Hazen

waterSMART
Water Management Solutions

South Saskatchewan River Operations Model (SSROM)

Model Training Workshop: Day 1

March 2022
A. Michael Sheer

Introduction and Welcome

Project objectives and schedule review

Training Agenda: SSROM Planning Model

Day 1: Platform & Model Overview, Data & Assumptions Review

1. Introduction & Welcome
   - **a)** Agenda Review
   - **b)** Project Objectives
   - **c)** Training Objectives
2. Model Platform (OASIS) Refresher
   - **a)** Glossary
   - **b)** Interface elements
3. Model Schematic Overview
   - **a)** Elements of the Schematic & OASIS Function
   - **b)** Extent of Model & Schematic Demo
4. SSROM Input Data and Assumptions Review
   - **a)** Naturalized Inflows
   - **b)** Irrigated Demands
   - **c)** Large Municipal Demands
   - **d)** Remaining non-irrigation demands
   - **e)** Time of Travel
   - **f)** Physical Constraints
5. [Coffee Break]
6. SSROM Operations – General
7. SSROM Operations – Red Deer
   - **a)** Red Deer Model Demo
8. SSROM Operations – Bow
   - **a)** Bow Model Demo
9. SSROM Operations – Oldman and Southern Tribs
   - **a)** Oldman & Southern Tibs Demo
10. SSROM Operations – Combined Model
    - **a)** Combined Model demo
11. Future Opportunities for SSROM
12. Questions & Closing Comments

Project Objective

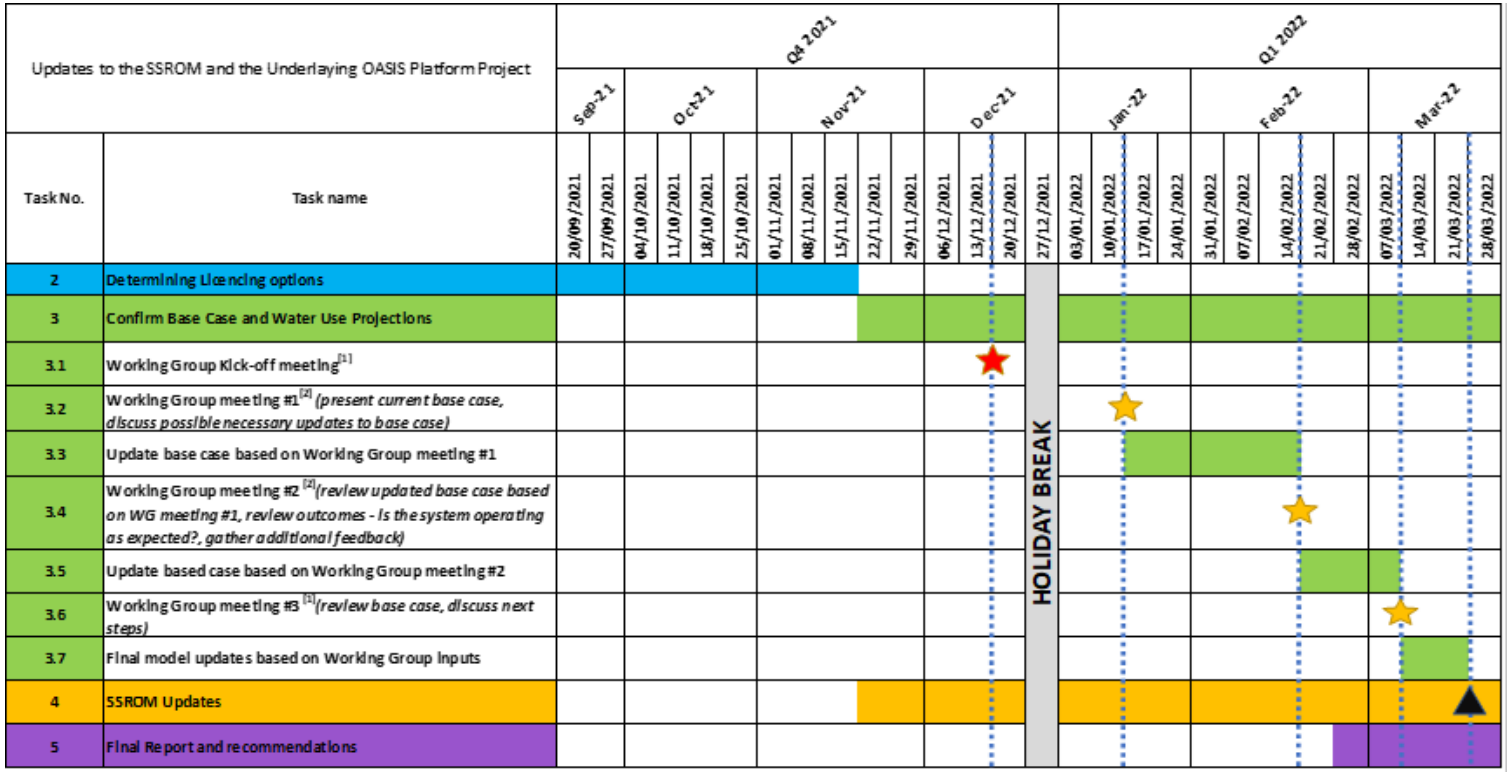
SSROM Model and Platform Updates Project

1. **Update the SSROM base case** so that it is reflective of how the system operates today
   - Update model assumptions and naturalized flows and validate with the GoA and irrigators
   - Ensure that the SSROM stakeholders have an accessible, up to date, facilitation tool

2. Update the SSROM model from **OASIS to OASIS Enterprise**
   - Upgrade the SSROM software to the latest version to increase functionality

3. Ensure that the SSROM is **accessible** to stakeholders
   - Establish options for hosting the model to ensure stakeholders have access to the model and the collaborative process is preserved

Project Schedule



Note:

- [1] Working Group Kick-off Meeting and Working Group meeting #3 will be held with all Working Group participants.
- [2] Working Group meetings #1 and #2 will be held in parallel streams.

SSROM Training Session Objectives

South Saskatchewan River Operations Model

- In order to understand and be able to gain the full benefits from the SSROM model, two specific training sessions and a thorough report are under preparation.
- Training goals are two-fold:
  - **Day 1 (Basics Training) is intended to give attendees a thorough understanding of the contents & assumptions of the model, how it operates, and a good sense of the types of analyses it is well suited to**
  - **Day 2 (Practitioner Training) is intended to educate participants in how to directly interact with the simulation, formulate and prepare scenarios, and interpret results. It will also go into more depth about the underlying linear solver and how it works.**
- Following training attendees will be well suited to contribute to on-going collaborative planning efforts with the model and, in the case of “Practitioner” attendees, contribute to the direct programming and analysis of planning scenarios
- These slides, a recording of the training, and a report will be available for review after these sessions

SSROM Training Day 1 Session Objectives

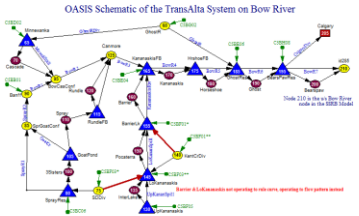
South Saskatchewan River Operations Model

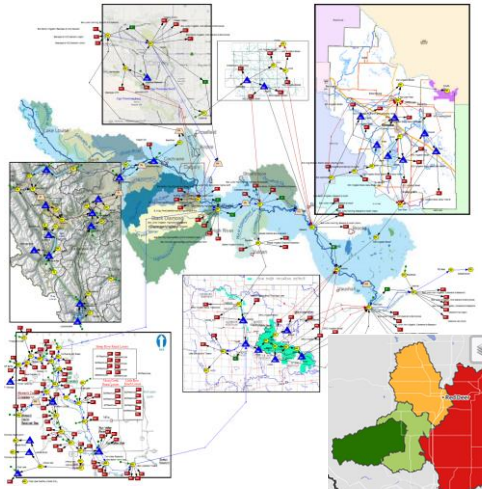
1. Review data and assumptions in the model
2. Explore the model's capabilities
3. Ensure alternative analyses are comparable
4. Describe future model opportunities

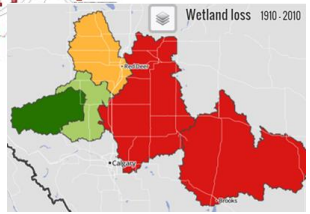
OASIS Platform

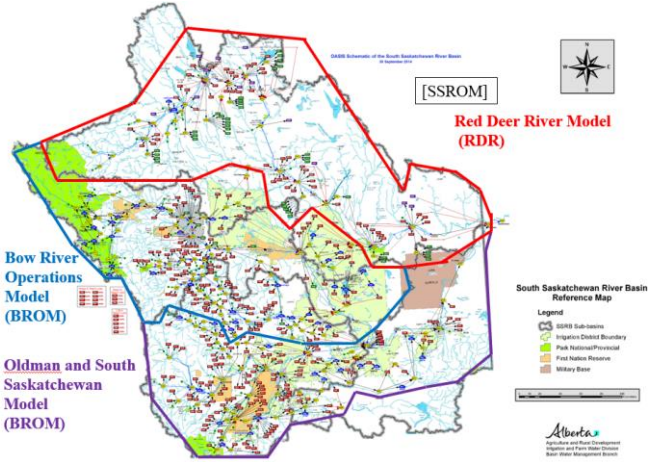
Key terms and general platform notes

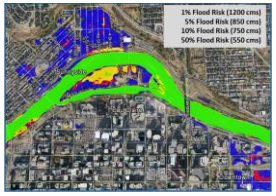
OASIS in Alberta

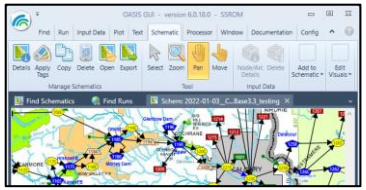












2005
Bow River Academic Exercise

2010
Bow River Operational Model

2011
Bow River Drought Exercise

2012
Bow Climate Change Analysis, Oldman River Ops Model

2014
Red Deer River Operations Model Land Use & Climate Analysis

2015
S. Sask Watershed Roadmap

2016-2020
Bow River Flood Operation Support Tool, Continuing Analyses

2020
St. Mary Irrigation District Decision Support Tool

2021-2022
S. Sask Model Enterprise Upgrade

20XX
Additional collaborative planning?

20XX
Expanding SSROM to include additional basins?

Key Terms

These change output

Operating Logic: A specific set of operations and logic that dictates how the model simulates the system. This could be the **Current Operations**, or new alternative operations that attempt to improve performance toward a specific measure. See also**: Alternative.**

Input Set: A specific set of input data that establishes the conditions under which operations function.

Example of input sets include**:** IJC entitlement flows, 2018 IDM demands, 2022 naturalized flows

This does not

Performance Measure (PM): A metric (graph, table, etc.) used to distinguish performance between alternatives or runs at meeting a specific goal. These measures should be able to distinguish whether a run is better or worse that the **Current Operations** and/or other **Alternatives**.

Key Terms

Scenario: A model simulation comprising of one **Input Set** and one **Operating Logic**.

These change output

Operating Logic:

Input Set:

This does not

Key Terms

Extended glossary available

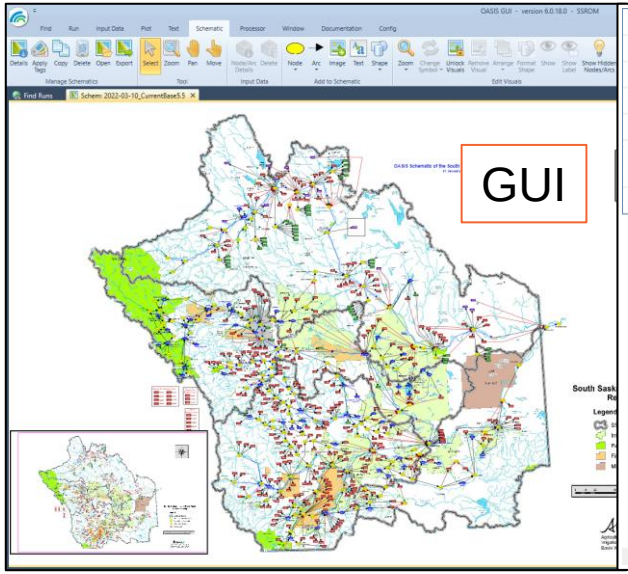
Current Base Operations: The baseline model **Operating Logic** that represents current operations. These are the starting point from which alternatives are developed with new or potential operations that target specific PM improvement. The Current Base operations do not imply a specific **Input Set**, only that the operations reflect current "real world" operations. Current Base operations should be run against each input scenario to allow for reliable comparisons of performance.

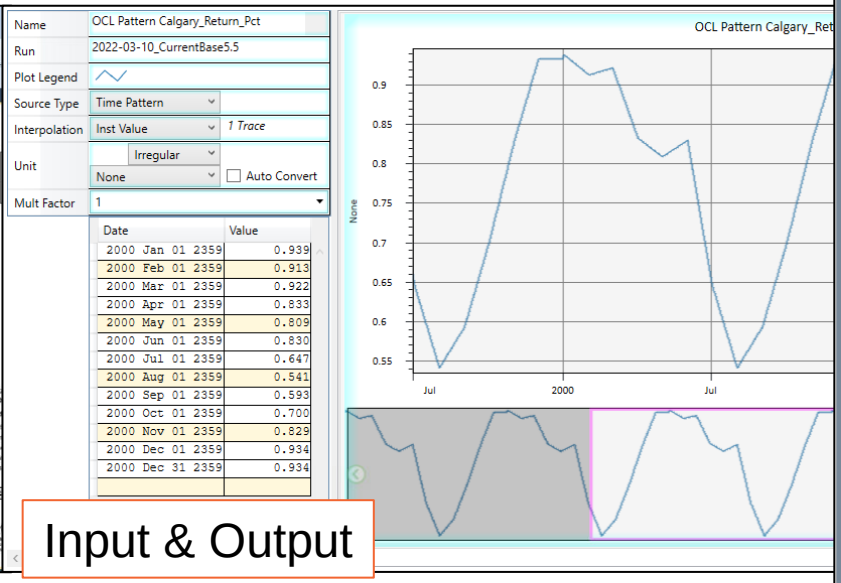
Version: A number representing the current edition of the model. If bugs or errors in the code are corrected (or other improvements are made), the "**Current Base**" version will increment (i.e. increase by 1, from 1 -> 2 -> 3). Alternatives should be re-run or redeveloped in the current "version" of the model to ensure that performance differences between runs are not the result of such bugs or code errors.

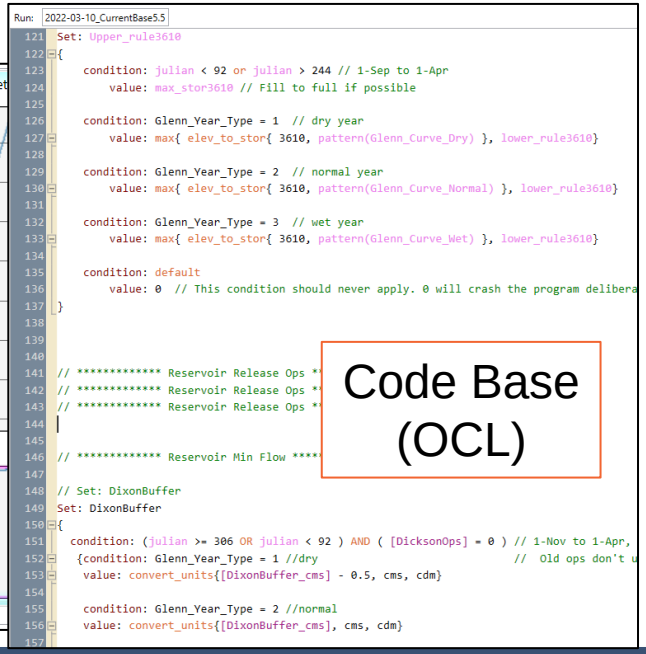
Platform Refresher

Operational Analysis and Simulation of Integrated Systems

- OASIS is the Planning Model Platform
  - **OASIS is like Microsoft Word, the SSROM is like a Word document**
- Suite of programs for modeling the operations of water resources systems. In OASIS Enterprise these are rolled into one database utility with multiple capabilities
- Emphasis is on reservoir operations







OASIS Overview

Operational Analysis and Simulation of Integrated Systems

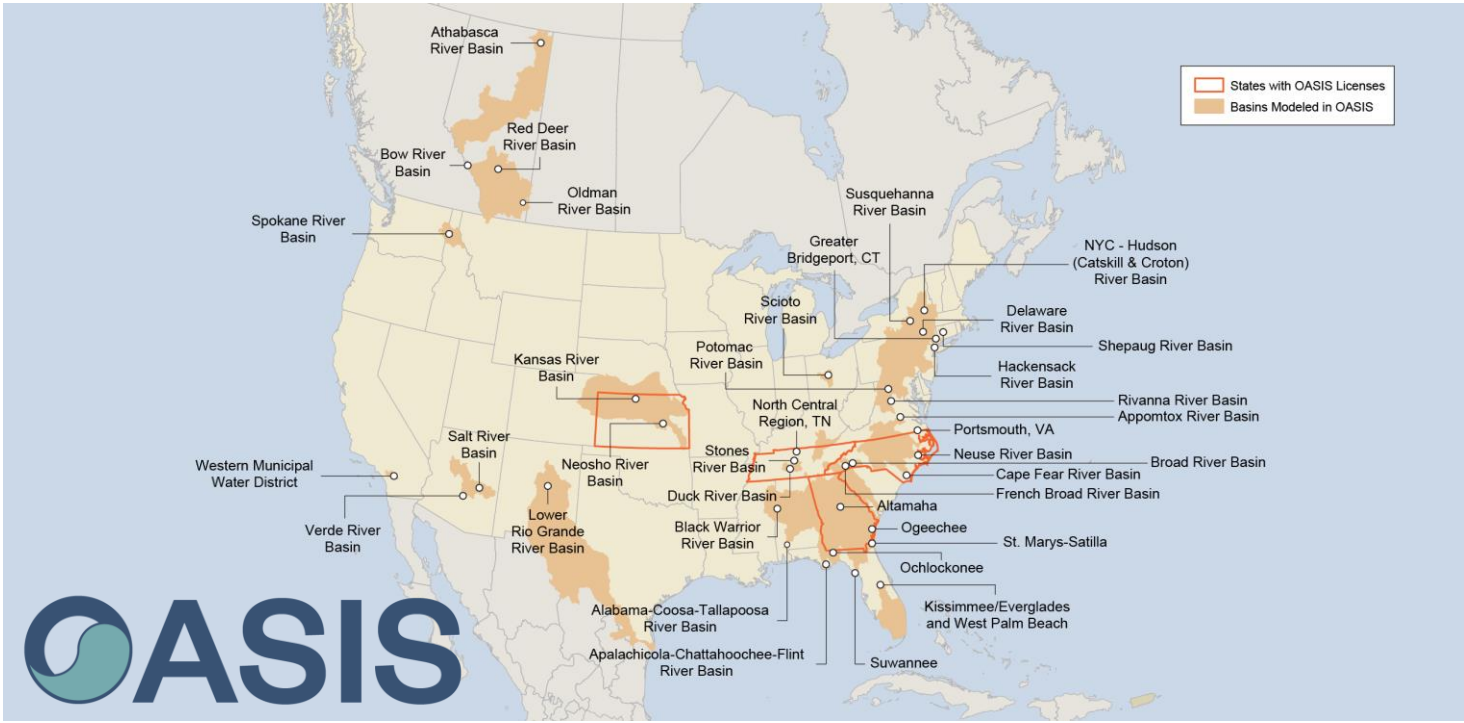
- A mass balance water accounting model
- Captures physical elements and operating rules of the system
- Typical Applications

River Basin Management

Water Supply

Hydropower

Conflict Resolution



Platform Refresher

Purpose of OASIS

- OASIS models give you solutions to modeling problems
  - **OASIS helps you organize data and simulate operations**
  - **The platform is designed to help you think about problems comprehensively rather than as collections of parts**

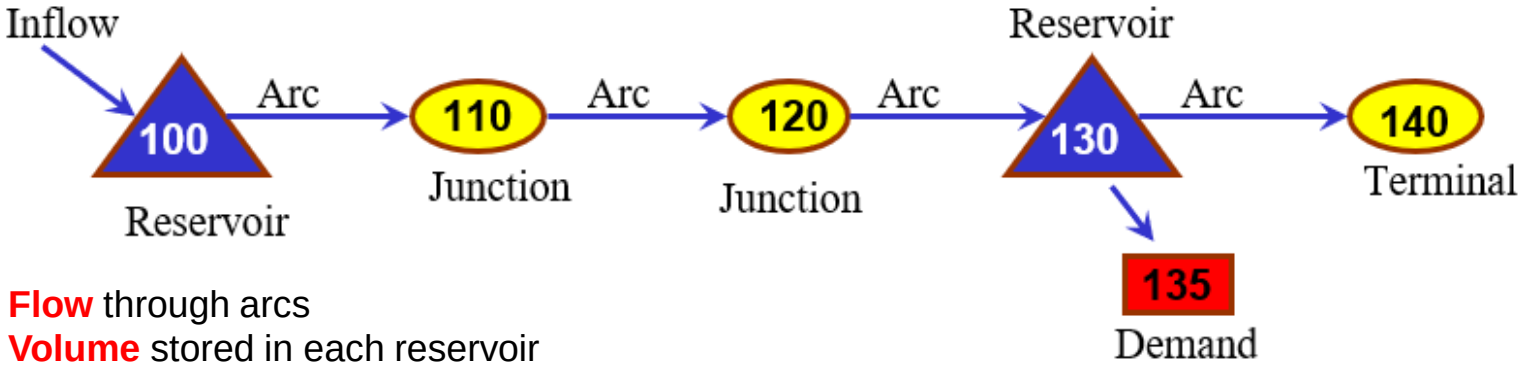
- OASIS models do **NOT** give you solutions to real-world problems
  - **You create the solutions**
  - **The model lets you evaluate them**

SSROM Schematic Review

How to read and demo

South Saskatchewan River Operations Model (SSROM) Platform

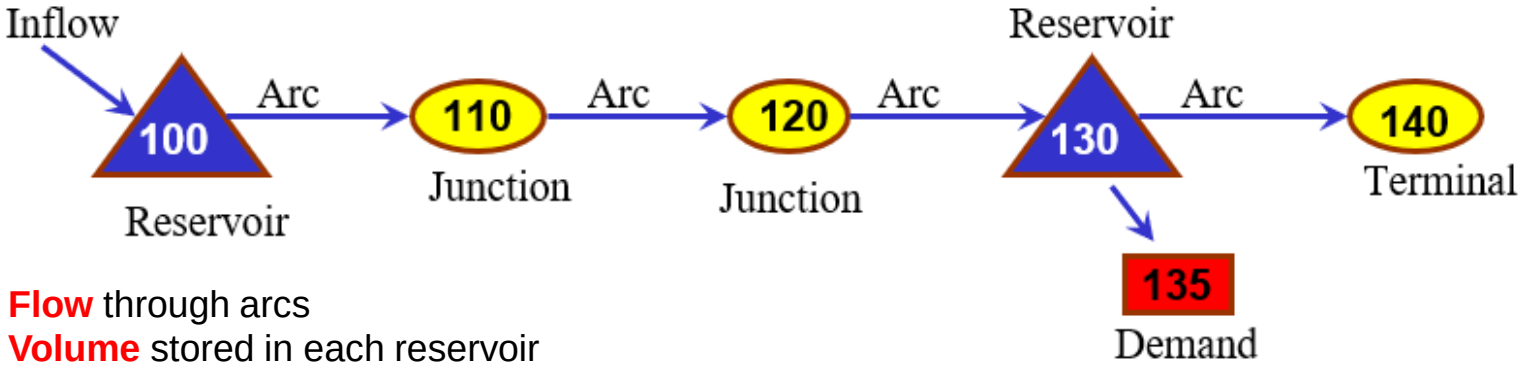
Structure and components



Flow through arcs
Volume stored in each reservoir
Delivery (volume) allocated to each demand node
… calculated every timestep for the period of record

