TECHNICAL MEMORANDUM:

Design of IMPs for Hydromodification and Water Quality Purposes for the Shadow Ranch Development

Pauma Valley, San Diego County, California

Prepared for:

Masson & Associates Inc.

May 1st, 2012. Reviewed: December 9th, 2013

TORY R. WALKER ENGINEERING, INC.
WATER RESOURCES PLANNING & ENGINEERING
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TECHNICAL MEMORANDUM:
Design of IMPs for Hydromodification and Water Quality Purposes for The Shadow Run Ranch Development. Pauma Valley, 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: May 1, 2012. Revised: December 9, 2013

RE: Summary of IMP Design for Hydromodification and Water Quality Compliance for the Hosking Ranch Development

1. INTRODUCTION

This technical memorandum summarizes the approach used to design 16 bioretention cells for the proposed Shadow Ranch Development (see General Project Map, Appendix 1). 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. Bioretention cells with infiltration capabilities 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 (together with infiltration devices), and the predominant Soil Type A of the area is conducive to design infiltration facilities. However, to avoid potential contamination of potential groundwater resources in the vicinity of the project, the infiltration facilities have an amended soil layer for biological treatment, and therefore, are actually bioretention cells without French Drains. Also, some of the IMPs will be located in Soils Type B, which also allows for the design of bioretention facilities with natural infiltration beneath (i.e., no French drain provided). The design process has been standardized for the 16 IMPs in this Tentative Plan submittal in terms of avoiding French Drains and a gravel sub-layer in all IMPs. 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 adding French-drains and gravel layers in some bioretention cells for size improvement, or in case infiltration measured on site is not large enough to guarantee adequate drawdown times.

As the contributing areas to the bioretention 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 bioretention 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 is usually larger than hydromodification size for the particular characteristics of this project, and consequently both sizing procedures are carried out.

It should be noted that from the point of view of Points of Compliance (POC) for hydromodification purposes, the BMPs are divided in 3 groups:

- Group 1, corresponding with BMPs that drain to the unnamed Creek to the East, along Adams Drive. Each IMP will discharge directly into the hills sheet flowing to the stream, and its discharge in itself could also be considered as a separate point of compliance.
- Group 2, corresponding with IMPs that drain into a culvert that eventually drains into the San Luis Rey River. IMP-2A, located upstream of IMP-2B, will have a separate drainage to avoid hydromodification overload of IMP-2B, and the discharge from IMP-2A will join the discharge from IMP-2B downstream of IMP-2B. Both drainages will then discharge to the aforementioned culvert. Additional IMPs with numbers (IMP-2A1, IMP-2A2, IMP-2A3, IMP-2A4 and IMP-2B1) are located upstream of the corresponding letter-labeled IMP, and their drainage will eventually discharge into the corresponding IMP (for example, IMP-2A2 discharges into IMP-2A). It must be pointed out that most of the drainage will infiltrate in the corresponding IMP and only large storms will find their way downstream, but with a released discharge that is going to be smaller than the discharge nature intended and therefore, not generating hydromodification effects.
- Group 3, corresponding with IMPs that drain to Frey Creek to the West. Each IMP will discharge directly into the hills sheet flowing to Frey Creek, and its discharge in itself could also be considered as a separate point of compliance.

2. 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 A, B or C (or a combination of those) 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 note 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 ($0.3Q_2$ 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 16 contributing areas in pre-development and post-development condition attached in Appendix 2, it is clear that in many cases mitigation has to occur for a combination of areas and slopes. For example, in IMP-2A.1, 0.02 acres of flat slope, Soil Type C slope become impervious areas; 0.25 acres of moderate slope, Soil Type C become impervious; and 0.03 acres of moderate slope Soil Type A 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 flat slope, Soil Type C is 0.11, for moderate slope, Soil Type C is also 0.11 and for moderate slope, Soil Type A is 0.045, the resulting IMP size would be 1,353 sq-ft :
0.11 x 0.02 + 0.11 x 0.25 + 0.045 x 0.03 = 0.03105 acres or 1353 sq-ft.

It is important to understand 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-1C, 0.03 acres of moderate slope, Soil Type B in pre-development conditions become 0.03 acres of flat slope, Soil Type B in post-development conditions, and 0.06 acres of steep slope, Soil Type B in pre-development conditions become 0.06 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. However, the net effect on the change of slope is considered for sizing purposes: if the amount of area that reduces in slope is larger than the amount of area that increases in slope, then the net effect is a reduction in slope and no factor is included. For example, in IMP-1E, 1.82 acres of moderate slope terrain with Soil Type A, become 1.82 acres of flat slope terrain with Soil Type A after development. In the same IMP, 0.68 acres of moderate slope terrain with Soil Type A become 0.68 acres of steep slope terrain with Soil Type A. We did not consider the effect of the increase in the slope, because in this example it is over-compensated by the effect of the reduction of slope (1.82 acres reducing slope compensate for 0.68 acres increasing slope). This is the reason that change-of-slope sizing factors were not considered in most IMPs in this development.

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 (2A-1, 2A-2, and 3A) have contributing areas in both Soil Type A and Soil Type C, while 2 IMPs (1A and 1B) have contributing areas in three types of soils (A, B and C). In those cases, 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 18 IMPs. Notice that if the size of the IMP is a combination of two or more factors, the corresponding linear equation used to determine the size is explicitly shown in each IMP table calculations.

2.1. 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, if such orifice is included in the design. For this project, all IMPs are located in Soil Type A or B, and therefore, they do not need French drains or low orifices to drawdown the runoff. The determination of Q_2 (and the lower threshold $0.1 \cdot Q_2$) is not as critical in this project, as no lower orifices will be selected (but nonetheless, Q_2 will be determined). It does not mean that the minimum threshold is not important: if the susceptibility of the receiving waters were to change, then the areas of the IMPs for hydromodification purposes could be reduced. However, as water quality constraints are more important than hydromodification constraints in this project for all but three IMPs, Q_2 determination is not as relevant as in most projects.

For the design of the riser, the determination of Q_{10} is important. For this design, it will be assumed that the riser is able to discharge the pre-development Q_{10} with a specified depth over its invert. In order to determine Q_2 and Q_{10}, the peak factors for soils Type A, Soil Type B and Soil Type C for flat, moderate and steep slopes are used (all 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 pre-development conditions.

For example, in the complex scenario of IMP-1A, there are 10 different areas in pre-development conditions: impervious, flat slope with soils A, B and C, moderate slope with soils A, B and C, and steep slope with soils A, B and C. Therefore, Q_2 and Q_{10} are a linear combination of the 10 sizing factors times the 10 respective areas. In the case of Q_{10}:

$$Q_{10} = 0.4637 \cdot 0.66 + 0.4867 \cdot 2.27 + 0.5183 \cdot 14.38 + 0.4182 \cdot 0.01 + 0.4533 \cdot 0.02 + 0.4874 \cdot 0.06 + 0.3454 \cdot 0.30 + 0.4199 \cdot 2.38 + 0.4757 \cdot 3.42 + 0.7771 \cdot (0.08 + 0.01 + 0.23) = 11.89 \text{ cfs.}$$

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). 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 for the 16 IMPs.

3. IMP SIZE FOR WATER QUALITY COMPLIANCE

The required area of a bioretention 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 bioretention cell, or can be established with the simple procedure explained in the SUSMP document, which can be summarized by the following equation:

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

where:

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

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

A_{PERV} : Pervious areas draining to the bioretention (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 bioretention cell (sq-ft). This area is zero for all sixteen (16) bioretention cells designed here.

It should be pointed out that Equation (1) does not make a distinction between 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.

3.1. 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, in many scenarios in this project 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 16 IMPs designed, 14 have larger water quality size than hydromodification size (all but IMP-1C and IMP-=2A.4). In this case, the IMP 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. As no French drain is needed because all IMPs are in Soil Types A or B, the gravel layer is nonexistent. Therefore, the depth of the surface layer could be reduced in such a way that the water quality BMP has the volume needed for hydromodification purposes at the surface (volume is required for hydromodification purposes, as the water is stored during the continuous simulation routing).

The typical depth of the surface layer below the invert of the riser is 10 inches for hydromodification purposes. In this report, and as an additional safety factor, the 10 inch depth will be used even if the IMP is much larger for WQ constrains than for hydromodification constraints. The area will only be reduced in those cases where the availability of space is not compatible with the existing grading proposed (IMP-1A, IMP-1B). In those cases, any reduction in the area of the IMP will be tied to the same increase in depth. In other words, if the area reduces to a fraction $X \cdot A_{BMP}$, (X smaller than 1), then the depth increases as 10"/X so that the volume at the surface remains the same. As the depth increases, then the drying time also increases, as less area is available for infiltration. For this reason, the area is reduced either to the available space or up to the point when the drying time increases to 72 hours (see next section). The final calculations are detailed in Appendix 2.

4. DRYING TIME OF IMPs

In order to demonstrate that IMPs drain in less than 72 hours to avoid potential mosquito or vector problems (conservative approach as the Hydromodification Management Plan and the California Department of Public Health allow a drying time up to 96 hours), the drying time of the surface volume was calculated under the assumption of constant discharge through infiltration, according to equation 2 below:

$$T = \frac{V}{f \cdot A_{IMP} / 12} \quad (2)$$

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

f : mean permeability, defined per page 4.20 of the HMP permit as 2·INFILT·INTFW, or equivalent to 0.27 in/hr for soils type A and 0.21 in/hr for soils type B.

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

Drying time values are added in Table 1, and they are significantly smaller than 96 hours for all cases.

5. 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)	Riser Diameter	H: Ponding depth (in)	R : Depth to discharge Q_{10} (in)	Total surface Depth, with 0.5' free-board (in)	Drying time (hr)
IMP-1A	3147	**4075**	4075	42	15	6	27	55
IMP-1B	394	**1240**	1240	30	15	4	25	71
IMP-1C	**1324**	1068	1324	12	10	2	18	48
IMP-1D	1021	**5110**	5110	48	10	5	21	37
IMP-1E	1823	**4220**	4220	42	10	4	21	37
* ~~IMP-1F~~	~~**747**~~	~~716~~	~~747~~	~~12~~	~~10~~	~~2~~	~~18~~	~~37~~
* ~~IMP-1G~~	~~420~~	~~**1706**~~	~~1706~~	~~12~~	~~10~~	~~2~~	~~18~~	~~37~~
IMP-1H	333	**639**	639	12	10	2	18	37
IMP-2A	4352	**9348**	9348	48	10	5	21	37
IMP-2A1	1353	**1415**	1415	36	10	3	21	37
IMP-2A2	2359	**3554**	3554	48	10	3	21	37
IMP-2A3	568	**1589**	1589	24	10	3	21	37
IMP-2A4	**995**	957	995	12	10	2	18	37
IMP-2B	529	**5215**	5215	36	10	5	21	37
IMP-2B1	647	**1474**	1474	24	10	3	21	37
IMP-3A	1764	**4288**	4288	42	10	5	21	37
IMP-3B	1392	**3337**	3337	36	10	4	21	37
IMP-3C	108	**340**	340	18	10	2	18	37

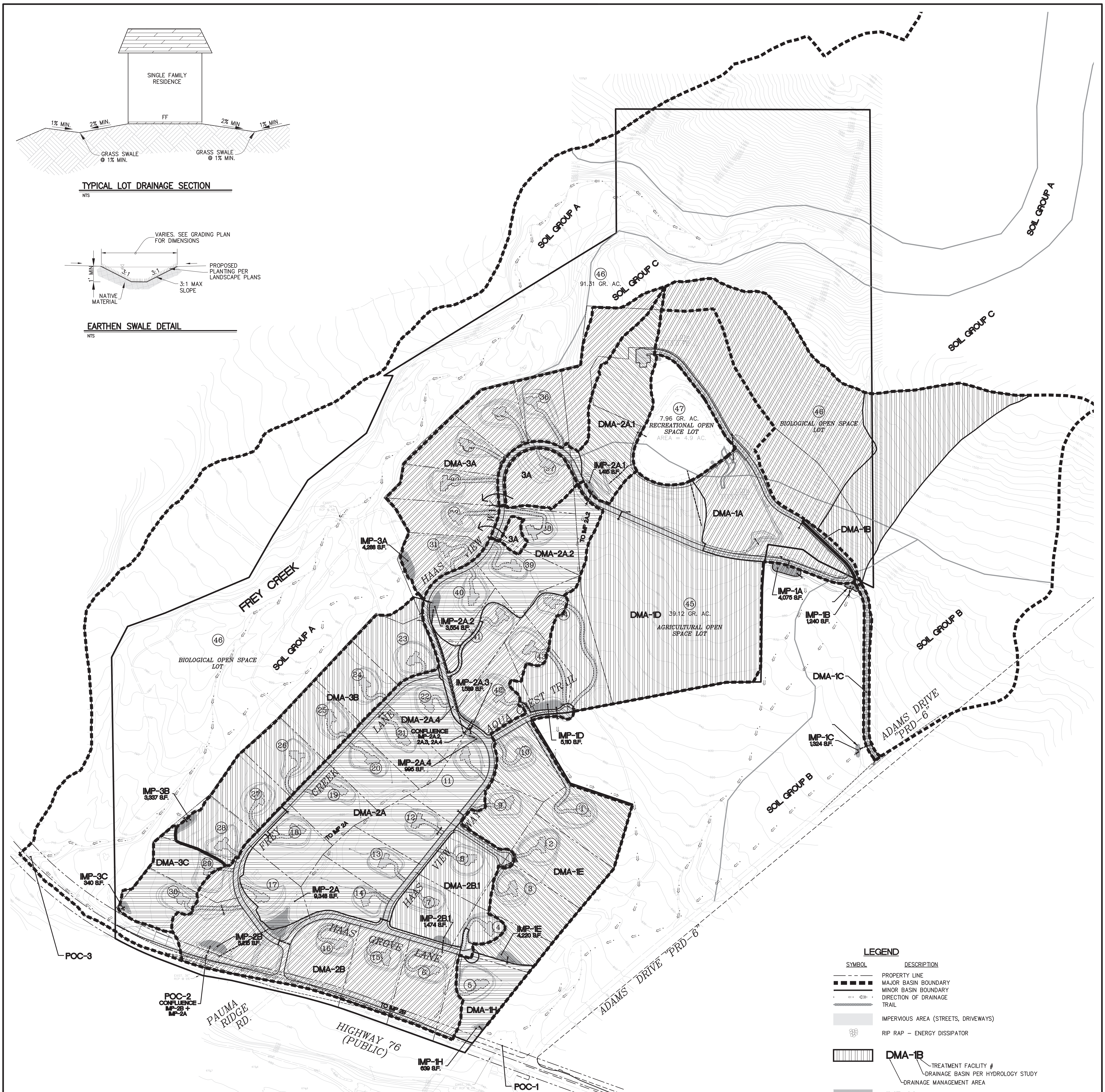
Note: * means removed on 12/9/2013 due to changes in final design (1F and 1G no longer needed).

APPENDICES

1. General Project Map, and detailed location of IMPs and POCs.
2. Excel Calculations from IMP-1A to IMP-3C
3. Typical Flow Duration Curves with Lake Wohlford rainfall data for Soil Types B and C 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 Soil Types B and C 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



LEGEND

SYMBOL	DESCRIPTION
	PROPERTY LINE
	MAJOR BASIN BOUNDARY
	MINOR BASIN BOUNDARY
	DIRECTION OF DRAINAGE
	TRAIL
	IMPERVIOUS AREA (STREETS, DRIVEWAYS)
	RIP RAP – ENERGY DISSIPATOR
	DMA-1B: TREATMENT FACILITY #; DRAINAGE BASIN PER HYDROLOGY STUDY; DRAINAGE MANAGEMENT AREA
	IMP-1C: TREATMENT FACILITY #; DRAINAGE BASIN PER HYDROLOGY STUDY; INTEGRATED MANAGEMENT PRACTICE

SINGLE RESIDENTIAL LOTS ARE DESIGNED TO INCORPORATE L.I.D. PRACTICES:
1) ROOF RUNOFF TO RUN OVER THE LAWN BEFORE ENTERING THE STORM DRAIN;
2) DISCONNECTING IMPERVIOUS SURFACES;
3) PITCHING DRIVEWAYS TOWARDS YARDS TO FILTER THE RUNOFF;
4) PAD GRADING WILL DIVERT RUNOFF AWAY FROM TOPS OF SLOPES.
5) SLOPES WILL BE PERMANENTLY STABILIZED WITH LANDSCAPING.

N

200 100 0 200 400 600
SCALE IN FEET
GRAPHIC SCALE
1"=200'

* REMOVED PER DESIGN CHANGE 12-9-2013 DUE TO CHANGES IN FINAL DESIGN (1F AND 1G NO LONGER NEEDED).

Table of Areas in Pre and Post Development conditions for all IMPs.

