DEQ

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Dynamic Reservoir Operation Rules and Evaporation Simulation Impact on Model Goodness of Fit in Lake Anna

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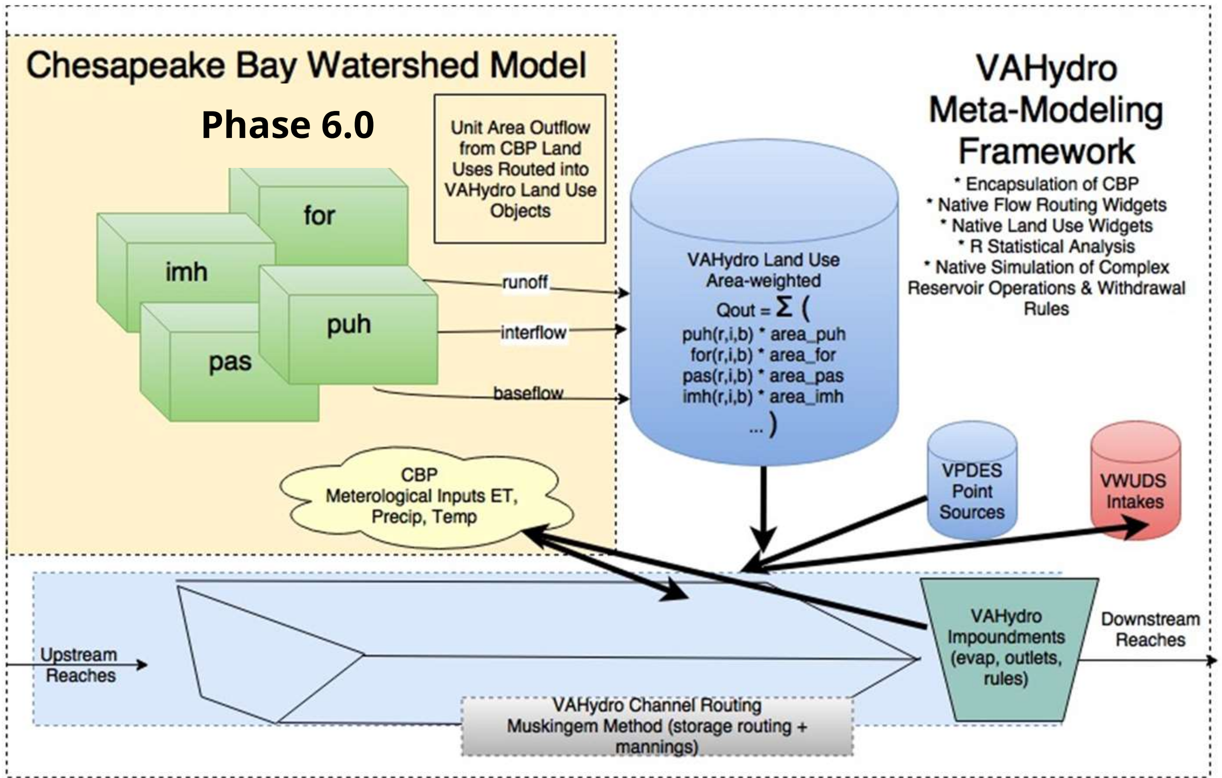
VADEQ OWS Water Supply Modeling

- Maintain database of annual reporting withdrawals in Virginia
- Planners work w/localities on unreported WD & to project future need.
    - Ex: Shenandoah Valley agriculture reported 3.3 mgd, estimated total ag demands 3.9 mgd (so ~80% of agricultural demands reported annually to DEQ)
    - Our Planning models include these locality estimates of un-reported demand.
- Use P6 rainfall-runoff model as baseline hydrology for quantity models.
    - We maintain reservoir/intake operational & channel models for all permitted withdrawals and some non-permitted withdrawals/reservoirs in Virginia
    - Water withdrawal permit applications.
    - Water supply plan scenario evaluation.
    - In high demand areas, we share models with VPDES to insure adequate dilution for waste assimilation. Worked with CBP/ICPRB on updates to FTABLEs for Phase 6 (and beyond).

Methods: Meta-Modeling (loose coupling)

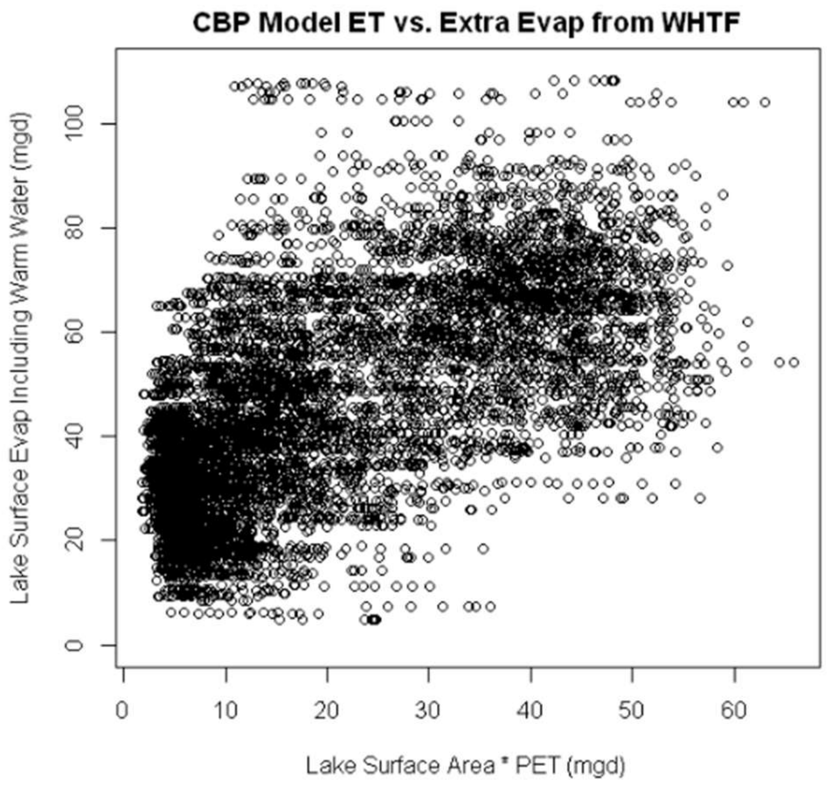
- Integrates:
    - Hydrology - HSPF
    - Water Quality - HSPF/R
    - Withdrawal reporting(1,500 users)
    - Water supply planning (100 localities)
    - Biological Response
- **We downscale to examine impacts on water availability and instream flows at project scale.**

