PREDICTING SETTLING POND HYDROLOGY AND CHEMISTRY FROM EXTREME WEATHER AND OPERATIONS

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Agenda

- Overview of GoldSim
- Build a water balance model of a theoretical mine settling pond
- Evaluate the response of the model to
  - Extreme weather events and climate change
  - Changes in operations

Overview of GoldSim

A dynamic, probabilistic software for modeling complex systems

Improved Decision Making

Cost & Time Savings

Regulatory Compliance & Environmental Protection

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Key Examples of GoldSim in Mining Sector

Mine Water Management

Water Quality Modeling

Tailings Management

Mine Closure & Reclamation

Risk Analysis & Reliability

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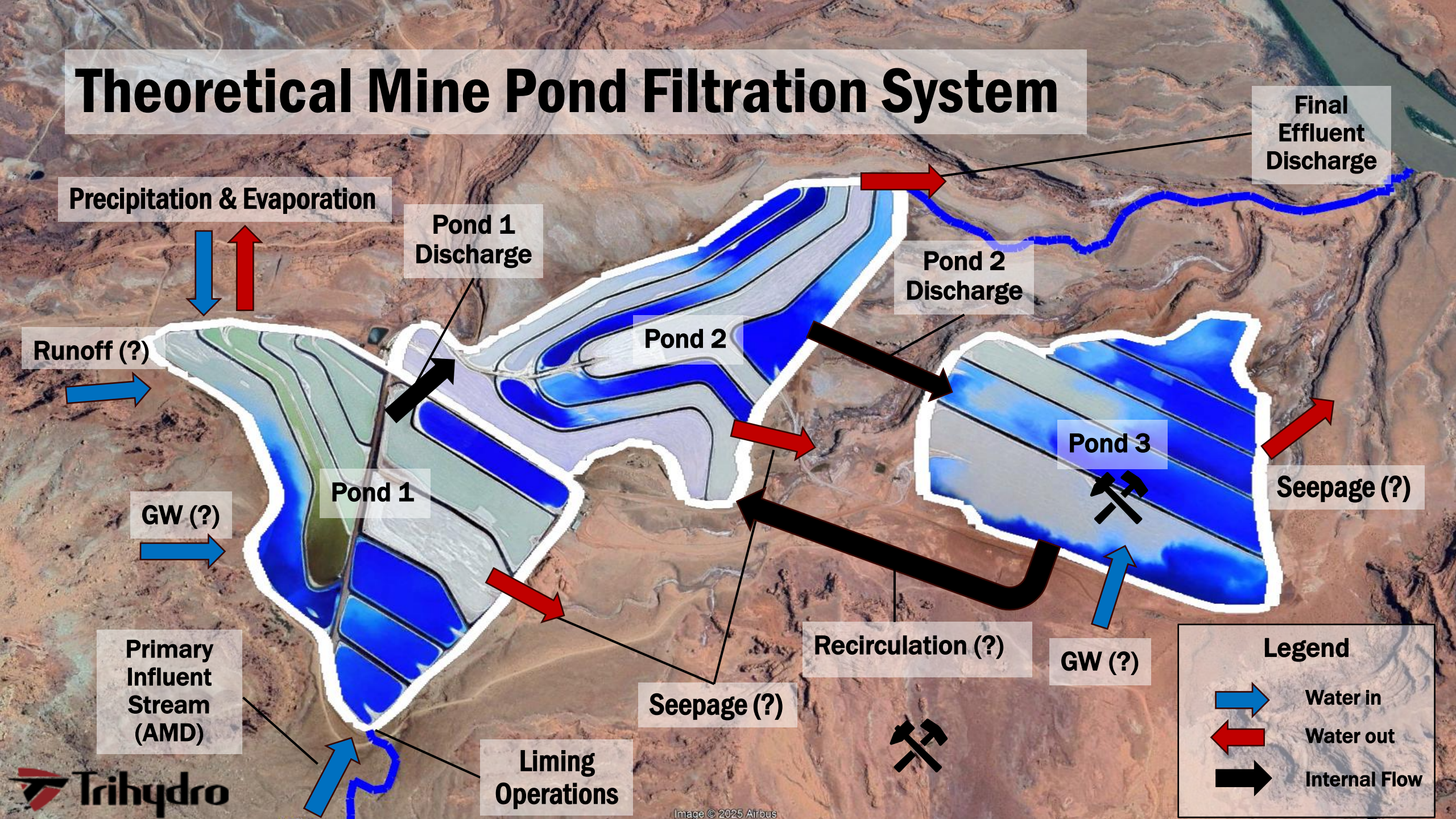
Theoretical Mine Pond Filtration System



