CE-QUAL-W2 and ResSim Integration

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W2 vs ResSim

- CE-QUAL-W2: 2D water quality and hydrodynamic model for rivers, reservoirs, lakes, estuaries [WES: ERDC]
- RESSIM: Reservoir simulation for real-time support of water management and multi-objective planning studies [HEC]

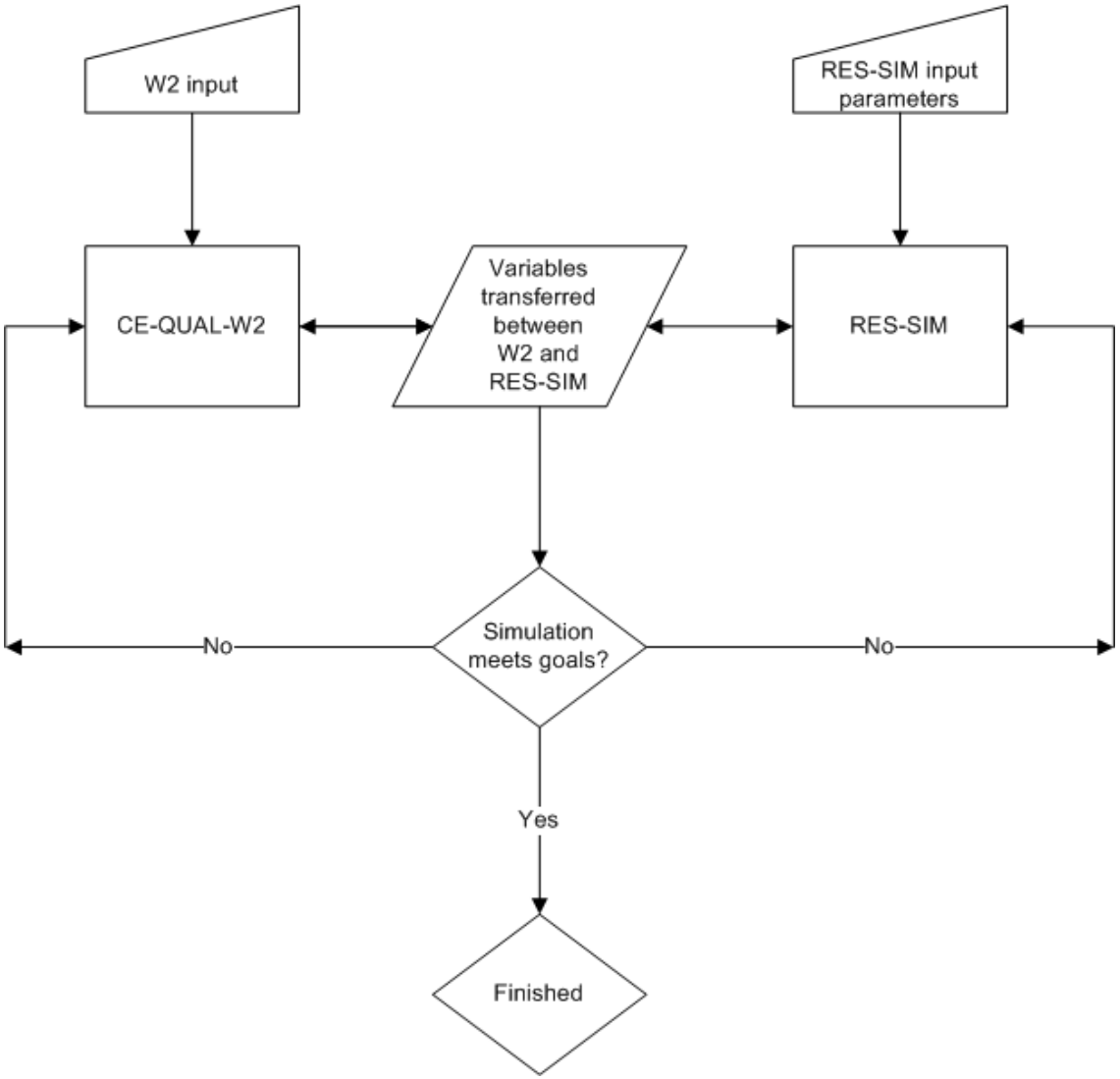
Why couple the 2 models?

- There is an increasing demand to include water quality operating objectives for real-time water management as well as planning studies
- Goal: Model the physical, chemical, and biological characteristics of water, and include the impact of water quality in reservoir system decision-making

Objective

- Couple the 2 models so that the water quality implications of operational strategies are modeled and fed back into the ResSim model for decision making

Conceptual Framework



Steps Performed in Phase I

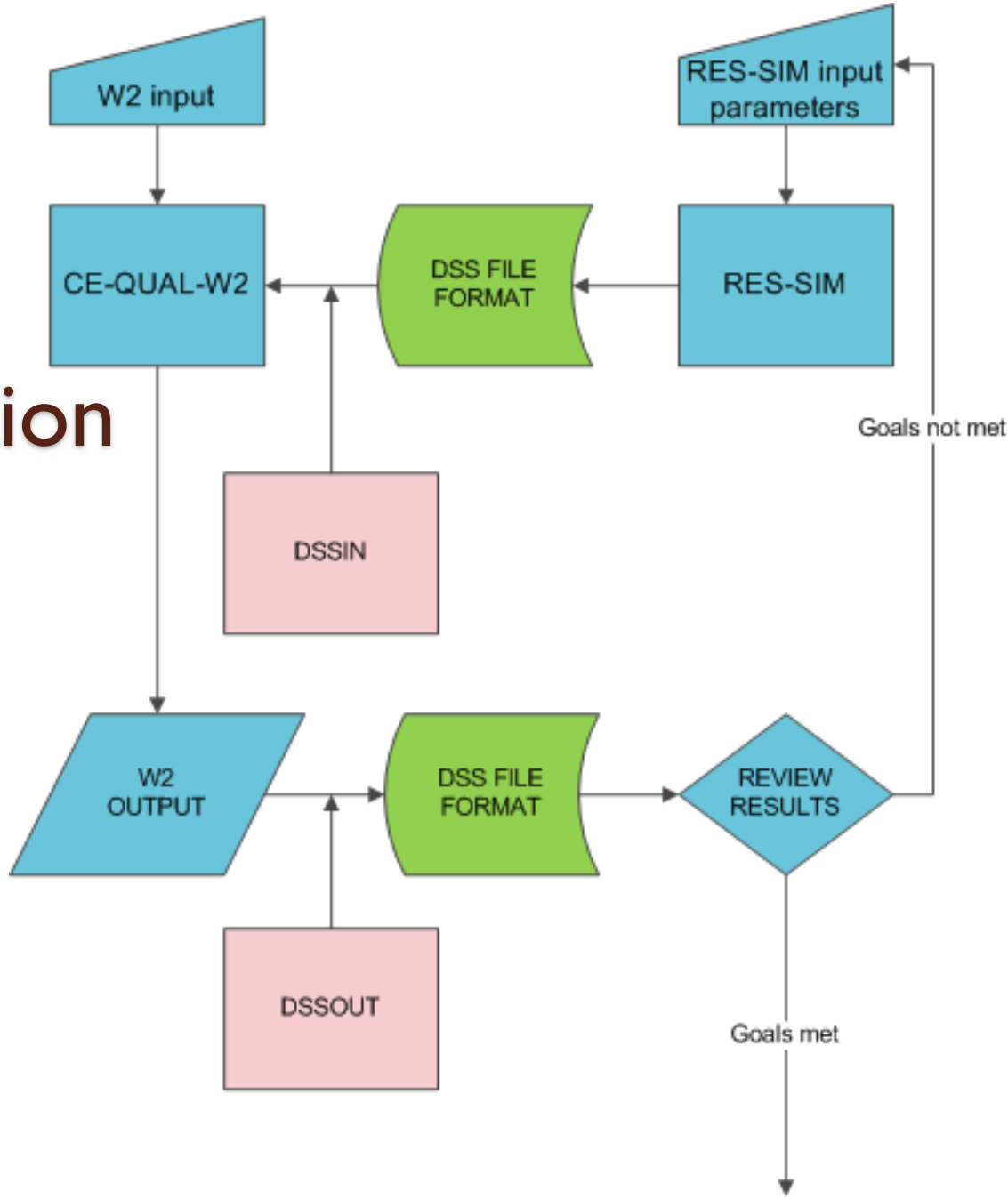
- Model to model communication
  - code to control W2-RESSIM simulation parameters within W2
  - code to adjust and write out new control file for CE-QUAL-W2 based on RESSIM
  - code to write results to RESSIM using DSS
  - code to read new boundary conditions from RESSIM using DSS
- Code refinements in CE-QUAL-W2 to allow for transition
  - date field change from Julian day to generic date field for time series inputs
  - free format input text time series files
  - RESTART capability working properly to improve simulation time
  - river routing improvements
    - trapezoidal channel
    - initial water surface calculation