	Pre-Development Conditions														Post-Development Conditions												
DAM Area	Pervious. Soil Type A			Pervious. Soil Type B			Pervious. Soil Type C			Impervious			TOTAL		Pervious. Soil Type A			Pervious. Soil Type B			Pervious. Soil Type C			House / Driveway / Streets Impervious			TOTAL
draining to:	0% - 5%	5% - 15%	≥ 15%	0% - 5%	5% - 15%	≥ 15%	0% - 5%	5% - 15%	≥ 15%	A	B	C	AREA	CHECK	0% - 5%	5% - 15%	≥ 15%	0% - 5%	5% - 15%	≥ 15%	0% - 5%	5% - 15%	≥ 15%	A	B	C	AREA
IMP-1A	0.30	2.38	3.42	0.01	0.02	0.06	0.66	2.27	14.38	0.08	0.01	0.23	23.82	0.00	0.29	2.03	3.42	0.00	0.01	0.01	0.61	1.93	14.29	0.44	0.08	0.71	23.82
IMP-1B	0.01	0.01	1.69	0.07	0.33	0.97	0.26	0.30	5.74	0.00	0.00	0.02	9.40	0.00	0.01	0.01	1.66	0.06	0.60	0.69	0.14	0.42	5.67	0.03	0.02	0.09	9.40
IMP-1C	0.00	0.00	0.00	0.09	0.13	0.19	0.00	0.00	0.00	0.00	0.23	0.00	0.64	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.00	0.64
IMP-1D	0.19	15.83	6.45	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	22.67	0.00	0.05	15.58	6.30	0.00	0.00	0.00	0.00	0.00	0.00	0.74	0.00	0.00	22.67
IMP-1E	0.31	12.63	0.91	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	14.05	0.00	2.13	9.20	1.59	0.00	0.00	0.00	0.00	0.00	0.00	1.13	0.00	0.00	14.05
IMP-1F	0.03	0.49	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.00	0.16	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.00	0.00	0.60
* IMP-1G																											
* IMP-1H																											
SUBTOTAL DA-1	**0.94**	**33.50**	**12.80**	**0.17**	**0.48**	**1.22**	**0.92**	**2.57**	**20.12**	**1.26**	**0.24**	**0.25**	**74.47**	**0.00**	**3.16**	**28.13**	**13.35**	**0.09**	**0.61**	**0.70**	**0.75**	**2.35**	**19.96**	**3.86**	**0.71**	**0.80**	**74.47**
IMP-2A	1.16	17.56	3.75	0.00	0.00	0.00	0.00	0.00	0.00	1.12	0.00	0.00	23.59	0.00	4.37	10.98	4.90	0.00	0.00	0.00	0.00	0.00	0.00	3.34	0.00	0.00	23.59
IMP-2A.1	0.00	0.21	1.20	0.00	0.00	0.00	0.21	3.38	0.42	0.00	0.00	0.00	5.42	0.00	0.06	0.12	1.20	0.00	0.00	0.00	0.19	3.10	0.45	0.03	0.00	0.27	5.42
IMP-2A.2	0.07	6.32	2.25	0.00	0.00	0.00	0.00	0.07	0.31	0.18	0.00	0.01	9.21	0.00	1.39	4.33	2.06	0.00	0.00	0.00	0.01	0.05	0.14	1.04	0.00	0.19	9.21
IMP-2A.3	0.02	5.15	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	5.61	0.00	1.49	2.96	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.00	0.00	5.61
IMP-2A.4	0.01	0.58	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.72	0.00	0.09	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.72
IMP-2B	1.21	8.97	2.82	0.00	0.00	0.00	0.00	0.00	0.00	1.45	0.00	0.00	14.45	0.00	2.37	6.91	3.45	0.00	0.00	0.00	0.00	0.00	0.00	1.72	0.00	0.00	14.45
IMP-2B.1	0.03	5.38	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.49	0.00	1.45	3.35	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	5.49
SUBTOTAL DA-2	**2.50**	**44.17**	**10.56**	**0.00**	**0.00**	**0.00**	**0.21**	**3.45**	**0.73**	**2.86**	**0.00**	**0.01**	**64.49**	**0.00**	**11.22**	**28.74**	**12.75**	**0.00**	**0.00**	**0.00**	**0.20**	**3.15**	**0.59**	**7.38**	**0.00**	**0.46**	**64.49**
IMP-3A	0.15	9.75	1.98	0.00	0.00	0.00	0.05	2.26	2.32	0.00	0.00	0.00	16.51	0.00	1.62	6.47	2.89	0.00	0.00	0.00	0.51	1.99	2.13	0.90	0.00	0.00	16.51
IMP-3B	0.48	9.96	2.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.76	0.00	2.32	7.07	2.66	0.00	0.00	0.00	0.00	0.00	0.00	0.71	0.00	0.00	12.76
IMP-3C	0.01	1.10	0.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.95	0.00	0.01	0.99	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.95
SUBTOTAL DA-3	**0.64**	**20.81**	**5.14**	**0.00**	**0.00**	**0.00**	**0.05**	**2.26**	**2.32**	**0.00**	**0.00**	**0.00**	31.22	**0.00**	**3.95**	**14.53**	**6.50**	**0.00**	**0.00**	**0.00**	**0.51**	**1.99**	**2.13**	**1.61**	**0.00**	**0.00**	**31.22**
TOTALS	**4.08**	**98.48**	**28.50**	**0.17**	**0.48**	**1.22**	**1.18**	**8.28**	**23.17**	**4.12**	**0.24**	**0.26**	**170.19**	**-0.01**	**18.33**	**71.40**	**32.60**	**0.09**	**0.61**	**0.70**	**1.46**	**7.49**	**22.68**	**12.85**	**0.71**	**1.26**	**170.18**

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EXHIBIT "C"
DRAINAGE MANAGEMENT AREA (DMA) EXHIBIT
SHADOW RUN RANCH, PAUMA VALLEY
TRACT NO. TM 5233 RPL-3

P.N. 4201 DATE: Dec 11, 13 4:55 pm

APPENDIX 2

EXCEL CALCULATIONS FROM IMP-1A TO IMP-3C

IMP-1A

Soil type: A, B and C

Notes on soil Transformation:

The next areas (ac) remain the same: 0.29 A-flat; 2.03 A-mod; 3.42 A-steep; 0.01 B-steep; 0.01 B-mod; 0.61 C-flat; 1.93 C-mod 14.29 acres C-steep; 0.32 acres impervious

0.01 acres flat slope A become 0.01 acres impervious

0.35 acres moderate slope A become 0.35 acres impervious

0.01 acres flat slope B become 0.01 acres impervious

0.01 acres moderate slope B become 0.01 acres impervious

0.05 acres steep slope B become 0.05 acres impervious

0.05 acres flat slope C become 0.05 acres impervious

0.34 acres moderate slope C become 0.34 acres impervious

0.09 acres steep slope C become 0.09 acres impervious

AREAS

Slope	Pre-A	Pre-B	Pre-C	Post-A	Post-B	Post-C
Flat	0.30	0.01	0.66	0.29	0.00	0.61
Moderate	2.38	0.02	2.27	2.03	0.01	1.93
Steep	3.42	0.06	14.38	3.42	0.01	14.29
Imperv.	0.08	0.01	0.23	0.44	0.08	0.71
TOTAL	6.18	0.10	17.54	6.18	0.10	17.54

USE OF THE SIZING TABLE:

Asumptions:

1) Mitigation has to occur for (a) 0.01 acres flat slope soil A; (b) 0.35 acres moderate slope, soil A; (c) 0.01 acres flat slope, soil B; (d) 0.01 acres moderate slope, soil B; (e) 0.05 acres steep slope, soil B; (f) 0.05 acres flat slope, soil C; (g) 0.34 acres moderate slope, soil C; and (h) 0.09 acres steep slope, soil C. All those areas become impervious and the corresponding sizing factors will be applied.

2) For areas that do not change in slope or in soil Type, no HMP mitigation is needed as the Flow Duration Curve (FDC) remains the same from pre-development to post-development conditions

SIZES:

Lake Wohlford Station, Soil Type A, $0.1Q_2$, Table 7.1 of the HMP Document:

Area factor, flat: 0.050 (Table 7.1, fraction of area that must become Bio-retention)
Area factor, moderate: 0.045 (Table 7.1, fraction of area that must become Bio-retention)
Area factor, steep: 0.040 (Table 7.1, fraction of area that must become Bio-retention)

Lake Wohlford Station, Soil Type B, $0.1Q_2$, Table 7.1 of the HMP Document:

Area factor, flat: 0.090 (Table 7.1, fraction of area that must become Bio-retention)
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, $0.1Q_2$, Table 7.1 of the HMP Document:

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

Area: 3147 sq-ft (1) (at the surface of bio-retention)
Ponding on top: 10 inches
Amended soil: 18 inches
gravel at the bottom: not needed (IMP located in soil type A).

(1): 43560·(0.01·0.05+0.35·0.045+0.01·0.09+0.01·0.085+0.05·0.065+0.05·0.11+0.34·0.11+0.09·0.09)

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 6 inches

Low flow discharge orifice is not needed

DETERMINATION OF Q_2 AND Q_{10}

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

Peak factor (Wohlford)	Q_2 (soil C) (cfs/acre)	Q_{10} (Soil C) (cfs/acre)	Q_2 (soil B) (cfs/acre)	Q_{10} (Soil B) (cfs/acre)	Q_2 (soil A) (cfs/acre)	Q_{10} (Soil A) (cfs/acre)
flat, grass	0.2037	0.4637	0.1443	0.4182	0.0829	0.3454
moderate, grass	0.2317	0.4867	0.1787	0.4533	0.1597	0.4199
steep, grass	0.2792	0.5183	0.2389	0.4874	0.2147	0.4757
Impervious, moderate	0.5051	0.7771	0.5051	0.7771	0.5051	0.7771

Q_2: 6.02 cfs — Convolution of Q_2 peak factors times areas

Q_{10}: 11.89 cfs — Convolution of Q_{10} peak factors times areas

Note: Q_2 and Q_{10} factors obtained with the SDHM Program, version 8-15-11 for Wohlford station.

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	10.84	41.4

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 area in post-dev. conditions.

A_{IMP}: ***6079 sq-ft*** V_{IMP}: 5066 cu-ft (at the top)

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

MODIFICATION OF THE DIMENSIONS OF THE IMP : WQ AREA REDUCTION

Assuming that the water quality volume is preserved, the area can be reduced to accommodate the bio-retention to the available space; the ponding on top can be increased to satisfy volume.

FINAL DIMENSIONS:

Final Area (A_f):	**4075 sq-ft**	(at the surface of bio-retention)
Ponding on top, H_P:	14.9 inches	Required ponding depth for modified area. $H_P = V_{IMP}/A_f$
Amended soil, h_{soil}:	18.0 inches	Minimum amended soil depth
Gravel depth, h_{gravel} :	not needed	

DRYING TIME

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

T : Drying time = $V/(f \cdot A_{IMP}/12)$

V : volume of the 30" in the surface (cu-ft) =	5066 cu-ft
Qsoil : infiltration capacity of amended soil :	0.472 cfs
A_{IMP} : Area of the IMP in sq-ft :	4075 sq-ft
f (1): infiltration of the bottom soil, in/hr :	0.27 in/hr
Bottom infiltration discharge, $Q_f = A_{IMP} \cdot f/(12 \cdot 3600)$	0.025 cfs
T : Drying time = $V/(3600 \cdot Q_{ave})$	55.3 hr

(1): Per the San Diego HMP, page 4.20, the mean permeability is 2·INFILT·INTFW. As INTFW is 1.5 for all soil types and slopes (see permit Table 3, page 11 of the Technical Memo "Selection of PERLND Parameters") and the parameter INFILT is 0.09 in/hr for soils type A, flat, per the same Table, the mean permeability is assumed 0.27 in/hr for soils Type A, flat for the purposes of determining the infiltration of the bottom of the bioretention. A more accurate calculation will be done at final design, when results from permeability tests are available.

IMP-1B

Soil type: A, B and C

AREAS

Slope	Pre-A	Pre-B	Pre-C	Post-A	Post-B	Post-C
Flat	0.01	0.07	0.26	0.01	0.06	0.14
Moderate	0.01	0.33	0.28	0.01	0.60	0.42
Steep	1.69	0.97	5.76	1.66	0.69	5.67
Imperv.	0.00	0.00	0.02	0.03	0.02	0.09
TOTAL	1.71	1.37	6.32	1.71	1.37	6.32

Notes on soil Transformation:

The next areas (acres) remain the same: 0.01 A-flat; 0.01 A-mod; 1.66 A-steep; 0.06 B-flat; 0.33 B-mod; 0.69 B-steep; 0.14 C-flat; 0.28 C-mod; 5.67 C-steep; and 0.02 acres impervious

0.03 acres steep slope A become 0.03 acres impervious

0.01 acres flat slope B become 0.01 acres impervious

0.01 acres steep slope B become 0.01 acres impervious

0.27 acres steep slope B become 0.27 acres moderate slope B

0.12 acres flat slope C become 0.12 acres moderate slope C

0.02 acres steep slope C become 0.02 acres moderate slope C

0.07 acres steep slope C become 0.07 acres impervious

USE OF THE SIZING TABLE:

Asumptions:

1) Mitigation has to occur for (a) 0.03 acres steep slope soil A; (b) 0.01 acres flat slope, soil B; (c) 0.01 acres steep slope, soil B; and (d) 0.07 acres steep slope, soil C. All those areas become impervious and the corresponding sizing factors will be applied.

2) Regarding the areas that change in slope but not in land use, as the overall slope reduce, no mitigation is needed. (pre-dev. overall slope: (0.27 x 20% + 0.12 x 2.5% + 0.02 x 20 %)/0.41 = 14.8% ; post-dev.: (0.27 x 10% + 0.12 x 10% + 0.02 x 10%)/0.41 = 10%

3) For areas that do not change in slope or in soil Type, no HMP mitigation is needed as the Flow Duration Curve (FDC) remains the same from pre-development to post-development conditions

SIZES:

Lake Wohlford Station, Soil Type A, $0.1Q_2$, Table 7.1 of the HMP Document:

Area factor, flat:	0.050	(Table 7.1, fraction of area that must become Bio-retention)
Area factor, moderate:	0.045	(Table 7.1, fraction of area that must become Bio-retention)
Area factor, steep:	0.040	(Table 7.1, fraction of area that must become Bio-retention)

Lake Wohlford Station, Soil Type B, $0.1Q_2$, Table 7.1 of the HMP Document:

Area factor, flat:	0.090	(Table 7.1, fraction of area that must become Bio-retention)
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, $0.1Q_2$, Table 7.1 of the HMP Document:

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

Area:	394 sq-ft (1)	(at the surface of bio-retention)
Ponding on top:	10 inches	(1): 43560·(0.03·0.04+0.01·0.09+0.01·0.065+0.07·0.09)
Amended soil:	18 inches	
gravel at the bottom:	not needed (IMP located in soil type B).	

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 4 inches

Low flow discharge orifice is not needed

DETERMINATION OF Q_2 AND Q_{10}

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

Peak factor (Wohlford)	Q_2 (soil C) (cfs/acre)	Q_{10} (Soil C) (cfs/acre)	Q_2 (soil B) (cfs/acre)	Q_{10} (Soil B) (cfs/acre)	Q_2 (soil A) (cfs/acre)	Q_{10} (Soil A) (cfs/acre)
flat, grass	0.2037	0.4637	0.1443	0.4182	0.0829	0.3454
moderate, grass	0.2317	0.4867	0.1787	0.4533	0.1597	0.4199
steep, grass	0.2792	0.5183	0.2389	0.4874	0.2147	0.4757
Impervious, moderate	0.5051	0.7771	0.5051	0.7771	0.5051	0.7771

Q_2: 2.40 cfs — Convolution of Q_2 peak factors times areas

Q_{10}: 4.72 cfs — Convolution of Q_{10} peak factors times areas

Note: Q_2 and Q_{10} factors obtained with the SDHM Program, version 8-15-11 for Wohlford station.

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	7.91	30.2

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}: ***1857 sq-ft*** — V_{IMP} : 1548 cu-ft

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

MODIFICATION OF THE DIMENSIONS OF THE IMP : WQ AREA REDUCTION

Assuming that the water quality volume is preserved, the area can be reduced to accommodate the bio-retention to the available space; the ponding on top can be increased to satisfy volume.

FINAL DIMENSIONS:

Final Area (A_f):	**1240 sq-ft**	(at the surface of bio-retention)
Ponding on top, H_P:	15.0 inches	Required ponding depth for modified area. $H_P = V_{IMP}/A_f$
Amended soil, h_{soil}:	18.0 inches	Minimum amended soil depth
Gravel depth, h_{gravel} :	not needed	

DRYING TIME

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

T : Drying time = $V/(f \cdot A_{IMP}/12)$

V : volume of the 30" in the surface (cu-ft) =	1548	cu-ft
Qsoil : infiltration capacity of amended soil :	0.144	cfs
A_{IMP} : Area of the IMP in sq-ft :	1240	sq-ft
f [(1)]: infiltration of the bottom soil, in/hr :	0.21	in/hr
Bottom infiltration discharge, $Q_f = A_{IMP} \cdot f/(12 \cdot 3600)$	0.006	cfs
T : Drying time = $V/(3600 \cdot Q_{ave})$	71.3	hr

(1): Per the San Diego HMP, page 4.20, the mean permeability is 2·INFILT·INTFW. As INTFW is 1.5 for all soil types and slopes (see permit Table 3, page 11 of the Technical Memo "Selection of PERLND Parameters") and the parameter INFILT is 0.07 in/hr for soils type B, flat, per the same Table, the mean permeability is assumed 0.21 in/hr for soils Type B, flat for the purposes of determining the infiltration of the bottom of the bioretention. A more accurate calculation will be done at final design, when results from permeability tests are available.

IMP-1C

Soil type: B

AREAS

Slope	Pre-B	Post-B
Flat	0.09	0.03
Moderate	0.21	0.00
Steep	0.11	0.00
Imperv.	0.23	0.61
TOTAL	0.64	0.64

Notes on soil Transformation:

0.06 acres B flat become 0.06 acres impervious

0.21 acres B moderate become 0.21 acres impervious

0.11 acres B steep become 0.11 acres impervious

0.23 acres impervious and 0.03 acres B flat do not change

USE OF THE SIZING TABLE:

Asumptions:

1) Mitigation has to occur for (a) 0.06 acres flat slope soil B; (b) 0.21 acresmoderateslope, soil B; and (c) 0.11 acres steep slope, soil B. All those areas become impervious and the corresponding sizing factors will be applied.