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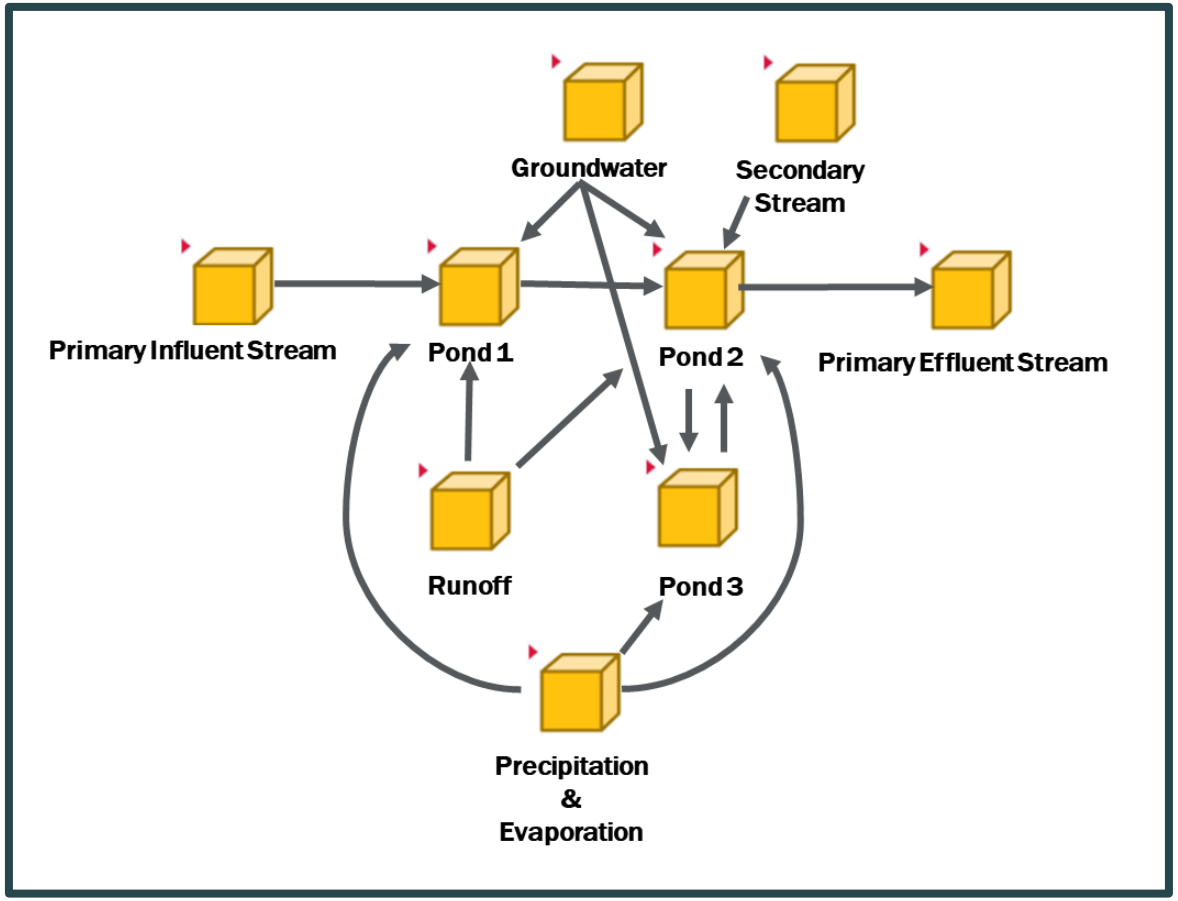
Building a GoldSim Model

- Gather available and identify data gaps
- Relevant data may include
  - Precipitation & Evaporation
  - Surface Water Flows
  - Groundwater Flows
  - Recirculation
  - Operations



