USEPA's Research for the Storm Water Management Model (SWMM)

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United States Environmental Protection Agency
International Conference of Water Management Modeling

February 25, 2021

Disclaimer

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Introduction

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Worked with SWMM since 2010

EPA Point of Contact for SWMM, since 2015

Talk Outline

Introduction

Recent Changes EPA's Stormwater Management Model (SWMM)

Open-Source Community Development

Testing and Documentation

Draft Protocol for EPA Acceptance

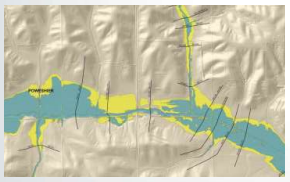
Summary

Why EPA Needs SWMM – CSO, MS4, TMDL, NPDES

Design and sizing of drainage system

Control of combined and sanitary sewer overflows

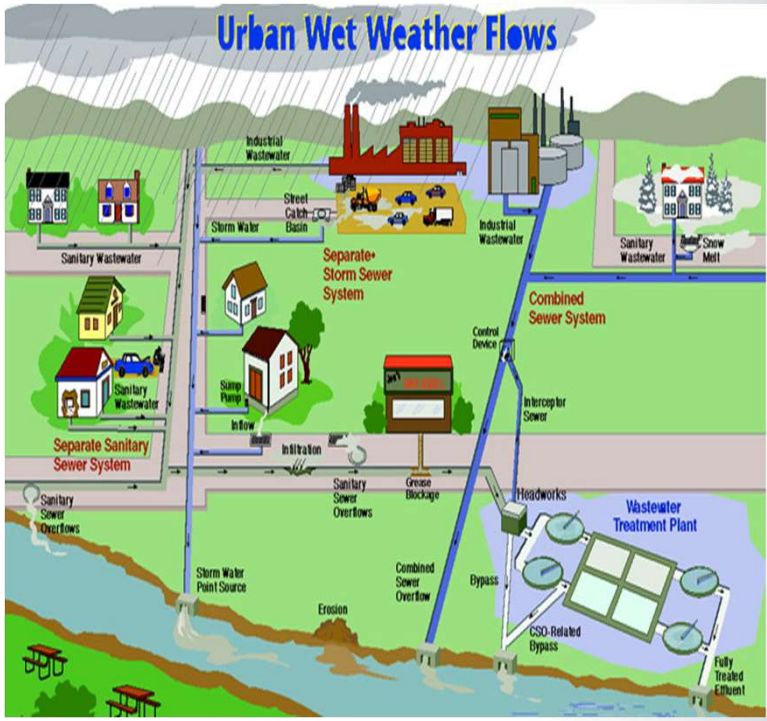
Modeling I&I in sanitary sewer systems



Generating non-point source pollutant loadings for waste load allocation studies

Evaluating green infrastructure

Flood plain mapping of natural channel systems

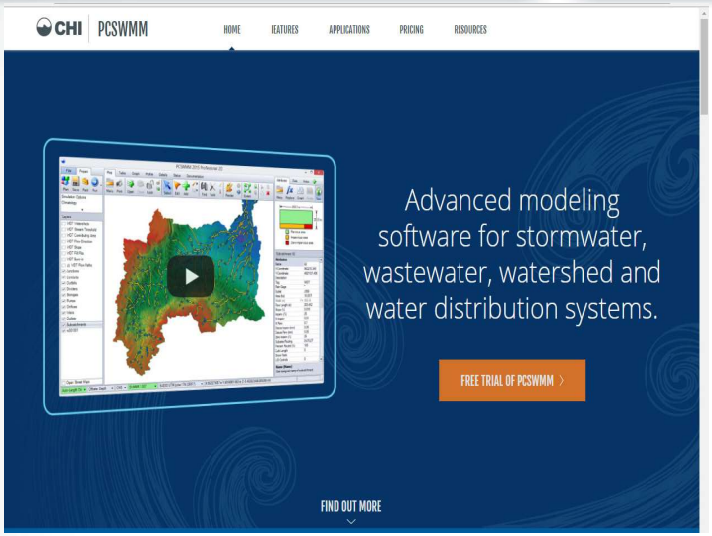


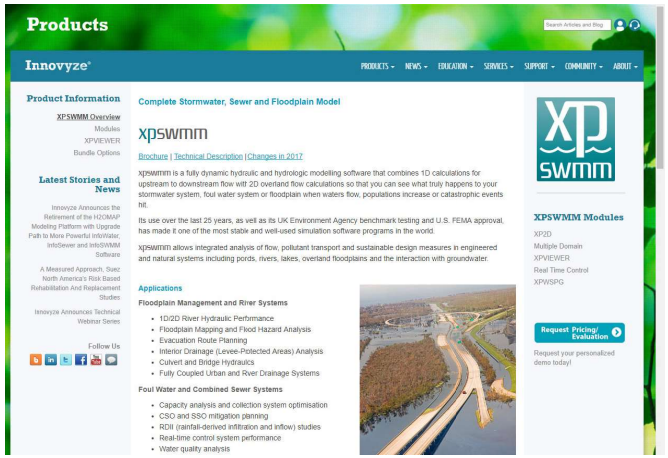
Combined Sewer Overflow Long Term Control Plans based on EPA SWMM And commercial products

