BUREAU OF RECLAMATION

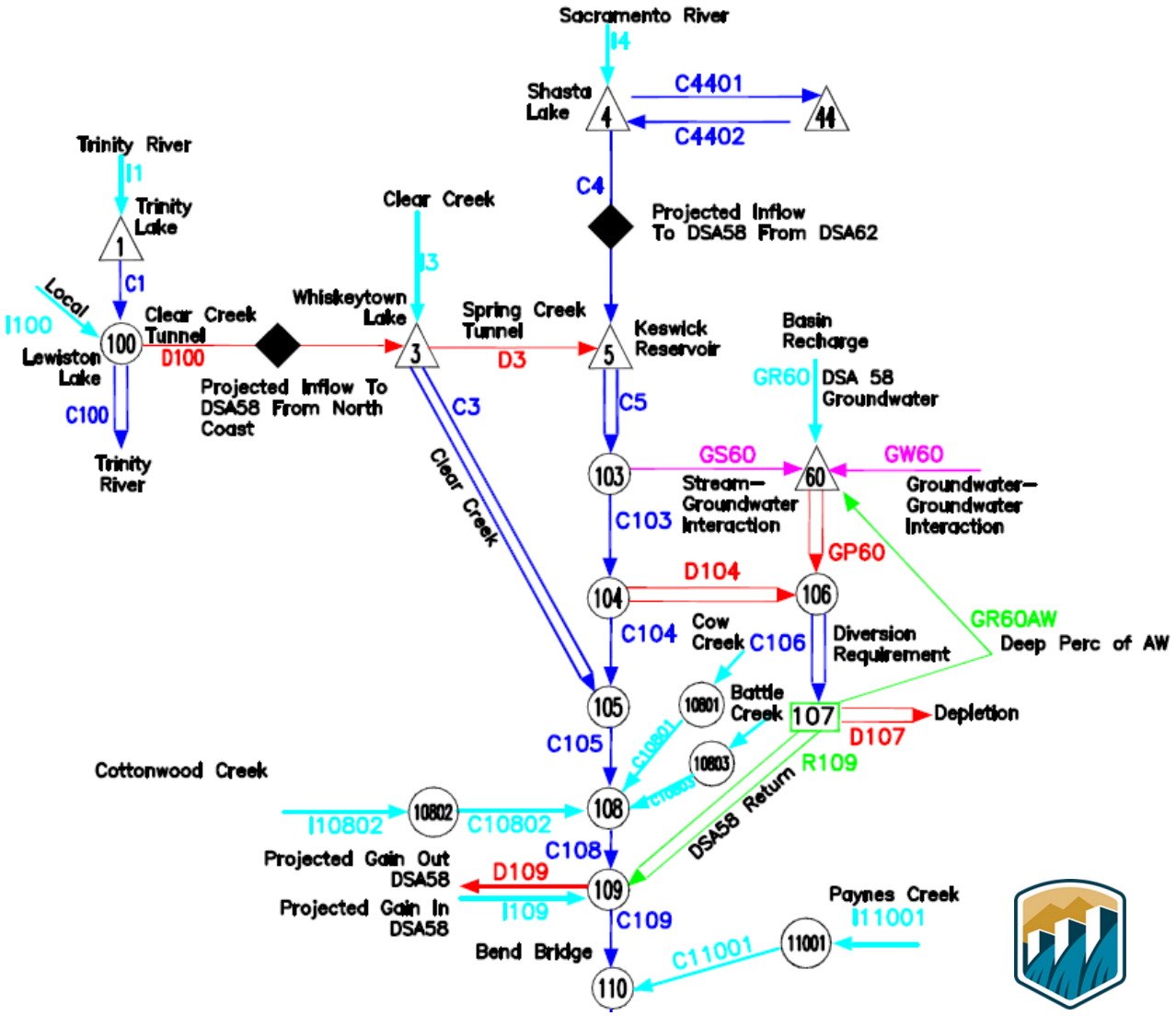
Cost on Shasta

Cost on Shasta – FlowTracker

FlowTracker is an accounting tool:

- WRIMs based
- Uses CalSim results as inputs
- Colors water by its source:
  - Reservoir Releases:
    - Shasta, Trinity, Folsom, Oroville
    - Pass-through Inflow
    - Previously Stored Water
  - Other:
    - Non-Project Inflow
    - Return Flows
    - Groundwater-Stream Interaction
    - San Joaquin River Inflow

How do we choose which source of water is used at which water use?



Cost on Shasta – FlowTracker

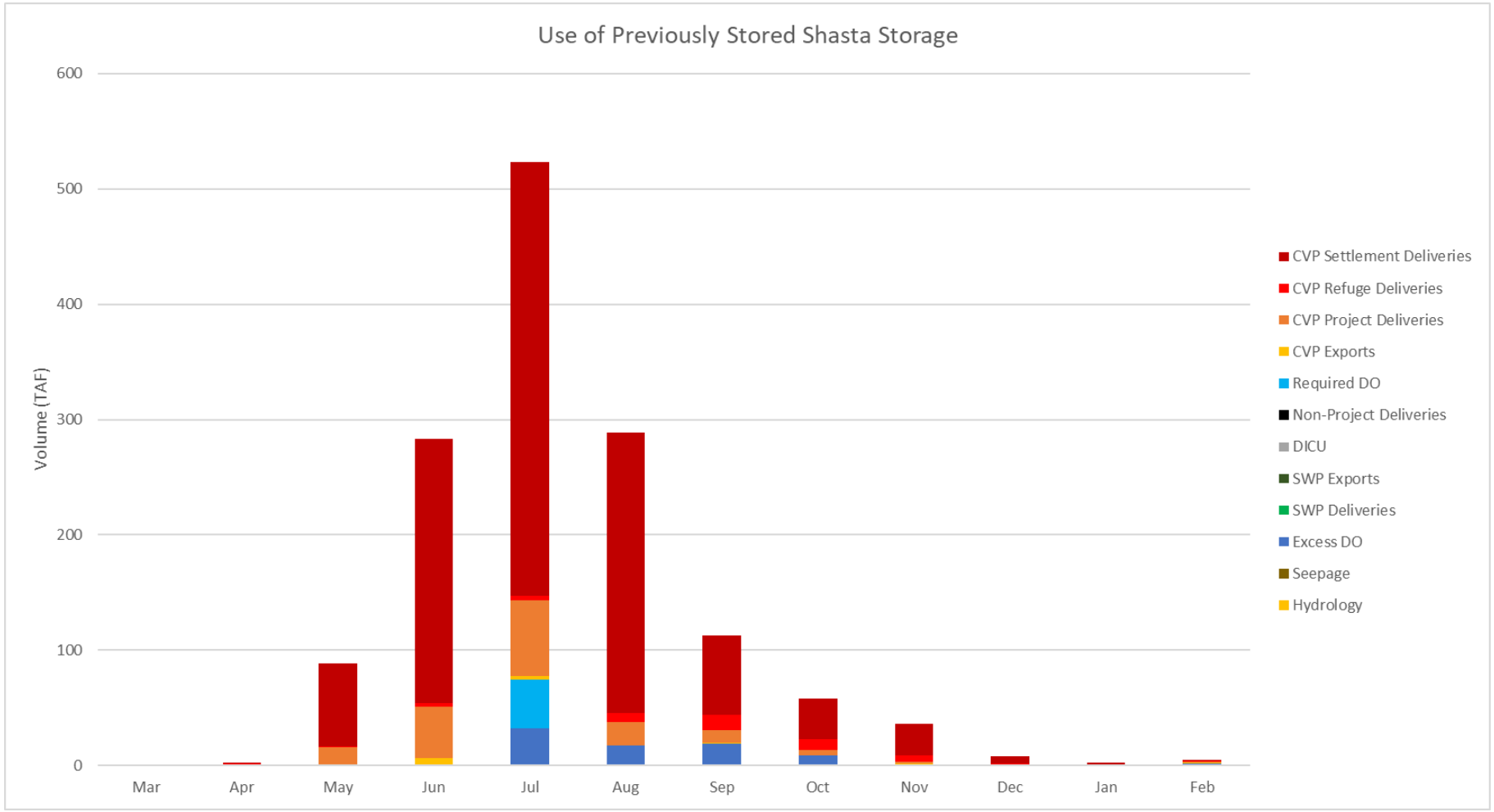
Weights are user defined:

- Shasta releases were used for CVP purposes before non-project purposes
- Shasta releases were used as high up in the system as possible
- Any Shasta releases present at Delta outflow is either excess or absolutely necessary to meet Delta outflow requirements

!Weights Formulation
!1 = NP_Hydro
!2 = DICU
!3 = NP_Del
!4 = CVP_PSC_PRF
!5 = CVP_PAG_PMI
!6 = SWP_PWR_PRF
!7 = SWP_PAG_PMI
!8 = Delta_Outflow
!9 = CVP_Export
!10 = SWP_Export

Water_Use	GW	RET	NPI	TLWS	TLWI	SKS	SKI	SWPS	SWPI	FNS	FNI	SJR
1	9000	8000	7000	-100	6000	-100	6000	-100	6000	-100	6000	9000
2	9000	8000	7000	-100	6000	-100	6000	-100	6000	-100	6000	9000
3	8900	7900	6900	1000	5900	1000	5900	1000	5900	1000	5900	9000
4	8800	7800	6800	9800	5800	9800	5800	-100	5800	9800	5800	9000
5	8700	7700	6700	9700	5700	9700	5700	-100	5700	9700	5700	9000
6	8800	7800	6800	-100	0000	-100	0000	9800	5800	-100	0000	9000
7	8700	7700	6700	-100	0000	-100	0000	9700	5700	-100	0000	9000
8	8850	7850	6800	0000	4600	0000	4600	0000	4600	0000	4600	8000
9	8600	7600	6600	3000	5600	2000	5600	-100	5500	3000	5600	9000
10	8600	7600	6600	-100	5500	-100	5500	9600	5600	-100	5500	9000

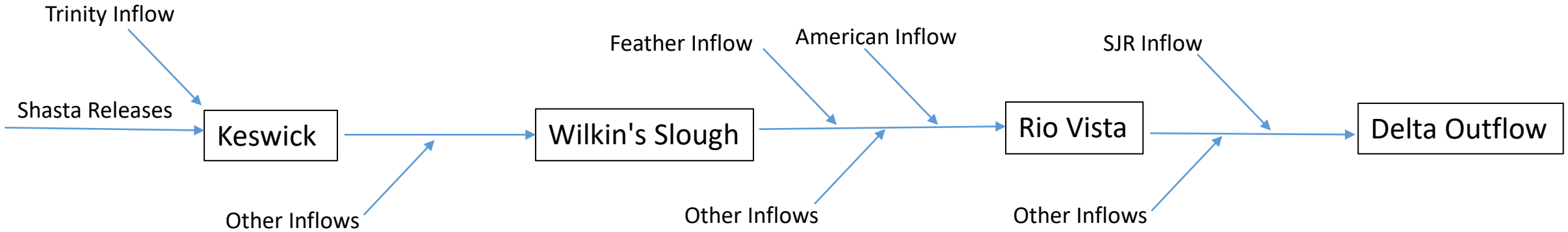
Cost On Shasta - FlowTracker



Cost on Shasta – Calculation

Releases to meet minimum flow calculated first:

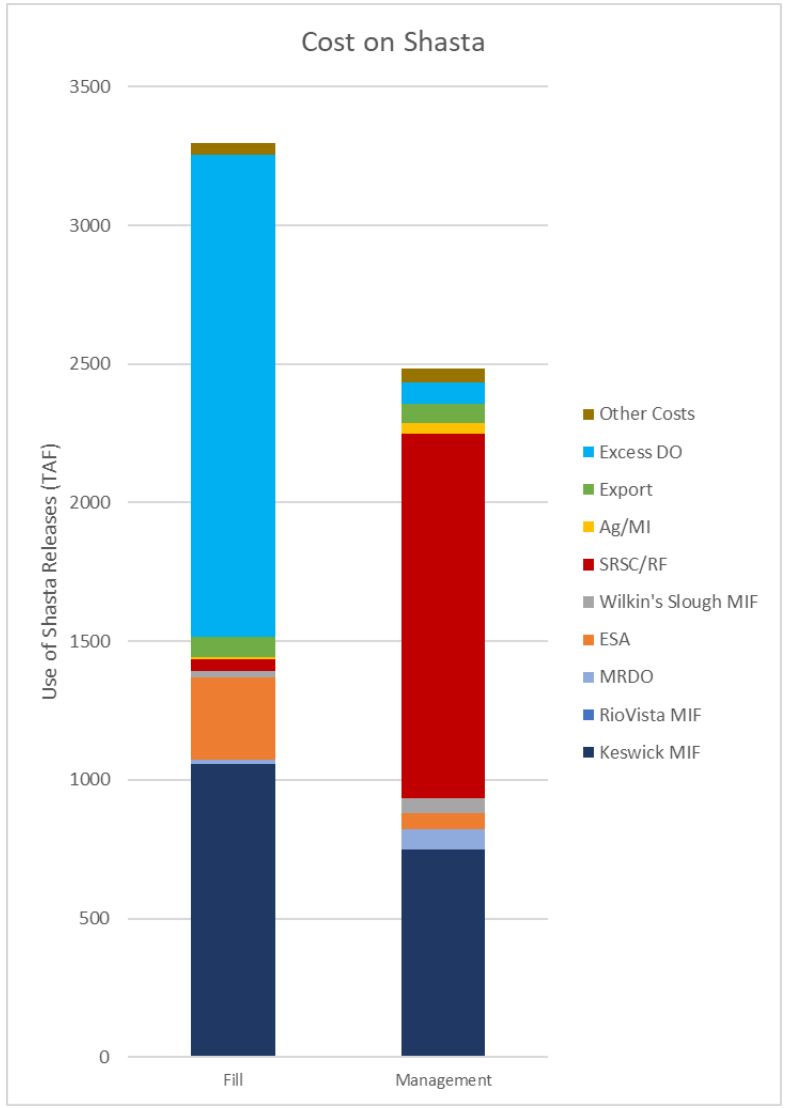
- Costs calculated in the following order: Keswick, Rio Vista, MRDO, ESA, Wilkin's Slough
- The cost on Shasta to meet minimum flow was calculated as the Shasta water needed above and beyond other sources of water (i.e. Trinity imports)
- Shasta Releases for Keswick minimum flows travel downstream to meet other minimum flows
- Downstream minimum flow costs were calculated as incremental Shasta releases needed above and beyond what was released for upstream minimum flows.



