



Center for Advanced Decision Support for
Water and Environmental Systems (CADSWES)

UNIVERSITY OF COLORADO **BOULDER**

Borg-RiverWare

2025 RiverWare User Group Meeting

Presenter: Edie Zagona, Patrick Lynn

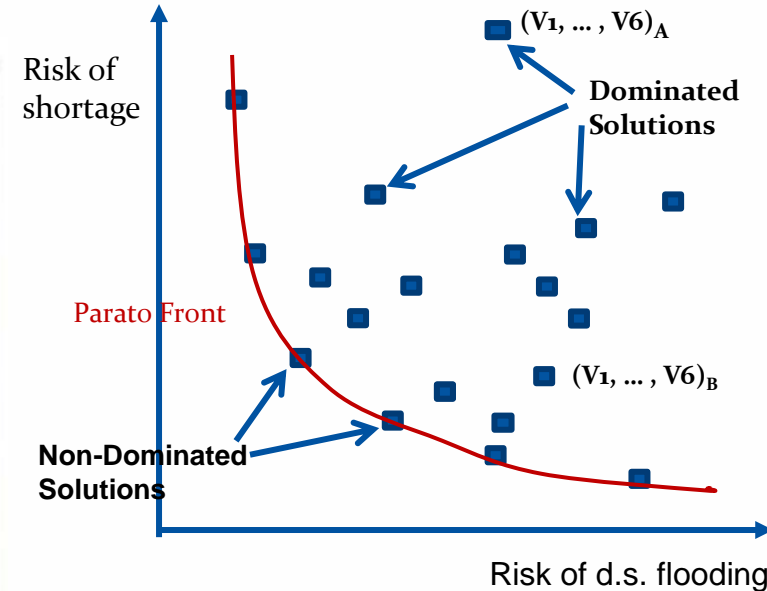
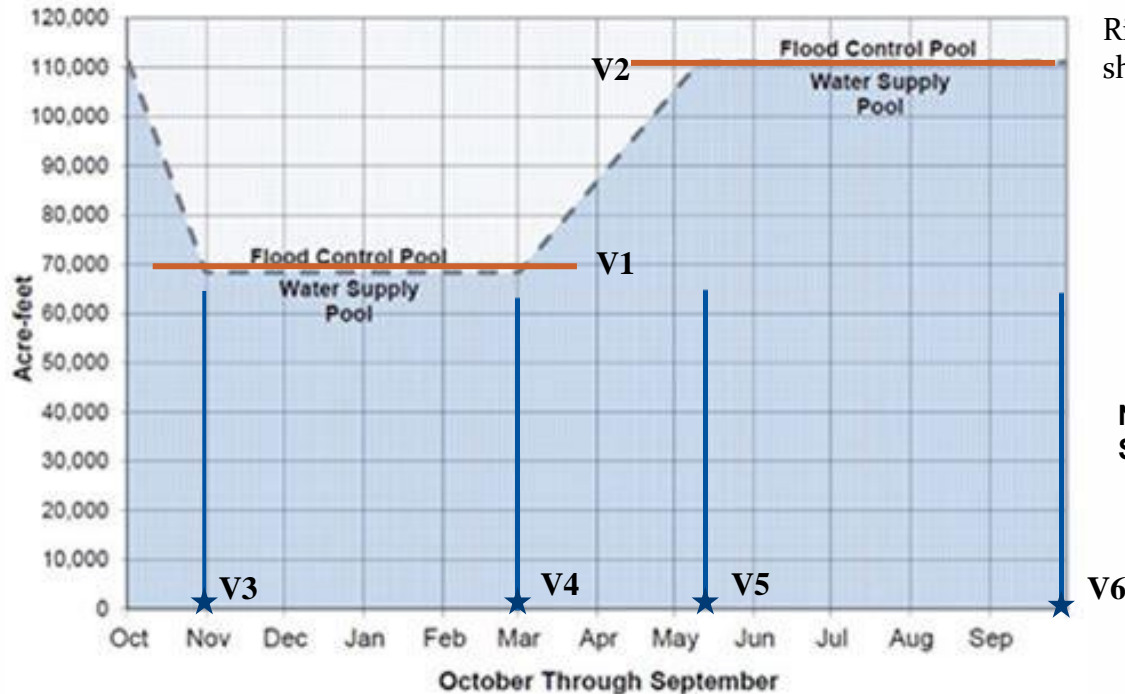
Multi-Objective Simulation-Based Optimization



Overview

Multi-objective simulation-based optimization

Example: find the “best” reservoir guide curve



Problem: Find the best set of values of these 5 variables for these

Conflicting objectives:

Minimize risk of flooding downstream

Minimize risk of water supply shortage

How to solve: 1. run many simulations, e.g. POR, with combinations of values of the variables.

2. Compute the values of the objectives for each.

1. Eliminate dominated solutions
2. Identify non-dominated solutions to consider for the policy
3. Decision-making: what tradeoff to accept between the objectives?