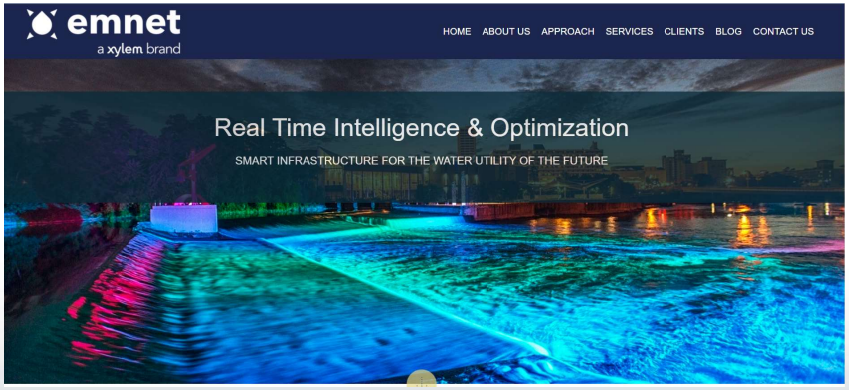
2015 Survey of 12 LTCP Cities

City	Cost, US$	Population
Cincinnati, OH	$3,200,000,000	855,000
Cleveland, OH	$3,000,000,000	1,000,000
Detroit, MI	$900,000,000	3,000,000
Kansas City, MO	$2,400,000,000	653,000
Louisville, KY	$900,000,000	693,000
Milwaukee, WI	$900,000,000	1,100,000
New York, NY	$5,300,000,000	8,400,000
Philadelphia, PA	$2,400,000,000	1,500,000
Portland, OR	$1,400,000,000	530,000
St Louis, MO	$4,700,000,000	1,400,000
Seattle, WA	$400,000,000	630,000
Washington, DC	$2,600,000,000	500,000
Totals	**$28,100,000,000**	**20,261,000**

Stakeholders - >30,000 annual downloads



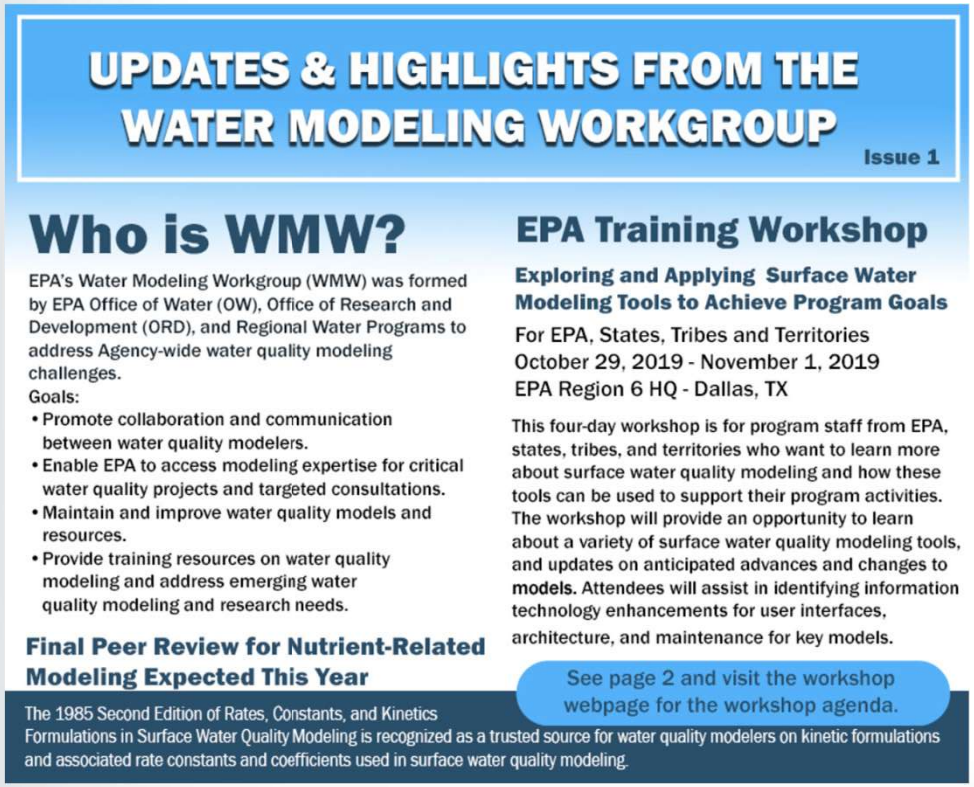




Regulators
Communities,
Utilities,
Private industry,
Consultants,
Academia

EPA Water Modeling Workgroup

https://www.epa.gov/waterdata/surface-water-quality-modeling



UPDATES & HIGHLIGHTS FROM THE WATER MODELING WORKGROUP

Issue 1

Who is WMW?