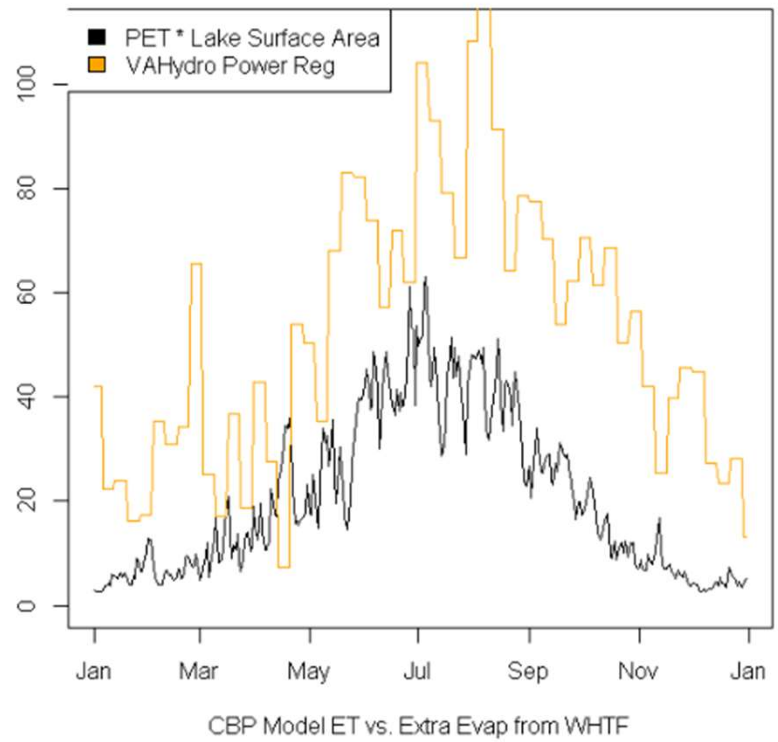


Case Study: Power Cooling Evap North Anna River Dam

- River Segment: YP2_6390_6330
- P6 considers WIthdrawals & Discharges
  - Power Cooling facilities almost always report both of these - great!
  - NAD withdraws 1,830 MGD on average, returns 1,800 MGD
  - Net consumptive loss of **30 MGD**
- Big Lakes = Big Evaporative Losses (model does this very well)
  - Lake Anna = ~13,000 acres
  - Upper 10% of PET modeled by CBP6 ~ 0.2”/day = **35 mgd**
- Some Operations return significantly warmer water, which can increase surface evaporation from the Lake
  - Regression model based on Dominion data estimates **25-65 mgd extra.**
- **All told natural evap from lake, cooling tower loss and extra evap can exceed 100 mgd, more than 1/3 of which is not *explicitly* accounted for in standard HSPF**

Regression Model to Match Historic Power Extra Evap





FTABLEs vs. Model Release Rules

CBP5.3.2: FTABLE

DEPTH	AREA	VOLUME	DISCH***
(FT)	(ACRES)	(AC-FT)	(CFS) ***
0	0	0	0
22.9	9020	194,766	0
23	9023	194,854	40
29	11049	255,651	40
30	11465	267,503	42
31	11882	279,354	45
32	12272	290,237	50
32.5	12525	297,506	70
32.6	12590	299,100	180
33.0	12777	301,775	200
33.1	12823	303,091	600
33.2	12869	304,412	1,847