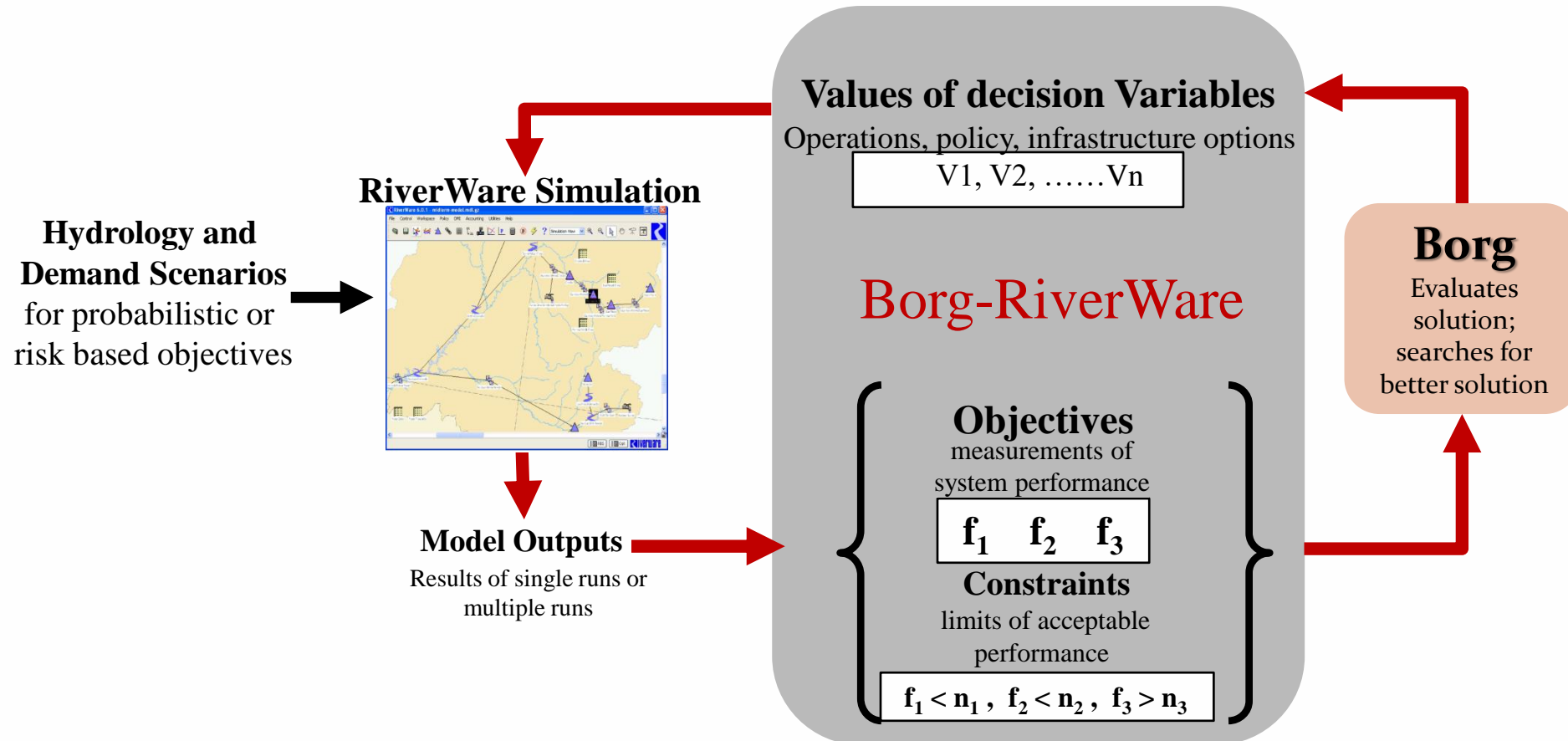
Automate by using MOEA
Multi-objective evolutionary algorithm

A search algorithm that generates many sets of variables and identifies the Pareto optimal solutions