EPA's Water Modeling Workgroup (WMW) was formed by EPA Office of Water (OW), Office of Research and Development (ORD), and Regional Water Programs to address Agency-wide water quality modeling challenges.

Goals:

- Promote collaboration and communication between water quality modelers.
- Enable EPA to access modeling expertise for critical water quality projects and targeted consultations.
- Maintain and improve water quality models and resources.
- Provide training resources on water quality modeling and address emerging water quality modeling and research needs.

Final Peer Review for Nutrient-Related Modeling Expected This Year

The 1985 Second Edition of Rates, Constants, and Kinetics Formulations in Surface Water Quality Modeling is recognized as a trusted source for water quality modelers on kinetic formulations and associated rate constants and coefficients used in surface water quality modeling.

EPA Training Workshop

Exploring and Applying Surface Water Modeling Tools to Achieve Program Goals

For EPA, States, Tribes and Territories
October 29, 2019 - November 1, 2019
EPA Region 6 HQ - Dallas, TX

This four-day workshop is for program staff from EPA, states, tribes, and territories who want to learn more about surface water quality modeling and how these tools can be used to support their program activities. The workshop will provide an opportunity to learn about a variety of surface water quality modeling tools, and updates on anticipated advances and changes to models. Attendees will assist in identifying information technology enhancements for user interfaces, architecture, and maintenance for key models.

See page 2 and visit the workshop webpage for the workshop agenda.

Coordinates modeling between EPA Office of Research and Development, Office of Water, and Regions

Hosts Training and Workshops:
https://www.epa.gov/waterdata/surface-water-quality-modeling-training

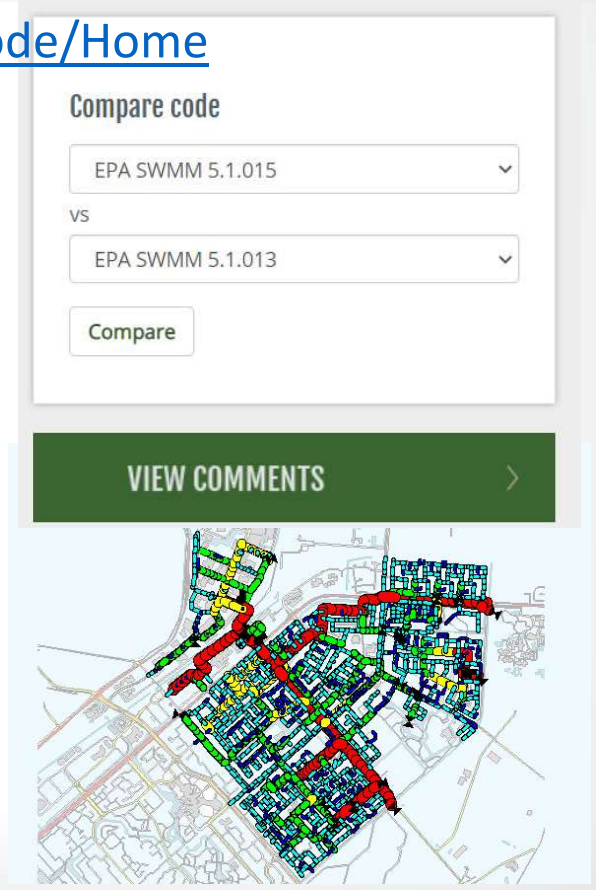
Peer Reviews Models and Data for Modeling:
Assessment of Surface Water Model Maintenance and Support Status
EPA/600/R-18/270, 2018.

https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=NHEERL&dirEntryId=342391