Current Phase

- Demonstrate a one-pass approach with CE-QUAL-W2 and ResSim with a real application, Detroit Lake

Model to Model Communication

Conceptual framework



Example Application: Detroit Lake

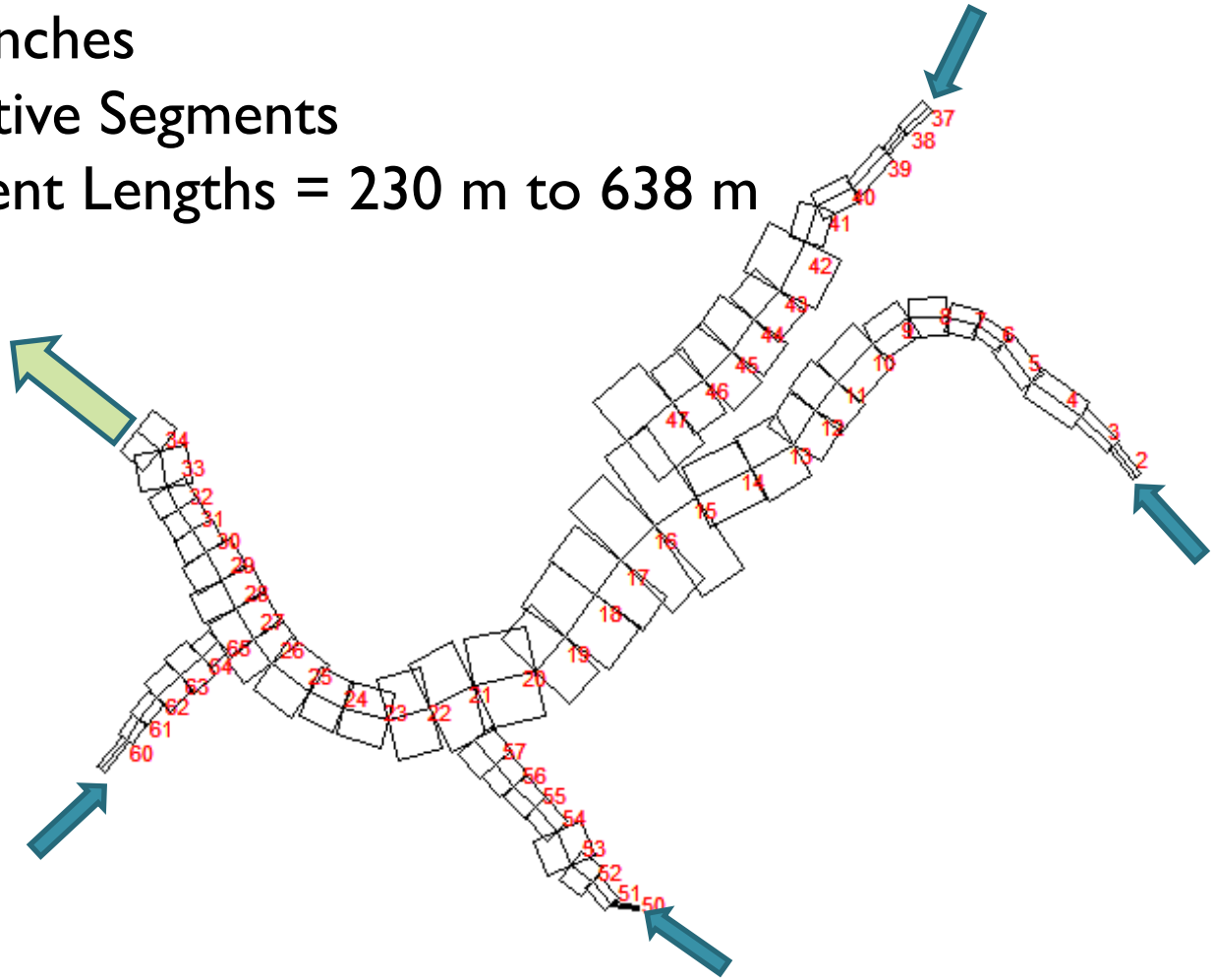
- CE-QUAL-W2 model developed by USGS using Version 3.1
- Existing ResSim model

Detroit Reservoir Model

- Converted 2002 and Winter 2005-2006 CE-QUAL-W2 Models from Version 3.1 to 3.6
- Year 2002 Model Simulates Time Period from January 1 to December 31
- Winter 2005-2006 Model Simulates Time Period from December 1, 2005 through February 2, 2006

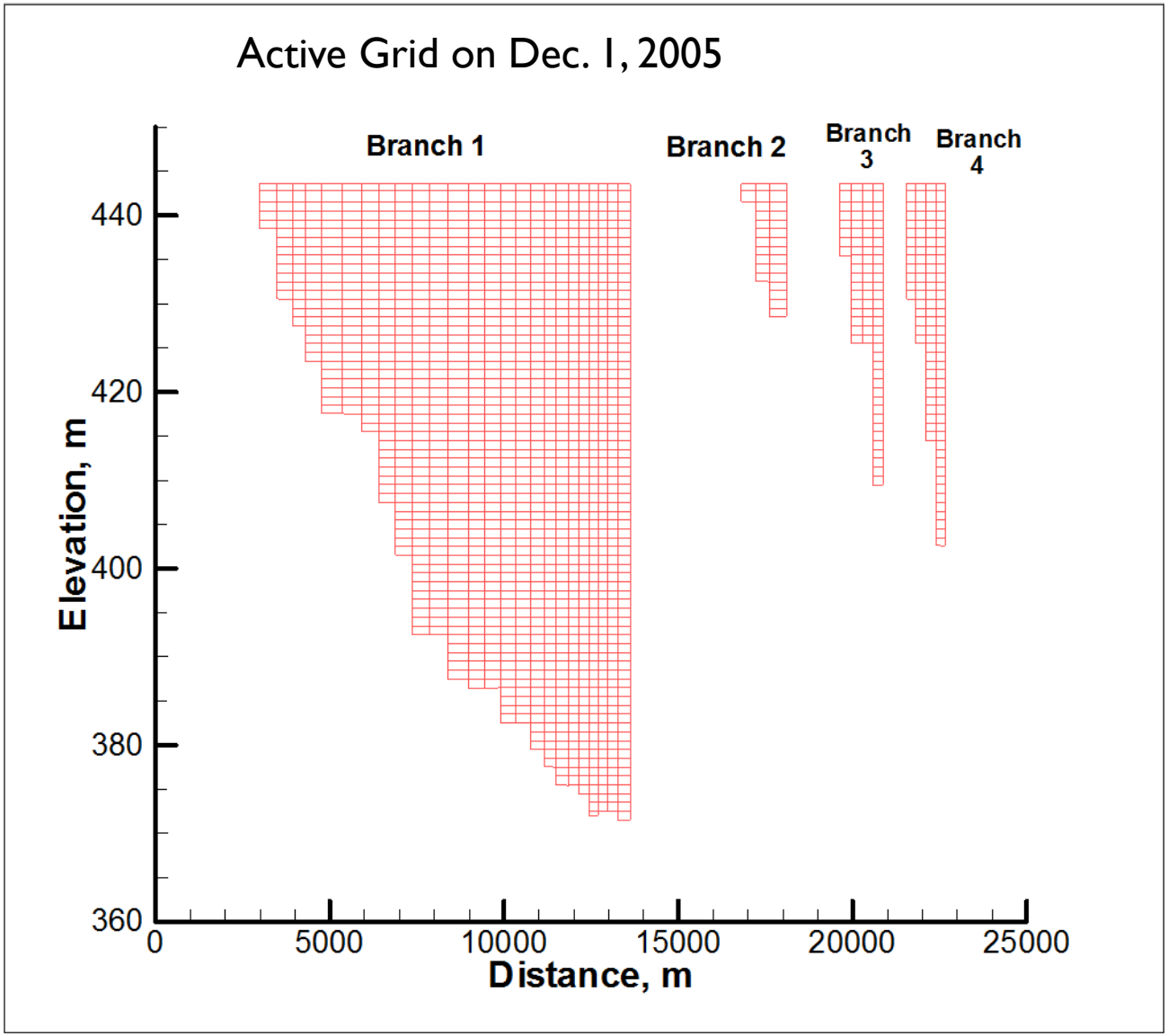
Detroit Reservoir Model

- 4 Branches
- 58 Active Segments
- Segment Lengths = 230 m to 638 m



Detroit Reservoir Model

- 115 vertical layers
- Layer 1 m



DSS→ CE-QUAL-W2

Detroit_ResSim_Wells_3outlets_1yr_SI.dss - HEC-DSSVue

File Edit View Display Utilities Help

CDEC Excel Precision USGS

File Name: C:\scott\research\corps of engineers\SOW July 2007 Res-sim and W2 scope\detroit lake model\model run with dss input\Detroit_ResSim_Wells_3outlets_1yr_SI.dss