Cost on Shasta – Calculation

Additional releases, above and beyond those made for minimum flows are attributed to a consumptive use:

- Consumptive use costs were calculated in the following order: senior water rights, service contract deliveries, exports, excess Delta outflow and other hydrologic uses (i.e. seepage)
- Water released for Keswick or Wilkin's Slough that was NOT needed for downstream minimum flows and which is delivered or exported is not an incremental cost on Shasta



BUREAU OF RECLAMATION

Shasta Operations Focused Exploratory Analysis

Shasta-Focused Questions

- Fill
- Carryover
- Hydrology
- Releases
  - Flood Control Spill
  - Temperature management
  - D1641
  - ESA regulatory requirements
  - Refuge Level 2 Delivery
  - Senior Water Rights Delivery – Sac. River Settlement, SJR Exchange
  - CVP Service Delivery

Shasta Focused Analysis

- Addressing Fill Targets
  - What determines fill?
    - Fill = f(carryover, inflow, spills, managed release of inflow)
    - Releases for:
      - MIF, D1641, ESA requirements, Water Supply
- Addressing Carryover Targets
  - What determines carryover?
    - Carryover = f(fill, inflow, spills, managed release of stored water and inflow)
    - Releases for:
      - MIF, D1641, ESA requirements,
      - SRSC, Refuge Level 2, Exchange Contractors, Service Contractors

Shasta Focused Analysis

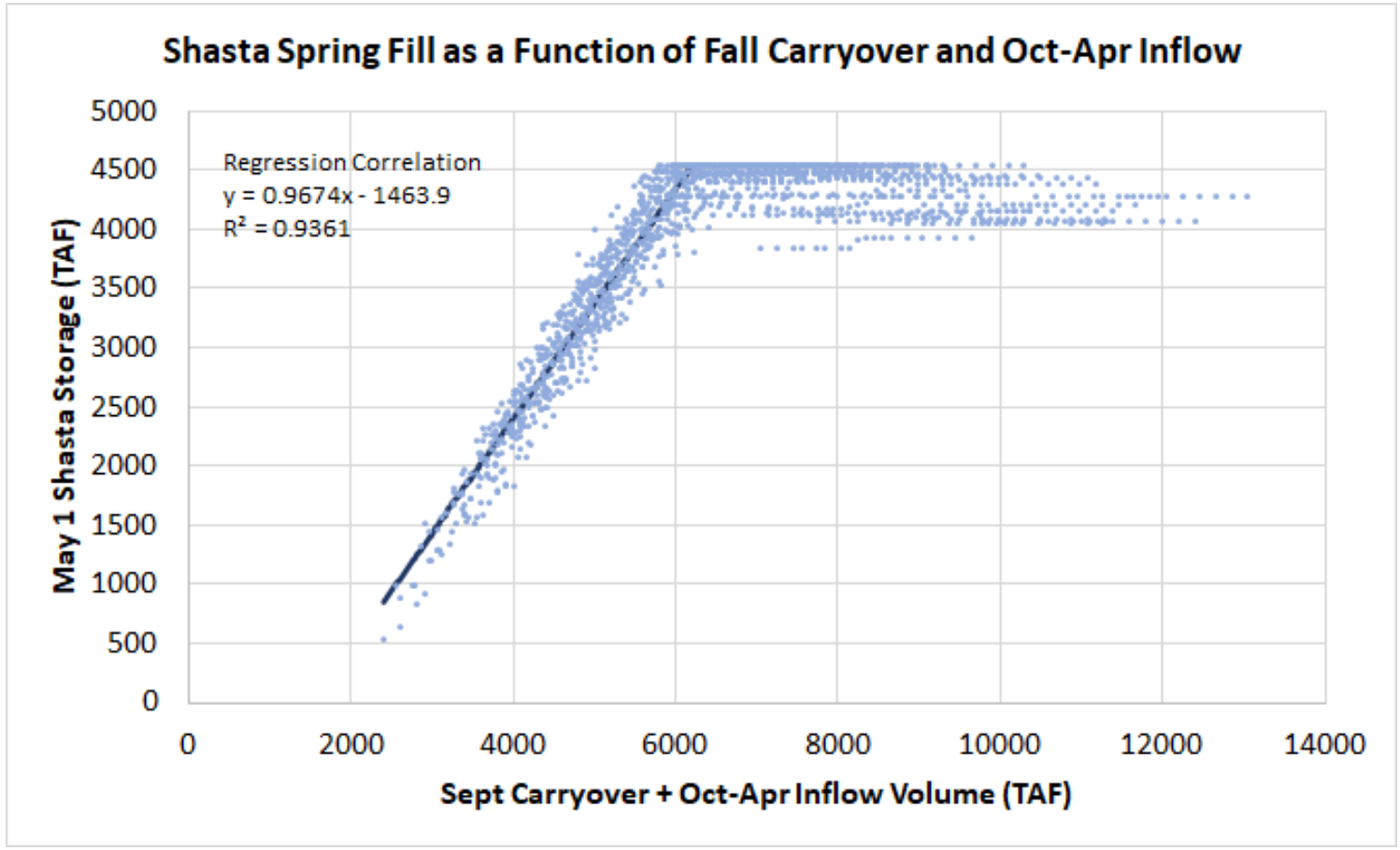
- Forward analysis: given initial conditions and forecasted inflow, what can be achieved?
- Backward analysis: what initial conditions are needed to meet a certain carryover target or reduce risk of spill?
- Analysis perspectives benefit from a large set of potential conditions for Shasta Fills and Carryovers along with the associated operations
- Running CalSim in position analysis mode provides that data set

CalSim Position Analysis Runs

- Tiering from CalSim 2 Exploratory Modeling
  - Using Scenarios EXP2.5B, EXP3, EXP4.95, and EXP5P
- Position analysis runs used 18 initial conditions for Shasta storage – 800, 1000, 1200, 1300, 1500, 1600, 1800, 1900, 2000, 2100, 2200, 2300, 2400, 2600, 2800, 3000, 3200, and 3400 TAF
  - Other system initial conditions set commensurately with Shasta initial condition
- 18 initial conditions X 82 = 1476 one-year simulations of Shasta operations
  - For each EXP condition
- Large pile of data to mine for information on variability in use and control of Shasta storage
  - D1641, ESA, Water Supply
  - What conditions lead to various fill and carryover levels

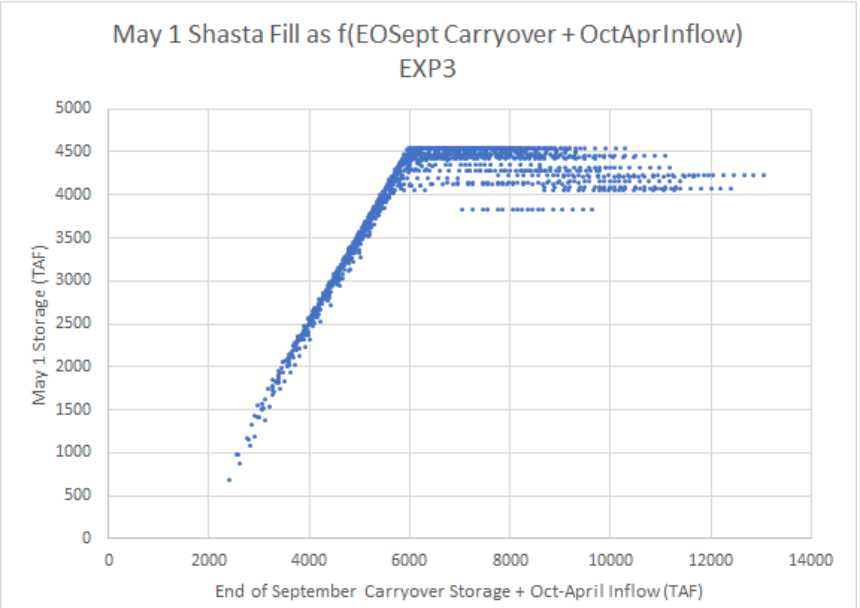
Filling Season Focus (October-April)

What Determines Shasta Fill?

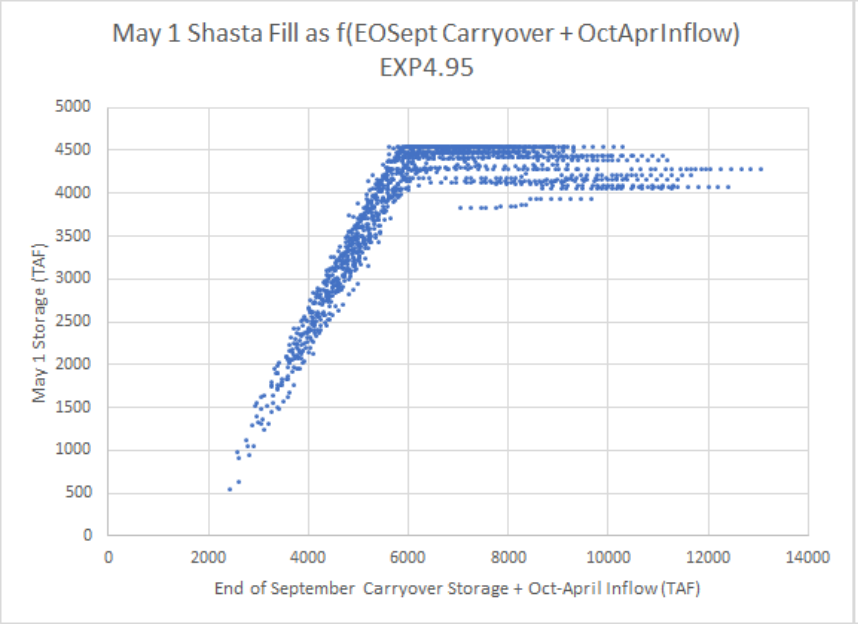


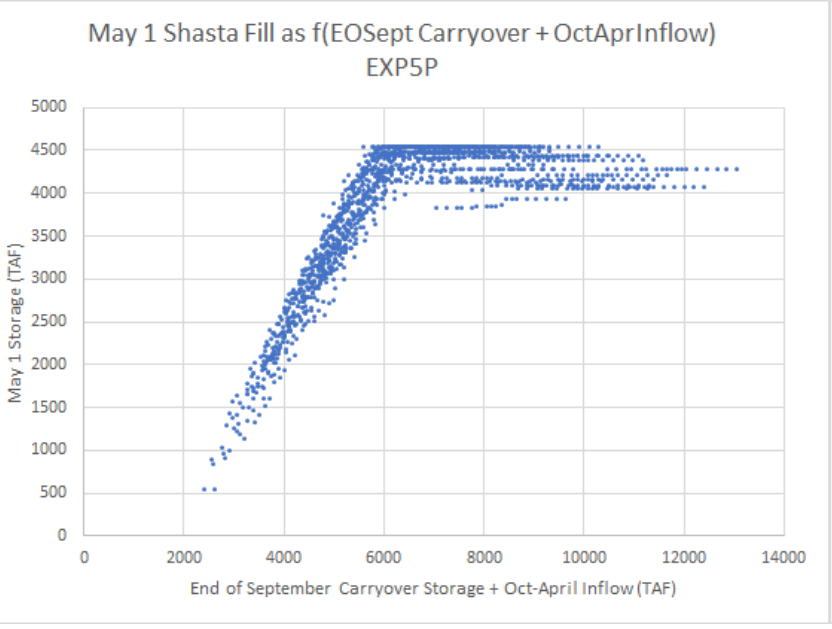
- Plot (Initial Storage + Inflow) vs. May 1 Fill
- Initial Storage 800-3400 TAF
- Oct-Apr Inflow 1600-9600 TAF
- 1476 unique one-year runs – each dot is one fill scenario
- Range of fill for given water supply reflects variability in
  - release for regulations (mostly)
  - delivery/export (low Oct-Apr)
- Inflection point around 6 MAF shows the combination of carryover and inflow needed to fill

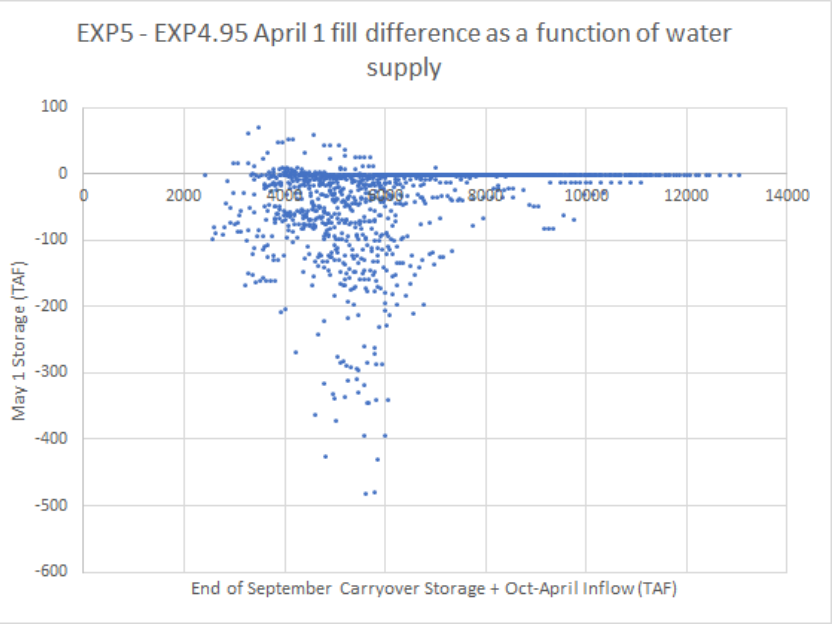
Shasta Fill under EXP Variations



- May 1 Fill is strongly correlated with Carryover + Inflow
- Fill variability indicates the range of regulatory criteria affecting releases of Shasta inflow – flood control, D1641, ESA, CVP reservoir balancing
- (EXP5P-EXP4.95) average difference in fill is 33 taf; only 10% of differences are 100 TAF or more, and most of those are in traces with high initial storage conditions and/or high inflow