Recent Changes to EPA SWMM

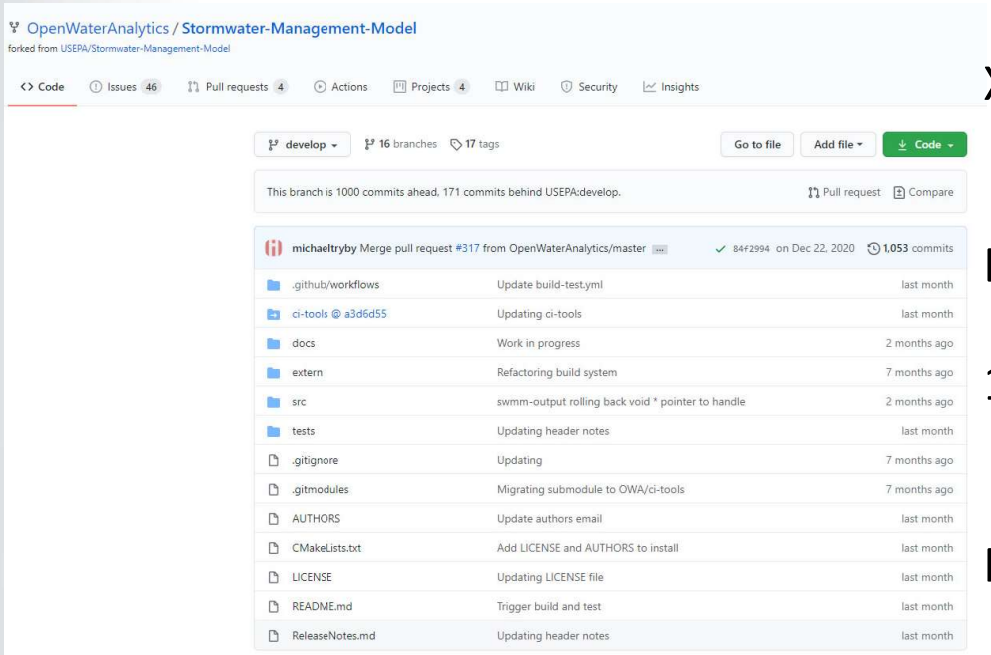
Epaswmm5_updates.txt https://www.openswmm.org/Code/Home

1. SWMM 5.1.013 – feature added - 2018
   Preissmann slot added
2. SWMM 5.1.014 – significant bug fixes - 2020
   E.g., program crashing when LIDs are present
   but no subcatchment,
   Program hanging when LID unit sent its outflow
   back onto pervious area
3. SWMM 5.1.015 – features added - 2020
   Mix of infiltration methods
   Grouped frequency table of routing steps
   Delphi 10.3



Open Source Community Development

https://github.com/OpenWaterAnalytics/Stormwater-Management-Model



Xylem's Bryant McDonnell and Jennifer Wu are OWA SWMM maintainer

Builds on US EPA SWMM Solver

17 volunteer contributors including EPA ORD personnel

First formal release this past December 2020 — OWA SWMM v5.1.13

Ratliff.Katherine@epa.gov
Tryby.michael@epa.gov

OWA SWMM ToolKit API

https://github.com/OpenWaterAnalytics/Stormwater-Management-Model

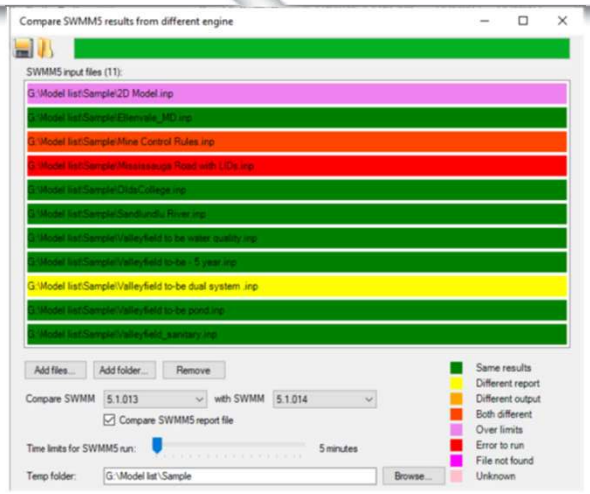
Eleven original API function calls
Plus over fifty new API functions for

- Project indexes and IDs
- Simulation options
- Model elements
- Summary statistics