VAHydro: Equations & Lists

Name: release
Key:lake_elev
Type: Lookup

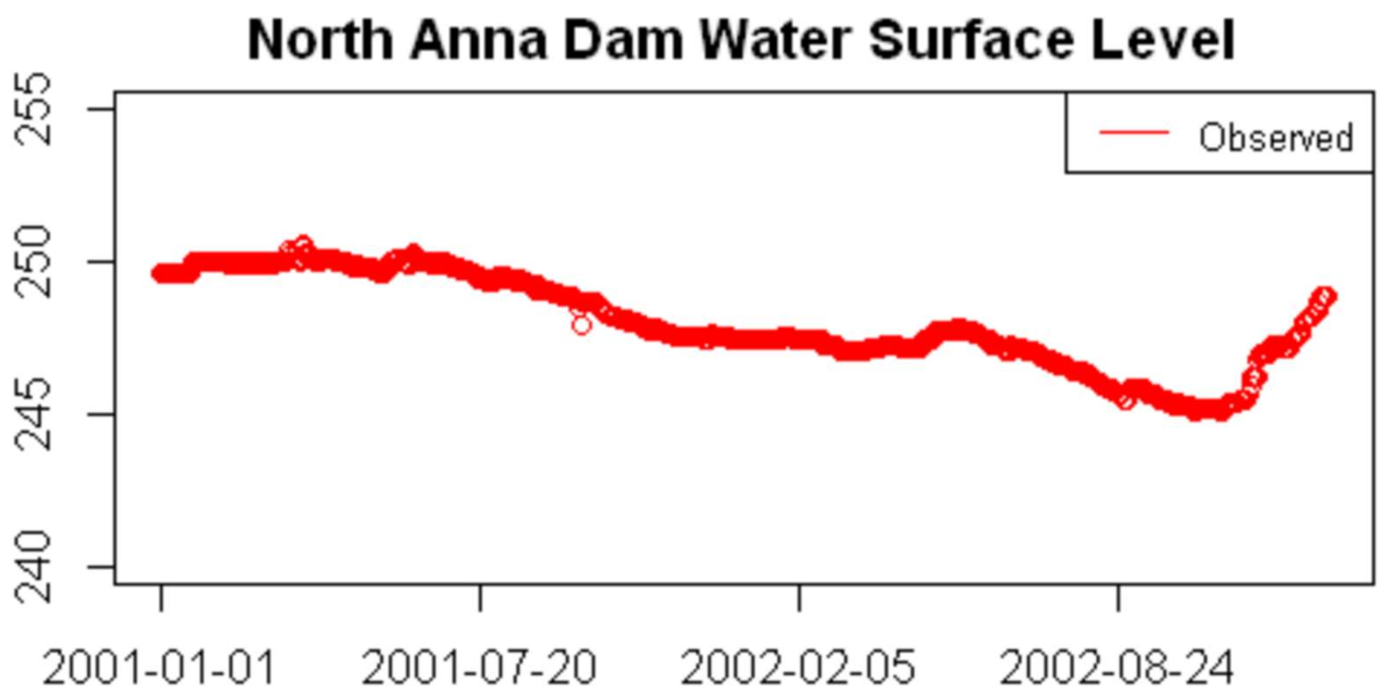
Elev	Release
170	20 (*empty)
240	20
248	40

Name: whtf_reg_mgd
Eq: 22.4622 + 1.936 * whtf_natevap_mgd + whtf_natevap_mgd -0.021 * whtf_natevap_mgd^2
Comment: Additional Evap from Lake

Name: wq_deficit
Eq: 37.0 - wq_baseflow_cfs
Note: extra release when base flows are low

1 week @ 180 cfs = (1.54 * (2600) / 3.07) / 7.0

Impact on Surface Elevation due to Warm Effluent & ET



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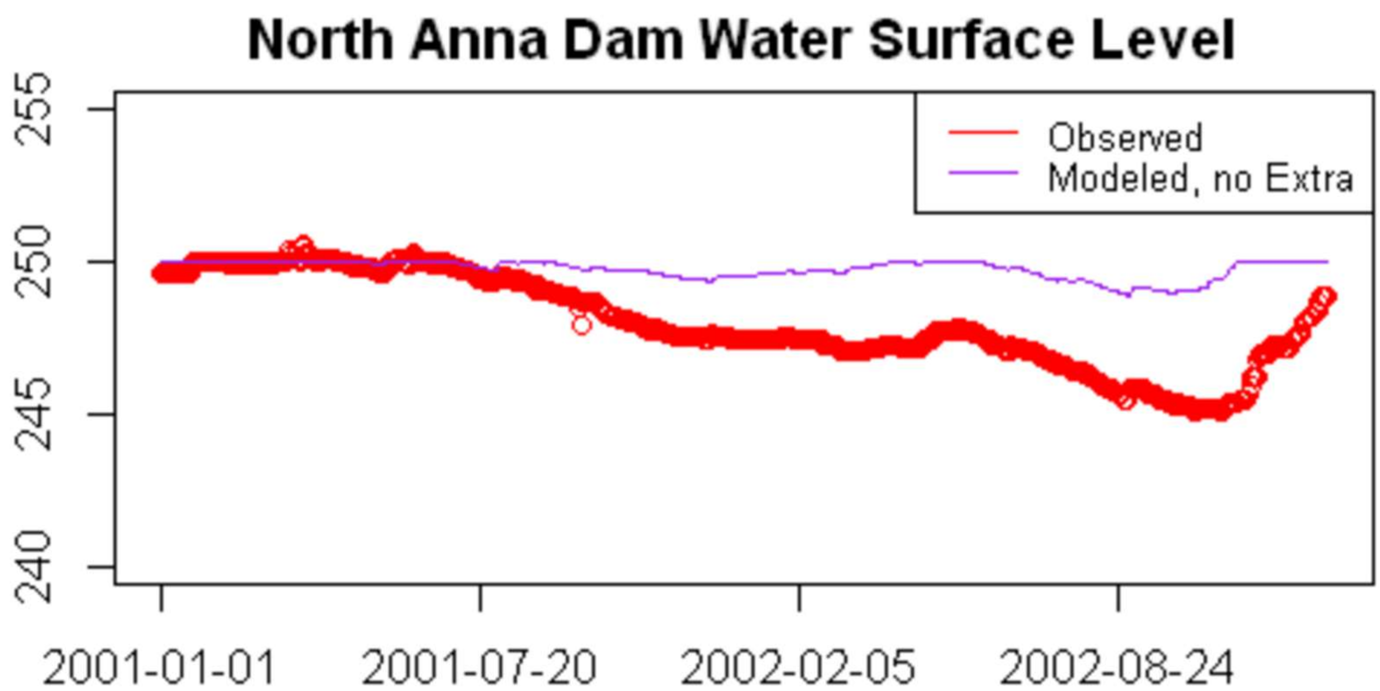