Pathnames Shown: 7 Pathnames Selected: 13 Pathnames in File: 91 File Size: 181 KB

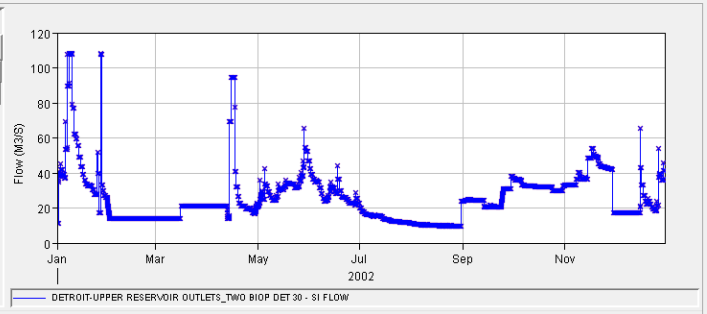
Search By Parts: A: B: C: D: E: F:

Number	A part	B part	C part	D part / range	E part	F part
1		DETROIT-CONSERVATION	ELEV-ZONE	01DEC2001 - 01DEC2002	1HOUR	BIOP DET 30
2		DETROIT-PENSTOCKS_TWO	FLOW	01DEC2001 - 01DEC2002	1HOUR	BIOP DET 30 - SI
3		DETROIT-POOL	ELEV	01DEC2001 - 01DEC2002	1HOUR	BIOP DET 30 - SI
4		DETROIT-POOL	FLOW-EVAP	01DEC2001 - 01DEC2002	1HOUR	BIOP DET 30 - SI
5		DETROIT-POOL	FLOW-IN	01DEC2001 - 01DEC2002	1HOUR	BIOP DET 30 - SI
6		DETROIT-SPILLWAY_6 BAYS	FLOW	01DEC2001 - 01DEC2002	1HOUR	BIOP DET 30 - SI
7		DETROIT-UPPER RESERVOIR OUTLETS_TWO	FLOW	01DEC2001 - 01DEC2002	1HOUR	BIOP DET 30 - SI

Graphical Editor

File Edit View

Selected Data Set: //DETROIT-UPPER RESERVOIR OUTLETS_TWO/FLOW/01DEC2001/1HOUR/BIOP DET 30 - SI/



Date/Time	Original (M3/S)	Estimate/Entry (M3/S)	Revised (M3/S)
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01Jan2002, 01:00	11.33	--	11.33
01Jan2002, 02:00	11.33	--	11.33
01Jan2002, 03:00	11.33	--	11.33
01Jan2002, 04:00	11.33	--	11.33
01Jan2002, 05:00	11.33	--	11.33
01Jan2002, 06:00	11.33	--	11.33
01Jan2002, 07:00	11.33	--	11.33
01Jan2002, 08:00	11.33	--	11.33
01Jan2002, 09:00	11.33	--	11.33
01Jan2002, 10:00	11.33	--	11.33
01Jan2002, 11:00	11.33	--	11.33
01Jan2002, 12:00	11.33	--	11.33

Estimate | Estimate Missing | Estimate All | Accept | Accept All | Add | Delete

//DETROIT-UPPER RESERVOIR OUTLETS_TWO/FLOW/01DEC2001 - 01DEC2002/1HOUR/BIOP DET 30 -

Select | De-Select | Clear Selections | Restore Selections | Set Time Window

No time window set.

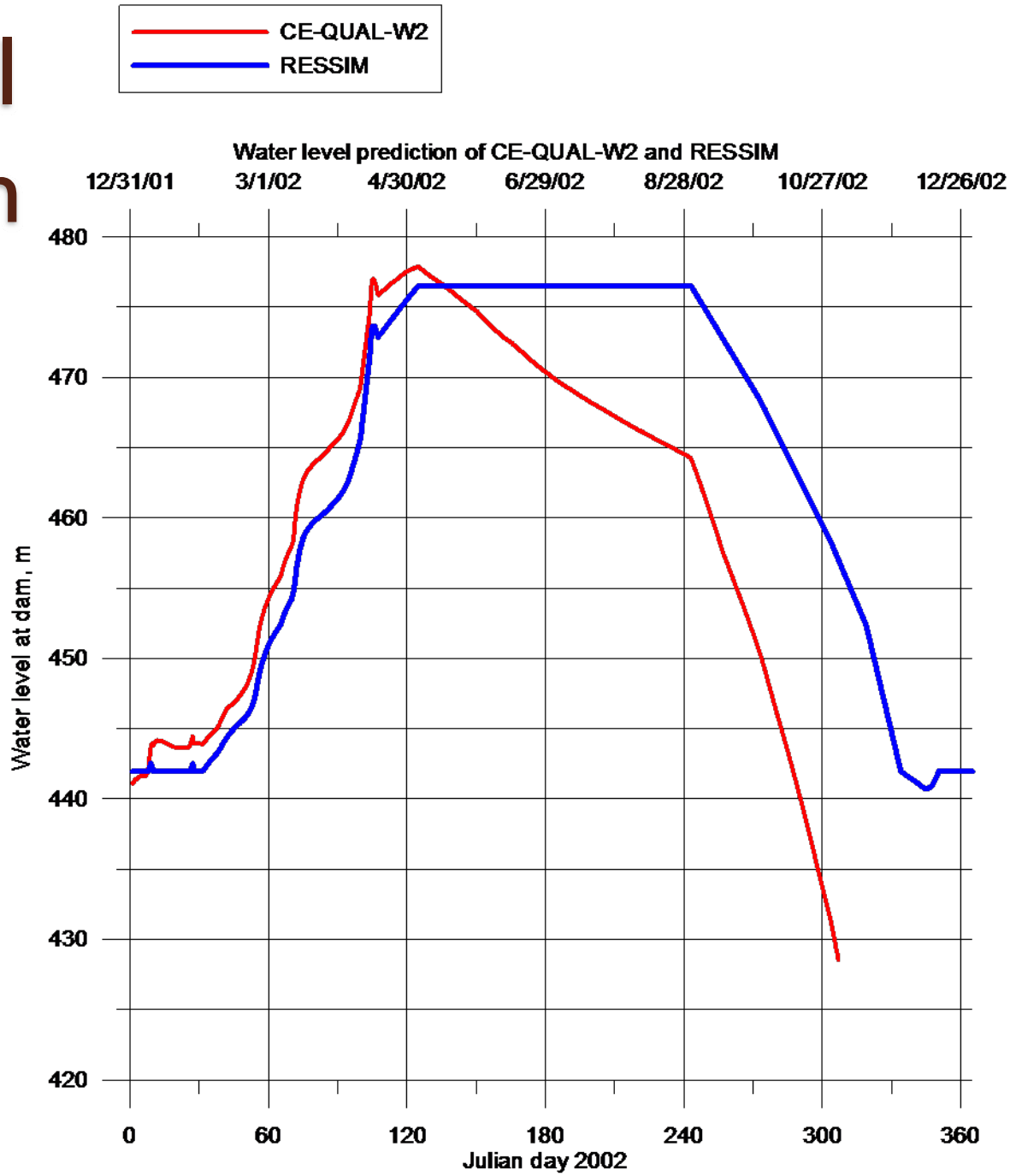
Inbox - Microsoft O... | Wall Street futures ... | C:\scott\research\c... | Microsoft PowerPoi... | HEC-DSSVue console | Detroit_ResSim_Well... | Graphical Editor | EN | 7:11 AM

