannot discharge more than 10% of Q_2 with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q₂ AND Q₁₀

 ${\bf Q}_{2}$ and ${\bf Q}_{10}$ are determined by the factors associated with rainfall station, soil type and slope.

Peak factor	Q_2	Q ₁₀	Note:
(B, Wohlford)	(cfs/acre) ((cfs/acre)	\mathbf{Q}_2 and \mathbf{Q}_{10} factors obtained with the
flat, grass	0.1443	0.4183	SDHM Program, version 8-15-11 for
moderate, grass	0.1928	0.4533	Wohlford station.
steep, grass	0.2389	0.4874	
Impervious, moderate	0.5051	0.7771	

Q_2 :	0.387 cfs	(0.1443 x 0.43 + 0.1928 x 0.21 + 0.2389 x 0.07 + 0.5051 x 0.53)
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$$Q_{10}$$
: 0.721 cfs (0.4183 x 0.43 + 0.4533 x 0.21 + 0.4874 x 0.07 + 0.7771 x 0.53)

Diameter of the lower level orifice:

Using the orifice equation with
$$c_{\rm g}$$
 = 0.61: $0.1Q_2=0.25\pi D^2 c_g \sqrt{2g \left(H_{orif}-0.5D\right)}$ $H_{\rm orif}$, D : from the orifice equation with $c_{\rm g}$ = 0.61: $0.1Q_2=0.25\pi D^2 c_g \sqrt{2g \left(H_{orif}-0.5D\right)}$

D (inches)	Discharge (cfs)
0.875	0.0321	

Solution: 7/8". (1" discharges more than 0.0387 cfs = $0.1Q_2$)

Note: orifice not need due to soil type, but provided to reduce drying time.

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

H (inches) L (ft) D_{riser} (inches)

0.0419

2.11 3.15 12.0 Solution: riser must be at least 12" in diameter.

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

A_{IMP}: **1580** sq-ft

As the area is *larger* than for the HMP requirement, the BMP area is used for design.

MODIFICATION OF THE DIMENSIONS OF THE HMP DESIGN

In order to preserve the volume of the bio-retention, as the area is increasing, the storage depth will be reduced :

FINAL DIMENSIONS:

Area:	1580 sq-ft	(at the surface of bio-retention)
Ponding on top:	10.0 inches	(volume is less than need so gravel volume will compensate)
Amended soil:	18 inches	(void volume is more than needed; gravel will reduce)
gravel at the bottom:	16.1 inches	gravel depth to satisfy HMP volume calculated with eq. below
		$\{((30+18) \times 0.4 + 10) \times 1298 / 1580 - 18 \times 0.4 - 10\}/0.4$

DRYING TIME

The time to dry the top volume of the bio-retention is:

 $T = V/(3600 \cdot Q_{\text{orif}} + f \cdot A_{\text{IMP}}/12)$

V: volume of the 10" in the surface (cu-ft) = 1317 cu-ft Q: discharge of the low orifice: 0.032 cfs A_{IMP} : Area of the IMP in sq-ft: 1580 sq-ft f⁽¹⁾: infiltration of the bottom soil, in/hr: 0.21 in/hr T: Drying time: 9.2 hr

Soil type: B

AREAS

Slope	Pre	Post
Flat	0.14	0.52
Moderate	0.89	0.05
Steep	0.09	0.12
Imperv.		0.43
	4.0	4 4 4

TOTAL 1.12 1.12

Notes:

Soil transformation:

0.03 acres moderate slope become 0.03 acres steep slope 0.38 acres moderate slope become 0.38 acres flat slope 0.14 acres flat, 0.05 acres moderate and 0.09 acres steep remain unchanged

0.43 acres moderate slope become impervious

USE OF THE SIZING TABLE:

Asumptions:

