Bill James SWMM Network Similarity Score for Machine Learning Classification

Robert Bio: @Innovyze PSL [InfoSWMM, InfoSewer] && Co-Developer [EPA SWMM 3,4,5+, XPSWMM, Visual SWMM] + Strategy Coordinator for SWMM6 w/NCIMM] Since 1978 he has worked: 160 Months at UF, 117 Months at XP Software Inc., 90 Months at CDM Inc., 134 Months at Innovyze Inc. 23+ Months w/NCIMM **He has known Bill James for 482 months**. Works in Tampa, FL USA w/Wife

Charles Rowney: @NCIMM Director of Operations && Senior Research Fellow at UT Austin

Matthew Anderson: @Innovyze Product Manager - Sewer Storm and Flood && **SCRUM Master**

Anthony Kuch - @Innovyze Vice President of Global Client Services

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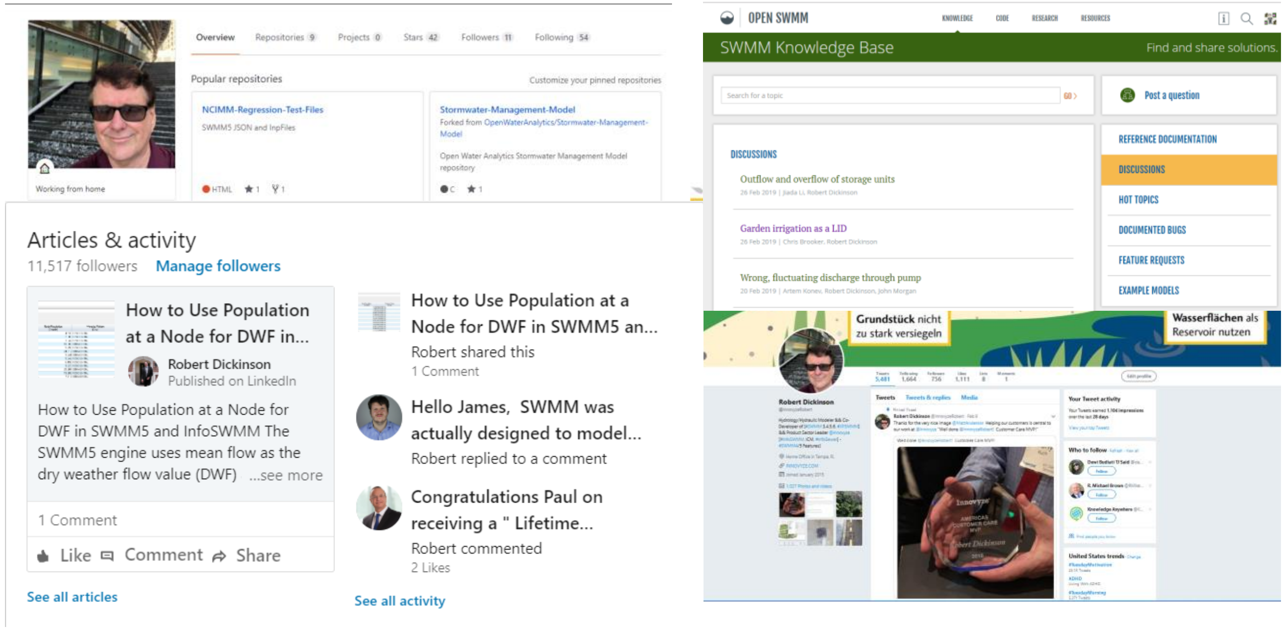


The Other Bill James - Baseball Similarity Score

Similarity Scores

Similarity scores are not our concept. Bill James introduced them in the mid-1980s, and we lifted his methodology from his book *The Politics of Glory* (p. 86-106). To compare one player to another, start at 1000 points and then subtract points based on the statistical differences of each player.

Batters

One point for each difference of 20 games played.
One point for each difference of 75 at bats.
One point for each difference of 10 runs scored.
One point for each difference of 15 hits.
One point for each difference of 5 doubles.
One point for each difference of 4 triples.
One point for each difference of 2 home runs.
One point for each difference of 10 RBI.
One point for each difference of 25 walks.
One point for each difference of 150 strikeouts.
One point for each difference of 20 stolen bases.
One point for each difference of .001 in batting average.
One point for each difference of .002 in slugging percentage.

Then there is a positional adjustment. Each position has a value, and you subtract the difference between the two players' position. James just uses primary position, but we computed an average position for players who had more than one primary position. (See Ernie Banks)

Similarity Scores

Explanation of Similarity Scores

Similar Batters

1. Barry Bonds (740.2)
2. Ted Williams (731.7) *
3. Lou Gehrig (705.6) *
4. Jimmie Foxx (700.5) *
5. Willie Mays (688.2) *
6. Hank Aaron (645.9) *
7. Mel Ott (644.2) *
8. Frank Robinson (641.8) *
9. Alex Rodriguez (635.7)
10. Ken Griffey Jr. (629.0) *

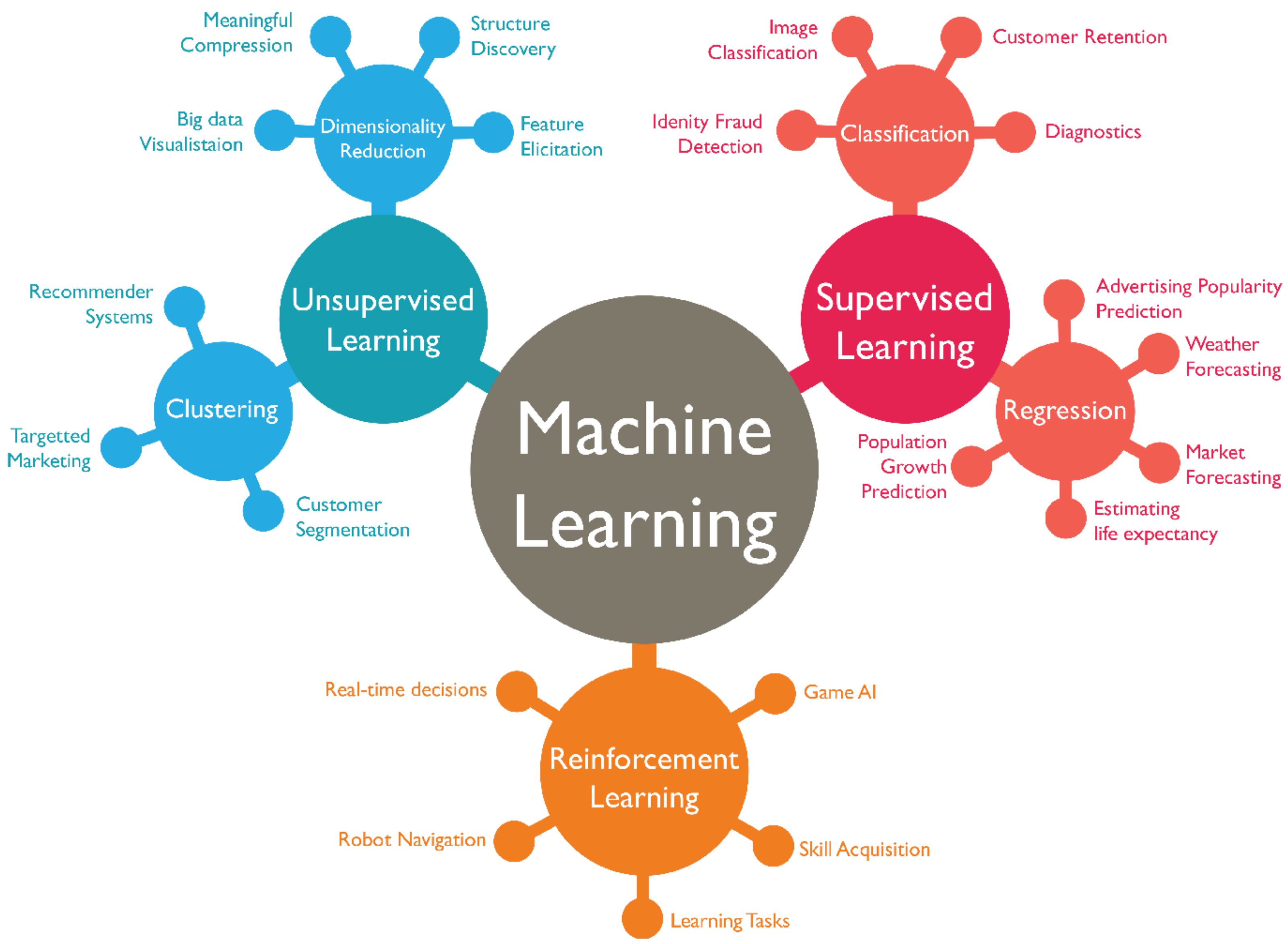
* - Signifies Hall of Famer

Most Similar by Ages

23. Will Clark (952.2) 2 3 4 5 6 7 8 9 10 C
24. Jeff Heath (940.7) 2 3 4 5 6 7 8 9 10 C
25. Chuck Klein (905.4) * 2 3 4 5 6 7 8 9 10 C
26. Ted Williams (913.0) * 2 3 4 5 6 7 8 9 10 C
27. Ted Williams (908.8) * 2 3 4 5 6 7 8 9 10 C
28. Ted Williams (914.9) * 2 3 4 5 6 7 8 9 10 C
29. Ted Williams (903.6) * 2 3 4 5 6 7 8 9 10 C
30. Ted Williams (883.5) * 2 3 4 5 6 7 8 9 10 C
31. Ted Williams (896.0) * 2 3 4 5 6 7 8 9 10 C
32. Ted Williams (878.3) * 2 3 4 5 6 7 8 9 10 C
33. Ted Williams (810.6) * 2 3 4 5 6 7 8 9 10 C
34. Manny Ramirez (790.5) 2 3 4 5 6 7 8 9 10 C
35. Jimmie Foxx (815.6) * 2 3 4 5 6 7 8 9 10 C
36. Jimmie Foxx (816.7) * 2 3 4 5 6 7 8 9 10 C
37. Jimmie Foxx (785.9) * 2 3 4 5 6 7 8 9 10 C
38. Barry Bonds (756.3) 2 3 4 5 6 7 8 9 10 C
39. Barry Bonds (779.8) 2 3 4 5 6 7 8 9 10 C
40. Barry Bonds (782.5) 2 3 4 5 6 7 8 9 10 C