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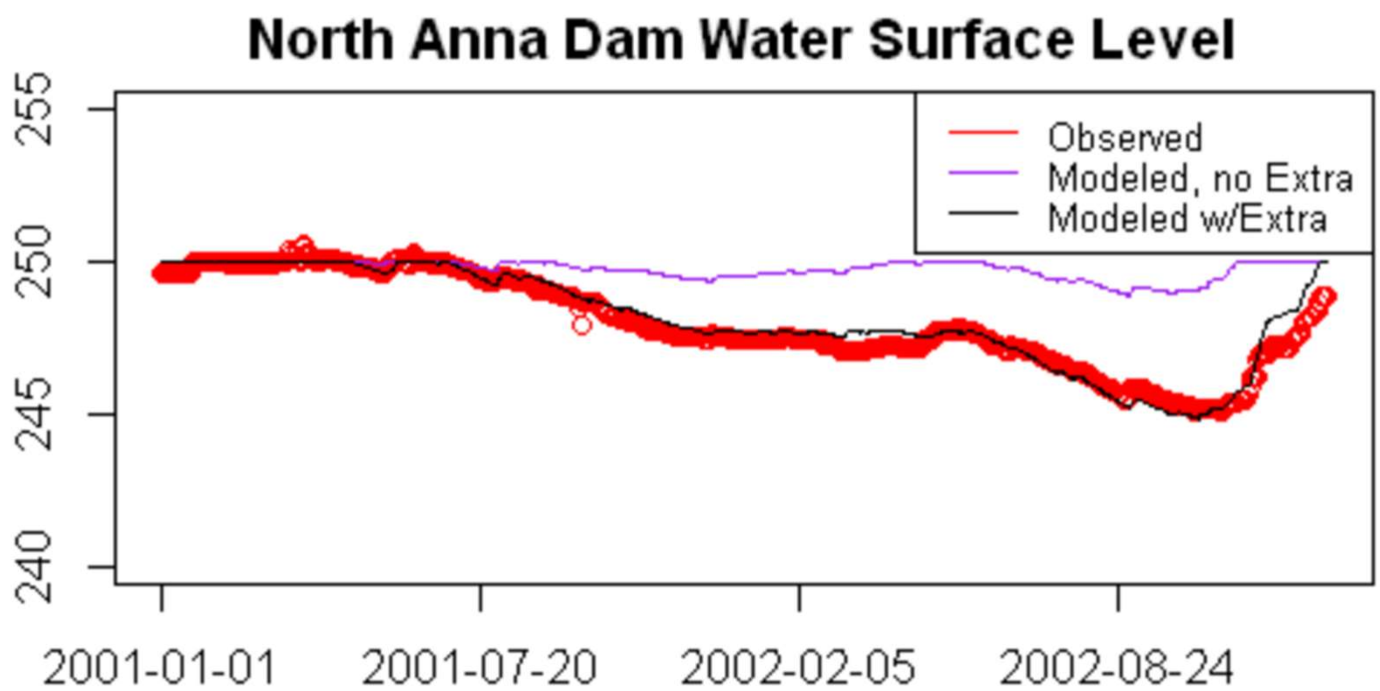
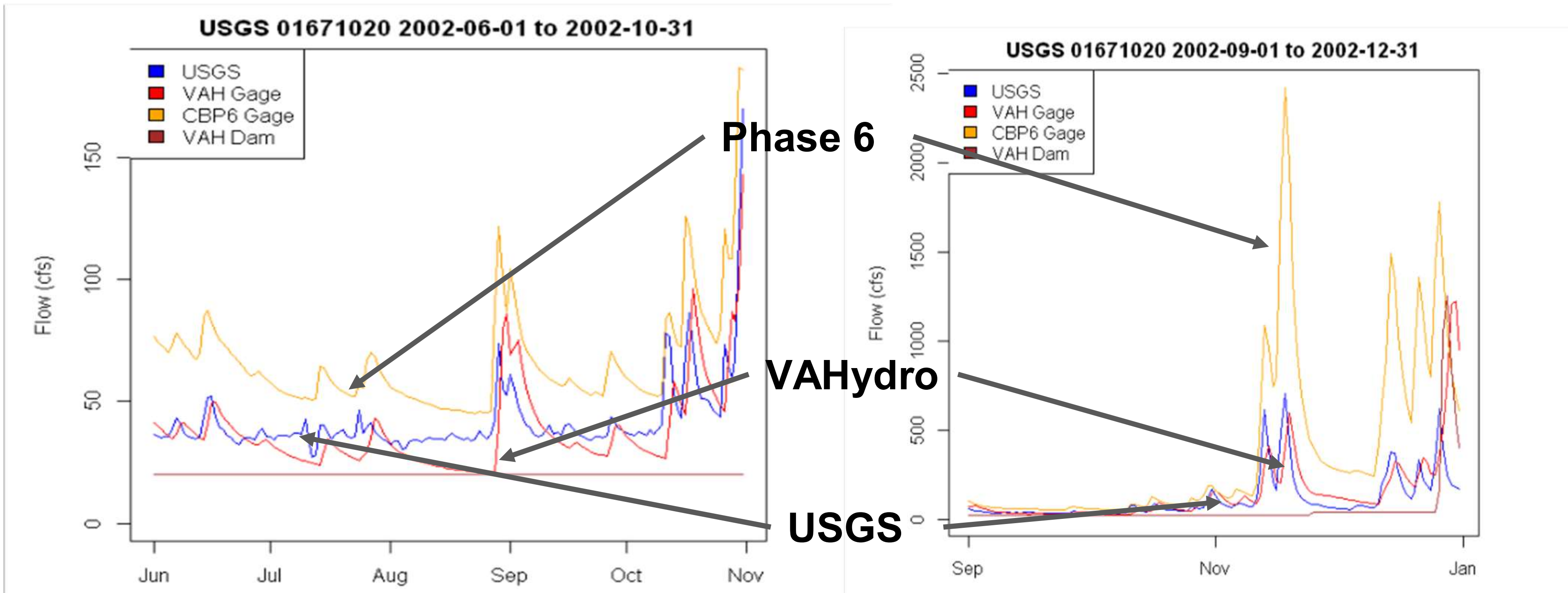