- 1) HMP mitigation has to occur for 0.43 acres of imperviousness starting as 0.43 acres of moderate slope.
- 2) The reduction in runoff from the combined transformation of 0.38 acres mod. slope pre-dev. into 0.38 acres flat slope post-dev. added to the increase in runoff from the transformation of 0.03 acres of moderate slope pre-dev. becoming 0.03 acres of steep slope post-dev. is neglected

SIZES:

Lake Wohlford Station, Soil Type B, 0.1Q2, moderate slope, Table 7.1 of the HMP Document:

Area factor: 0.085 (Table 7.1, fraction of area that must become Bio-retention)

Volume V_1 factor: 0.0708 (equivalent of 10 inches of ponding on top of the bio-retention, or 0.110 x 10/12)

DIMENSIONS:

Area: 1592 sq-ft (at the surface of bio-retention)

Ponding on top: 10 inches
Amended soil: 18 inches
gravel at the bottom: 30 inches

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 2 inches Low flow discharge cannot discharge more than 10% of Q_2 with an hydraulic head H_{orif} of 2.5 ft

DETERMINATION OF Q2 AND Q10

 Q_2 and Q_{10} are determined by the factors associated with rainfall station, soil type and slope.

Peak factor	Q_2 Q_{10}	Note:
(B, Wohlford)	(cfs/acre) (cfs/acre)	Q_{2} and Q_{10} factors obtained with the
flat, grass	0.1443 0.4183	SDHM Program, version 8-15-11 for
moderate, grass	0.1928 0.4533	Wohlford station.
steep, grass	0.2389 0.4874	

Q₂:
$$0.213 \text{ cfs}$$
 $(0.1443 \times 0.14 + 0.1928 \times 0.89 + 0.2389 \times 0.09)$
Q₁₀: 0.506 cfs $(0.4183 \times 0.14 + 0.4533 \times 0.89 + 0.4874 \times 0.09)$

Diameter of the lower level orifice:

Using the orifice equation with
$$c_g$$
 = 0.61: $0.1Q_2 = 0.25\pi D^2 c_g \sqrt{2g \left(H_{orif} - 0.5D\right)}$ H_{orif} , D : ft

D (inches)	Discharge (cfs)
0.625	0.0164
0.75	0.0236

Solution: 5/8". (3/4" discharges more than 0.0213 cfs = $0.1Q_2$)

Note: orifice not need due to soil type, but provided to reduce drying time.

Diameter of upper level riser:

Using the weir eq. with K=3.1, H (ft), and L = perimeter: $Q_{10} = K \cdot L \cdot H^{1.5}$

H (inches) L (ft) D_{riser} (inches)

2 2.40 9.2 Solution: riser must be at least 12" in diameter.

IMP AREA NEEDED FOR WATER QUALITY PURPOSES

For water quality purposes, usually the area needed is smaller than for hydromodification purposes. It would be calculated as 4% of the impervious areas plus 0.4% of the pervious areas in post-development conditions:

A_{IMP}: 869 sq-ft

As the area is smaller than for the HMP requirement, the HMP design is the dominant design.

DRYING TIME

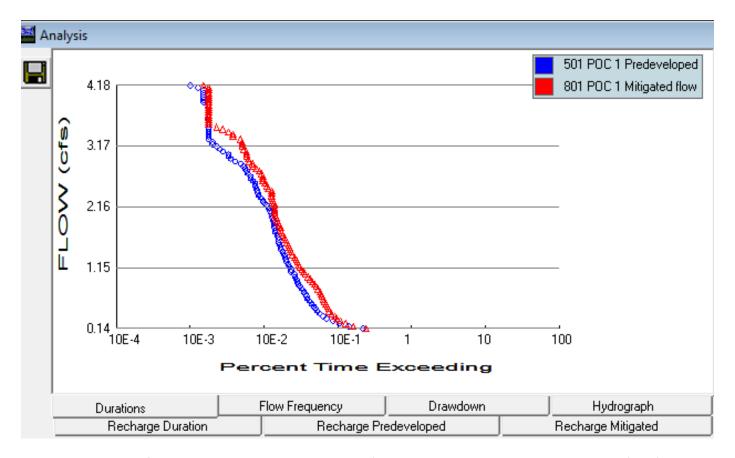
The time to dry the top volume of the bio-retention is:

