Navigating Clean Waters: ALCOSAN's Modeling Journey

2025 ICWMM Conference, Toronto
March 5-7, 2025

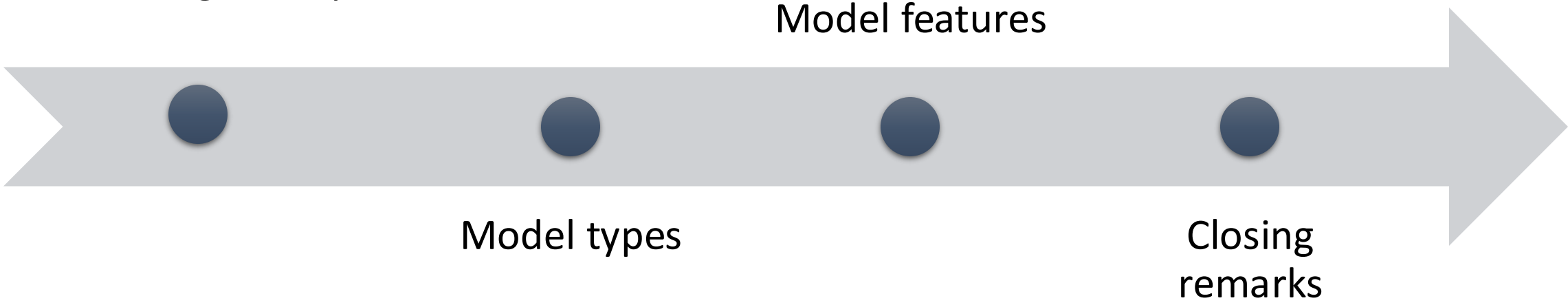
Sam Shamsi, PhD, PE: H&H Analyst, ALCOSAN

PRESENTER

- B.Sc. Civil Engineering, AMU, India, 1982
- M.Sc. Water Resources Engineering, AIT, Thailand, 1984
- Ph.D. Civil Engineering, University of Pittsburgh, USA, 1988
- Private sector to government sector (2018)
- Over 100 papers + 4 books

  2023 book: Search GIS Shamsi on Amazon
- Licensed Professional Engineer: PA, OH, WV, GA
- Interests: golf, fishing, kites, cricket, GIS, modeling
- **27th** paper in this conference

TODAY'S JOURNEY



WHY MODEL?

1

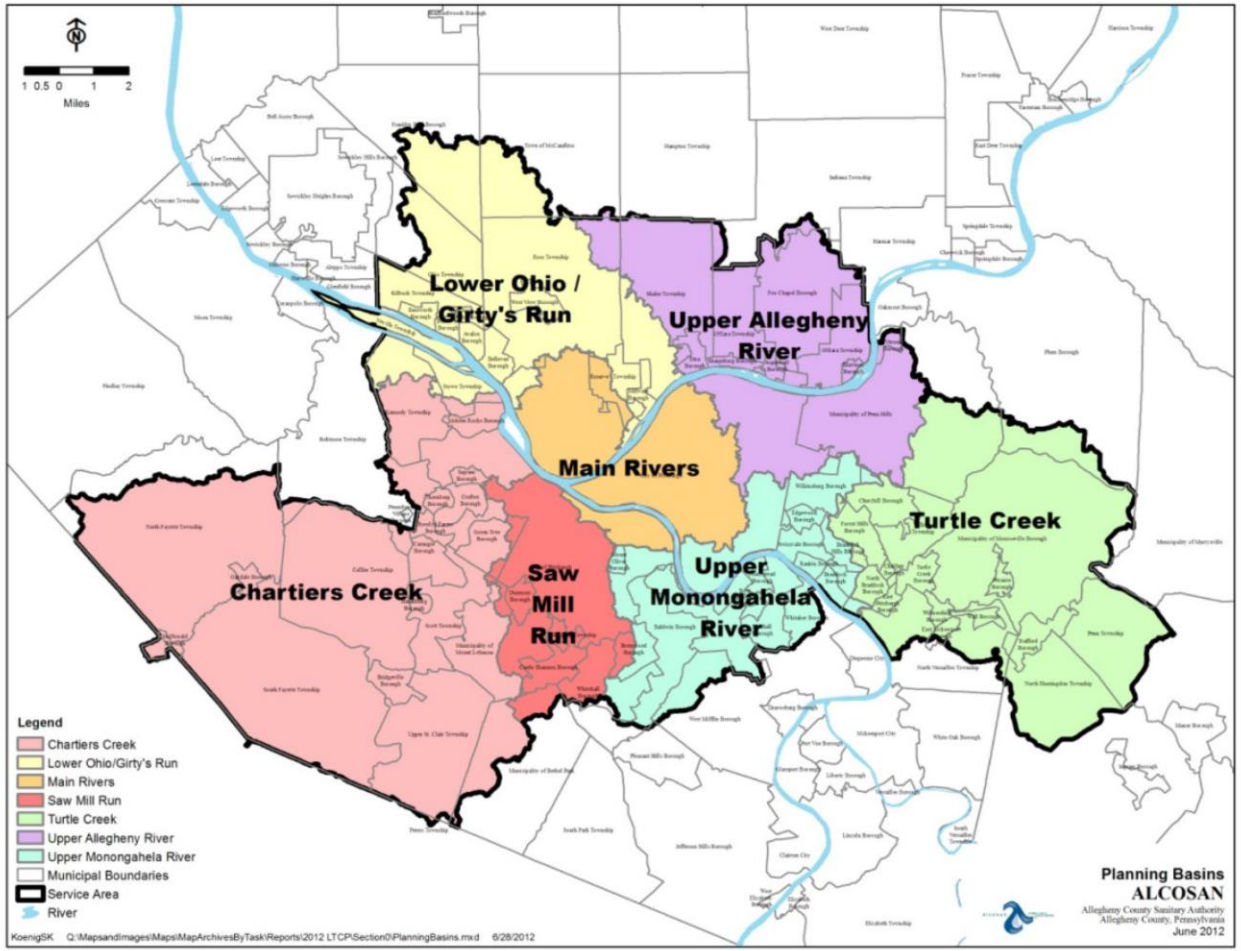
ALCOSAN is implementing a Clean Water Plan (CWP) mandated by a USEPA Consent Decree (2008 modified 2020).

2

Compliance with the Consent Decree is partly based upon ***a model-based solution to a model-based problem.***

ALCOSAN MODELS

- 7 planning basins
  - •Main Rivers (MR) (Pittsburgh /PWSA, **8% by area, 20% by population (2020)**
  - •Chartiers Creek (CC), **30%, 20% (largest by area and pop)**
  - •Lower Ohio / Girty's Run (LOGR), 14%, 12%
  - •Saw Mill Run (SMR), 6%, 12%, smallest area
  - •Turtle Creek (TC), 18%, 10%, smallest pop
  - •Upper Allegheny (UA), 14%, 13%
  - •Upper Monongahela (UM), 10%, 13%
- 83 municipalities
- 90 mi interceptor (+30/175 mi regionalized trunk sewers > 255)
- 298 overflows (250 CSO)
- 310 SM service area
- 20% combined
- ≈ 800K customers