Impacts on Low Flow (drawdown), High Flow (after refill)



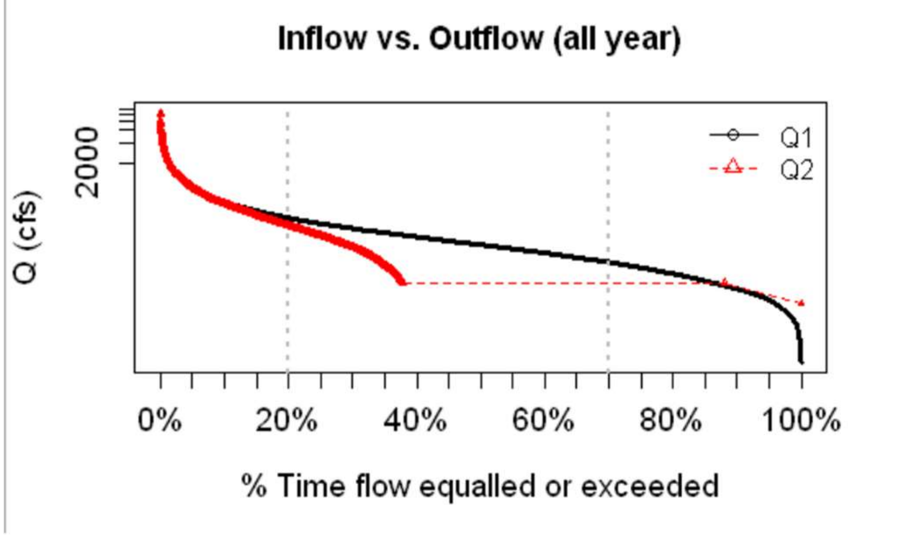
Before Refill June-October 2002

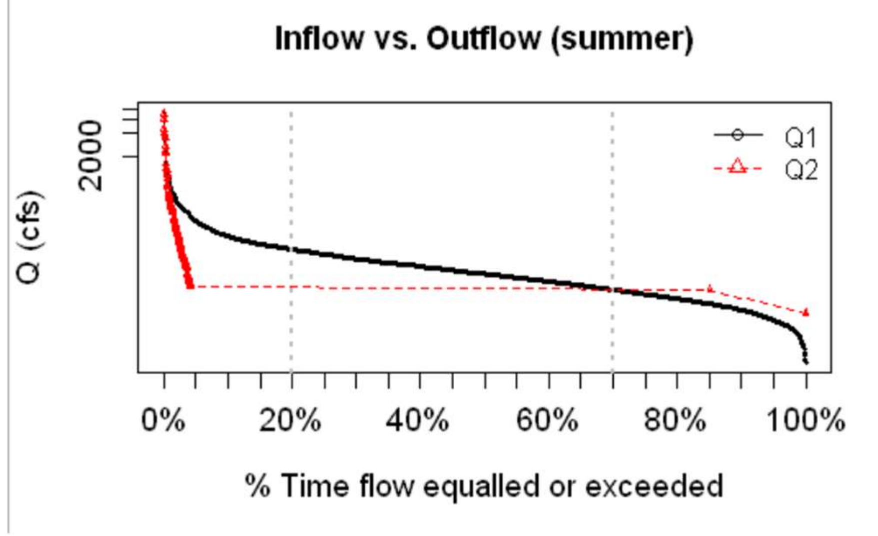
During/After Refill June-October 2002

When Do Impoundments Matter (for flow)?

Majority of flow alteration comes during droughts and small to medium sized storms.