 $T = V/(3600 \cdot Q_{\text{orif}} + f \cdot A_{\text{IMP}}/12)$

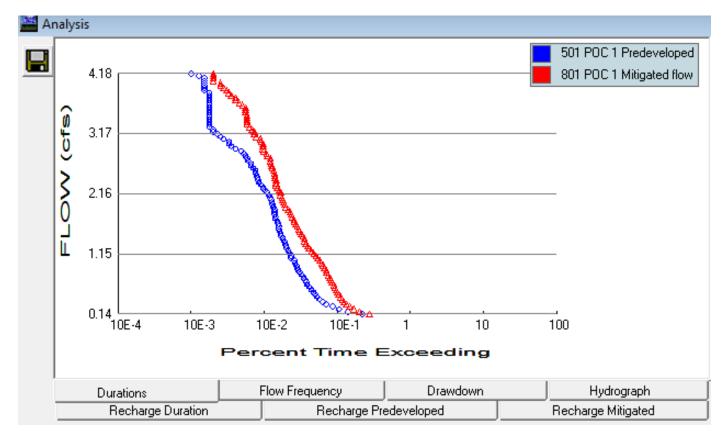
V: volume of the 10" in the surface (cu-ft) = 1327 cu-ft Q: discharge of the low orifice: 0.0164 cfs A_{IMP} : Area of the IMP in sq-ft: 1592 sq-ft f⁽¹⁾: infiltration of the bottom soil, in/hr: 0.21 in/hr T: Drying time: 15.3 hr

APPENDIX 3

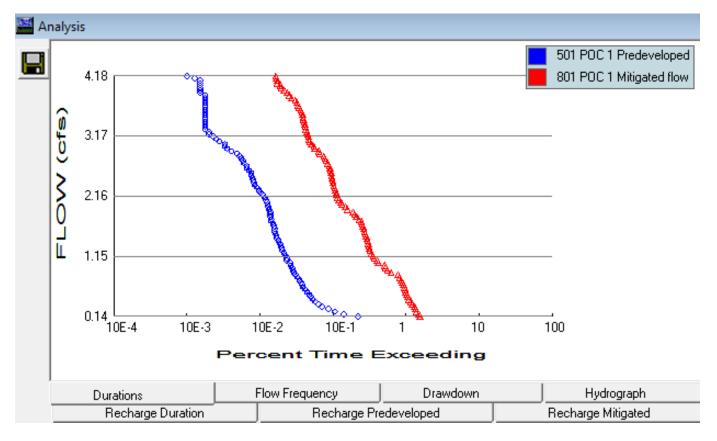
Typical SDHM Flow Duration Curves with Lake Wohlford Rainfall Data Soils Type B and C and Different Combinations of Slope and Land Use



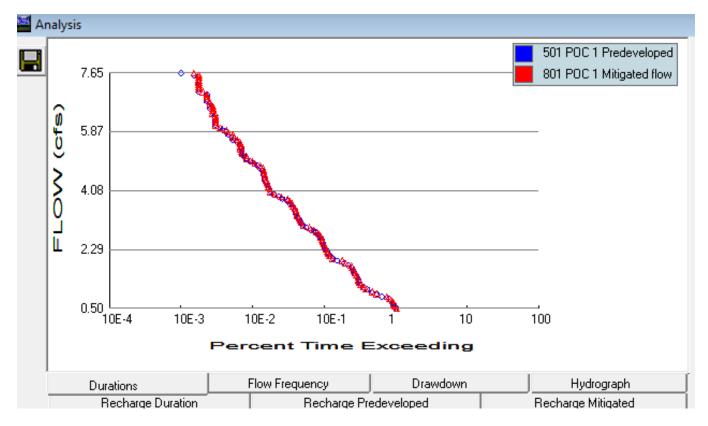
Flow duration Curve from the SDHM Model. Comparison of a Standard 10 acre Lot. Pre-development (blue): Flat Slope. Post-development (red): Moderate Slope. Soil Type B. Wohlford Station.