2) For areas that do not change in slope or in soil Type, no HMP mitigation is needed as the Flow Duration Curve (FDC) remains the same from pre-development to post-development conditions

SIZES:

Lake Wohlford Station, Soil Type B, $0.1Q_2$, Table 7.1 of the HMP Document:

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

DIMENSIONS:

Area:	**1324 sq-ft**[(1)]	(at the surface of bio-retention)	V_{IMP} :	1104 cu-ft
Ponding on top:	10 inches	(1): 43560·(0.06·0.09+0.21·0.085+0.11·0.065)		
Amended soil:	18 inches			
gravel at the bottom:	not needed (IMP located in soil type B).			

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 2 inches

Low flow discharge orifice is not needed

DETERMINATION OF Q_2 AND Q_{10}

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

Peak factor	Q_2	Q_{10}
(**B**, Wohlford)	(cfs/acre)	(cfs/acre)
flat, grass	0.1443	0.4183
moderate, grass	0.1928	0.4533
steep, grass	0.2389	0.4874
impervious, mod.	0.5051	0.7771

Q_2: 0.20 cfs (4 coefficients x 4 areas)

Q_{10}: 0.37 cfs (4 coefficients x 4 areas)

Note: Q_2 and Q_{10} factors obtained with the SDHM Program, version 8-15-11 for Wohlford station.

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)
2.00	1.73	6.6

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}: 1068 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 : Drying time = $V/(f \cdot A_{IMP}/12)$

V : volume of the 30" in the surface (cu-ft) =	1104	cu-ft
Qsoil : infiltration capacity of amended soil :	0.124	cfs
A_{IMP} : Area of the IMP in sq-ft :	1324	sq-ft
f [(1)]: infiltration of the bottom soil, in/hr :	0.21	in/hr
Bottom infiltration discharge, $Q_f = A_{IMP} \cdot f/(12 \cdot 3600)$	0.006	cfs
T : Drying time = $V/(3600 \cdot Q_{ave})$	47.6	hr

(1): Per the San Diego HMP, page 4.20, the mean permeability is 2·INFILT·INTFW. As INTFW is 1.5 for all soil types and slopes (see permit Table 3, page 11 of the Technical Memo "Selection of PERLND Parameters") and the parameter INFILT is 0.07 in/hr for soils type B, flat, per the same Table, the mean permeability is assumed 0.21 in/hr for soils Type B, flat for the purposes of determining the infiltration of the bottom of the bioretention. A more accurate calculation will be done at final design, when results from permeability tests are available.

IMP-1D

Soil type: A

AREAS

Slope	Pre-A	Post-A
Flat	0.19	0.42
Moderate	15.83	15.23
Steep	6.45	6.28
Imperv.	0.20	0.74
TOTAL	22.67	22.67

Notes on soil Transformation:

0.37 acres A moderate become 0.37 acres impervious

0.17 acres A steep become 0.17 acres impervious

0.23 acres A moderate become 0.23 acres A flat

0.20 acres impervious do not change

0.19, 15.23 and 6.28 acres A flat, mod. & steep (respectively) do not change

USE OF THE SIZING TABLE:

Asumptions:

1) Mitigation is not needed for pervious areas whose slope is reducing (0.23 acres A-mod. becoming flat)

2) Mitigation is needed for 0.37 acres A moderate and 0.17 acres A steep becoming impervious

SIZES:

Lake Wohlford Station, Soil Type A, $0.1Q_2$, Table 7.1 of the HMP Document:

Area factor, flat:	0.050	(Table 7.1, fraction of area that must become Bio-retention)
Area factor, moderate:	0.045	(Table 7.1, fraction of area that must become Bio-retention)
Area factor, steep:	0.040	(Table 7.1, fraction of area that must become Bio-retention)

DIMENSIONS:

Area:	1021 sq-ft[(1)]	(at the surface of bio-retention)
Ponding on top:	10 inches	(1): 43560·(0.37·0.045+0.17·0.04)
Amended soil:	18 inches	
gravel at the bottom:	not needed (IMP located in soil type A).	

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 5 inches

Low flow discharge orifice is not needed

DETERMINATION OF Q_2 AND Q_{10}

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

Peak factor	Q_2	Q_{10}
(**A**, Wohlford)	(cfs/acre)	(cfs/acre)
flat, grass	0.0829	0.3454
moderate, grass	0.1597	0.4199
steep, grass	0.2147	0.4757
impervious, mod.	0.5051	0.7771

Q_2: 4.03 cfs (4 coefficients x 4 areas)

Q_{10}: 9.94 cfs (4 coefficients x 4 areas)

Note: Q_2 and Q_{10} factors obtained with the SDHM Program, version 8-15-11 for Wohlford station.

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)
5.00	11.92	45.5

Solution: riser must be at least 48" 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}: **5110 sq-ft** V_{IMP} : 4259 cu-ft

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

DRYING TIME

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

T : Drying time = $V/(f \cdot A_{IMP}/12)$

V : volume of the 30" in the surface (cu-ft) =	4259	cu-ft
Qsoil : infiltration capacity of amended soil :	0.591	cfs
A_{IMP} : Area of the IMP in sq-ft :	5110	sq-ft
f [(1)]: infiltration of the bottom soil, in/hr :	0.27	in/hr
Bottom infiltration discharge, $Q_f = A_{IMP} \cdot f/(12 \cdot 3600)$	0.032	cfs
T : Drying time = $V/(3600 \cdot Q_{ave})$	37.0	hr

(1): Per the San Diego HMP, page 4.20, the mean permeability is 2·INFILT·INTFW. As INTFW is 1.5 for all soil types and slopes (see permit Table 3, page 11 of the Technical Memo "Selection of PERLND Parameters") and the parameter INFILT is 0.09 in/hr for soils type A, flat, per the same Table, the mean permeability is assumed 0.27 in/hr for soils Type A, flat for the purposes of determining the infiltration of the bottom of the bioretention. A more accurate calculation will be done at final design, when results from permeability tests are available.

IMP-1E

Soil type: A

AREAS

Slope	Pre-A	Post-A
Flat	0.31	2.13
Moderate	12.63	9.20
Steep	0.91	1.59
Imperv.	0.20	1.13
TOTAL	14.05	14.05

Notes on soil Transformation:

0.93 acres A moderate become 0.93 acres impervious

0.68 acres A moderate become 0.68 acres A steep

1.82 acres A moderate become 1.82 acres A flat

0.20 acres impervious do not change

0.31, 9.20 and 0.91 acres A flat, mod. & steep (respectively) do not change

USE OF THE SIZING TABLE:

Asumptions:

1) Mitigation has to occur for (a) 0.93 acres moderate slope, soil A

The previous area become impervious and the corresponding sizing factor will be applied.

2) Mitigation is not needed for pervious areas whose slope is reducing (1.82 acres A-mod becoming flat)

3) Mitigation is not needed for pervious areas whose slope is increasing (0.68 acres A-mod becoming steep).

(The reason is because the overall slope reduces (1.82 acres reducing slope compensates for 0.68 acres increasing slope))

4) For areas that do not change in slope or in soil Type, no HMP mitigation is needed as the Flow Duration Curve (FDC) remains the same from pre-development to post-development conditions

SIZES:

Lake Wohlford Station, Soil Type A, $0.1Q_2$, Table 7.1 of the HMP Document:

Area factor, flat:	0.050	(Table 7.1, fraction of area that must become Bio-retention)
Area factor, moderate:	0.045	(Table 7.1, fraction of area that must become Bio-retention)
Area factor, steep:	0.040	(Table 7.1, fraction of area that must become Bio-retention)

DIMENSIONS:

Area:	1823 sq-ft[1]	(at the surface of bio-retention)
Ponding on top:	10 inches	(1): 43560·(0.93·0.045)
Amended soil:	18 inches	
gravel at the bottom:	not needed (IMP located in soil type A).	

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 4 inches

Low flow discharge orifice is not needed

DETERMINATION OF Q_2 AND Q_{10}

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

Peak factor (**A**, Wohlford)	Q_2 (cfs/acre)	Q_{10} (cfs/acre)
flat, grass	0.0829	0.3454
moderate, grass	0.1597	0.4199
steep, grass	0.2147	0.4757
impervious, mod.	0.5051	0.7771

Q_2:	2.34 cfs	(4 coefficients x 4 areas)	Note: Q_2 and Q_{10} factors obtained with the SDHM
Q_{10}:	6.00 cfs	(4 coefficients x 4 areas)	Program, version 8-15-11 for Wohlford station.

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)
4.00	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}: **4220 sq-ft** V_{IMP} : 3517 cu-ft

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

DRYING TIME

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

T : Drying time = $V/(f \cdot A_{IMP}/12)$

V : volume of the 30" in the surface (cu-ft) =	3517	cu-ft
Qsoil : infiltration capacity of amended soil :	0.488	cfs
A_{IMP} : Area of the IMP in sq-ft :	4220	sq-ft
f [(1)]: infiltration of the bottom soil, in/hr :	0.27	in/hr
Bottom infiltration discharge, $Q_f = A_{IMP} \cdot f/(12 \cdot 3600)$	0.026	cfs
T : Drying time = $V/(3600 \cdot Q_{ave})$	37.0	hr

(1): Per the San Diego HMP, page 4.20, the mean permeability is 2·INFILT·INTFW. As INTFW is 1.5 for all soil types and slopes (see permit Table 3, page 11 of the Technical Memo "Selection of PERLND Parameters") and the parameter INFILT is 0.09 in/hr for soils type A, flat, per the same Table, the mean permeability is assumed 0.27 in/hr for soils Type A, flat for the purposes of determining the infiltration of the bottom of the bioretention. A more accurate calculation will be done at final design, when results from permeability tests are available.

IMP-1H

Soil type: A

AREAS

Slope	Pre-A	Post-A
Flat	0.04	0.50
Moderate	1.86	1.10
Steep	0.24	0.37
Imperv.	0.00	0.17
TOTAL	2.14	2.14

Notes on soil Transformation:

0.17 acres A moderate become 0.17 acres impervious

0.13 acres A moderate become 0.13 acres A steep

0.46 acres A moderate become 0.46 acres A flat

0.04, 1.10 and 0.24 acres A flat, mod. & steep (respectively) do not change

USE OF THE SIZING TABLE:

Asumptions:

1) Mitigation is not needed for pervious areas whose slope is reducing (0.46 acres A-mod. becoming flat)

2) Mitigation is not needed for pervious areas whose slope is increasing (0.13 acres A-mod becoming steep).

(The reason is because the overall slope reduces (0.46 acres reducing slope compensates for 0.13 acres increasing slope))

3) Mitigation is needed for 0.17 acres A moderate becoming impervious

SIZES:

Lake Wohlford Station, Soil Type A, $0.1Q_2$, Table 7.1 of the HMP Document:

Area factor, flat:	0.050	(Table 7.1, fraction of area that must become Bio-retention)
Area factor, moderate:	0.045	(Table 7.1, fraction of area that must become Bio-retention)
Area factor, steep:	0.040	(Table 7.1, fraction of area that must become Bio-retention)

DIMENSIONS:

Area:	333 sq-ft[(1)]	(at the surface of bio-retention)
Ponding on top:	10 inches	(1): 43560·(0.17·0.045)
Amended soil:	18 inches	
gravel at the bottom:	not needed (IMP located in soil type A).	

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 2.5 inches

Low flow discharge orifice is not needed

DETERMINATION OF Q_2 AND Q_{10}

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

Peak factor	Q_2	Q_{10}
(**A**, Wohlford)	(cfs/acre)	(cfs/acre)
flat, grass	0.0829	0.3454
moderate, grass	0.1597	0.4199
steep, grass	0.2147	0.4757
impervious, mod.	0.5051	0.7771

Q_2: 0.35 cfs (4 coefficients x 4 areas)

Q_{10}: 0.91 cfs (4 coefficients x 4 areas)

Note: Q_2 and Q_{10} factors obtained with the SDHM Program, version 8-15-11 for Wohlford station.

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)
2.50	3.08	11.8

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}: **639 sq-ft** V_{IMP} : 533 cu-ft

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

DRYING TIME

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

T : Drying time = $V/(f \cdot A_{IMP}/12)$

V : volume of the 30" in the surface (cu-ft) =	533	cu-ft
Qsoil : infiltration capacity of amended soil :	0.074	cfs
A_{IMP} : Area of the IMP in sq-ft :	639	sq-ft
f [(1)]: infiltration of the bottom soil, in/hr :	0.27	in/hr
Bottom infiltration discharge, $Q_f = A_{IMP} \cdot f/(12 \cdot 3600)$	0.004	cfs
T : Drying time = $V/(3600 \cdot Q_{ave})$	37.0	hr

(1): Per the San Diego HMP, page 4.20, the mean permeability is 2·INFILT·INTFW. As INTFW is 1.5 for all soil types and slopes (see permit Table 3, page 11 of the Technical Memo "Selection of PERLND Parameters") and the parameter INFILT is 0.09 in/hr for soils type A, flat, per the same Table, the mean permeability is assumed 0.27 in/hr for soils Type A, flat for the purposes of determining the infiltration of the bottom of the bioretention. A more accurate calculation will be done at final design, when results from permeability tests are available.

IMP-2A (does not include area draining to 2A-1, 2A-2, 2A-3, and 2A-4)

Soil type: A

AREAS

Slope	Pre-A	Post-A
Flat	1.16	4.37
Moderate	17.56	10.98
Steep	3.75	4.90
Imperv.	1.12	3.34
TOTAL	23.59	23.59

Notes on soil Transformation:

The next areas (acres) remain the same: 1.16 A-flat; 10.98 A-mod; 3.75 A-steep; 1.12 Impervious.

3.21 acres moderate slope A become 3.21 acres flat slope A

1.15 acres moderate slope A become 1.15 acres steep slope A

2.22 acres moderate slope A become 2.22 acres impervious

USE OF THE SIZING TABLE:

Asumptions:

1) Mitigation has to occur for (a) 2.22 acres moderate slope, soil A

The previous area become impervious and the corresponding sizing factor will be applied.

2) Mitigation is not needed for pervious areas whose slope is reducing (3.21 acres A-mod becoming flat)

3) Mitigation is not needed for pervious areas whose slope is increasing (1.15 acres A-mod becoming steep).

(The reason is because the overall slope reduces (3.21 acres reducing slope compensates for 1.15 acres increasing slope))

4) For areas that do not change in slope or in soil Type, no HMP mitigation is needed as the Flow Duration Curve (FDC) remains the same from pre-development to post-development conditions

SIZES:

Lake Wohlford Station, Soil Type A, $0.1Q_2$, Table 7.1 of the HMP Document:

Area factor, flat:	0.050	(Table 7.1, fraction of area that must become Bio-retention)
Area factor, moderate:	0.045	(Table 7.1, fraction of area that must become Bio-retention)
Area factor, steep:	0.040	(Table 7.1, fraction of area that must become Bio-retention)

DIMENSIONS:

Area:	4352 sq-ft[(1)]	(at the surface of bio-retention)
Ponding on top:	10 inches	(1): 43560·(2.22·0.045)
Amended soil:	18 inches	
gravel at the bottom:	not needed (IMP located in soil type A).	

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 5 inches

Low flow discharge orifice is not needed

DETERMINATION OF Q_2 AND Q_{10}

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

Peak factor (**A**, Wohlford)	Q_2 (cfs/acre)	Q_{10} (cfs/acre)
flat, grass	0.0829	0.3454
moderate, grass	0.1597	0.4199
steep, grass	0.2147	0.4757
impervious, mod.	0.5051	0.7771

Q_2:	4.27 cfs	(4 coefficients x 4 areas)	Note: Q_2 and Q_{10} factors obtained with the SDHM
Q_{10}:	10.43 cfs	(4 coefficients x 4 areas)	Program, version 8-15-11 for Wohlford station.

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	12.51	47.8

Solution: riser must be at least 48" 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}: **9348 sq-ft** V_{IMP} : 7790 cu-ft

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

DRYING TIME

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

T : Drying time = $V/(f \cdot A_{IMP}/12)$

V : volume of the 30" in the surface (cu-ft) =	7790	cu-ft
Qsoil : infiltration capacity of amended soil :	1.082	cfs
A_{IMP} : Area of the IMP in sq-ft :	9348	sq-ft
f [(1)]: infiltration of the bottom soil, in/hr :	0.27	in/hr
Bottom infiltration discharge, $Q_f = A_{IMP} \cdot f/(12 \cdot 3600)$	0.058	cfs
T : Drying time = $V/(3600 \cdot Q_{ave})$	37.0	hr

(1): Per the San Diego HMP, page 4.20, the mean permeability is 2·INFILT·INTFW. As INTFW is 1.5 for all soil types and slopes (see permit Table 3, page 11 of the Technical Memo "Selection of PERLND Parameters") and the parameter INFILT is 0.09 in/hr for soils type A, flat, per the same Table, the mean permeability is assumed 0.27 in/hr for soils Type A, flat for the purposes of determining the infiltration of the bottom of the bioretention. A more accurate calculation will be done at final design, when results from permeability tests are available.

IMP-2A.1

Soil type: A, and C

Notes on soil Transformation:

The next areas (acres) remain the same: 1.20 A-steep; 0.12 A-mod; 0.19 C-flat; 3.10 C-mod; 0.42 C-steep

0.03 acres moderate slope A become 0.03 acres impervious

0.06 acres moderate slope A become 0.06 acres flat slope A

0.02 acres flat slope C become 0.02 acres impervious

0.25 acres moderate slope C become 0.25 acres impervious

0.03 acres moderate slope C become 0.03 acres steep slope

AREAS

Slope	Pre-A	Pre-C	Post-A	Post-C
Flat	0.00	0.21	0.06	0.19
Moderate	0.21	3.38	0.12	3.10
Steep	1.20	0.42	1.20	0.45
Imperv.	0.00	0.00	0.03	0.27
TOTAL	1.41	4.01	1.41	4.01

USE OF THE SIZING TABLE:

Asumptions:

1) Mitigation has to occur for (a) 0.02 acres flat slope soil C; (b) 0.25 acres moderate slope, soil C; (c) 0.03 acres moderate slope, soil A.