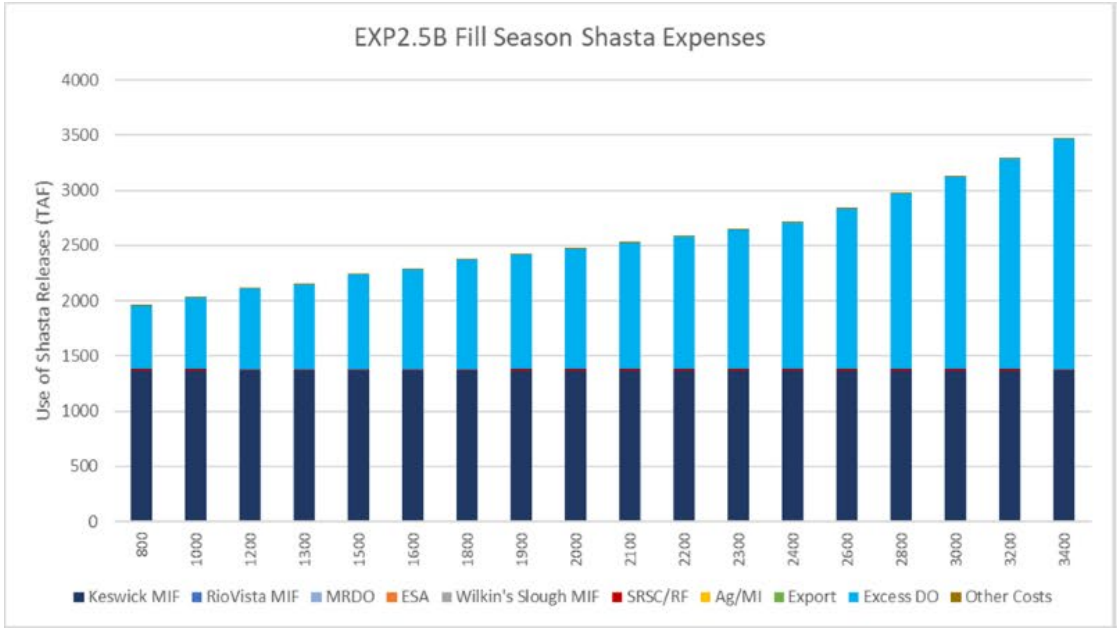


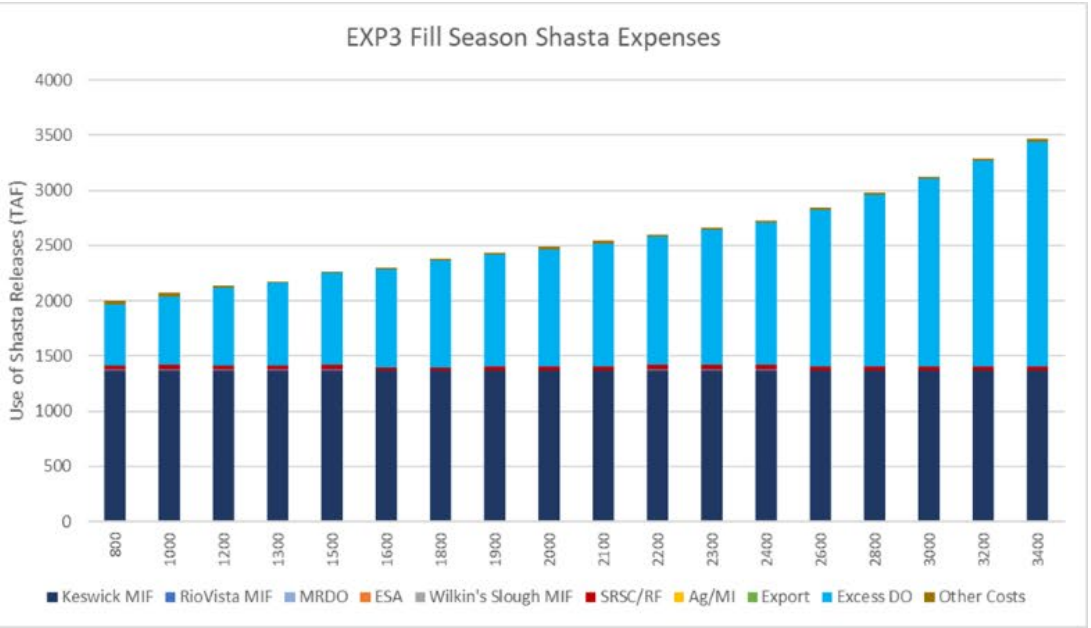
Fill Probability Questions and Issues

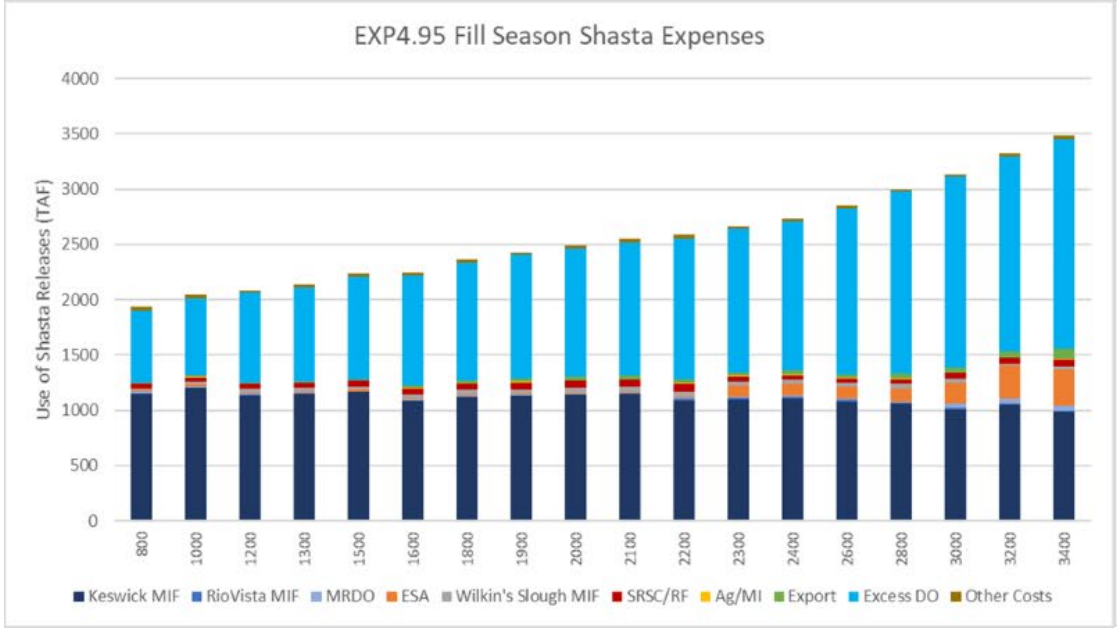
- What operations affect fill?

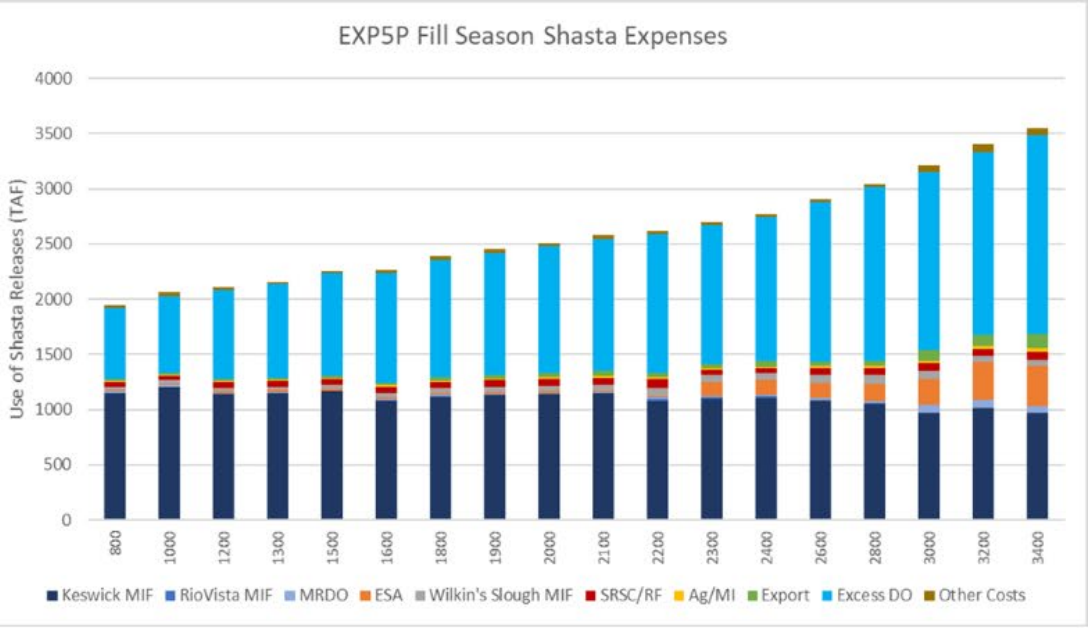
- Releases to meet D1641 (mostly Keswick)
- Releases to meet ESA
- Releases for flood control
- Releases for delivery and export