Issues with running W2 model with RESSIM inputs

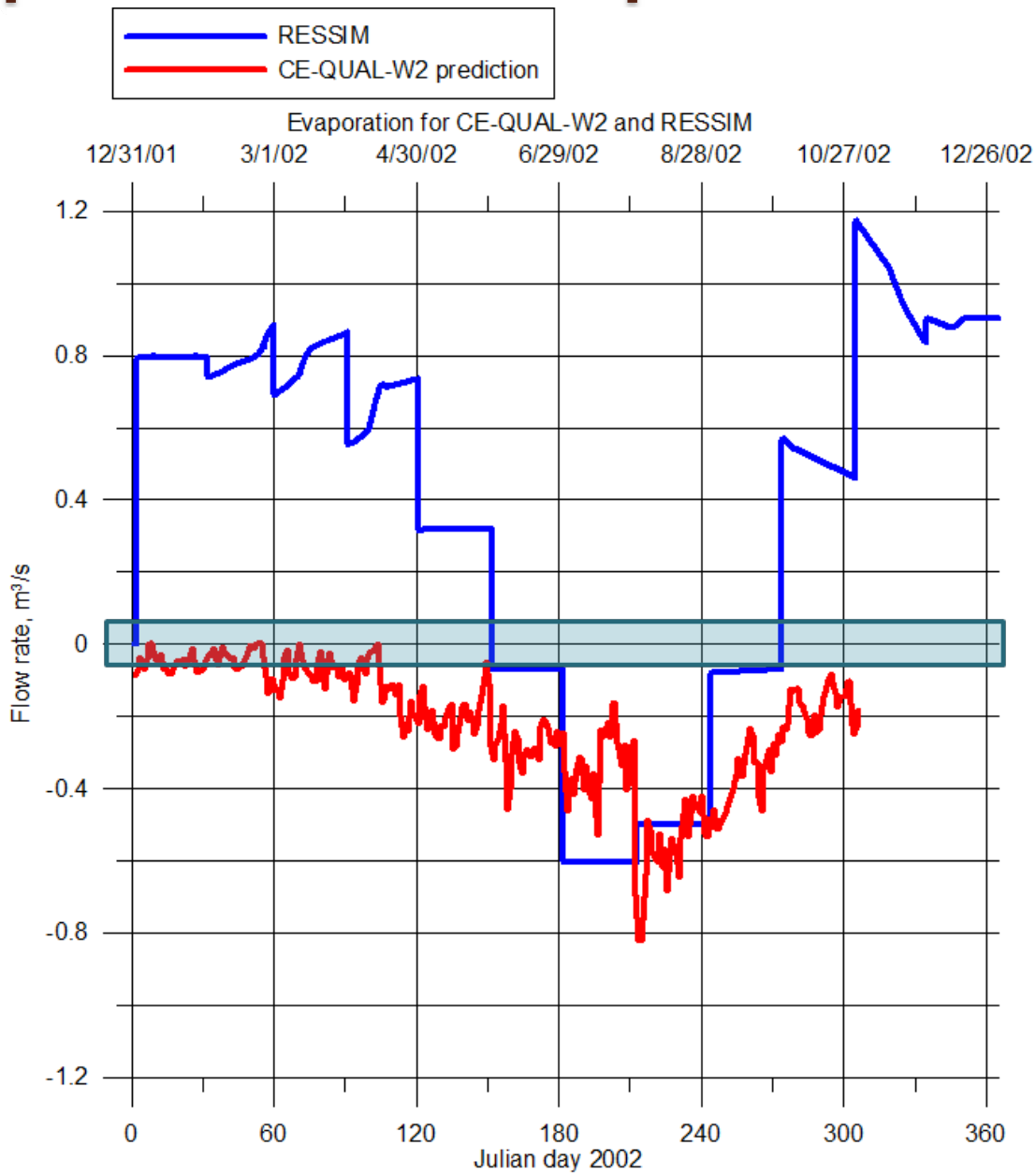
- Flow balance
  - CE-QUAL-W2 had 4 inflows from different inflow locations, 4 precipitation accretion flows, and 4 water distributed inflows and dynamically computed evaporation
  - RESSIM had one inflow
- Evaporation

Water level comparison

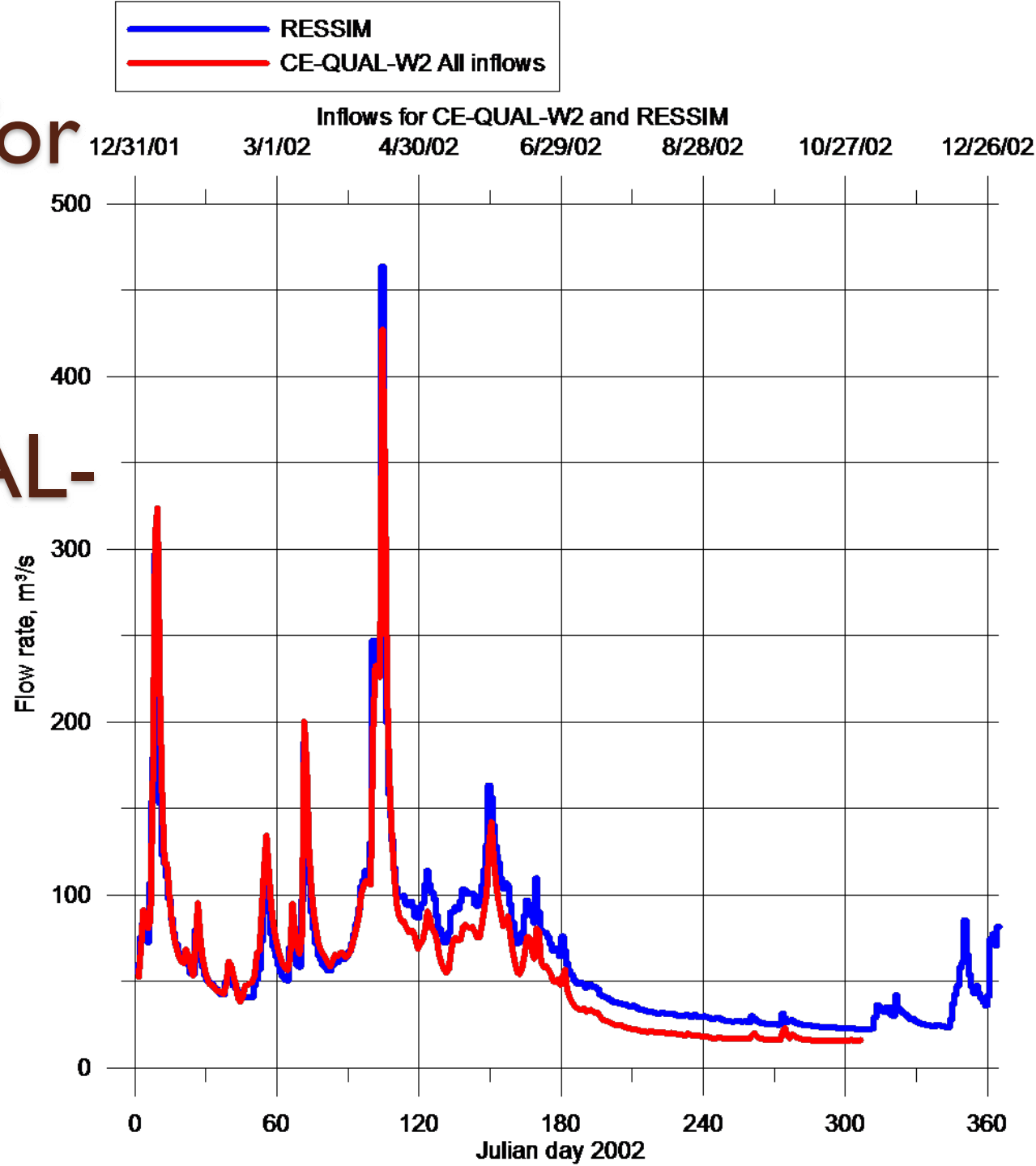
- Water levels not consistent between RESSIM and W2