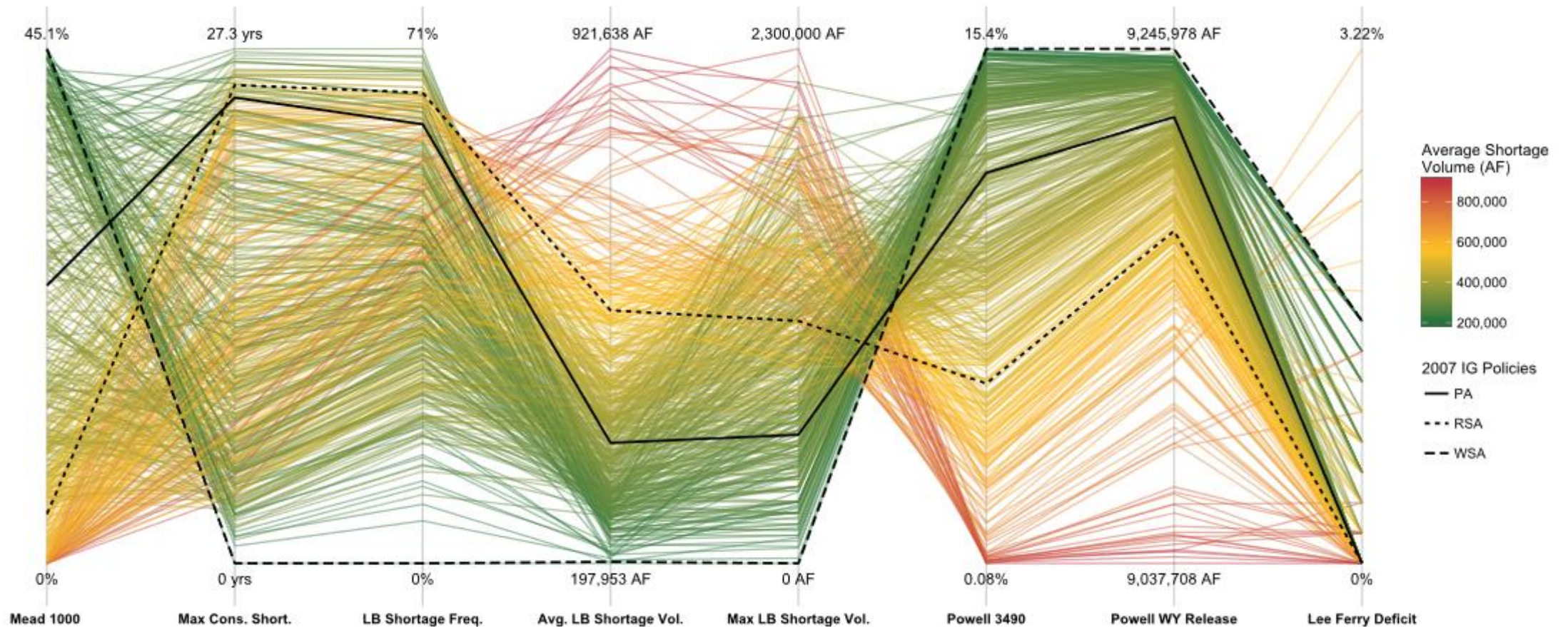
Borg-RiverWare Wrapper

Software that exchanges information between simulator RiverWare and the MOEA Borg to find a non-dominated (pareto optimal) set of solutions

Borg is an MOEA developed by David Hadka and Patrick Reed at the Pennsylvania State University and licensed by The Pennsylvania State University. See borgmoea.org



Tradeoffs among multiple objectives can be visualized using parallel coordinates plots; each axis is an objective. Each line is an approximate Pareto optimal solution. (Alexander, MS Thesis 2018)





Borg-RiverWare



Demo and Future Development

Configuring & Executing a Search

- **Problem formulation:** decision variables + objectives
-  **RiverWare:**
 - Identify decision variable slots, create objective slots
 - Create DMIs to exchange data with Borg-RiverWare
 - Configure search (needs environment variable)
-  **Borg-RiverWare**
 - Execute Search
 - Analyze results

Modeling Decision Variables

Object Viewer

File Edit View Slot Account Group Object Tabs

Cedar System Data

Object: Cedar

Slots Methods Accounts Accounting Methods Attributes Description

December 31, 2017

Slot Name	Value	Units	
Available for Diversion	NaN	cms	L
Canal Flow	NaN	cms	
Convergence Percentage	0.00	NONE	
Diversion	NaN	cms	L
Diversion Capacity	NaN	cms	
Diversion Min Elevation	221.40	m	C
Elevation Volume Table			
Flow FROM Pumped Storage	NaN	cms	
Flow TO Pumped Storage	NaN	cms	

Order: Column Sort Filter Slots

RPL Viewer - Arbor Basin Rules (from MRM run)