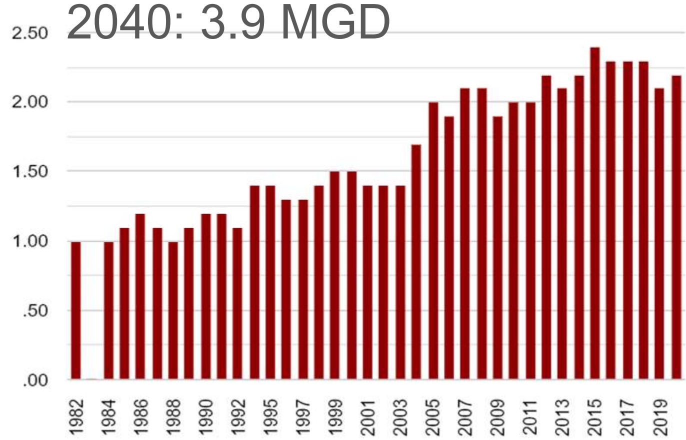
	0%	25%	50%	75%	100%
Qin	2.9	65.2	138.4	276.2	10,509
Qout	20.0	40.0	40.0	187.2	10,467

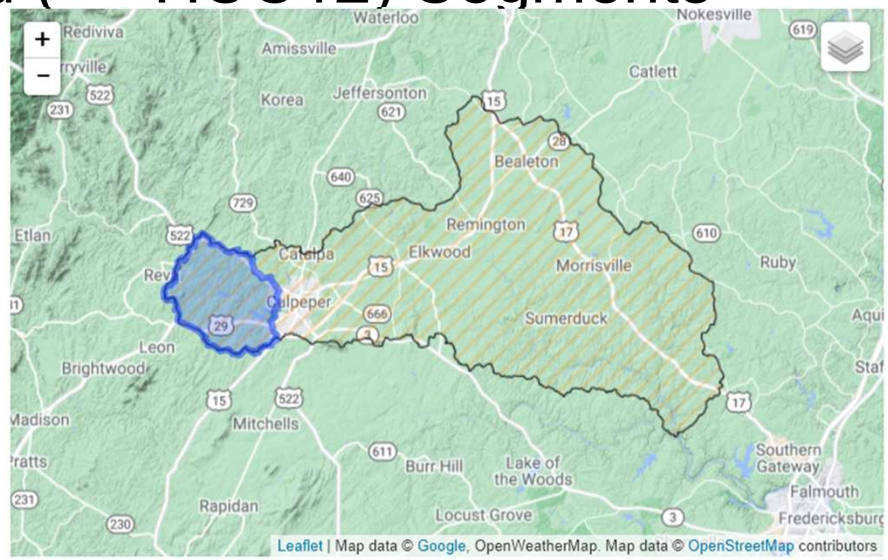


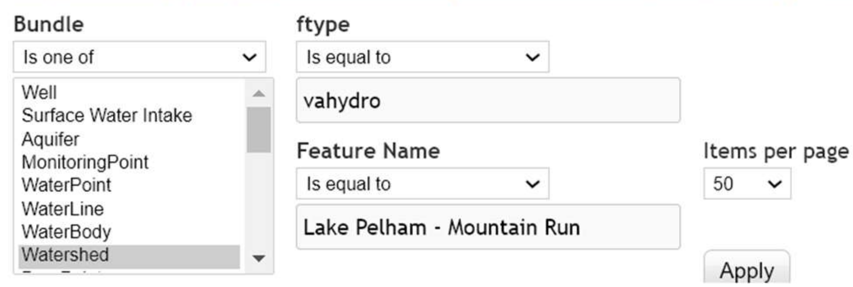


Downscaling to Medium Sized (<= HUC12) Segments

- **River Name:** Mountain Run
- **Drainage Area:** 26.15 sq. mi.
- **Parent Segment:** RU4_5640_6030
- **Defining Features:** Lake Pelham
- **Water Use:** 2020: 2.1 MGD → 2040: 3.9 MGD