* - Signifies Hall of Famer

Bill James Model Similarity Score and Machine Learning



Bill James Model Similarity Score and Machine Learning

WHY IS THERE SUCH A DIVIDE BETWEEN SIMULATION AND MACHINE-LEARNING

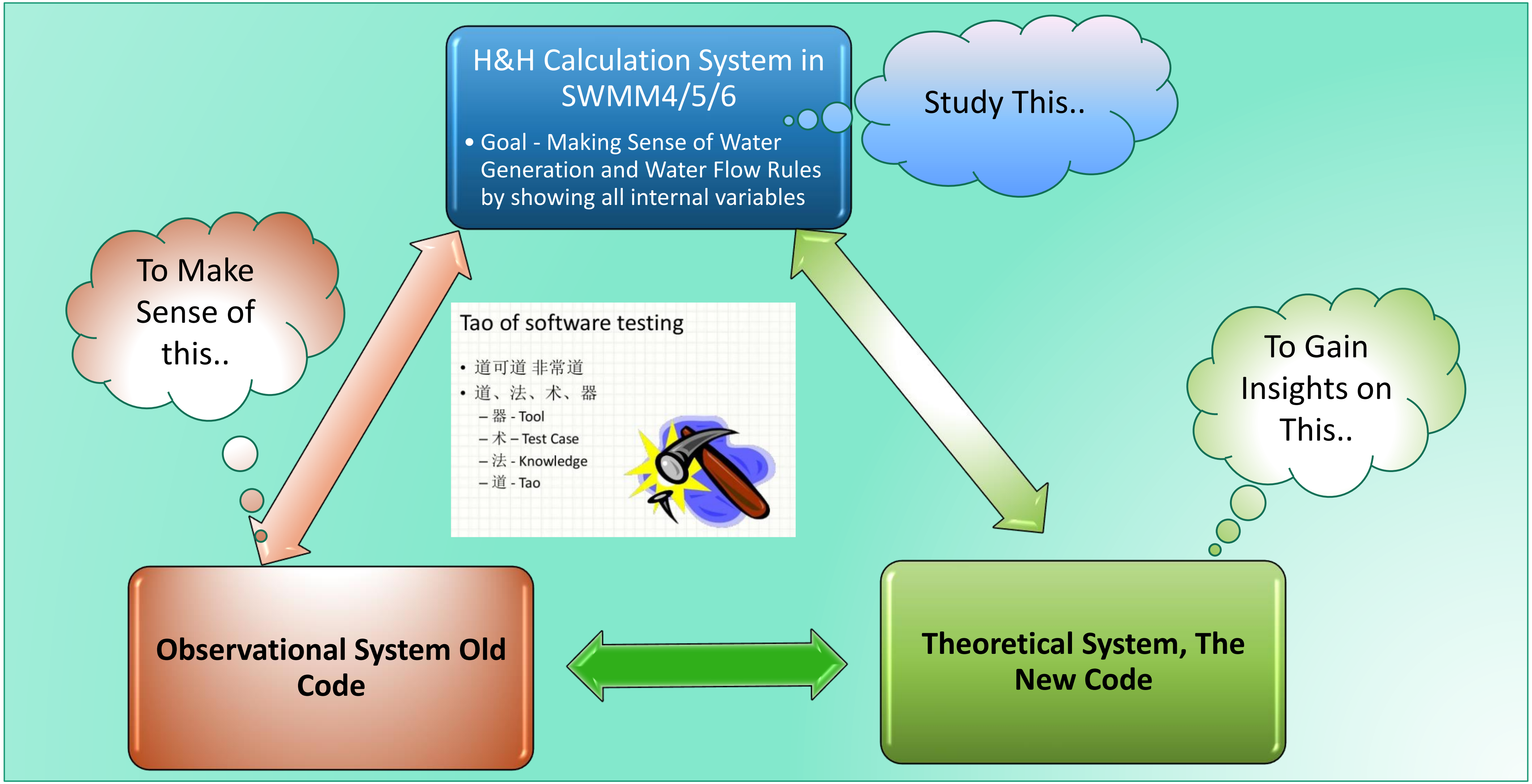
If I tell you that simulation is extremely powerful and massively undervalued, I likely preach to the choir. If I tell you that machine-learning (ML) can be extremely successful at solving business problems, you will yawn. However, **have you noticed how they never work together?** Weird, isn't it? They both apply "models", they both handle data, they both are good at solving certain problems. Why are they mixed so rarely?

The main reason for the divide I see is this: simulation models are build "process-centric" while ML models are built "data-centric". What I mean is this:

- For a simulation model, the modeler needs to understand the processes going on, he needs to talk to operators and decision-makers. He needs to gather the relevant data. He needs to see and observe the system (ideally on site)
- For a ML model, the modeler needs data. More often than not, that is it. Very often, data scientists are thrown at with data and the instruction "go find something". Very little (if any) situational awareness is required by the modeller.

Hence, simulation modellers and data scientists are a different breed with a different skillset. Since it is unlikely that the data scientists of this world will collectively decide to embrace this fringe simulation modelling stuff we love, I suggest we go the other way and embrace ML.

SWMM5.1.013 Simulations Versus Observation

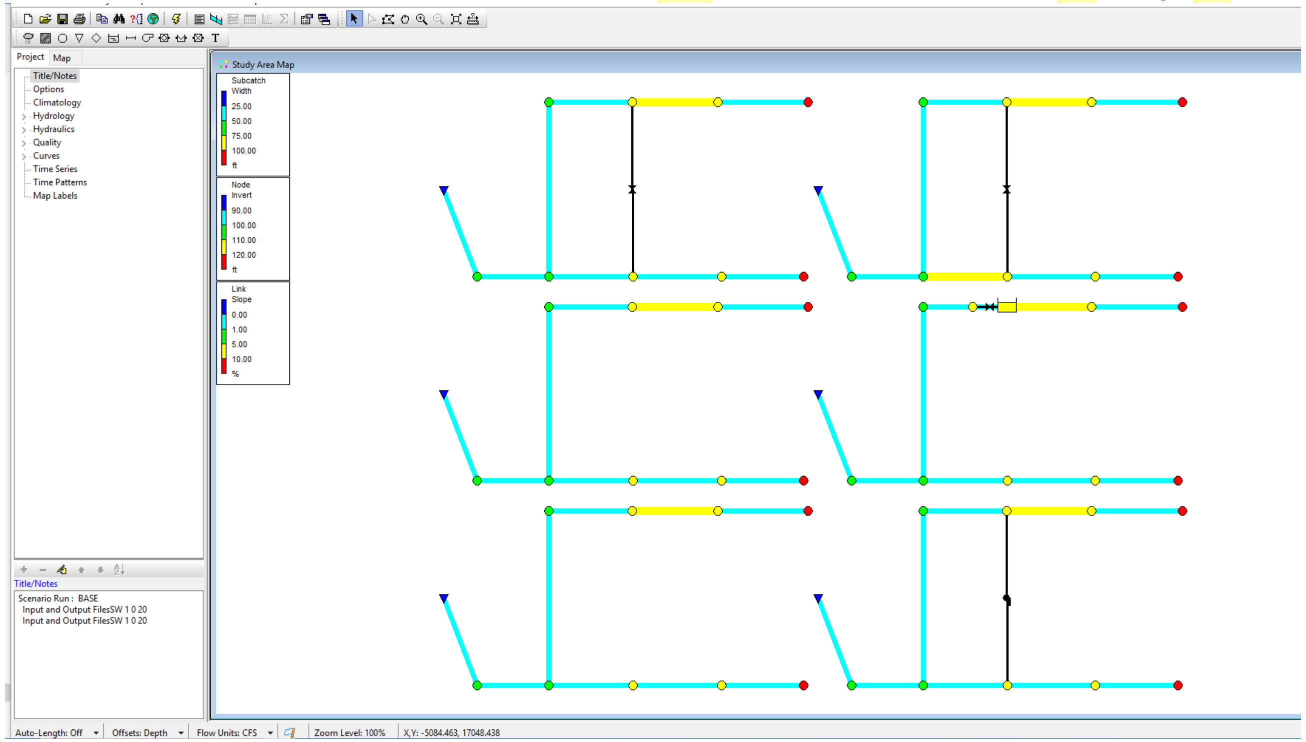


SWMM 1, 2, 3, 3.5, Extran 3 Test Models

n swmm_crada_files

Name	Date modified	Type	Size	Folder
SWDAT1.DAT	5/19/1989 8:39 AM	DAT File	27 KB	SWMM4 (D:\SWM...
SWDAT2.DAT	2/16/1989 4:07 PM	DAT File	6 KB	SWMM4 (D:\SWM...
SWDAT3.DAT	5/27/1989 10:35 AM	DAT File	6 KB	SWMM4 (D:\SWM...
SWDAT4.DAT	5/19/1989 7:17 AM	DAT File	5 KB	SWMM4 (D:\SWM...
SWDAT5.DAT	5/18/1989 2:36 PM	DAT File	6 KB	SWMM4 (D:\SWM...
SWDAT6.DAT	5/30/1989 7:41 AM	DAT File	1 KB	SWMM4 (D:\SWM...