OWA SWMM v5.1.13

Tryby.michael@epa.gov,
Ratliff.Katherine@epa.gov

Code Testing



GitHub Actions

- Unit Testing
- Regression Testing

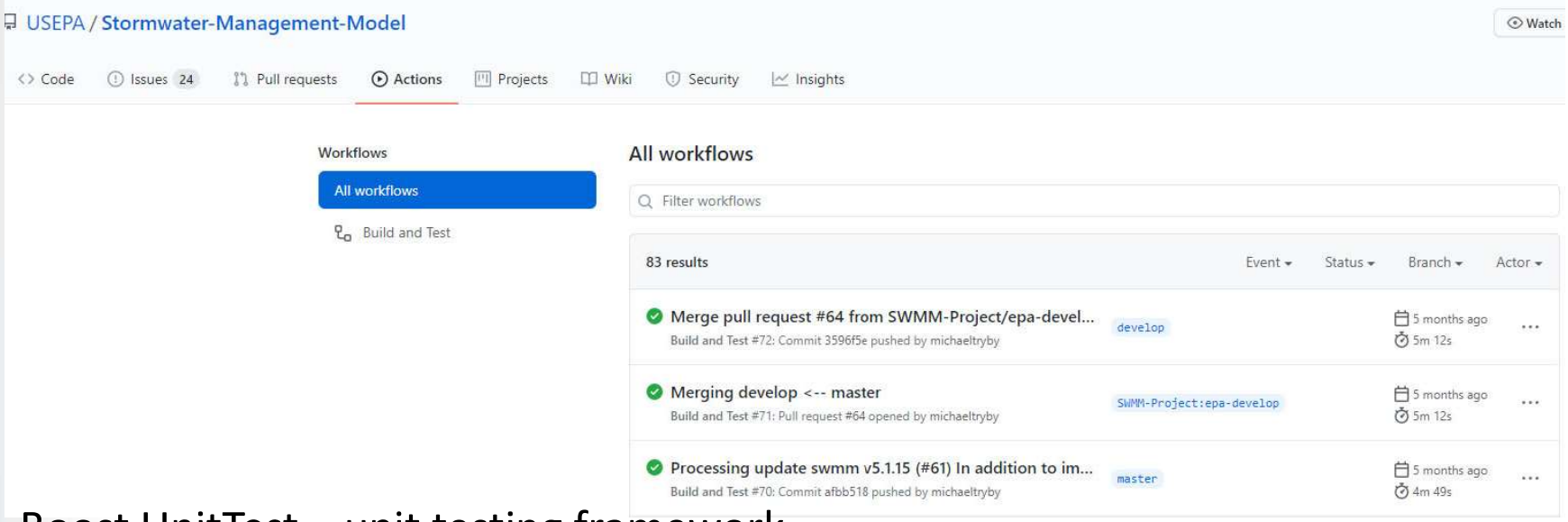
EPA Internal Testing

CHI Water Testing

Metamorphic Testing

EPA GitHub Actions

https://github.com/USEPA/Stormwater-Management-Model/actions



Boost UnitTest – unit testing framework
CTest – unit test runner
Nrtest – numerical regression testing framework
CI - Tools – custom build and test workflow scripting
GitHub Actions – CI build/test workflow

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CHI Testing

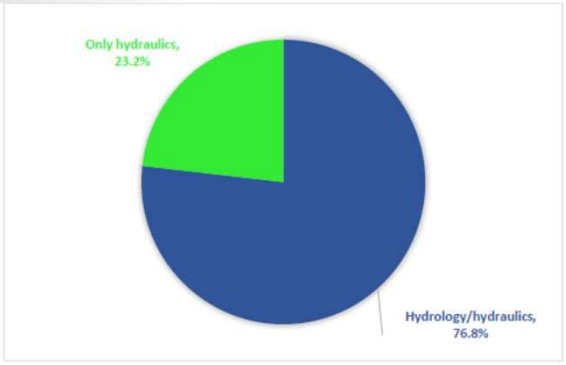
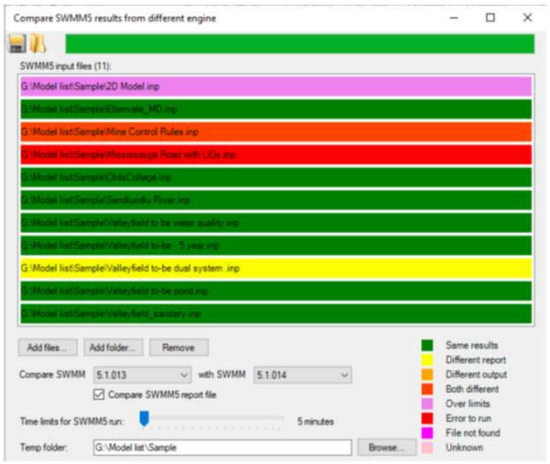