South Saskatchewan River Operations Model (SSROM) Platform

Structure and components



Flow through arcs
Volume stored in each reservoir
Delivery (volume) allocated to each demand node
… calculated every timestep for the period of record

But the secret is…

A **linear programming solver**

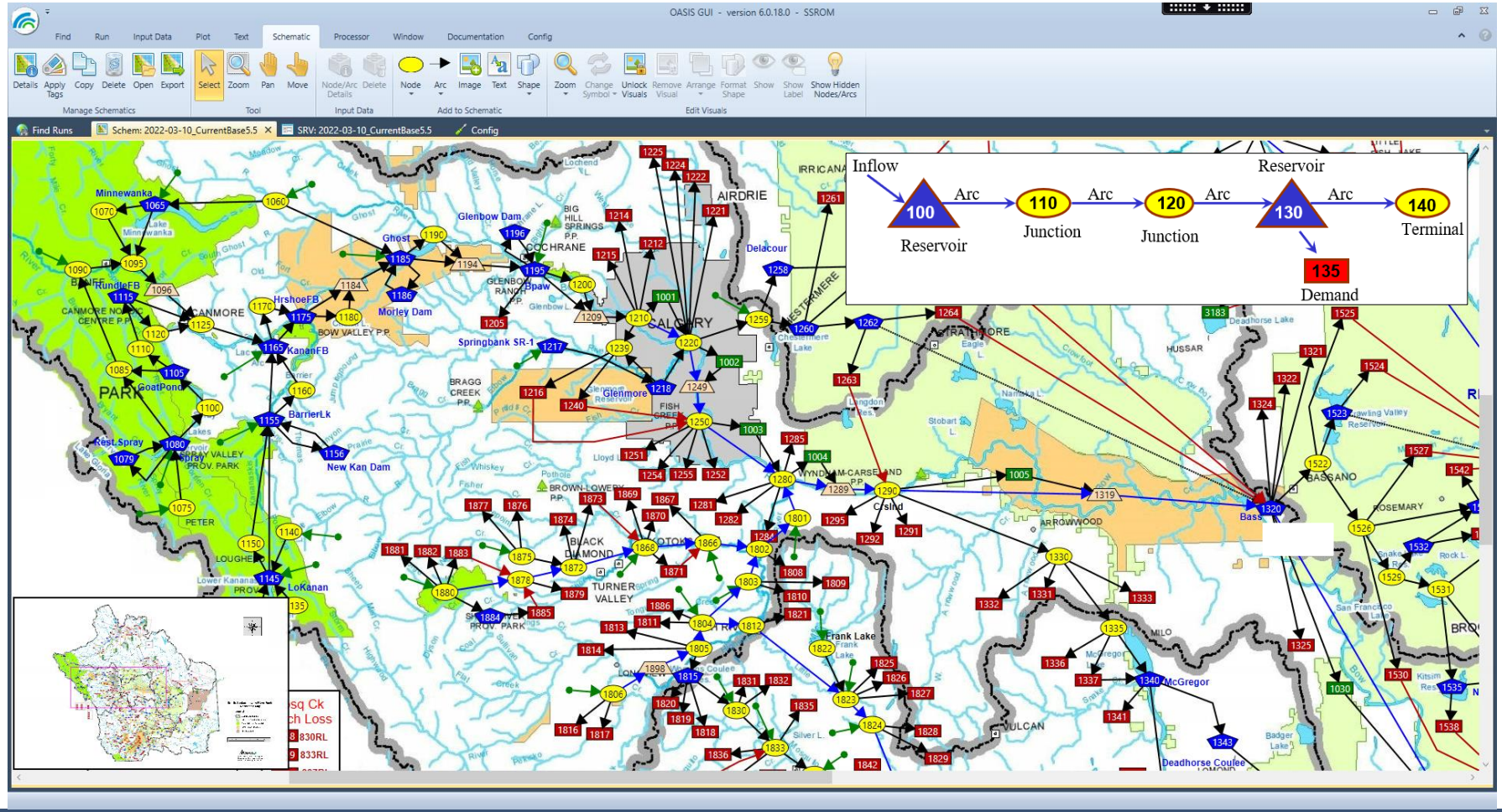
called every time step

Constraints: rules that OASIS must obey
Goal: rule that OASIS tries to meet

You specify ***what*** to do but don't have to tell OASIS ***how*** to do it.

The solver is a "smart operator" who obeys the laws of physics (and other specified constraints).

Graphical User Interface (GUI) Demo



SSROM Data

Input Data and Assumptions

Data Set Overviews

Inflows

- Source: AEP Naturalized Streamflow dataset (2009 dataset with a 2010-2015 extension)
- Disaggregated to a daily level from weekly data

Reservoir Net Evaporation

- Precipitation and Evaporation from AEP dataset combined to net evaporation in inches
- Applied to each reservoir based on area-elevation relationship

Physical data

- Reservoir and canal/pipe physical information (SAE & flow limits) from operator's datasets

Non-Irrigation Demand

- Pattern data from Alberta Environment and Park's Water Resources Management Model (WRMM)
- Assumed full license demand
- Some individual licenses in the Red Deer

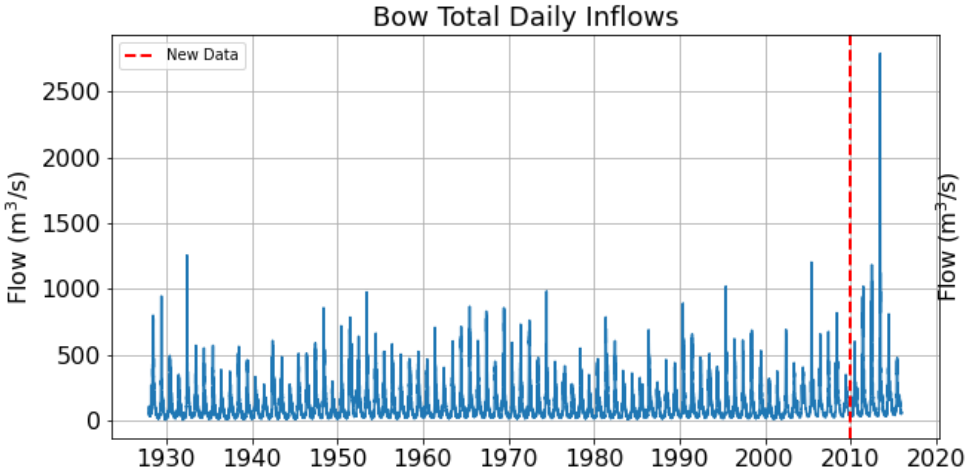
Irrigation Demand

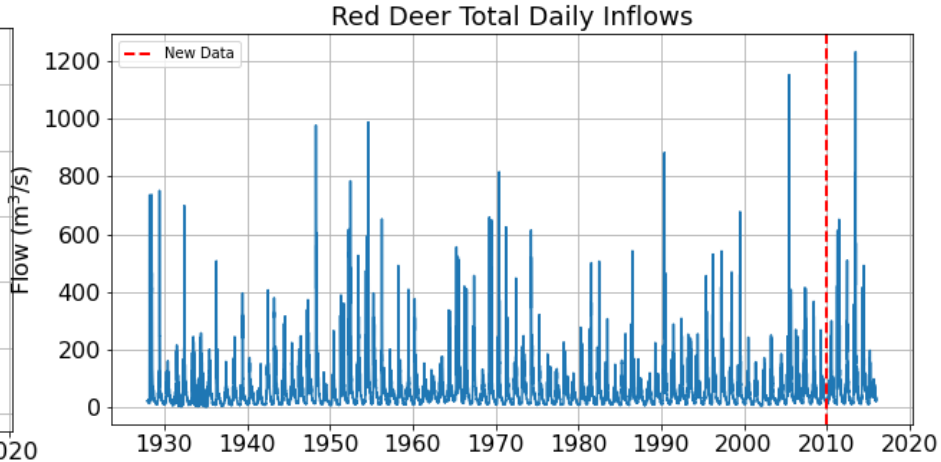
- Alberta Agriculture's Irrigation Demand Model (IDM)
  - **2018 Acreages and crop allocations**
  - **Reports 90% of ideal crop demand based on historical conditions**
  - **Acreages scaled up to 2020 assessed acres**
  - **Includes seepage and evaporative losses**

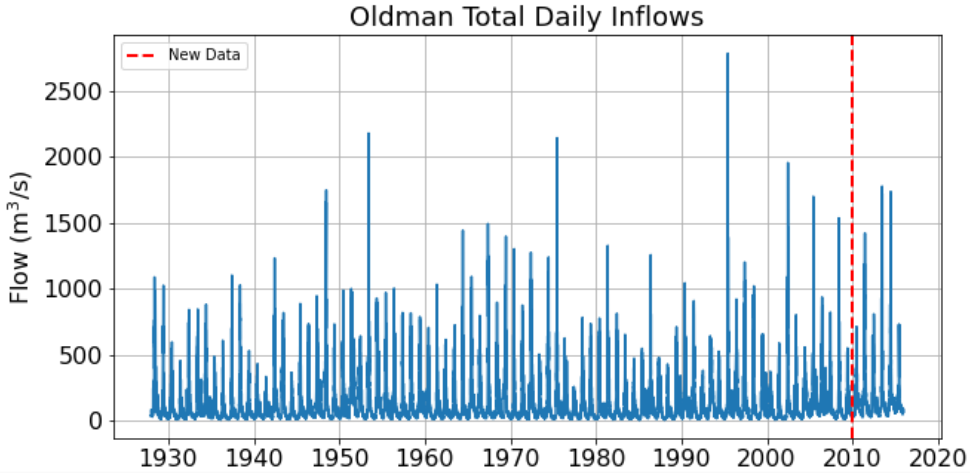
Municipal Demand

- Demand for the largest municipal users has been manually entered (e.g. Calgary, Lethbridge, etc.)

Data Sources: Naturalized Inflows



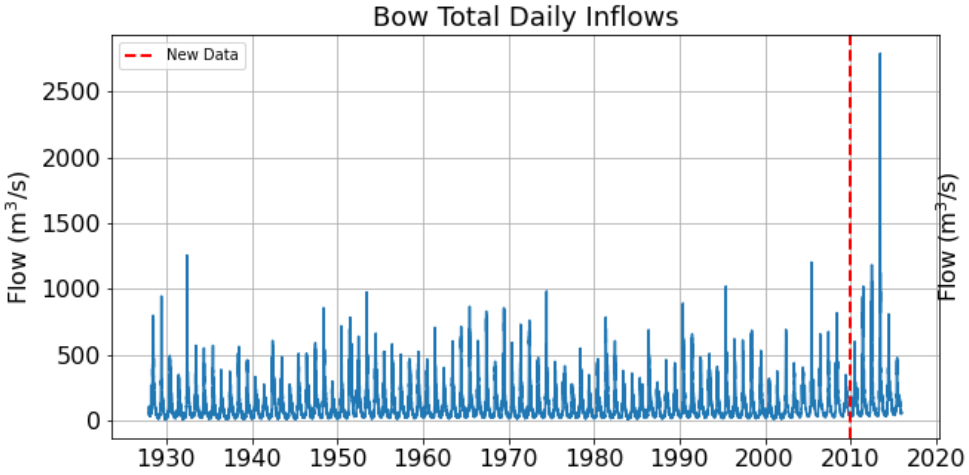


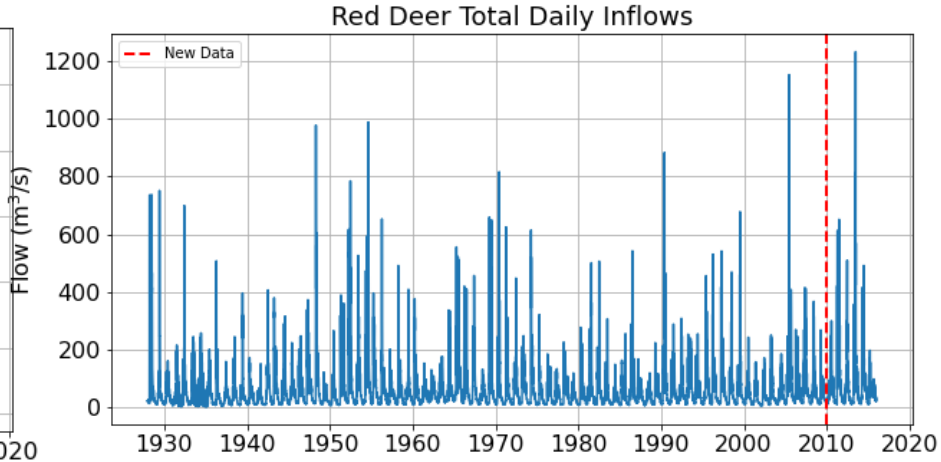


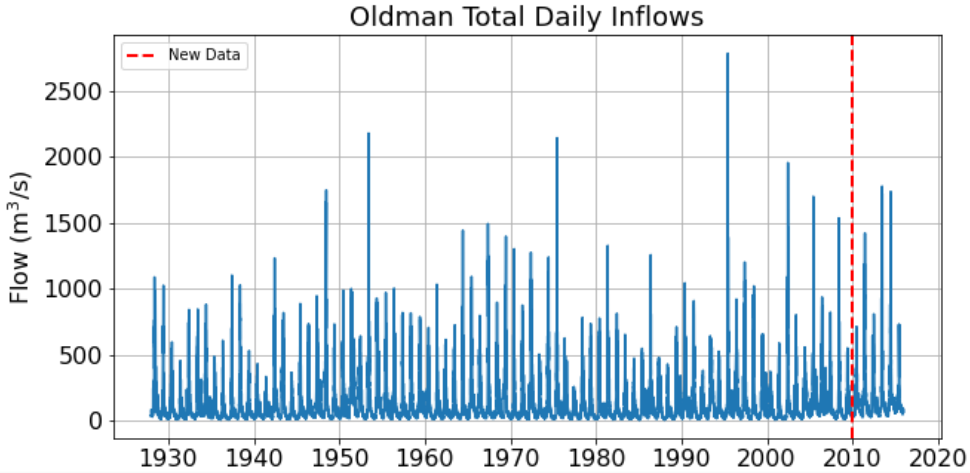
Weekly provincial data disaggregated to daily via comparison to nearby daily observed gages

Net evaporation 1928 – 2009 based on historical data, 2010-2015 based on estimated patterns

Data Sources: Naturalized Inflows







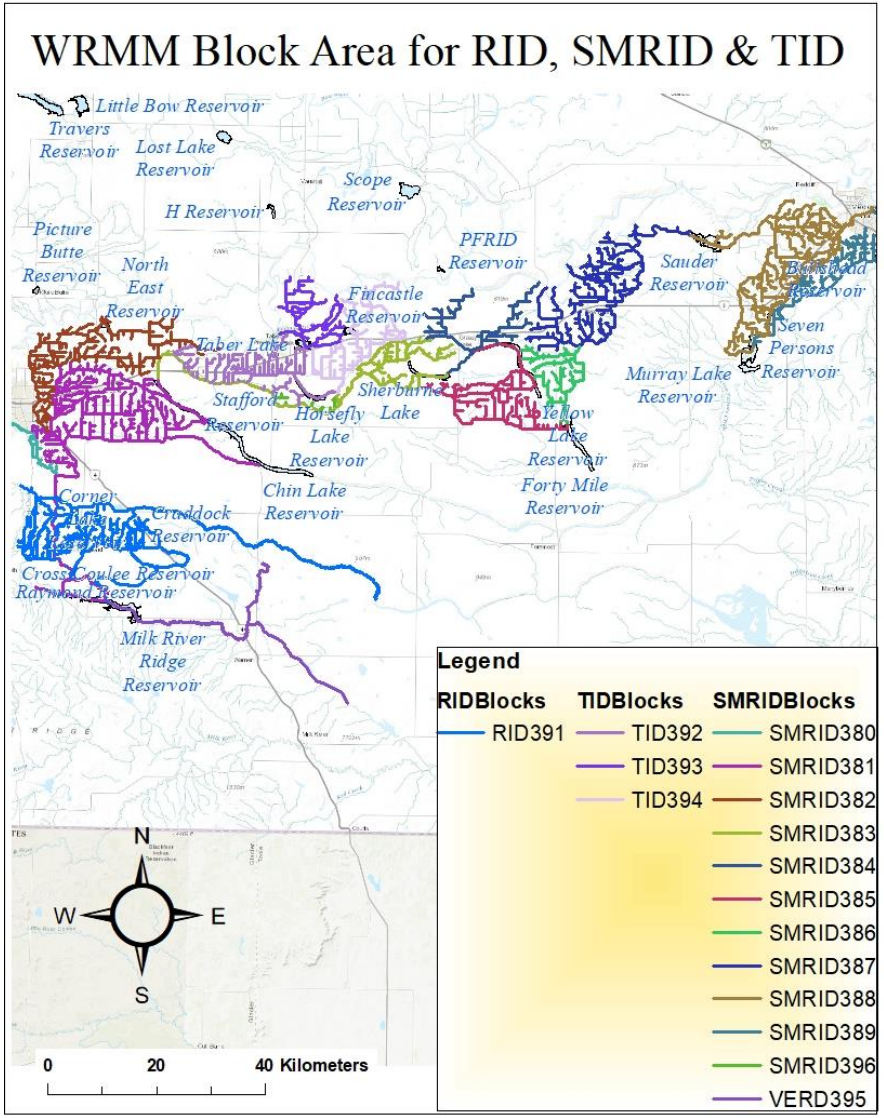
Weekly provincial data disaggregated to daily via comparison to nearby daily observed gages

Net evaporation 1928 – 2009 based on historical data, 2010-2015 based on estimated patterns

Data Sources: Irrigated Demands

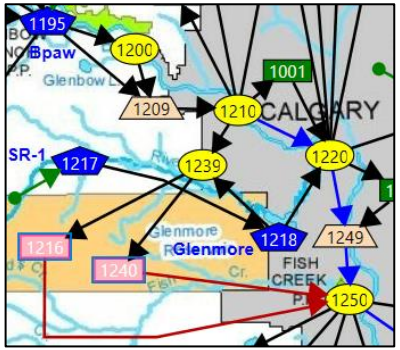
- Demands are generated from the Irrigation Demand Model
  - aka IDM
  - Represent 90% of ideal flow
  - Scaled up to 2020 assessed acres, including annual agreements
  - Evaporative and seepage losses are included

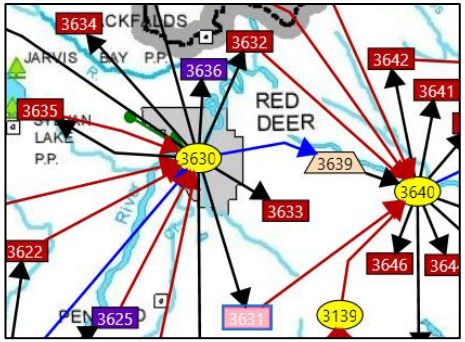
Irrigation District	2018 (IDM hectares)	2018 (IDM acres)	2020 assessment roll acres[1]	Acre change	% change
Bow River basin					
BRID	100,407	248,110	279,441	31,331	12.6
EID	122,941	303,793	307,588	3,795	1.2
WID	36,756	90,826	95,000	4,174	4.6
Oldman River basin					
LNID	75,718	187,103	195,063	7,960	4.3
MID	7,418	18,330	18,300	-30	-0.2
MVID	1,482	3,663	3,647	-16	-0.4
RID	18,357	45,360	48,095	2,735	6
SMRID	156,166	385,894	410,772	24,878	6.4
TID	32,934	81,382	90,347	8,965	11
UID	13,894	34,333	34,797	464	1.4

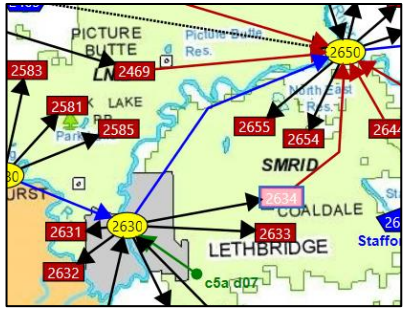


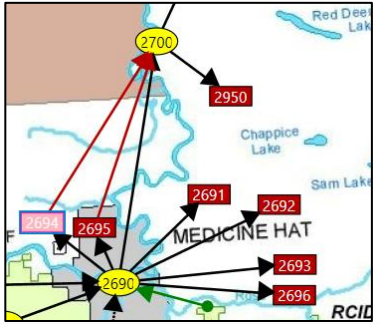
Data Sources: Large Municipal Demands

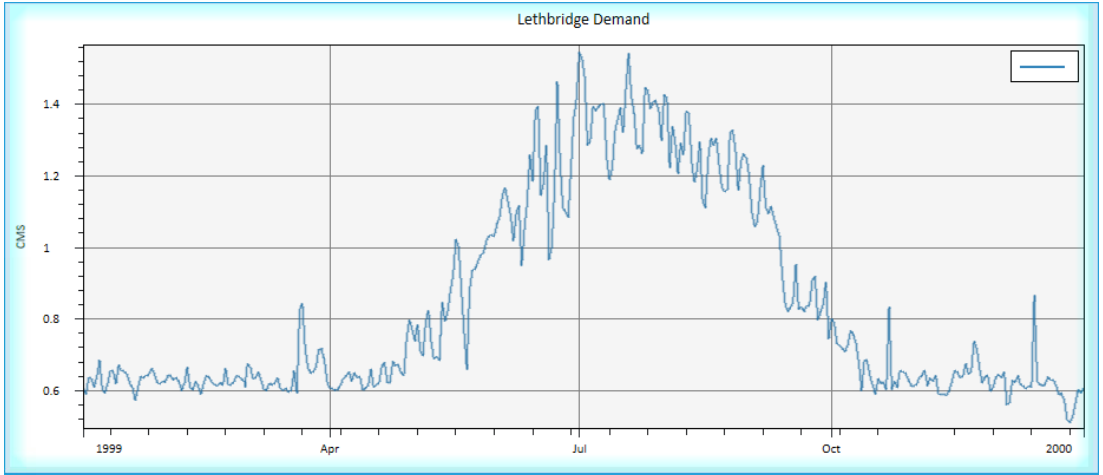
- Large municipal demands
  - Red Deer*, Calgary, Lethbridge, and Medicine Hat
  - Manually entered based on actual use and returns
  - Repeating annual patterns