- Limited Tests
- Slow
- Mainframes



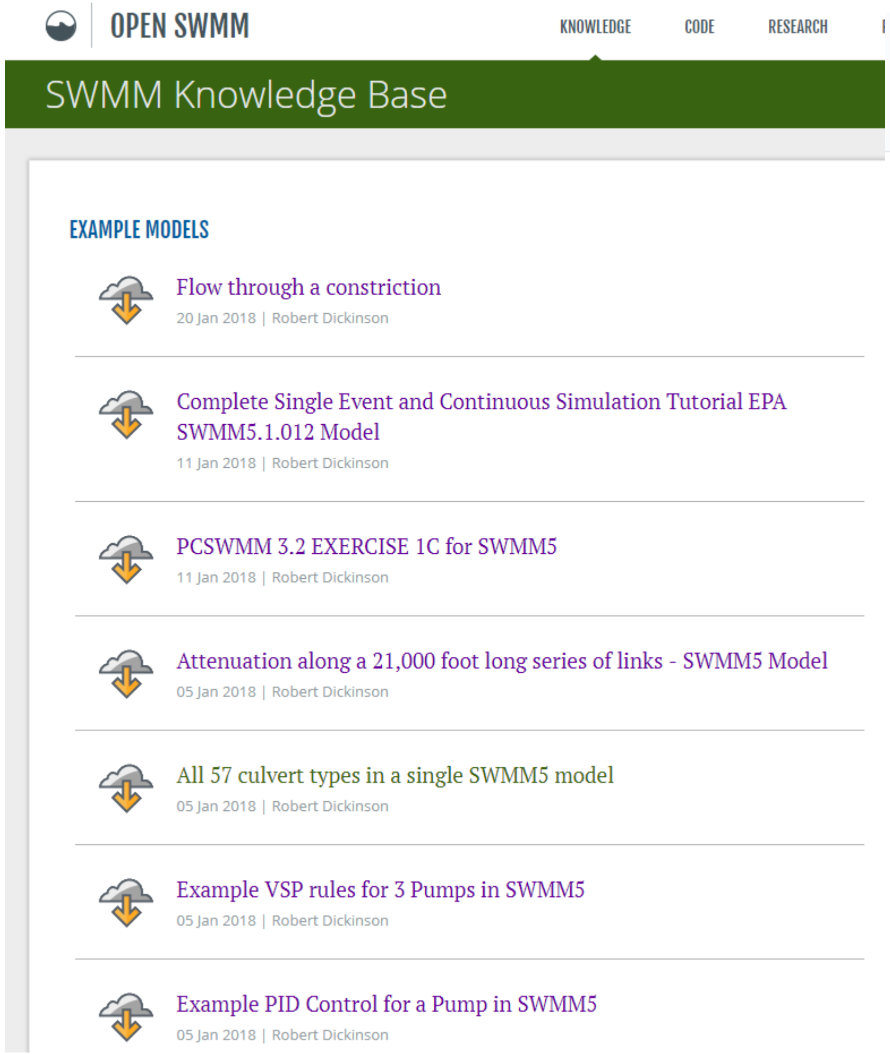
SWMM 4/5 Test Models

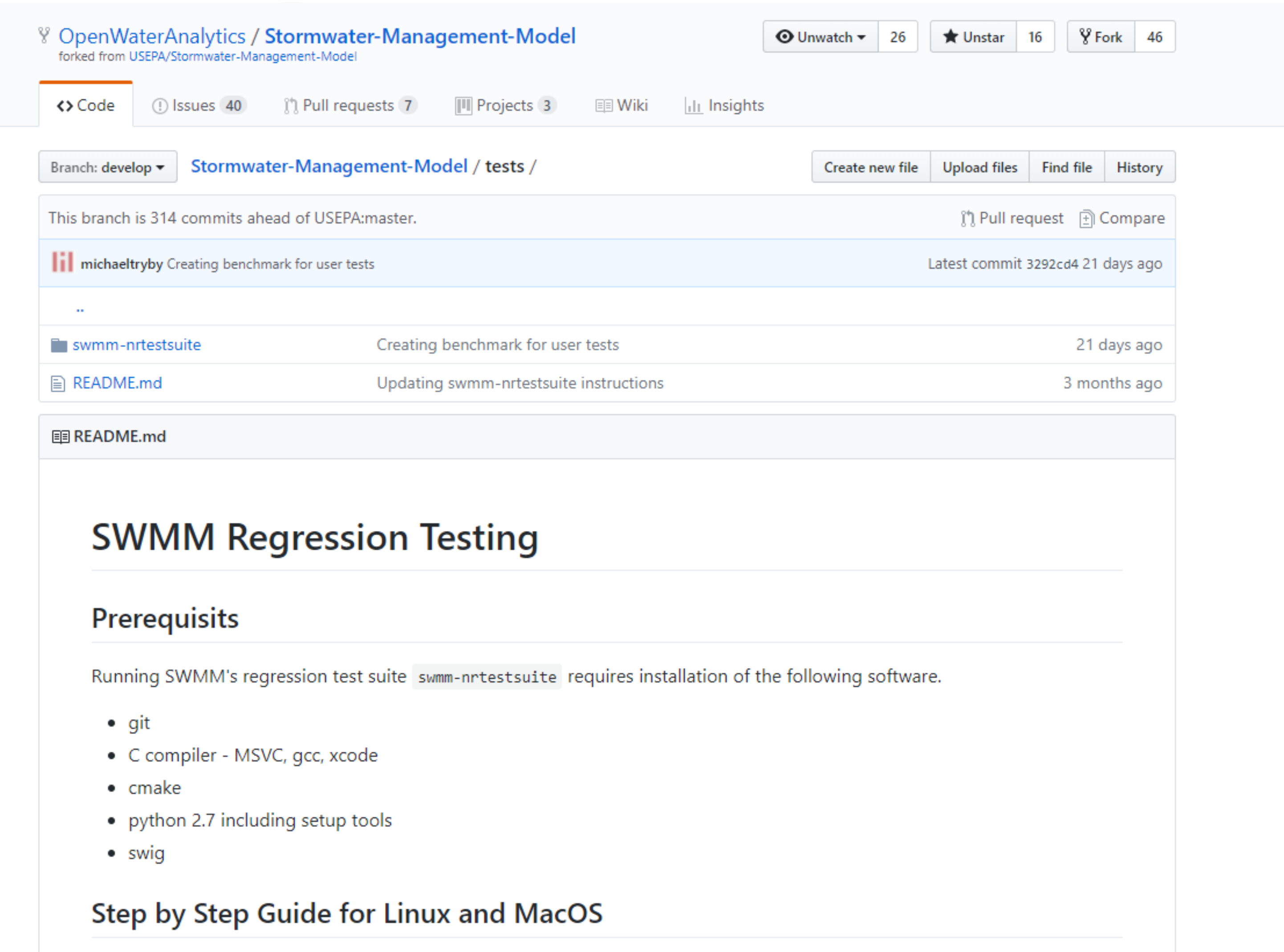
- More Tests
- Faster
- Tools on PC

All Files > ☆ SWMM5 QAQC Files

Name	Updated	Size
More Complicated QA QC Files for SWMM 5	Jun 28, 2018 by Robert Dickinson	17 Files
Other SWMM5 Files	Jun 28, 2018 by Robert Dickinson	594 Files
SWMM 5 Files from SWMM4 Extran	Jun 28, 2018 by Robert Dickinson	160 Files
SWMM5 Files from SWMM4 Runoff	Jun 28, 2018 by Robert Dickinson	266 Files

Key To White Box Testing are Good Example Files





Case Coverage vs Code coverage

What most people don't realize is that there are two kinds of coverage:

1. **Code coverage:** how much of the code is exercised, and
2. **Case coverage:** how many of the use-cases are covered by the test suites

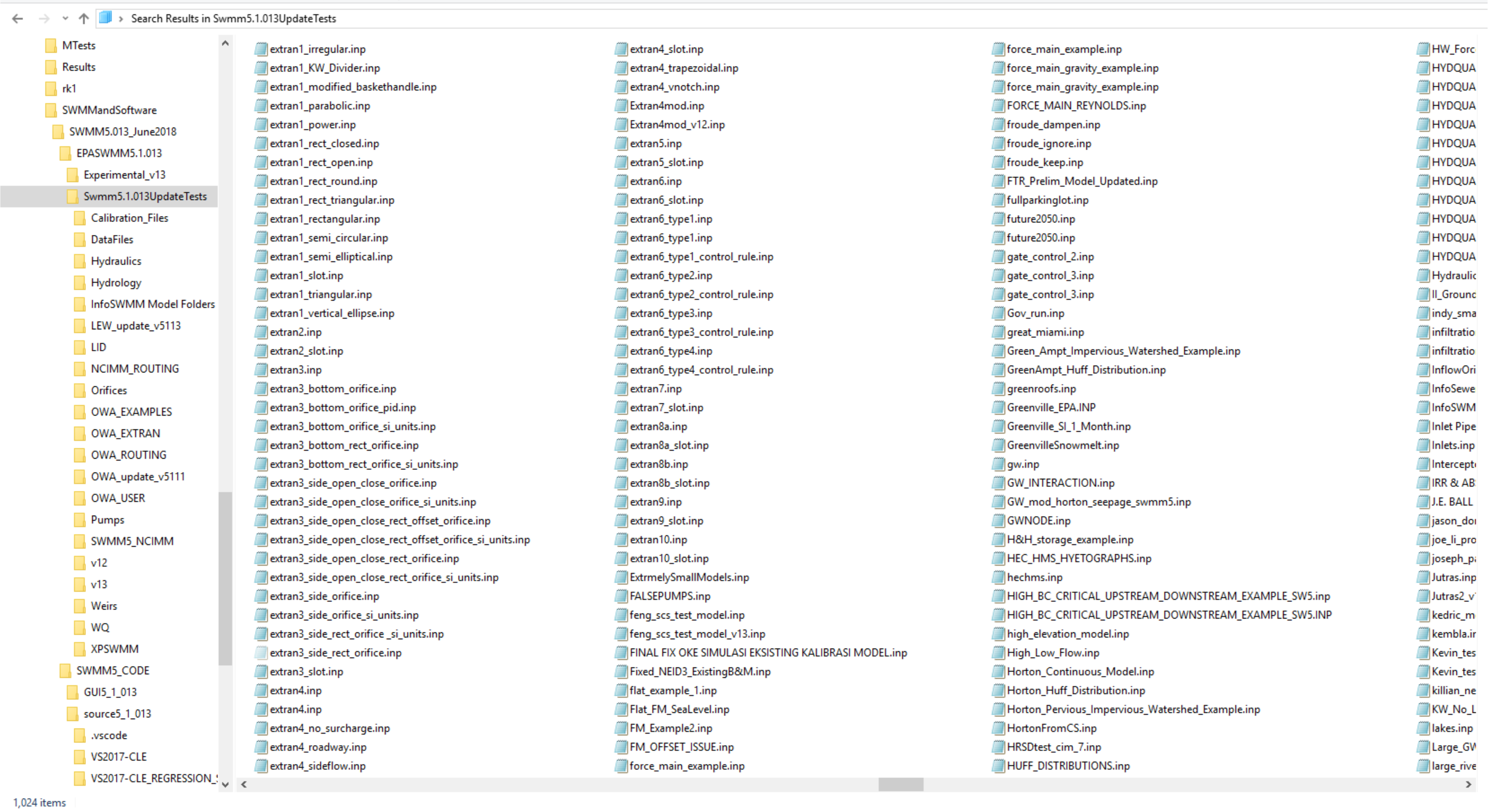
Case coverage refers to use-case scenarios: How the code will behave in the context of real world environment, with real users, real networks, and even hackers intentionally trying to subvert the design of the software for nefarious purposes.

Coverage reports identify code-coverage weaknesses, not case-coverage weaknesses. The same code may apply to more than one use-case, and a single use-case may depend on code outside the subject-under-test, or even in a separate application or 3rd party API.

Because use-cases may involve the environment, multiple units, users, and networking conditions, it is impossible to cover all required use-cases with a test suite that only contains unit tests. Unit tests by definition test units in isolation, not in integration, meaning that a test suite containing only unit tests will always have close to 0% case coverage for integration and functionaluse-case scenarios.

100% code coverage does not guarantee 100% case coverage.

Case Coverage vs Code coverage



SWMM Output API from OWA

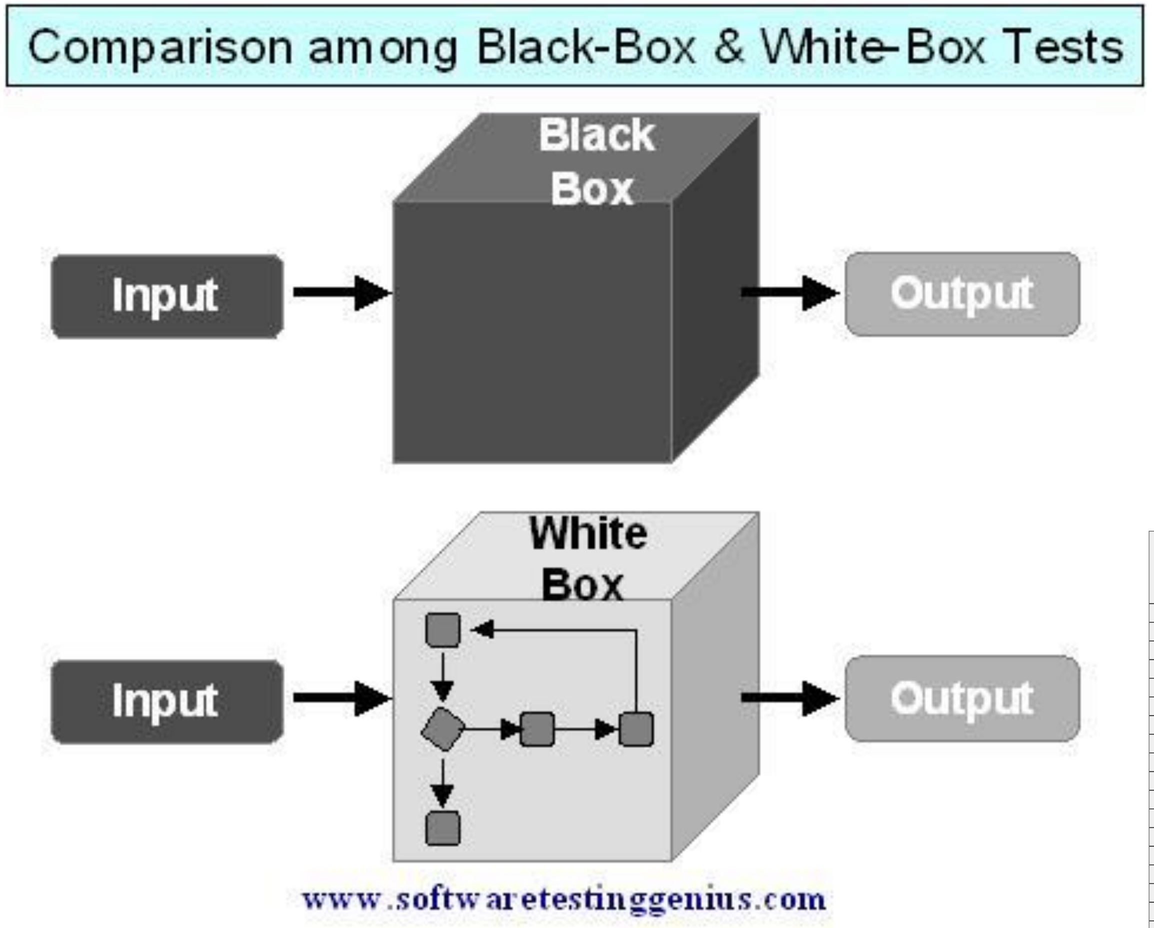
```c
#define MAX_STATISTICAL_RESULTS 17      // NCIMM
enum StatsType {
        SIM,            // Simulated Mean
        OBS,            // Observed Mean
        RMSE,           // Root Mean Square Error
        MAE,            // Mean Average Error
        MSLSE,          // Mean Simple Least Square Error
        STDSIM,         // Simulated Standard Deviation
        STDOBS,         // Simulated Standard Deviation
        SkewnessSim,    // Skewness of Simulated
        KurtosisSim,    // Kurtosis of Simulated
        SkewnessObs,    // Skewness of Observed
        KurtosisObs,    // Kurtosis of Observed
        LogNASH,        // Log Nash-Sutcliffe Efficiency
        IndexD,         // Index of Agreement
        ISE,            // Integral square error
        KGE,            // Kling-Gupta
        R,              // Correlation coefficient
        NASH};          // Nash-Sutcliffe Efficiency
```

swmm_output.c | output.c | objects.h | rain.c | rdii.c | routing.c | massbal.c

SWMM55.013_June2018-DLL | (Global Scope)

```c
/*
 * swmm_output.c - SWMM Output API
 *
 *      Author: Colleen Barr
 *          US EPA - ORD/NHEERL
 *
 *      Modified by: Michael E. Tryby,
 *                   Bryant McDonnell
 *
 */

#include "swmm_output.h"

#include <stdlib.h>
#include <stdio.h>
#include <string.h>
#include "errormanager.h"
#include "messages.h"
//#include "datetime.h"
#define _CRT_SECURE_NO_DEPRECATE
```