Figure 3: Distribution of SWMM models based on hydrology/hydraulics



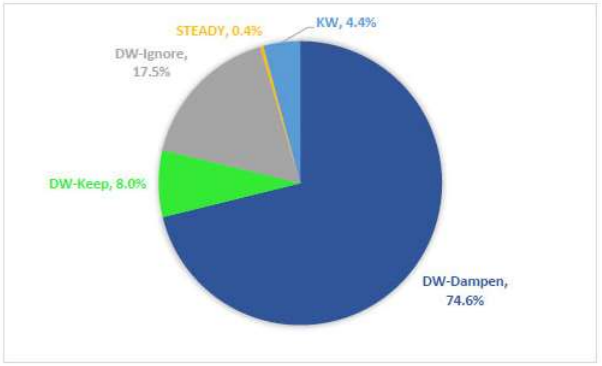


Figure 5: Distribution of SWMM models based on routing method used

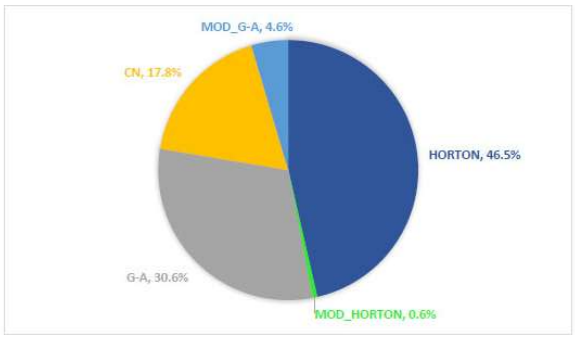


Figure 4: Distribution of SWMM models based on infiltration method used in subcatchments

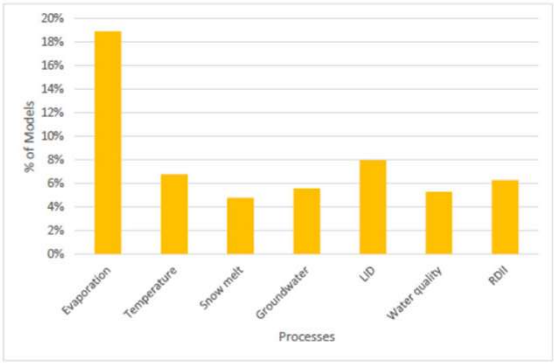


Figure 6: Variety of processes simulated

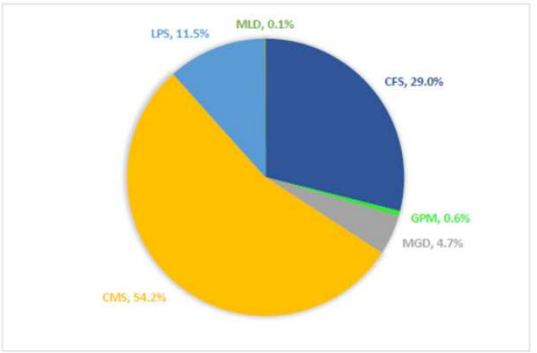


Figure 2: Distribution of SWMM models based on flow units

University of CINCINNATI

Discovering Metamorphic Relations from OpenSWMM

Xuanyi Lin[1] (*linx7@mail.uc.edu*), Michelle Simon[2],
Zedong Peng[1], Nan Niu[1]

UNIVERSITY OF Cincinnati | *Department of* Electrical Engineering & Computer Science

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY | *Water Infrastructure Division*

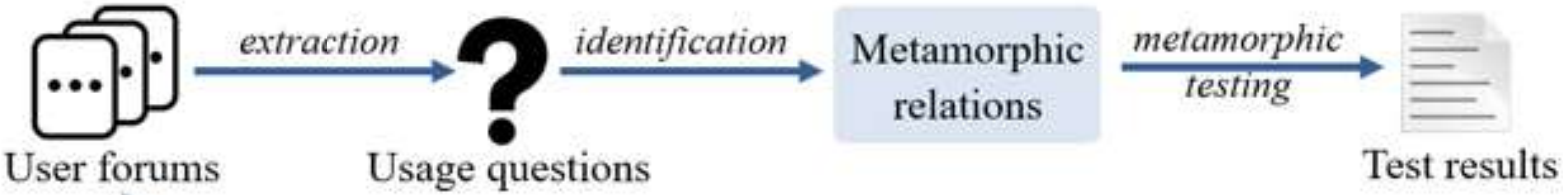
February 25, 2020

Inferring Metamorphic Relations

University of CINCINNATI

User forum analysis

- Use the user forums as sources and explore the identification of metamorphic relations from them.



OPEN SWMM

- 25 years
- 1,818 contributors
- 15,919 posts

2018

https://catalog.data.gov/dataset/this-excel-sheet-contains-1344-issues-from-2018-posted-to-the-openswmm-list-serv

Metamorphic Relation Results

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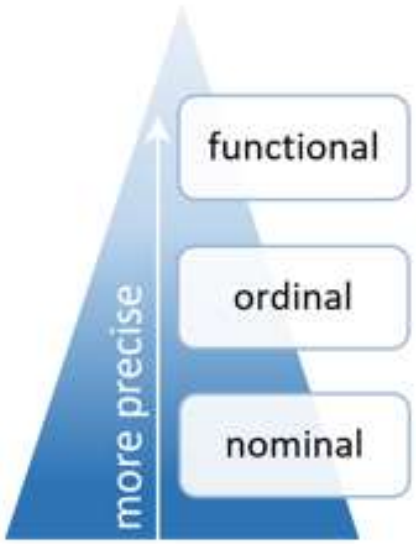
The forums where end users post questions and exchange concerns are valuable sources to discover metamorphic relations.