ALCOSAN's Modeling Journey Through Time 1991-2024

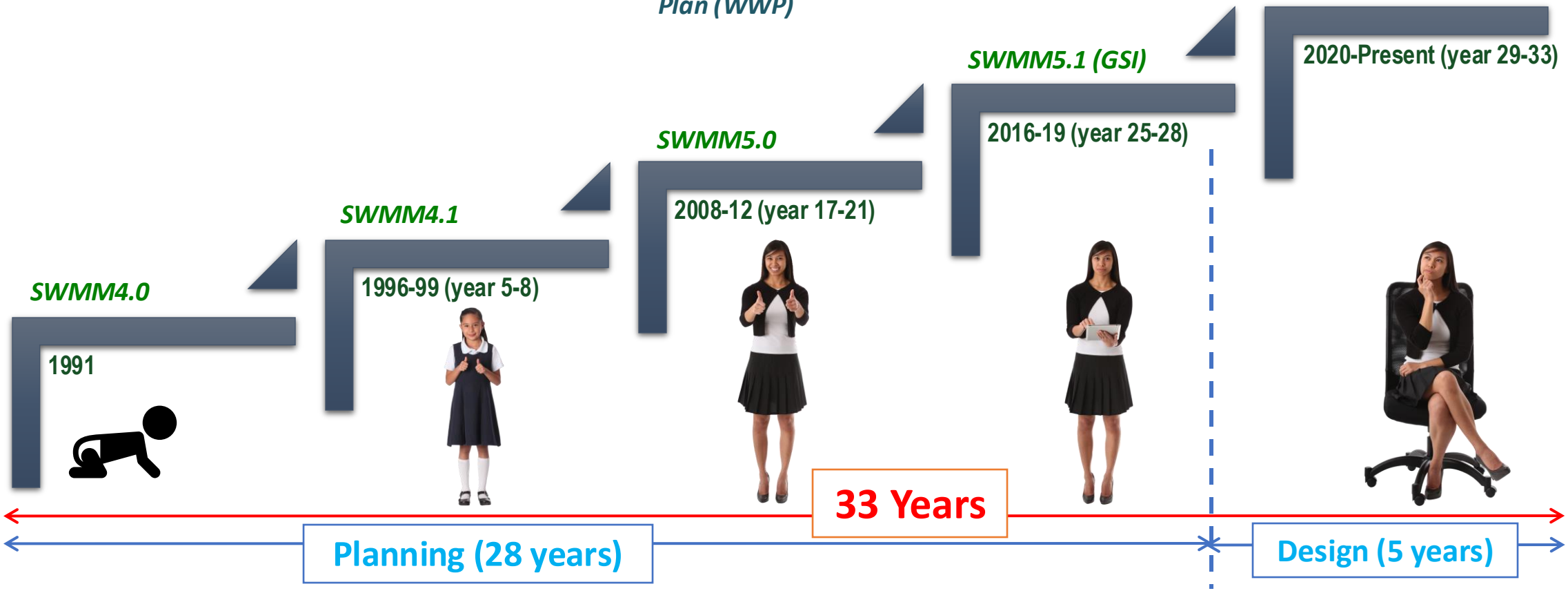
1st SWMM Model, Chartiers Creek Basin

1996: H&H Characterization report
1999: LTCP

2008: Consent Decree
2008: Regional Flow Monitoring at 550 sites
2010: Basin Planning (BP) models and model sharing with munis.
2011: WQ model
2012: Wet Weather Plan (WWP)

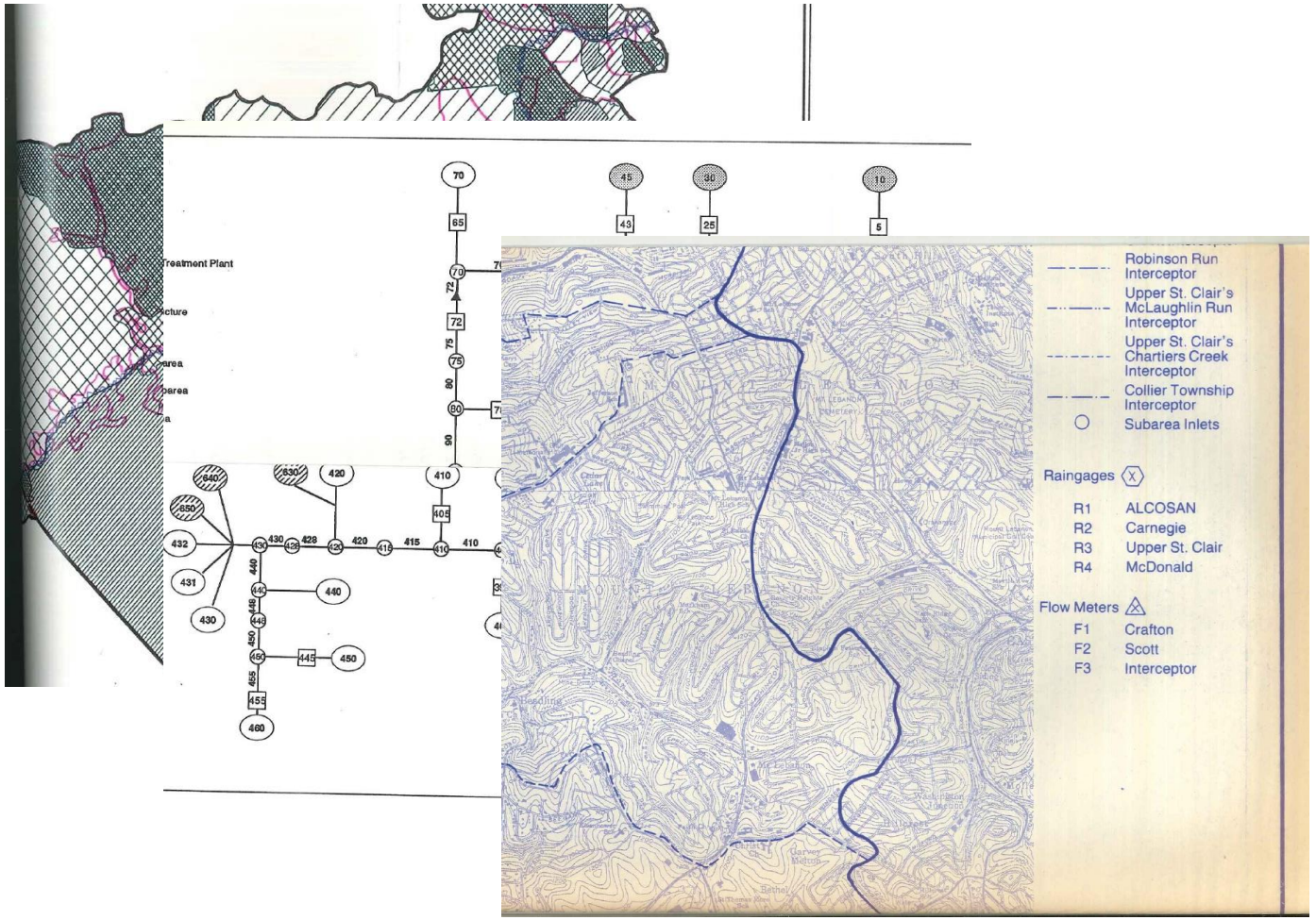
2016: Systemwide and GROW models
2019: Clean Water Plan (CWP)
2019: Tunnel planning

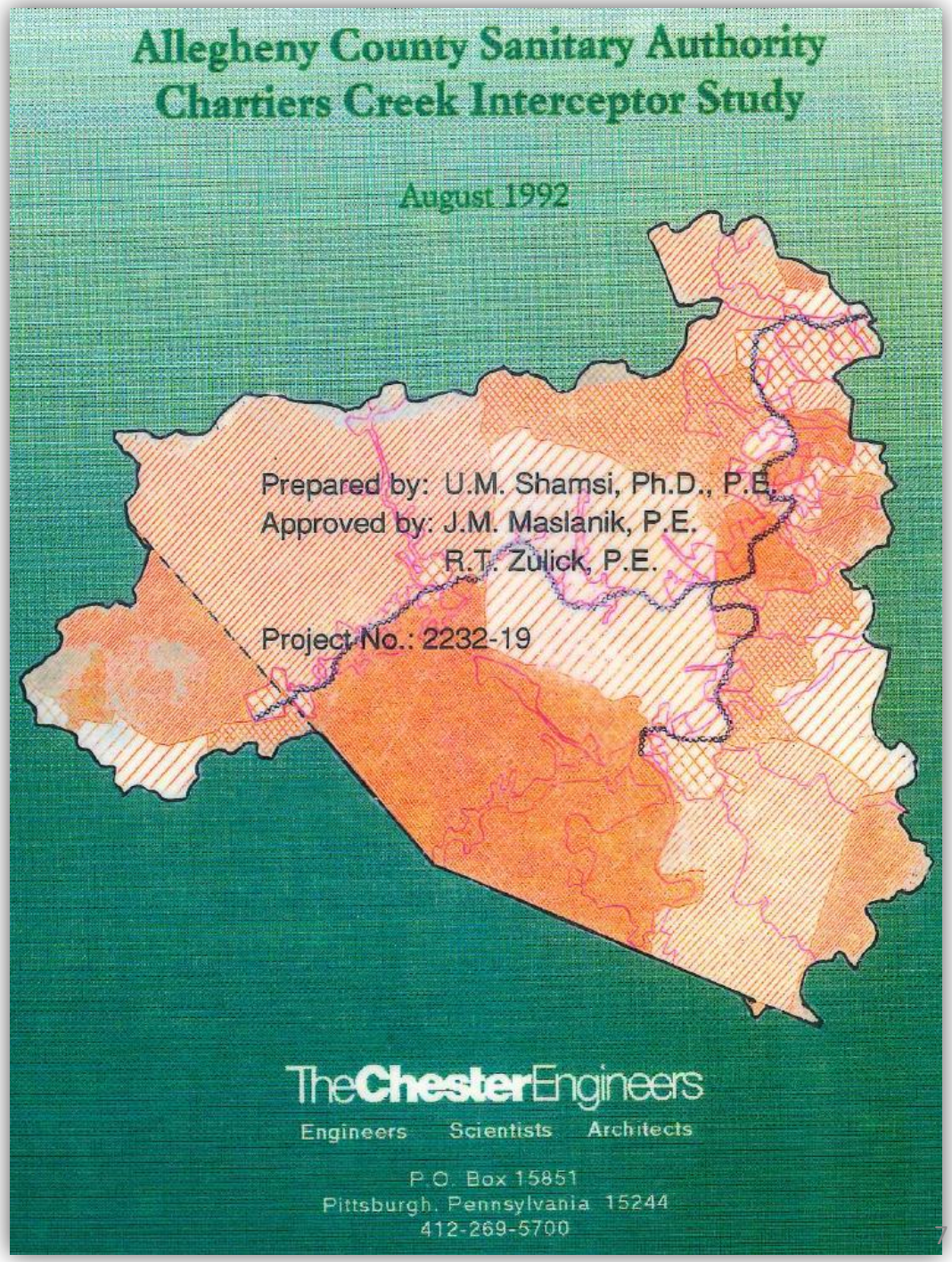
2020: Modified Consent Decree
2020: Annual Updates
2021: Tunnel design
2022: Model sharing with munis for Phase II Consent Orders
2022: Updated systemwide WQ model
2023-24: model enhancements