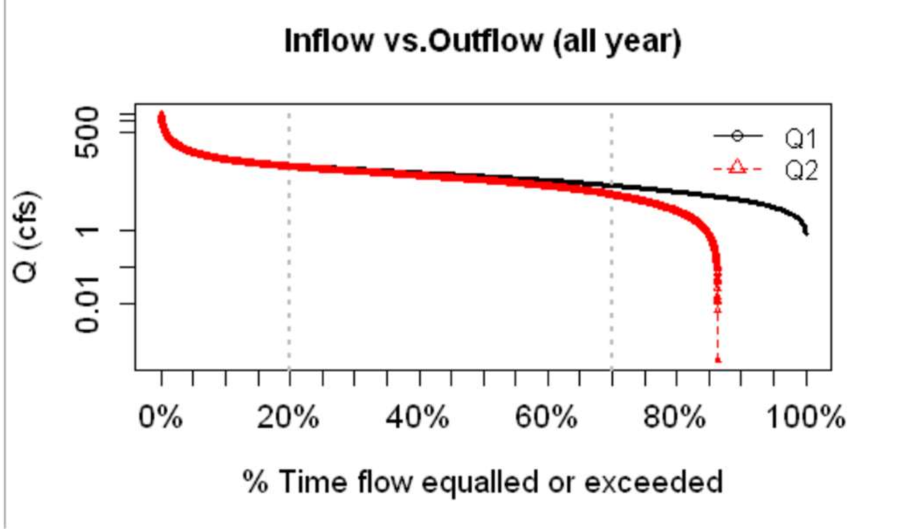


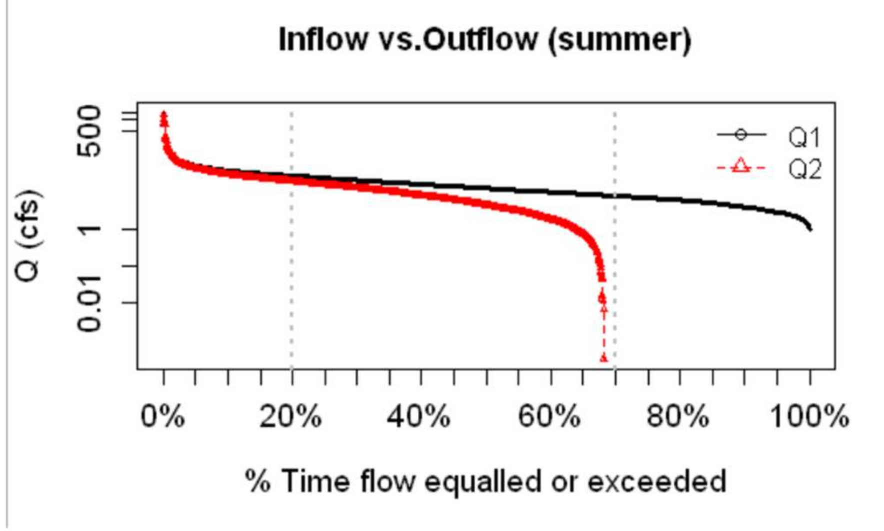


Inflow vs. Outflow Duration Curves: Small Impoundment

Majority of flow alteration comes during droughts and small to medium sized storms.

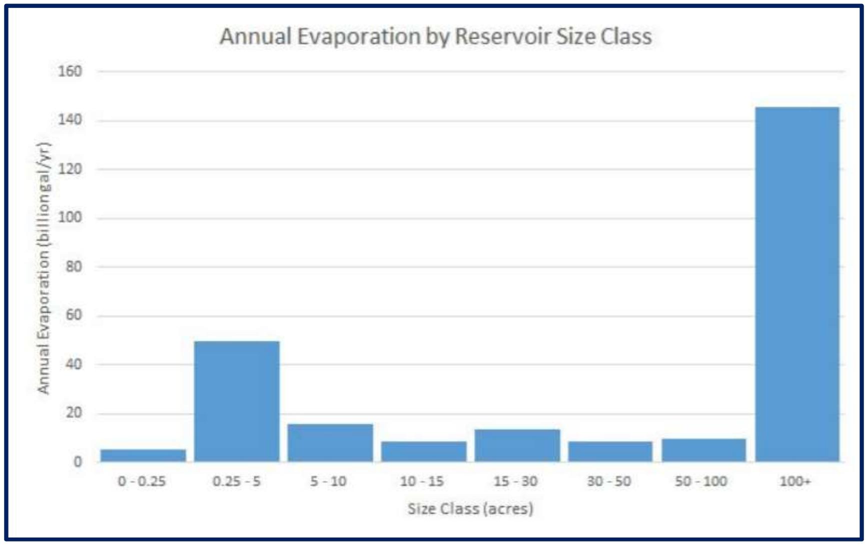
	0%	25%	50%	75%	100%
Qin	1.0	7.2	13.3	25.1	1,364
Qout	0.0	0.0	4.6	16.8	1,360