All those areas become impervious and the corresponding sizing factors will be applied.

2) Mitigation is not needed for pervious areas whose slope is reducing (0.06 acres A-mod. becoming flat)

3) Mitigation is not needed for pervious areas whose slope is increasing (0.03 acres C-mod becoming steep).

(The reason is because the overall slope reduces (0.06 acres reducing slope compensates for 0.03 acres increasing slope))

4) For areas that do not change in slope or in soil Type, no HMP mitigation is needed as the Flow Duration Curve (FDC) remains the same from pre-development to post-development conditions

SIZES:

Lake Wohlford Station, Soil Type A, $0.1Q_2$, Table 7.1 of the HMP Document:

Area factor, flat:	0.050	(Table 7.1, fraction of area that must become Bio-retention)
Area factor, moderate:	0.045	(Table 7.1, fraction of area that must become Bio-retention)
Area factor, steep:	0.040	(Table 7.1, fraction of area that must become Bio-retention)

Lake Wohlford Station, Soil Type C, $0.1Q_2$, Table 7.1 of the HMP Document:

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

Area, A:	1353 sq-ft [(1)]	(at the surface of bio-retention)
Ponding on top:	10 inches	(1): 43560·(0.02·0.11+0.25·0.11+0.03·0.045)
Amended soil:	18 inches	
gravel at the bottom:	not needed (IMP located in soil type A).	

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 3 inches

Low flow discharge orifice is not needed

DETERMINATION OF Q_2 AND Q_{10}

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

Peak factor (Wohlford)	Q_2 (soil C) (cfs/acre)	Q_{10} (Soil C) (cfs/acre)	Q_2 (soil A) (cfs/acre)	Q_{10} (Soil A) (cfs/acre)
flat, grass	0.2037	0.4637	0.0829	0.3454
moderate, grass	0.2317	0.4867	0.1597	0.4199
steep, grass	0.2792	0.5183	0.2147	0.4757
Impervious, moderate	0.5051	0.7771	0.5051	0.7771

Q_2: 1.23 cfs — Convolution of Q_2 peak factors times areas

Q_{10}: 2.62 cfs — Convolution of Q_{10} peak factors times areas

Note: Q_2 and Q_{10} factors obtained with the SDHM Program, version 8-15-11 for Wohlford station.

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)
3	6.76	25.8

Solution: riser must be at least 36" 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}: **1415 sq-ft** V_{IMP} : 1179 cu-ft

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

DRYING TIME

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

T : Drying time = $V/(f \cdot A_{IMP}/12)$

V : volume of the 30" in the surface (cu-ft) =	1179 cu-ft
Qsoil : infiltration capacity of amended soil :	0.164 cfs
A_{IMP} : Area of the IMP in sq-ft :	1415 sq-ft
f [(1)]: infiltration of the bottom soil, in/hr :	0.27 in/hr
Bottom infiltration discharge, $Q_f = A_{IMP} \cdot f/(12 \cdot 3600)$	0.009 cfs
T : Drying time = $V/(3600 \cdot Q_{ave})$	37.0 hr

(1): Per the San Diego HMP, page 4.20, the mean permeability is 2·INFILT·INTFW. As INTFW is 1.5 for all soil types and slopes (see permit Table 3, page 11 of the Technical Memo "Selection of PERLND Parameters") and the parameter INFILT is 0.09 in/hr for soils type A, flat, per the same Table, the mean permeability is assumed 0.27 in/hr for soils Type A, flat for the purposes of determining the infiltration of the bottom of the bioretention. A more accurate calculation will be done at final design, when results from permeability tests are available.

IMP-2A.2

Soil type: A, and C

AREAS

Slope	Pre-A	Pre-C	Post-A	Post-C
Flat	0.07	0.00	1.39	0.01
Moderate	6.32	0.07	4.33	0.05
Steep	2.25	0.31	2.06	0.14
Imperv.	0.18	0.01	1.04	0.19
TOTAL	8.82	0.39	8.82	0.39

Notes on soil Transformation:

The next areas (acres) remain the same: 2.06 A-steep; 4.33 A-mod; 0.07 A-flat; 0.05 C-mod; 0.14 C-steep

0.19 acres steep slope A become 0.19 acres impervious

0.67 acres moderate slope A become 0.67 acres impervious

1.32 acres moderate slope A become 1.32 acres flat slope A

0.01 acres moderate slope C become 0.01 acres flat slope C

0.01 acres moderate slope C become 0.01 acres impervious

0.17 acres steep slope C become 0.17 acres impervious

USE OF THE SIZING TABLE:

Asumptions:

1) Mitigation has to occur for (a) 0.19 acres steep slope soil A; (b) 0.67 acres moderate slope, soil A; (c) 0.01 acres moderate slope, soil C; (d) 0.17 acres steep slope, soil C.

All those areas become impervious and the corresponding sizing factors will be applied.

2) Mitigation is not needed for perv. areas whose slope is reducing (1.32 acres A-mod. and 0.01 acres C-mod. becoming flat)

4) For areas that do not change in slope or in soil Type, no HMP mitigation is needed as the Flow Duration Curve (FDC) remains the same from pre-development to post-development conditions

SIZES:

Lake Wohlford Station, Soil Type A, $0.1Q_2$, Table 7.1 of the HMP Document:

Area factor, flat: 0.050 (Table 7.1, fraction of area that must become Bio-retention)
Area factor, moderate: 0.045 (Table 7.1, fraction of area that must become Bio-retention)
Area factor, steep: 0.040 (Table 7.1, fraction of area that must become Bio-retention)

Lake Wohlford Station, Soil Type C, $0.1Q_2$, Table 7.1 of the HMP Docur

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

Area, A: 2359 sq-ft [(1)] (at the surface of bio-retention)
Ponding on top: 10 inches (1): 43560·(0.01·0.11+0.17·0.09+0.67·0.045+0.19·0.04)
Amended soil: 18 inches
gravel at the bottom: not needed (IMP located in soil type A).

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 3 inches

Low flow discharge orifice is not needed

DETERMINATION OF Q_2 AND Q_{10}

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

Peak factor (Wohlford)	Q_2 (soil C) (cfs/acre)	Q_{10} (Soil C) (cfs/acre)	Q_2 (soil A) (cfs/acre)	Q_{10} (Soil A) (cfs/acre)
flat, grass	0.2037	0.4637	0.0829	0.3454
moderate, grass	0.2317	0.4867	0.1597	0.4199
steep, grass	0.2792	0.5183	0.2147	0.4757
Impervious, moderate	0.5051	0.7771	0.5051	0.7771

Q_2:	1.70 cfs	Convolution of Q_2 peak factors times areas	Note: Q_2 and Q_{10} factors obtained with the SDHM
Q_{10}:	4.09 cfs	Convolution of Q_{10} peak factors times areas	Program, version 8-15-11 for Wohlford station.

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)	
3	10.56	40.3	Solution: riser must be at least 48" 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}: ***3534 sq-ft*** V_{IMP} : 2945 cu-ft

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

MODIFICATION OF THE DIMENSIONS OF THE IMP : WQ AREA REDUCTION

Assuming that the water quality volume is preserved, the area can be reduced to accommodate the bio-retention to the available space; the ponding on top can be increased to satisfy volume.

FINAL DIMENSIONS:

Final Area (A_f):	**3534 sq-ft**	(at the surface of bio-retention)
Ponding on top, H_P:	10.0 inches	Required ponding depth for modified area. $H_P = V_{IMP}/A_f$
Amended soil, h_{soil}:	18.0 inches	Minimum amended soil depth
Gravel depth, h_{gravel} :	not needed	

DRYING TIME

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

T : Drying time = $V/(f \cdot A_{IMP}/12)$

V : volume of the 30" in the surface (cu-ft) =	2945 cu-ft
Qsoil : infiltration capacity of amended soil :	0.409 cfs
A_{IMP} : Area of the IMP in sq-ft :	3534 sq-ft
f [(1)]: infiltration of the bottom soil, in/hr :	0.27 in/hr
Bottom infiltration discharge, $Q_f = A_{IMP} \cdot f/(12 \cdot 3600)$	0.022 cfs
T : Drying time = $V/(3600 \cdot Q_{ave})$	37.0 hr

(1): Per the San Diego HMP, page 4.20, the mean permeability is 2·INFILT·INTFW. As INTFW is 1.5 for all soil types and slopes (see permit Table 3, page 11 of the Technical Memo "Selection of PERLND Parameters") and the parameter INFILT is 0.09 in/hr for soils type A, flat, per the same Table, the mean permeability is assumed 0.27 in/hr for soils Type A, flat for the purposes of determining the infiltration of the bottom of the bioretention. A more accurate calculation will be done at final design, when results from permeability tests are available.

IMP-2A.3

Soil type: A

AREAS

Slope	Pre-A	Post-A
Flat	0.02	1.49
Moderate	5.15	2.96
Steep	0.34	0.77
Imperv.	0.10	0.39
TOTAL	5.61	5.61

Notes on soil Transformation:

The next areas (acres) remain the same: 0.02 A-flat; 2.96 A-mod; 0.34 A-steep; 0.10 Impervious.

1.47 acres moderate slope A become 1,47 acres flat slope A

0.43 acres moderate slope A become 0.43 acres steep slope A

0.29 acres moderate slope A become 0.29 acres impervious

USE OF THE SIZING TABLE:

Asumptions:

1) Mitigation has to occur for (a) 0.29 acres moderate slope, soil A
The previous area become impervious and the corresponding sizing factor will be applied.

2) Mitigation is not needed for pervious areas whose slope is reducing (1.47 acres A-mod becoming flat)

3) Mitigation is not needed for pervious areas whose slope is increasing (0.43 acres A-mod becoming steep).
(The reason is because the overall slope reduces (1.47 acres reducing slope compensates for 0.43 acres increasing slope))

4) For areas that do not change in slope or in soil Type, no HMP mitigation is needed as the Flow Duration Curve (FDC) remains the same from pre-development to post-development conditions

SIZES:

Lake Wohlford Station, Soil Type A, $0.1Q_2$, Table 7.1 of the HMP Document:

Area factor, flat: 0.050 (Table 7.1, fraction of area that must become Bio-retention)

Area factor, moderate: 0.045 (Table 7.1, fraction of area that must become Bio-retention)

Area factor, steep: 0.040 (Table 7.1, fraction of area that must become Bio-retention)

DIMENSIONS:

Area: 568 sq-ft[(1)] (at the surface of bio-retention)

Ponding on top: 10 inches (1): 43560·(0.29·0.045)

Amended soil: 18 inches

gravel at the bottom: not needed (IMP located in soil type A).

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 3 inches

Low flow discharge orifice is not needed

DETERMINATION OF Q_2 AND Q_{10}

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

Peak factor (Wohlford)	Q_2 (soil C) (cfs/acre)	Q_{10} (Soil C) (cfs/acre)	Q_2 (soil A) (cfs/acre)	Q_{10} (Soil A) (cfs/acre)
flat, grass	0.2037	0.4637	0.0829	0.3454
moderate, grass	0.2317	0.4867	0.1597	0.4199
steep, grass	0.2792	0.5183	0.2147	0.4757
Impervious, moderate	0.5051	0.7771	0.5051	0.7771

Q_2:	0.95 cfs	Convolution of Q_2 peak factors times areas	Note: Q_2 and Q_{10} factors obtained with the SDHM
Q_{10}:	2.41 cfs	Convolution of Q_{10} peak factors times areas	Program, version 8-15-11 for Wohlford station.

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)
3	6.22	23.7

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}: **1589 sq-ft** V_{IMP} : 1324 cu-ft

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

DRYING TIME

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

T : Drying time = $V/(f \cdot A_{IMP}/12)$

V : volume of the 30" in the surface (cu-ft) =	1324	cu-ft
Qsoil : infiltration capacity of amended soil :	0.184	cfs
A_{IMP} : Area of the IMP in sq-ft :	1589	sq-ft
f [(1)]: infiltration of the bottom soil, in/hr :	0.27	in/hr
Bottom infiltration discharge, $Q_f = A_{IMP} \cdot f/(12 \cdot 3600)$	0.010	cfs
T : Drying time = $V/(3600 \cdot Q_{ave})$	37.0	hr

(1): Per the San Diego HMP, page 4.20, the mean permeability is 2·INFILT·INTFW. As INTFW is 1.5 for all soil types and slopes (see permit Table 3, page 11 of the Technical Memo "Selection of PERLND Parameters") and the parameter INFILT is 0.09 in/hr for soils type A, flat, per the same Table, the mean permeability is assumed 0.27 in/hr for soils Type A, flat for the purposes of determining the infiltration of the bottom of the bioretention. A more accurate calculation will be done at final design, when results from permeability tests are available.

IMP-2A.4

Soil type: A

AREAS

Slope	Pre-A	Post-A
Flat	0.01	0.09
Moderate	0.58	0.09
Steep	0.12	0.01
Imperv.	0.01	0.53
TOTAL	0.72	0.72

Notes on soil Transformation:

The next areas (acres) remain the same: 0.01 A-flat; 0.09 A-mod; 0.01 A-steep; 0.01 Impervious.

0.08 acres moderate slope A become 0.08 acres flat slope A

0.41 acres moderate slope A become 0.41 acres impervious

0.11 acres steep slope A become 0.11 acres impervious

USE OF THE SIZING TABLE:

Asumptions:

1) Mitigation has to occur for (a) 0.11 acres steep slope soil A; (b) 0.41 acres moderate slope, soil A
All those areas become impervious and the corresponding sizing factors will be applied.

2) Mitigation is not needed for pervious areas whose slope is reducing (0.08 acres A-mod. becoming flat)

3) For areas that do not change in slope or in soil Type, no HMP mitigation is needed as the Flow Duration Curve (FDC) remains the same from pre-development to post-development conditions

SIZES:

Lake Wohlford Station, Soil Type A, $0.1Q_2$, Table 7.1 of the HMP Document:

Area factor, flat:	0.050	(Table 7.1, fraction of area that must become Bio-retention)
Area factor, moderate:	0.045	(Table 7.1, fraction of area that must become Bio-retention)
Area factor, steep:	0.040	(Table 7.1, fraction of area that must become Bio-retention)

DIMENSIONS:

Area:	**995 sq-ft**[(1)]	(at the surface of bio-retention)
Ponding on top:	10 inches	(1): 43560·(0.41·0.045+0.11·0.04)
Amended soil:	18 inches	
gravel at the bottom:	not needed (IMP located in soil type A).	

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 3 inches

Low flow discharge orifice is not needed

DETERMINATION OF Q_2 AND Q_{10}

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

Peak factor (Wohlford)	Q_2 (soil C) (cfs/acre)	Q_{10} (Soil C) (cfs/acre)	Q_2 (soil A) (cfs/acre)	Q_{10} (Soil A) (cfs/acre)
flat, grass	0.2037	0.4637	0.0829	0.3454
moderate, grass	0.2317	0.4867	0.1597	0.4199
steep, grass	0.2792	0.5183	0.2147	0.4757
Impervious, moderate	0.5051	0.7771	0.5051	0.7771

Q_2:	0.12 cfs	Convolution of Q_2 peak factors times areas	Note: Q_2 and Q_{10} factors obtained with the SDHM
Q_{10}:	0.31 cfs	Convolution of Q_{10} peak factors times areas	Program, version 8-15-11 for Wohlford station.

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)
3	0.80	3.1

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}: 957 sq-ft V_{IMP} : 1371 cu-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:

$T = V/(f \cdot A_{IMP}/12)$

V : volume of the 10" in the surface (cu-ft) =	829	cu-ft
A_{IMP} : Area of the IMP in sq-ft :	995	sq-ft
f [(1)]: infiltration of the bottom soil, in/hr :	0.27	in/hr
Bottom infiltration discharge, $Q_f = A_{IMP} \cdot f/(12 \cdot 3600)$	0.006	cfs
T : Drying time = $V/(3600 \cdot Q_{ave})$	37.0	hr

(1): Per the San Diego HMP, page 4.20, the mean permeability is 2·INFILT·INTFW. As INTFW is 1.5 for all soil types and slopes (see permit Table 3, page 11 of the Technical Memo "Selection of PERLND Parameters") and the parameter INFILT is 0.09 in/hr for soils type A, flat, per the same Table, the mean permeability is assumed 0.27 in/hr for soils Type A, flat for the purposes of determining the infiltration of the bottom of the bioretention. A more accurate calculation will be done at final design, when results from permeability tests are available.

IMP-2B (does not include area draining to 2B-1)

Soil type: A

AREAS

Slope	Pre-A	Post-A
Flat	1.21	2.37
Moderate	8.97	6.91
Steep	2.82	3.45
Imperv.	1.45	1.72
TOTAL	14.45	14.45

Notes on soil Transformation:

The next areas (acres) remain the same: 1.21 A-flat; 6.91 A-mod; 2.82 A-steep; 1.45 Impervious.

1.16 acres moderate slope A become 1.16 acres flat slope A

0.63 acres moderate slope A become 0.63 acres steep slope A

0.27 acres moderate slope A become 0.27 acres impervious

USE OF THE SIZING TABLE:

Asumptions:

1) Mitigation has to occur for (a) 0.27 acres moderate slope, soil A

The previous area become impervious and the corresponding sizing factor will be applied.