1991 CC BASIN MODEL

- Used GIS data to estimate population / flow
- EPA SWMM4 software





INPUT: SWMM4 vs. SWMM5 vs. PCSWMM

SWMM4: text file (like HEC-1)

EXAM1.DAT - Notepad

File Edit Format Help

```
*   E.G.,
*   ISOL KSUPER
*B0  2    1
*   A LARGER TIME STEP IS USUALLY POSSIBLE USING ISOL = 1 OR 2, E.G.,
*    NTCYC DELT  TZERO NSTART INTER JNTER REDO
*B1  192   150.0  0.0    1     100   100    0
*
*   HERE, CONTINUE THE EXTRAN INPUT SHOWN IN TABLE 3-1 OF USER'S MANUAL.
*
*    NTCYC   DELT  TZERO NSTART INTER JNTER REDO
B1    1440   20.0  0.0    45    45     45    0
*    METRIC NEQUAL  AMEN ITMAX SURTOL
B2       0      0     0.0    30   0.05
* NHPRT NQPRT NPLT LPLT NJSW
B3    6    6     6    6    3
*    PRINT HEADS
B4   80608 16009 16109 15009 82309 80408
*    PRINT FLOWS
B5   1030 1630 1600 1602 1570 8130
*    PLOT HEADS
B4   80608 16009 16109 15009 82309 80408
*    PLOT FLOWS
B7   1030 1630 1600 1602 1570 8130
*    CONDUIT DATA
*    NCOND NJ1  NJ2   QO  NKLASS AFULL DEEP WIDE LEN   Z
C1   8040 80408 80608 0.0 1       0.0  4.0  0.0 1800.  C
C1   8060 80608 82309 0.0 1       0.0  4.0  0.0 2075.  C
C1   8100 81009 81309 0.0 1       0.0  4.5  0.0 5100.  C
C1   8130 81309 15009 0.0 1       0.0  4.5  0.0 3500.  C
C1   1030 10309 10208 0.0 6       0.0  9.0  0.0 4500.  C
C1   1570 15009 16009 0.0 1       0.0  5.5  0.0 5000.  C
C1   1600 16009 16109 0.0 1       0.0  6.0  0.0  500.  C
```

SWMM5: text file w/ tabular data (like EPANET)

Example1.inp - Notepad

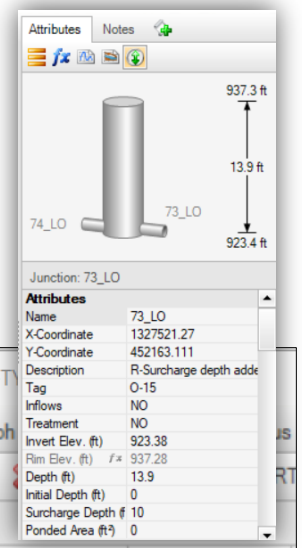
File Edit Format Help

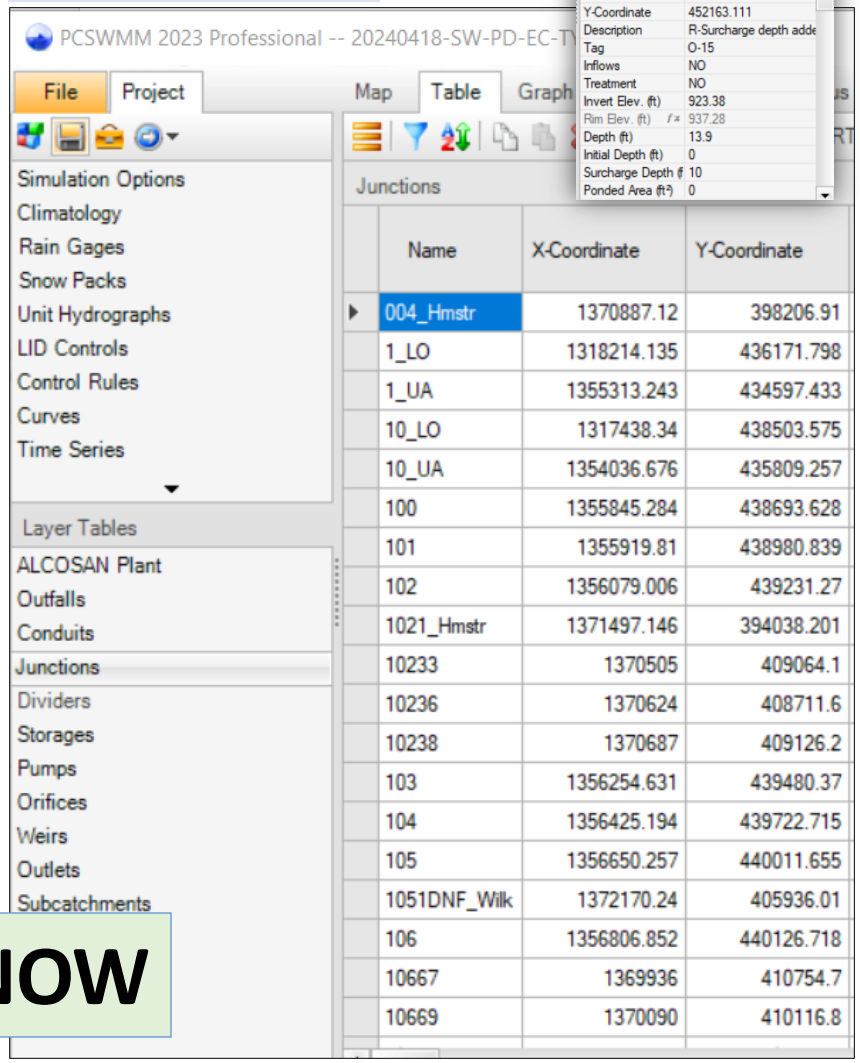
```
[JUNCTIONS]
;Name           Invert      Max.       Init.      Surcharge  Ponded
;              Elev.       Depth      Depth      Depth      Area
;-------------------------------------------------------------------
 9              1000        3          0          0          0
 10             995         3          0          0          0
 13             995         3          0          0          0
 14             990         3          0          0          0
 15             987         3          0          0          0
 16             985         3          0          0          0
 17             980         3          0          0          0
 18             975         3          0          0          0
 19             1010        3          0          0          0
 20             1005        3          0          0          0
 21             990         3          0          0          0
 22             987         3          0          0          0
 23             990         3          0          0          0
 24             984         3          0          0          0

[CONDUITS]
;              Inlet       Outlet                 Manning    Inlet      Outlet     Init
;Name          Node        Node       Length      N          Height     Height     Flow
;-------------------------------------------------------------------------------------
 1              9           10         400         0.01       0          0          0
 4              19          20         200         0.01       0          0          0
 5              20          21         200         0.01       0          0          0
 6              10          21         400         0.01       0          1          0
 7              21          22         300         0.01       1          1          0
 8              22          16         300         0.01       0          0          0
 10             17          18         400         0.01       0          0          0
 11             13          14         400         0.01       0          0          0
 12             14          15         400         0.01       0          0          0
 13             15          16         400         0.01       0          0          0
 14             23          24         400         0.01       0          0          0
 15             16          24         100         0.01       0          0          0
 16             24          17         400         0.01       0          0          0

[XSECTIONS]
;Link           Type        Geom1      Geom2      Geom3      Geom4
;-------------------------------------------------------------------
 1              CIRCULAR    1.5        0          0          0
 4              CIRCULAR    1          0          0          0
 5              CIRCULAR    1          0          0          0
 6              CIRCULAR    1          0          0          0
 7              CIRCULAR    2          0          0          0
 8              CIRCULAR    2          0          0          0
 10             CIRCULAR    2          0          0          0
```