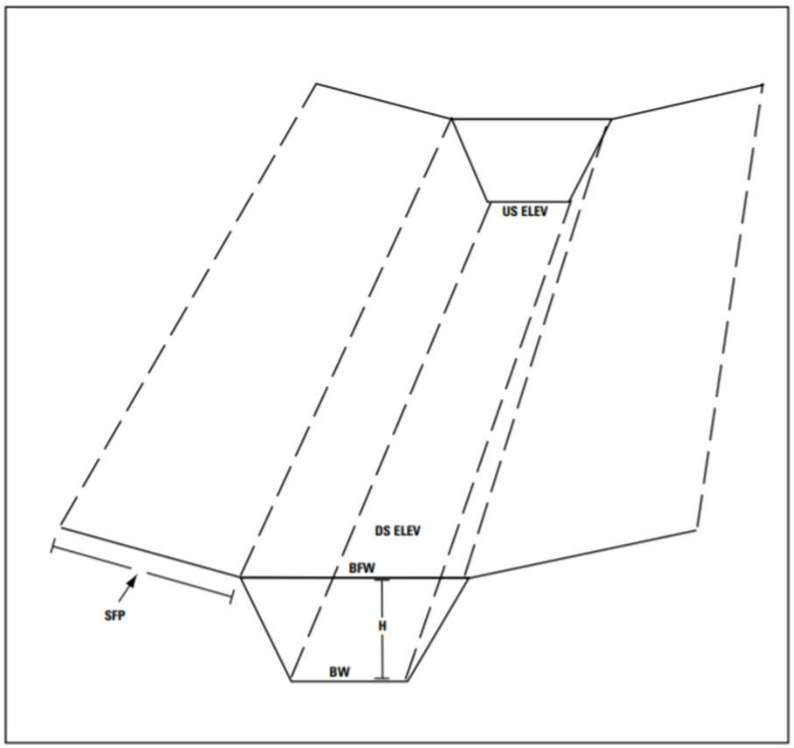


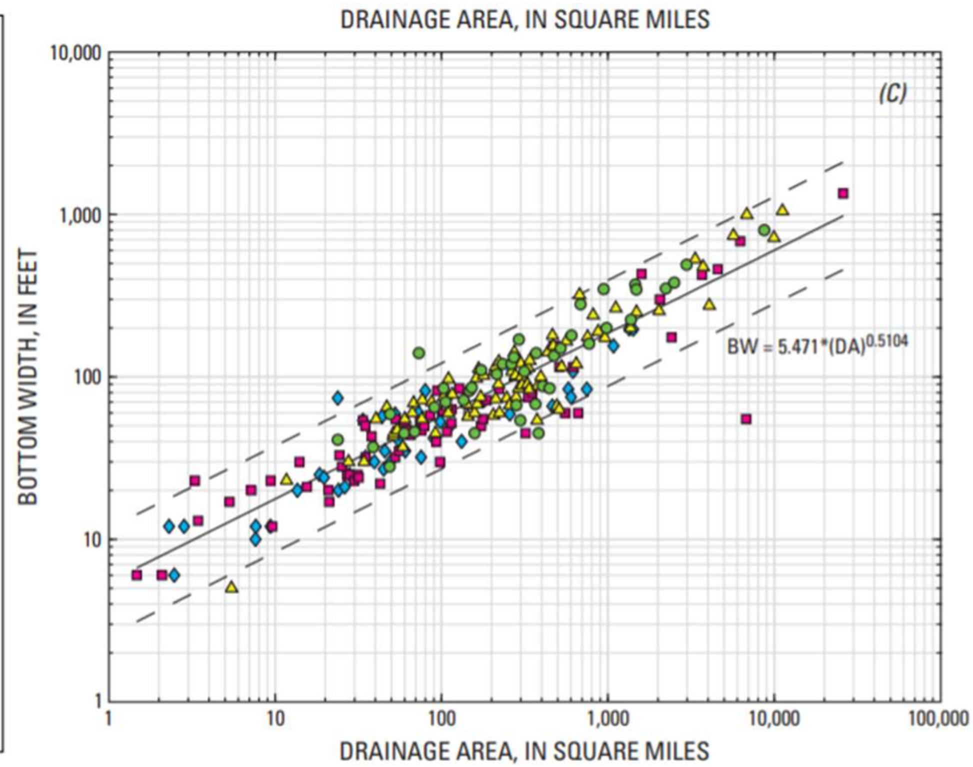
Conclusions

- Evaporative losses from impoundments in Virginia are very high, 1.0-1.5 BGD in summer.
  - We have roughly half of large (100+ acres) impoundments in VA Phase 6
- The Phase 6 model provides a good baseline water budget for water availability models.
  - coupling reservoir management and evaporative loss models improves low flows.
- Drawdown in reservoirs can substantially impact low and medium flows, including “capturing” storms after prolonged drought.
- Calibrated models will shift the effects of impoundments onto land ET, UZ storage, GW , etc. if impoundments are not explicitly simulated.
- Hydrology calibration for lower 50-75% of flow regime can improve, seasonality can improve with impoundments.



Downscaling: Channel Morphology = f(Drainage Area)





References

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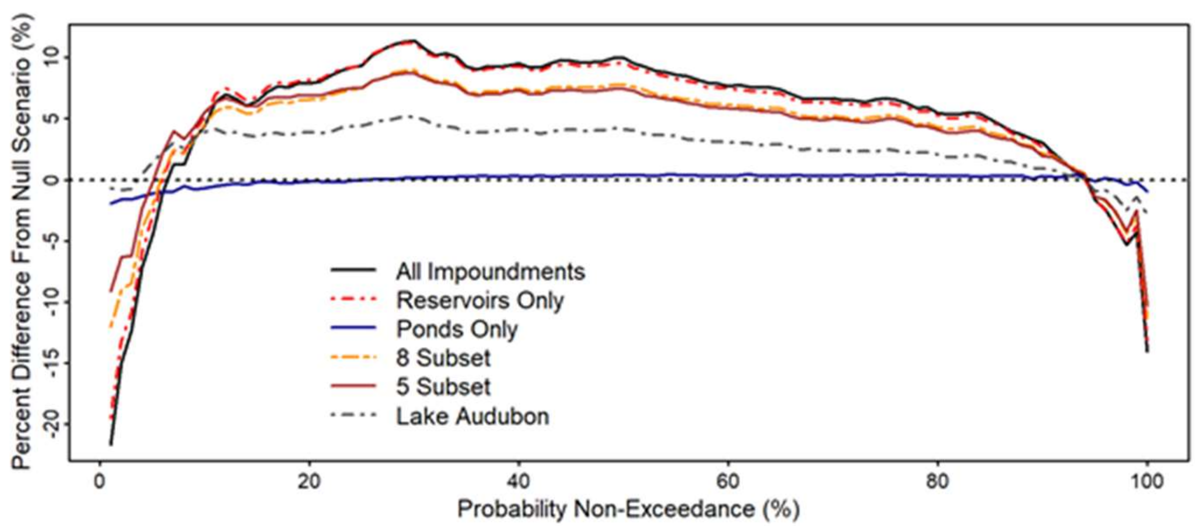
- Kleiner, J., Passero, E., Burgholzer, R., Rapp, J., & Scott, D. (2020). **elfgen: A New Instream Flow Framework for Rapid Generation and Optimization of Flow–Ecology Relations**. JAWRA Journal of the American Water Resources Association, 56(6), 949–966. https://doi.org/10.1111/1752-1688.12876
- Rapp, J. L., Burgholzer, R., Kleiner, J., Scott, D., & Passero, E. M. (2020). **Application of a New Species-Richness Based Flow Ecology Framework for Assessing Flow Reduction Effects on Aquatic Communities**. JAWRA Journal of the American Water Resources Association, 56(6), 967–980. https://doi.org/10.1111/1752-1688.12877

Downscaling: Reservoir + Channel Effects

- Change in peak flows by having longer channel network (resolution)
  - Difficult Run RO*area_sqmi, Single Channel
- Cumulative Impoundment Impacts



Brogan, et al 2021