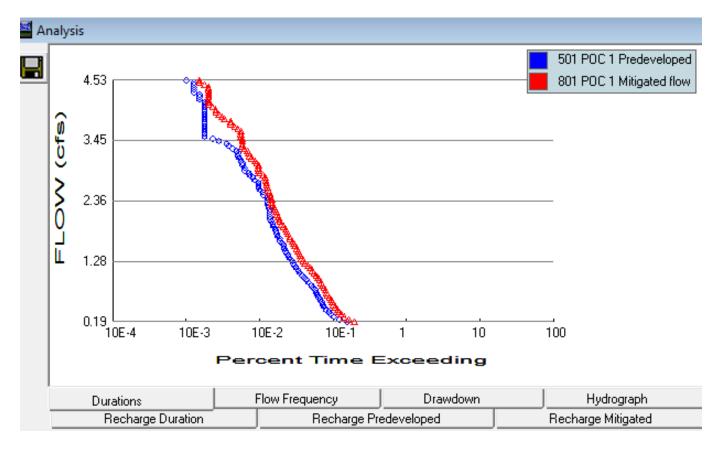
Flow duration Curve from the SDHM Model. Comparison of a Standard 10 acre Lot. Pre-development (blue): Flat Slope. Post-development (red): Steep Slope. Soil Type B. Wohlford Station.



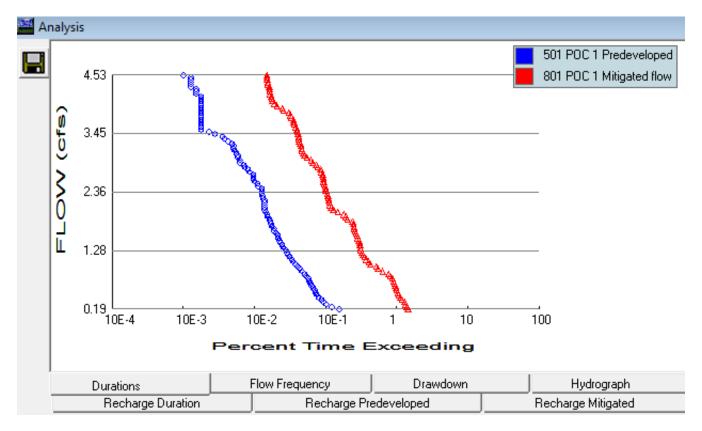
Flow duration Curve from the SDHM Model. Comparison of a Standard 10 acre Lot. Pre-development (blue): Flat Slope. Post-development (red): Impervious, flat slope. Soil Type B. Wohlford Station.



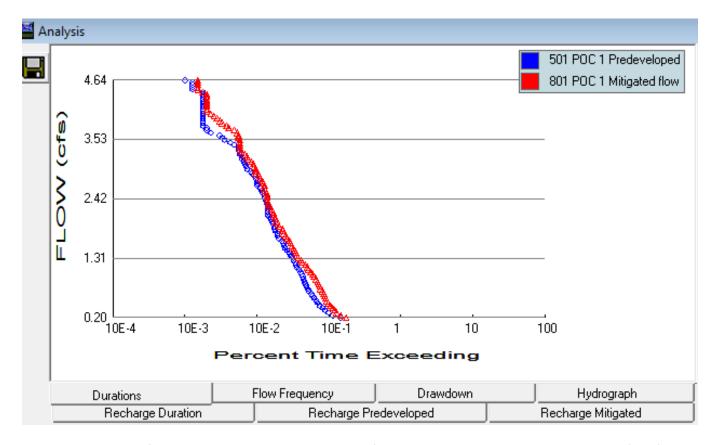
Flow duration Curve from the SDHM Model. Comparison of a Standard 10 acre Lot. Pre-development (blue): Flat Slope, impervious. Post-development (red): Impervious, moderate slope. Soil Type B. Wohlford Station. Almost no difference.