PCSWMM: database





1991 ⟫ **2010** ⟫ **NOW**

OUTPUT: SWMM4 vs. SWMM5 vs. PCSWMM

SWMM4: text output

```
************************************
*    INITIAL MODEL CONDITION       *
* INITIAL TIME =      0.00 HOURS   *
************************************

JUNCTION / DEPTH  / ELEVATION    ===>  "*" JUNCTION IS SURCHARGED.
    30001/   0.00 /   802.00     30002/   0.00 /   801.00     30003/   0.00 /   800.50
    30004/   0.00 /   802.50     30005/   0.00 /   801.50     30007/   0.00 /   803.00
    30006/   0.00 /   800.00     30081/   1.50 /   800.50     30082/   1.50 /   799.50
    30083/   2.00 /   798.00

  CONDUIT/       FLOW   ===> "*" CONDUIT USES THE NORMAL FLOW OPTION.
    10001/       0.00      10002/       0.00      10003/       0.00      10004/       0.00
    10005/       0.00      10007/       0.00      10006/       0.00      10081/      20.00
    10082/      20.00      90010/       0.00

  CONDUIT/   VELOCITY
    10001/       0.00      10002/       0.00      10003/       0.00      10004/       0.00
    10005/       0.00      10007/       0.00      10006/       0.00      10081/       0.41
    10082/       0.69

  CONDUIT/ CROSS SECTIONAL AREA
    10001/       0.00      10002/       0.00      10003/       0.00      10004/       0.00
    10005/       0.00      10007/       0.00      10006/       6.28      10081/      48.98
    10082/      29.13

  CONDUIT/ HYDRAULIC RADIUS
    10001/       0.00      10002/       0.00      10003/       0.00      10004/       0.00
    10005/       0.00      10007/       0.00      10006/       0.57      10081/       0.97
    10082/       0.86

  CONDUIT/ UPSTREAM/ DOWNSTREAM ELEVATION
    10001/   801.00/   801.00     10002/   800.50/   800.50     10003/   800.00/   800.00
    10004/   801.50/   801.50     10005/   800.00/   800.00     10007/   800.00/   800.00
    10006/   800.00/   800.50     10081/   800.50/   799.50     10082/   799.50/   798.00

# # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # #
===> System inflows (data group K3) at     0.00 hours ( Junction / Inflow,cfs )

     30001/ 0.00E+00      30004/ 0.00E+00      30007/ 0.00E+00
# # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # #
===> System inflows (data group K3) at     1.00 hours ( Junction / Inflow,cfs )

     30001/ 0.00E+00      30004/ 0.00E+00      30007/ 0.00E+00
# # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # #
# # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # #
===> System inflows (data group K3) at     1.50 hours ( Junction / Inflow,cfs )
```

SWMM5: tabular output

Table - Link 1602

Days	Hours	Flow (CFS)
0	00:15:00	5.59
0	00:30:00	42.46
0	00:45:00	70.17
0	01:00:00	70.27
0	01:15:00	70.31
0	01:30:00	70.35
0	01:45:00	70.36
0	02:00:00	70.36
0	02:15:00	70.36
0	02:30:00	70.35
0	02:45:00	70.35
0	03:00:00	70.33
0	03:15:00	50.30
0	03:30:00	36.09
0	03:45:00	21.16
0	04:00:00	11.92
0	04:15:00	6.12
0	04:30:00	3.36
0	04:45:00	2.03
0	05:00:00	1.37
0	05:15:00	0.97
0	05:30:00	0.71
0	05:45:00	0.54
0	06:00:00	0.44
0	06:15:00	0.38

PCSWMM: database

Map | Table | Graph | Profile | Details | Status | Documentation | Scripts

Menu | Filter | Sort | Paste | Copy | Delete | Select | Flash | Replace | Render | SRTC

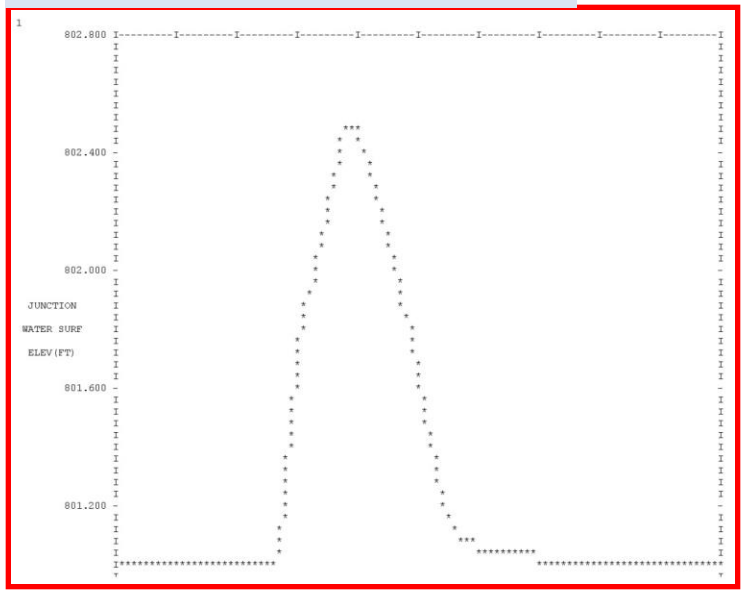
Conduits

Name	Max. |Flow| (mgd)	Time Max. Flow (M/D/Y)	Max. |Velocity| (ft/s)	Max/Full Flow	Max/Full Depth
004_HmstrA	16.902	07/18/2003 16:47 PM	10.19	1.31	0.76
004_HmstrB	1.306	07/18/2003 16:47 PM	2.99	6.17	0.8
1_LO	12.49	11/19/2003 13:52 PM	6.15	1.38	1
1_UA	8.085	12/10/2003 23:12 PM	6.62	0.99	0.74
10_LO	12.59	11/19/2003 14:06 PM	8.06	0.85	1
10_UA	7.728	12/10/2003 22:17 PM	7.5	1.05	1
100	8.676	12/11/2003 00:23 AM	4.58	0.98	1
101	8.715	06/12/2003 18:59 PM	4.56	2.07	1
102	8.697	06/12/2003 18:59 PM	4.28	0.93	1
1021_Hmstr	13.006	11/19/2003 11:31 AM	7.16	2.44	0.84
10233	16.234	08/29/2003 21:19 PM	20.47	1.31	1
10236	4.614	08/07/2003 17:00 PM	15.67	0.35	0.4
10238	71.715	08/07/2003 17:00 PM	15.31	0.35	0.7
103	8.672	12/11/2003 00:25 AM	5.79	0.67	1
104	8.703	06/12/2003 19:07 PM	5	1.75	1
105	8.695	06/12/2003 19:08 PM	4.28	1.1	1
1051DNF_Wilk	12.745	07/04/2003 19:10 PM	11.1	0.2	0.65
106	7.86	06/12/2003 19:09 PM	4.02	1.07	1
10667	120.737	08/07/2003 17:00 PM	16.75	0.48	0.55
10669	179.156	08/07/2003 17:00 PM	20.69	0.7	0.65
10678	141.445	08/07/2003 17:00 PM	15.79	0.31	0.37
10679	52.266	06/20/2003 19:13 PM	14.1	1.12	1
10680	51.559	06/20/2003 20:24 PM	13.43	1.11	1
10682	60.765	08/07/2003 17:00 PM	16.71	1.04	1