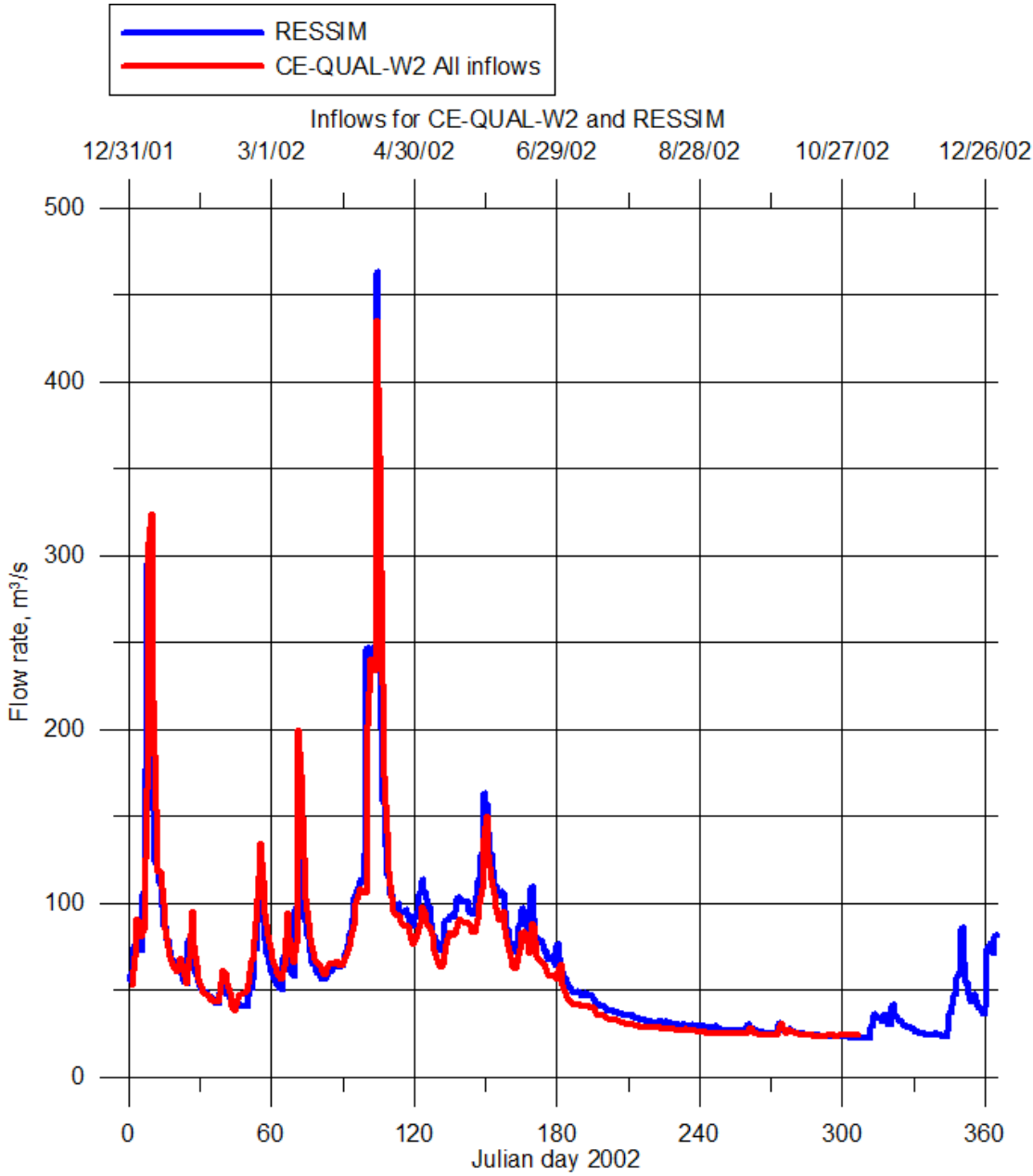
Evaporation Comparison



Inflows for RESSIM and CE-QUAL-W2

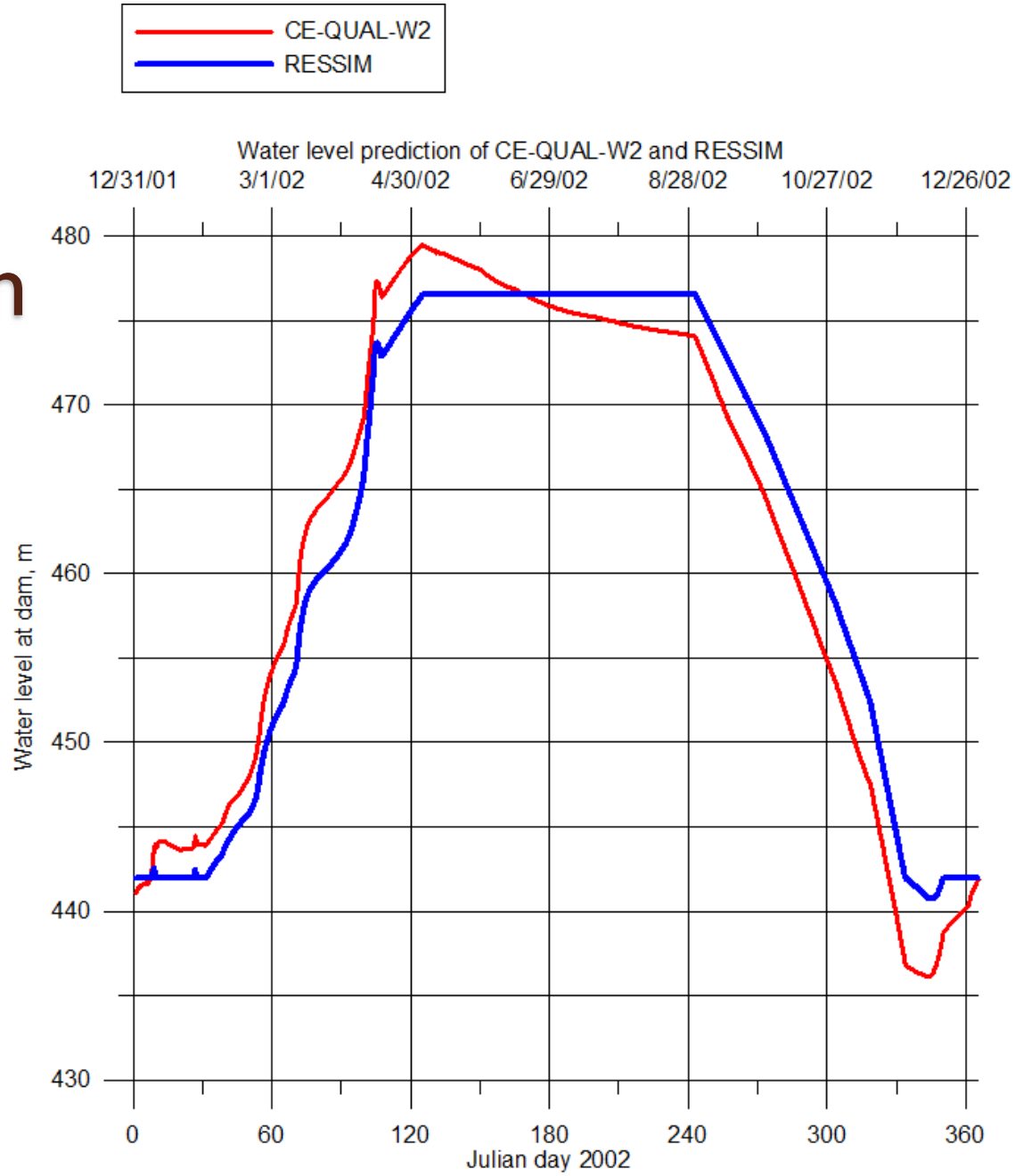


Revised inflows for CE-QUAL-W2

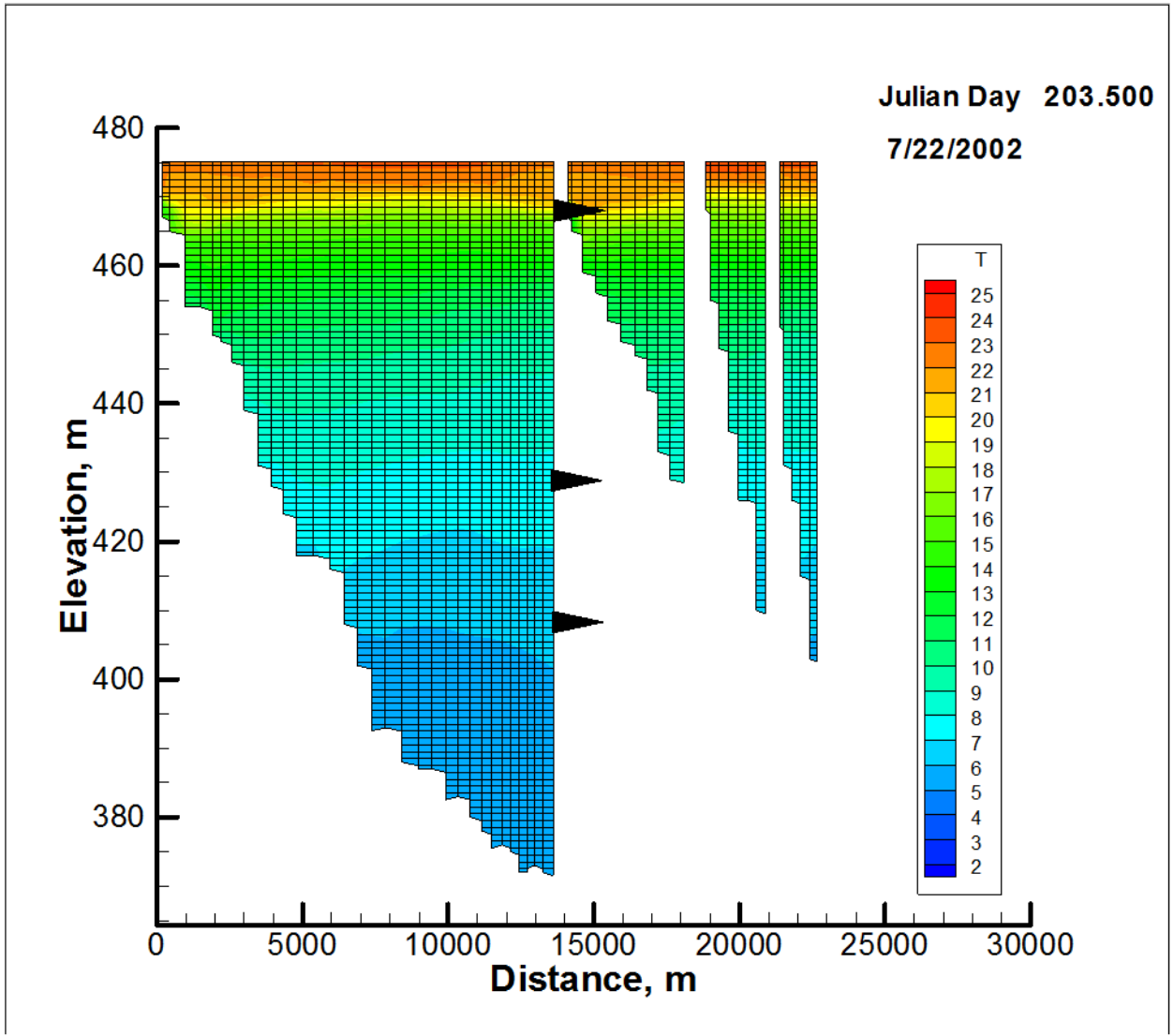