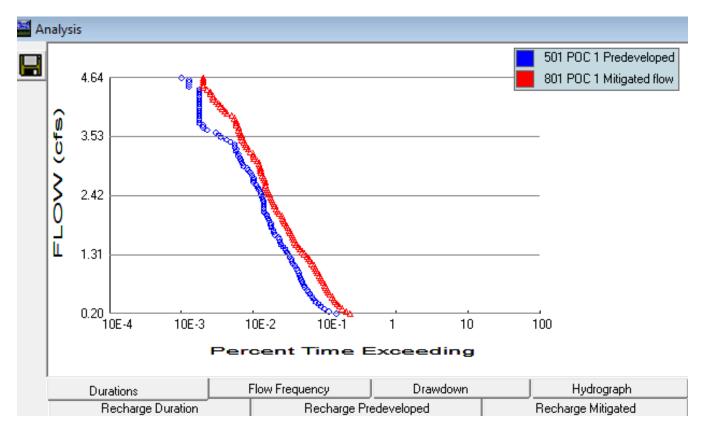
Flow duration Curve from the SDHM Model. Comparison of a Standard 10 acre Lot. Pre-development (blue): Moderate Slope. Post-development (red): Steep Slope. Soil Type B. Wohlford Station.



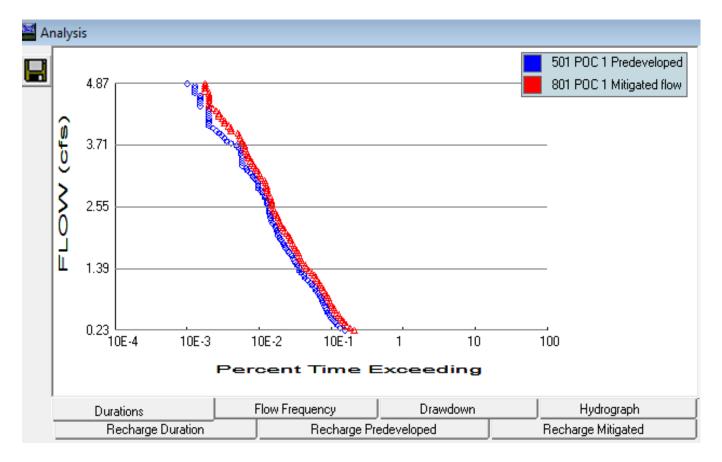
Flow duration Curve from the SDHM Model. Comparison of a Standard 10 acre Lot. Pre-development (blue): Moderate Slope. Post-development (red): Impervious Moderate Slope. Soil Type B. Wohlford Station.



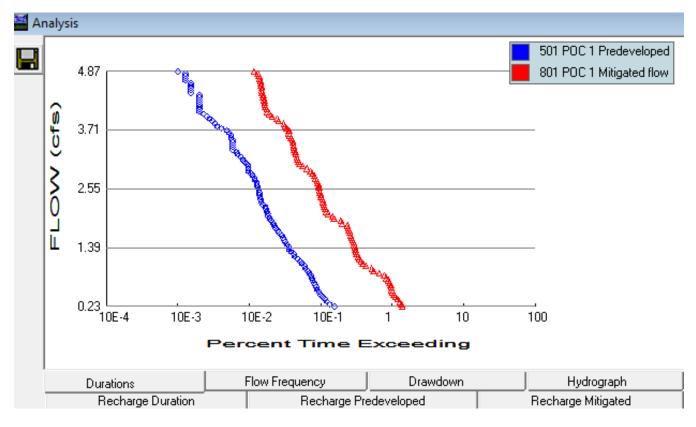
Flow duration Curve from the SDHM Model. Comparison of a Standard 10 acre Lot. Pre-development (blue): Flat Slope. Post-development (red): Moderate Slope. Soil Type C. Wohlford Station.