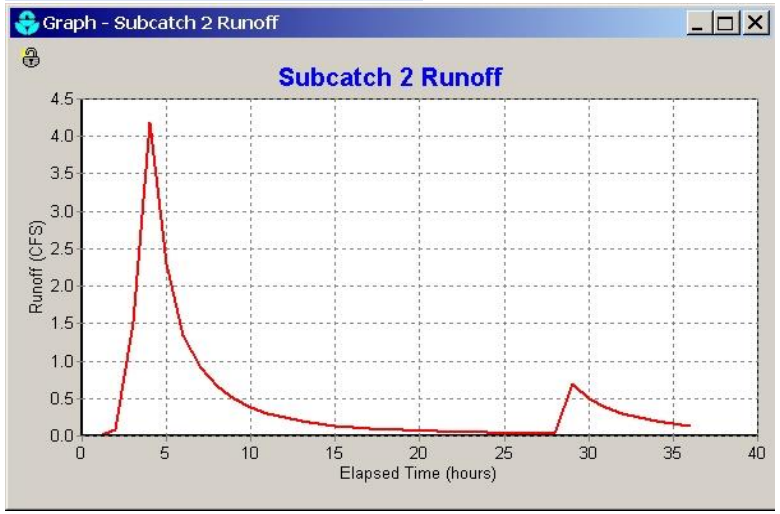
1991 ⟫ **2010** ⟫ **NOW**

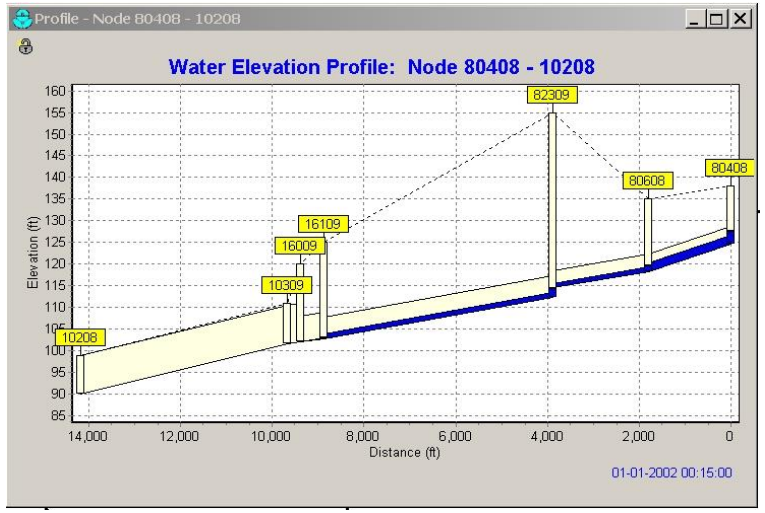
GRAPHS: SWMM4 vs. SWMM5 vs. PCSWMM

SWMM4: dot matrix graphs

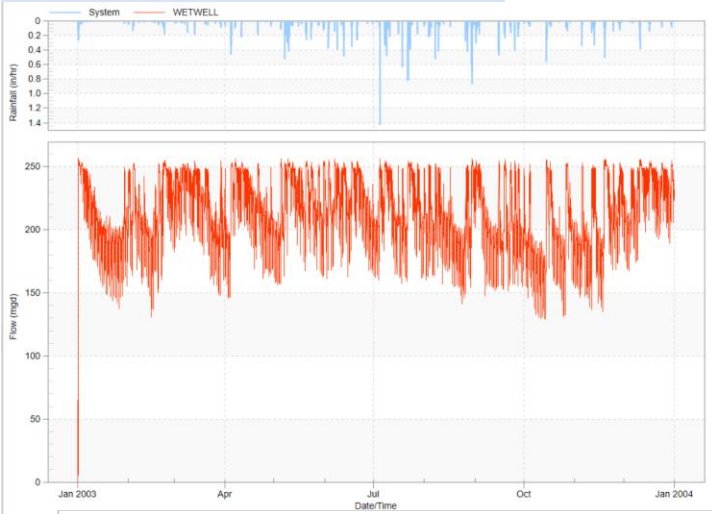


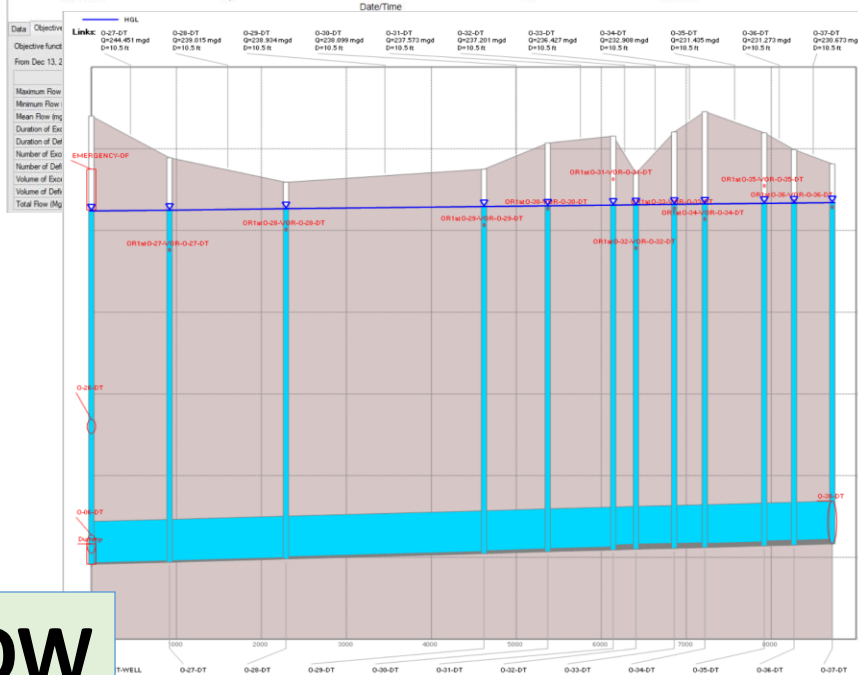
SWMM5: charts





PCSWMM: charts (enhanced)