SWMM Testing as Black and White Boxes

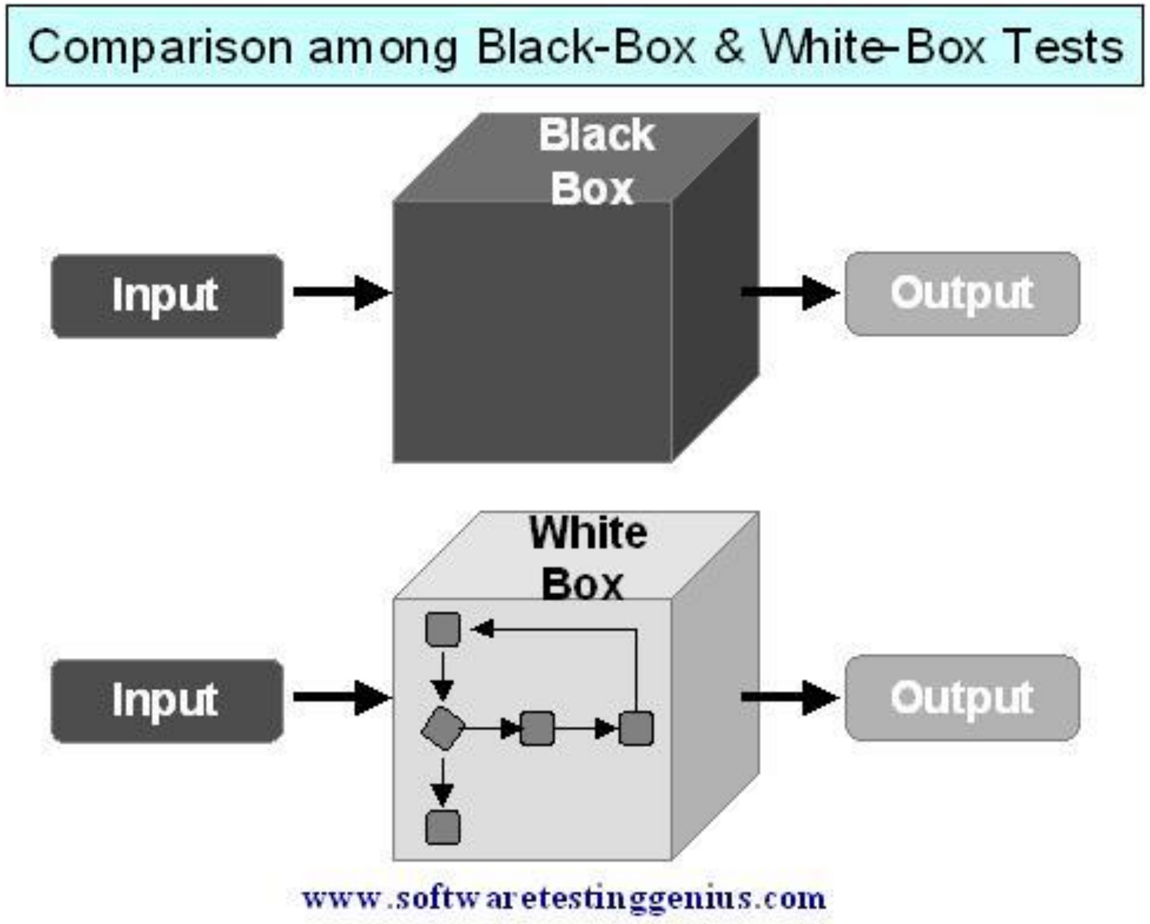


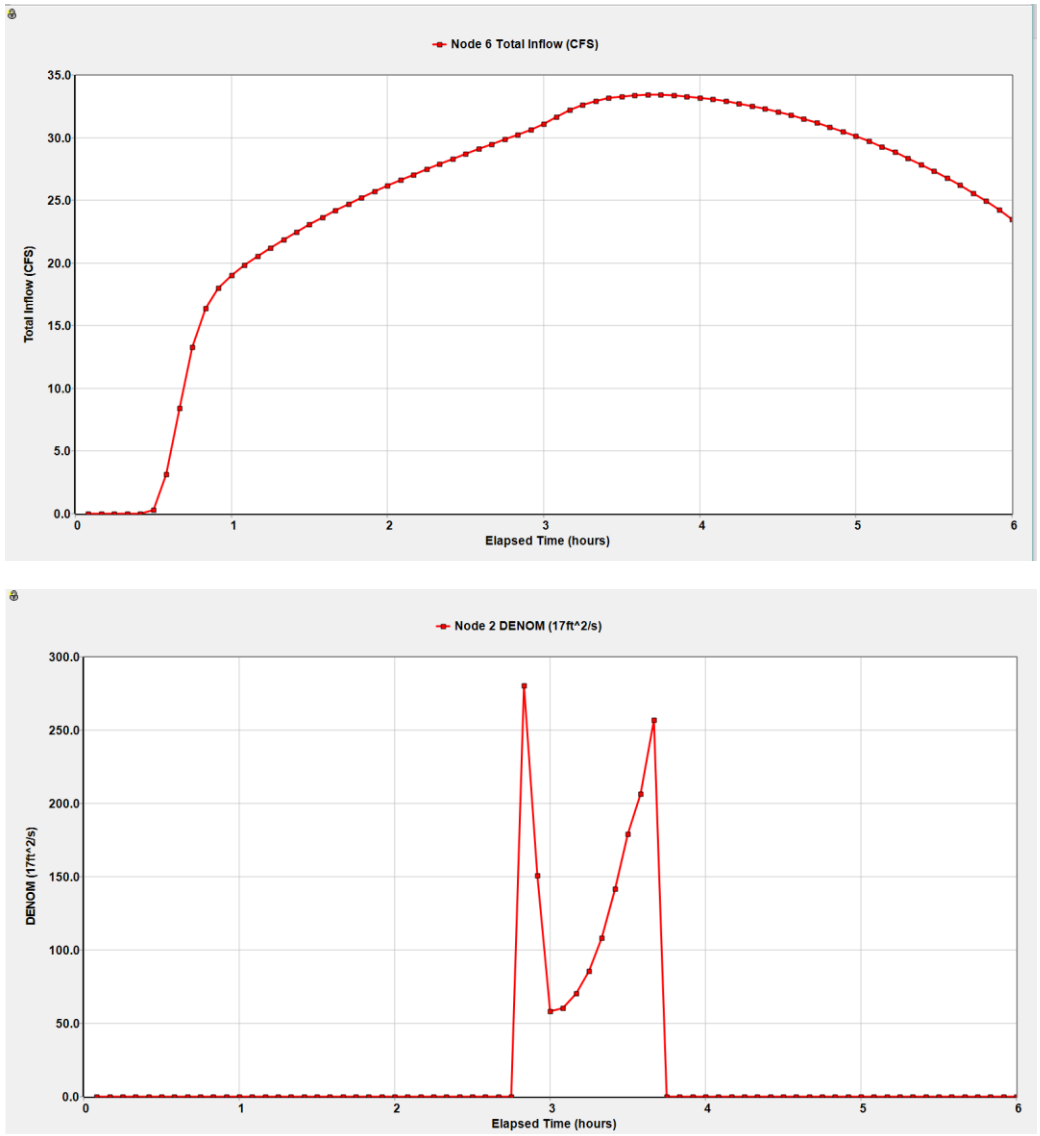
Objective Function (Fitness Evaluation Method) :

Type #1: [RMSE] Root Mean Square Error (Ideal Value: 0.0)
Type #2: [SLSE] Simple Least Square Error (Ideal Value: 0.0)
Type #3: [MLSE] Mean Least Square Error (Ideal Value: 0.0)
Type #4: [DTV] Difference in Total Volume (Ideal Value: 0.0)
Type #5: [NSEC] Nash-Sutcliffe Efficiency Criterion (Ideal Value: 1.0)
Type #6: [R-Square] R^2 (Ideal Value: 1.0)
Type #7: [MCE] Modified Coefficient of Efficiency (Ideal Value: 1.0)
Type #8: [DRMSE] Dimensionless Root Mean Square Error (Ideal Value: 0.0)
Type #9: [DSLSE] Dimensionless Simple Least Square Error (Ideal Value: 0.0)

Days	Hours	UH2 (10cfs)	UH3 (11cfs)	DWFFlow (12cfs)	OUTFlow (13cfs)	INFlow (14cfs)	NODE_CE (15cfs)	DQDH (16ft^2/s)	DENOM (17ft^2/s)	Node F (18#)	YCROWN (19ft)
0	00:05:00	0.000	0.000	0.000	0.000	0.000	0.000	0.442	0.000	0.000	12.000
0	00:10:00	0.000	0.000	0.000	0.000	0.000	0.000	2.061	0.000	0.000	12.000
0	00:15:00	0.000	0.000	0.000	0.000	0.000	0.000	4.956	0.000	0.000	12.000
0	00:20:00	0.000	0.000	0.000	0.000	0.000	0.000	8.035	0.000	0.000	12.000
0	00:25:00	0.000	0.000	0.000	0.000	0.000	0.000	10.143	0.000	0.000	12.000
0	00:30:00	0.000	0.000	0.000	0.000	0.000	0.000	11.872	0.000	0.000	12.000
0	00:35:00	0.000	0.000	0.000	0.000	0.000	0.000	13.467	0.000	0.000	12.000
0	00:40:00	0.000	0.000	0.000	0.000	0.000	0.000	14.925	0.000	0.000	12.000
0	00:45:00	0.000	0.000	0.000	0.000	0.000	0.000	16.256	0.000	0.000	12.000
0	00:50:00	0.000	0.000	0.000	0.000	0.000	0.000	17.503	0.000	0.000	12.000
0	00:55:00	0.000	0.000	0.000	0.000	0.000	0.000	18.746	0.000	0.000	12.000
0	01:00:00	0.000	0.000	0.000	0.000	0.000	0.000	20.080	0.000	0.000	12.000
0	01:05:00	0.000	0.000	0.000	0.000	0.000	0.000	21.320	0.000	0.000	12.000
0	01:10:00	0.000	0.000	0.000	0.000	0.000	0.000	22.507	0.000	0.000	12.000
0	01:15:00	0.000	0.000	0.000	0.000	0.000	0.000	23.635	0.000	0.000	12.000
0	01:20:00	0.000	0.000	0.000	0.000	0.000	0.000	24.724	0.000	0.000	12.000
0	01:25:00	0.000	0.000	0.000	0.000	0.000	0.000	25.767	0.000	0.000	12.000
0	01:30:00	0.000	0.000	0.000	0.000	0.000	0.000	26.769	0.000	0.000	12.000
0	01:35:00	0.000	0.000	0.000	0.000	0.000	0.000	27.731	0.000	0.000	12.000
0	01:40:00	0.000	0.000	0.000	0.000	0.000	0.000	28.653	0.000	0.000	12.000
0	01:45:00	0.000	0.000	0.000	0.000	0.000	0.000	29.538	0.000	0.000	12.000
0	01:50:00	0.000	0.000	0.000	0.000	0.000	0.000	30.383	0.000	0.000	12.000
0	01:55:00	0.000	0.000	0.000	0.000	0.000	0.000	31.194	0.000	0.000	12.000

SWMM Testing as Black and White Boxes

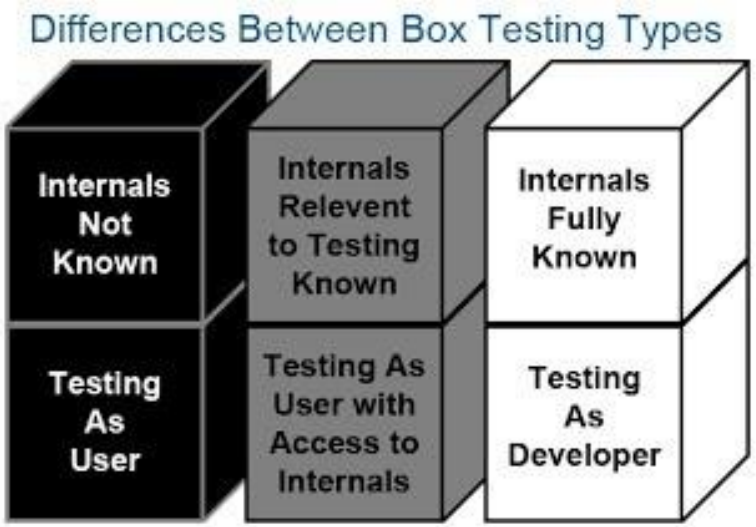




Grey Box vs White Box vs Black Box

The "box" approach

Software testing methods are traditionally divided into white- and black-box testing. These two approaches are used to describe the point of view that the tester takes when designing test cases. A hybrid approach called grey-box testing may also be applied to software testing methodology.[18][19] With the concept of grey-box testing—which develops tests from specific design elements—gaining prominence, this "arbitrary distinction" between black- and white-box testing has faded somewhat.[20]