2) Mitigation is not needed for pervious areas whose slope is reducing (1.16 acres A-mod becoming flat)

3) Mitigation is not needed for pervious areas whose slope is increasing (0.63 acres A-mod becoming steep).

(The reason is because the overall slope reduces (1.16 acres reducing slope compensates for 0.63 acres increasing slope))

4) For areas that do not change in slope or in soil Type, no HMP mitigation is needed as the Flow Duration Curve (FDC) remains the same from pre-development to post-development conditions

SIZES:

Lake Wohlford Station, Soil Type A, $0.1Q_2$, Table 7.1 of the HMP Document:

Area factor, flat:	0.050	(Table 7.1, fraction of area that must become Bio-retention)
Area factor, moderate:	0.045	(Table 7.1, fraction of area that must become Bio-retention)
Area factor, steep:	0.040	(Table 7.1, fraction of area that must become Bio-retention)

DIMENSIONS:

Area:	529 sq-ft(1)	(at the surface of bio-retention)
Ponding on top:	10 inches	(1): 43560·(0.27·0.045)
Amended soil:	18 inches	
gravel at the bottom:	not needed (IMP located in soil type A).	

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 5 inches

Low flow discharge orifice is not needed

DETERMINATION OF Q_2 AND Q_{10}

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

Peak factor (**A**, Wohlford)	Q_2 (cfs/acre)	Q_{10} (cfs/acre)
flat, grass	0.0829	0.3454
moderate, grass	0.1597	0.4199
steep, grass	0.2147	0.4757
impervious, mod.	0.5051	0.7771

Q_2:	2.87 cfs	(4 coefficients x 4 areas)	Note: Q_2 and Q_{10} factors obtained with the SDHM
Q_{10}:	6.65 cfs	(4 coefficients x 4 areas)	Program, version 8-15-11 for Wohlford station.

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	7.98	30.5

Solution: riser must be at least 36" 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}: **5215 sq-ft** V_{IMP} : 4346 cu-ft

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

DRYING TIME

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

T : Drying time = $V/(f \cdot A_{IMP}/12)$

V : volume of the 30" in the surface (cu-ft) =	4346	cu-ft
Qsoil : infiltration capacity of amended soil :	0.604	cfs
A_{IMP} : Area of the IMP in sq-ft :	5215	sq-ft
f [(1)]: infiltration of the bottom soil, in/hr :	0.27	in/hr
Bottom infiltration discharge, $Q_f = A_{IMP} \cdot f/(12 \cdot 3600)$	0.033	cfs
T : Drying time = $V/(3600 \cdot Q_{ave})$	37.0	hr

(1): Per the San Diego HMP, page 4.20, the mean permeability is 2·INFILT·INTFW. As INTFW is 1.5 for all soil types and slopes (see permit Table 3, page 11 of the Technical Memo "Selection of PERLND Parameters") and the parameter INFILT is 0.09 in/hr for soils type A, flat, per the same Table, the mean permeability is assumed 0.27 in/hr for soils Type A, flat for the purposes of determining the infiltration of the bottom of the bioretention. A more accurate calculation will be done at final design, when results from permeability tests are available.

IMP-2B.1

Soil type: A

AREAS

Slope	Pre-A	Post-A
Flat	0.03	1.45
Moderate	5.38	3.35
Steep	0.08	0.36
Imperv.	0.00	0.33
TOTAL	5.49	5.49

Notes on soil Transformation:

The next areas (acres) remain the same: 0.03 A-flat; 3.35 A-mod; 0.08 A-steep.

1.42 acres moderate slope A become 1,42 acres flat slope A

0.28 acres moderate slope A become 0.28 acres steep slope A

0.33 acres moderate slope A become 0.33 acres impervious

USE OF THE SIZING TABLE:

Asumptions:

1) Mitigation has to occur for (a) 0.33 acres moderate slope, soil A

The previous area become impervious and the corresponding sizing factor will be applied.

2) Mitigation is not needed for pervious areas whose slope is reducing (1.42 acres A-mod becoming flat)

3) Mitigation is not needed for pervious areas whose slope is increasing (0.28 acres A-mod becoming steep).

(The reason is because the overall slope reduces (1.42 acres reducing slope compensates for 0.28 acres increasing slope))

4) For areas that do not change in slope or in soil Type, no HMP mitigation is needed as the Flow Duration Curve (FDC) remains the same from pre-development to post-development conditions

SIZES:

Lake Wohlford Station, Soil Type A, 0.1Q_2, Table 7.1 of the HMP Document:

Area factor, flat:	0.050	(Table 7.1, fraction of area that must become Bio-retention)
Area factor, moderate:	0.045	(Table 7.1, fraction of area that must become Bio-retention)
Area factor, steep:	0.040	(Table 7.1, fraction of area that must become Bio-retention)

DIMENSIONS:

Area:	647 sq-ft[(1)]	(at the surface of bio-retention)
Ponding on top:	10 inches	(1): 43560·(0.33·0.045)
Amended soil:	18 inches	
gravel at the bottom:	not needed (IMP located in soil type A).	

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 5 inches

Low flow discharge orifice is not needed

DETERMINATION OF Q_2 AND Q_{10}

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

Peak factor (**A**, Wohlford)	Q_2 (cfs/acre)	Q_{10} (cfs/acre)
flat, grass	0.0829	0.3454
moderate, grass	0.1597	0.4199
steep, grass	0.2147	0.4757
impervious, mod.	0.5051	0.7771

Q_2:	0.88 cfs	(4 coefficients x 4 areas)	Note: Q_2 and Q_{10} factors obtained with the SDHM
Q_{10}:	2.31 cfs	(4 coefficients x 4 areas)	Program, version 8-15-11 for Wohlford station.

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)
3	5.95	22.7

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}: **1474 sq-ft** V_{IMP} : 1228 cu-ft

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

DRYING TIME

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

T : Drying time = $V/(f \cdot A_{IMP}/12)$

V : volume of the 30" in the surface (cu-ft) =	1228	cu-ft
Qsoil : infiltration capacity of amended soil :	0.171	cfs
A_{IMP} : Area of the IMP in sq-ft :	1474	sq-ft
f (1): infiltration of the bottom soil, in/hr :	0.27	in/hr
Bottom infiltration discharge, $Q_f = A_{IMP} \cdot f/(12 \cdot 3600)$	0.009	cfs
T : Drying time = $V/(3600 \cdot Q_{ave})$	37.0	hr

(1): Per the San Diego HMP, page 4.20, the mean permeability is 2·INFILT·INTFW. As INTFW is 1.5 for all soil types and slopes (see permit Table 3, page 11 of the Technical Memo "Selection of PERLND Parameters") and the parameter INFILT is 0.09 in/hr for soils type A, flat, per the same Table, the mean permeability is assumed 0.27 in/hr for soils Type A, flat for the purposes of determining the infiltration of the bottom of the bioretention. A more accurate calculation will be done at final design, when results from permeability tests are available.

IMP-3A

Soil type: A, and C

AREAS

Slope	Pre-A	Pre-C	Post-A	Post-C
Flat	0.15	0.05	1.62	0.51
Moderate	9.75	2.26	6.47	1.99
Steep	1.98	2.32	2.89	2.13
Imperv.	0.00	0.00	0.90	0.00
TOTAL	11.88	4.63	11.88	4.63

Notes on soil Transformation:

The next areas (acres) remain the same: 0.15 A-flat; 6.47 A-mod; 1.98 A-steep; 0.05 C-flat; 1.99 C-mod; 2.13 C-steep

0.90 acres moderate slope A become 0.90 acres impervious

0.91 acres moderate slope A become 0.91 acres steep slope A

1.47 acres moderate slope A become 1.47 acres flat slope A

0.27 acres moderate slope C become 0.27 acres flat slope C

0.19 acres steep slope C become 0.19 acres flat slope C

USE OF THE SIZING TABLE:

Asumptions:

1) Mitigation has to occur for 0.90 acres moderate slope soil A becoming impervious.

2) Mitigation is not needed for pervious areas whose slope is reducing (1.47 acres A-mod. becoming flat, 0.27 acres C-mod. Becoming flat, 0.19 acres C-steep becoming flat).

3) Mitigation is not needed for pervious areas whose slope is increasing (0.91 acres A-mod becoming steep).

(The reason is because the overall slope reduces (1.47+0.27+0.19 acres reducing slope compensates for 0.91 acres increasing slope))

4) For areas that do not change in slope or in soil Type, no HMP mitigation is needed as the Flow Duration Curve (FDC) remains the same from pre-development to post-development conditions

SIZES:

Lake Wohlford Station, Soil Type A, $0.1Q_2$, Table 7.1 of the HMP Document:

Area factor, flat: 0.050 (Table 7.1, fraction of area that must become Bio-retention)

Area factor, moderate: 0.045 (Table 7.1, fraction of area that must become Bio-retention)

Area factor, steep: 0.040 (Table 7.1, fraction of area that must become Bio-retention)

Lake Wohlford Station, Soil Type C, $0.1Q_2$, Table 7.1 of the HMP Document:

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

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:

Area: 1764 sq-ft [(1)] (at the surface of bio-retention)

Ponding on top: 10 inches (1): 43560·(0.045·0.9)

Amended soil: 18 inches

gravel at the bottom: not needed (IMP located in soil type A).

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 5 inches

Low flow discharge orifice is not needed

DETERMINATION OF Q_2 AND Q_{10}

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

Peak factor (Wohlford)	Q_2 (soil C) (cfs/acre)	Q_{10} (Soil C) (cfs/acre)	Q_2 (soil A) (cfs/acre)	Q_{10} (Soil A) (cfs/acre)
flat, grass	0.2037	0.4637	0.0829	0.3454
moderate, grass	0.2317	0.4867	0.1597	0.4199
steep, grass	0.2792	0.5183	0.2147	0.4757
Impervious, moderate	0.5051	0.7771	0.5051	0.7771

Q_2: 3.18 cfs — Convolution of Q_2 peak factors times areas

Q_{10}: 7.41 cfs — Convolution of Q_{10} peak factors times areas

Note: Q_2 and Q_{10} factors obtained with the SDHM Program, version 8-15-11 for Wohlford station.

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	8.89	34.0

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}: **4288 sq-ft** V_{IMP} : 3573 cu-ft

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

DRYING TIME

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

$T = V/(f \cdot A_{IMP}/12)$

V : volume of the 10" in the surface (cu-ft) =	3573	cu-ft
A_{IMP} : Area of the IMP in sq-ft :	4288	sq-ft
f [(1)]: infiltration of the bottom soil, in/hr :	0.27	in/hr
Bottom infiltration discharge, $Q_f = A_{IMP} \cdot f/(12 \cdot 3600)$	0.027	cfs
T : Drying time = $V/(3600 \cdot Q_{ave})$	37.0	hr

(1): Per the San Diego HMP, page 4.20, the mean permeability is 2·INFILT·INTFW. As INTFW is 1.5 for all soil types and slopes (see permit Table 3, page 11 of the Technical Memo "Selection of PERLND Parameters") and the parameter INFILT is 0.09 in/hr for soils type A, flat, per the same Table, the mean permeability is assumed 0.27 in/hr for soils Type A, flat for the purposes of determining the infiltration of the bottom of the bioretention. A more accurate calculation will be done at final design, when results from permeability tests are available.

IMP-3B

Soil type: A

AREAS

Slope	Pre-A	Post-A
Flat	0.48	2.32
Moderate	9.96	7.07
Steep	2.32	2.66
Imperv.	0.00	0.71
TOTAL	12.76	12.76

Notes on soil Transformation:

0.71 acres A moderate become 0.71 acres impervious

0.34 acres A moderate become 0.34 acres A steep

1.84 acres A moderate become 1.84 acres A flat

0.48, 7.07 and 2.32 acres A flat, mod. & steep (respectively) do not change

USE OF THE SIZING TABLE:

Asumptions:

1) Mitigation is not needed for pervious areas whose slope is reducing (1.84 acres A-mod. becoming flat)

2) Mitigation is not needed for pervious areas whose slope is increasing (0.34 acres A-mod becoming steep).

(The reason is because the overall slope reduces (1.84 acres reducing slope compensates for 0.34 acres increasing slope))

3) Mitigation is needed for 0.71 acres A moderate becoming impervious

SIZES:

Lake Wohlford Station, Soil Type A, $0.1Q_2$, Table 7.1 of the HMP Document:

Area factor, flat: 0.050 (Table 7.1, fraction of area that must become Bio-retention)

Area factor, moderate: 0.045 (Table 7.1, fraction of area that must become Bio-retention)

Area factor, steep: 0.040 (Table 7.1, fraction of area that must become Bio-retention)

DIMENSIONS:

Area: 1392 sq-ft[(1)] (at the surface of bio-retention)

Ponding on top: 10 inches (1): 43560·(0.71·0.045)

Amended soil: 18 inches

gravel at the bottom: not needed (IMP located in soil type A).

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 4 inches

Low flow discharge orifice is not needed

DETERMINATION OF Q_2 AND Q_{10}

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

Peak factor	Q_2	Q_{10}
(**A**, Wohlford)	(cfs/acre)	(cfs/acre)
flat, grass	0.0829	0.3454
moderate, grass	0.1597	0.4199
steep, grass	0.2147	0.4757
impervious, mod.	0.5051	0.7771

Q_2: 2.13 cfs (4 coefficients x 4 areas)

Q_{10}: 5.45 cfs (4 coefficients x 4 areas)

Note: Q_2 and Q_{10} factors obtained with the SDHM Program, version 8-15-11 for Wohlford station.

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)
4.00	9.14	34.9

Solution: riser must be at least 36" 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}: **3337 sq-ft**

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

DRYING TIME

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

$T = V/(f \cdot A_{IMP}/12)$

V : volume of the 10" in the surface (cu-ft) =	2781	cu-ft
A_{IMP} : Area of the IMP in sq-ft :	3337	sq-ft
f [(1)]: infiltration of the bottom soil, in/hr :	0.27	in/hr
Bottom infiltration discharge, $Q_f = A_{IMP} \cdot f/(12 \cdot 3600)$	0.021	cfs
T : Drying time = $V/(3600 \cdot Q_{ave})$	37.0	hr

(1): Per the San Diego HMP, page 4.20, the mean permeability is 2·INFILT·INTFW. As INTFW is 1.5 for all soil types and slopes (see permit Table 3, page 11 of the Technical Memo "Selection of PERLND Parameters") and the parameter INFILT is 0.09 in/hr for soils type A, flat, per the same Table, the mean permeability is assumed 0.27 in/hr for soils Type A, flat for the purposes of determining the infiltration of the bottom of the bioretention. A more accurate calculation will be done at final design, when results from permeability tests are available.

IMP-3C

Soil type: A

AREAS

Slope	Pre-A	Post-A
Flat	0.01	0.01
Moderate	1.10	0.99
Steep	0.84	0.95
Imperv.	0.00	0.00
TOTAL	1.95	1.95

Notes on soil Transformation:

0.11 acres A moderate become 0.11 acres A steep

0.01, 0.99 and 0.84 acres A flat, mod. & steep (respectively) do not change

USE OF THE SIZING TABLE:

Asumptions:

1) As the only hydromodification change is an increase of slope for 0.11 acres (from moderate to steep), and as there is not a sizing factor for such scenario, half of the sizing factor from moderate to impervious will be used

SIZES:

Lake Wohlford Station, Soil Type A, $0.1Q_2$, Table 7.1 of the HMP Document:

Area factor, flat: 0.050 (Table 7.1, fraction of area that must become Bio-retention)

Area factor, moderate: 0.045 (Table 7.1, fraction of area that must become Bio-retention)

Area factor, steep: 0.040 (Table 7.1, fraction of area that must become Bio-retention)

DIMENSIONS:

Area: 108 sq-ft[(1)] (at the surface of bio-retention)

Ponding on top: 10 inches

(1): 43560·(0.11·0.045/2)

Amended soil: 18 inches

gravel at the bottom: not needed (IMP located in soil type A).

DISCHARGE:

Overflow relief has to discharge Q_{10} with an hydraulic head H of 2 inches

Low flow discharge orifice is not needed

DETERMINATION OF Q_2 AND Q_{10}

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

Peak factor	Q_2	Q_{10}
(**A**, Wohlford)	(cfs/acre)	(cfs/acre)
flat, grass	0.0829	0.3454
moderate, grass	0.1597	0.4199
steep, grass	0.2147	0.4757
impervious, mod.	0.5051	0.7771

Q_2: 0.36 cfs (4 coefficients x 4 areas)

Q_{10}: 0.86 cfs (4 coefficients x 4 areas)

Note: Q_2 and Q_{10} factors obtained with the SDHM Program, version 8-15-11 for Wohlford station.

