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TO: File

CC:

FROM: Douglas Beyerlein, P.E.

SUBJECT: Comparison of Contra Costa IMP and BAHM/WWHM3/HSPF

The purpose of this memo is to compare the Contra Costa Integrated Management Practice (IMP) stormwater sizing tool and the Bay Area Hydrology Model (BAHM). Both are designed to meet HMP requirements for jurisdictions in the San Francisco Bay Area. In addition, information on the Western Washington Hydrology Model version 3 (WWHM3) and HSPF is included.

SUMMARY: IMP has an easy-to-use interface for the sizing of HMP facilities that make it attractive to use. However, the limitations in the IMP options provided to the user to accurately size and design their HMP facilities together with some questionable HSPF parameter values limits IMP's usefulness. It should be used only on very small sites (1-2 acres maximum) where HMP sizing errors will not have a major impact on the surrounding aquatic resources.

Disclaimer: The opinions expressed in this memo are those of Doug Beyerlein, Principal Engineer, Clear Creek Solutions, Inc., and are not necessarily those of any of the clients of Clear Creek Solutions. Clear Creek Solutions is the developer of WWHM3 and BAHM. For more information contact Doug Beyerlein at the address above or go to www.clearcreeksolutions.com.

Three sets of comparisons are presented in this memo:

1. basic features
2. specific model features
3. HSPF parameter values

The basic features of the four software systems are presented in Table 1.

Table 1. Basic Features Comparison

Model	IMP	BAHM	WWHM3	HSPF
Counties	Contra Costa	Alameda Santa Clara San Mateo	19 counties of Western Washington	world-wide
In Use Since	2005	2007	2001	1979
Computational Engine	HSPF	HSPF	HSPF	HSPF
Model Interface	Windows-based	Windows-based	Windows-based	text-based
Recommended Project Size	small sites	all sites	all sites	all sites
Easy of Use	very easy	moderately easy	moderately easy	very difficult
Training Required	1 hour	4 hours	4 hours	40 hours
Flexibility of Use	many limitations	few limitations	few limitations	no limitations
Computations	static	dynamic	dynamic	dynamic
Length of Rainfall Record	35 years	35-50 years	35-50 years	user selected
Predevelopment Conditions	existing	existing	forest	user defined
Runoff Increase from Native to Urban Pervious?	No	Yes	Yes	user defined
Facility Sizing Options	limited to pre-selected values	unlimited	unlimited	unlimited
Flow Duration Lower Limit	0.5Q2	0.1Q2	0.5Q2	user defined
Flow Duration Upper Limit	Q10	Q10	Q50	user defined
WQ Treatment Standard	80%	91% (preliminary)	91%	user defined

The significant difference in the basic features comparison between IMP and BAHM is that all of the runoff (both pre- and post-development) has been precomputed in IMP. In contrast, BAHM dynamically runs HSPF in the background after the user selects land use and HMP facility features.

The advantages of using IMP are quick computational time and a very simple and easy-to-use user interface. The disadvantages are related to the limitations in selecting HMP facility options, as these options have been pre-selected for the user. For example, infiltration trench depth options are limited to 3, 4, or 5 feet; the riser height and diameter are fixed and cannot be changed by the user.

IMP assumes that there is no increase in runoff when the land use changes from native soil and vegetation to constructed pervious areas consisting of compacted soil from construction activities, the replacement of native vegetation with urban vegetation, and the addition of irrigation. BAHM computes the existing pervious runoff and the developed pervious runoff based on different HSPF parameter values for each land condition and includes an irrigation time series for urban vegetation. IMP does not.

The specific model features of the four software systems are presented in Table 2.

Table 2. Specific Model Features Comparison

Model	IMP	BAHM	WWHM3	HSPF
Types of HMP Facilities		Stormwater Pond Stormwater Vault Stormwater Tank In-Ground Planter Flow-Through Planter Vegetated Swale Bioretention Area Dry Well Infiltration Trench Infiltration Basin Rain Garden (1) Green Roof (4) User defined (5)	Stormwater Pond Stormwater Vault Stormwater Tank In-Ground Planter (1) Flow-Through Planter (1) Vegetated Swale (1) Bioretention Area (1) Dry Well (2) Infiltration Trench (3) Infiltration Basin (2) Rain Garden (1) Green Roof (4) User defined (5)	user defined
Soil Groups Modeled	A B (1) C (2) D	A B C D	A B (6) C D/Saturated	user defined
Vegetation Groups Modeled	Shrub	Forest Shrub Grass (native) Urban	Forest Pasture Lawn	user defined
Land Slopes Modeled	10%	5% 10% 15% 25%	5% 10% 20%	user defined
User can model:				
treatment plus flow control	Yes	Yes	Yes	N/A
treatment only	Yes	Yes	Yes	N/A
open channels	No	Yes	Yes	Yes
pipes/culverts	No	Yes (4)	Yes (4)	Yes
flow splitters	No	Yes	Yes	Yes
urban irrigation	No	Yes	Yes	Yes
wetlands	No	Yes	Yes	Yes
User can view:				
frequency results	No	Yes	Yes	N/A
duration match	No	Yes	Yes	N/A
hydrographs	No	Yes	Yes	Yes
report file	Yes	Yes	Yes	N/A
User can change:				
flow duration criteria	No	Yes	Yes	N/A
WQ treatment criteria	No	Yes	Yes	N/A
HSPF parameter values	No	Yes	Yes	Yes
precipitation time series	No	Yes	Yes	Yes
evaporation time series	No	Yes	Yes	Yes
computational time step	No	Yes (4)	Yes (4)	Yes
User can link model to:				
input flow time series	No	Yes	Yes	Yes
HY8	No	Yes (4)	Yes (4)	No
GIS	No	Yes (4)	Yes (4)	No
SWMM	No	Yes (4)	Yes (4)	No
HEC-RAS	No	Yes (4)	Yes (4)	No

Notes	IMP	BAHM	WWHM
1	same as A soils	Bioretention Swale	Bioretention Swale
2	same as D soils	Pond with infiltration	Pond with infiltration
3		Gravel Trench Bed	Gravel Trench Bed
4		only in PRO version	only in PRO version
5		SSD Table	SSD Table
6			same as A soils

IMP provides small site HMP solutions: planters, vegetated swales, bioretention areas, and infiltration facilities (dry wells, infiltration trenches, and infiltration basins). BAHM provides comparable solutions plus stormwater ponds, vaults, and tanks.