Calibration Files

Flog, // Other SWMM5 Output File Comparion log // NCIUMM 2018

FoutCompare, // Other SWMM5 Output File // "

Fall_log, // All log files combined // " // "

FcalibrationS, // Calibration file Innovyze RED 2016 // Storage Volume in a Storage Node

FcalibrationR, // Calibration file Innovyze RED 2016 Runoff

FcalibrationE, // Calibration file Innovyze RED 2016 Groundwater Elevation

FcalibrationG, // Calibration file Innovyze RED 2016 Groundwater Q

FcalibrationH, // Calibration file Innovyze RED 2016 Node Depth

FcalibrationNH, // Calibration file Innovyze RED 2016 Node Head

FcalibrationNF, // Calibration file Innovyze RED 2016 Node Flooding

FcalibrationL, // Calibration file Innovyze RED 2016 Node Lateral Q

FcalibrationQ, // Calibration file Innovyze RED 2016 Link Q

FcalibrationV, // Calibration file Innovyze RED 2016 Link V

FcalibrationD, // Calibration file Innovyze RED 2016 Link D

FcalibrationHGL, // Calibration file Innovyze RED 2016 Link HGL

FcalibrationNA, // Calibration file Innovyze RED 2018 Node Area

FcalibrationNSA; // Calibration file Innovyze RED 2018 Node DQDH

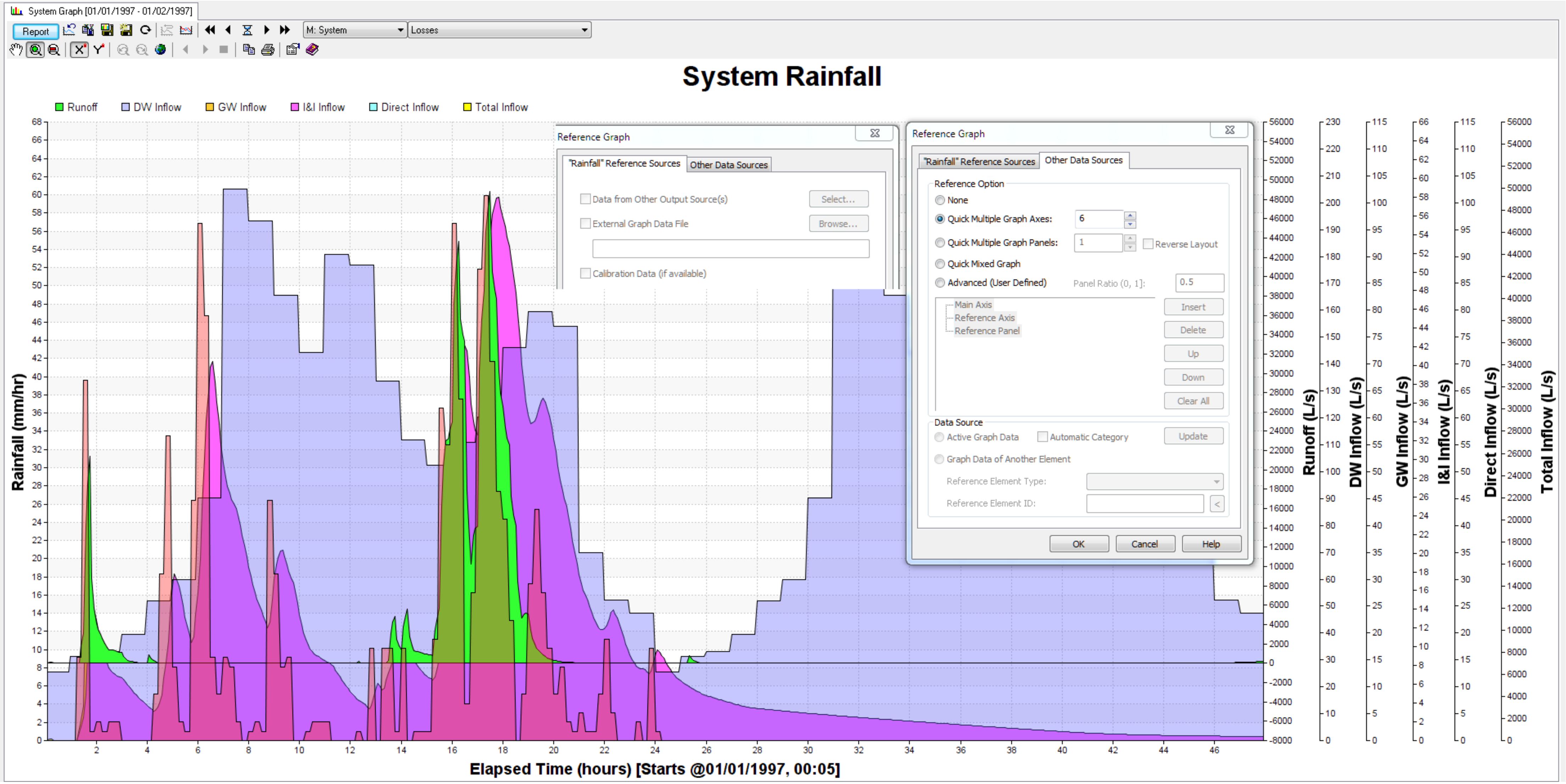
Performance Evaluation Functions

- SIM, // Simulated Mean
- OBS, // Observed Mean
- RMSE, // Root Mean Square Error
- MAE, // Mean Average Error
- MSLSE, // Mean Simple Least Square Error
- STDSIM, // Simulated Standard Deviation
- STDOBS, // Simulated Standard Deviation
- SkewnessSim, // Skewness of Simulated
- KurtosisSim, // Kurtosis of Simulated
- SkewnessObs, // Skewness of Observed
- KurtosisObs, // Kurtosis of Observed
- R, // Correlation coefficient
- LogNASH, // Log Nash–Sutcliffe Efficiency
- IndexD, // Index of Agreement
- ISE, // Integral square error
- KGE, // Kling-Gupta
- NASH}; // Nash–Sutcliffe Efficiency

Evaluated Results

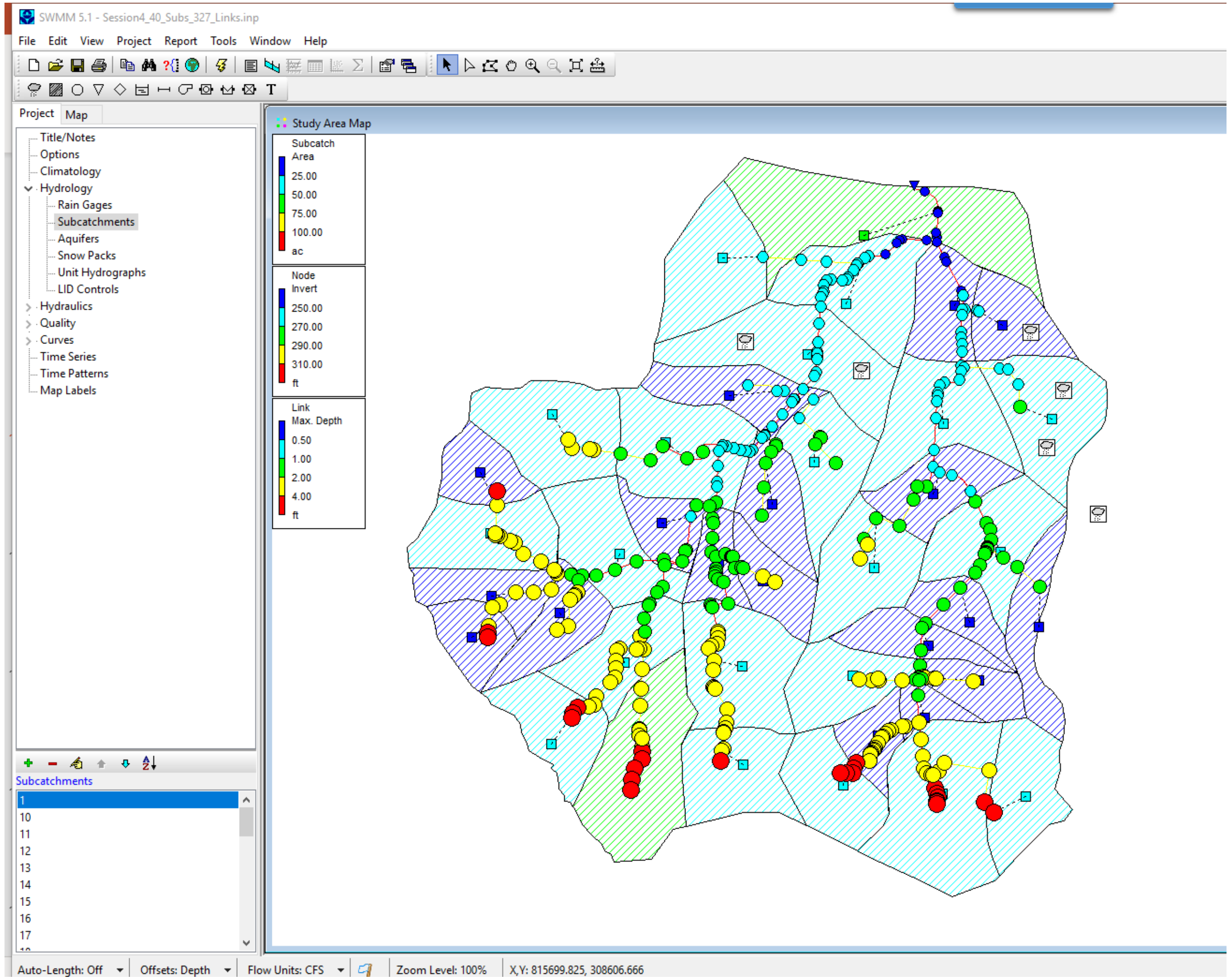
Subcatchment Runoff	Subcatchment Infiltration	Node Depth	Node Lateral Flow	Node Total Flow
Link Flow	Link Depth	Link WQ	Node WQ	Subcatchment WQ
SYS_TEMPERATURE, // air temperature	SYS_RAINFALL, // rainfall intensity	SYS_SNOWDEPTH, // snow depth	SYS_INFIL, // infil	SYS_RUNOFF, // runoff flow
SYS_DWFLOW, // dry weather inflow	SYS_GWFLOW, // ground water inflow	SYS_IIFLOW, // RDII inflow	SYS_EXFLOW, // external inflow	SYS_INFLOW, // total lateral inflow
SYS_FLOODING, // flooding outflow	SYS_OUTFLOW, // outfall outflow	SYS_STORAGE, // storage volume	SYS_EVAP, // evaporation	SYS_PET}; // potential ET