Filling Season Costs

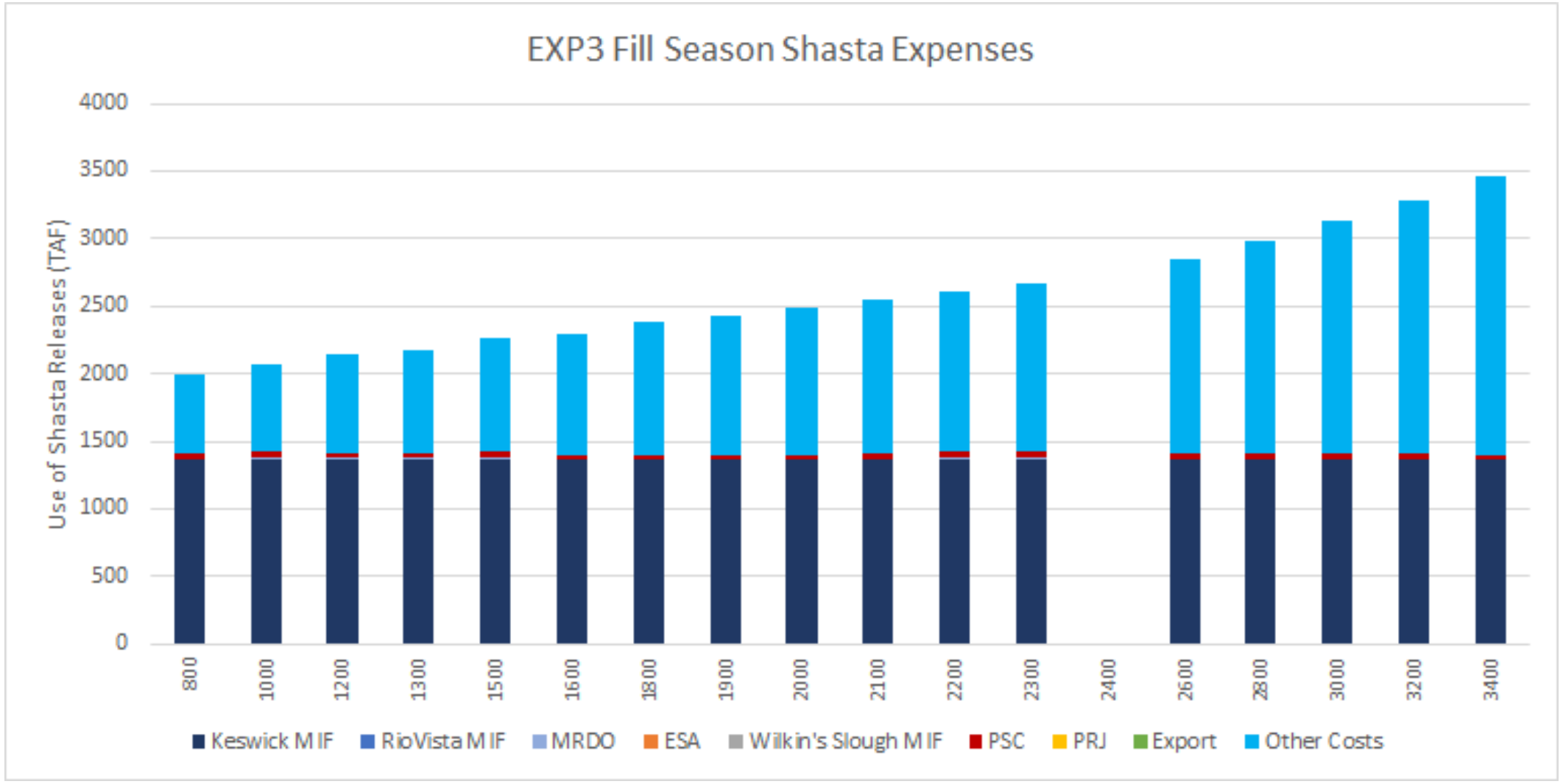




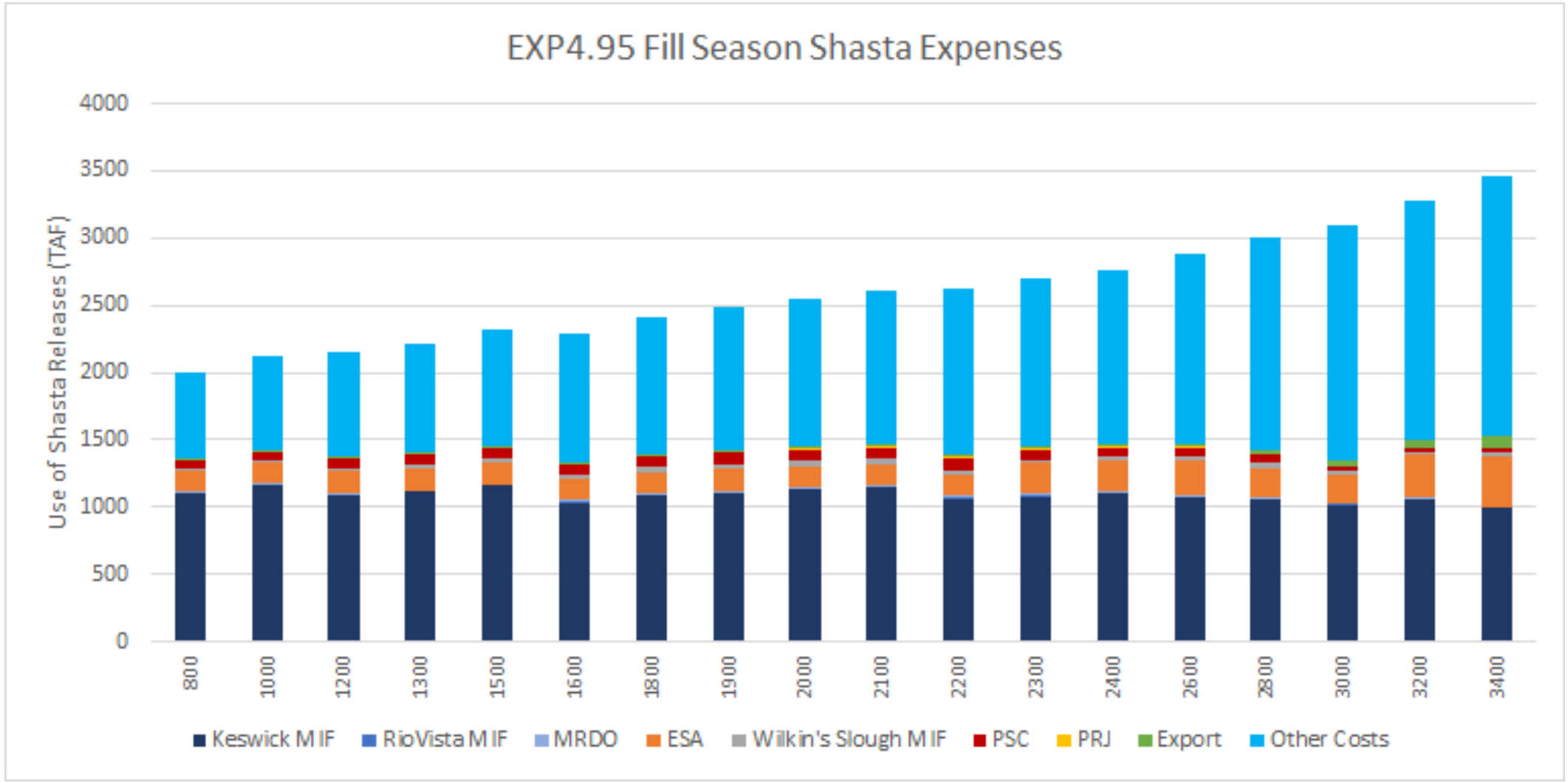




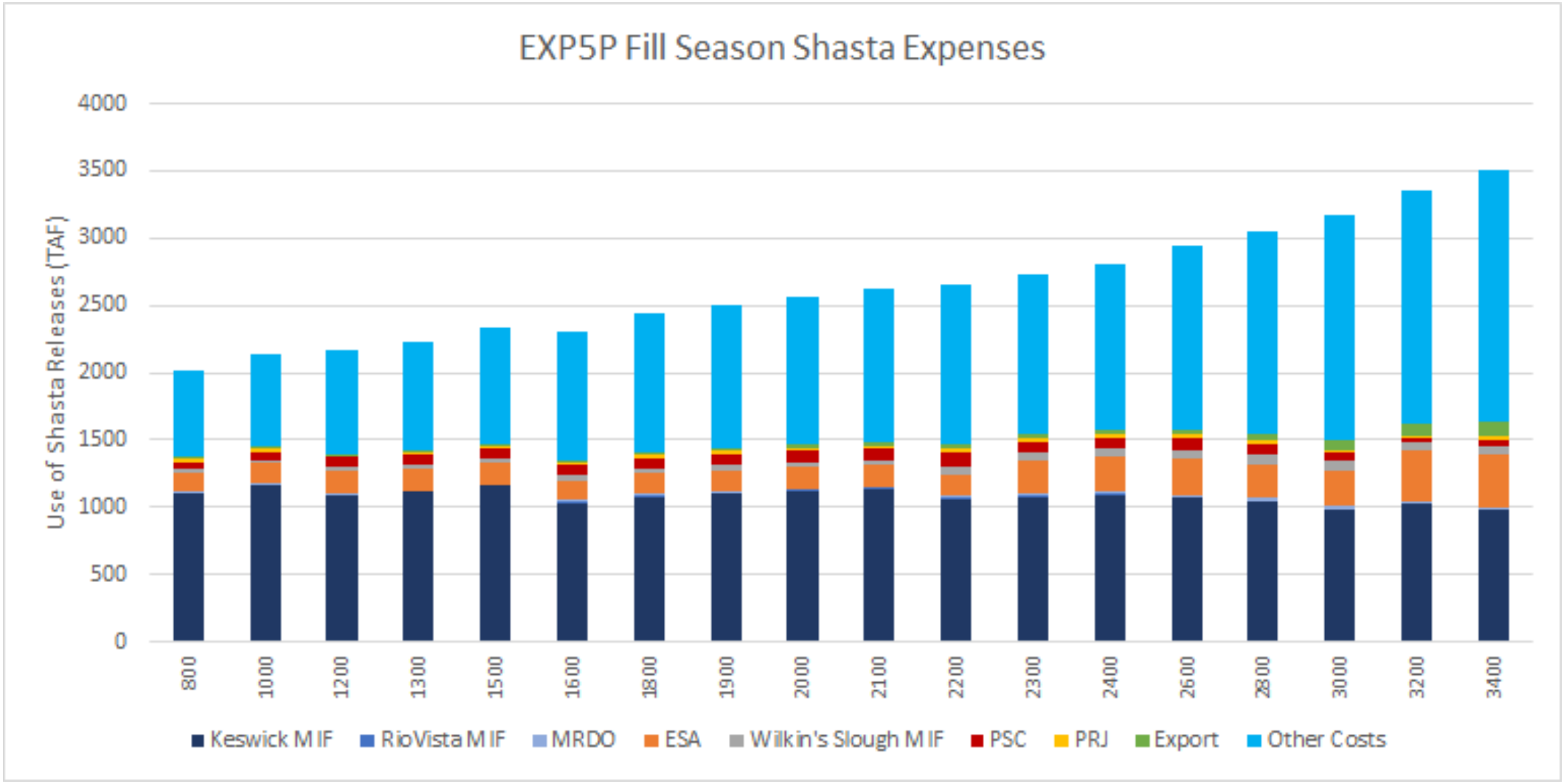
EXP3 – Fill Season Release Accounting



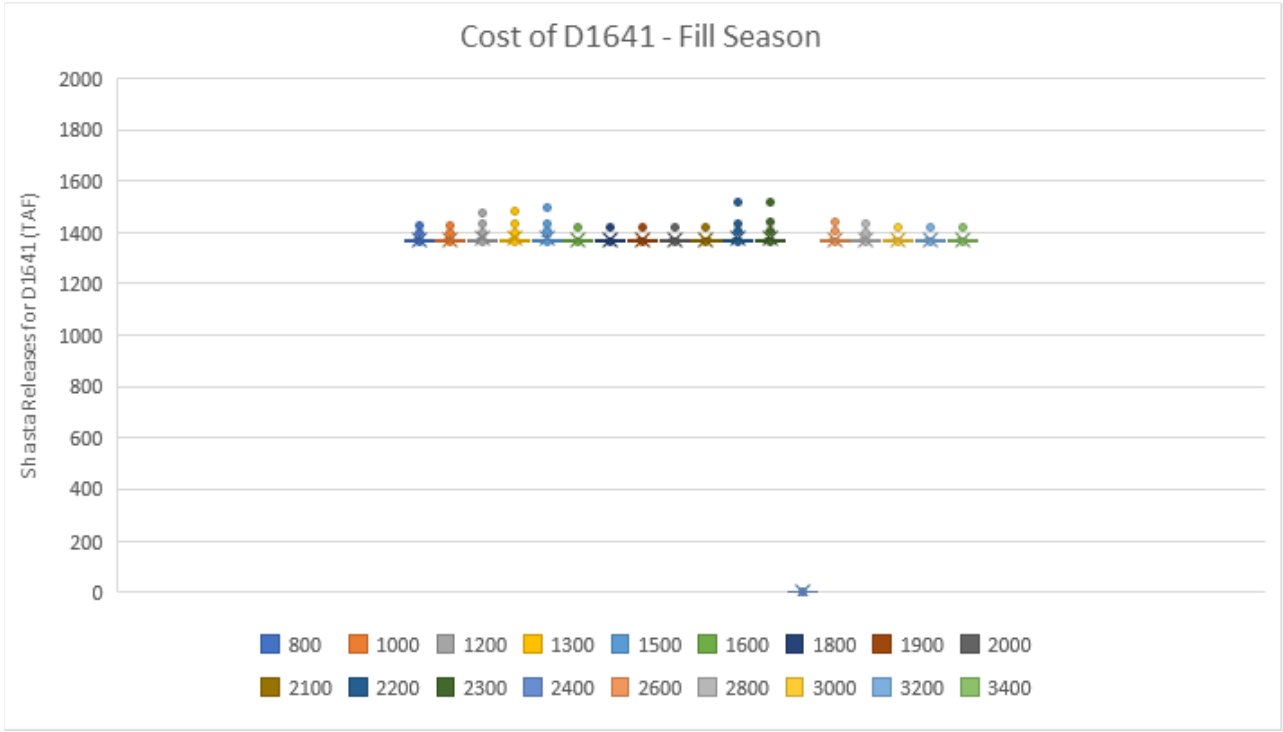
EXP4.95 – Fill Season Release Accounting