MR	EXPLANATION
MR_{weir}	apply different weir types at runtime and check for the quantitative prediction
MR_{ditch}	increase inflow and check for outflow
$MR_{iteration}$	increase simulation iterations and check for reduced continuity error
MR_{date}	adjust the date format in the input data and check for errors at runtime
MR_{file}	change the format type of input data file and check for errors at runtime
MR_{flow}	select different flow routing methods and check if the output varies



References for UC-EPA Work

Zedong Peng, Xuanyi. Lin, Michelle Simon, and Nan Niu. (2021). "Unit and Regression Tests of Scientific Software: A Study on SWMM?" invited paper submitted to a special issue of *Journal of Computational Science*

Xuanyi. Lin, Michelle Simon, and Nan Niu. (2021). "Scientific Software Testing Goes Serverless: Creating and Invoking Metamorphic Functions." submitted to a special issue of *IEEE Software*

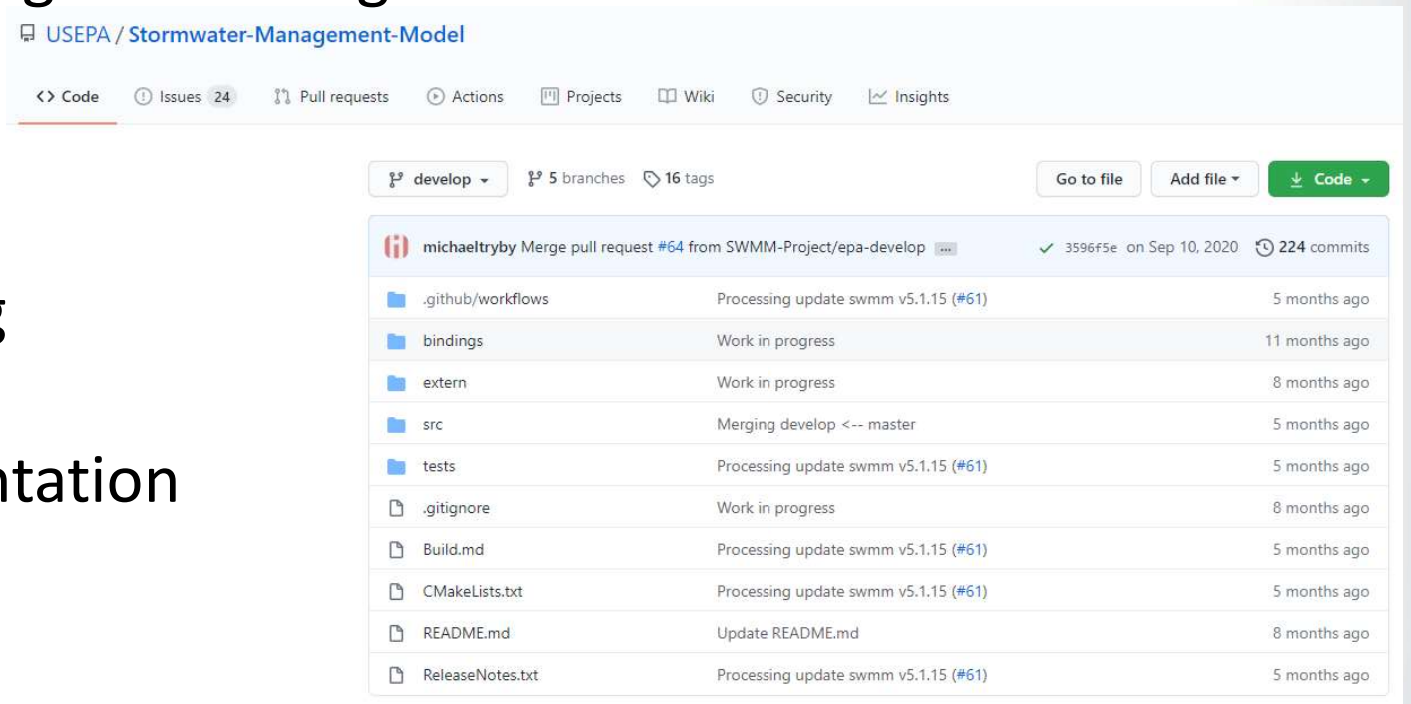
Xuanyi. Lin, **Michelle Simon**, Zedong Peng, and Nan Niu. (2021). "Discovering Metamorphic Relations for Scientific Software from User Forums." *Computing in Science and Engineering*

Xuanyi Lin, Michelle Simon, Nan Niu (2018). "Hierarchical Metamorphic Relations for Testing Scientific Software." *Journal of the ACM,* 1(1) Article 1.