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)
2.00	4.10	15.7

Solution: riser must be at least 18" 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}: **340 sq-ft**

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

DRYING TIME

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

$T = V/(f \cdot A_{IMP}/12)$

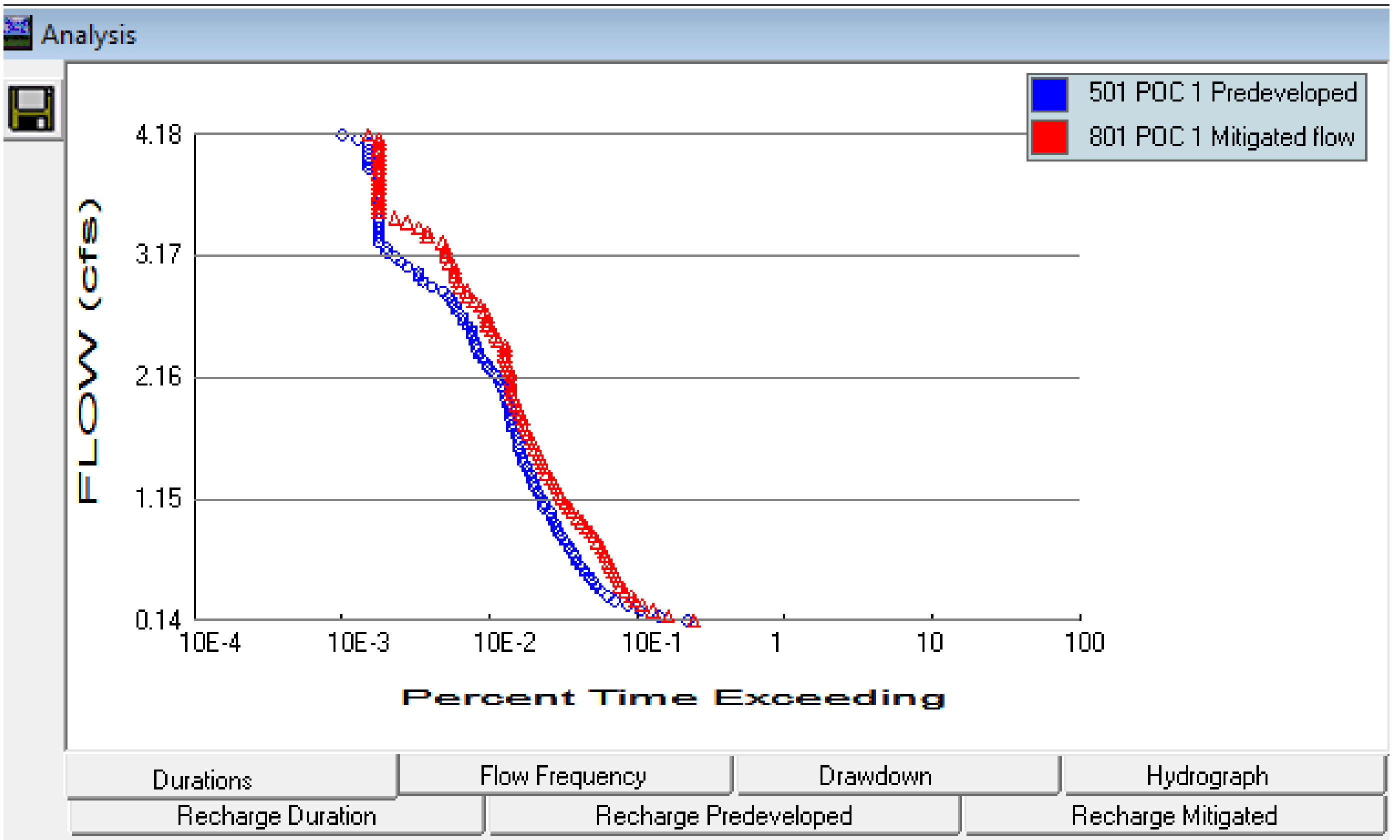
V : volume of the 10" in the surface (cu-ft) =	283	cu-ft
A_{IMP} : Area of the IMP in sq-ft :	340	sq-ft
f [(1)]: infiltration of the bottom soil, in/hr :	0.27	in/hr
Bottom infiltration discharge, $Q_f = A_{IMP} \cdot f/(12 \cdot 3600)$	0.002	cfs
T : Drying time = $V/(3600 \cdot Q_{ave})$	37.0	hr

(1): Per the San Diego HMP, page 4.20, the mean permeability is 2·INFILT·INTFW. As INTFW is 1.5 for all soil types and slopes (see permit Table 3, page 11 of the Technical Memo "Selection of PERLND Parameters") and the parameter INFILT is 0.09 in/hr for soils type A, flat, per the same Table, the mean permeability is assumed 0.27 in/hr for soils Type A, flat for the purposes of determining the infiltration of the bottom of the bioretention. A more accurate calculation will be done at final design, when results from permeability tests are available.

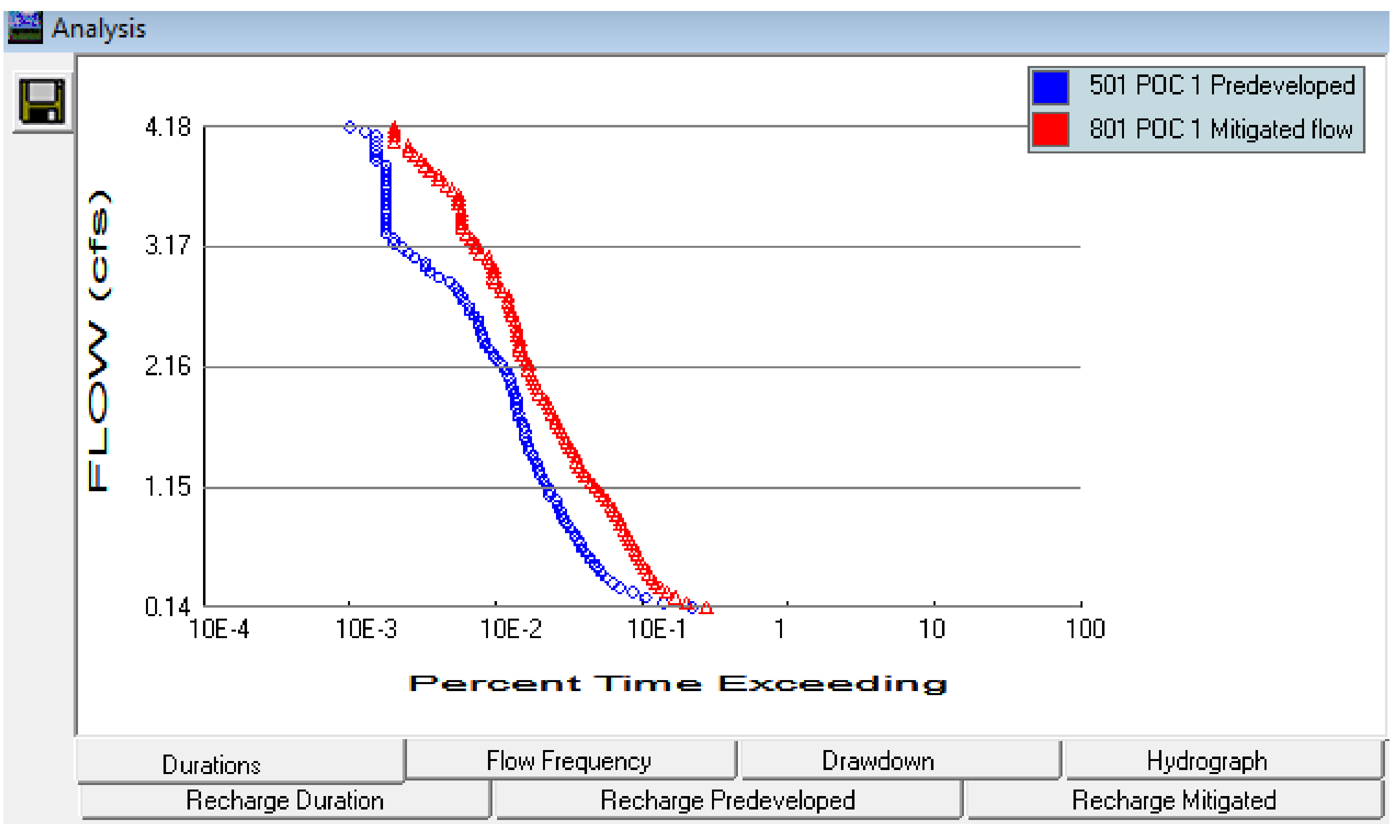
APPENDIX 3

Typical SDHM Flow Duration Curves with Lake Wohlford Rainfall Data

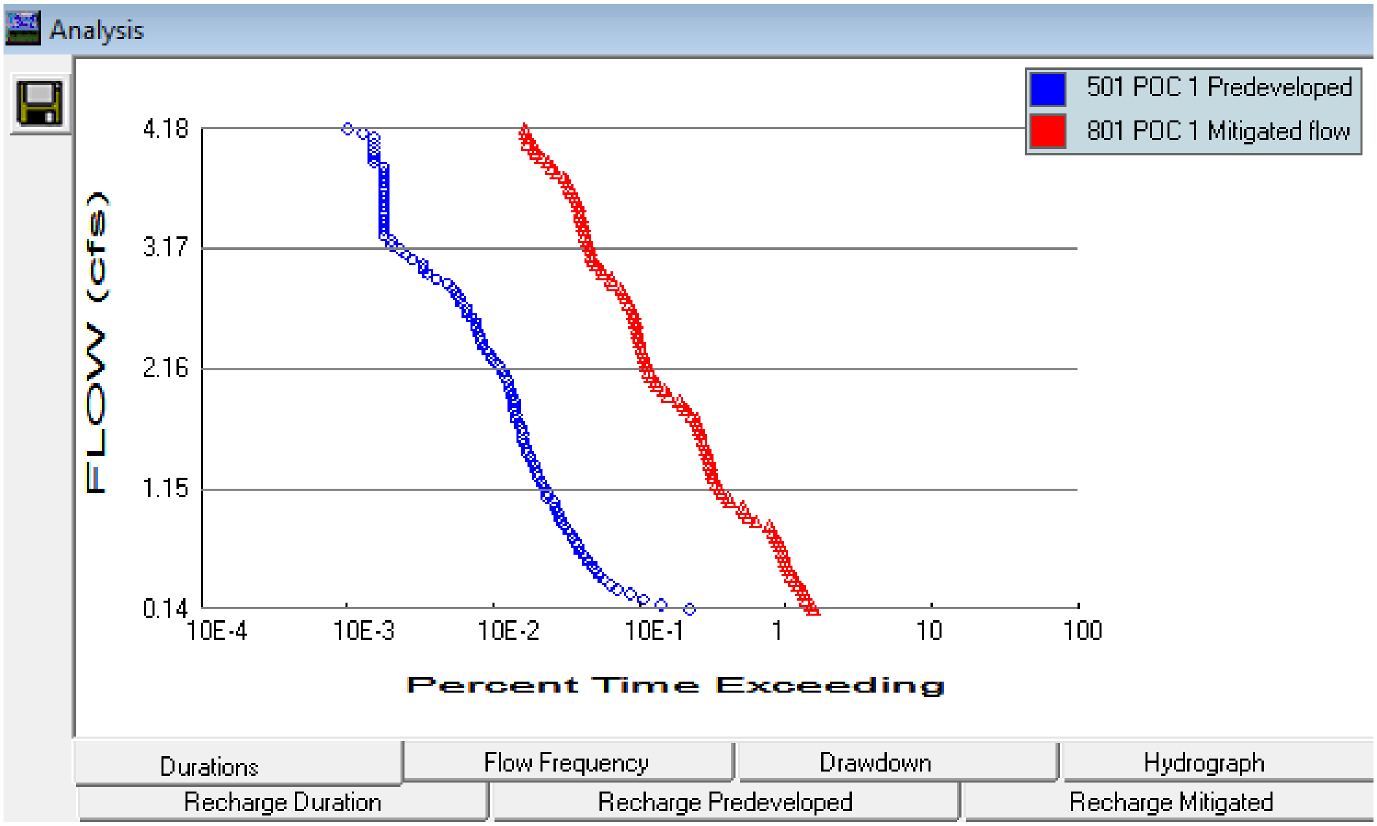
Soils Type B and C and Different Combinations of Slope and Land Use



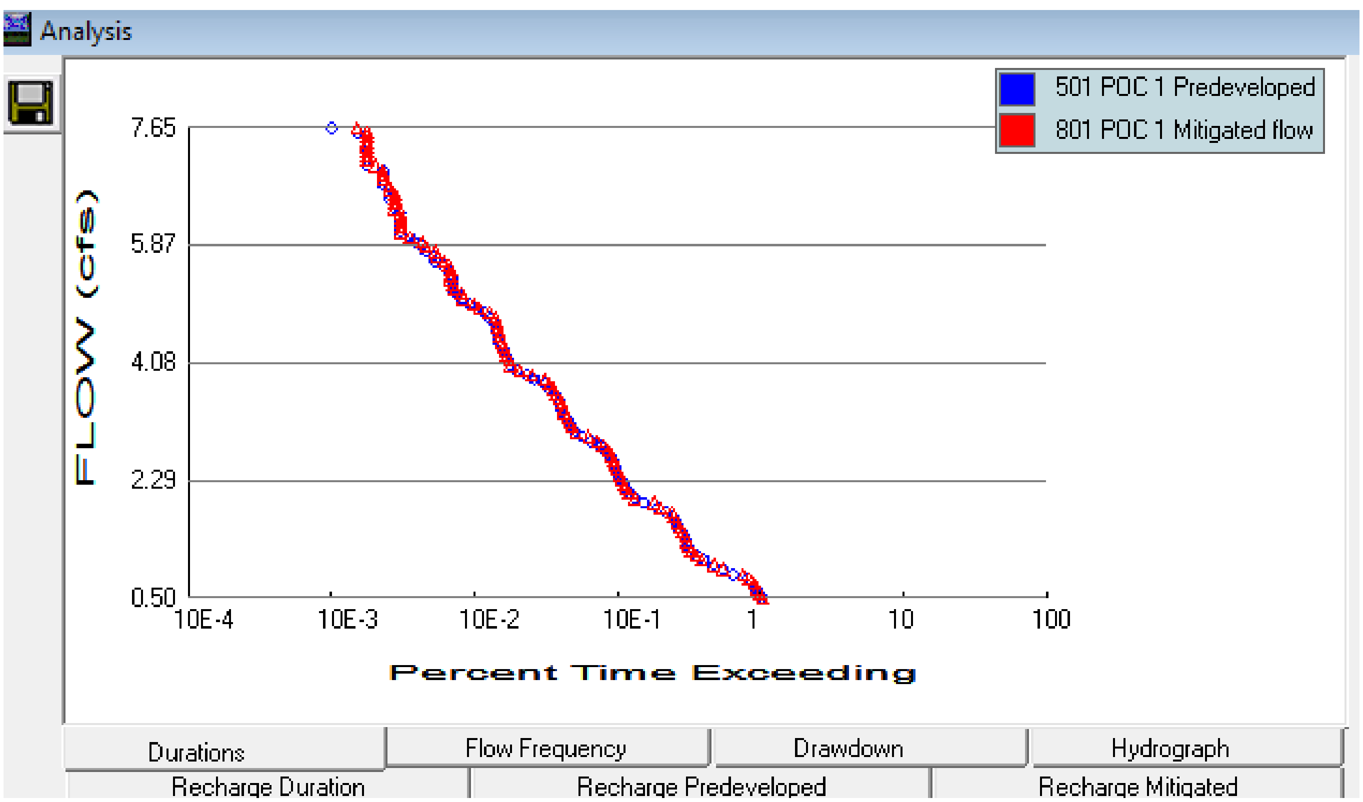
Flow duration Curve from the SDHM Model. Comparison of a Standard 10 acre Lot. Pre-development (blue): Flat Slope. Post-development (red): Moderate Slope. Soil Type B. Wohlford Station.



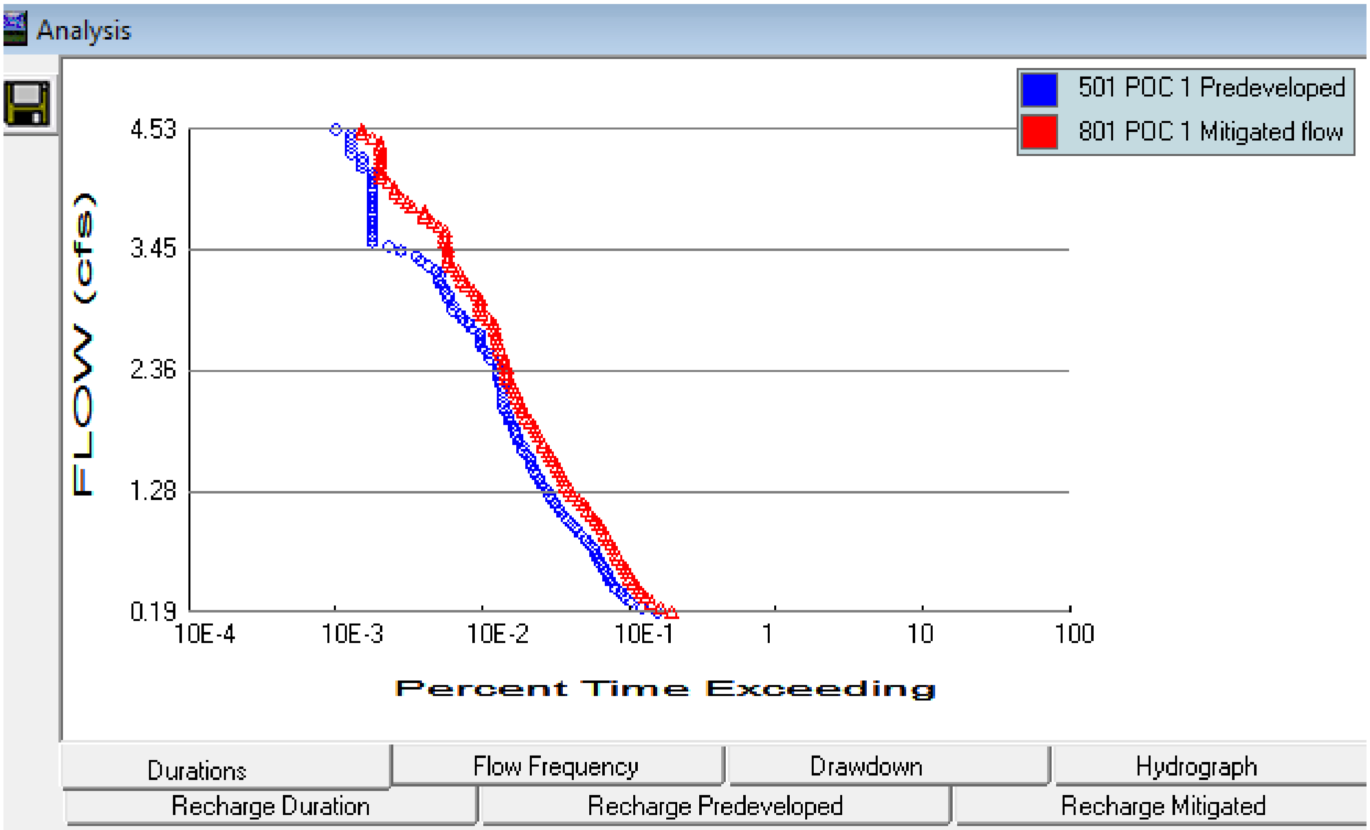
Flow duration Curve from the SDHM Model. Comparison of a Standard 10 acre Lot. Pre-development (blue): Flat Slope. Post-development (red): Steep Slope. Soil Type B. Wohlford Station.