SWMM 5 Holistic System Graph

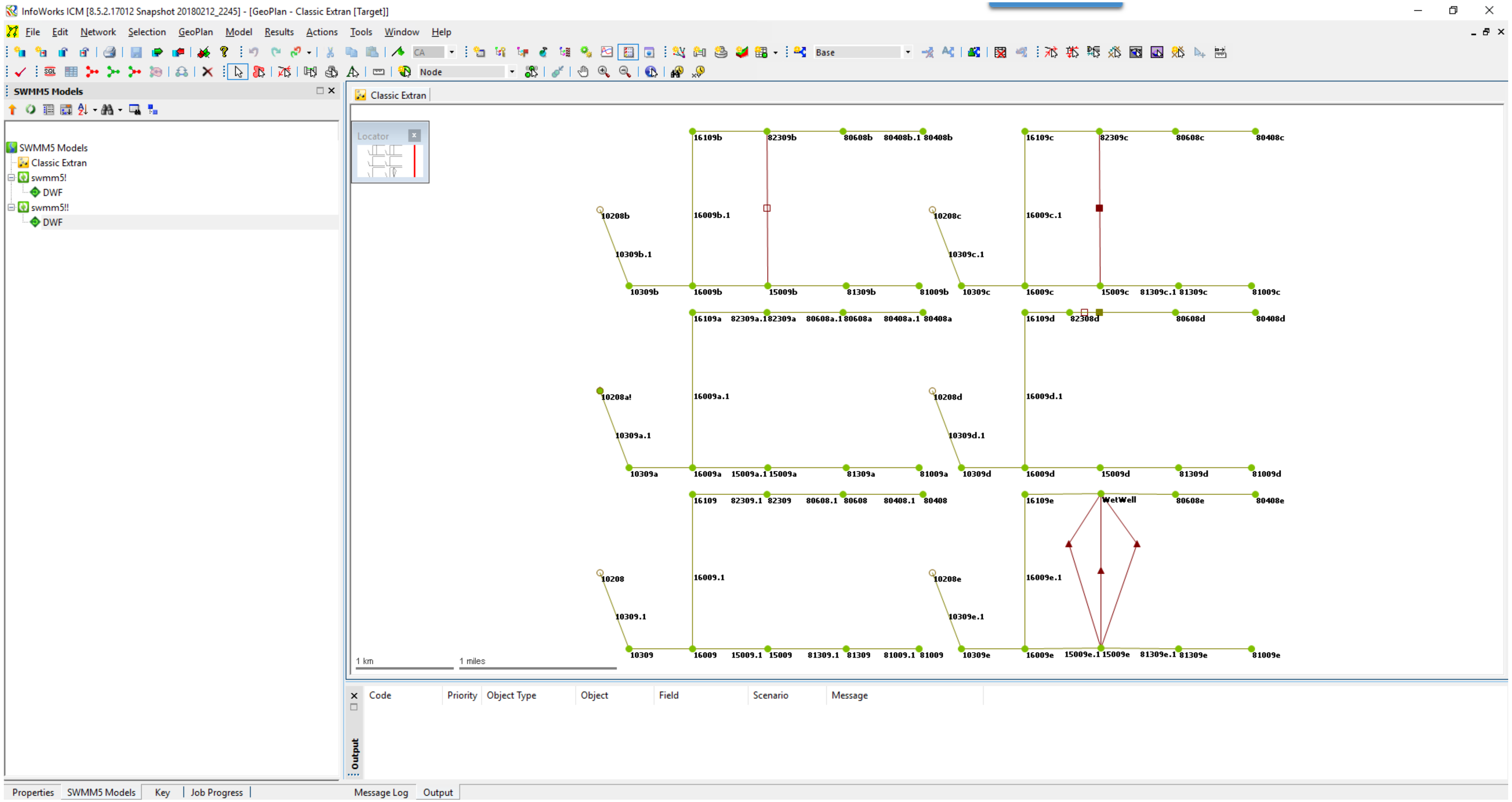


All Test Models have the Same ID's

- Raingage
- Subcatchment
- Link
- Node



Famous Extran 3 Models in InfoWorks ICM



Master Hydraulics Model

It should be medium size (100 to 200 elements) but runs in a second

It should test closed and open conduits as they are the two main conduit types,

It should test the flows from zero, partial, surcharge and flooding/surcharge at the node, this can be done using a flow TS.

There are really five solutions in SWMM: Dampen, Keep, Ignore, KW and Steady State

Two options for Node Surcharging: Extran and Slot

Two Types of Nodes: Storage and Junction

Ponding or No Ponding/Surcharge Depth or Surcharge Depth

Four options for Link Offsets: No Offset, Upstream Offset, Downstream Offset and Both Offsets from the Node Invert

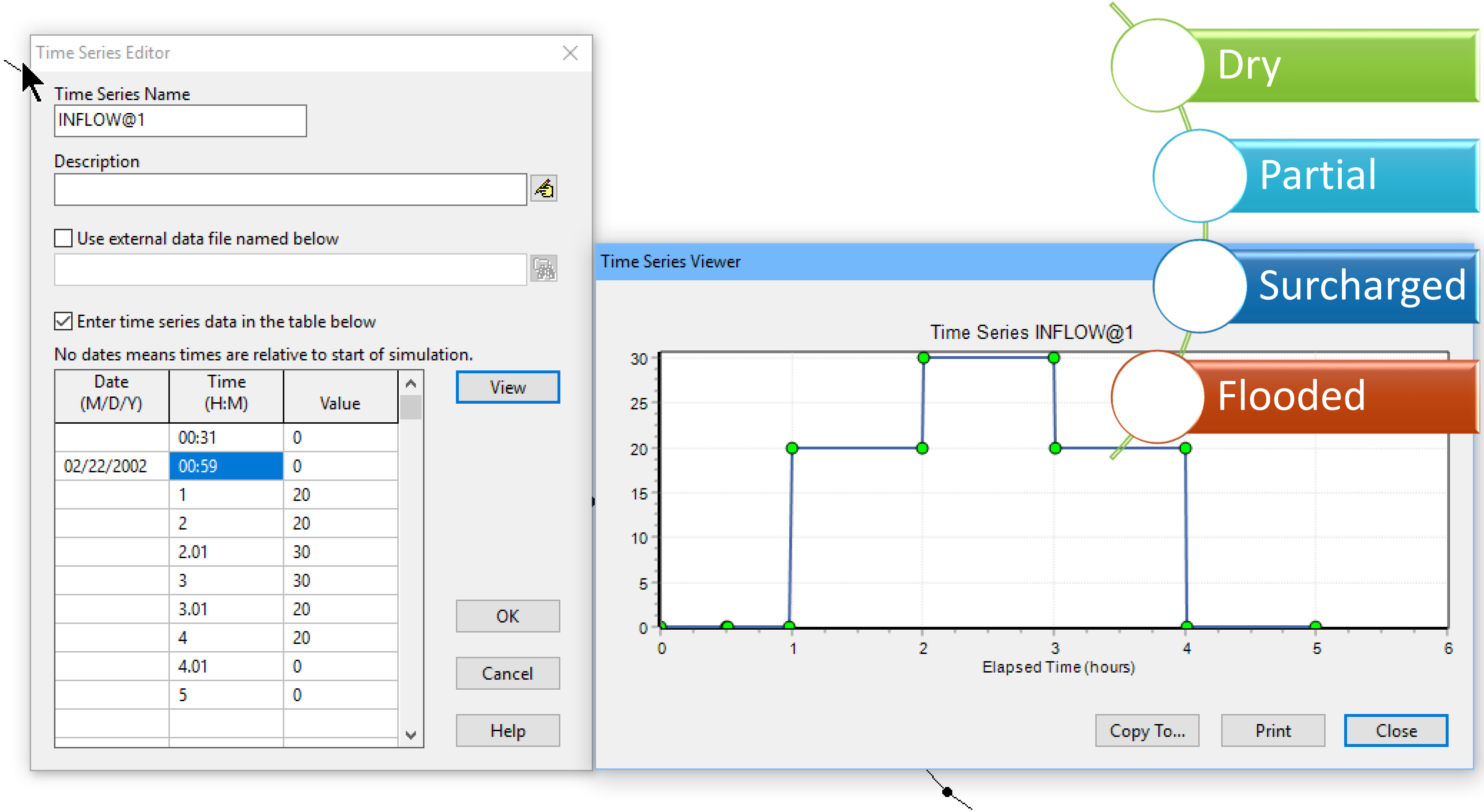
Losses or No Losses in the Links

Seepage or No Seepage in the Links/Nodes

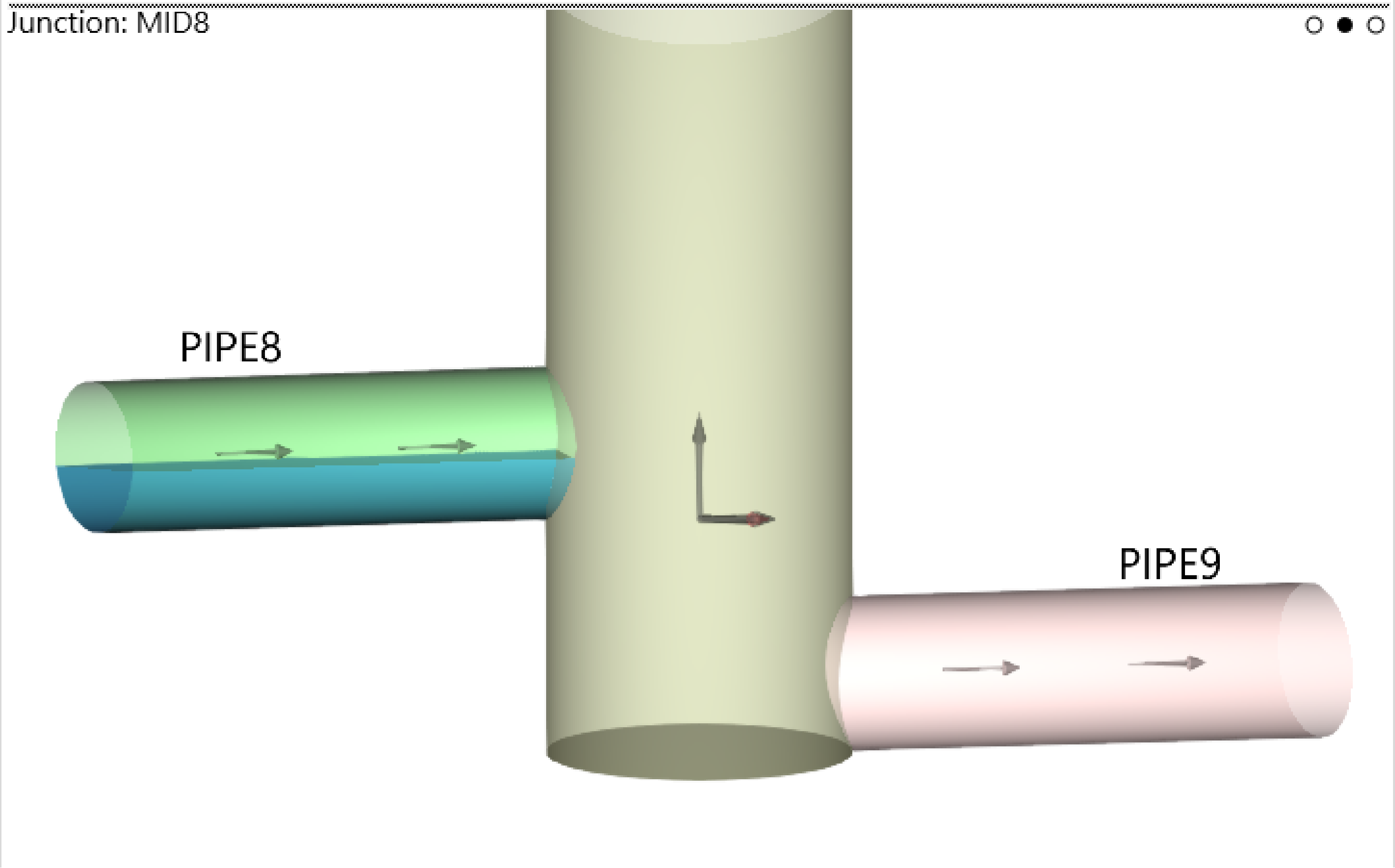
Water Quality/No Treatment Equations or No Water Quality or Water Quality w/ Treatment Equations

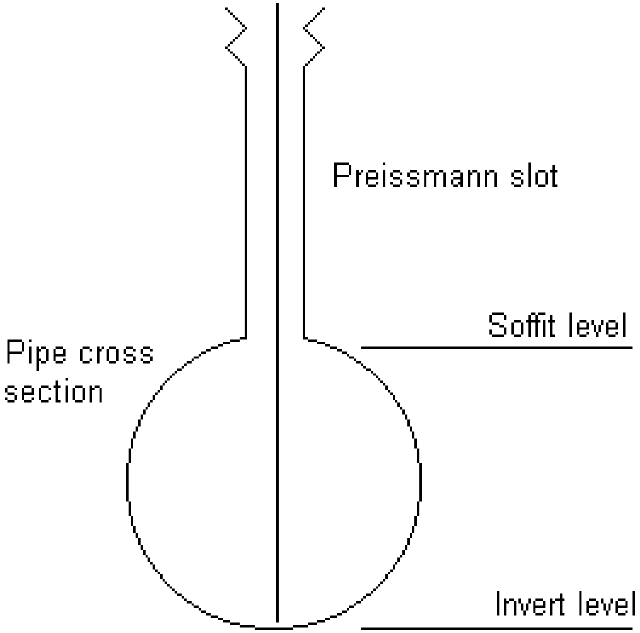
By my counting that means 1 * 24 * 1 * 5 * 2 * 2 * 3 * 4 * 2 * 2 * 3 or a total of **69,120** very similar networks