Adjusted inflow in CE-QUAL-W2:
Increase main branch inflow by 8 m^3/s between JD 100 and 240 and 5 m^3/s afterward

Water level comparison



Water temperature outlet predictions of CE-QUAL-W2 model



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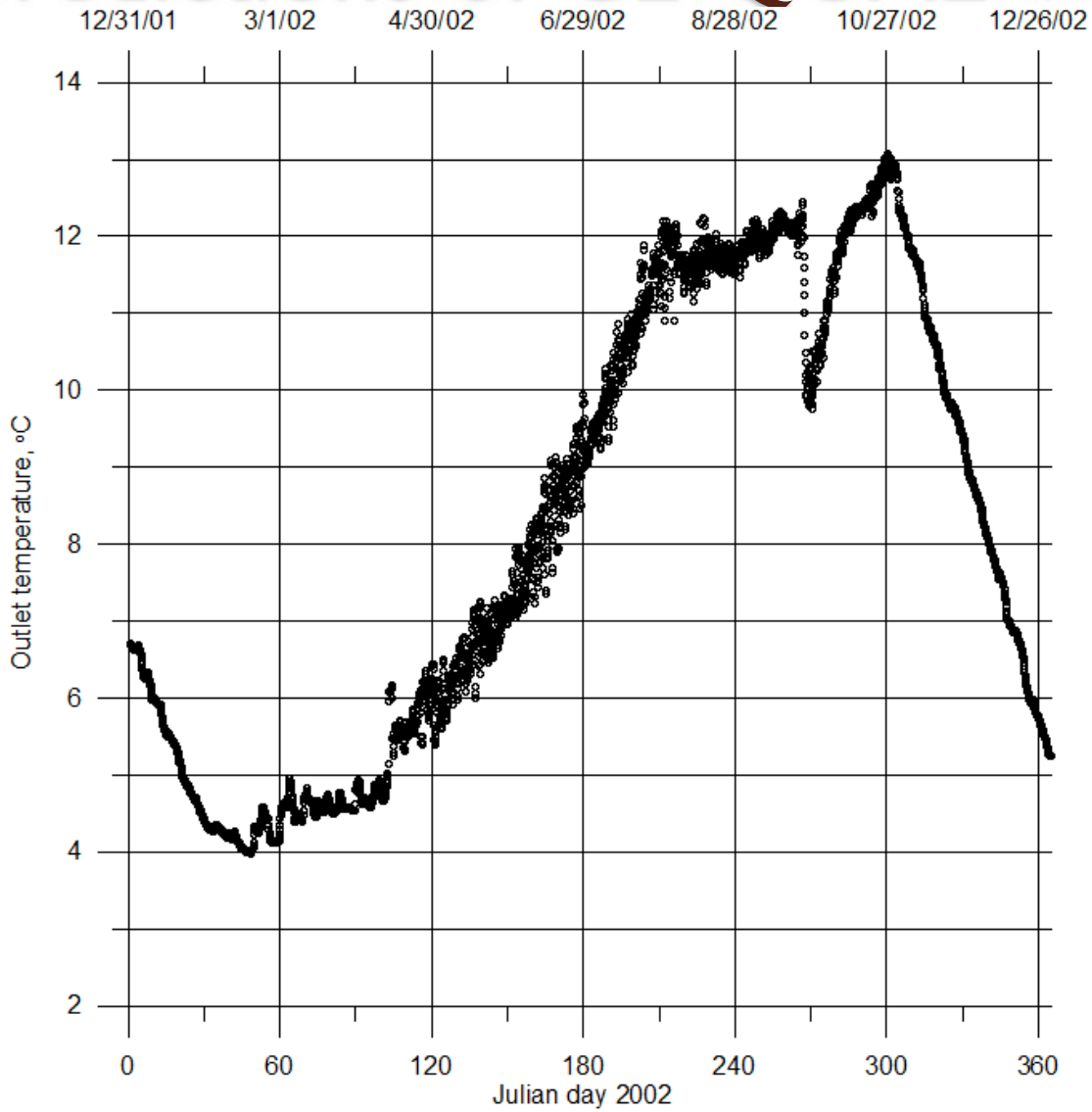
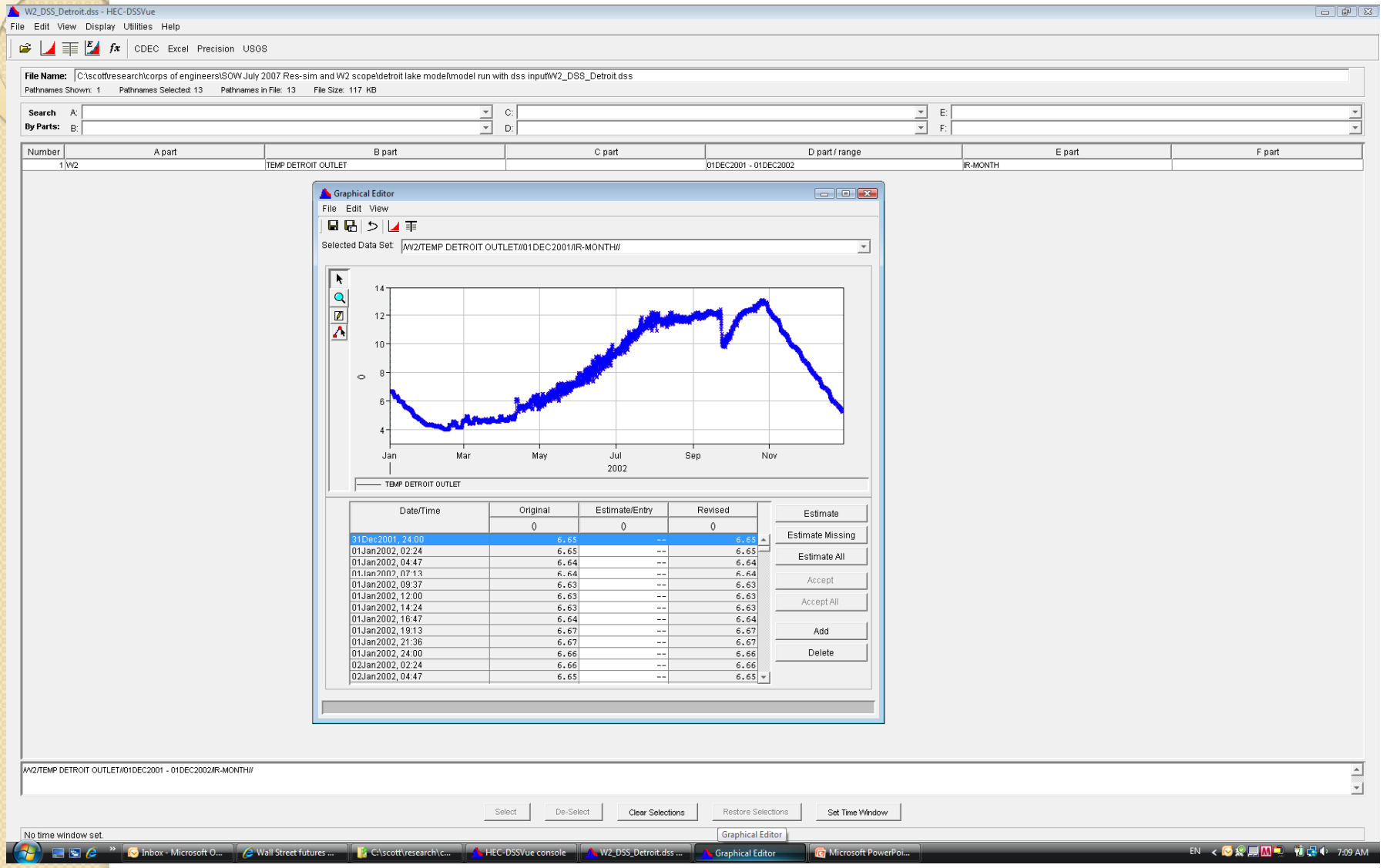
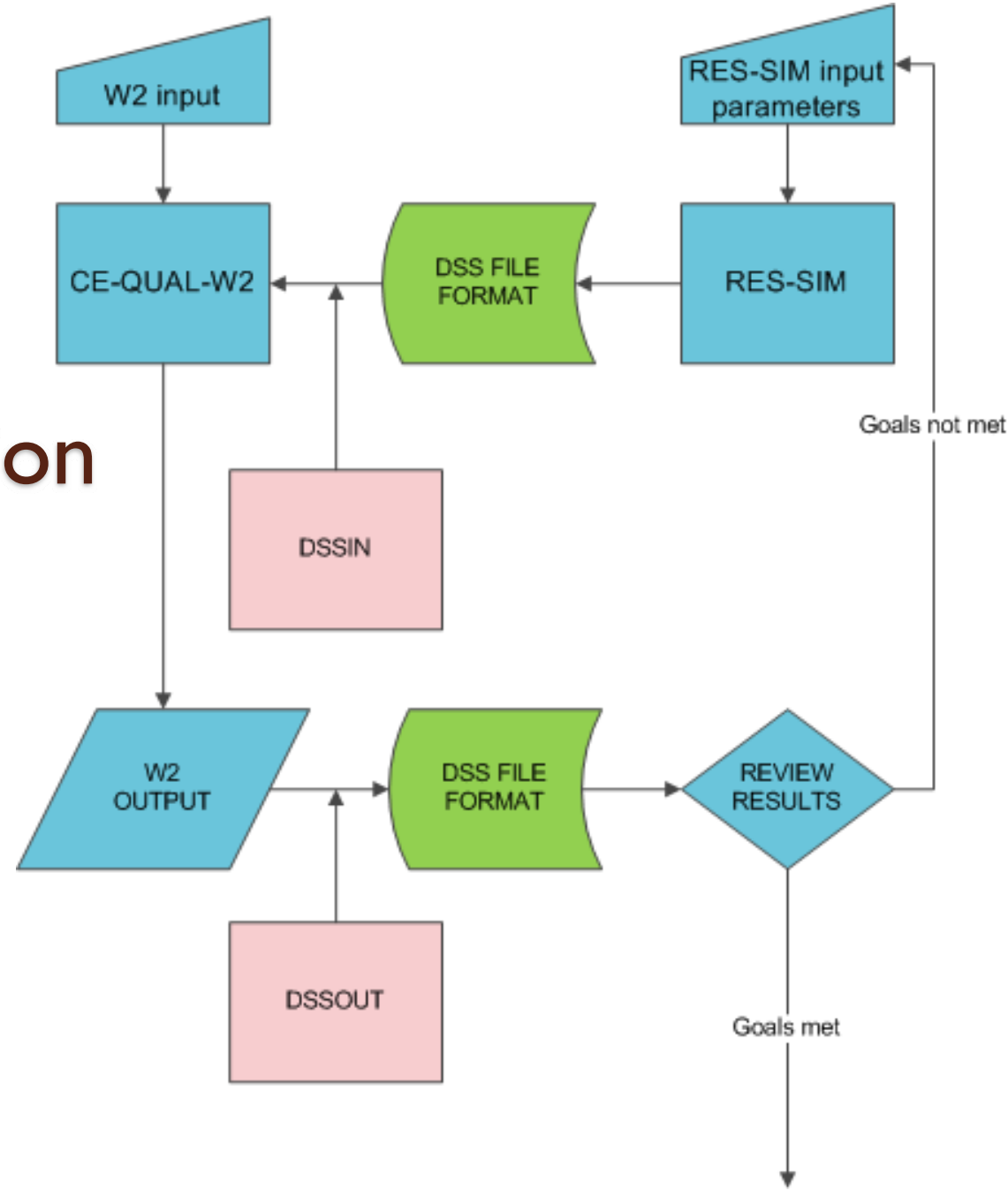