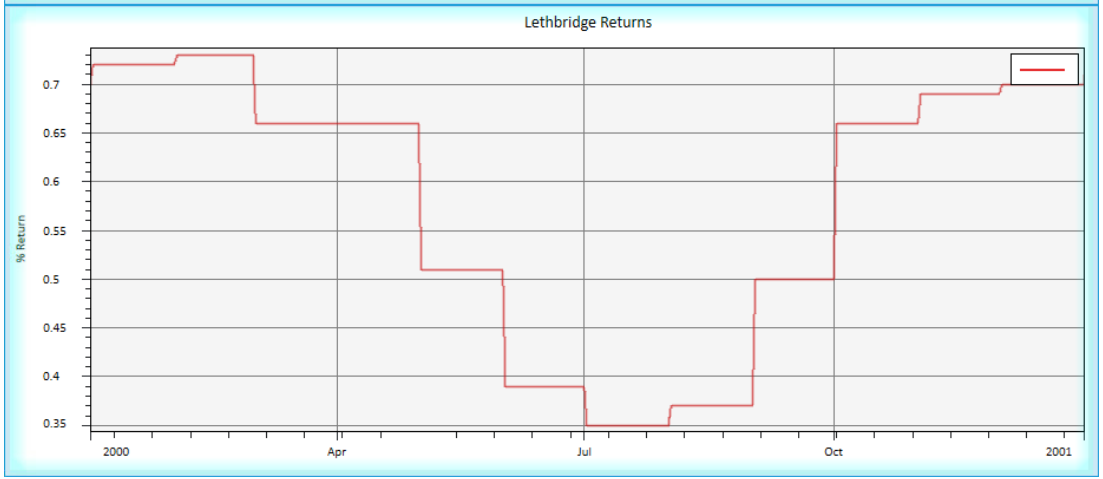




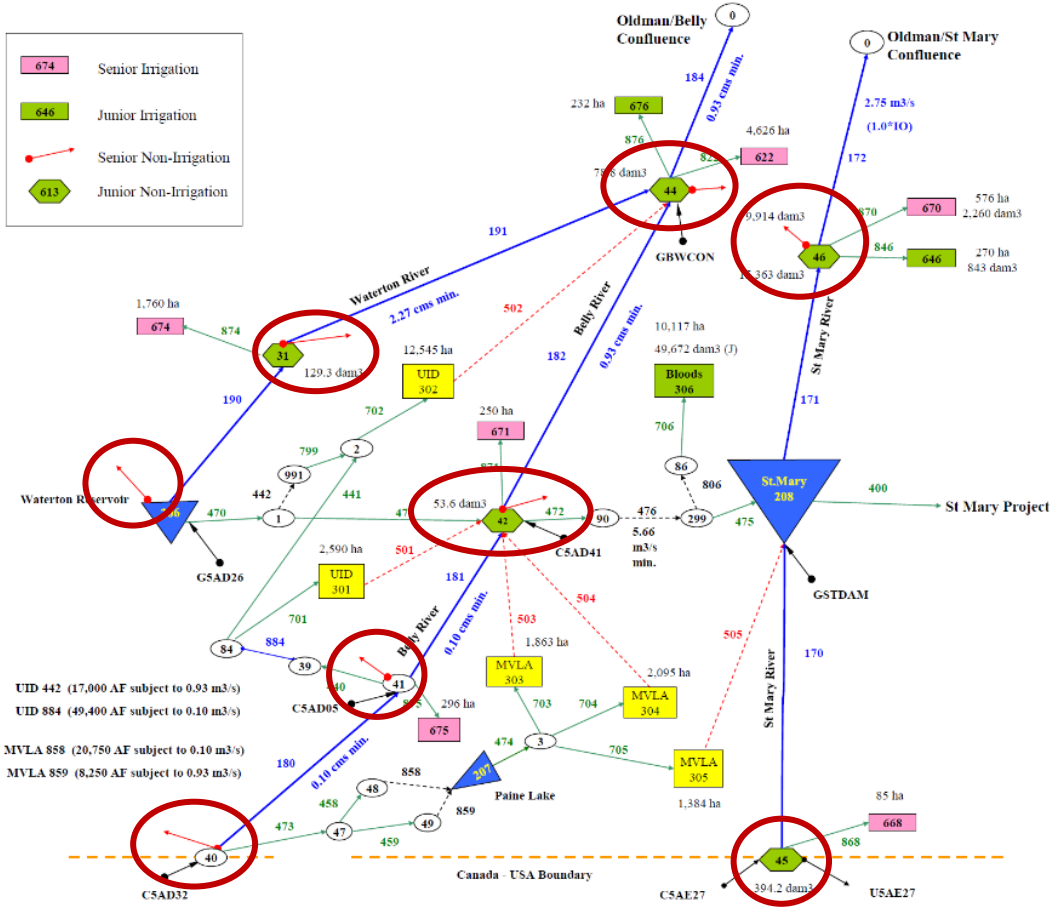








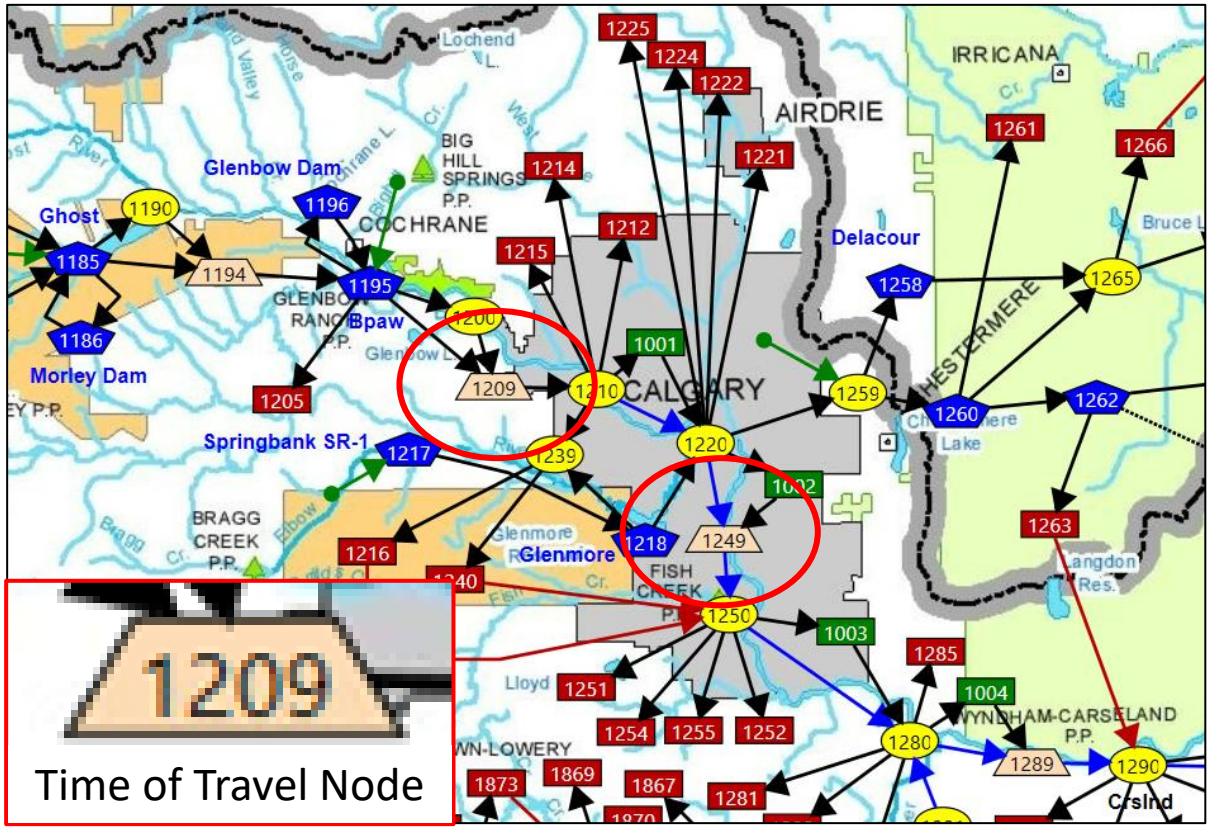
Data Sources: Additional Non-Irrigation Demands



- Remaining non-irrigation demands are sourced from the AEP WRMM models
- Assume full license allocation and use at all times
- Comparatively small volume relative to irrigation and large municipal together

In the case of the Red Deer River, this is applied to city use as well!

Data Sources: Time of Travel



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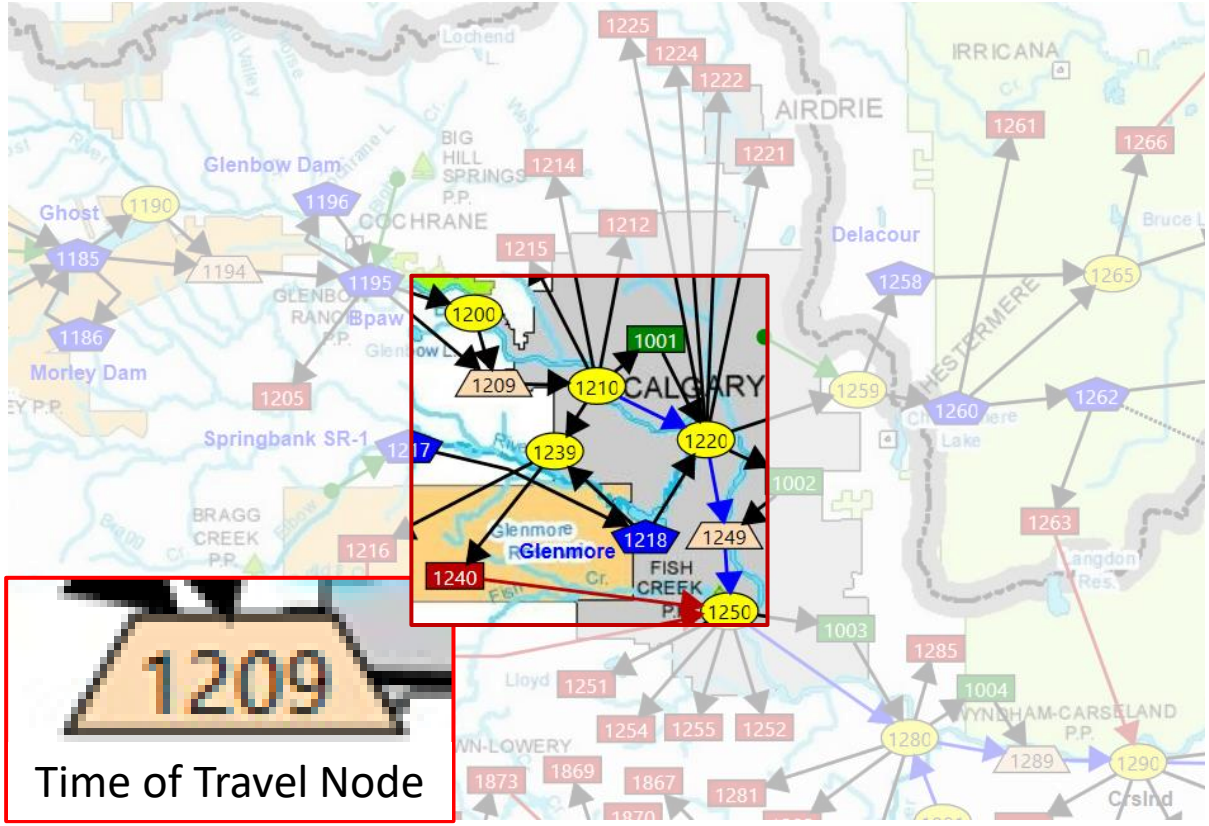
Time of Travel Node

SSROM leverages prior SSAR routing work, converting it into “Muskingum” routing coefficients.

Essentially:

1. Water travels within a reach within the same day
2. Some portion of the water is able to pass through within the same day (high flow portion)
3. Some portion will come through the second day
4. Some portion will travel the third day

Data Sources: Time of Travel



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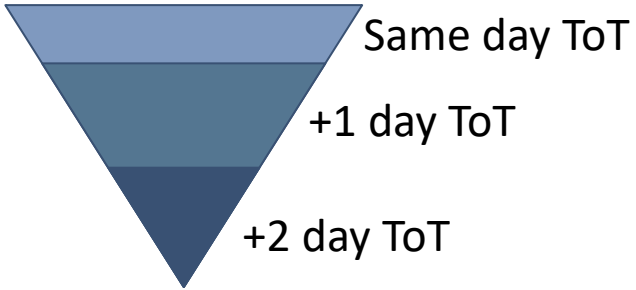
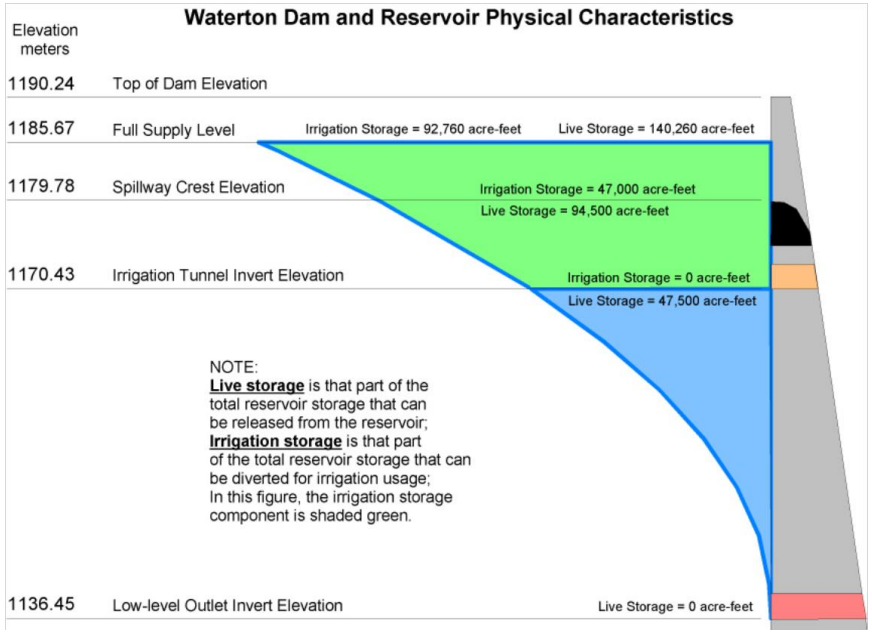


Data Source: Physical Constraints

Reservoirs & Canal Capacities

- Reservoir Storage-Area-Elevation Tables sourced from reservoir operators and IDs
- Canal physical capacities applied based on data from local sources
- Other physical data (e.g. generation capacities) described by operators or knowledgeable parties



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04/14	0.00
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10/15	70.00
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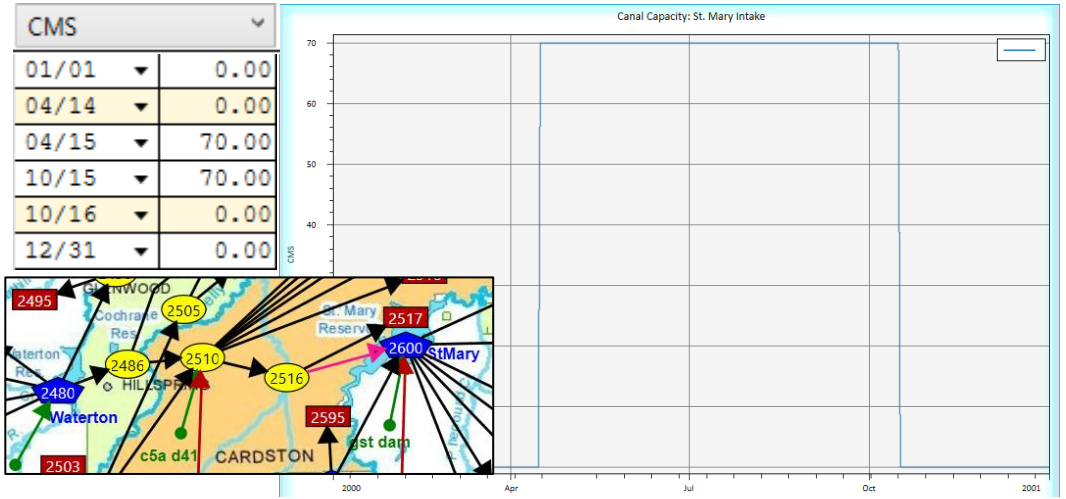
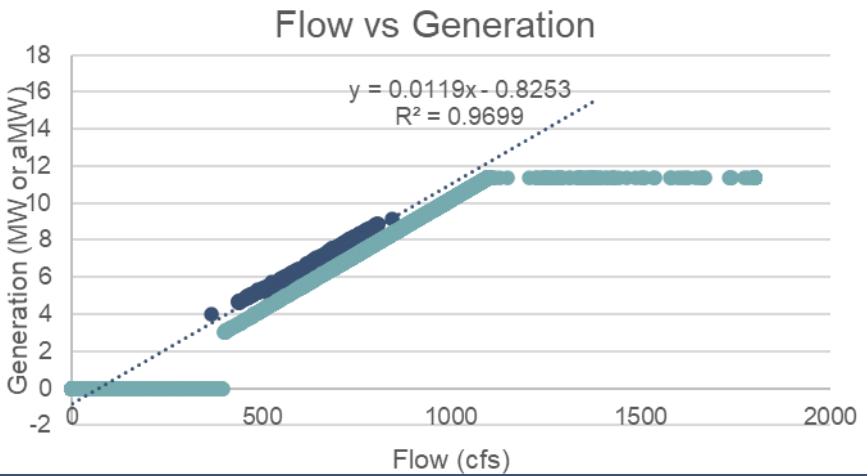




Break

Coffee and otherwise

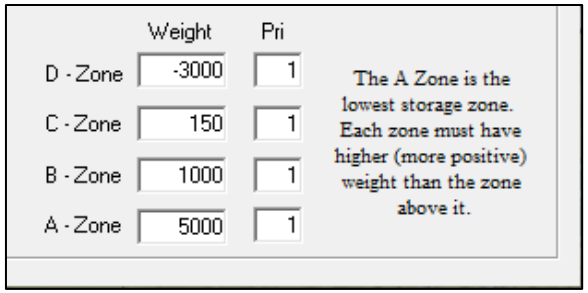
See you in 10 minutes!

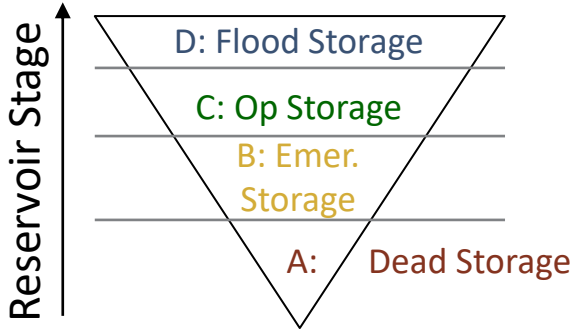
SSROM Operations

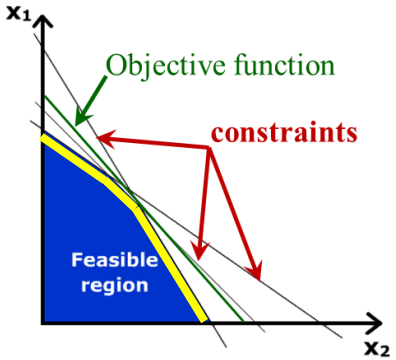
General OASIS Operations

Operations: OASIS Platform

- The modeler assigns a **weight** value to every operating goal in the model to construct the objective function
- The linear program (LP) solution scores **points** by multiplying the weight value by the value of the associated decision variable
- In every time step, OASIS determines the values of the decision variables by solving the LP
  - **The solution obeys every constraint**
  - **The solution is the set of decision variable values that gets the maximum number of points from the set of goals**







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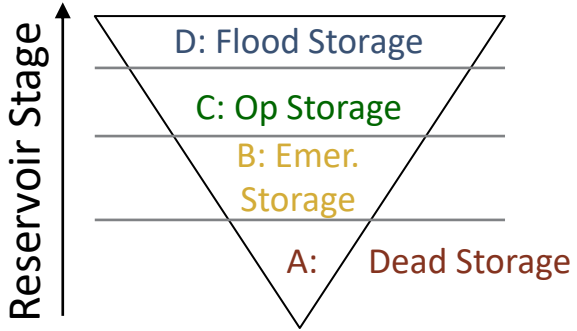
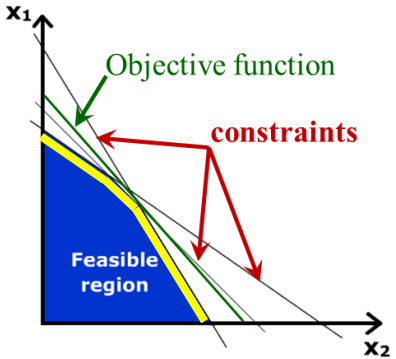
- In every time step, OASIS determin… …ision variables by solving the LP
  - **The solution obeys ev…**
  - **The solution… …able values that gets the maximum number of points from the set of goals**

OASIS has the user list priorities and then operates the system to meet those priorities

	Weight	Pri
D - Zone	-3000	1
C - Zone	150	1
B - Zone	1000	1
A - Zone	5000	1

The A Zone is the lowest storage zone. Each zone must have higher (more positive) weight than the zone above it.





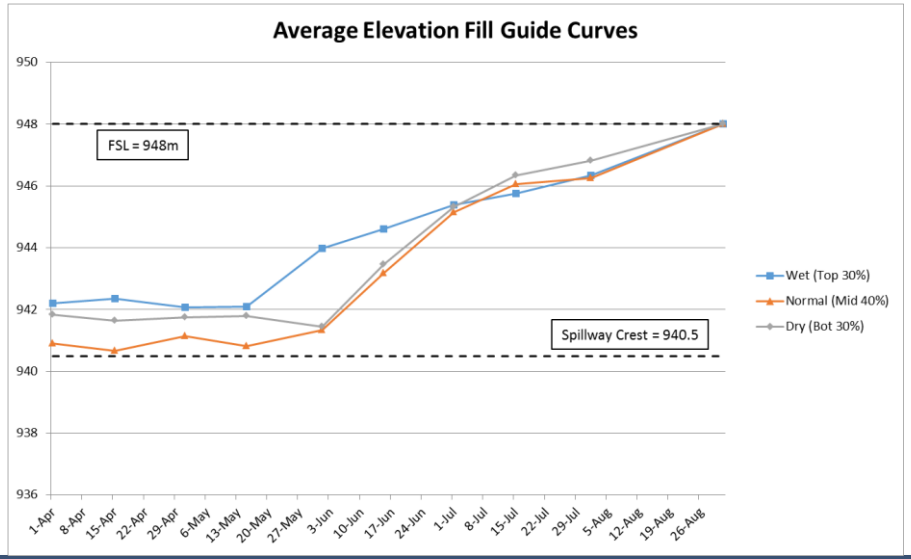
SSROM Operations

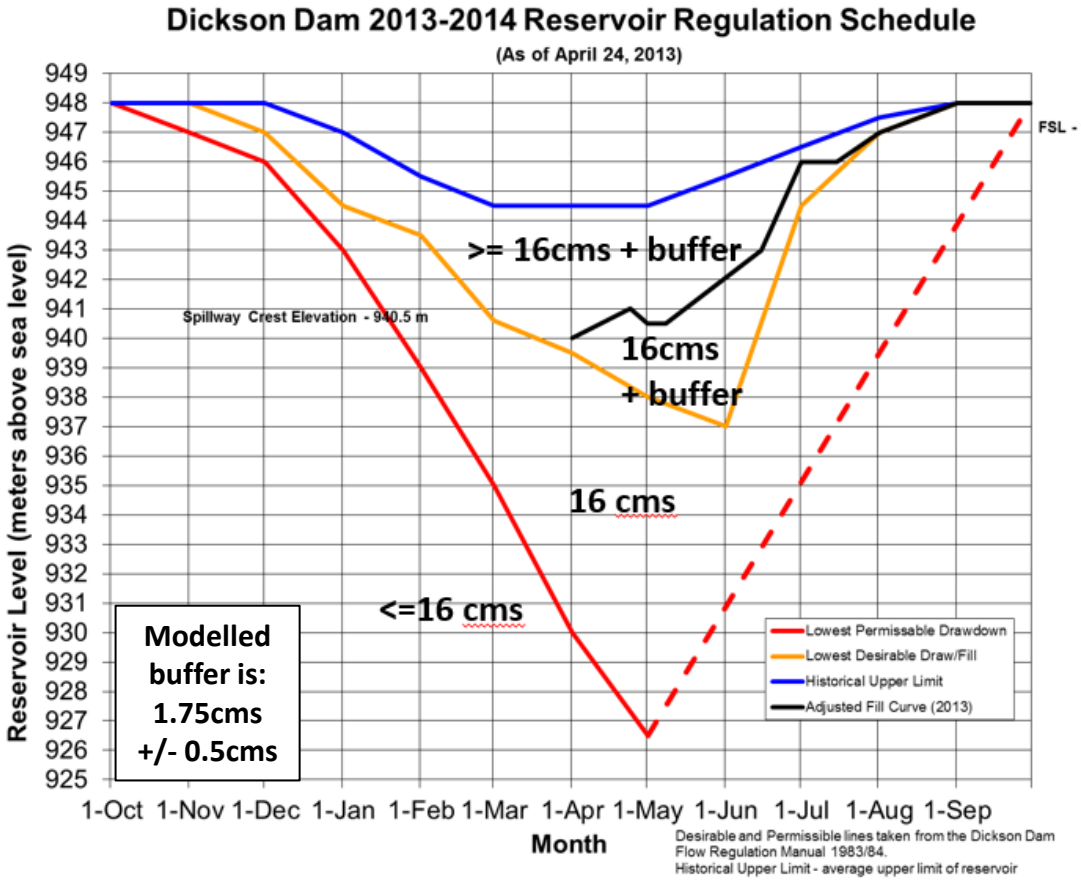
Bow River System (former RDROM Model)