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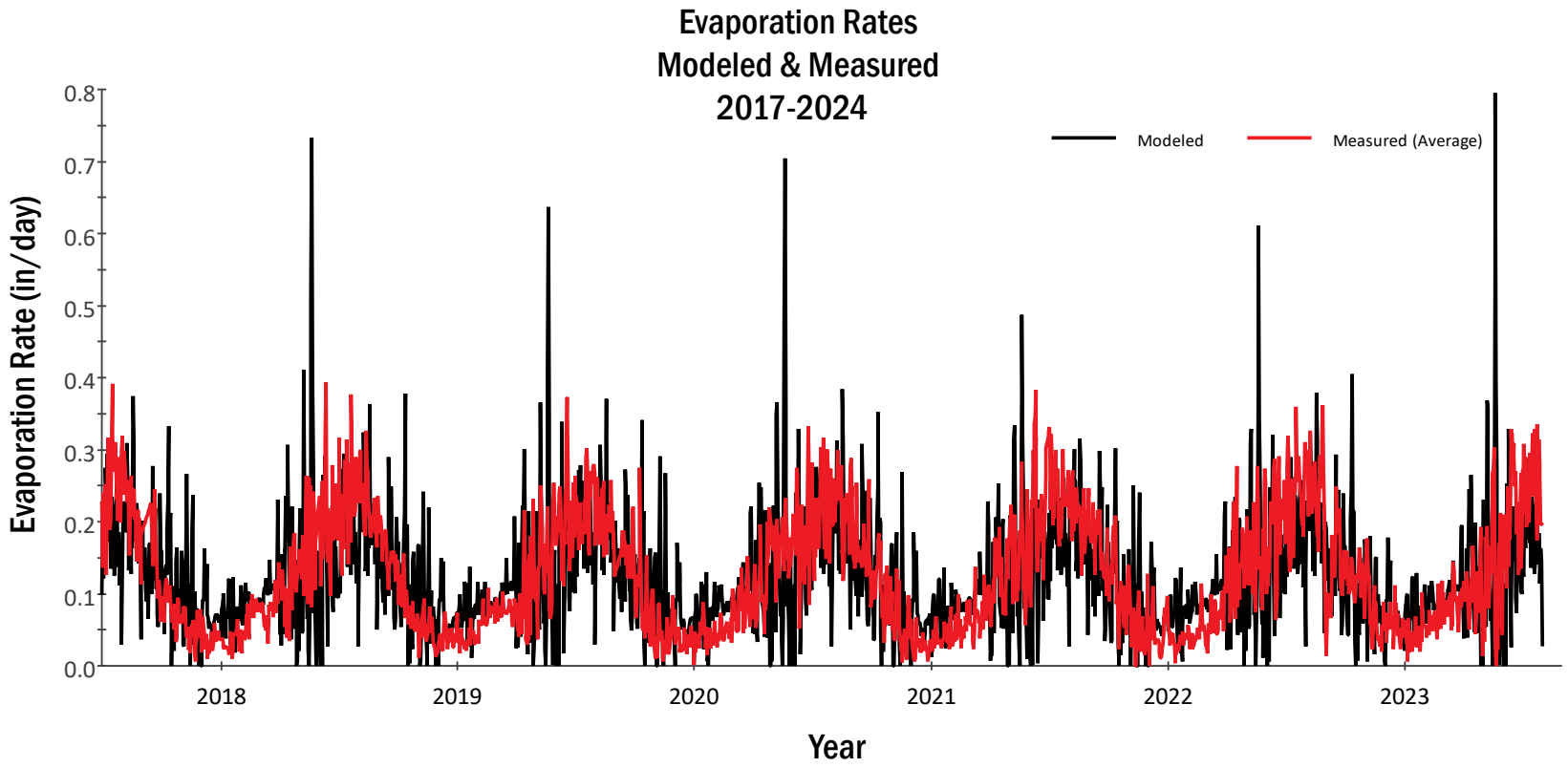
Precipitation & Evaporation

There are many options for precipitation/evaporation, which can utilize observed, modeled, or calculated data.