Xuanyi Lin, Michelle Simon, Nan Niu (2018). "Exploratory Metamorphic Testing for Scientific Software." *Computing in Science and Engineering*. DOI: 10.1109/MCSE.2018.2880577

EPA's *Draft* Protocol for Acceptance of code from the Open Source Community

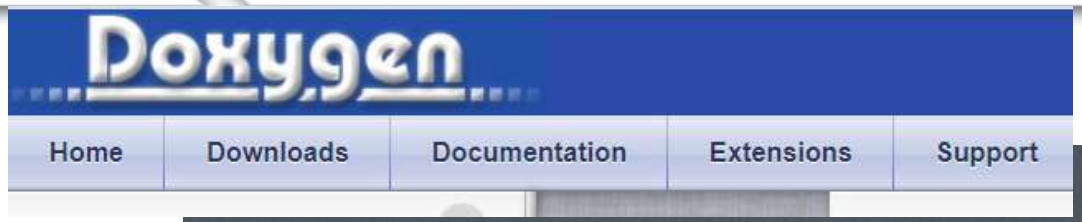
1. Developer debugging and testing
2. GitHub Actions
3. EPA and CHI Testing
4. Adequate Documentation



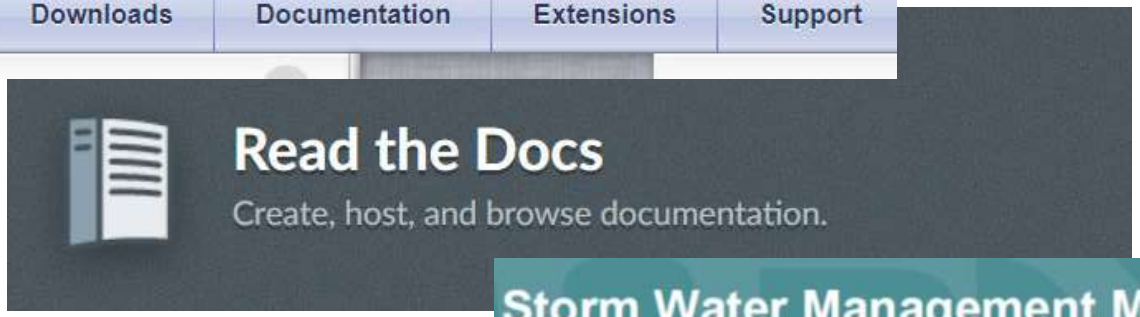
https://www.epa.gov/water-research/storm-water-management-model-swmm

Documentation

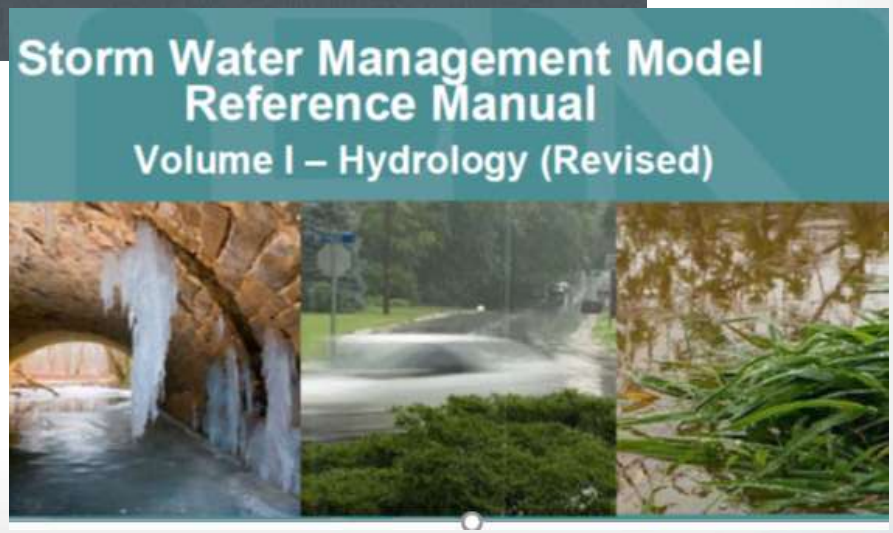
Doxygen



Read the docs



User Manuals and
Reference Manuals



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EPA – Curator of SWMM Code

Contribute to improving scientific underpinnings of SWMM

Work with Stakeholder community

Assist where possible with testing and ground-truthing of SWMM's numerical models and other software

Publish an Official Version of SWMM

https://www.epa.gov/water-research/storm-water-management-model-swmm

Thank-you

https://github.com/USEPA/Stormwater-Management-Model

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https://www.epa.gov/water-research/storm-water-management-model-swmm