Operations: Red Deer

Reservoirs: Dickson Dam

- Dickson fill curve is based on fill guide curves and inflow to date as of April 1st
- Releases are determined by stage
- Flood Releases use perfect knowledge and pre-release 3 days ahead of the flood



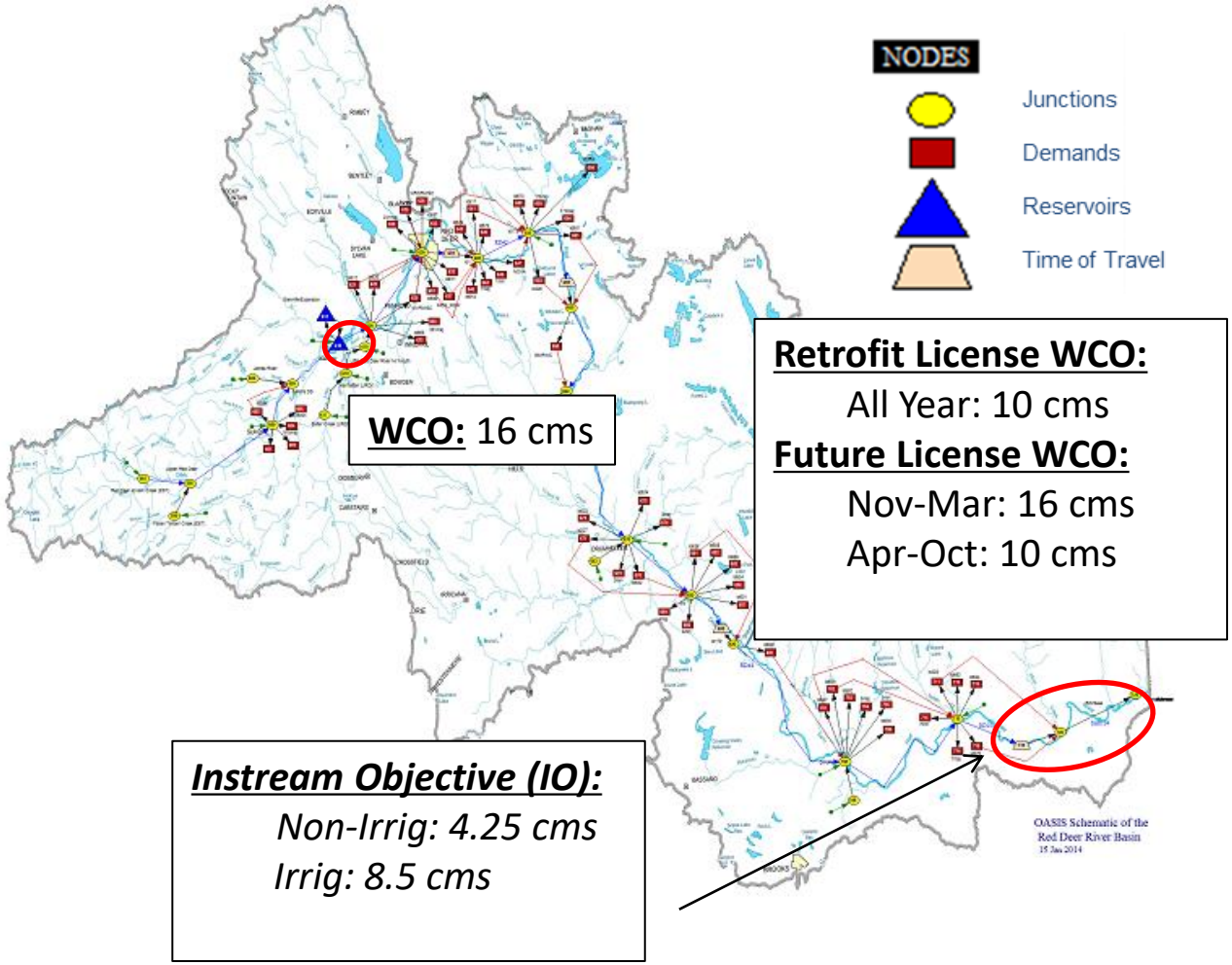


Forecasted Max Incoming Daily Flow	Pre-release Min Volume
> 300 cms	200 cms
200-300 cms	100 cms
100-200 cms	50 cms

Operations: Red Deer

Minimum and Target Flows

- WCOs are calculated weekly in two locations:
  - D/S of Dickson
  - Mouth of Red Deer
- All licenses presumed bound by IO, only new licenses bound by WCO
  - Vesta, TDLs, and "future" uses



Operations: Red Deer

Shortage Distribution: By License Priority

License Holder	Type	Max Ann Allocation (m^3)	Sum of Returns	% Return
ALBERTA ENVIRONMENT AND WATER - WATER OPERATIONS		54,672,490	0	
DUCKS UNLIMITED CANADA, EDMONTON		28,353,090	0	
CITY OF RED DEER	URBAN	27,546,640	24,775,650	89.94%
ALBERTA ENVIRONMENT AND SUSTAINABLE RESOURCE DEVELOPMENT		26,339,770	0	
NOVA CHEMICALS CORPORATION		23,858,690	2,090,750	8.76%
HEARTLANDS (Frmr: ATCO ELECTRIC LTD)	COOLING	22,075,490	8,387,680	38.00%
NORTH RED DEER RIVER WATER SERVICES COMMISSION	URBAN	13,391,000	0	
MOUNTAIN VIEW REGIONAL WATER SERVICES COMMISSION	URBAN	9,962,960	5,970,050	59.92%
SHIRLEY MCCLELLAN REGIONAL WATER SERVICES COMMISSION	URBAN	5,545,460	0	
VESTA		5,120,000	0	
ALBERTA ENVIRONMENT AND WATER - WATER OPERATIONS	CROP	4,594,940	0	
MEGLOBAL CANADA INC.		4,593,950	1,192,770	25.96%
TOWN OF DRUMHELLER	URBAN	4,107,490	3,285,990	80.00%
ALBERTA ENVIRONMENT AND WATER - WATER OPERATIONS	FLOODCNT	3,034,360	0	
EXXONMOBIL CANADA LTD.		2,466,960	0	
DOW CHEMICAL CANADA ULC		2,305,000	829,800	36.00%
CONOCOPHILLIPS CANADA RESOURCES CORP.		2,033,100	0	
SPECIAL AREAS BOARD	STCKWT	1,599,819	0	
SHELL CANADA LIMITED		1,493,730	0	
SPECIAL AREAS BOARD II		867,390	124,580	14.36%
TOWN OF SUNDRE	URBAN	249,145	199,316	80.00%
MOUNTAIN VIEW COUNTY	FISHERY	43,170	0	

Temporary Diversion Licenses (TDLS):

U/S of Red Deer:
12,865 cdm

D/S of Red Deer:
9,913 cdm

Represents roughly 75% of licensed volume in the basin

Operations: Red Deer

Shortage Distribution: By License Priority

WRMM broke licenses down into approximately 5 levels of seniority.

1. Senior Irrigation Blocks
2. Major Demand Blocks
3. Mid-License Irrigator Blocks
4. Junior Irrigator Blocks
5. Minor Demand Blocks

In SSROM, demands are split:

1. Senior Irrigation Blocks
2. Major Demand Blocks
3. ***Senior Licenses (with individual priorities)***
4. Mid-License Irrigator Blocks
5. ***Junior Licenses (with individual priorities)***
6. Junior Irrigator Blocks
7. Minor Demand Blocks

2009 Analysis

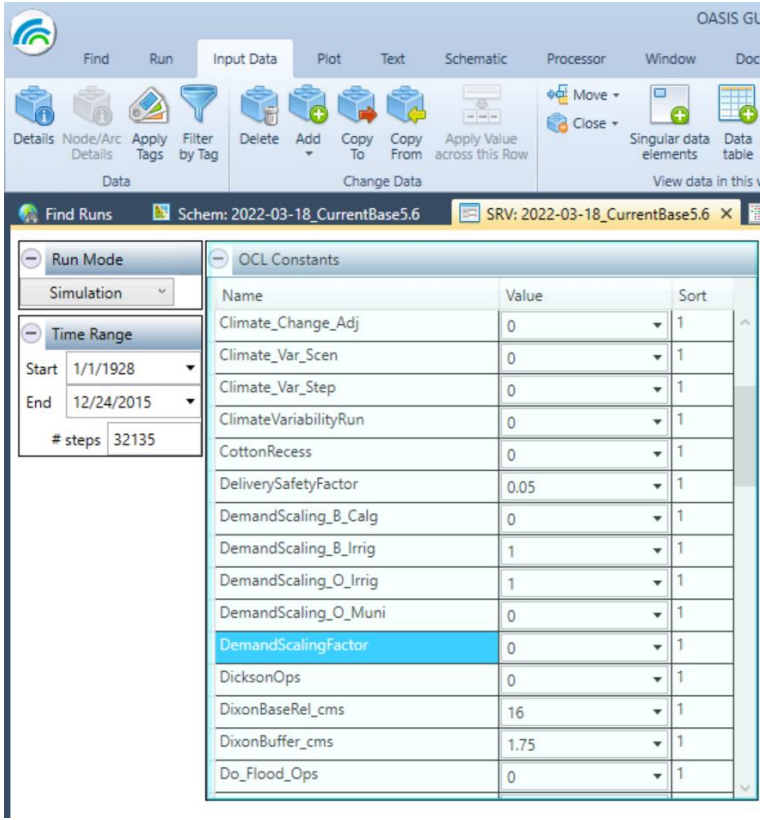
Average	Demand	Returns	Net Use
Indiv Licensed Dmds (72%)	239,428	24,234	214,304
Remaining Dmd in WRMM Blocks	31,999	0	31,999
Irrigation Demands (from IDM)	64,391	1,100	63,291
Total Avg Yearly Demand	335,818	25,334	309,594

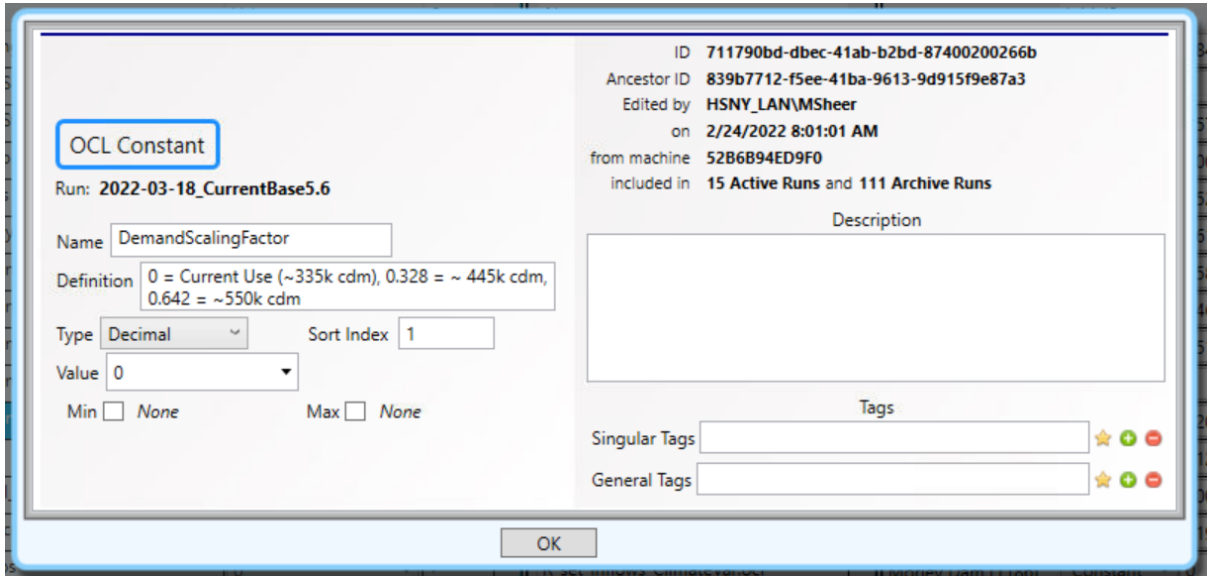
1929 (Peak)	Demand	Returns	Net Use
Indiv Licensed Dmds (72%)	239,324	24,256	214,178
Remaining Dmd in WRMM Blocks	37,211	0	37,211
Irrigation Demands (from IDM)	83,444	1,174	82,270
Total Peak (1929) Yearly Demand	359,979	25,430	333,659

Licenses split Senior/Junior at 17-Apr-82 (#18)
50% of total SSROM licenses volume

Red Deer Demo Analysis

Increasing use in the Red Deer





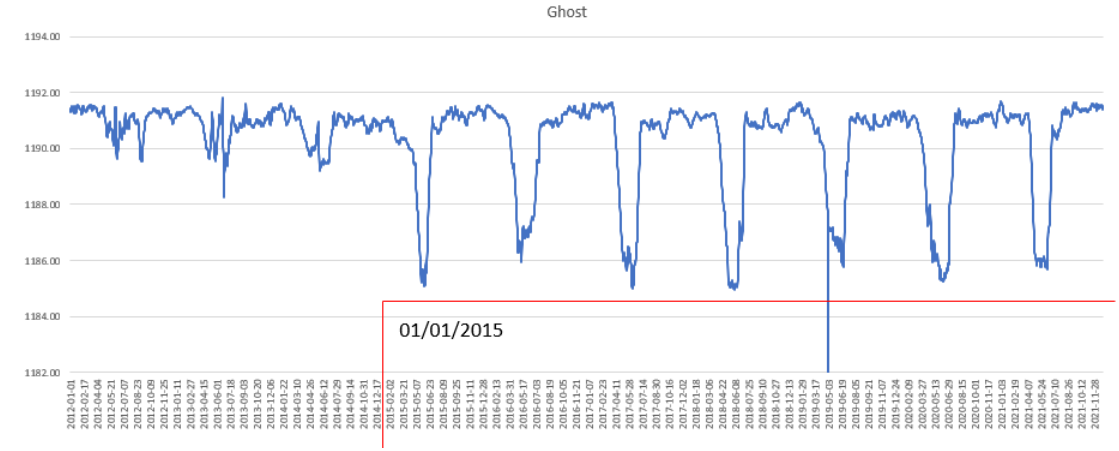
SSROM Operations

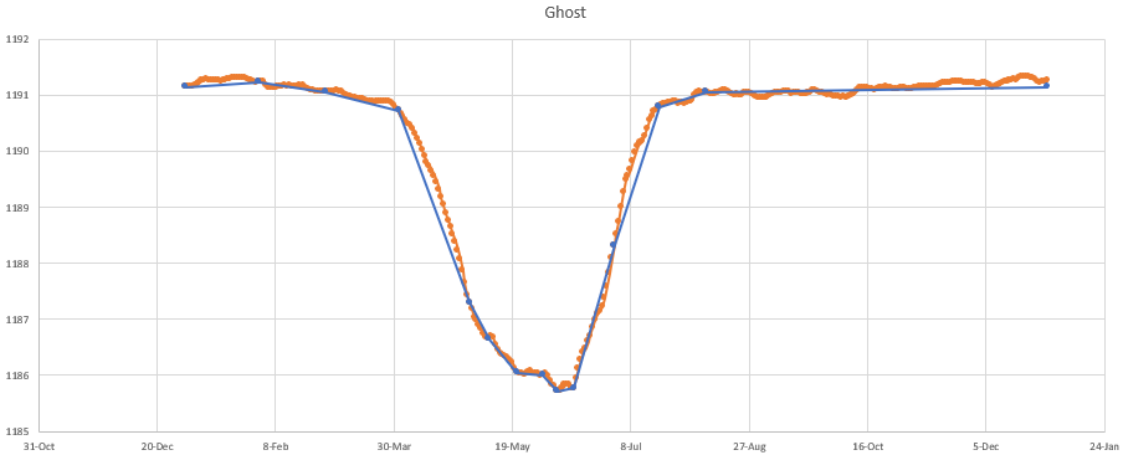
Bow River System (former BROM Model)

Operations: Bow

Reservoirs: TransAlta Hydropower

- TransAlta operations contain commercially sensitive data
- TA employees worked with us in 2009 to find an appropriate alternative that would be “representative” of their ops for our analyses
- TA worked with us to again refine those ops for the 2022 update
- TA reservoirs follow a “normal pattern” or average elevation derived from the last 10 years.
  - **Ghost, Barrier, and Lower Kananaskis use the last 7 years due to 2015 operational changes from the provincial agreement**





Orange = Daily Averages
Blue = Applied pattern in OASIS

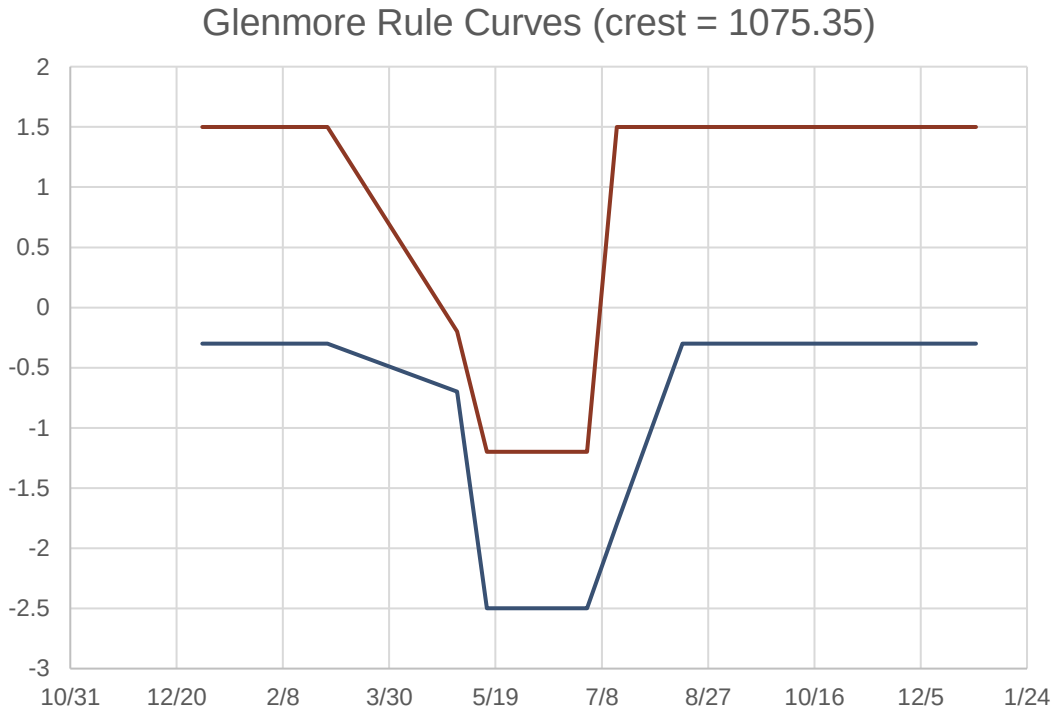
Operations: Bow

Reservoirs: Calgary

- Previously, Glenmore operations included stoplogs and old storage-area-elevation curves
- Now updated to current infrastructure

- Flood ops utilize Springbank (SR-1) as an “early warning system.”
  - **If SR-1 has utilized storage (i.e. incoming flood), Glenmore begins to draw down**
  - **Max of -3.5m drawdown**
  - **Refills with Elbow flow and Glenmore releases**

- Minimum release of 1.5 m^3/s

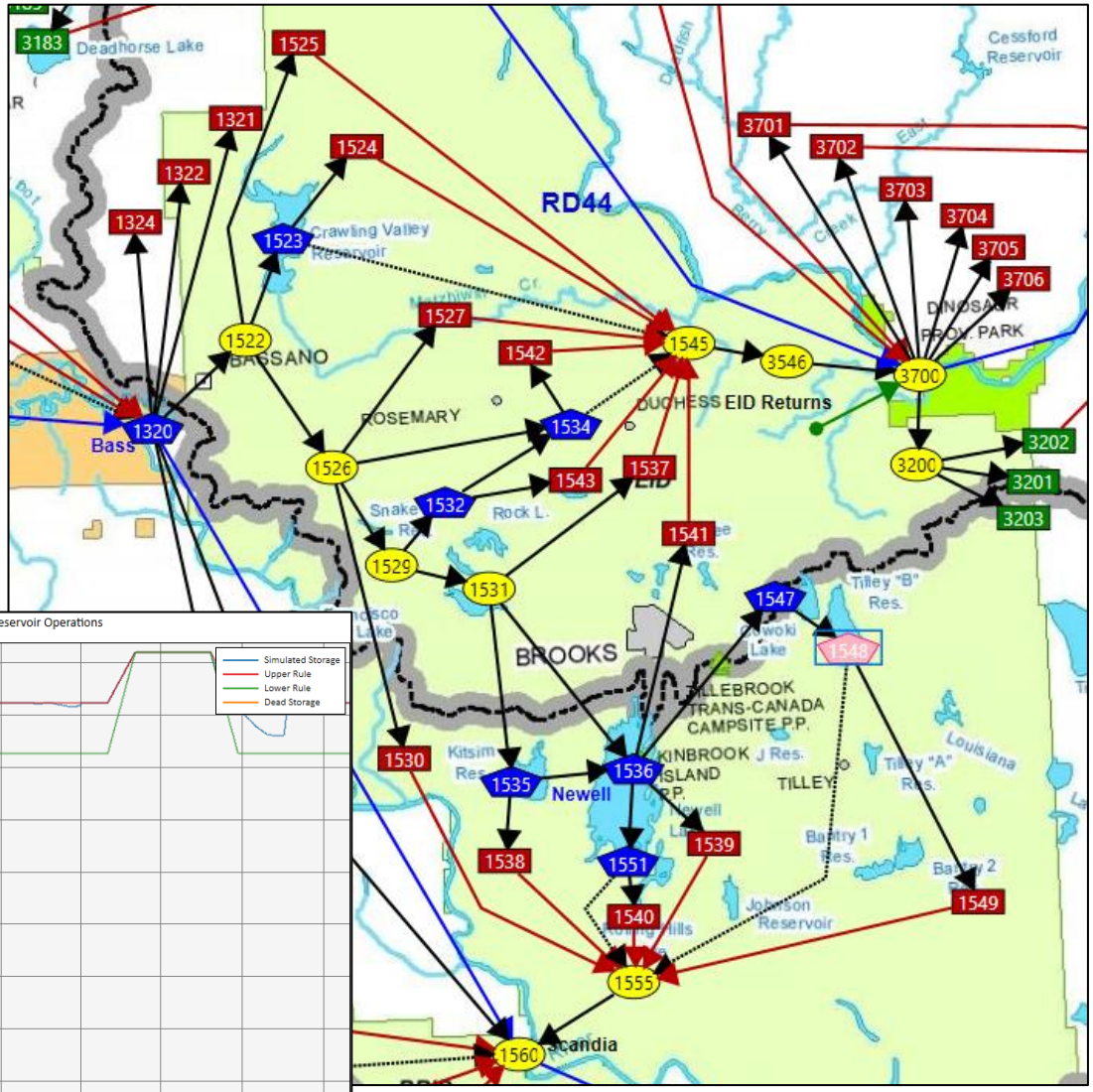


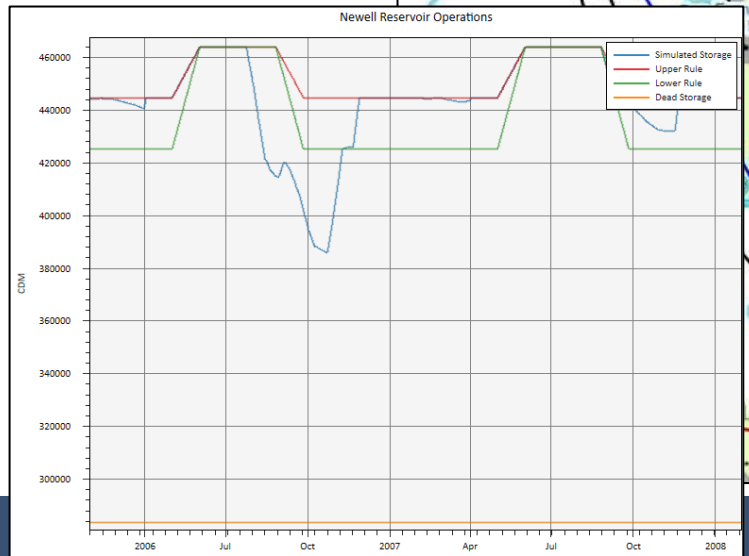
Operations: Bow

Reservoirs: Irrigation - EID

- Most irrigation reservoirs in the Bow system operate fairly simply
  - Upper rule that attempts to fill to
  - Lower rule that tries to balance drawdown among reservoirs
  - Full ability to draw down to dead storage in support of irrigation demand