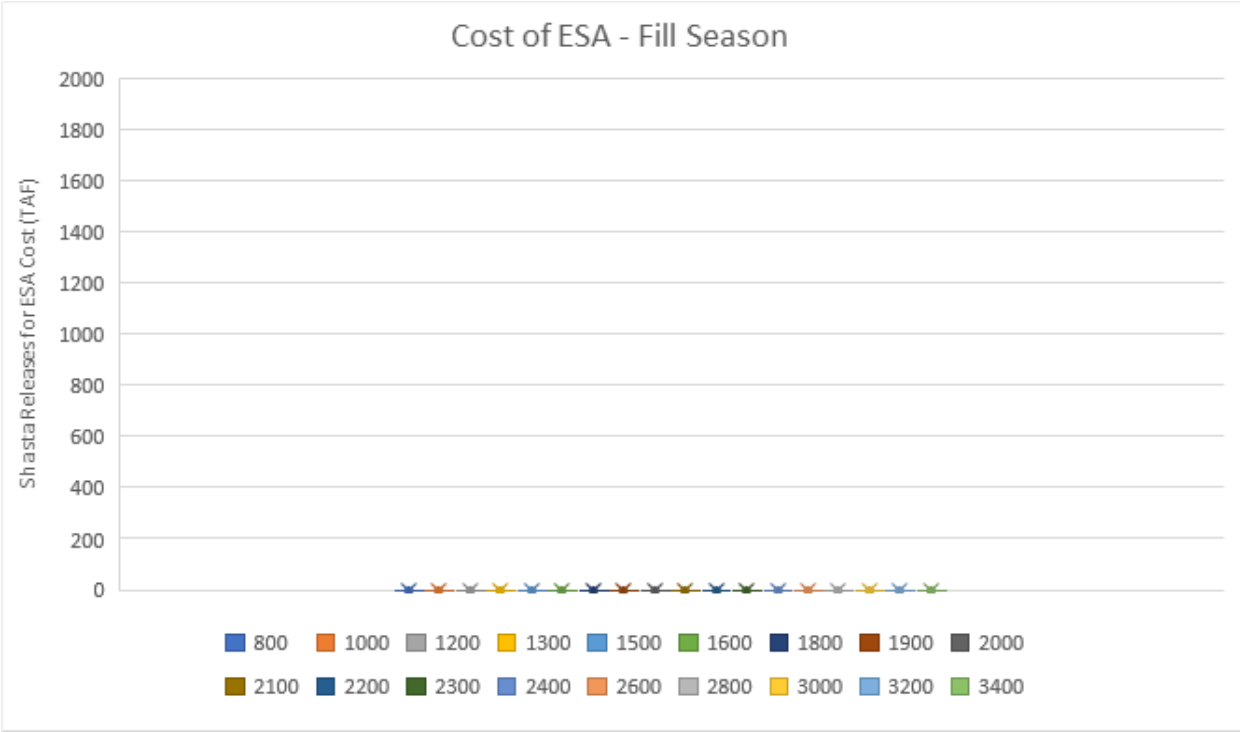


EXP5P – Fill Season Release Accounting



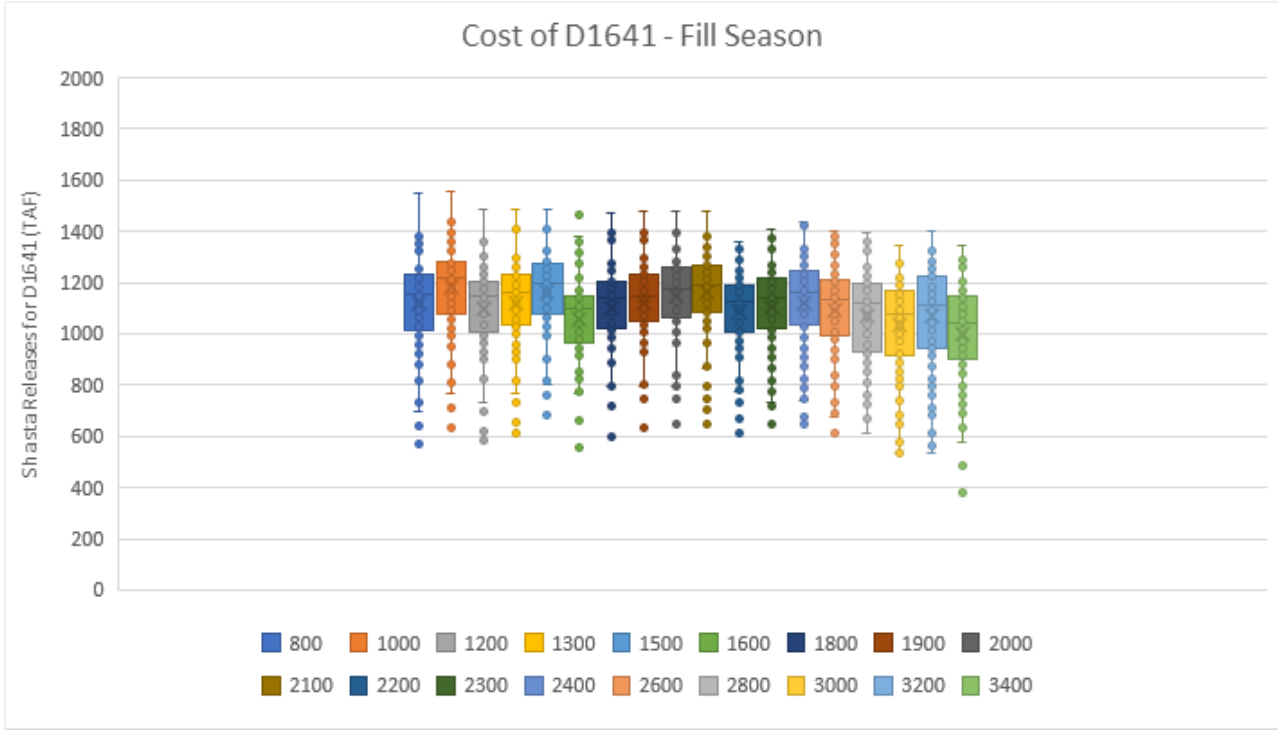
EXP3 - Cost of Regulations

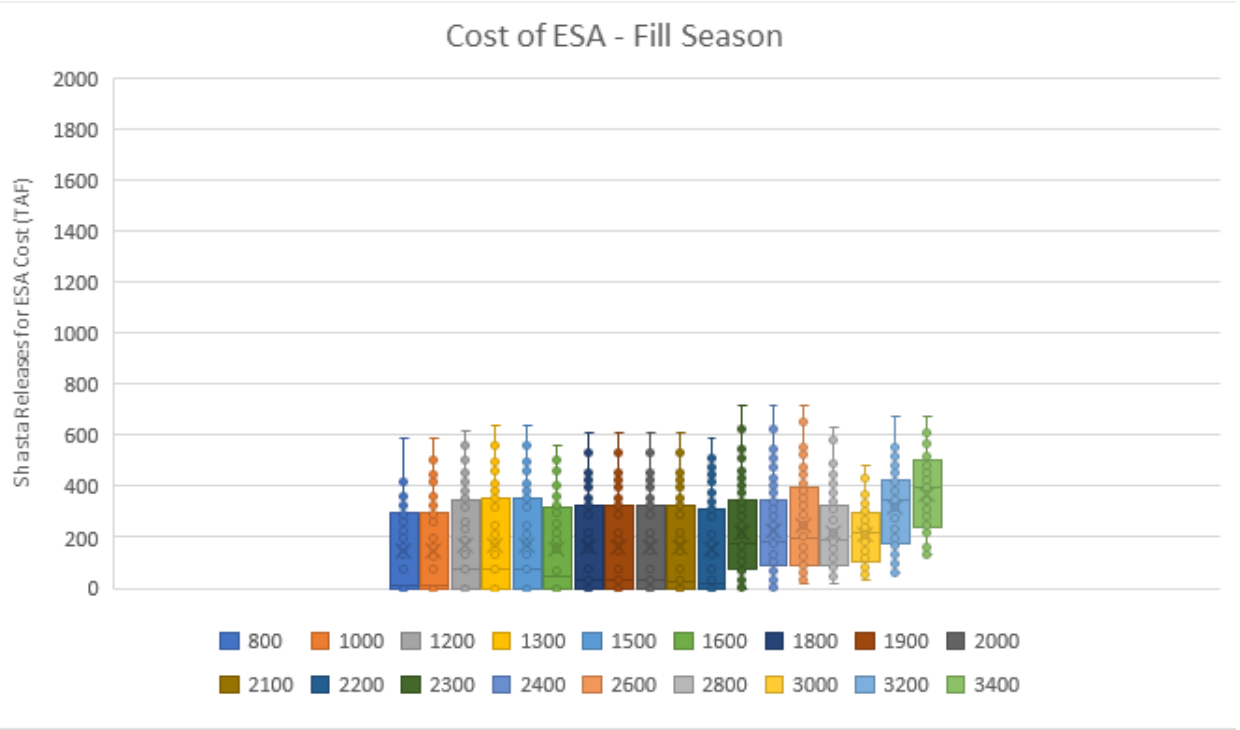




- Minimum flow at below Keswick (3250 cfs) primarily controls the cost of D1641
- No Trinity Import in EXP3, so the entire cost of meeting Keswick falls on Shasta
- No ESA Regulations

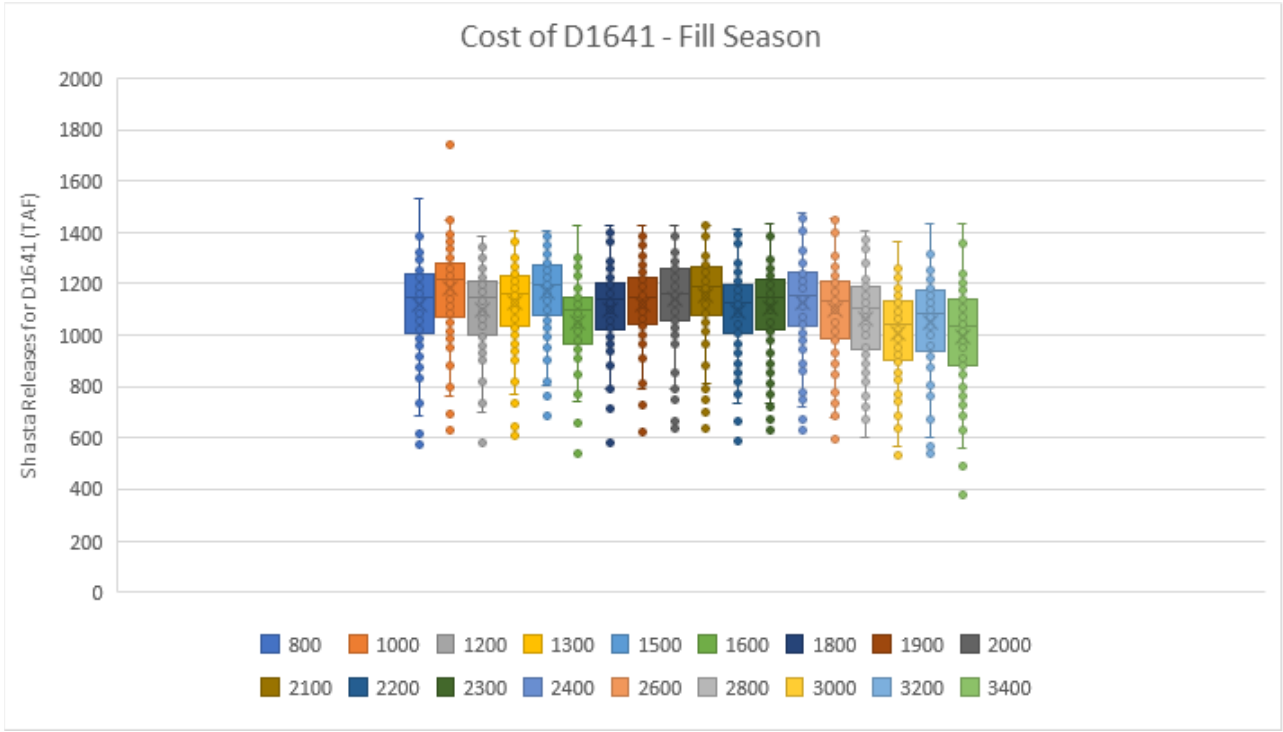
EXP4.95 - Cost of Regulations

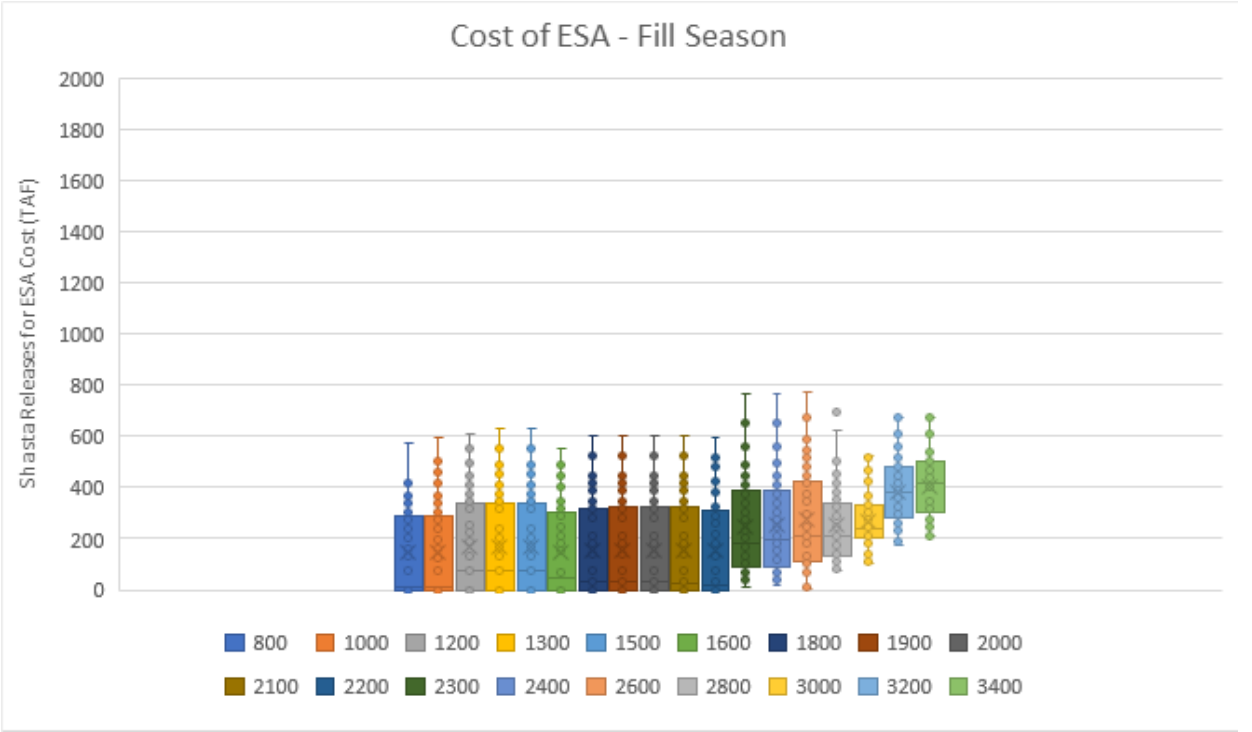




- Variability in the cost of D1641 is not related to initial Shasta storage.
- ESA costs
  - October Fall X2 – wet and above normal years
  - Fall Stability Flows – activated for September carryover above 2200 TAF
  - Spring Pulse Releases – based on assessed likelihood of filling to 4100

EXP5P - Cost of Regulations



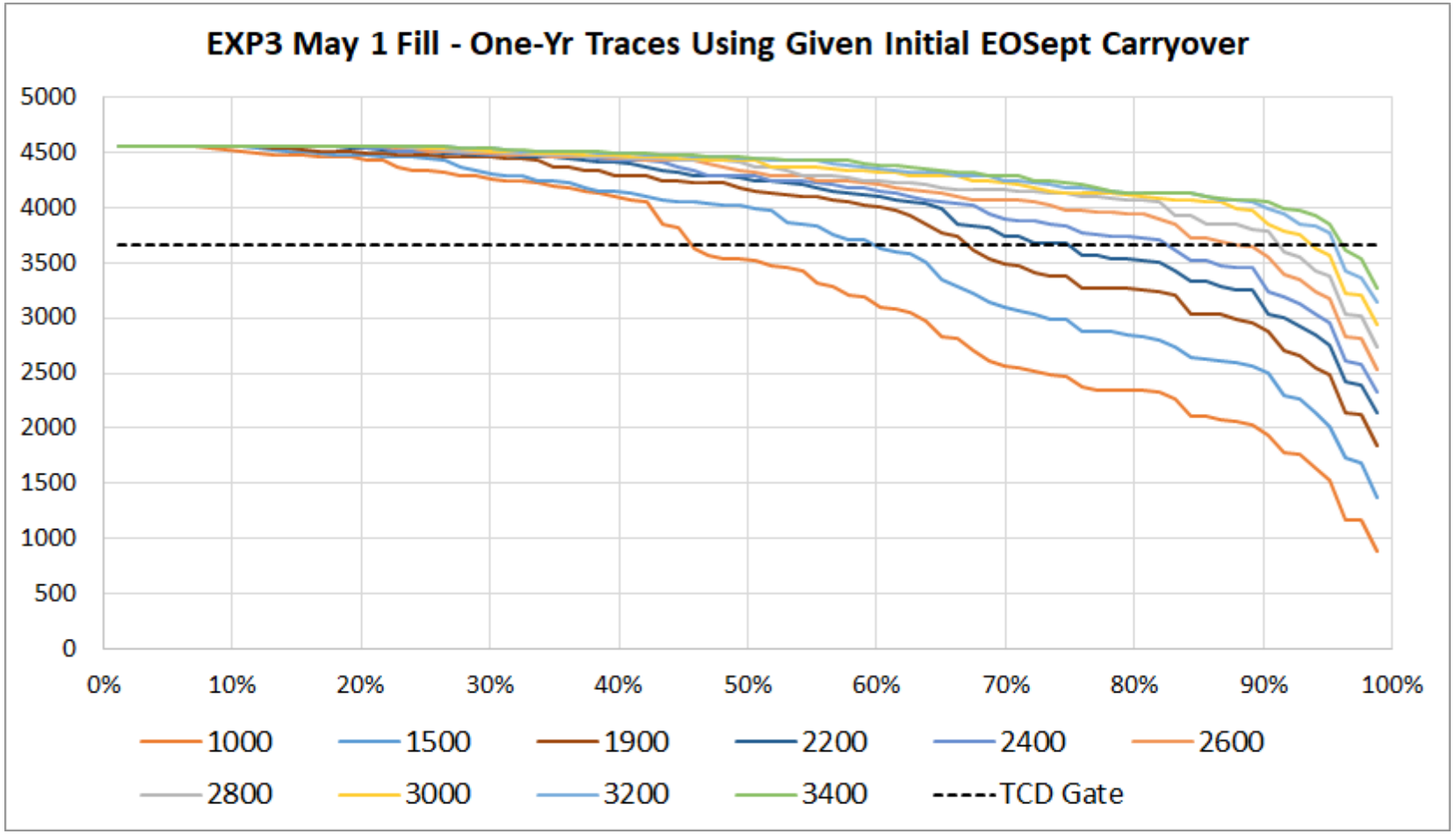


- Very little difference in the cost of D1641 and ESA between Exp 4.95 and Exp 5P.
- Variations among initial conditions likely due to varying contributions from Trinity and other reservoir balancing in the model.
- The range of costs is consistent for all initial storage conditions.