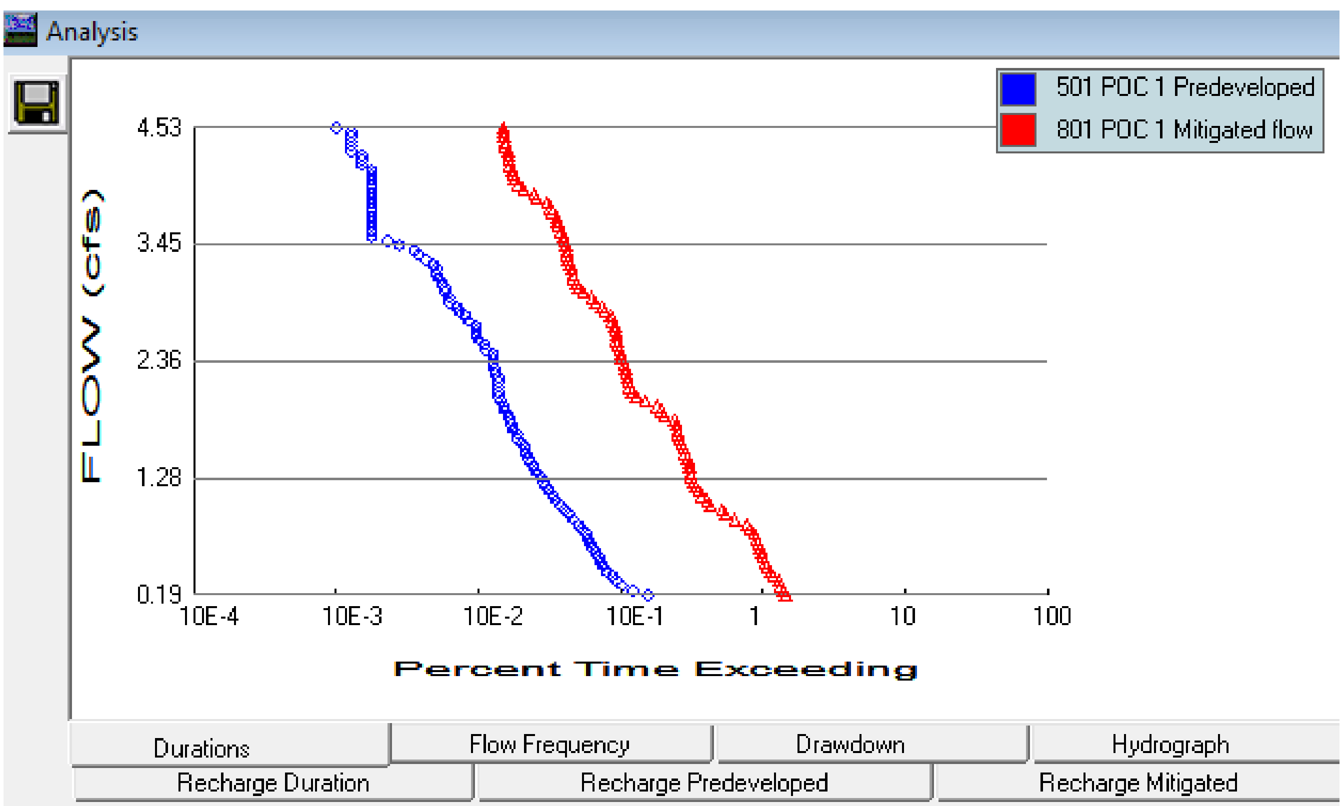
Flow duration Curve from the SDHM Model. Comparison of a Standard 10 acre Lot. Pre-development (blue): Flat Slope. Post-development (red): Impervious, flat slope. Soil Type B. Wohlford Station.



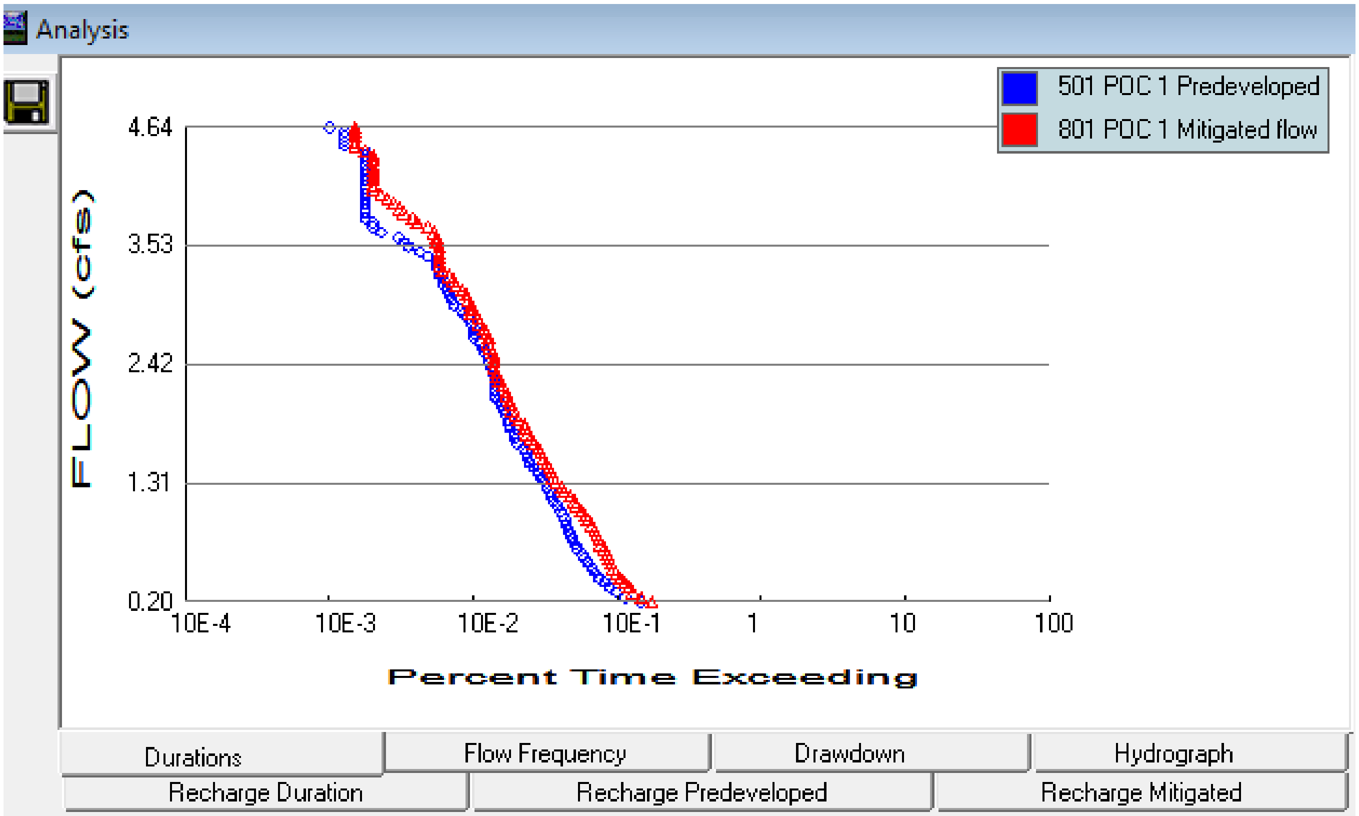
Flow duration Curve from the SDHM Model. Comparison of a Standard 10 acre Lot. Pre-development (blue): Flat Slope, impervious. Post-development (red): Impervious, moderate slope. Soil Type B. Wohlford Station. Almost no difference.



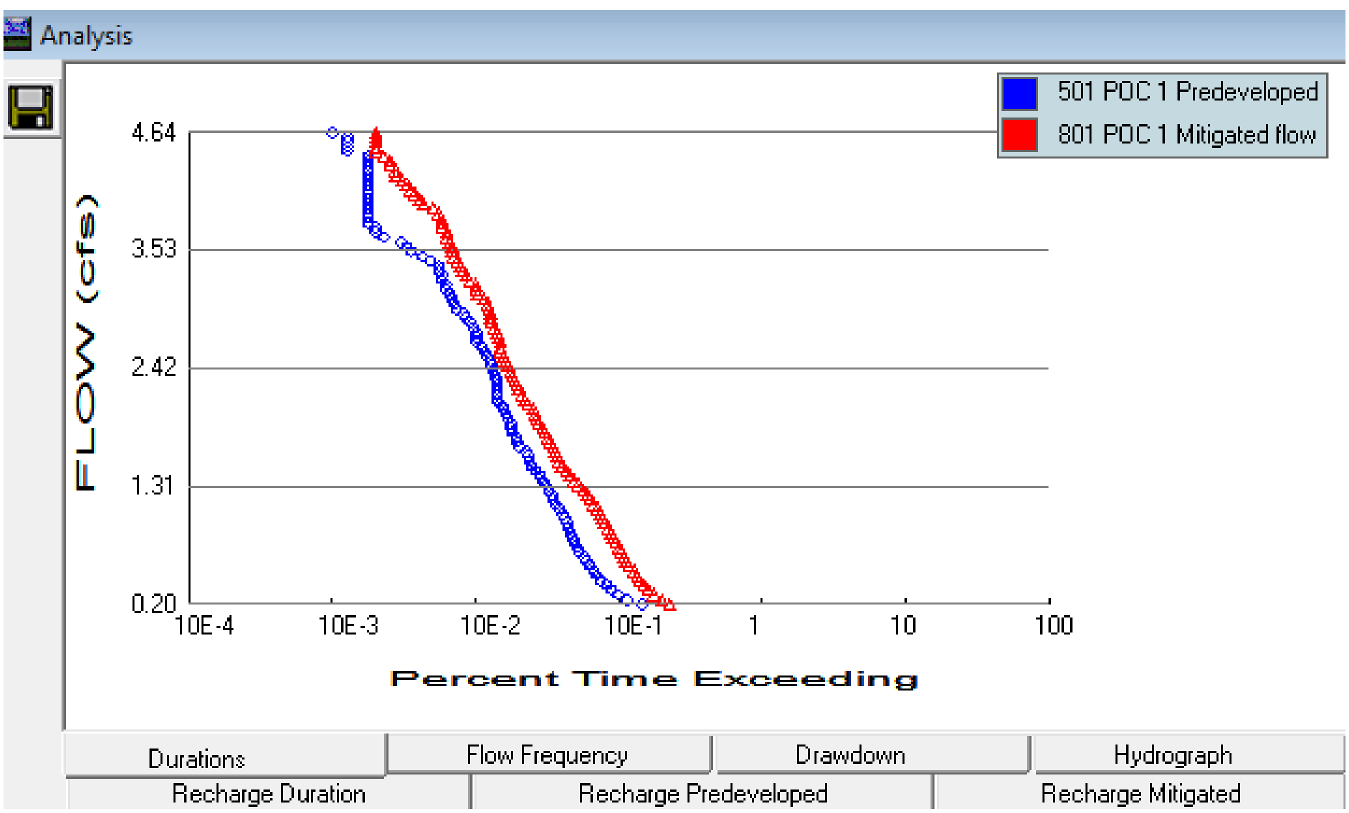
Flow duration Curve from the SDHM Model. Comparison of a Standard 10 acre Lot. Pre-development (blue): Moderate Slope. Post-development (red): Steep Slope. Soil Type B. Wohlford Station.



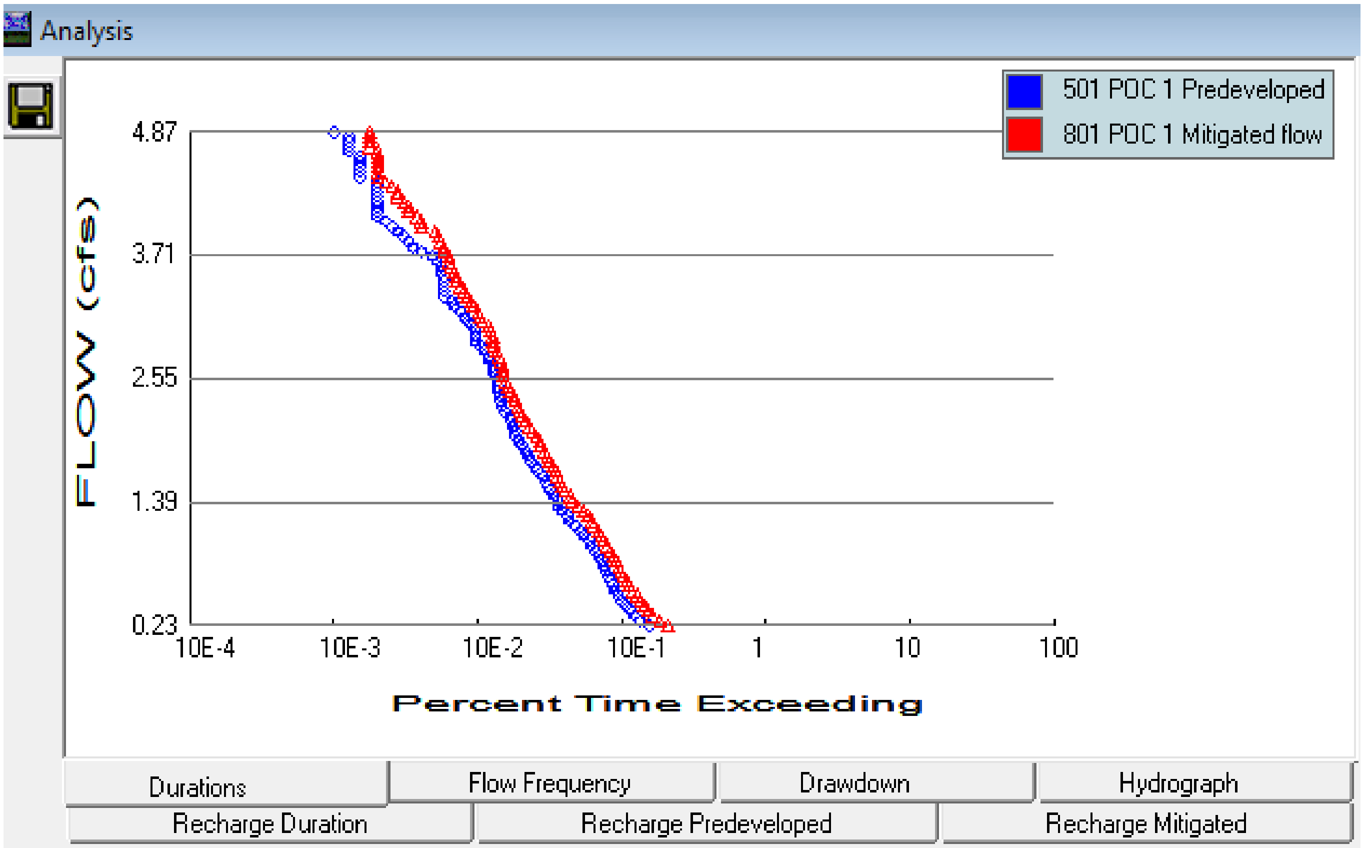
Flow duration Curve from the SDHM Model. Comparison of a Standard 10 acre Lot. Pre-development (blue): Moderate Slope. Post-development (red): Impervious Moderate Slope. Soil Type B. Wohlford Station.