- EID reservoirs:
  - Crawling Valley
  - Snake
  - Rock
  - Kitsim
  - Newell
  - Rolling Hills
  - Cowocki
  - Tilley B



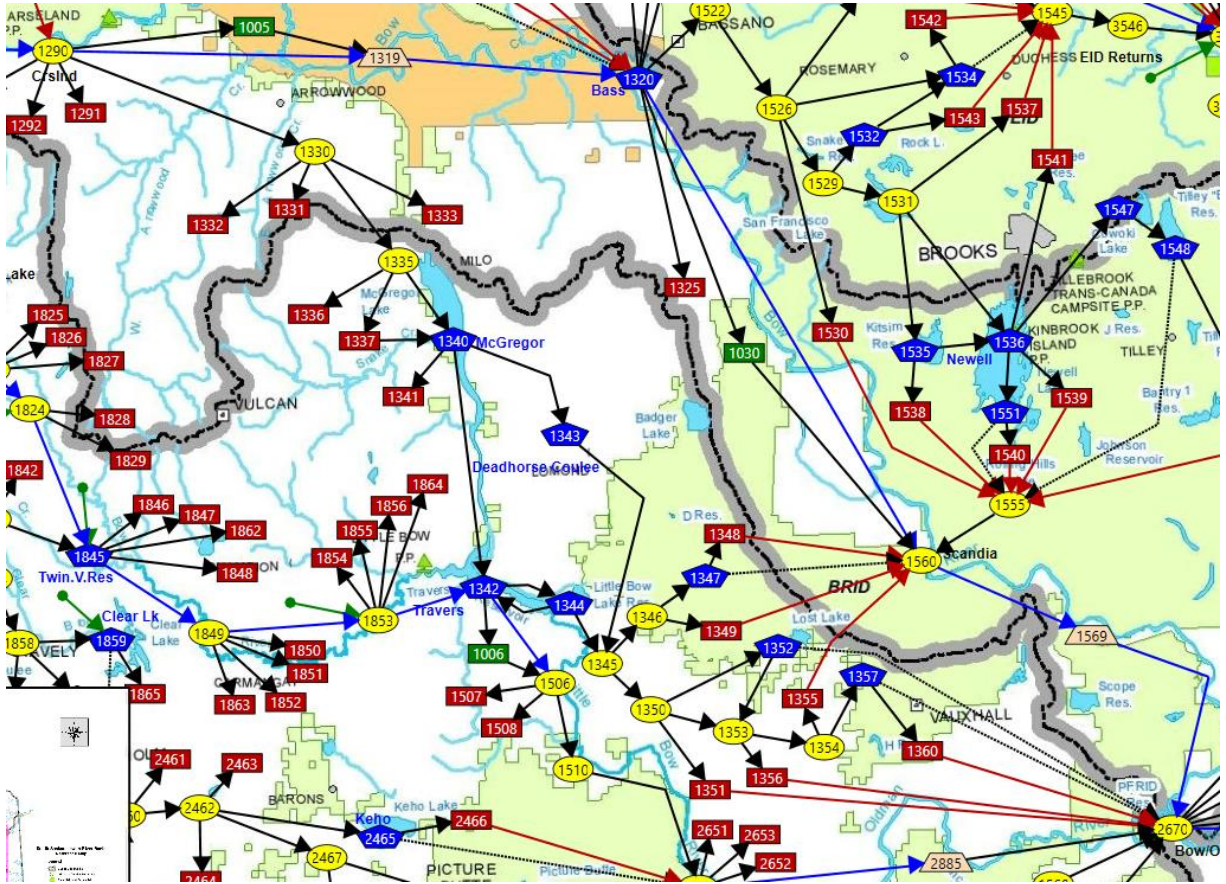


Operations: Bow

Reservoirs: Irrigation - BRID

- BRID reservoirs:
  - **McGregor**
  - **Travers & Little Bow**
    - *Drawn down before McGregor*
    - *Routes Little Bow flows straight through below 12cms, min flow 20 cfs*
  - **Badger**
  - **Lost Lake**
  - **Scope**

- McGregor operates a little differently
  - **Off-reservoir demand requires a higher elevation**
  - **Reservoir will draw substantially below that if needed**
  - **Also must be able to absorb 300 cfs headworks carriage flow**



Operations: Bow

Reservoirs: Irrigation - BRID

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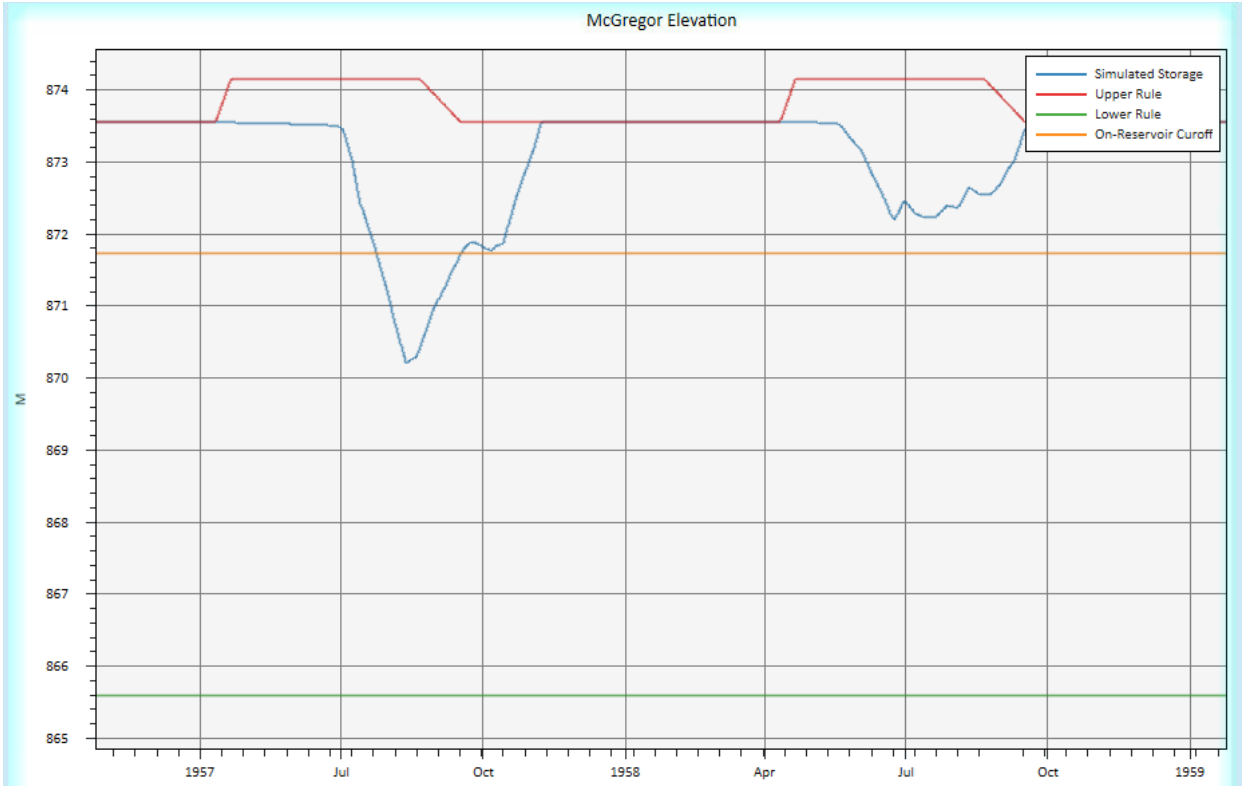
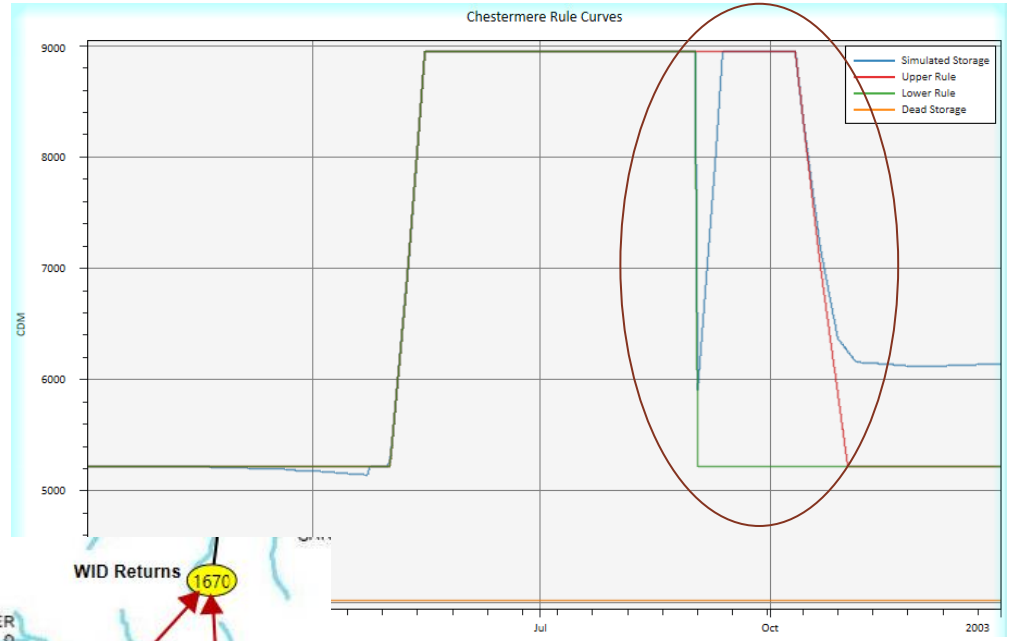
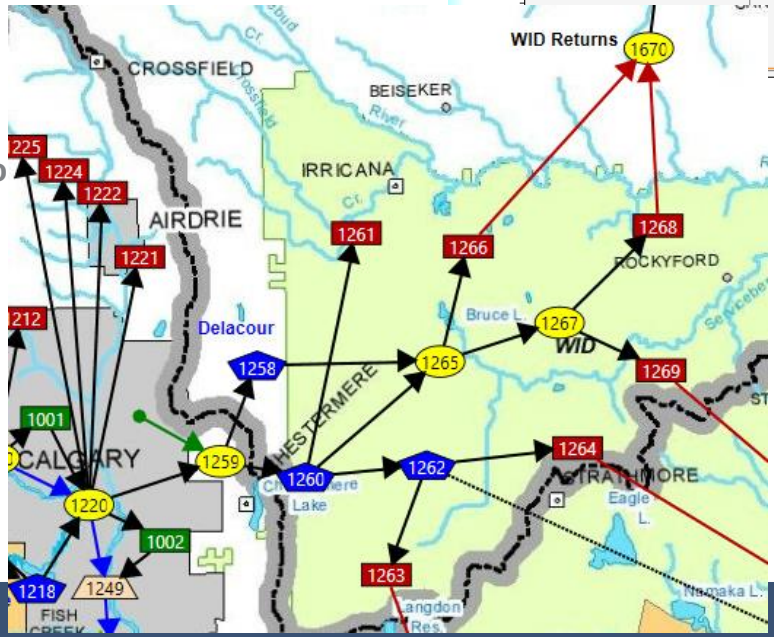


Operations: Bow

Reservoirs: Irrigation - WID

- WID reservoirs:
  - Chestermere
  - Langdon
- Chestermere
  - Functionally no storage
- Langdon modeled very simply
  - 12,000 AF live storage
  - No SAE in model at present, easy to update later





Operations: Bow

Minimum Flows

- Two major minimum flows:
  - **1,250 cfs at Calgary**
    - *Handshake agreement*
  - **400 cfs at Bassano**
    - *Licensed diversion limit*

- Other license limitations on diversion are also maintained

NOTE: This describes how the licenses are modeled, not the full list of licenses & conditions which have more flexibility and nuance

WID:

- Natural flow <= 155 m^3/s, Low Stage = 450 cfs diversion
- Natural flow <= 300 m^3/s, High Stage = 600 cfs diversion
- Natural flow > 300 m^3/s, Flood Stage = 750 cfs diversion

BRID:

- 3-Day average flow past Carseland < 80 m^3/s, Diversion = 1,460 cfs
  - Likely temperature problem conditions
- All other times = 1,800 cfs

EID:

- Model the new license conditions
  - Reversion to old license is possible but would be “exceptional operations.” Therefore, it’s not modeled as Base Case operations
  - Same idea as municipal drought plan implementation
  - Is junior to BRID
- Irrigation Season (1-May to 30-Sept) = 3,400 cfs diversion
- Non-Irrigation Season (1-Oct to 30-Apr) = 825 cfs diversion
- Minimum pass-by of 400cfs at all times

Operations: Bow

Shortage Distribution: Grouped

- Water in the Bow is delivered in the following order:
  1. **Junior Demands (<10% of total Bow River demand)**
  2. **Municipal Demands**
  3. **Irrigation Districts**

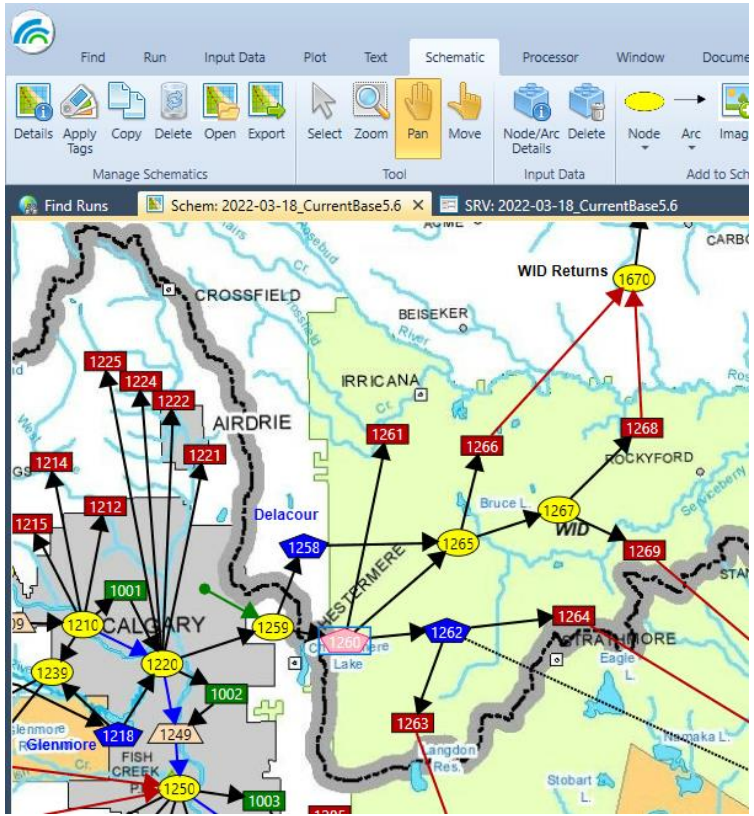
- Irrigation districts follow an informal agreement, though they still follow broad seniority:
  - **River-dependent blocks are fed first**
  - **Storage-supported blocks are fed second**
  - **Reservoir storage is filled**
  - **Demand within each ID sub-category is met in approximate license order:**

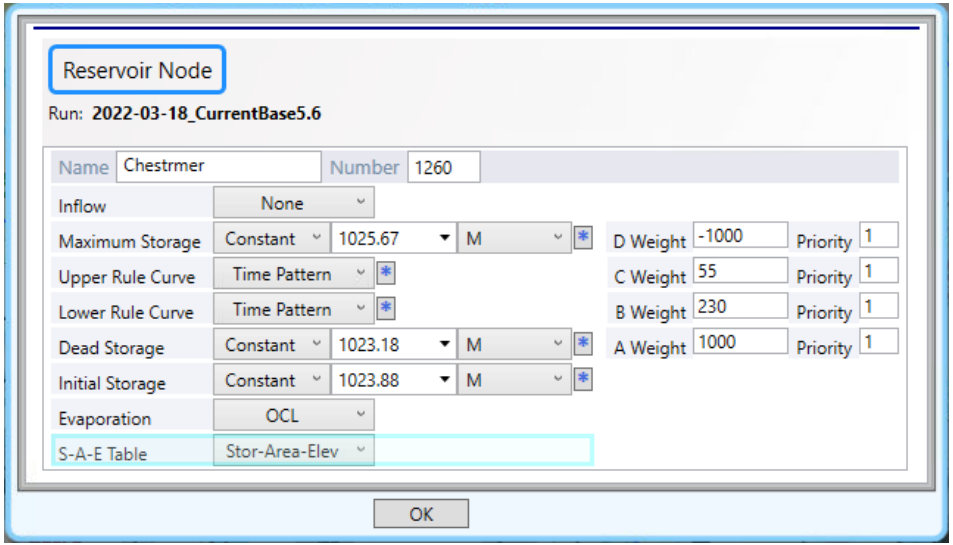
EID's new license is modeled as "Base Case." The new license is junior to BRID. Old license reversion rules would be an excellent scenario for analysis.

River Dependent Demands	Storage-Supported Demands	Reservoir Storage Filling
WID	WID	WID
BRID	BRID	BRID
EID	EID	EID
#1	**#2**	**#3**

Bow Demo Analysis

Allow full use of Chestermere





Adjust Lower Rule & Dead Storage to 0

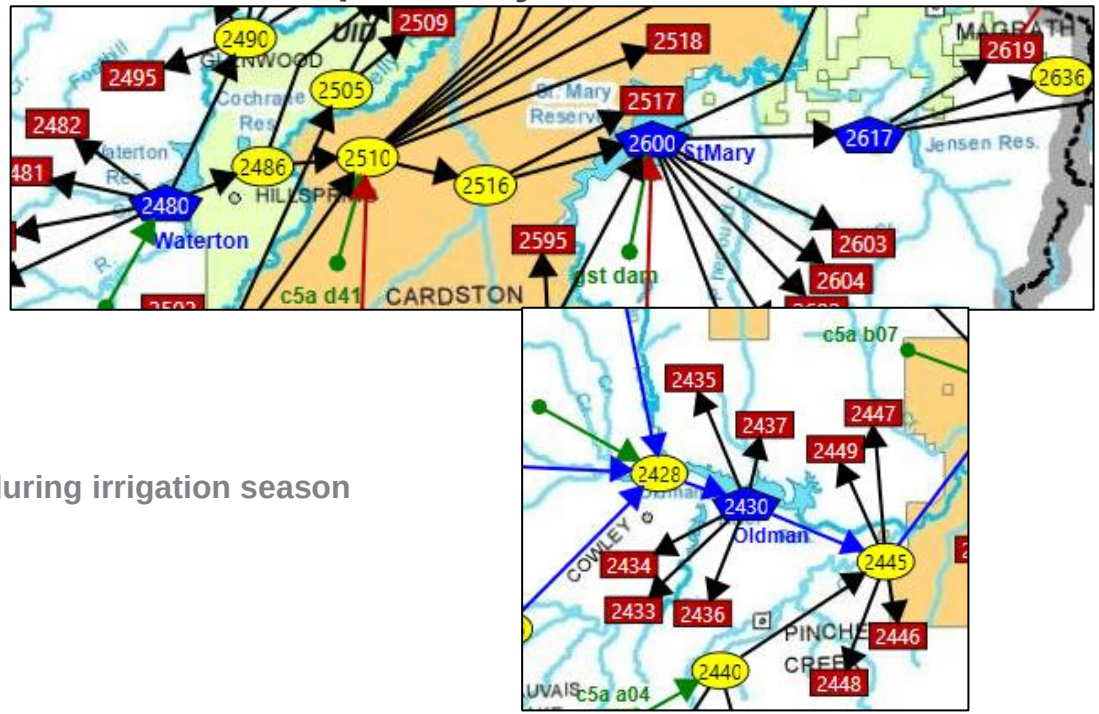
SSROM Operations

Oldman and Southern Tributaries System (former OSSK model)

Operations: Oldman & Southern Tributaries

Reservoirs: Oldman, Waterton, & St. Mary

The “big 3” reservoirs in the O&S system are modeled independently in SSROM



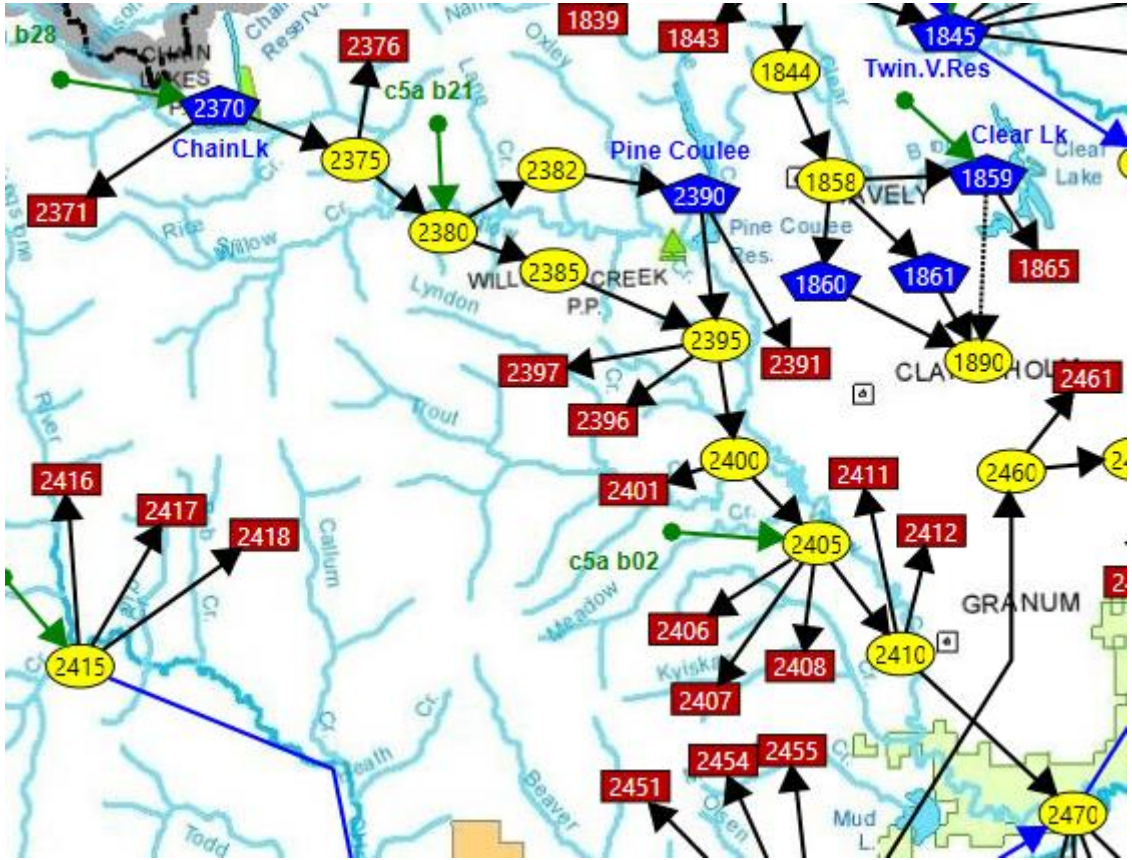
- Oldman releases:
  - **Downstream irrigation & non-irrigation use**
  - **1,000 cfs at Medicine Hat**
  - **Forecast expected d/s incoming flows**
- Waterton releases:
  - **IO at the mouth**
    - *Waterton & Belly*
  - **“Local” demands**
  - **Canal releases to keep St. Mary as full as possible during irrigation season**
- St. Mary releases:
  - **IO at the mouth**
  - **“Local Demands”**
  - **Irrigation diversion up to license limits**

St. Mary and Waterton reservoirs do not release to augment or provide flows on the Oldman River