Fill Probability Questions and Issues

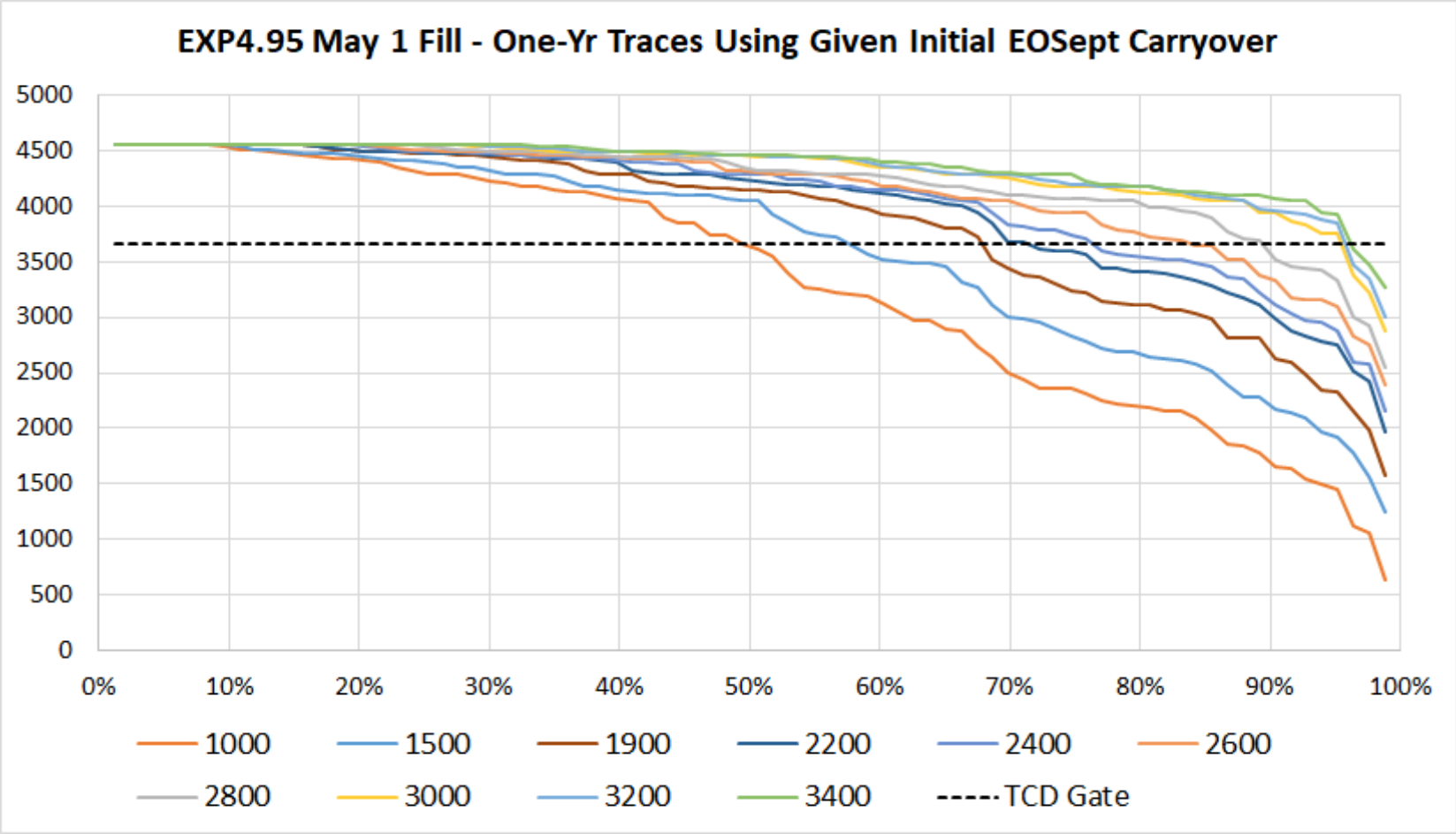
- What is the likelihood of fill, given carryover storage?
- What layers of Shasta responsibility affect fill?

EXP3 – Fill results for selected initial conditions



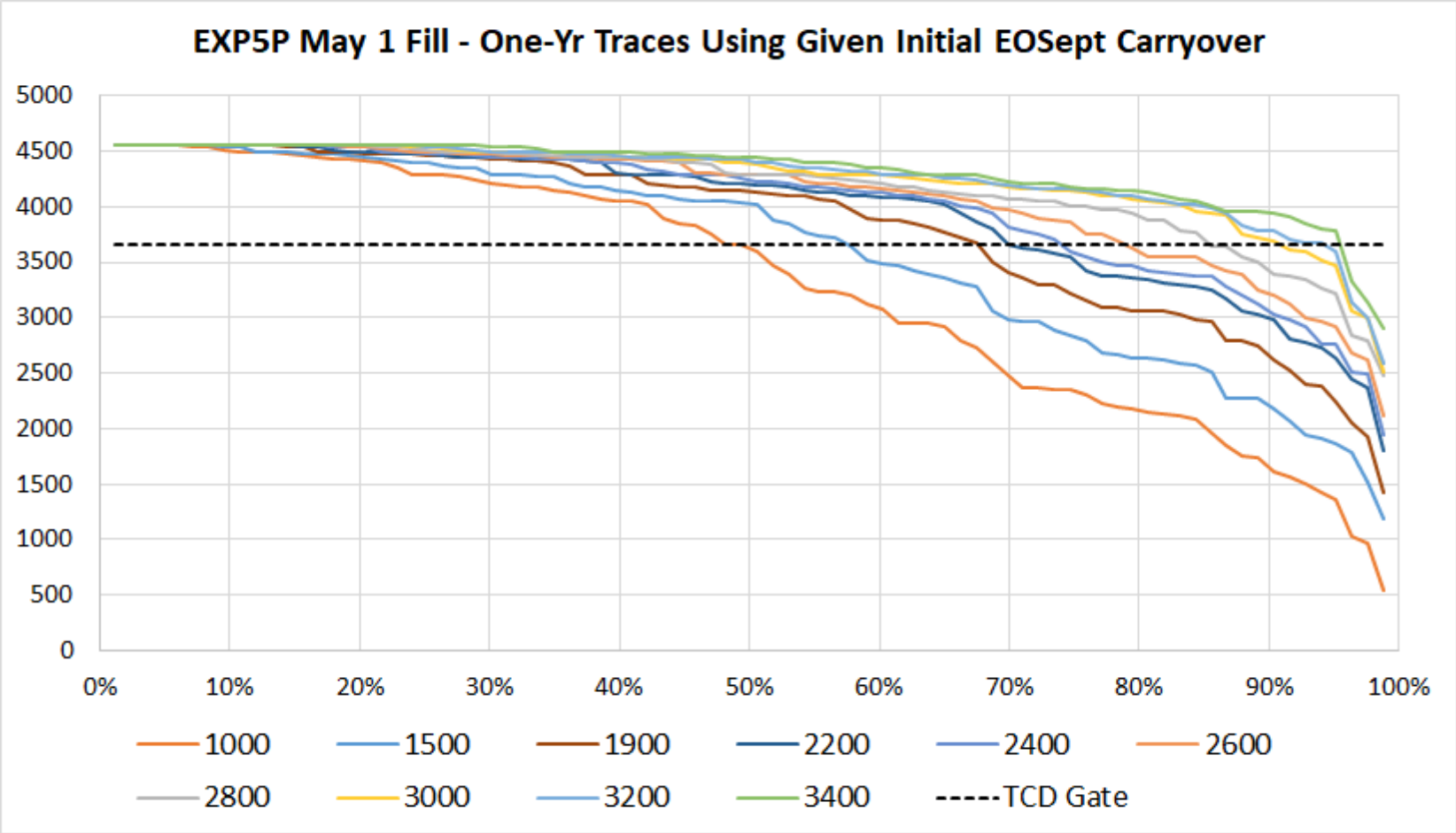
- Higher carryover results in higher fill
- Scroll through plots for the layers of EXP run assumptions (3, 4.95, 5P)
- Discretionary operations have little influence on fill

EXP4.95 – Fill results for selected initial conditions



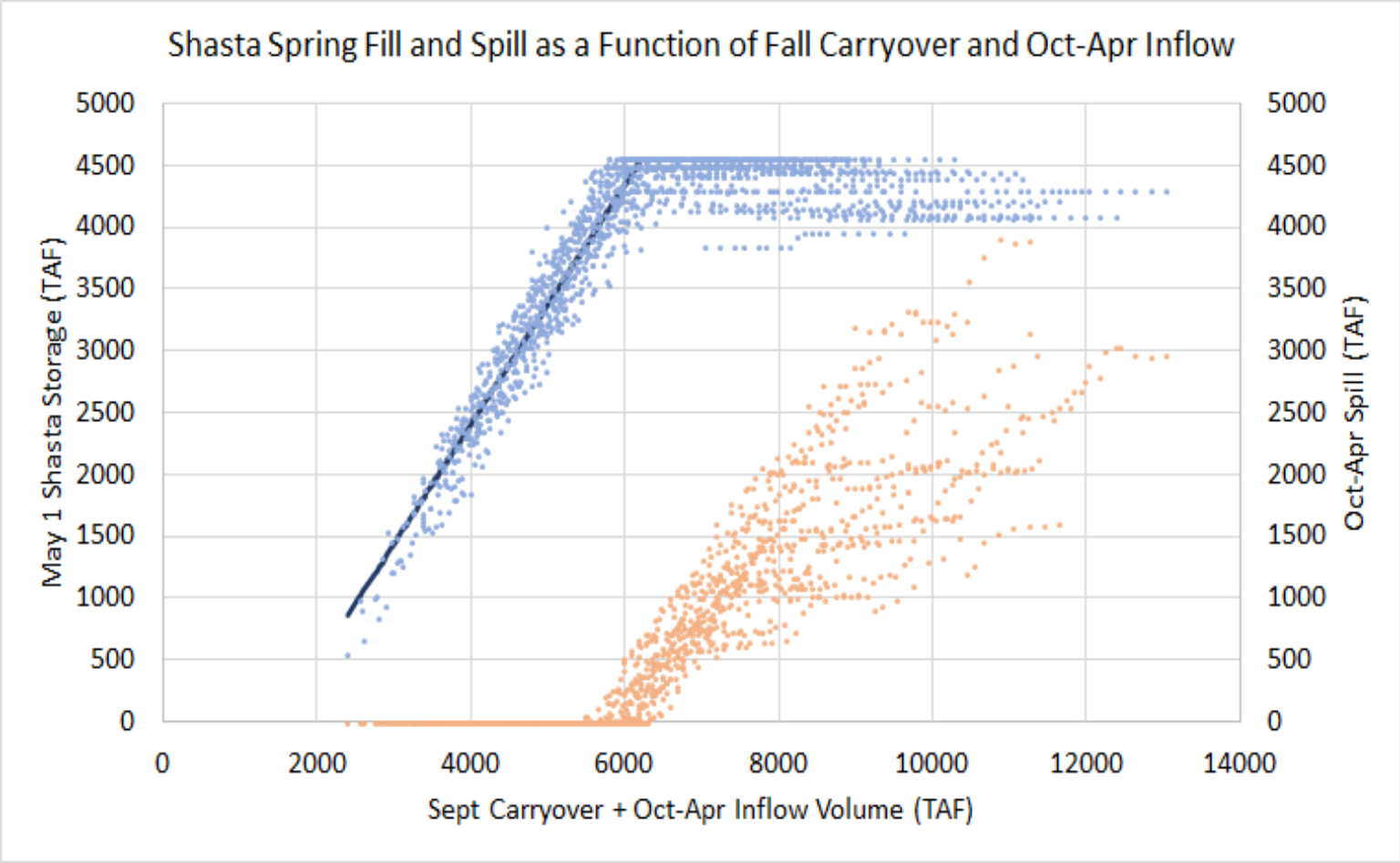
- Higher carryover results in higher fill
- But even without discretionary releases, even the highest carryover will not always result in optimal fill