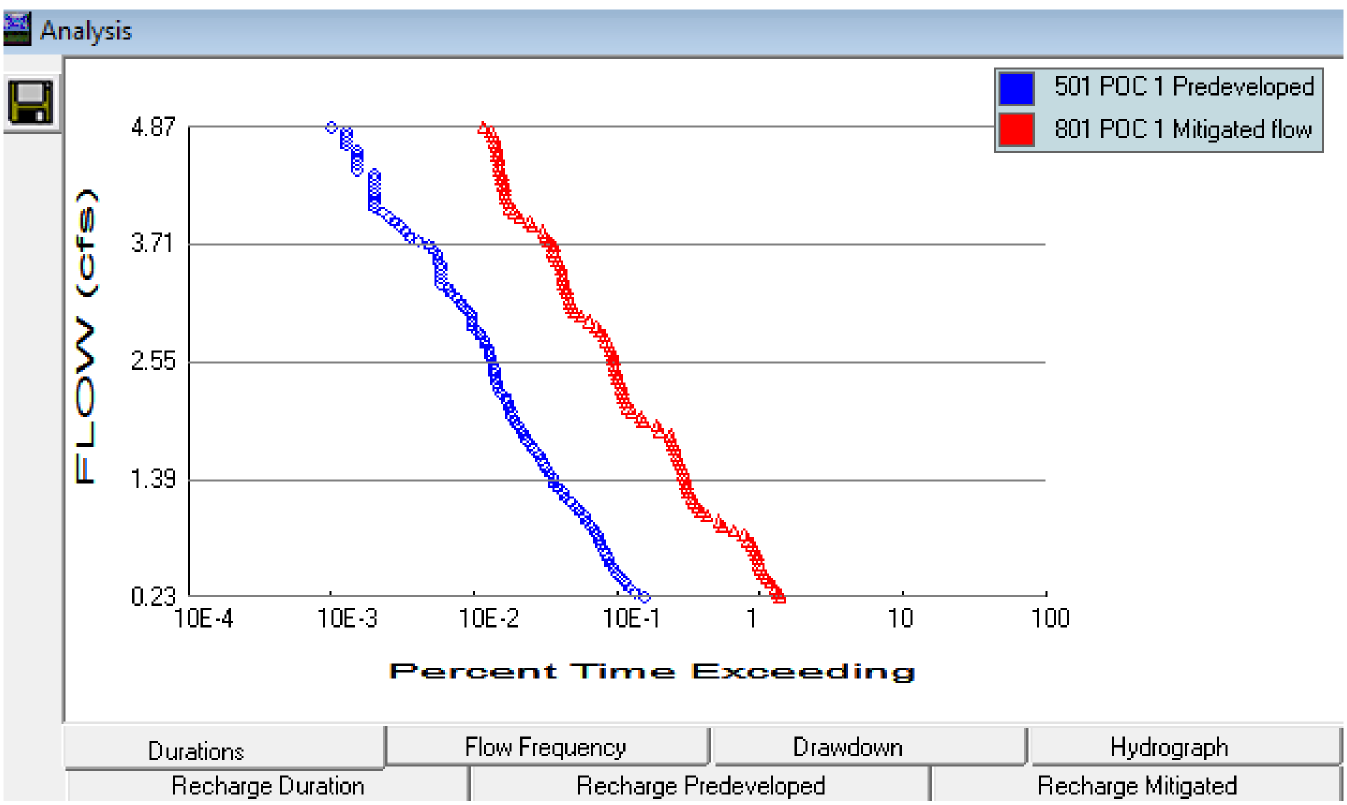
Flow duration Curve from the SDHM Model. Comparison of a Standard 10 acre Lot. Pre-development (blue): Flat Slope. Post-development (red): Moderate Slope. Soil Type C. Wohlford Station.



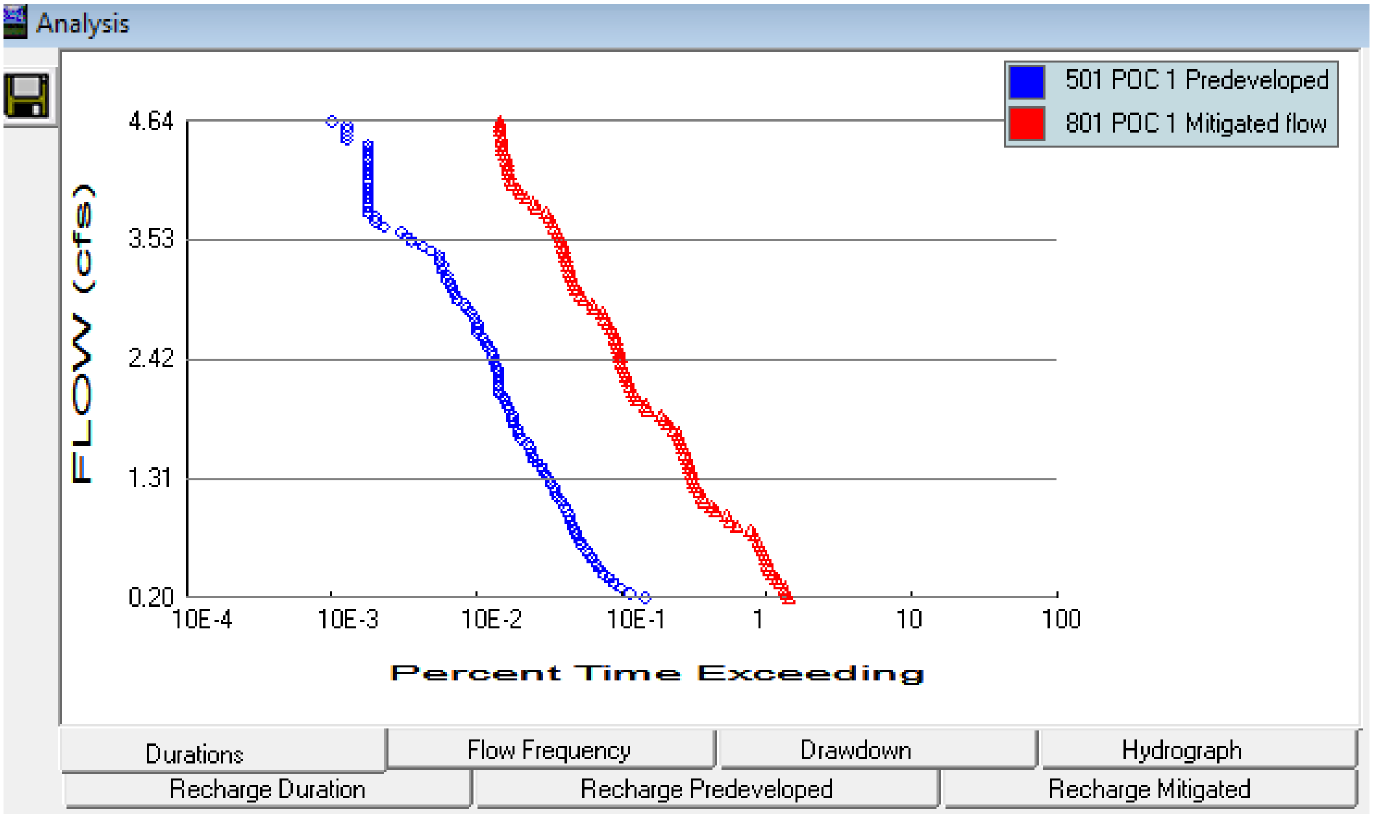
Flow duration Curve from the SDHM Model. Comparison of a Standard 10 acre Lot. Pre-development (blue): Flat Slope. Post-development (red): Steep Slope. Soil Type C. Wohlford Station.



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.

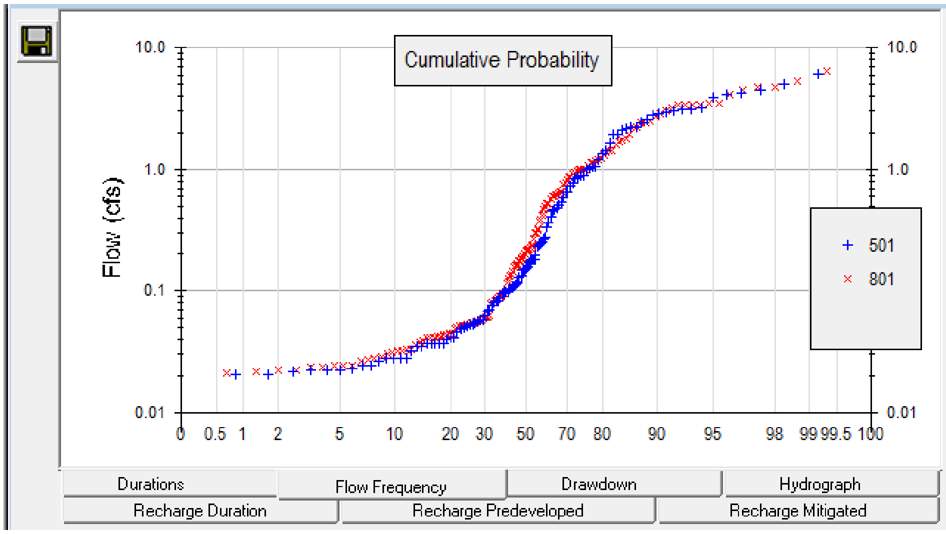


Flow duration Curve from the SDHM Model. Comparison of a Standard 10 acre Lot. Pre-development (blue): Flat Slope. Post-development (red): Impervious, flat slope. Soil Type C. Wohlford Station.

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

Flow(cfs)		Predeveloped	Mitigated
2 Year	=	1.4434	1.7865
5 Year	=	3.0740	3.4280
10 Year	=	4.1821	4.5331
25 Year	=	4.8550	5.1856

Annual Peaks

1	0.0226	0.0433
2	0.4659	0.0828
3	0.0574	0.7617
4	0.1028	0.1365
5	0.1184	0.0413
6	0.0504	0.2163
7	0.0676	0.4202
8	0.1123	0.4899
9	1.2245	0.3040
10	0.3691	1.7865
11	0.7251	0.5998
12	0.0205	1.0058
13	0.2351	0.0324
14	4.1773	0.8782

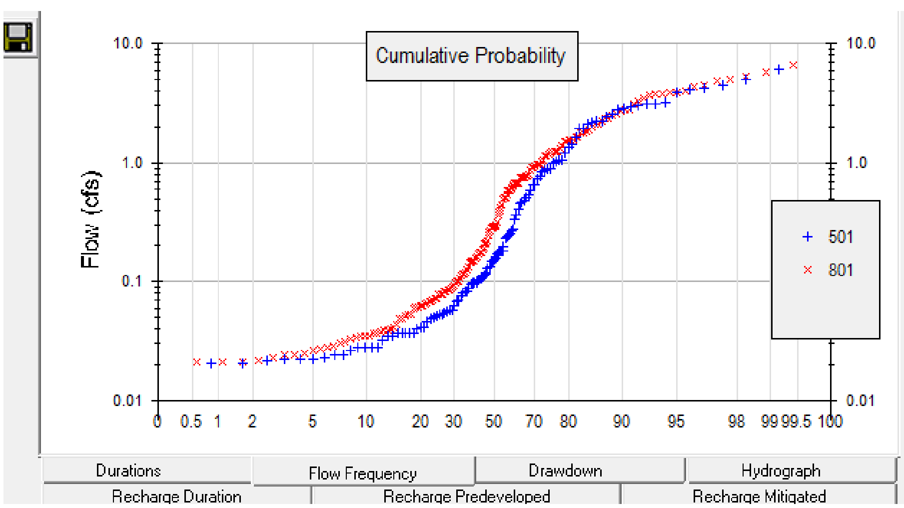
Flow Frequency values: Pre-development: 10 acres, flat, Soil Type B, Wohlford.

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

Flow(cfs)		Predeveloped	Mitigated
2 Year	=	1.4434	2.3894
5 Year	=	3.0740	3.9302
10 Year	=	4.1821	4.8744
25 Year	=	4.8550	5.5805

Annual Peaks

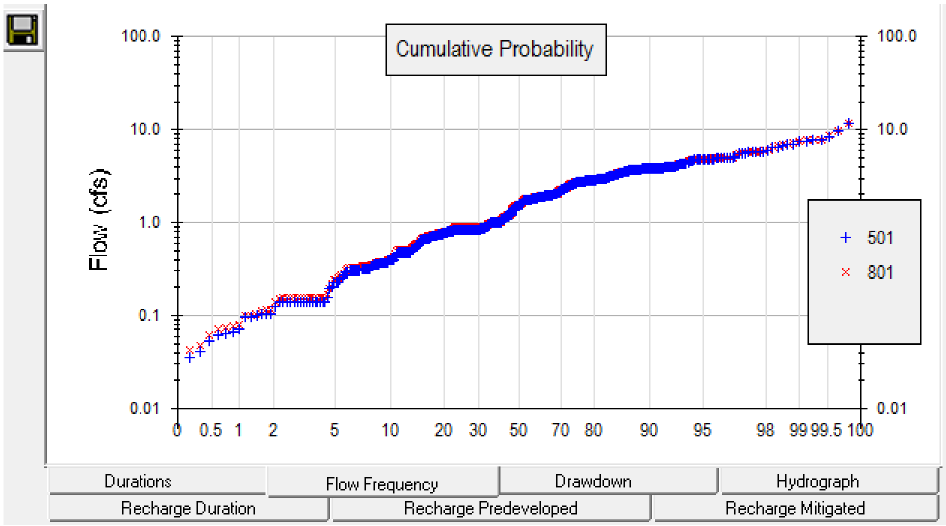
1	0.0226	0.1622
2	0.4659	0.2170
3	0.0574	1.1536
4	0.1028	0.5047
5	0.1184	0.0997
6	0.0504	0.0493
7	0.0676	0.0241
8	0.1123	0.7538
9	1.2245	0.9719
10	0.3691	0.0268
11	0.7251	0.9371
12	0.0205	0.6532
13	0.2351	2.3894

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

Flow(cfs)		Predeveloped	Mitigated
2 Year	=	5.0127	5.0512
5 Year	=	6.8859	6.9353
10 Year	=	7.6549	7.7713
25 Year	=	9.3249	9.5076

Annual Peaks

1	3.7159	3.7752
2	0.3082	0.3322
3	0.6768	0.6860
4	3.2065	3.2911
5	2.2243	2.2508
6	1.8053	1.8503
7	3.7622	3.8121
8	1.7272	1.7492
9	0.5180	0.5417
10	3.5314	3.5601
11	1.9504	2.0194
12	0.0954	0.0979
13	1.9067	1.9337
14	1.3924	1.3976

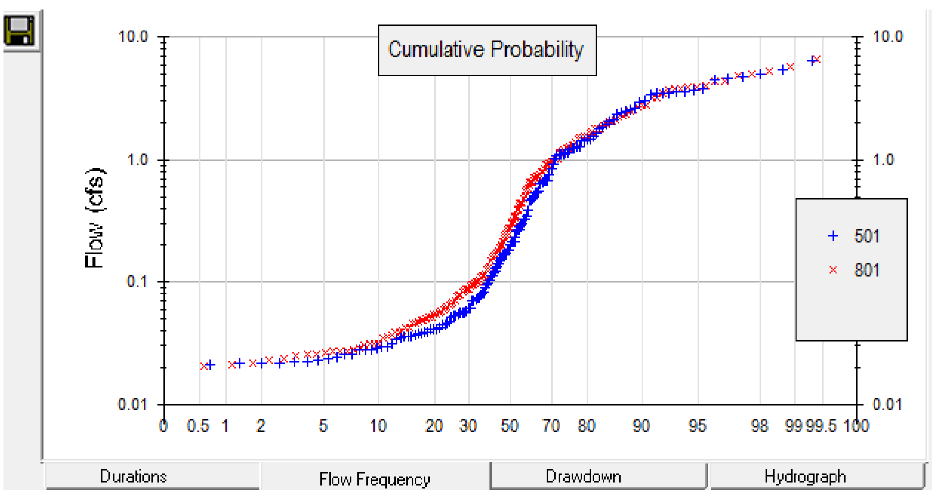
Flow Frequency values: Pre-development: 10 acres, flat, impervious, Soil Type B, Wohlford.

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

Flow(cfs)		Predeveloped	Mitigated
2 Year	=	2.0369	2.3167
5 Year	=	3.6168	3.9303
10 Year	=	4.6372	4.8673
25 Year	=	5.3250	5.5748

Annual Peaks

1	0.0467	0.1617
2	0.0830	0.2136
3	0.9259	1.1400
4	0.1298	0.3443
5	0.0409	0.0923
6	0.2707	0.0392
7	0.2989	0.0201
8	0.4998	0.6630
9	0.3415	0.9480
10	1.9350	0.0207
11	0.6829	0.9403
12	1.0702	0.6655
13	[illegible]	[illegible]

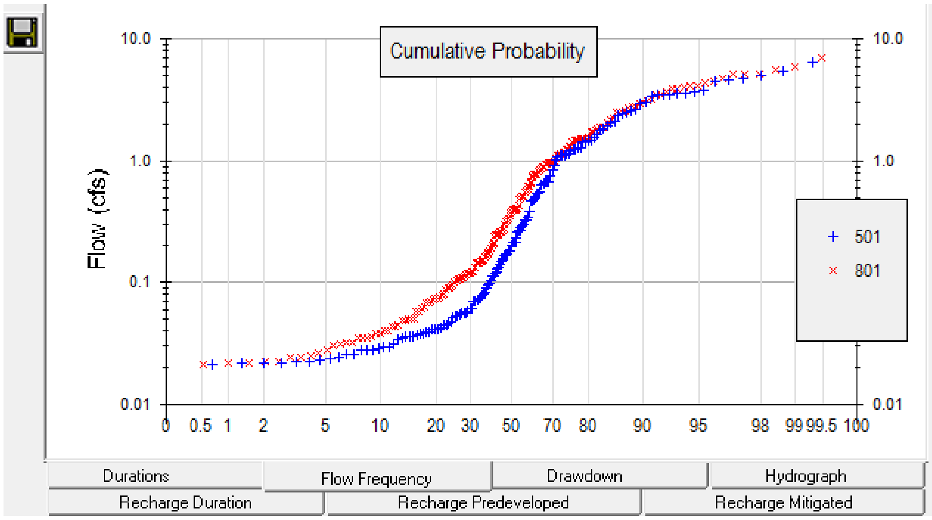
Flow Frequency values: Pre-development: 10 acres, flat, Soil Type C, Wohlford.

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

Flow(cfs)		Predeveloped	Mitigated
2 Year	=	2.0369	2.7917
5 Year	=	3.6168	4.2597
10 Year	=	4.6372	5.1834
25 Year	=	5.3250	5.8430

Annual Peaks

1	0.0467	0.4779
2	0.0830	0.3231
3	0.9259	1.4745
4	0.1298	0.7713
5	0.0409	0.1551
6	0.2707	0.1194
7	0.2989	0.0277
8	0.4998	0.0571
9	0.3415	1.1004
10	1.9350	0.0266
11	0.6829	1.3185
12	1.0702	0.0405
13	0.0294	1.2479
14	0.6707	0.0495

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)