Operations: Oldman & Southern Tributaries

Reservoirs: Willow Creek

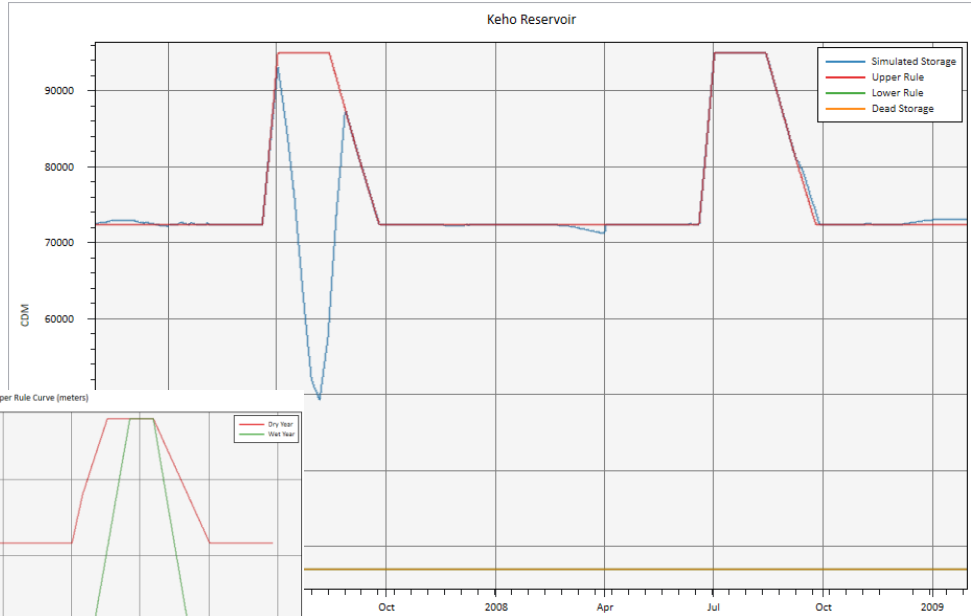
- Willow Creek is operated as a “sub-model”
  - Water on Willow Creek is not made available for O&S use unless it is a surplus
- Chain Lakes
  - Operate to meet reservoir demand
  - Follow seasonal minimum release requirements
- Pine Coulee
  - Operates to meet reservoir demand
  - Maintains pass-by flow requirements when diverting
  - Follows seasonal minimum release requirements



Operations: Oldman & Southern Tributaries

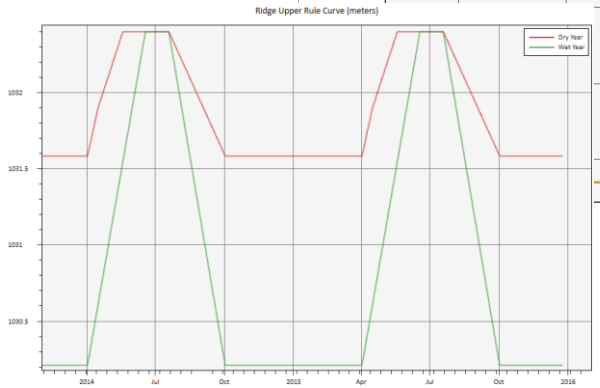
Reservoirs: Irrigation

- Irrigation reservoirs consist of LNID's Keho and the SMRID/RID/TID system
- Keho operates as a standard irrigation reservoir



- SMRID's system is more complex
  - **Includes secondary canal hydropower generation**
    - *Prefer hydropower, but don't put irrigation at risk*
  - **Balances reservoirs internally**
  - **Avoids two reservoirs due to cost or recreational impacts**

- Includes Ridge & Jensen reservoirs
  - **Jensen only "nominally" a reservoir**
  - **Ridge includes wet/dry year operations**

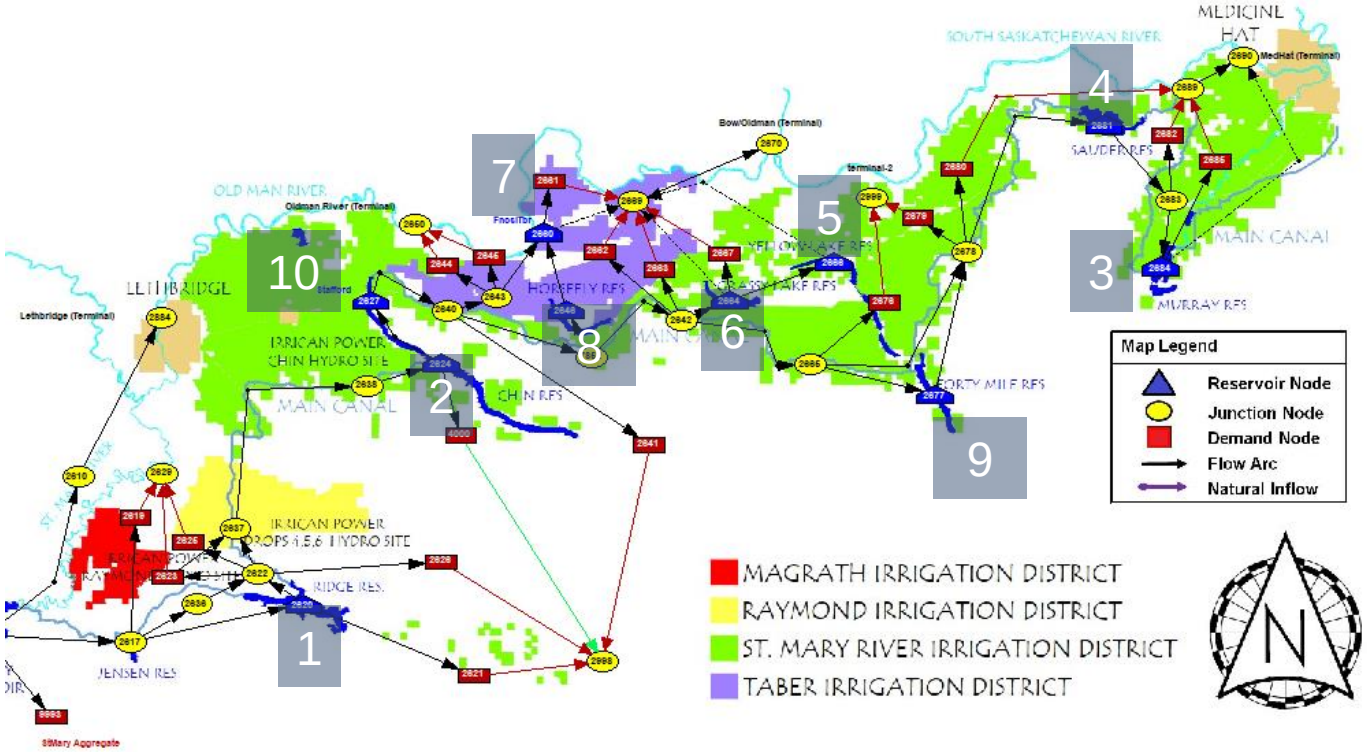


Operations: Oldman & Southern Tributaries

Reservoirs: Irrigation

Order of use:

1. Ridge
2. Chin
3. Murray
4. Sauder
5. Yellow
6. Grassy
7. Fincastle/Taber
8. Horsefly
9. 40 Mile
10. Stafford



Operations: Oldman & Southern Tributaries

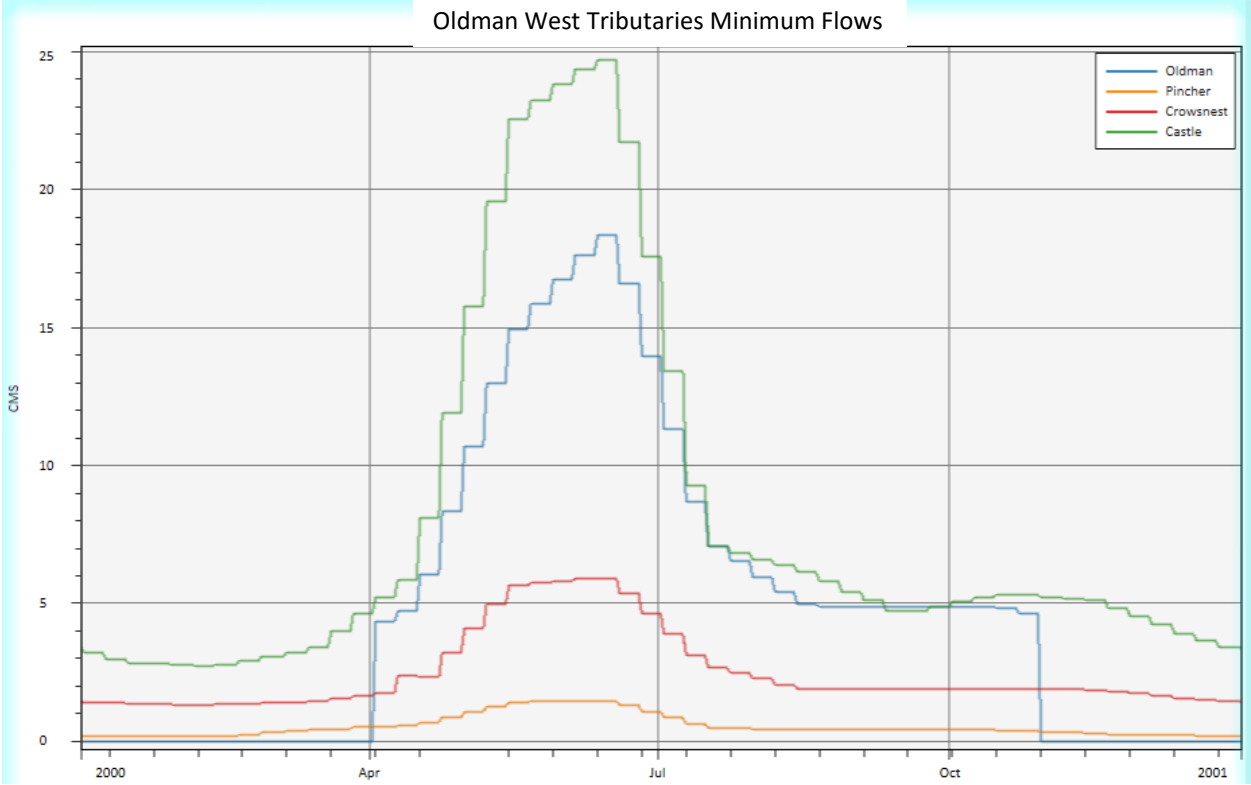
Minimum & Target Flows

- Several minimum flow targets exist in the O&S system
  - **Many are patterns, some are fixed (i.e. WCO vs IO)**

Oldman & Southern Trib Min Flows

- Willow Creek at the mouth
- Oldman upstream tributaries
- St. Mary/Waterton/Belly IOs
- 1,000cfs at Medicine Hat

Note: SSROM assumes US entitlement flows in the St. Mary across the border in the base case!



Operations: Oldman & Southern Tributaries

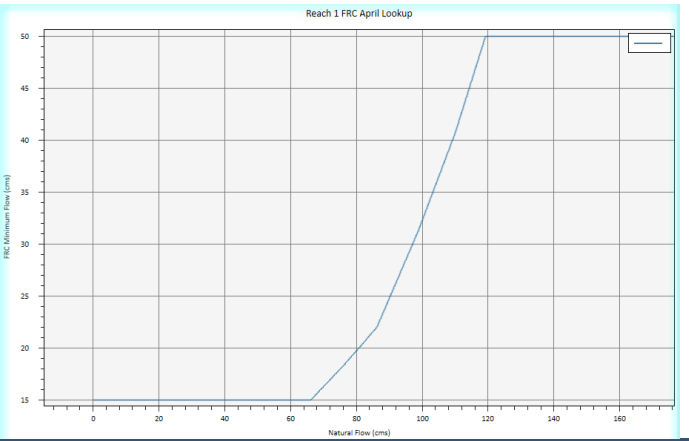
Minimum & Target Flows

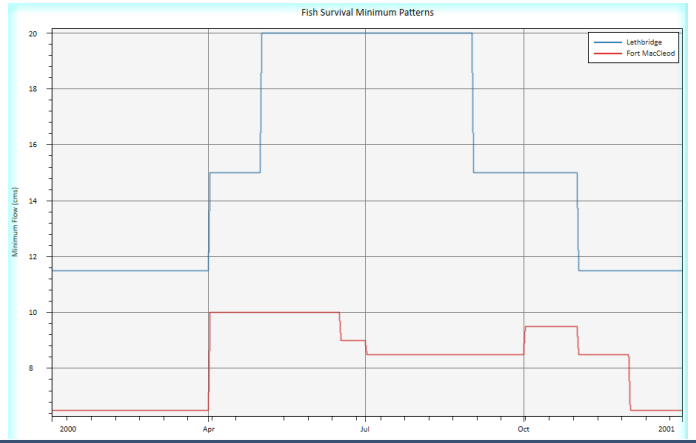
Oldman Dam attempts to make releases to meet 80% of the Fish Rule Curve

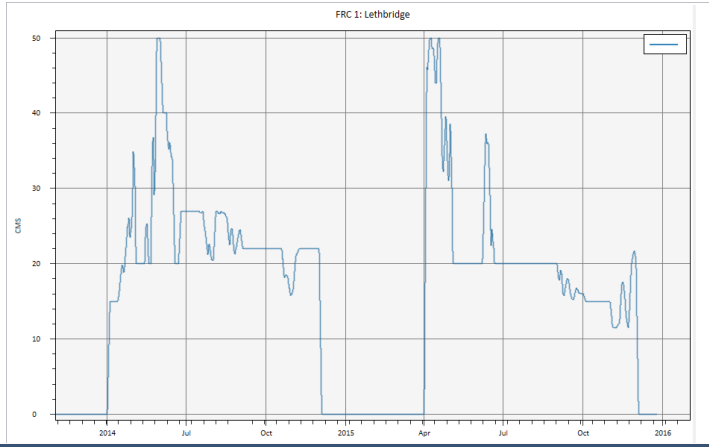
FRC 1 = Lethbridge, FRC 3 = Fort McCleod, FRC 4 = LNID Weir d/s

FRC release is calculated by:

1. **Compare natural flow against reach- and month-specific table**
2. **Ensure lookup exceeds the Fort McCleod and Lethbridge fish survival minimum patterns**
3. **Add a 0.5 to 2.0 cms buffer depending on conditions**







Operations: Oldman & Southern Tributaries

Shortage Distribution: Hybrid license/Grouped

- O&S system licenses are applied to large irrigation districts
- Smaller demands and private irrigators are kept whole
  - **Total relative volume is small**

Water is distributed:

1. Municipalities,
2. Small demands
3. Irrigation lacking licence priority information
4. Large Irrigation Districts

Full Licenses applied for:

- **SMRID, TID, RID, MID, LNID, UID, MVLA**
- **Blood Tribe, Piikani**
- **Medicine Hat, Lethbridge, Taber**

Operations: Oldman & Southern Tributaries

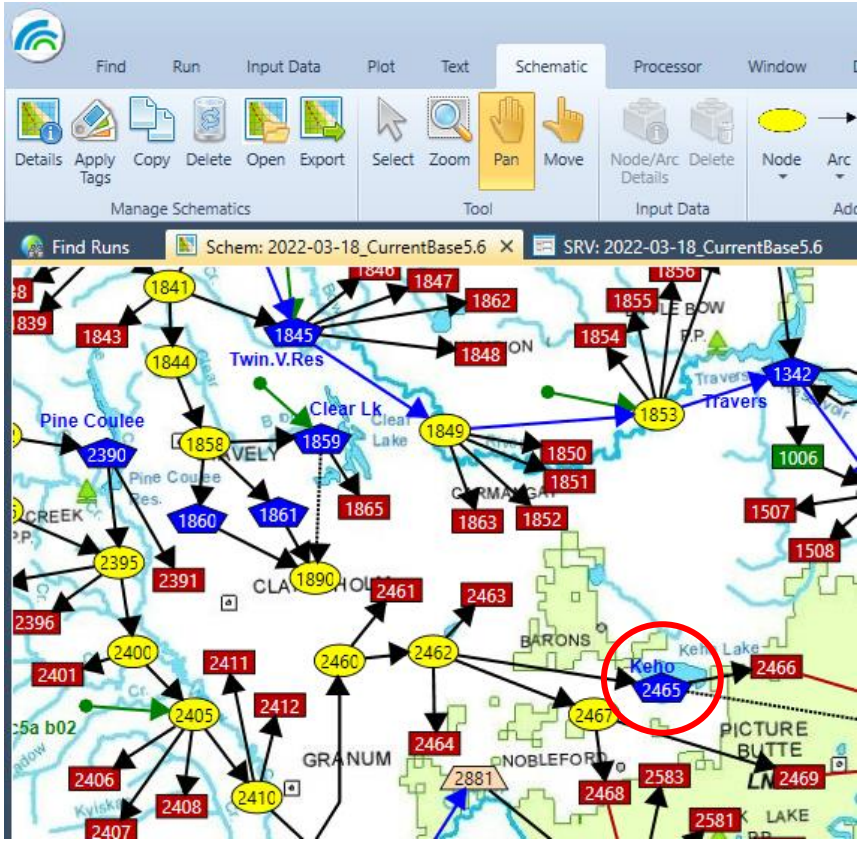
Shortage Distribution: Hybrid license/Grouped

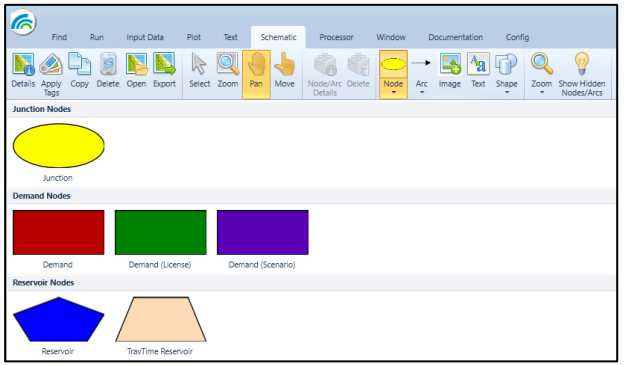
District	Extended Name	Priority	Volume (cdm)
SMRID	St Mary River	1899020701	207441
TID	Taber	1899020702	41939
RID	Raymond	1899020703	15098
MID	Magrath	1899020704	11324
Medicine Hat	City of	1901	1684.94
Lethbridge		1909	13367
Medicine Hat	City of	1913	8285.3
LNID	Lethbridge Northern	1917111601	185025
MLVA	Mountain View	1923071003	9251
MVLA	Leavitt	1939061701	9560
MVLA	Aetna	1945063001	6784
SMRID	St Mary River	1950053107	409309
MID	Magrath	1950053108	5329
MID	Magrath	1950053109	16652
MID	Magrath	1950053110	3701
RID	Raymond	1950053114	15431
RID	Raymond	1950053115	30529
RID	Raymond	1950053116	6784
TID	Taber	1950053117	41322
TID	Taber	1950053118	83261
TID	Taber	1950053119	18503

District	Extended Name	Priority	Volume (cdm)
LNID	Lethbridge Northern	1974110401	82645
Taber	Town of	1975	2837
Medicine Hat	City of	1977	64038
Lethbridge	City of	1978	11318
LNID	Lethbridge Northern	1982041501	61675
Taber	Town of	1984	667.31
Medicine Hat	City of	1985	88810.7
Lethbridge	City of	1987	6171
UID	United	1991032401	62909
MID	Magrath	1991082204	4934
LNID	Lethbridge Northern	1991082301	61675
RID	Raymond	1991082302	32071
SMRID	St Mary River	1991082309	273837
TID	Taber	1991082602	9868
BTAP	Blood Tribe and Piikani	19911107001	49672
MLVA	Mountain View	1991121702	617
MVLA	Aetna	1991122301	4317
MVLA	Leavitt	1991123004	5242
UID	United	1993051701	20970
Piikani		20021206002	43200

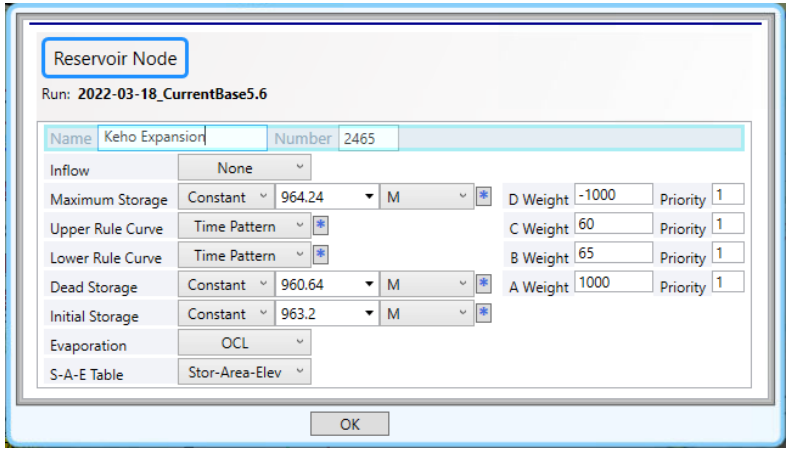
Oldman & Southern Tributaries Demo Analysis

Expand Keho Reservoir





Add an "expansion" reservoir

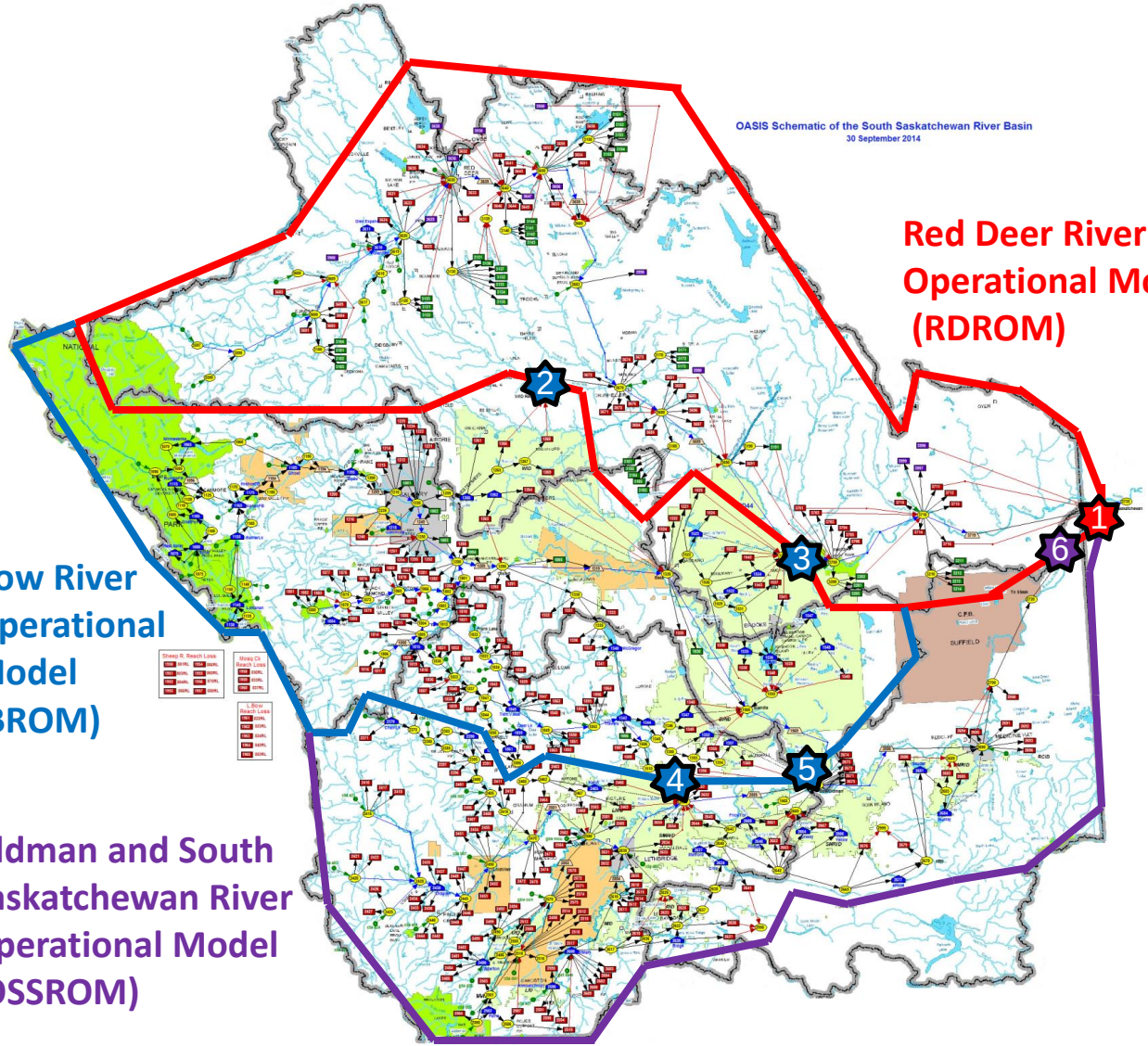


Scenario Analyses Considerations

Unified South Saskatchewan River Basin Operations Model (SSROM)