EXP5P – Fill results for selected initial conditions



- Higher carryover results in higher fill
- Under the input hydrology assumptions, probability of Shasta achieving full access to the upper TCD gates by May 1 increases from 68% to 70% if carryover is 2200 taf instead of 1900 taf**

Shasta Previous Year's Carryover vs Fill



- Same blue dots
- Orange dots are Oct-Apr spill volume
- Inflection point of ~6 MAF for fill is mirrored by trigger of increased spills
- Higher carryover has diminishing returns for accomplishing fill

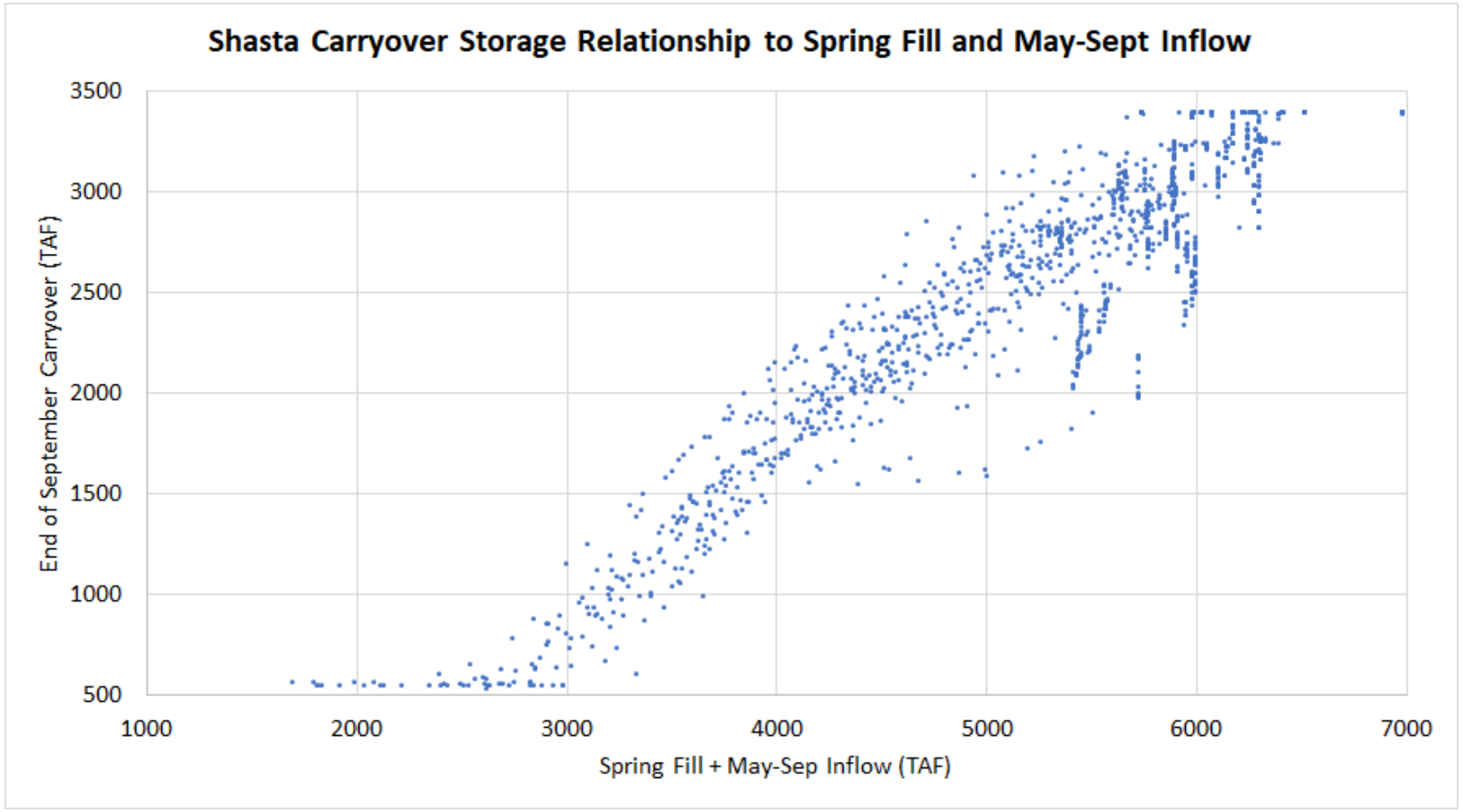
What initial conditions are needed to meet a certain carryover target or reduce risk of spill?

Filling Season Summary Points

- Fill is a function of inflow, carryover storage, and release
- Carryover storage helps, to a point
- Release for regulatory criteria lends uncertainty to fill potential
- The main driver of Shasta release is Keswick flow – this goes on to meet the bulk of criteria further downstream
- Delivery & export during the filling season have a limited effect on fill
- Pronouncing a fill target does not make meeting it more likely

Management Season Focus (May - September)

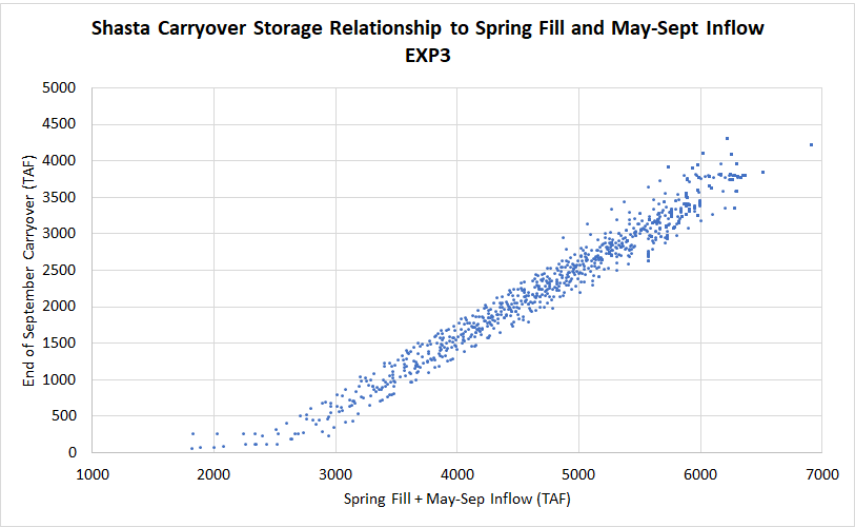
What Determines Shasta Carryover?



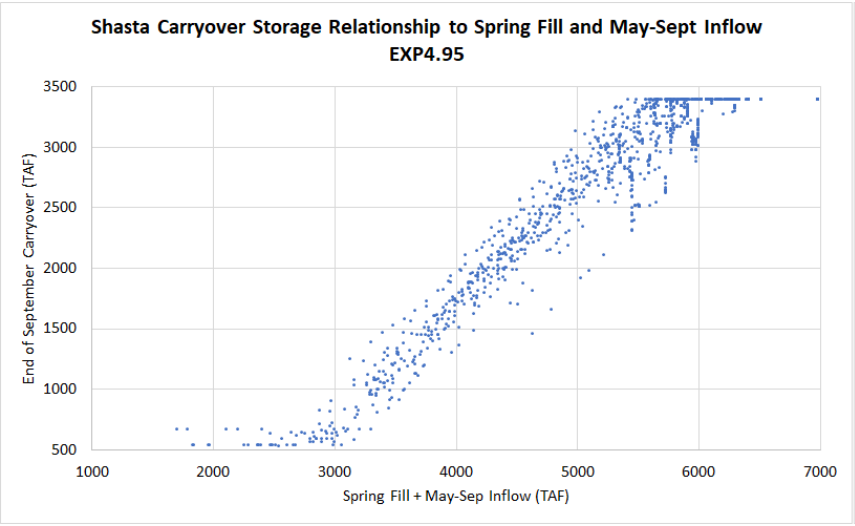
With initial conditions and forecasted inflow, what can be achieved?

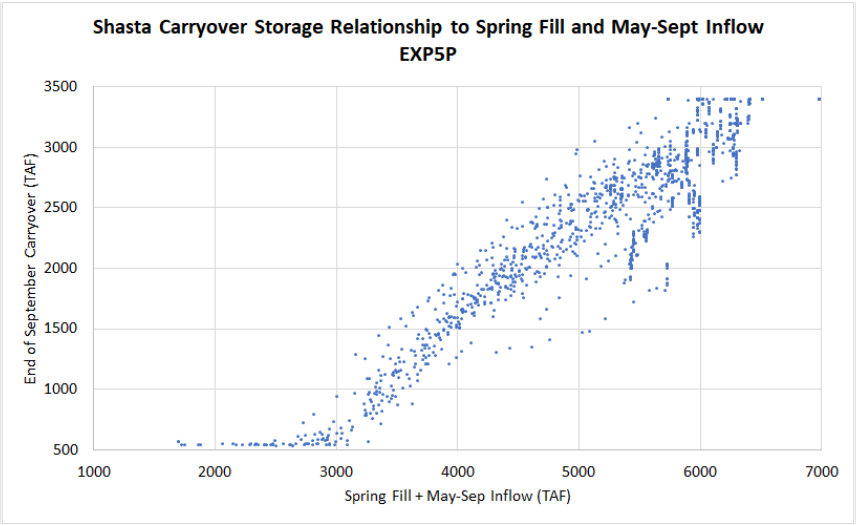
- What conditions and operations produce various levels of carryover?
  - Spring Fill
  - May-Sept Inflow
  - Reservoir Release
- Plot shows carryover storage as a function of Fill+Inflow
- Fill range 550-4552 TAF
- Inflow range 824-2579 TAF
- 1476 unique one-year runs – each dot is a scenario
- Range of carryover for a given fill+inflow reflects variable
  - release for regulations
  - project deliveries

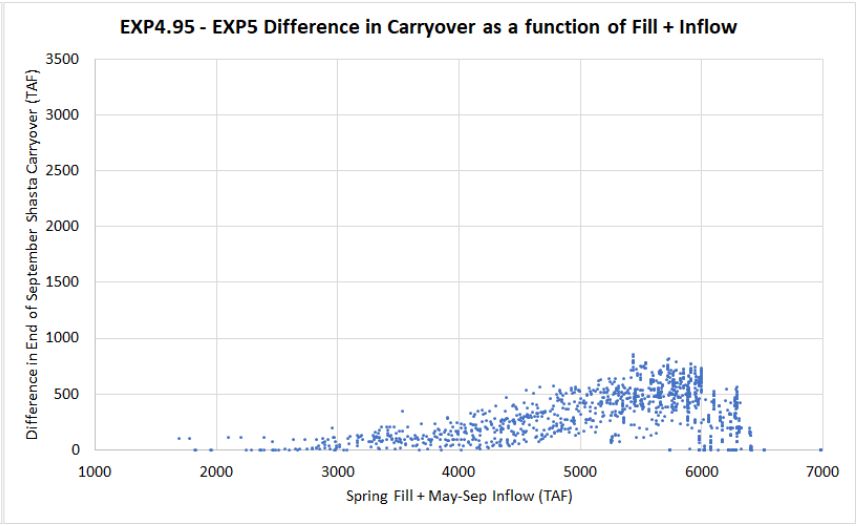
Shasta Carryover



- Carryover storage is a function of spring fill, hydrology, regulatory criteria, and delivery
- EXP3 releases only for D1641 and Settlement Contract Delivery
- EXP4.95 carryover reflects ESA (Fall X2, SMSCG) and WQ costs associated with export of delta surplus
- EXP4.95 – EXP5 differences indicate releases for export and project delivery, and are higher in years with more water supply