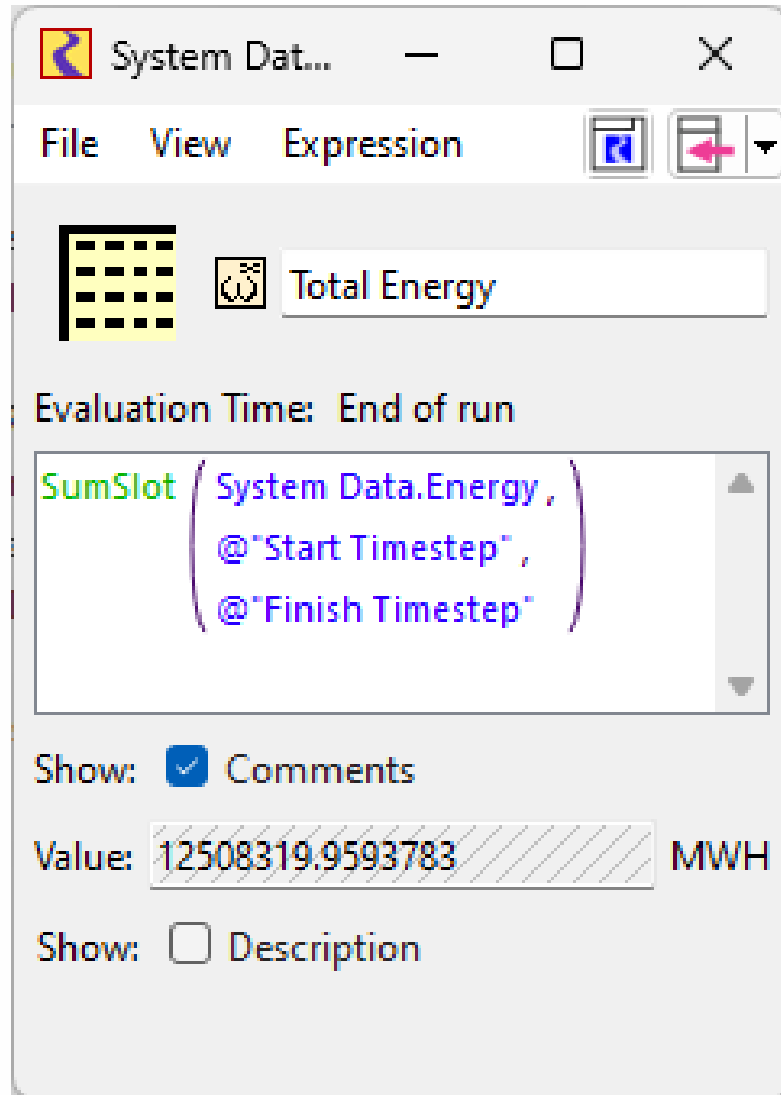
File Edit Rule Statement View

Cedar Available for Diversion RPL Set Loaded

```
Cedar.Available for Diversion []  
= IF ( Cedar.Pool Elevation [ @'t - 1' ] > Cedar.Diversion Min Elevation [ ] ) THEN  
  Max ( VolumeToFlow ( Cedar.Storage [ @'t - 1' ]  
    - ElevationToStorage ( Cedar,  
      Cedar.Diversion Min Elevation [ ] ),  
    @'t'  
  + Cedar.Inflow [ ]  
  - Cedar.Outflow Min [ ],  
  0.00 "cms"  
ELSE  
  0.00 "cms"  
END IF
```

Show: Execution Constraint Description Notes Comments

Computing Objectives



System Dat... — □ ×

File View Expression

Total Energy

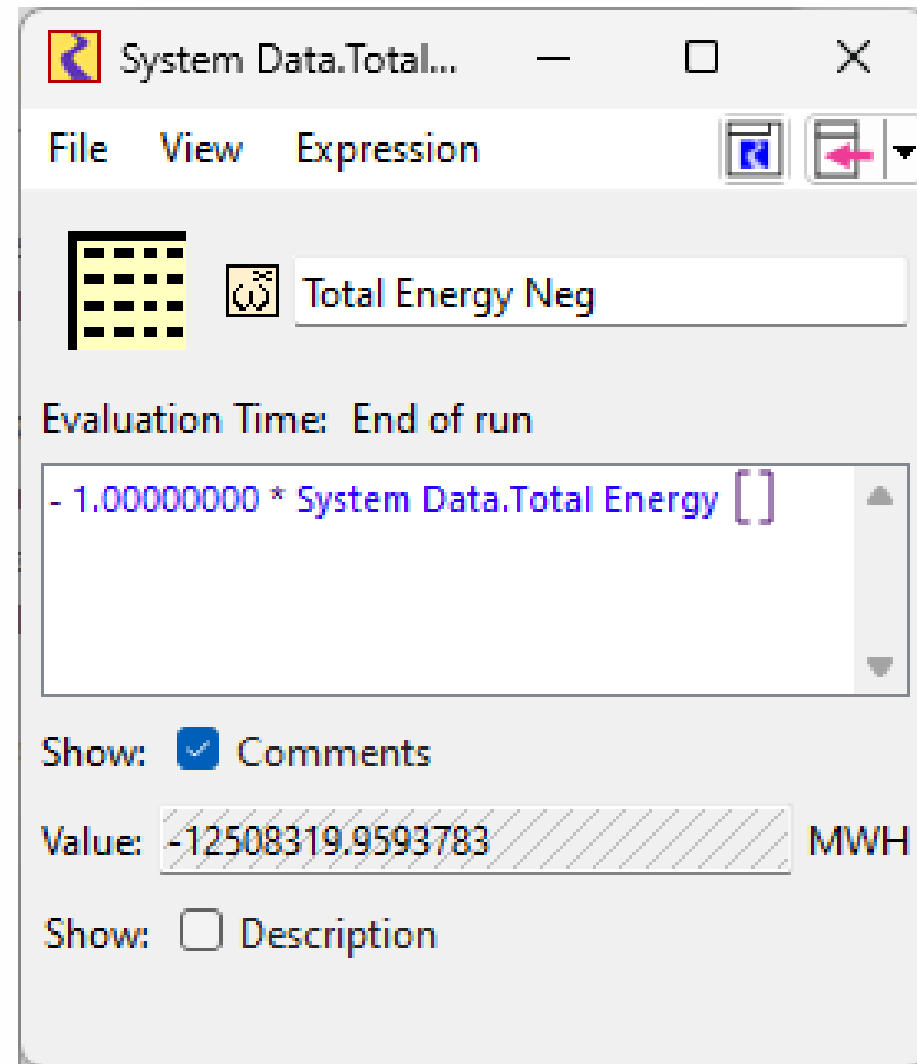
Evaluation Time: End of run

SumSlot (System Data.Energy ,
@"Start Timestep" ,
@"Finish Timestep")