Operations: Unified SSROM

- No real unified operations between basins
- Oldman keeps 1,000 cfs past Med. Hat
  - **Apportionment is only part of rationale**
- Returns and cross-basin flows are the main considerations

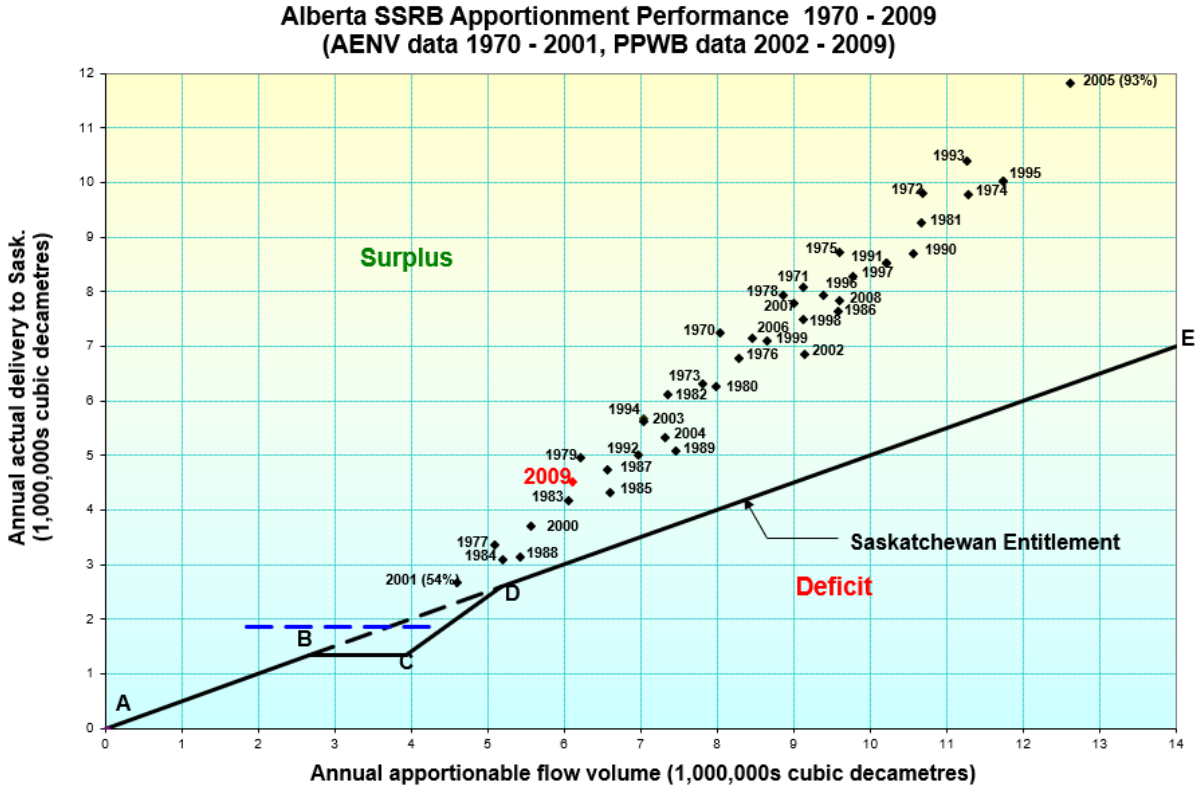


Operations: Unified SSROM

Apportionment

- Apportionment treated as a performance measure
  - Alberta is required to deliver 50% of the apportionable flow to Saskatchewan
  - If apportionable flow is below 5,180,000 dam^3 Alberta is allowed a total depletion of 2,590,000 dam^3
  - If Alberta reduces flow below 42.5 m^3/s at any time, the required delivery to Saskatchewan returns to 50% of apportionable flow

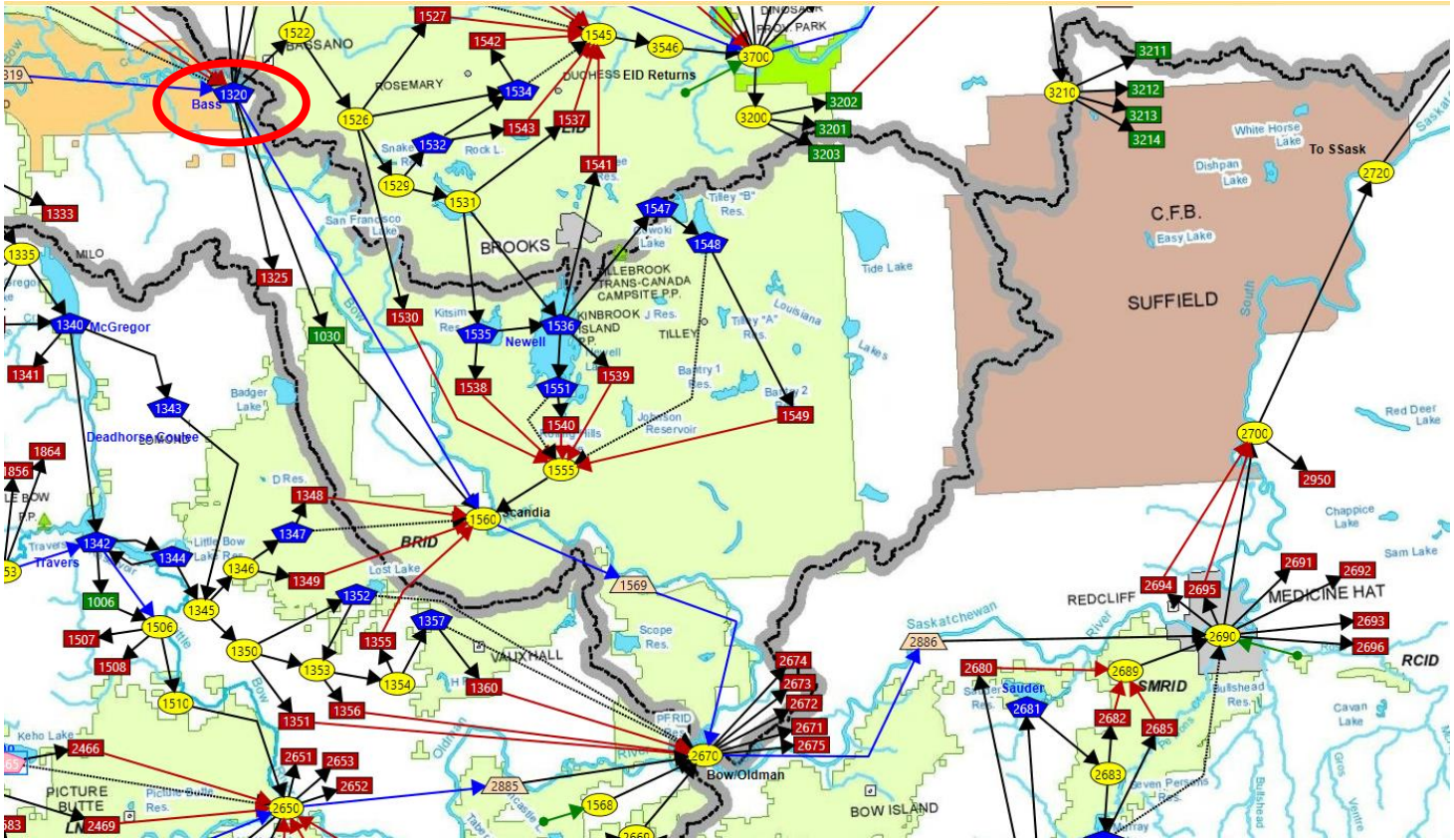
Apportionment considerations do not drive operations!



SSROM Demo Analysis

Eyremore Reservoir

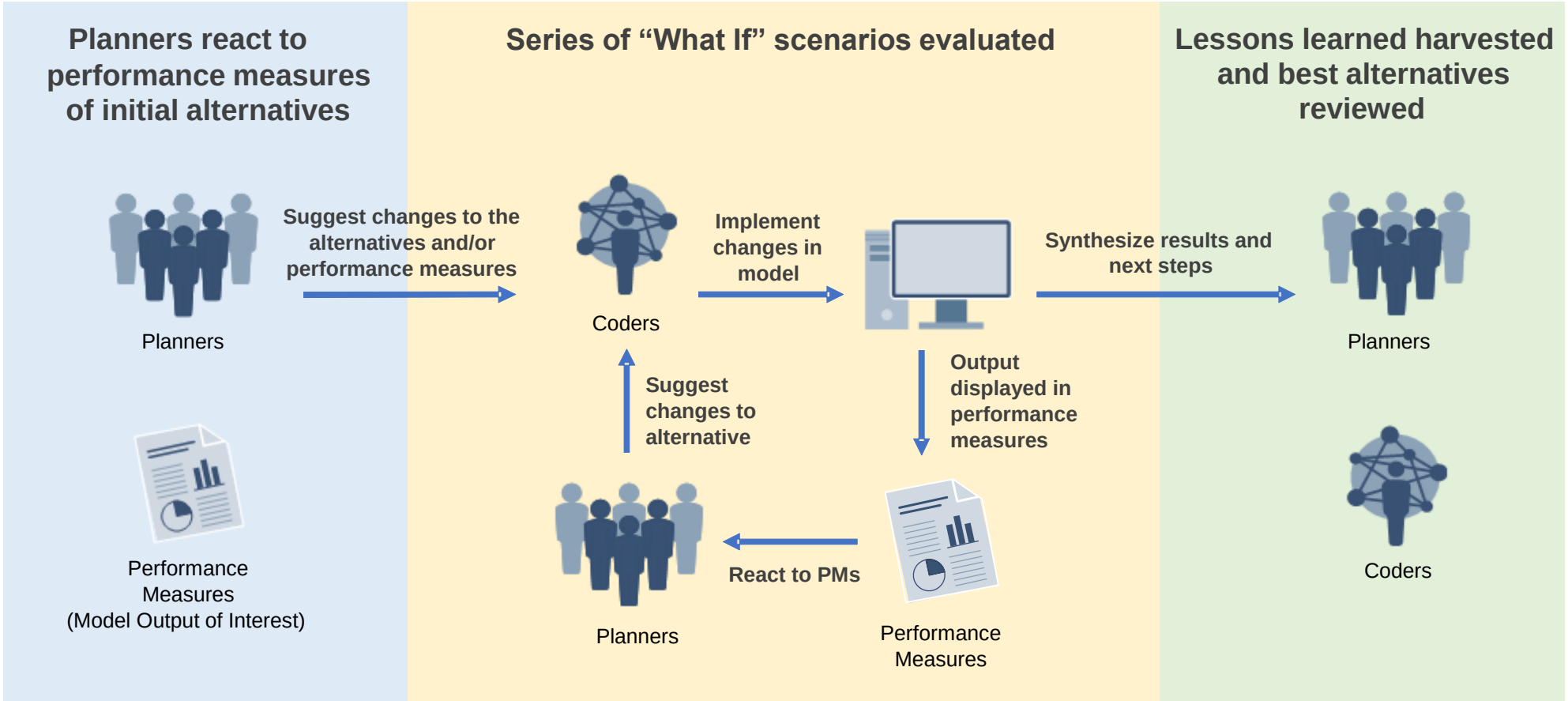
- Turn Bassano dam into Eyremore Reservoir
- Eyremore operates to help Oldman Reservoir meet obligations downstream of the Bow confluence.
  - **Medicine Hat 1000 cfs**
  - **Downstream demands**
  - **Potentially apportionment**



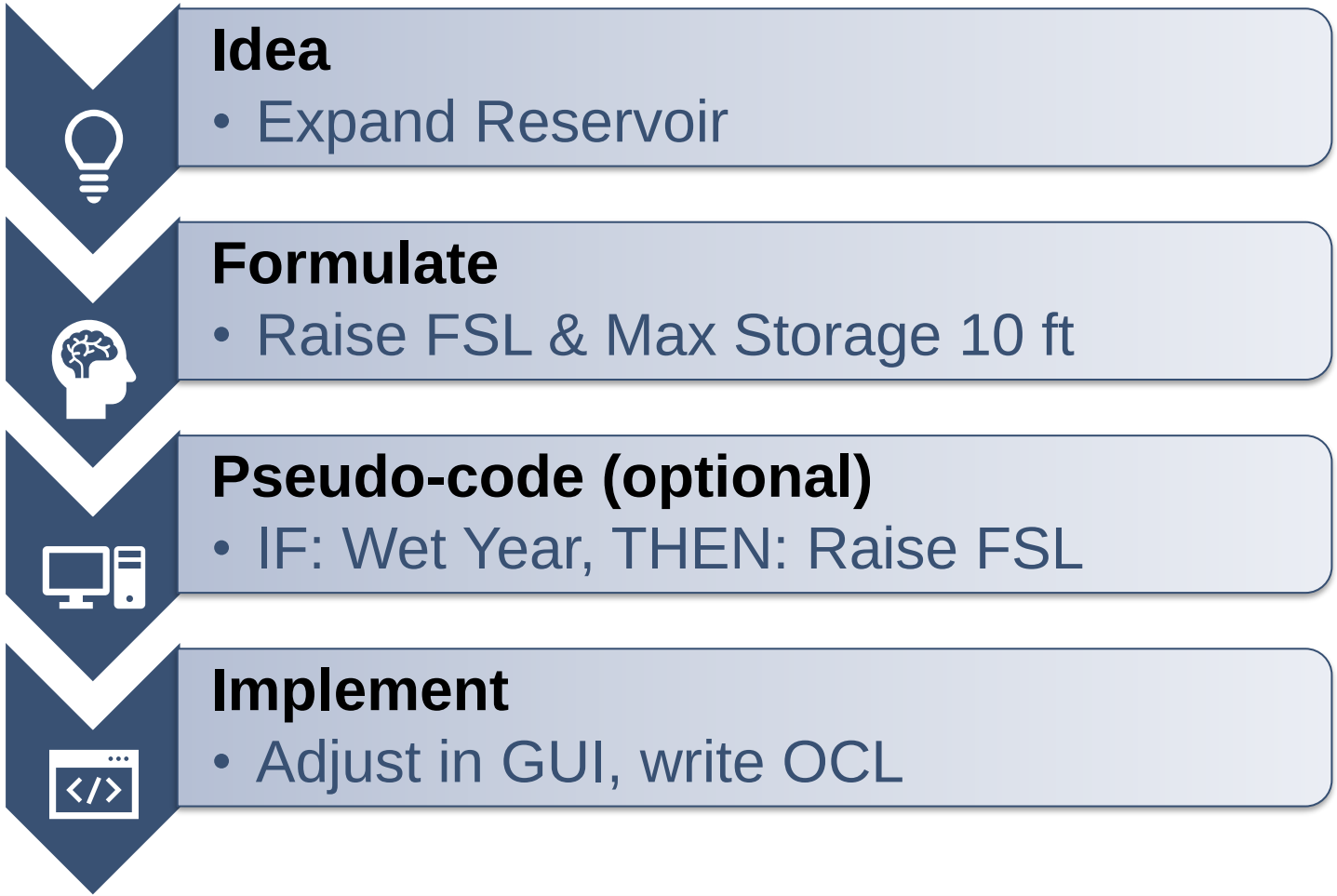
Scenario Analyses Considerations

Planning Tool Processes

Collaborative setting

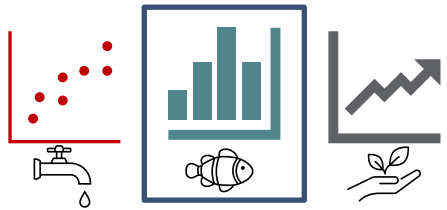


Scenario Development



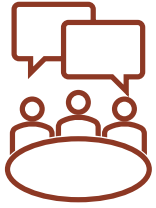
Step 1: What?

Identify an interest/objective



Step 2: How?

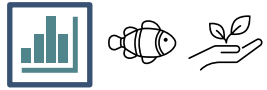
Discuss how to improve



Code into OASIS

Review results

Target PM ⊕ &
Other PMs ⊖



Step 3: Next?

Iterate back To Step 2

Discuss Results

Revision Needed	Successful Strategy

Promote

Full Group Assessment

Scenario Comparisons

Ensure “apples to apples” results

Input ***Scenario***	**Operations/Logic** ***Run***	**Performance Measure (PMs)** ***Metric***
Historic inflows	Current Operations	Refill capability
Historic inflows	Current Operations with revised reservoir rule curve	Refill capability

Same

Different

OK

Valid Comparison

Scenario Comparisons

Ensure “apples to apples” results

Input ***Scenario***	**Operations/Logic** ***Run***	**Performance Measure (PMs)** ***Metric***
Historic inflows	Current Operations	Refill capability
Historic inflows	Current Operations with revised reservoir rule curve	Refill capability
Historic inflows	Current Operations	System shortages
Entitlement inflows	Current Operations	System shortages

Different

Same

OK

Valid Comparison

Scenario Comparisons

Ensure "apples to apples" results

Input *Scenario*	Operations/Logic *Run*	Performance Measure (PMs) *Metric*
Historic inflows	Current Operations	Refill capability
Historic inflows	Current Operations with revised reservoir rule curve	Refill capability
Historic inflows	Current Operations	System shortages
Entitlement inflows	Current Operations	System shortages
Historic inflows	Current Operations	System shortages
Entitlement inflows	Revised reservoir rule curve	System shortages

Different

Different

Caution!

Both the inputs and the operations changed; difficult to distinguish which change caused differences in run output, unless you have already done the previous two sets of runs.

Future Model Possiblities

Gaming with OASIS

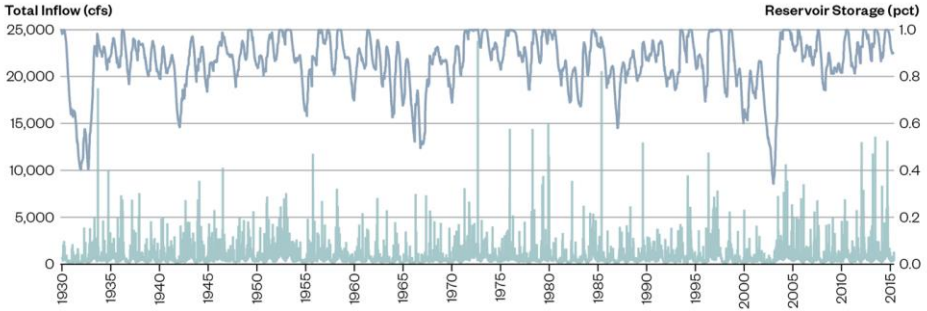
Live management exercises

- Drought games for preparation
- Basin-wide stakeholder games to:
  - **Surface ideas and pressure points**
  - **Test newly developed management plans**
  - **Educate stakeholders**
  - **Pilot new forecast products**
- Institutional knowledge
- Inter- or intra-agency coordination

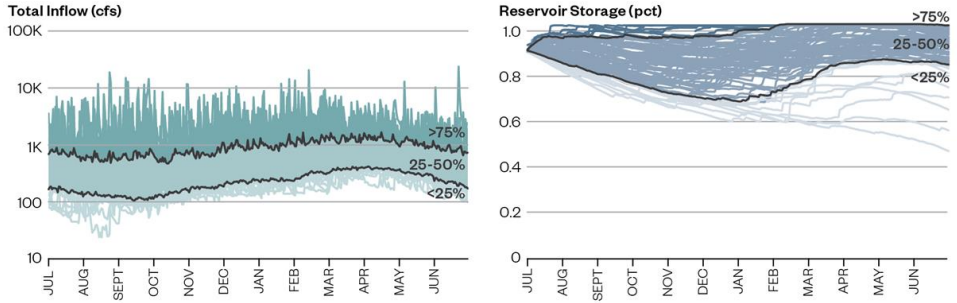
OASIS Run Modes: Simulation vs Position Analysis (PA)

Operation Support Tool (OST)

Simulation Mode (Planning)



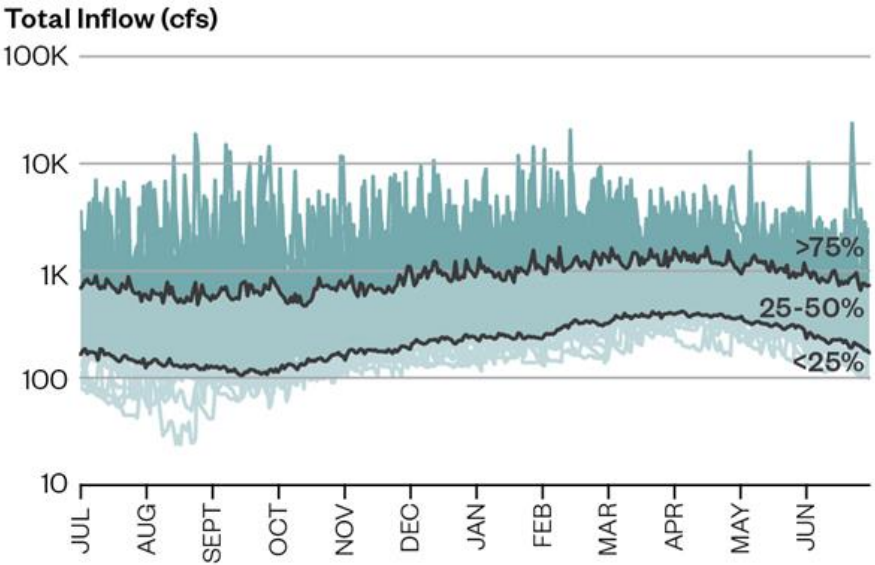
Position Analysis Mode (Operations)

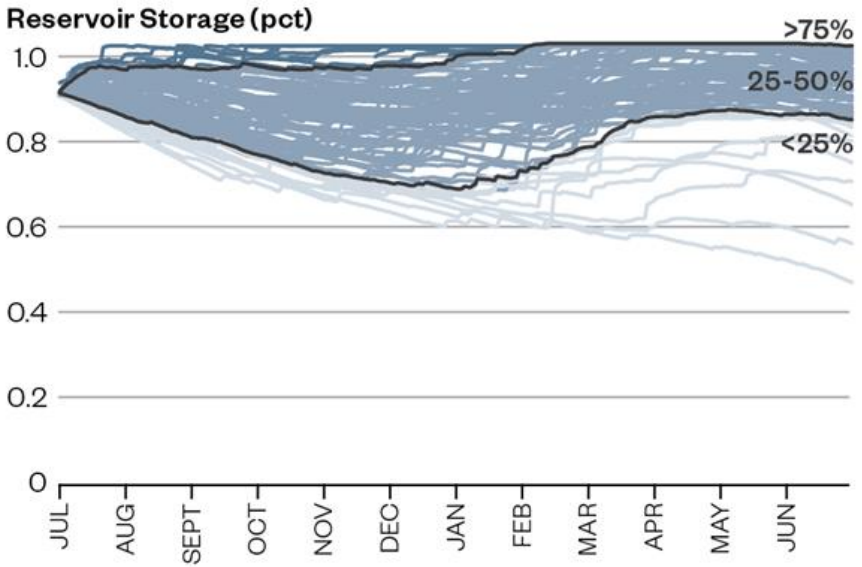


Position Analysis (PA)

Operation Support Tool (OST)

"Position analysis" describes simulations that start at a common position and diverge based on forecast ensembles