W2 output → DSS



Model to Model communication

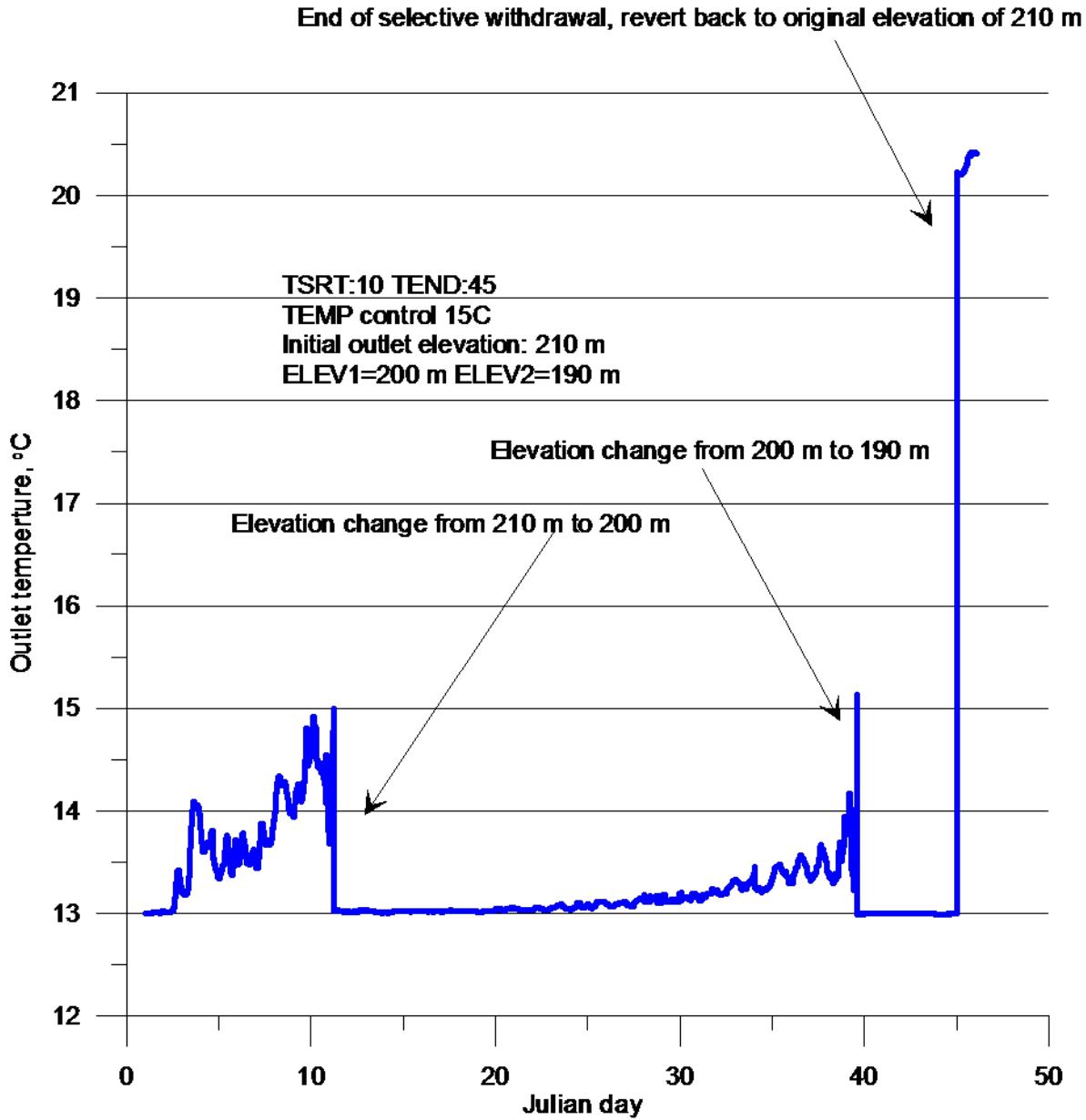
User review



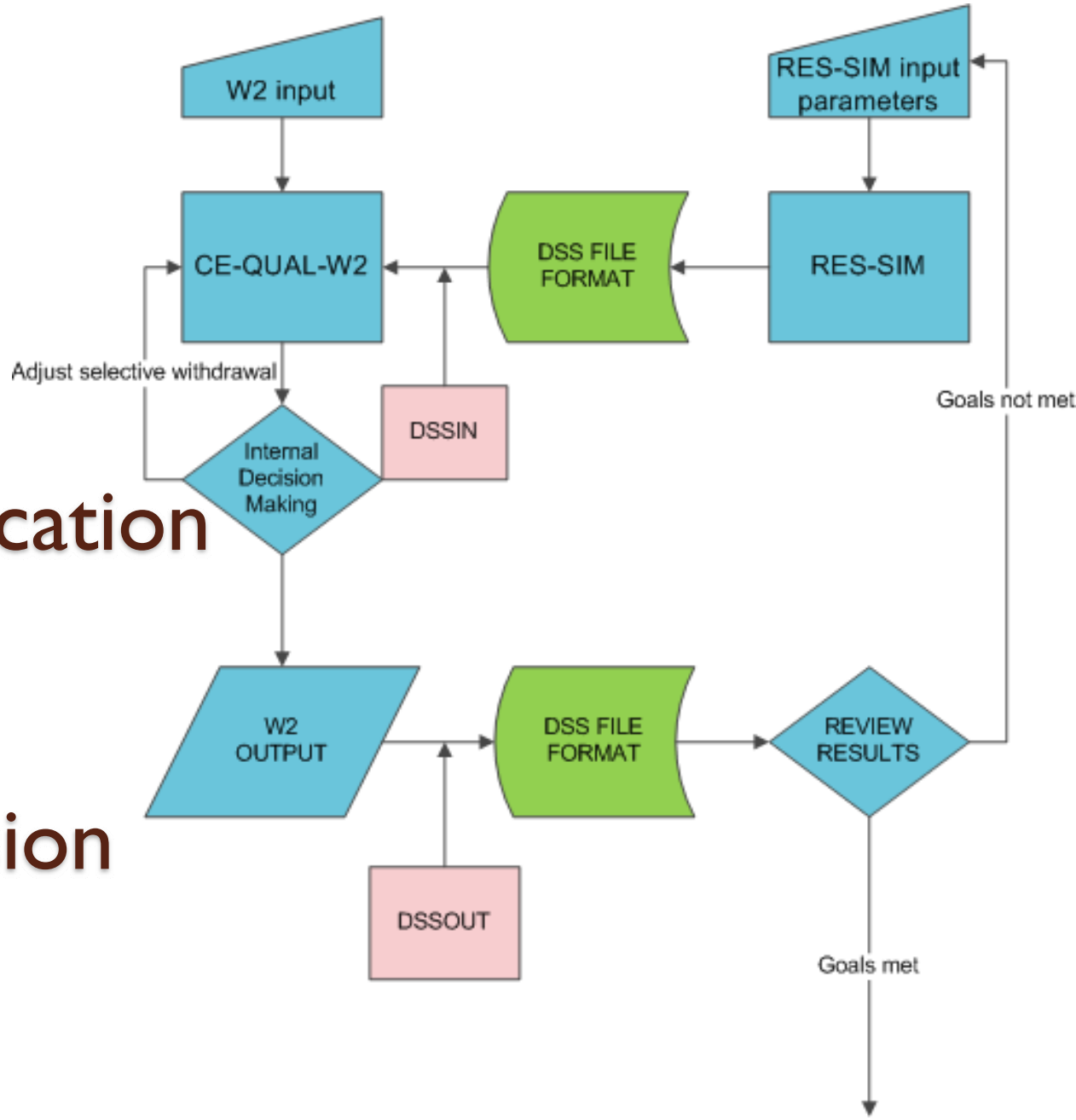
CE-QUAL-W2 Decision Making

- Integrate decision rules within CE-QUAL-W2
- For each structure, the user can dynamically set rules that will adjust the elevation of the discharge according to time and temperature of the outlet water.
- The model user will provide
  - a beginning upper elevation for withdrawal
  - The time series of outflows
- The model will then dynamically lower or raise the elevation of the outlet using as a starting point the starting elevation defined for the structure.
- Flow blending can also be accomplished to meet goals.

CE-QUAL-W2 Decision Making



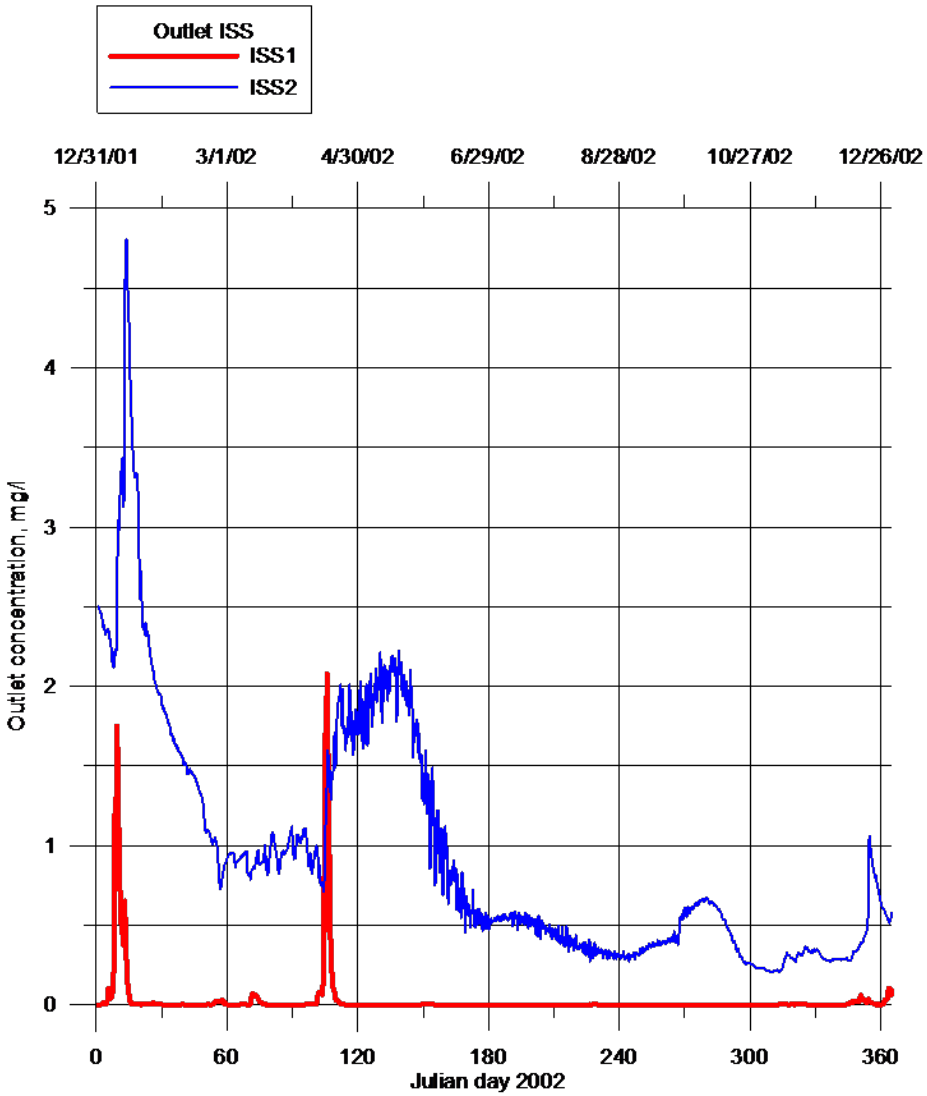
Model to Model communication



W2 decision making

Next steps for closer integration

- Resolve the water balance issues
- Develop batch files or Windows Application to automate the process
- Detroit Lake model takes about 1 hour to run the model year for 2002; explore RESTART features of the model to reduce time for evaluation of model run
- Add riverine model section below Detroit Lake to explore feedback with a combined reservoir river attempting to meet a target; test ResSim vs W2 for stream routing
- Refine decision making approach within CE-QUAL-W2 and within ResSim

Next steps for closer integration

- Explore water quality in addition to temperature