Show: Comments

Value: 12508319.9593783 MWH

Show: Description



System Data.Total... — □ ×

File View Expression

Total Energy Neg

Evaluation Time: End of run

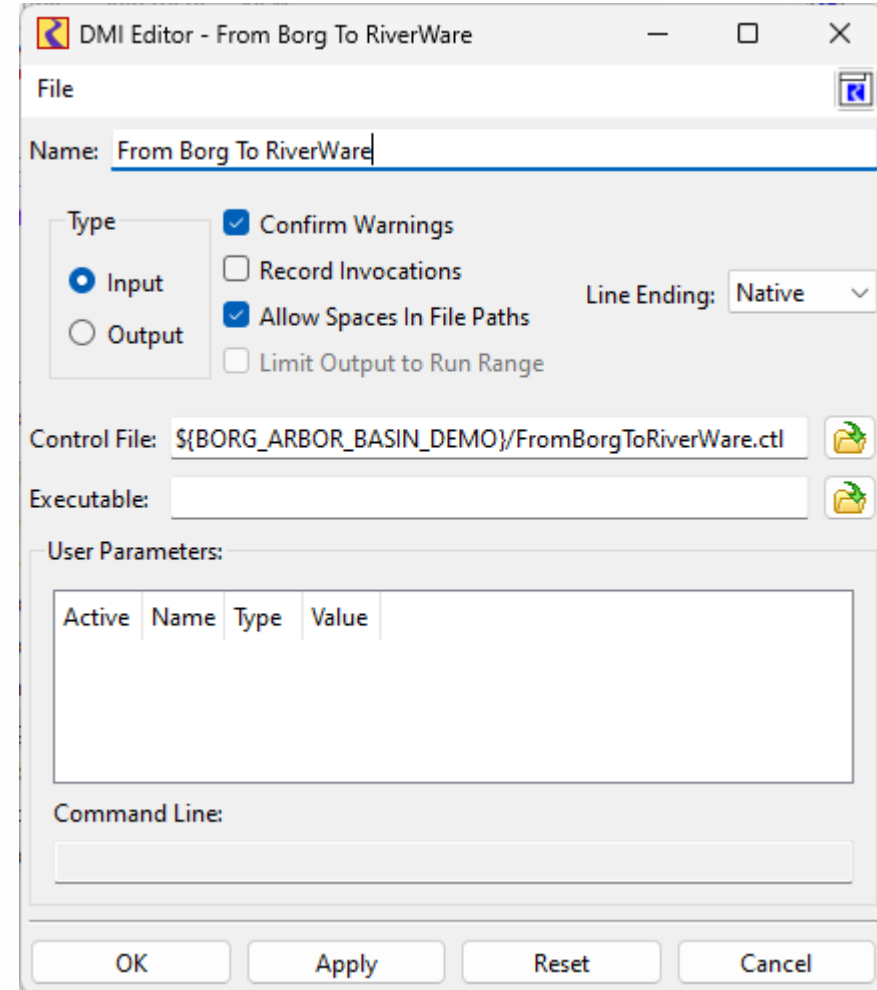
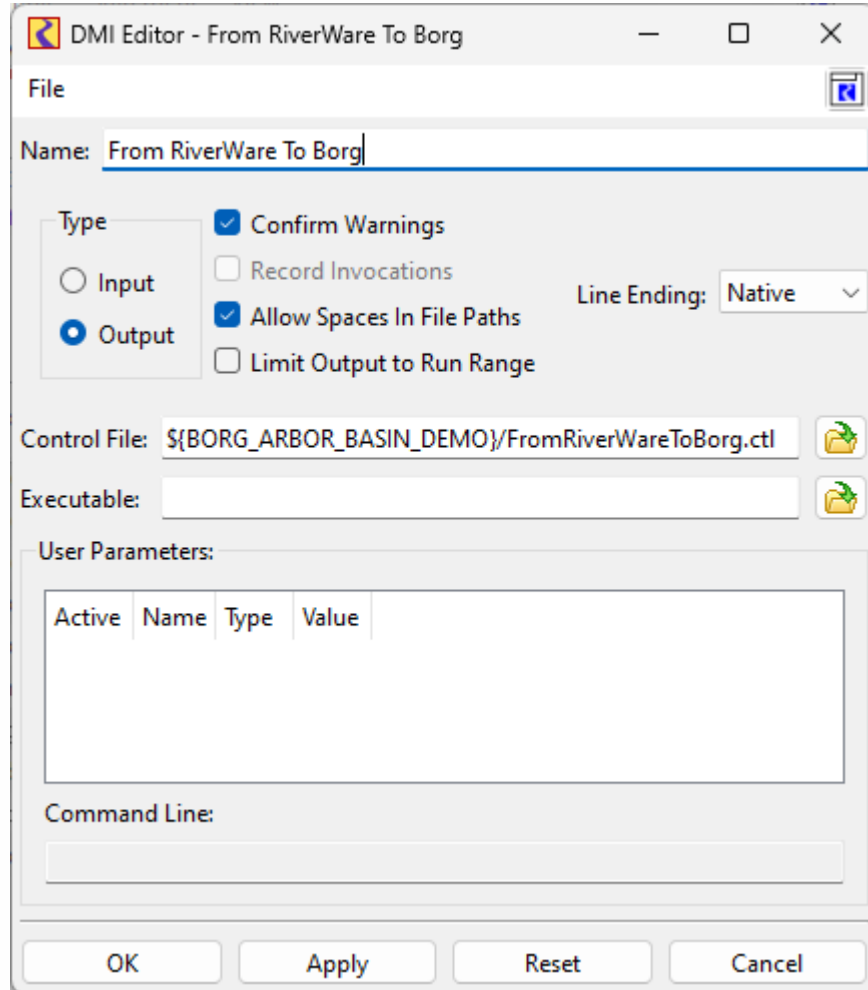
- 1.00000000 * System Data.Total Energy []