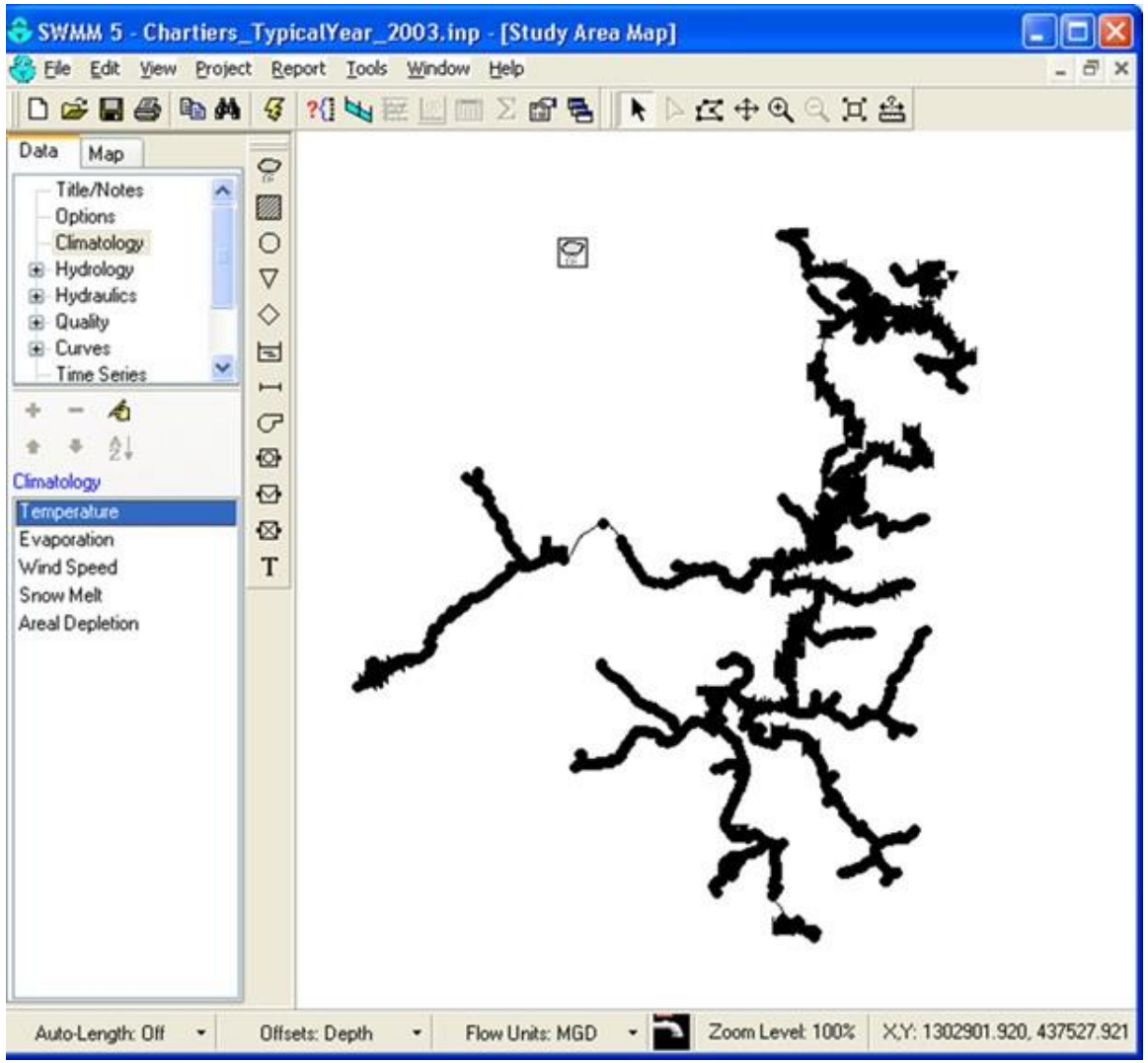




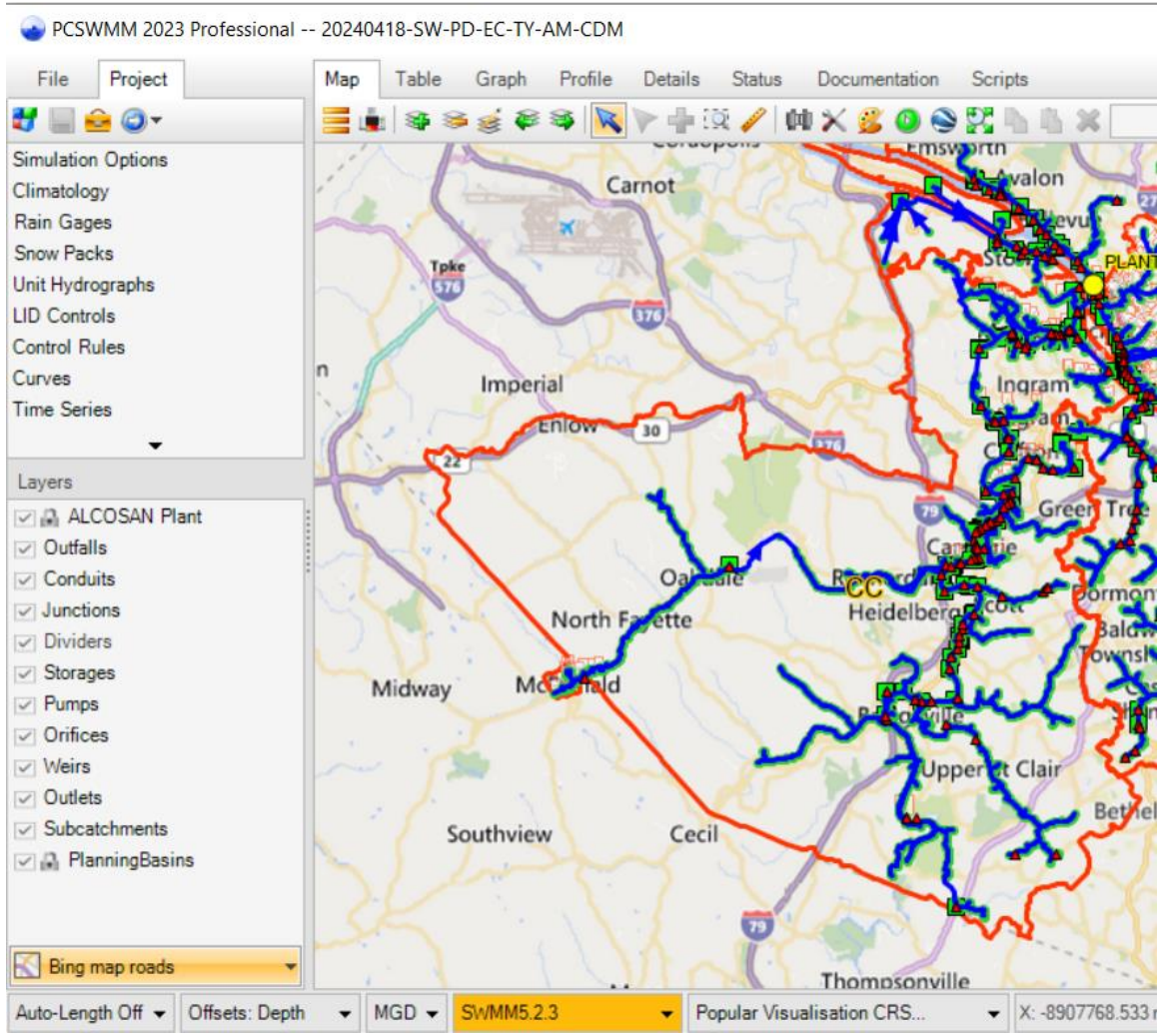
1991 ⟫ **2010** ⟫ **NOW**

MAPS: SWMM5 vs. PCSWMM

SWMM5: no base maps (2010 chartiers creek bp model on DVD)

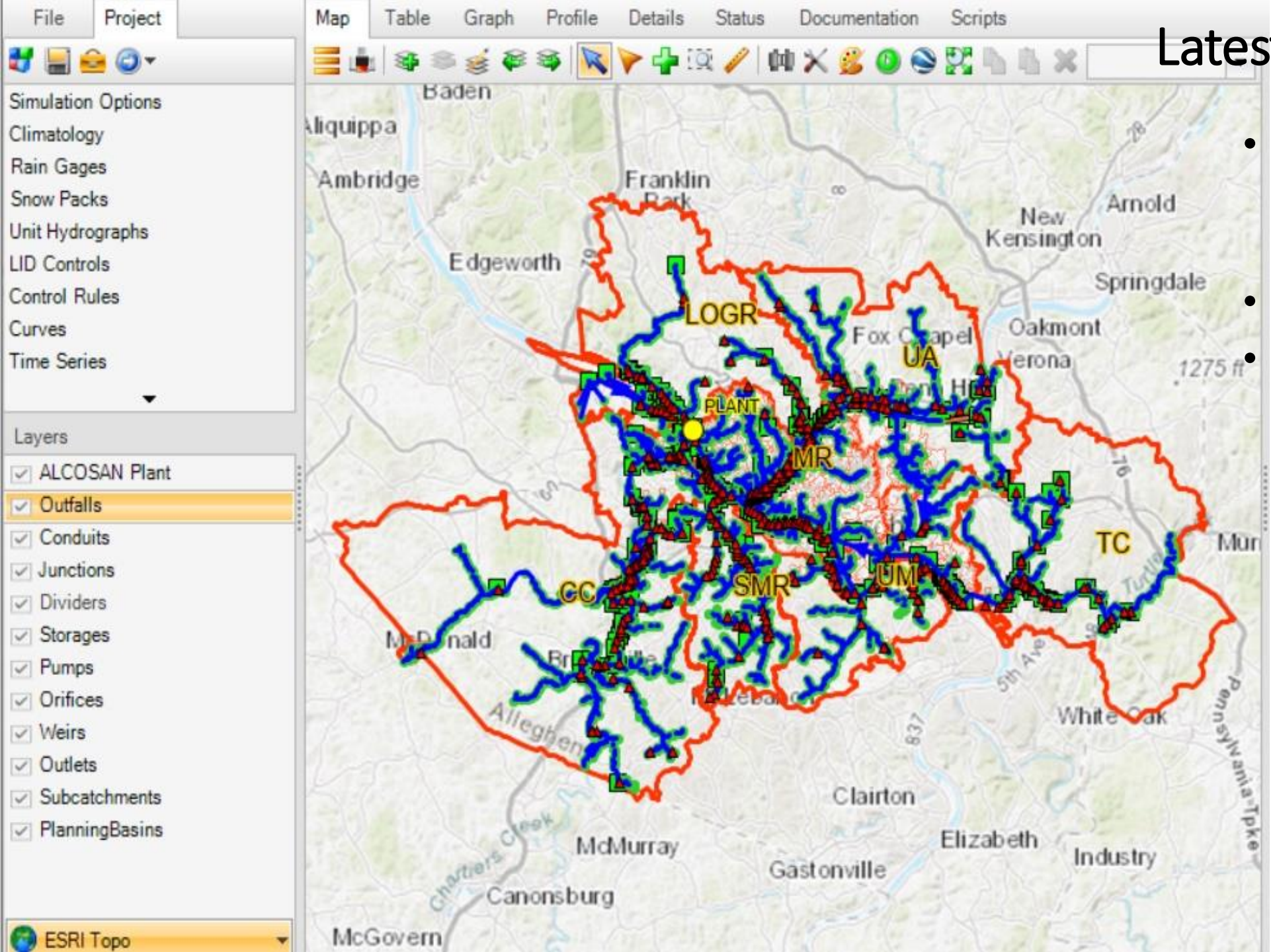


PCSWMM: GIS layers and base maps



2010 ⟫ **NOW**

Latest Model Highlights



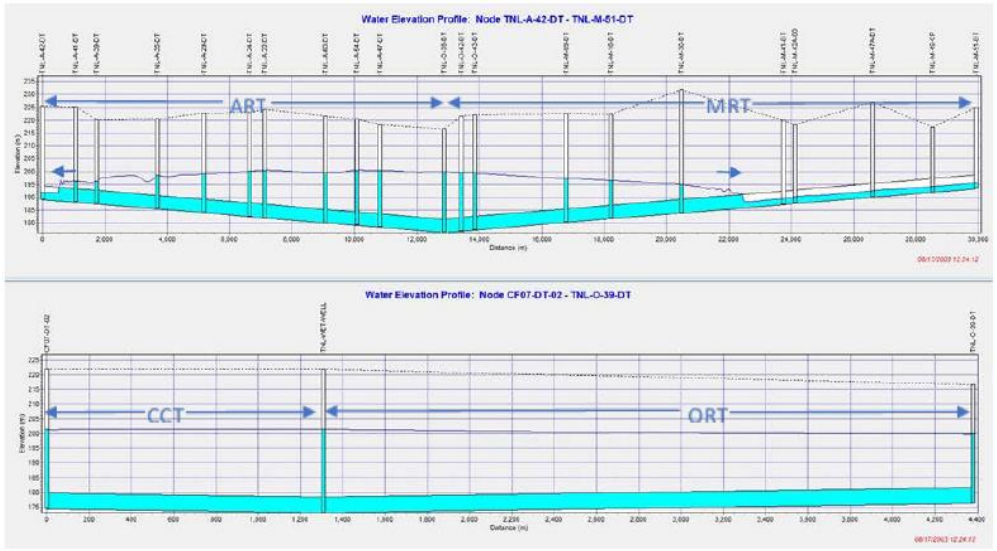
- One systemwide model for 7 planning basins
- PCSWMM software
- Existing Conditions model (EC-2024)
  - Nodes: 9,519
  - Conduits: 9,665
  - Subcatchments: 3,822
  - Storage nodes (actual): 15
  - Outfall nodes: 458
  - Rain gages: 107
  - RDII inflows: 1,313
  - Pumps: 55
  - Orifice links: 747
  - Weir links: 346
  - Control rules: 384
  - Time series (inflow): 1525
  - ***Run time: 35 hr (2019) >> 15:51 hr (2024)***