Forcing Function for Hydraulics



The Famous Link Slot





SWMM5.1.013 Generation of Calibration Files

```
EXTERN TFile
Finp,                     // Input file
Fout,                     // Output file
Frpt,                     // Report file
Fclimate,                 // Climate file
Frain,                    // Rainfall file
Frunoff,                  // Runoff file
Frdii,                    // RDII inflow file
Fhotstart1,               // Hot start input file
Fhotstart2,               // Hot start output file
Finflows,                 // Inflows routing file
Foutflows,                // Outflows routing file
Flog,                     // Other SWMM5 Output File Comparion log    // NCIUMM 2018
FoutCompare,              // Other SWMM5 Output File                  // "
Fall_log,                 // All log files combined                   // "
FcalibrationS,            // Calibration file Innovyze RED 2016       // Storage Vol
FcalibrationR,            // Calibration file Innovyze RED 2016          Runoff
FcalibrationE,            // Calibration file Innovyze RED 2016          Groundwater
FcalibrationG,            // Calibration file Innovyze RED 2016          Groundwater
FcalibrationH,            // Calibration file Innovyze RED 2016          Node Depth
FcalibrationNH,           // Calibration file Innovyze RED 2016          Node Head
FcalibrationNF,           // Calibration file Innovyze RED 2016          Node Floodi
FcalibrationL,            // Calibration file Innovyze RED 2016          Node Latera
FcalibrationQ,            // Calibration file Innovyze RED 2016          Link Q
FcalibrationV,            // Calibration file Innovyze RED 2016          Link V
FcalibrationD,            // Calibration file Innovyze RED 2016          Link D
FcalibrationHGL,          // Calibration file Innovyze RED 2016          Link HGL
FcalibrationNA,           // Calibration file Innovyze RED 2018          Node Area
FcalibrationNSA;          // Calibration file Innovyze RED 2018          Node DQDH
```

› SWMMandSoftware › SWMM5.013_June2018 › EPASWMM5.1.013 › Swmm5.1.013UpdateTests

Name	Date modified	Type	Size
Calibration_Files	1/27/2019 1:11 PM	File folder	
DataFiles	1/27/2019 12:54 PM	File folder	
Hydraulics	1/28/2019 3:17 PM	File folder	
Hydrology	1/27/2019 2:15 PM	File folder	
InfoSWMM Model Folders	2/24/2019 5:25 PM	File folder	
LEW_update_v5113	1/27/2019 1:11 PM	File folder	
LID	1/27/2019 1:11 PM	File folder	
NCIMM_ROUTING	1/8/2019 9:00 AM	File folder	
Orifices	1/9/2019 7:33 PM	File folder	
OWA_EXAMPLES	1/27/2019 1:11 PM	File folder	
OWA_EXTRAN	1/27/2019 1:11 PM	File folder	
OWA_ROUTING	1/27/2019 1:11 PM	File folder	
OWA_update_v5111	1/27/2019 1:11 PM	File folder	
OWA_USER	1/27/2019 1:11 PM	File folder	
Pumps	1/13/2019 5:21 PM	File folder	
SWMM5_NCIMM	2/13/2019 11:48 PM	File folder	
v12	2/25/2019 3:57 PM	File folder	
v13	2/25/2019 4:47 PM	File folder	
Weirs	1/13/2019 5:27 PM	File folder	
WQ	12/19/2018 6:09 PM	File folder	
XPSWMM	1/22/2019 12:01 PM	File folder	
cleanup.bat	1/27/2019 12:57 PM	Windows Batch File	4 KB
hydraulics_only.bat	1/11/2019 7:39 PM	Windows Batch File	28 KB
hydrology_only.bat	1/11/2019 9:46 PM	Windows Batch File	32 KB
make_dir.bat	11/8/2018 9:20 AM	Windows Batch File	1 KB
NCIMM_REGRESSION_STATS.BAT	1/11/2019 9:44 PM	Windows Batch File	75 KB
OWA_ONLY.BAT	1/27/2019 12:58 PM	Windows Batch File	27 KB
SWMM5.DLL	1/25/2019 9:18 PM	Application extens...	425 KB
SWMM5.EXE	1/1/2019 8:20 PM	Application	110 KB

Batch Comparison of SWMM5 Output Text Files

D:\MTests\NCIMM\NCIMM_Batch_All.bat • (SWMM5.012_QAQC) - Sublime Text

File Edit Selection Find View Goto Tools Project Preferences Help

NCIMM_Batch_All.bat

```
REM SET the Directories
REM
SET OWA="D:\MTests\OWACore\tests\swmm-nrtestsuite\benchmark\swmm-5112\"
SET ENGINE10="D:\MTests\Swmm5.1.013\Setup\SWMM5v10.EXE"
SET ENGINE11="D:\MTests\Swmm5.1.013\Setup\SWMM5v11.EXE"
SET ENGINE12="D:\MTests\Swmm5.1.013\Setup\SWMM5v12.EXE"
SET ENGINE13a="D:\MTests\Swmm5.1.013\Setup\swmm5v13a.exe"
SET ENGINE13b="D:\MTests\Swmm5.1.013\Setup\swmm5v13b.exe"
SET V12=D:\MTests\NCIMM\v12\
SET v13a=D:\MTests\NCIMM\v13a\
SET V13b=D:\MTests\NCIMM\v13b\
REM
REM Run the example Files
REM
REM  SWMM5.1.012 Engine
%ENGINE12%   test1.inp %v12%test1.rpt %v12%test1.out
%ENGINE12%   test2.inp %v12%test2.rpt %v12%test2.out
%ENGINE12%   test3.inp %v12%test3.rpt %v12%test3.out
%ENGINE12%   test4.inp %v12%test4.rpt %v12%test4.out
%ENGINE12%   test5.inp %v12%test5.rpt %v12%test5.out
%ENGINE12%   user1.inp %v12%user1.rpt %v12%user1.out
%ENGINE12%   user2.inp %v12%user2.rpt %v12%user2.out
%ENGINE12%   user3.inp %v12%user3.rpt %v12%user3.out
%ENGINE12%   user4.inp %v12%user4.rpt %v12%user4.out
%ENGINE12%   user5.inp %v12%1user5.rpt %v12%1user5.out
%ENGINE12%   example1.inp %v12%example1.rpt %v12%example1.out
%ENGINE12%   example2.inp %v12%example2.rpt %v12%example2.out
%ENGINE12%   example3.inp %v12%example3.rpt %v12%example3.out
%ENGINE12%   example4.inp %v12%example4.rpt %v12%example4.out
%ENGINE12%   example5.inp %v12%example5.rpt %v12%example5.out
%ENGINE12%   example6.inp %v12%example6.rpt %v12%example6.out
%ENGINE12%   extran1.inp %v12%extran1.rpt %v12%extran1.out
%ENGINE12%   extran2.inp %v12%extran2.rpt %v12%extran2.out
%ENGINE12%   extran3.inp %v12%extran3.rpt %v12%extran3.out
%ENGINE12%   extran4.inp %v12%extran4.rpt %v12%extran4.out
%ENGINE12%   extran5.inp %v12%extran5.rpt %v12%extran5.out
%ENGINE12%   extran6.inp %v12%extran6.rpt %v12%extran6.out
%ENGINE12%   extran7.inp %v12%extran7.rpt %v12%extran7.out
%ENGINE12%   extran9.inp %v12%extran9.rpt %v12%extran9.out
%ENGINE12%   extran8b.inp %v12%extran8a.rpt %v12%extran8a.out
%ENGINE12%   extran8b.inp %v12%extran8b.rpt %v12%extran8b.out
%ENGINE12%   extran10.inp %v12%extran10.rpt %v12%extran10.out
%ENGINE12%   exam80a.inp %v12%exam80a.rpt %v12%exam80a.out
```

FOLDERS

- SWMM5.012_QAQC
  - makefiles
  - climate (2).c
  - climate (3).c
  - climate.c
  - climateM3008.c
  - consts (2).h
  - consts (3).h
  - consts.h
  - constsM3008.c
  - controls (2).c
  - controls (3).c
  - controls M3008.c
  - controls.c
  - culvert (2).c
  - culvert (3).c
  - culvert.c
  - datetime (2).c
  - datetime (2).h
  - datetime (3).c
  - datetime (3).h
  - datetime.c
  - datetime.h
  - dwflow (2).c
  - dwflow (3).c
  - dwflow.c
  - dynqual.c
  - dynwave (2).c
  - dynwave (3).c
  - dynwave M3008.c
  - dynwave.c
  - enums (2).h
  - enums (3).h
  - enums M3008.c
  - enums.h
  - error (2).c
  - error (2).h

Summary of Each Network in a Log File

- 20+ Metrics
- Subcatchment
- Link
- Node
- System

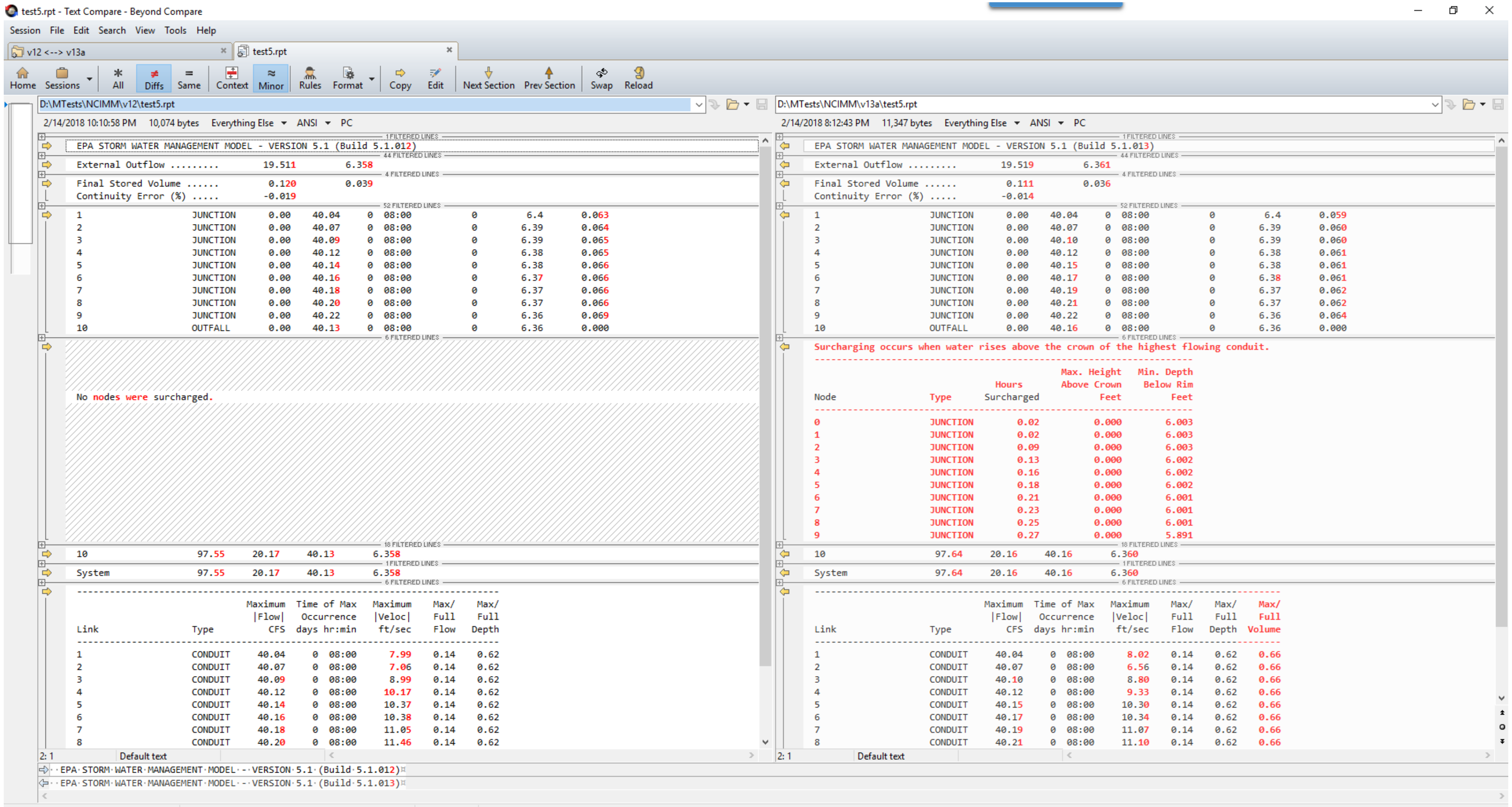
```
 Fout.file Version                                        51013
 Fout.file MagicNumber                                    516114522
 Fout.file Flow units                                     0
 Fout.file Report Step                                    900
 Fout.file Nperiods                                       32
 Fout.file Starting file position of ID names             28
 Fout.file Starting file position of input data           190
 Fout.file Starting file position of output data          702
 Fout.file number of bytes per time period                488
 Fout.file Number of subcatchment output variables        8
 Fout.file Number of node output variables                6
 Fout.file Number of link output variables                5
 Fout.file Number of subcatchments reported on            0
 Fout.file Number of nodes reported on                    10
 Fout.file Number of links reported on                    9
 Fout.file Number of pollutants reported on               0

 FoutCompare.file Version                                 51011
 FoutCompare.file MagicNumber                             516114522
 FoutCompare.file Flow units                              0
 FoutCompare.file Nperiods                                32
 FoutCompare.file Starting file position of ID names      28
 FoutCompare.file Starting file position of input data    190
 FoutCompare.file Starting file position of output data   702
 FoutCompare.file number of bytes per time period         488
 FoutCompare.file Number of subcatchment output variables 8
 FoutCompare.file Number of node output variables         6
 FoutCompare.file Number of link output variables         5
 FoutCompare.file Number of subcatchments reported on     0
 FoutCompare.file Number of nodes reported on             10
 FoutCompare.file Number of links reported on             9
 FoutCompare.file Number of pollutants reported on        0

************************************
*Node Depth Statistics Comparisons *
************************************
```