Show: Comments

Value: -12508319.9593783 MWH

Show: Description

DMIs



Configuring the Search

Borg-RiverWare Configuration Editor - ArborBasinConfig.xml

File Utilities

Configuration Path: R:/doc/24SponsorStatus/PresentationsAndModels/04.Borg-RiverWare/ArborBasinConfig.xml

RiverWare Model & Search | Decision Slots | Objectives | Metrics | Constraints | Settings

RiverWare Model

Model: ArborBasin.mdl

RiverWare Run Type: Single Run

RiverWare Batch Execution Script (RCL): ArborBasin.rcl Generate Automatically

Data Communication (Between Borg and RiverWare)

Borg-to-RiverWare DMI: From Borg To RiverWare Control File: FromBorgToRiverWare.ctf

RiverWare-to-Borg DMI: From RiverWare To Borg Control File: FromRiverWareToBorg.ctf

Generate Control Files Automatically

Search

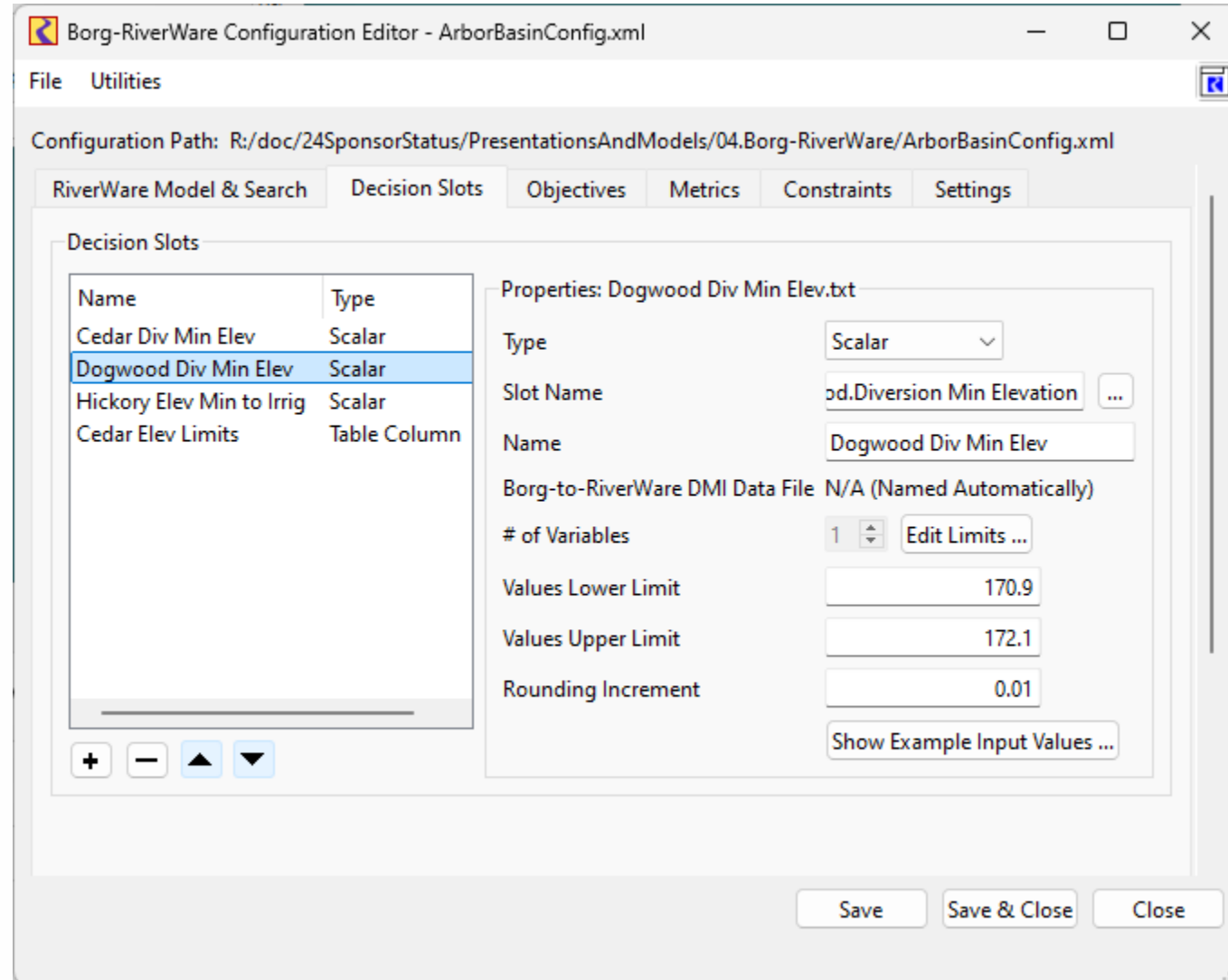
Initial Population Size: 5

Maximum Number of Evaluations: 20

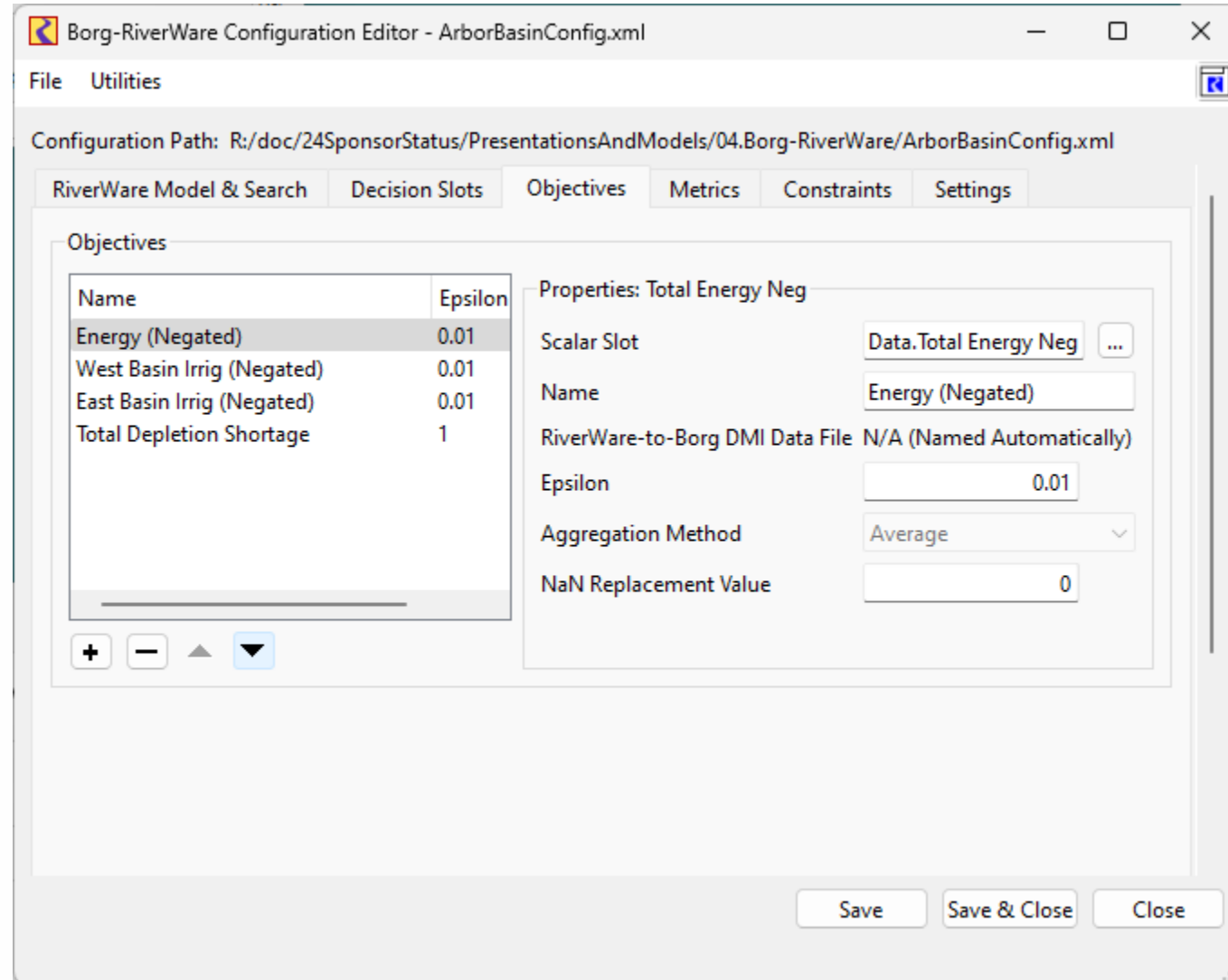
Random Number Generation Seed: 1

Save Save & Close Close

Configuring the Search



Configuring the Search



Execute the Search

The screenshot displays the Borg-RiverWare application window titled "Borg-RiverWare - ArborBasinConfig.xml". The interface includes a menu bar with "File" and "Help", and three tabs: "Search Execution", "Search Results", and "Results Plot". Below the tabs are buttons for "Open Configuration ..." and "Edit Configuration ...".