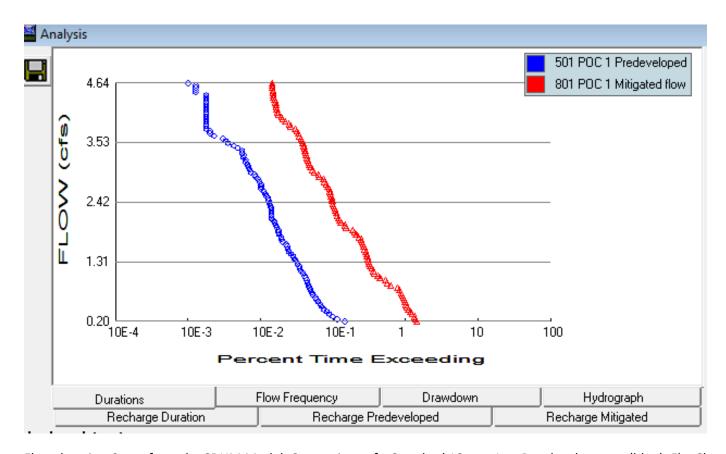
Flow duration Curve from the SDHM Model. Comparison of a Standard 10 acre Lot. Pre-development (blue): Flat Slope. Post-development (red): Steep Slope. Soil Type C. Wohlford Station.



Flow duration Curve from the SDHM Model. Comparison of a Standard 10 acre Lot. Pre-development (blue): Moderate Slope. Post-development (red): Steep Slope. Soil Type C. Wohlford Station.



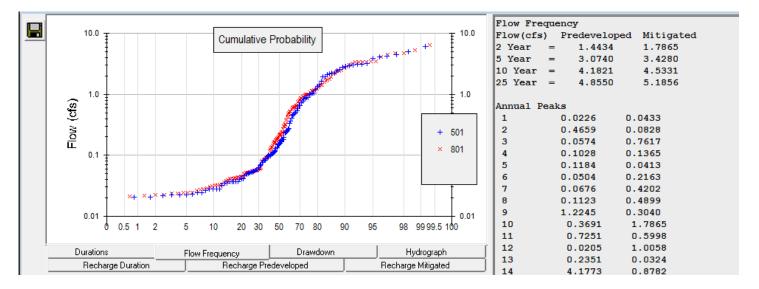
Flow duration Curve from the SDHM Model. Comparison of a Standard 10 acre Lot. Pre-development (blue): Moderate Slope. Post-development (red): Impervious Moderate Slope. Soil Type C. Wohlford Station.



Flow duration Curve from the SDHM Model. Comparison of a Standard 10 acre Lot. Pre-development (blue): Flat Slope. Post-development (red): Impervious, flat slope. Soil Type C. Wohlford Station.

APPENDIX 4

Typical SDHM Peak Flow Values with Lake Wohlford Rainfall Data Soils Type B and C and Different Combinations of Slope and Land Use



Flow Frequency values:

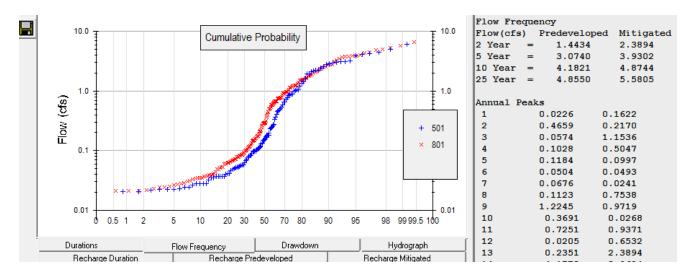
Pre-development: 10 acres, flat, Soil Type B, Wohlford.

Mitigated (Post-dev): 10 acres, moderate, soil Type B, Wohlford.