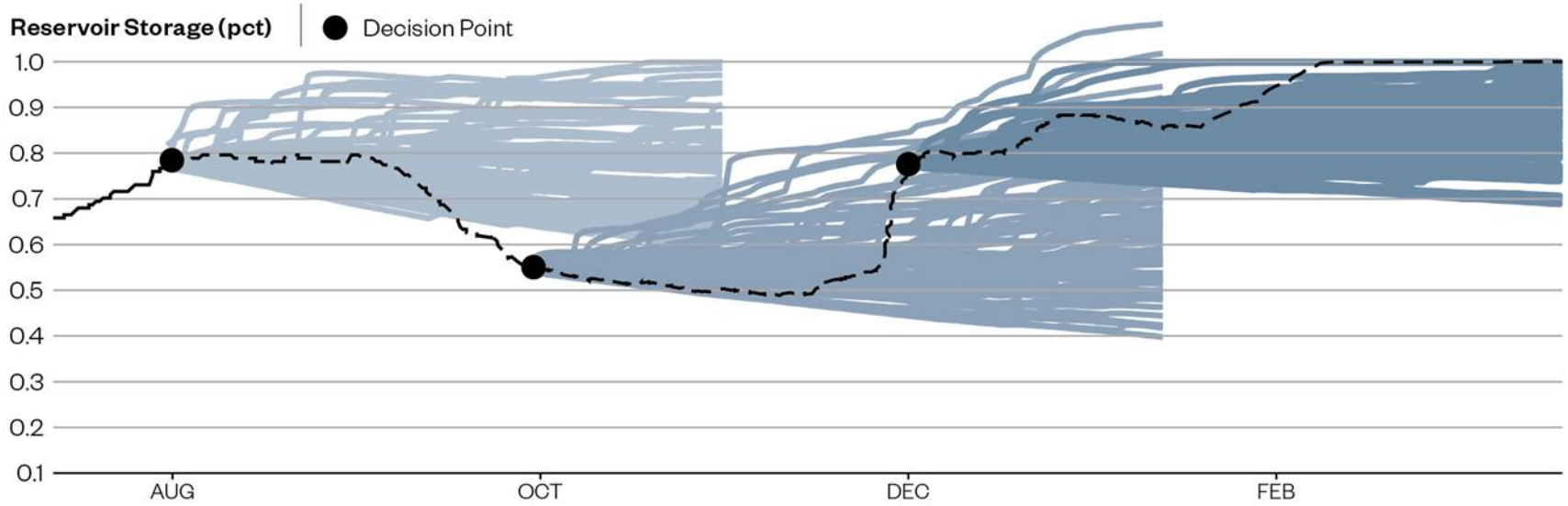




Position Analysis (PA)

Operation Support Tool (OST)

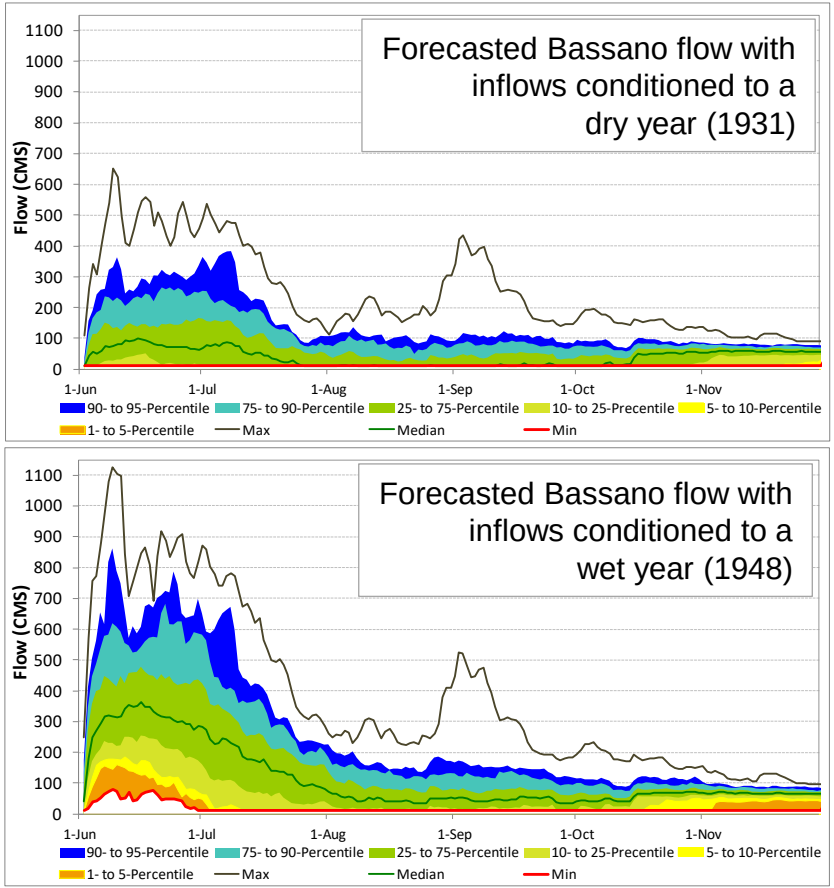
Forecasts can provide key decision support during drought



Position Analysis (PA)

Hirsch Forecast Example Near Calgary

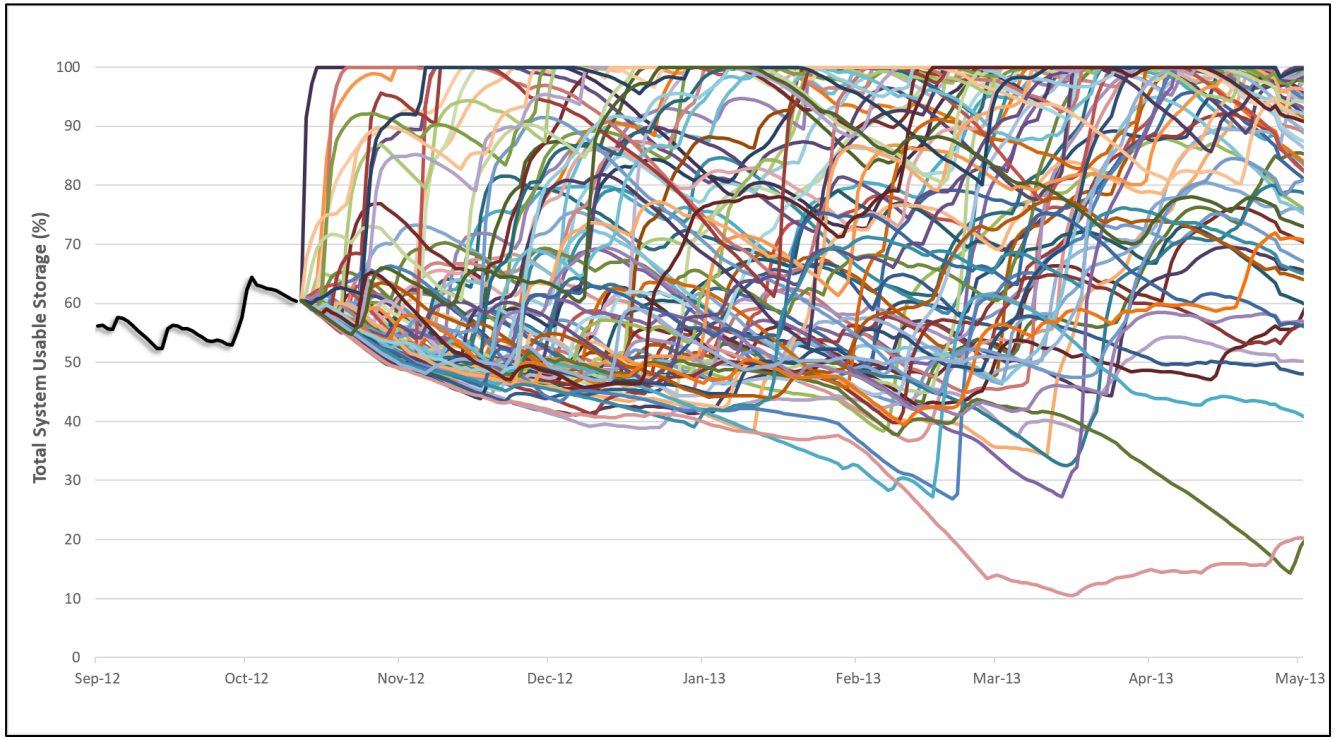
- We often implement streamflow ensembles conditioned on current basin conditions
- One trace for each year in the record (1928-2009)
- Used in the Delaware, for NYC, the Susquehanna, Bow River, and many other places
- For SSROM, we will need to implement snowpack effects as well
  - **St. Mary & Waterton inflows**
  - **Several possible approaches**



Position Analysis (PA)

The “spaghetti” plot

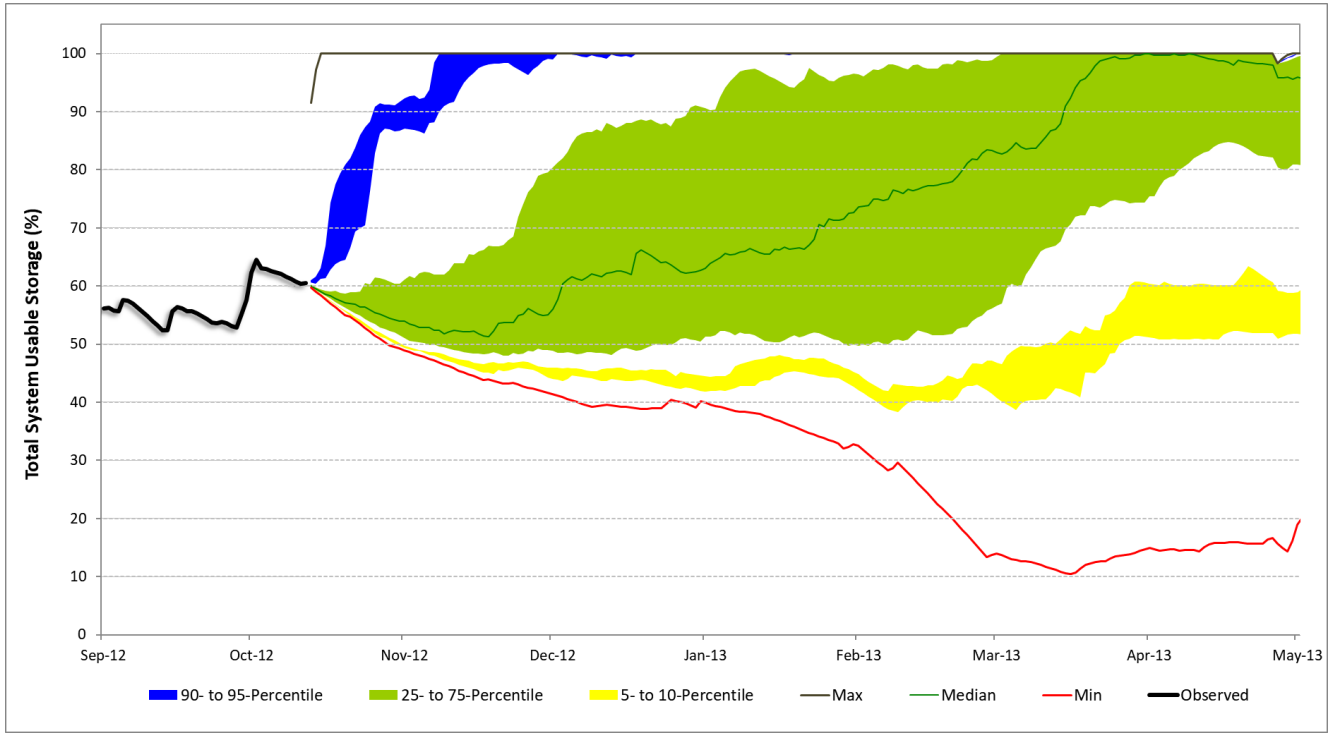
Each of the 81 traces from 1928-2009 becomes an equally likely “scenario"



Position Analysis (PA)

The “lasagna” plot

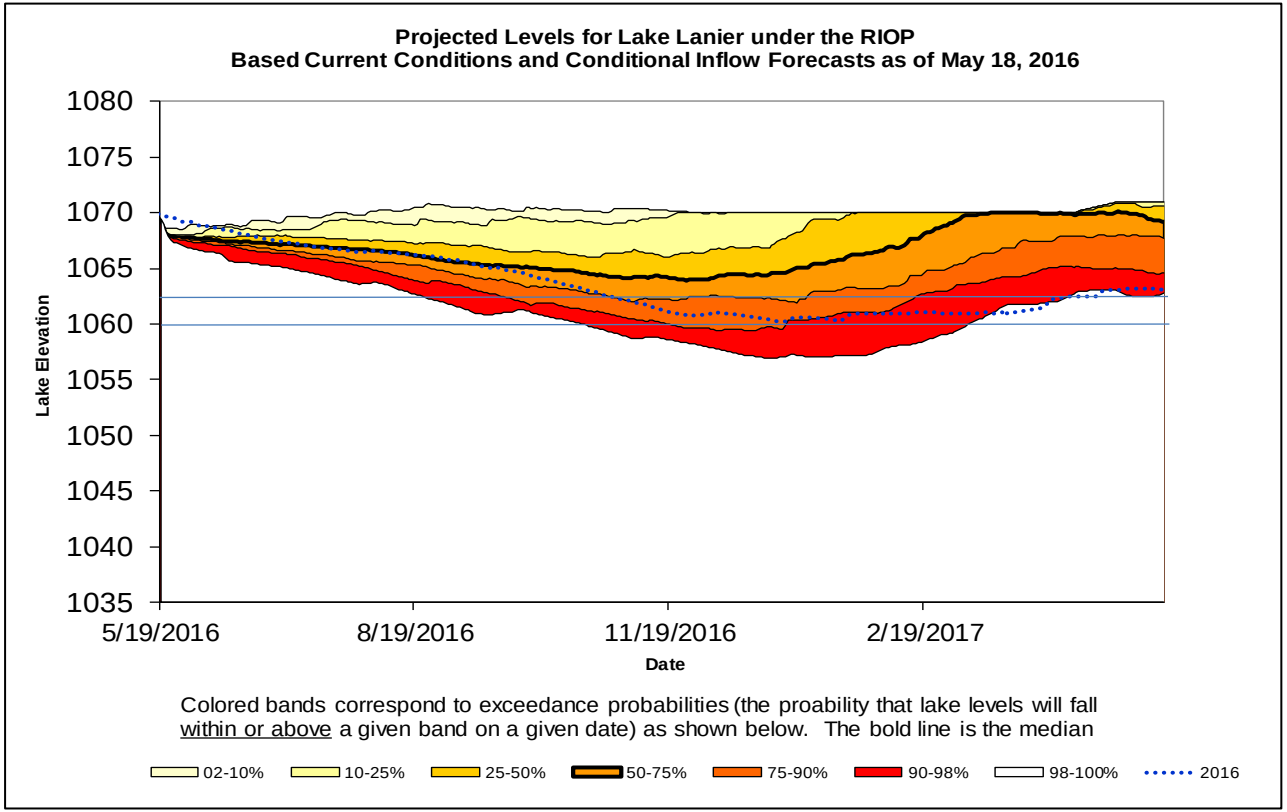
Which can then be converted into a probability plot



Position Analysis (PA)

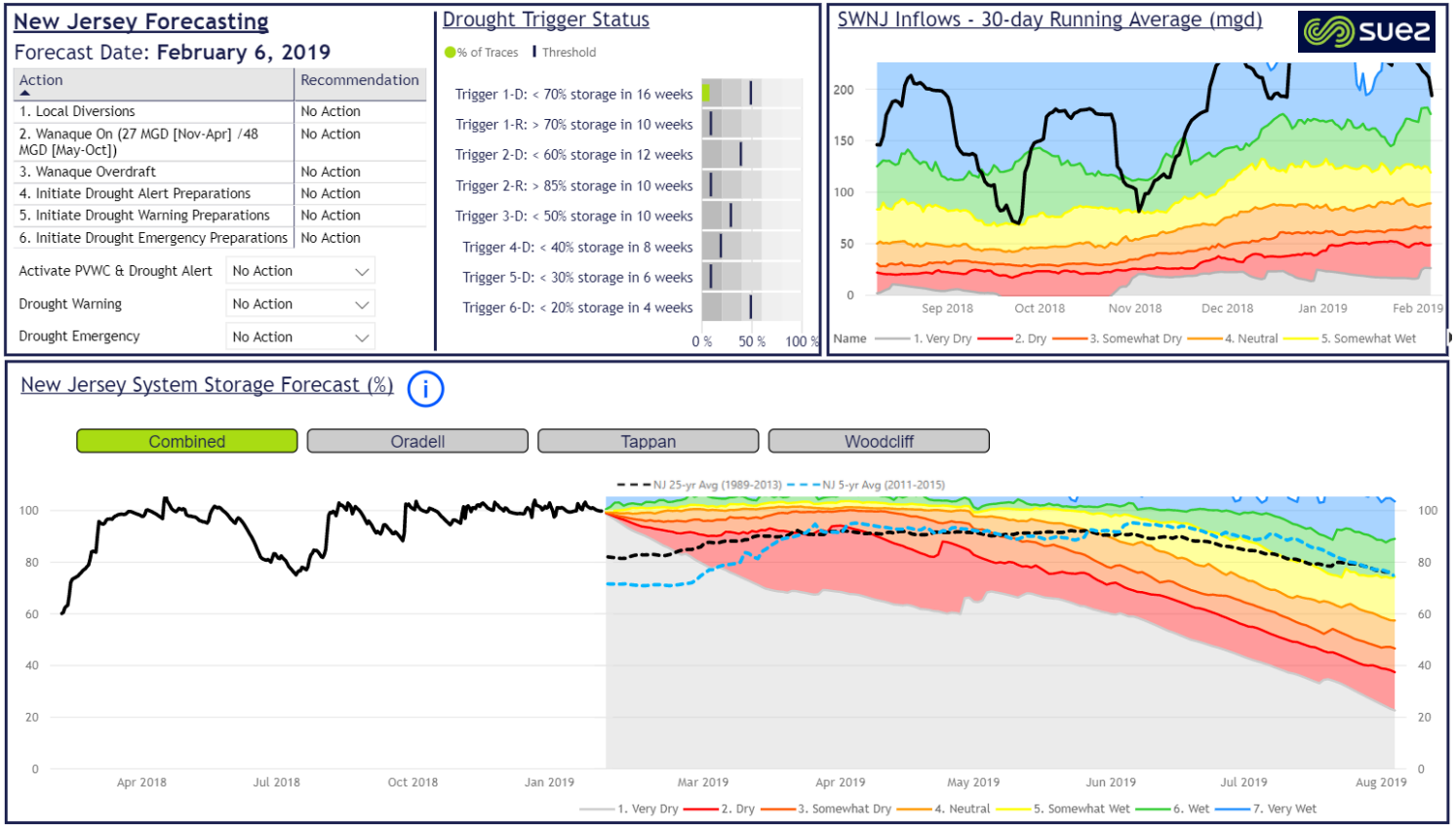
The “lasagna” plot

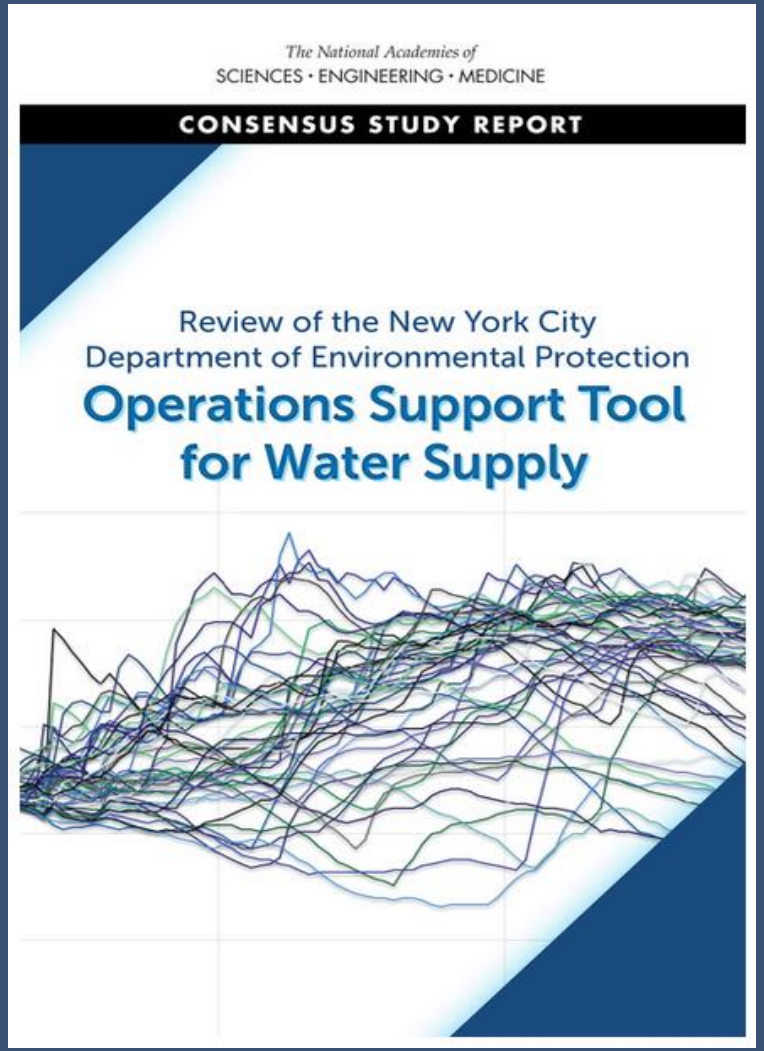
Provides likely storage forecasts



Operations Support Tool Dashboards

SUEZ North America: New Jersey



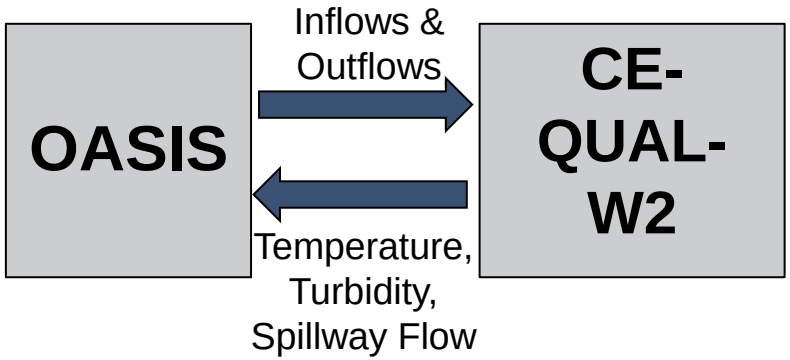


OST Review by the National Academy of Sciences Expert Panel

- *"One of the most advanced and complex support tools for water supply operations of its kind in the world."*
- Continue to update forecasts and water quality models
- Conduct additional model validation and evaluation of the benefits of OST on operations
- Consider range of approaches for long-term planning inputs to OST

Integration with Other Tools

Example of Linkage:
CE-QUAL-W2 MODEL FOR NEW YORK CITY



CE-QUAL-W2 is used to simulate water quality in Schoharie reservoir, dividing the reservoir to about 30 layers of 1 m deep by approximately 17 longitudinal sections. The model is very computationally intensive

Details of Linkage

MODULE INITIALIZE

Process:

Call original subroutine from CE-QUAL-W2. The subroutine reads original CE-QUAL-W2 Input files and makes initial calculations

MODULE STEP

Input from OASIS:
Inflow and outflow to Schoharie Reservoir, as computed by OASIS model

Process:

Call original subroutine from CE-QUAL-W2.

The subroutine simulates the dynamics of Schoharie Reservoir, including temperature, stratification, particulate concentrations, and flow over dam's spillway.

It reads from original CE-QUAL-W2 input files and writes to output files.

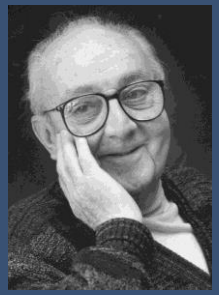
Output to OASIS:
Temperature and turbidity at select locations in the reservoir. Flow over the dam's spillway.

MODULE SHUTDOWN

Process:

Call original subroutine from CE-QUAL-W2. The subroutine writes final output to file, then closes all input and output files

Questions?



"All models are wrong, but some are useful."
– George E. P. Box

"I know that you believe that you understood what you think I said, but I am not sure you realize that what you heard is not what I meant."
– Robert J. McCloskey