The "Configuration Summary" section provides the following details:

- Configuration: R:/doc/24SponsorStatus/PresentationsAndModels/04.Borg-RiverWare/ArborBasinConfig.xml
- Search Directory: R:/doc/24SponsorStatus/PresentationsAndModels/04.Borg-RiverWare
- Model: ArborBasin.mdl
- Maximum Evaluations: 20
- Initial Population: 5
- Decision Variables: 5
- Metrics: 0
- Objectives: 4
- Constraints: 0

The "Execution" section shows the search type set to "Standard". A progress bar is at 100% with the state "Completed Successfully". A "Start" button is visible. The execution timeline is as follows:

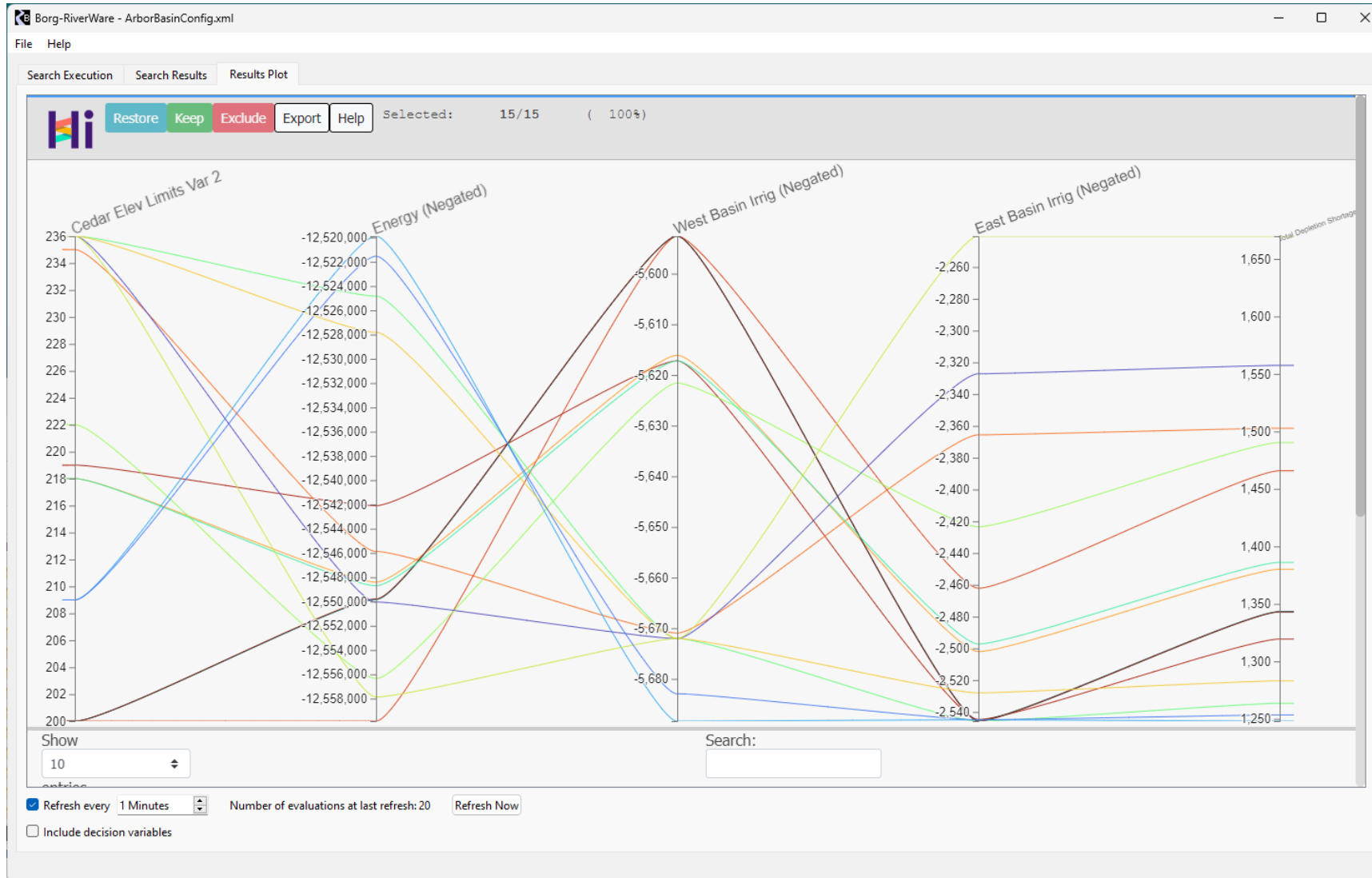
Start	Wed Jan 29 2025 11:38:57	Finish	Wed Jan 29 2025 11:40:34
Elapsed	0:01:37	Evaluations	20 of 20 (2 evaluations failed)
Non-dominated Solutions	15	Population Size	5

The "Log" section contains the following text:

```
***** Completed Borg step 10 (1 function evaluations in step)
Saved search to SearchOutputs/StudyState.txt.

Search execution complete.
```

Execute the Search



Future of Borg-RiverWare

- **Goal:** easy and effective for any RiverWare user
- **Initial public release**
 - Licensing
 - Documentation and examples
 - Installation