Node ID	Mean Sim	Mean Obs	RMSE	MAE	MSLSE	STD Sim	STD Obs	Skewn..Sim
80408	4.1741	4.1743	0.0004	0.0002	0.0000	1.0599	1.0599	1.0000
80608	5.5717	5.5723	0.0021	0.0008	0.0000	1.3746	1.3745	1.0000
81009	1.1082	1.1084	0.0004	0.0003	0.0000	0.2167	0.2167	1.0000
81309	1.3131	1.3132	0.0006	0.0004	0.0000	0.2308	0.2308	1.0000
82309	7.6466	7.6472	0.0030	0.0016	0.0000	1.7096	1.7095	1.0000
10309	1.4786	1.4788	0.0011	0.0007	0.0000	0.1801	0.1801	1.0000
15009	1.1288	1.1289	0.0006	0.0004	0.0000	0.1762	0.1762	1.0000
16009	1.5370	1.5372	0.0011	0.0007	0.0000	0.1933	0.1932	1.0000
16109	1.3860	1.3862	0.0009	0.0006	0.0000	0.2162	0.2161	1.0000
10208	1.3074	1.3077	0.0009	0.0006	0.0000	0.1711	0.1711	1.0000

Summary of 1000+ Models in a Log File

```
Opening D:\SWMMandSoftware\SWMM5.013_June2018\EPASWMM5.1.013\Swmm5.1.013UpdateTests\OWA_USER\user5_slot.inp
Mean NSE, Mean Sim, Mean Obs, RMSE, MAE, MSLSE Subcatchment Runoff        1.0000      88.0682      88.0682       0.0000       0.0000       0.0000
Mean NSE, Mean Sim, Mean Obs, RMSE, MAE, MSLSE Node Depth                 0.9896     249.1287     249.2546      14.1670       4.1800       0.0000
Mean NSE, Mean Sim, Mean Obs, RMSE, MAE, MSLSE Lateral Flow               1.0000     149.5703     149.6118       1.3504       0.1781       0.0047
Mean NSE, Mean Sim, Mean Obs, RMSE, MAE, MSLSE Total Inflow               0.9451    3940.8863    3915.2981    1893.4737     385.4881       6.5975
Mean NSE, Mean Sim, Mean Obs, RMSE, MAE, MSLSE Link Flow                 -0.0697    3740.3005    3692.6335    2057.0522     410.1077       7.1674
Mean NSE, Mean Sim, Mean Obs, RMSE, MAE, MSLSE Link Depth                 0.6081     269.1337     264.3545      13.2374       7.3252       0.0461
Opening D:\SWMMandSoftware\SWMM5.013_June2018\EPASWMM5.1.013\Swmm5.1.013UpdateTests\OWA_USER\user1_2threads.inp
Mean NSE, Mean Sim, Mean Obs, RMSE, MAE, MSLSE Subcatchment Runoff        1.0000       1.3280       1.3280       0.0000       0.0000       0.0000
Mean NSE, Mean Sim, Mean Obs, RMSE, MAE, MSLSE Node Depth                 0.9893      10.7189      10.6535       1.7310       0.3241       0.0000
Mean NSE, Mean Sim, Mean Obs, RMSE, MAE, MSLSE Lateral Flow               1.0000       1.3292       1.3292       0.0000       0.0000       0.0000
Mean NSE, Mean Sim, Mean Obs, RMSE, MAE, MSLSE Total Inflow               0.9987      13.8685      13.8677       1.0738       0.4033       0.0026
Mean NSE, Mean Sim, Mean Obs, RMSE, MAE, MSLSE Link Flow                  0.9955      12.5325      12.5317       1.1313       0.4087       0.0027
Mean NSE, Mean Sim, Mean Obs, RMSE, MAE, MSLSE Link Depth                 0.9981       7.8877       7.9116       0.3972       0.1894       0.0009
Opening D:\SWMMandSoftware\SWMM5.013_June2018\EPASWMM5.1.013\Swmm5.1.013UpdateTests\OWA_USER\user2_2threads.inp
Mean NSE, Mean Sim, Mean Obs, RMSE, MAE, MSLSE Subcatchment Runoff        1.0000     197.6582     197.6582       0.0000       0.0000       0.0000
Mean NSE, Mean Sim, Mean Obs, RMSE, MAE, MSLSE Node Depth                 1.0000     102.8343     102.8311       0.0303       0.0083       0.0000
Mean NSE, Mean Sim, Mean Obs, RMSE, MAE, MSLSE Lateral Flow               1.0000     197.6959     197.6959       0.0000       0.0000       0.0000
Mean NSE, Mean Sim, Mean Obs, RMSE, MAE, MSLSE Total Inflow               1.0000    4821.1581    4821.3068      10.6204       1.3451       0.0246
Mean NSE, Mean Sim, Mean Obs, RMSE, MAE, MSLSE Link Flow                  1.0000    4621.7603    4621.6623       9.5989       1.3595       0.0222
Mean NSE, Mean Sim, Mean Obs, RMSE, MAE, MSLSE Link Depth                 1.0000      98.2236      98.2209       0.0240       0.0075       0.0001
Opening D:\SWMMandSoftware\SWMM5.013_June2018\EPASWMM5.1.013\Swmm5.1.013UpdateTests\OWA_USER\user3_2threads.inp
Mean NSE, Mean Sim, Mean Obs, RMSE, MAE, MSLSE Subcatchment Runoff        1.0000      13.4266      13.4266       0.0000       0.0000       0.0000
Mean NSE, Mean Sim, Mean Obs, RMSE, MAE, MSLSE Node Depth                 0.9999     153.5566     153.5572       0.0290       0.0052       0.0000
Mean NSE, Mean Sim, Mean Obs, RMSE, MAE, MSLSE Lateral Flow               1.0000      13.4286      13.4286       0.0000       0.0000       0.0000
Mean NSE, Mean Sim, Mean Obs, RMSE, MAE, MSLSE Total Inflow               1.0000     131.6714     131.6712       0.0310       0.0075       0.0001
Mean NSE, Mean Sim, Mean Obs, RMSE, MAE, MSLSE Link Flow                  1.0000     117.1237     117.1235       0.0313       0.0076       0.0001
Mean NSE, Mean Sim, Mean Obs, RMSE, MAE, MSLSE Link Depth                 1.0000     108.8714     108.8716       0.0025       0.0010       0.0000
```

Graphical Comparison of SWMM5 Text Files



Now there is too Much Output

- 20+ Metrics
- Subcatchment
- Link
- Node
- System

> "Whatever universe a professor believes in must at any rate be a universe that lends itself to lengthy discourse. A universe definable in two sentences is something for which the professorial intellect has no use. No faith in anything of that cheap kind!
>
> **William James**

Bill James Model Similarity Score based on System Variables

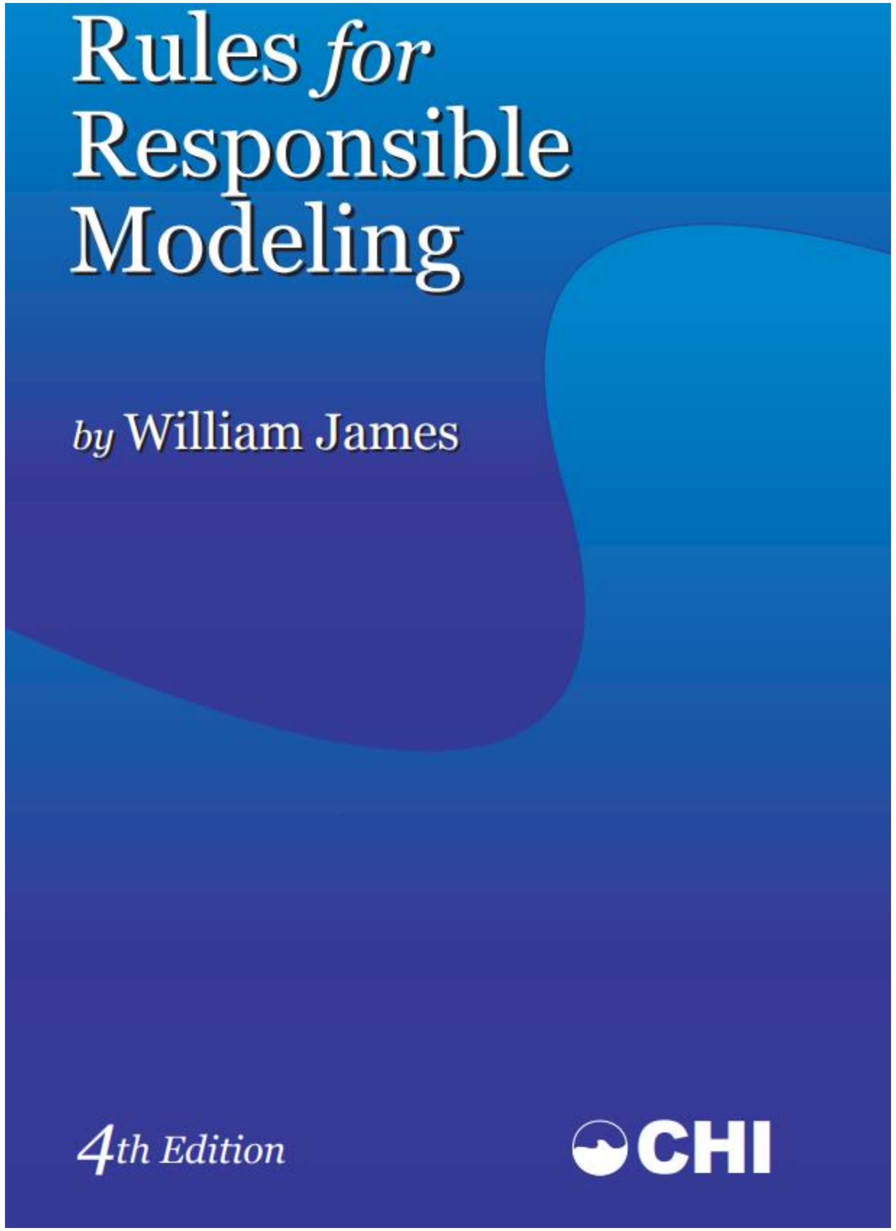
25. Baffaut (1988) sequentially ranked the objectives of her modeling effort, considering that: firstly, the runoff volumes should be correct, on the average; secondly, the peak discharges should match, on the average; thirdly, the times-to-peak should be correct on the average; and lastly, the root mean square of the hydrograph shape should match on the average. To avoid the problem of an evidently poor evaluation being computed for a relatively small error in timing, but for an otherwise good fit, the standard square error of the shape was weighted 0.7, and the volume 0.3.

The equations used are:

$$volume\ difference = \frac{1}{N}\sum\frac{V_m - V_p}{V_m}$$

$$peak\ difference = \frac{1}{N}\sum\frac{P_m - P_p}{P_m}$$

$$time\ difference = \frac{1}{N}\sum\left(T_m - T_p\right)$$



Thank You, CHI and Bill James!