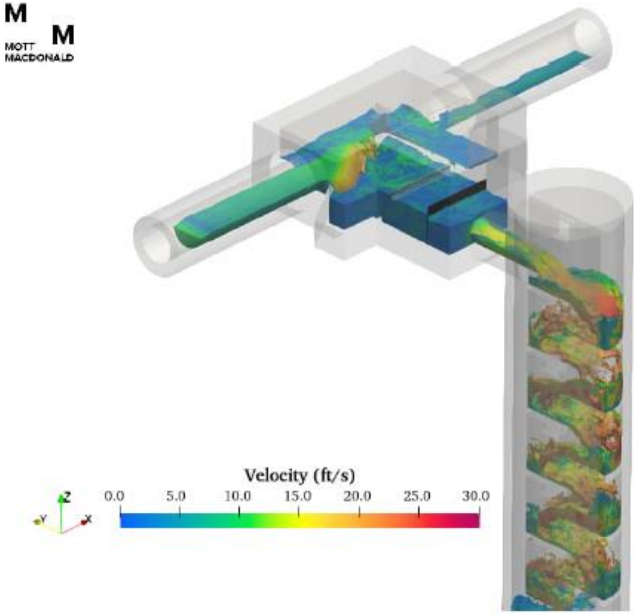
MODEL TYPES

1. Typical Year
2. Design Storms (2, 5, 10-year)
3. Scenarios
    1. EC – Existing Conditions
    2. FC – Future Conditions
    3. IP – Interim Plan
    4. SP – Selected Plan
    5. DMR – Discharge Monitoring Report
4. WQ (EPA EFDC) Environmental Fluid Dynamics Code
5. Transient/surge (ITM & SHAFT)
6. CFD models (Flow-3D Hydro)
7. Physical (lab) models

SURGE MODELING > ILLINOIS TRANSIENT MODEL (ITM)

Figure 4-25: Surge Propagation for 18' Diameter Tunnel (5-Year Design Event, Selected Plan, 5th Largest TY Peak Rates for Select ART Locations)





MODEL INVENTORY (2024)

CO2 reduction ≈ 8 tons

- Since: 1991
- Years: 33
- Total models ≈ 1700
- Size ≈ 3.9 TB / 10 TB (not on cloud)
- Files ≈ 83,000

Our models are NOT on the cloud!

CO2 reduction ≈ 8 tons

The larger the cloud file size, the higher the carbon footprint due to the increased energy needed for storage & data transfer in data centers.

Storing 100 gigabytes in the cloud
≈ 0.2 ton of CO2 carbon footprint
≈ emissions from burning 224 pounds of coal
≈ 7 kilowatt-hours of electricity
≈ 4% of annual electricity usage at home

Saving large files in cloud takes a million times more energy than saving to hard drive.

Ref: CMU Study, 2017 and Google AI, Oct 28, 2024.

Environmentally Conscious Model Sharing

CO2 reduction = 3,280 lbs

Eliminated over 500 CDs by sharing models online

- Production of 1 CD produces approx. 0.176 kg of CO2 (espressiveaudio.com)
- ***88 kg (194 pounds) of CO2 reduction***
- Eliminated landfill disposal of 500 CDs

Reduced file size

- ***Approach reduced file size from 830GB to 112GB***
- ***1,400 kg (3,086 pounds) of CO2 reduction*** (per CMU Study).

MAJOR ACCOMPLISHMENTS SINCE 2019

Dedicated network server
10 TB
M-Drive (M for Models)

Modeling Guidance document
120 pages + 700-page appendix
Updated Annually

Helps municipalities.

Typical year model run time reduced
From 35 hours (2019) to 15 hours (2024)

Helps municipalities.

Un-editable 3 GB inflow file (the Beast) replaced by smaller editable Excel files

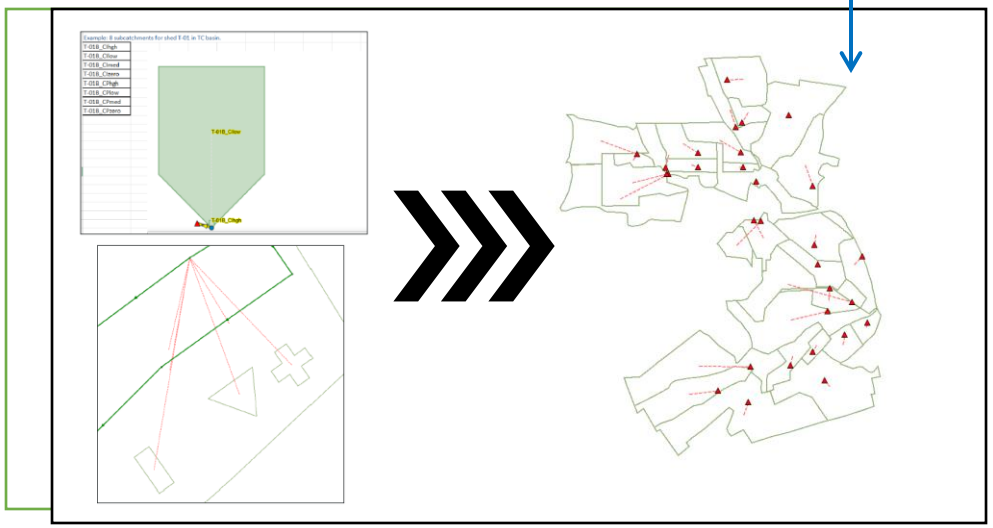
Helps municipalities and the environment!

Underway

Sync with Asset Management / GIS database

Replace rectangular subcatchments with their actual shapes

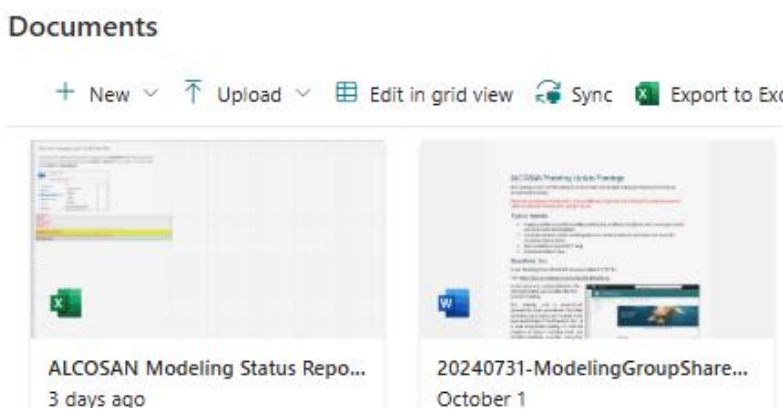
Will help municipalities.

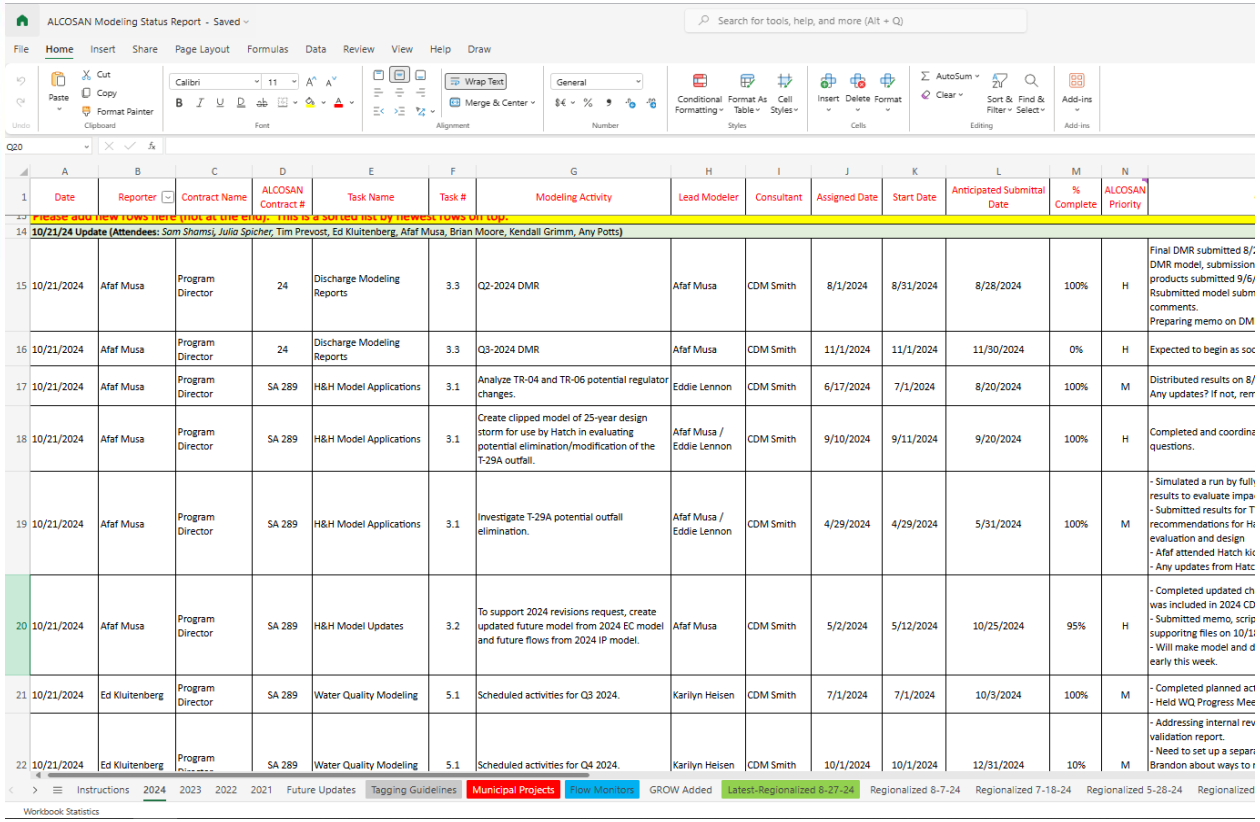


COLLABORATIVE MODELING TEAM

One collaborative modeling community.