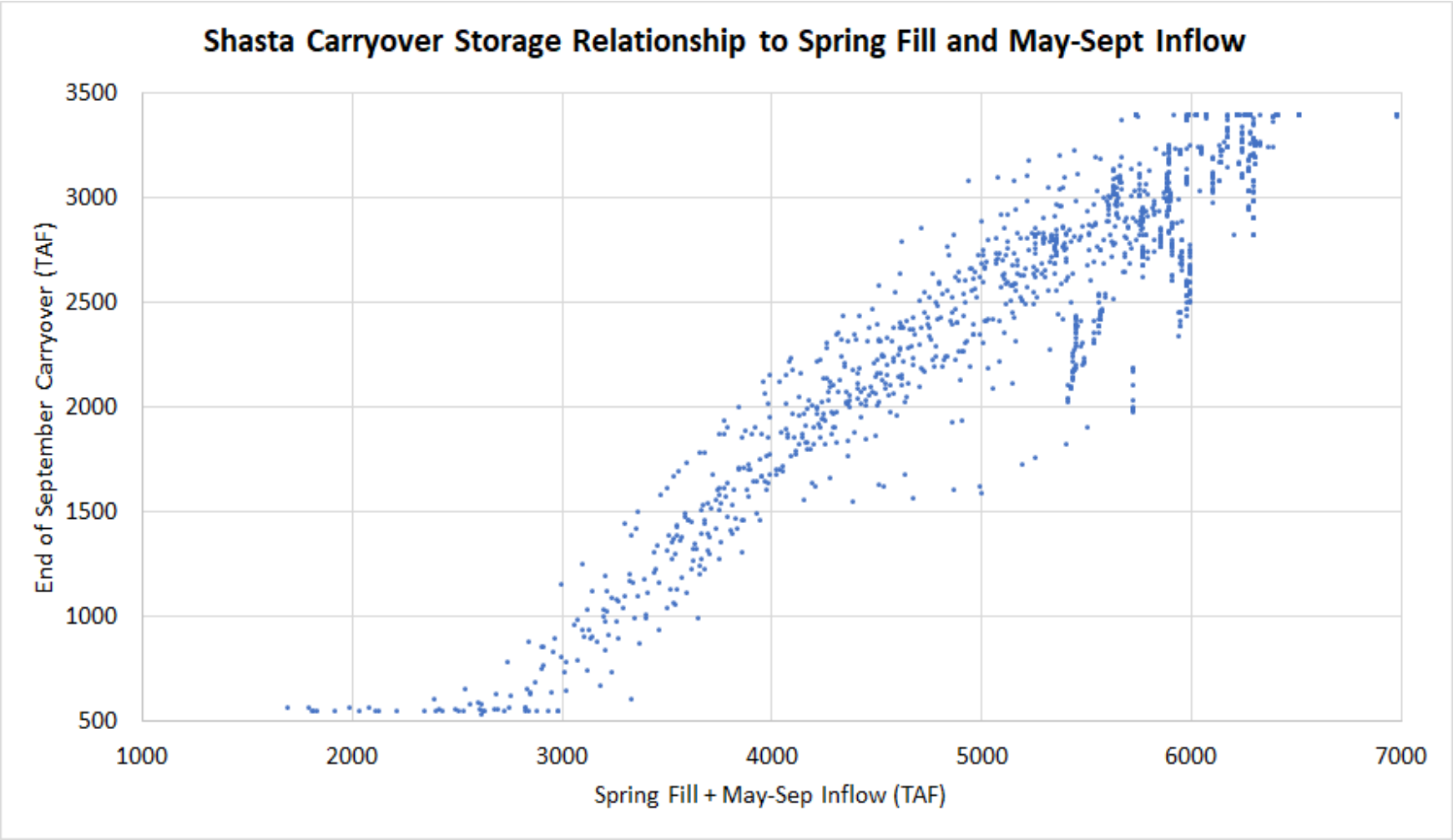


Management Season Releases

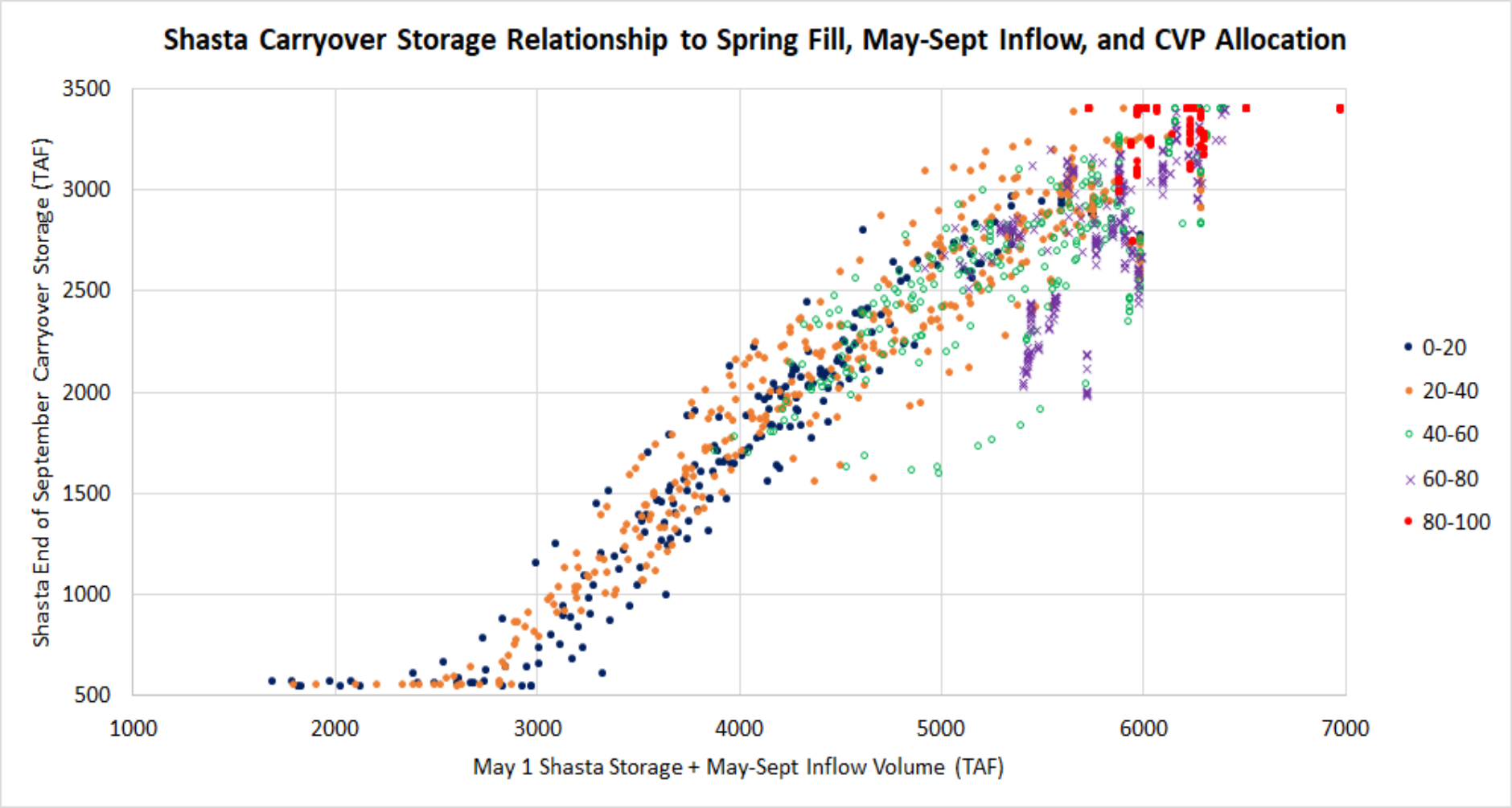
- What operations affect carryover storage?

- Final flood control actions
- D1641 – Keswick, NDOI, X2, Water Quality
- ESA – SMSCG costs, Fall X2 (Aug/Sept)
- Senior Water Rights ("PSC" includes refuges in this analysis)
- Project Delivery and Exports
- Release accounting is done in increments
  - upstream-to-downstream
  - regulatory-then-delivery
  - releases are not double-counted

What Determines Shasta Carryover?

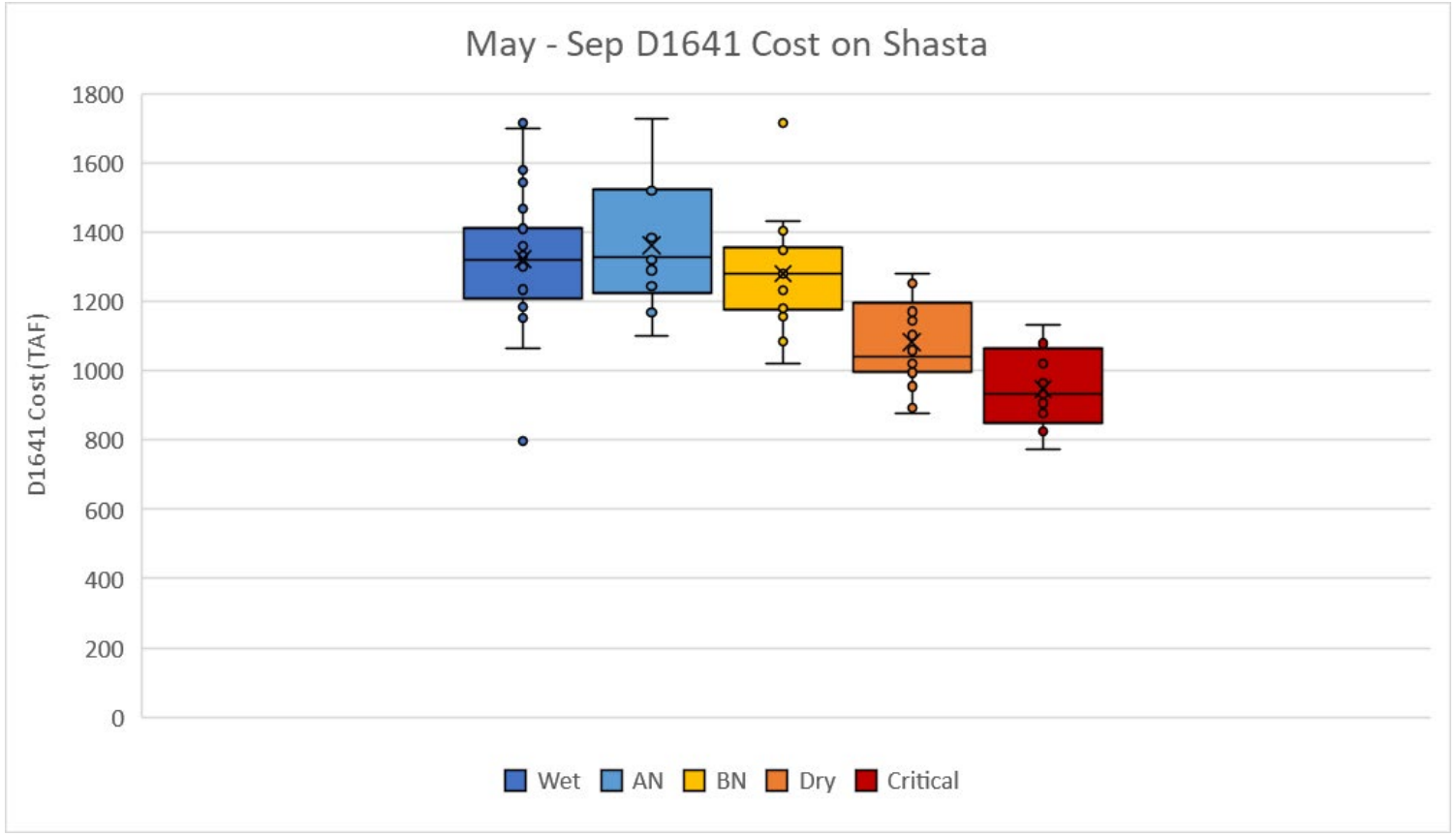


Shasta Carryover



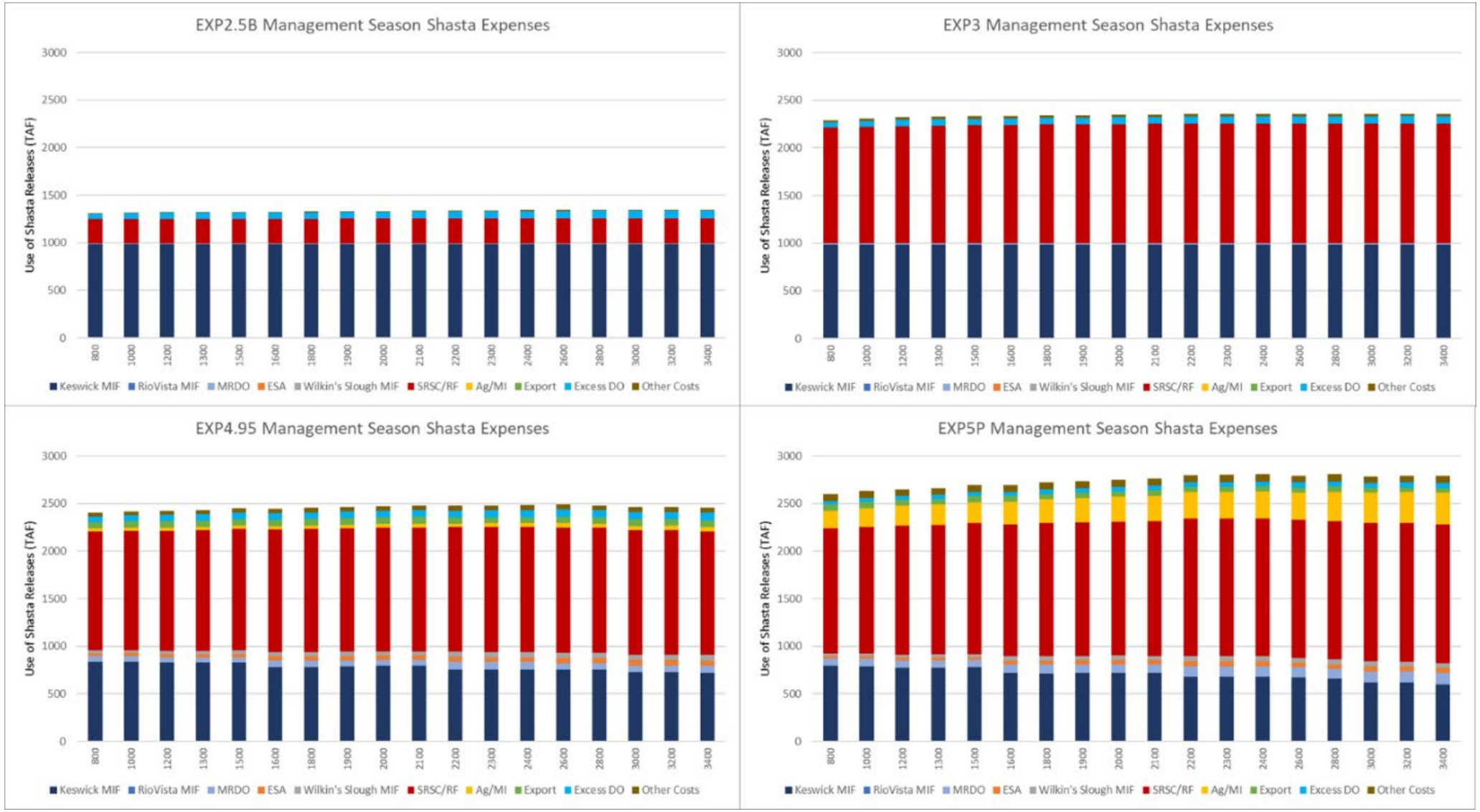
- Same plot, same dots
- Color coded by CVP SOD Ag allocation (%)
- Allocations below 40% create carryover from dead pool to 3400 taf
- Low fill and low inflow -> low carryover, even with low allocation
- High allocations in wetter years do not create low carryover
- Lower green dots…
  - All 1928 traces with lower init conditions
  - Fall X2 cost
  - High MaySep D1641 cost
  - Low Folsom inflow

Management Season D1641 & MIF Costs



- The range of costs in every year type affects carryover
- The cost and range of cost are smaller compared to the fill season
  - Fill season includes Spring X2, winter base flows, spring pulse flows

Management Season Costs



Management Season Summary Points

- Carryover storage in Shasta is affected by:
  - Fill
  - Delivery/export
  - Regulatory criteria
  - Inflow
- Ranges of regulatory costs lend uncertainty to final carryover storage
- Releases for delivery and export are significant