Results:

 Q_2 : 0.1443 cfs/acre. Q_{10} : 0.4182 cfs/acre (flat, B, Wohlford)

 Q_2 : 0.1787 cfs/acre. Q_{10} : 0.4533 cfs/acre (moderate, B, Wohlford)



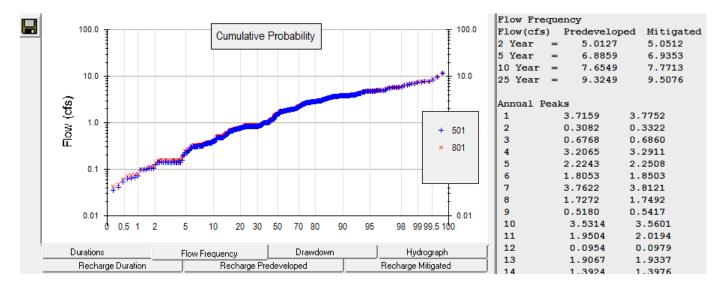
Flow Frequency values:

Pre-development: 10 acres, flat, Soil Type B, Wohlford.

Mitigated (Post-dev): 10 acres, steep, soil Type B, Wohlford.

Additional Result:

 Q_2 : 0.2389 cfs/acre. Q_{10} : 0.4874 cfs/acre (steep, B, Wohlford)



Flow Frequency values:

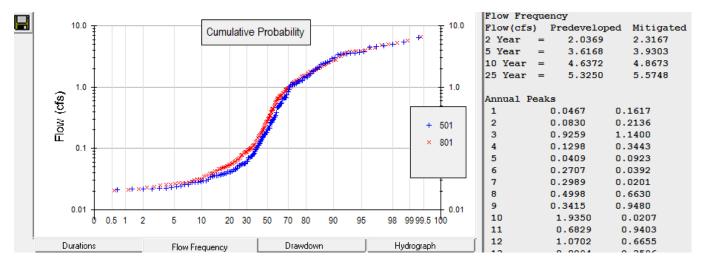
Pre-development: 10 acres, flat, impervious, Soil Type B, Wohlford.

Mitigated (Post-dev): 10 acres, moderate, impervious, soil Type B, Wohlford.

Results:

 Q_2 : 0.5013 cfs/acre. Q_{10} : 0.7655 cfs/acre (impervious, flat, B, Wohlford)

 Q_2 : 0.5051 cfs/acre. Q_{10} : 0.7771 cfs/acre (impervious, moderate, B, Wohlford)



Flow Frequency values:

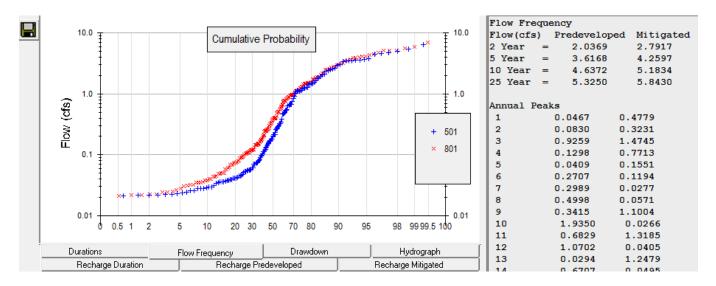
Pre-development: 10 acres, flat, Soil Type C, Wohlford.

Mitigated (Post-dev): 10 acres, moderate, soil Type C, Wohlford.

Results:

 Q_2 : 0.2037 cfs/acre. Q_{10} : 0.4637 cfs/acre (flat, C, Wohlford)

 Q_2 : 0.2317 cfs/acre. Q_{10} : 0.4867 cfs/acre (moderate, C, Wohlford)



Flow Frequency values:

Pre-development: 10 acres, flat, Soil Type C, Wohlford.

Mitigated (Post-dev): 10 acres, steep, soil Type C, Wohlford.

Additional Result:

 Q_2 : 0.2792 cfs/acre. Q_{10} : 0.5183 cfs/acre (steep, C, Wohlford)