Sam Shamsi, PhD, PE, H&H Analyst, ALCOSAN





	Date	Reporter	Contract Name	ALCOSAN Contract #	Task Name	Task #	Modeling Activity	Lead Modeler	Consultant	Assigned Date	Start Date	Anticipated Submittal Date	% Complete	ALCOSAN Priority	
15	10/21/2024	Afaf Musa	Program Director	24	Discharge Modeling Reports	3.3	Q2-2024 DMR	Afaf Musa	CDM Smith	8/1/2024	8/31/2024	8/28/2024	100%	H	Final DMR submitted 8/ DMR model, submission products submitted 9/6/ Rsubmitted model subm comments. Preparing memo on DM
16	10/21/2024	Afaf Musa	Program Director	24	Discharge Modeling Reports	3.3	Q3-2024 DMR	Afaf Musa	CDM Smith	11/1/2024	11/1/2024	11/30/2024	0%	H	Expected to begin as soc
17	10/21/2024	Afaf Musa	Program Director	SA 289	H&H Model Applications	3.1	Analyze TR-04 and TR-06 potential regulator changes.	Eddie Lennon	CDM Smith	6/17/2024	7/1/2024	8/20/2024	100%	M	Distributed results on 8/ Any updates? If not, rem
18	10/21/2024	Afaf Musa	Program Director	SA 289	H&H Model Applications	3.1	Create clipped model of 25-year design storm for use by Hatch in evaluating potential elimination/modification of the T-29A outfall.	Afaf Musa / Eddie Lennon	CDM Smith	9/10/2024	9/11/2024	9/20/2024	100%	H	Completed and coordina questions.
19	10/21/2024	Afaf Musa	Program Director	SA 289	H&H Model Applications	3.1	Investigate T-29A potential outfall elimination.	Afaf Musa / Eddie Lennon	CDM Smith	4/29/2024	4/29/2024	5/31/2024	100%	M	- Simulated a run by full results to evaluate impa - Submitted results for T recommendations for Ha evaluation and design - Afaf attended Hatch kic - Any updates from Hatc
20	10/21/2024	Afaf Musa	Program Director	SA 289	H&H Model Updates	3.2	To support 2024 revisions request, create updated future model from 2024 EC model and future flows from 2024 IP model.	Afaf Musa	CDM Smith	5/2/2024	5/12/2024	10/25/2024	95%	H	- Completed updated ch was included in 2024 CD - Submitted memo, scrip supporitng files on 10/1 - Will make model and d early this week.
21	10/21/2024	Ed Kluitenberg	Program Director	SA 289	Water Quality Modeling	5.1	Scheduled activities for Q3 2024.	Karilyn Heisen	CDM Smith	7/1/2024	7/1/2024	10/3/2024	100%	M	- Completed planned act - Held WQ Progress Mee
22	10/21/2024	Ed Kluitenberg	Program	SA 289	Water Quality Modeling	5.1	Scheduled activities for Q4 2024.	Karilyn Heisen	CDM Smith	10/1/2024	10/1/2024	12/31/2024	10%	M	- Addressing internal rev validation report. - Need to set up a separ Brandon about ways to r

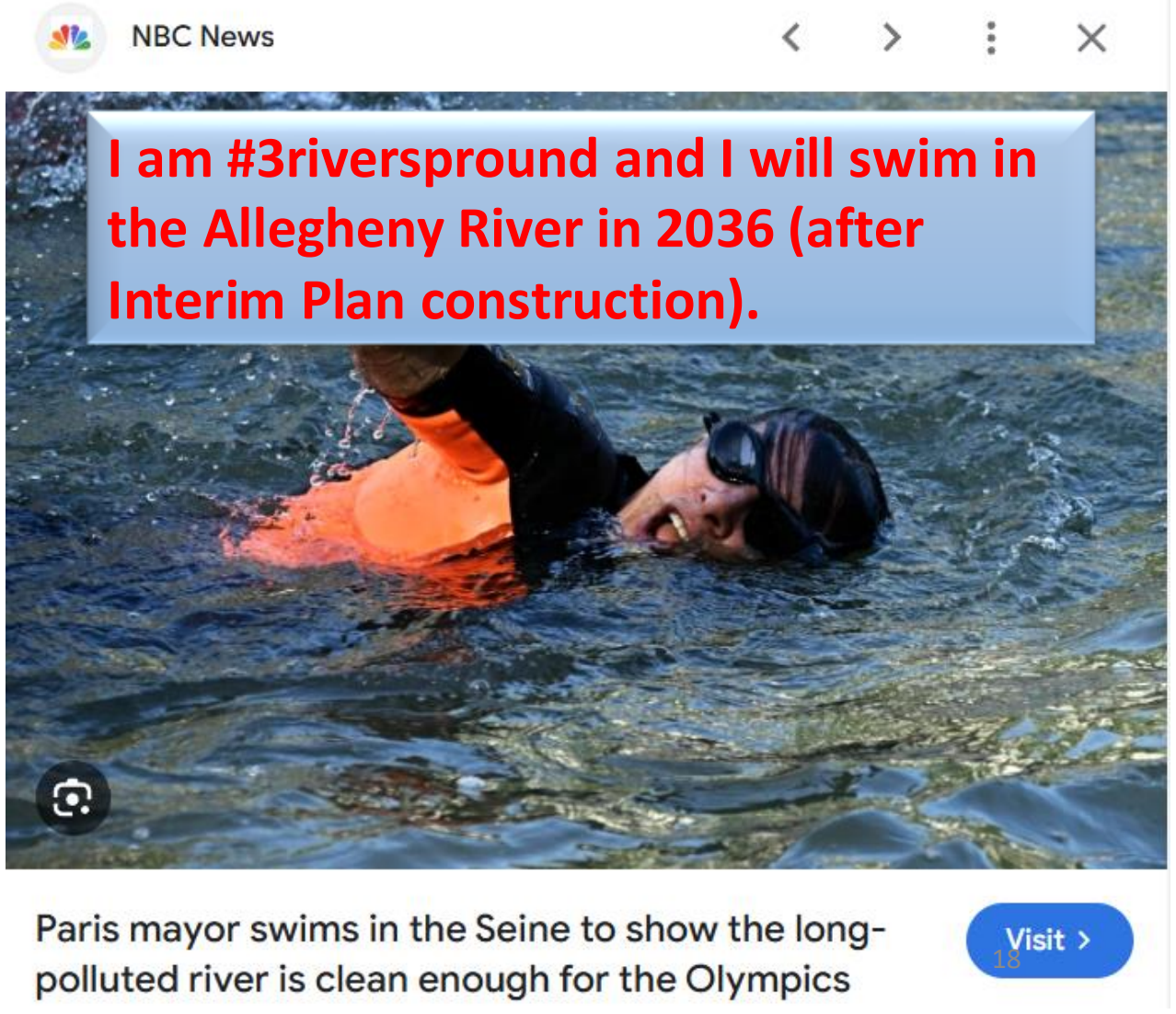
CONCLUSIONS

- ALCOSAN models are efficient engineering tools for facility design and demonstrating regulatory compliance.
  - Updated regularly
  - Municipal friendly
  - ***Environmentally conscious***
- CWP projects will improve WQ and provide enhanced recreational use experience for Pittsburgh residents and visitors.

3 RIVERS PROUD

#alcosan
#3riversproud
#samshamsi

July 17, 2024: Paris Mayor Anne Hidalgo swims in Seine River to demonstrate **safe water quality** for Olympic swimmers. How? $1.5 billion wet weather project including sewer and treatment plant improvements and a 13 MG underground equalization basin.



Acknowledgements

- Arletta Scott Williams, Executive Director, ALCOSAN
- Mike Lichte, Director of Regional Conveyance, ALCOSAN
- Tim Prevost, Manager of Wet Weather Programs, ALCOSAN
- Julia Spicher, Manager of Regionalization, ALCOSAN
- Dave Montz, Executive Director, 3RWW
- PM Team, 3RWW
- Modeling Team
  - CDM Smith: Ed Kluitenberg, Afaf Musa, Colleen Hughes, Karilyn Heisen, Mark Loehlein, Mitch Heineman
  - Wade Trim: Brad Boddy, Brian Moore, Craig Robinson
  - Jacobs: Andy Potts, Suibing Liu
  - R2O: Kendall Grimm
  - Former: Khalid Khan, Amanda Sourbeer

Thank You!
Cannot wait to answer your questions after the session!