BAHM also includes more soil types, types of vegetation, and slope categories. BAHM also allows the user to model open channels, culverts, flow splitters, and wetlands, if needed.

Both IMP and BAHM allow the user to create and view a report file. BAHM also allows the user to view frequency results, flow duration matches, and hydrographs. The user can also change the flow duration criteria, water quality treatment criteria, HSPF parameter values, precipitation time series, evaporation time series, and computational time step, if appropriate and approved by the reviewing agency.

Users can input land use information through BAHM's GIS Import interface. BAHM also allows the user to link the HSPF-generated output to other software hydraulic routing packages (HY8, SWMM, and HEC-RAS) to take advantage of their special features. These are special features available only in BAHM PRO packages.

HSPF parameter values used in IMP and BAHM are shown in Table 3.

Table 3. HSPF Parameter Value Comparison

Model	IMP	BAHM	WWHM3	HSPF
Parameter values based on	Calabazas Cr, Santa Clara Co WWHM3 values	Castro Valley Cr, Alameda Co Alameda Cr, Alameda Co Ross Cr, Santa Clara Co Thompson Cr, Santa Clara Co	King Co & Snohomish Co watersheds	user selected
Pre-development land use	Shrub	Shrub	Forest	user selected
Land slope	all	moderate	moderate	user selected
INFILT A	0.70	0.07	2.00	user selected
INFILT D	0.03	0.04	0.08	user selected
LZSN A	7.0	4.8	5.0	user selected
LZSN D	7.0	4.5	4.5	user selected
INTFW A	0.4	3.2	0.0	user selected
INTFW D	0.4	1.2	6.0	user selected
UZSN A	0.5	0.7	0.5	user selected
UZSN D	0.5	0.7	0.5	user selected
IRC A	0.30	0.45	0.70	user selected
IRC D	0.30	0.45	0.50	user selected
CEPSC A	0.06-0.10	0.13-0.15	0.20	user selected
CEPSC D	0.08-0.15	0.13-0.15	0.20	user selected
LZETP A	0.4-0.6	0.50-0.65	0.70	user selected
LZETP D	0.5-0.7	0.50-0.65	0.70	user selected

No Contra Costa watershed was used to calibrate the HSPF parameter values for IMP.

A comparison of IMP and BAHM HSPF parameter values shows that IMP provides more stormwater runoff from D soils than BAHM. In particular, the D soil IMP INTFW (interflow) value is very low (0.4). This is probably why the IMP D soil produces peak runoff rates that are approximately 70 to 90 percent of the impervious surface peak runoff rates (Brown and Caldwell memo dated 12 May 2005, p. 23). In the experience of this reviewer, pervious peaks will not equal 70 to 90 percent of impervious peaks, even for D soils. The computed pervious peaks appear to be too large.

Based on the differences in IMP and BAHM HSPF parameter values it is expected that IMP will compute higher predevelopment/existing peak flows than BAHM. This will produce smaller-sized HMP facilities than BAHM.

SUMMARY: IMP has an easy-to-use interface for the sizing of HMP facilities that make it attractive to use. However, the limitations in the IMP options provided to the user to accurately size and design their HMP facilities together with some questionable HSPF parameter values limits IMP's usefulness. It should be used only on very small sites (1-2 acres maximum) where HMP sizing errors will not have a major impact on the surrounding aquatic resources.

References:

Bay Area Hydrology Model Draft User Manual. Clear Creek Solutions. November 2006.

Hydrological Simulation Program – Fortran User's Manual for Version 11. EPA/600/R-97/080. AQUA TERRA Consultants. August 1997.

IMP Sizing Tool Documentation is available at http://www.cccleanwater.org/construction/Publications/SizingCalculator_12-18-06/IMP%20Sizing%20Tool%20Documentation-Help-12-18-06.pdf

Stormwater C.3 Guidebook. 2006. Contra Costa Clean Water Program. Stormwater Quality Requirements for Development Applications. Third Edition. October 2006. Appendix I: Sizing Integrated Management Practices.

Stormwater C.3 Guidebook. 2006. Contra Costa Clean Water Program. Stormwater Quality Requirements for Development Applications. Third Edition. October 2006. Appendix I: Attachment 2 – Brown and Caldwell Memorandum. May 12, 2005. Including Appendix A: HSPF Parameters for Pervious Land Surfaces: Parameter Values and Descriptions; Appendix B: Assumed Water Movement Hydraulics for Modeling IMPs; and Appendix C: Summary of Sensitivity Analysis for the HSPF Modeling and IMP Sizing.

Stormwater C.3 Guidebook. 2006. Contra Costa Clean Water Program. Stormwater Quality Requirements for Development Applications. Third Edition. October 2006. Appendix I: Attachment 3 – Brown and Caldwell Memorandum. May 4, 2005.

Western Washington Hydrology Model Version 3.0 User Manual. Clear Creek Solutions. August 2006.

WWHM3 Project Book. Clear Creek Solutions. August 2006.