- Observed data:
  - Local weather station
  - Mine weather station
- Modeled data:
  - Gridded climate model dataset (PRISM)
  - Downscaled global circulation models (LOCA2 for CMIP6)
- Calculated data:
  - Physical based formulas for estimating evapotranspiration (ET)
  - GoldSim based model designed to simulate daily precipitation (PrecipGen)

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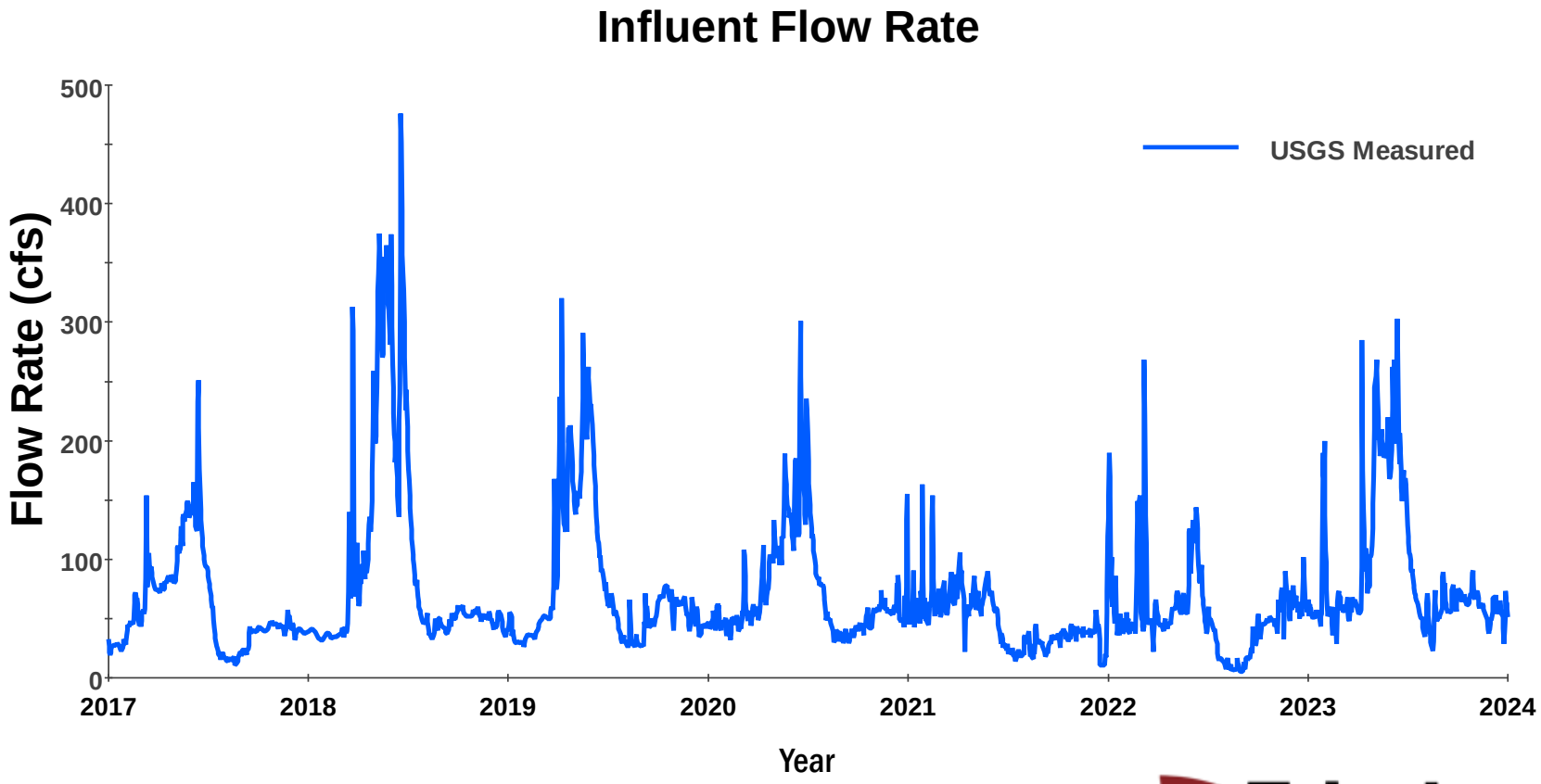
Surface Water Flows

- Flow rates are often available via on-site measurements, or using measurements from the USGS



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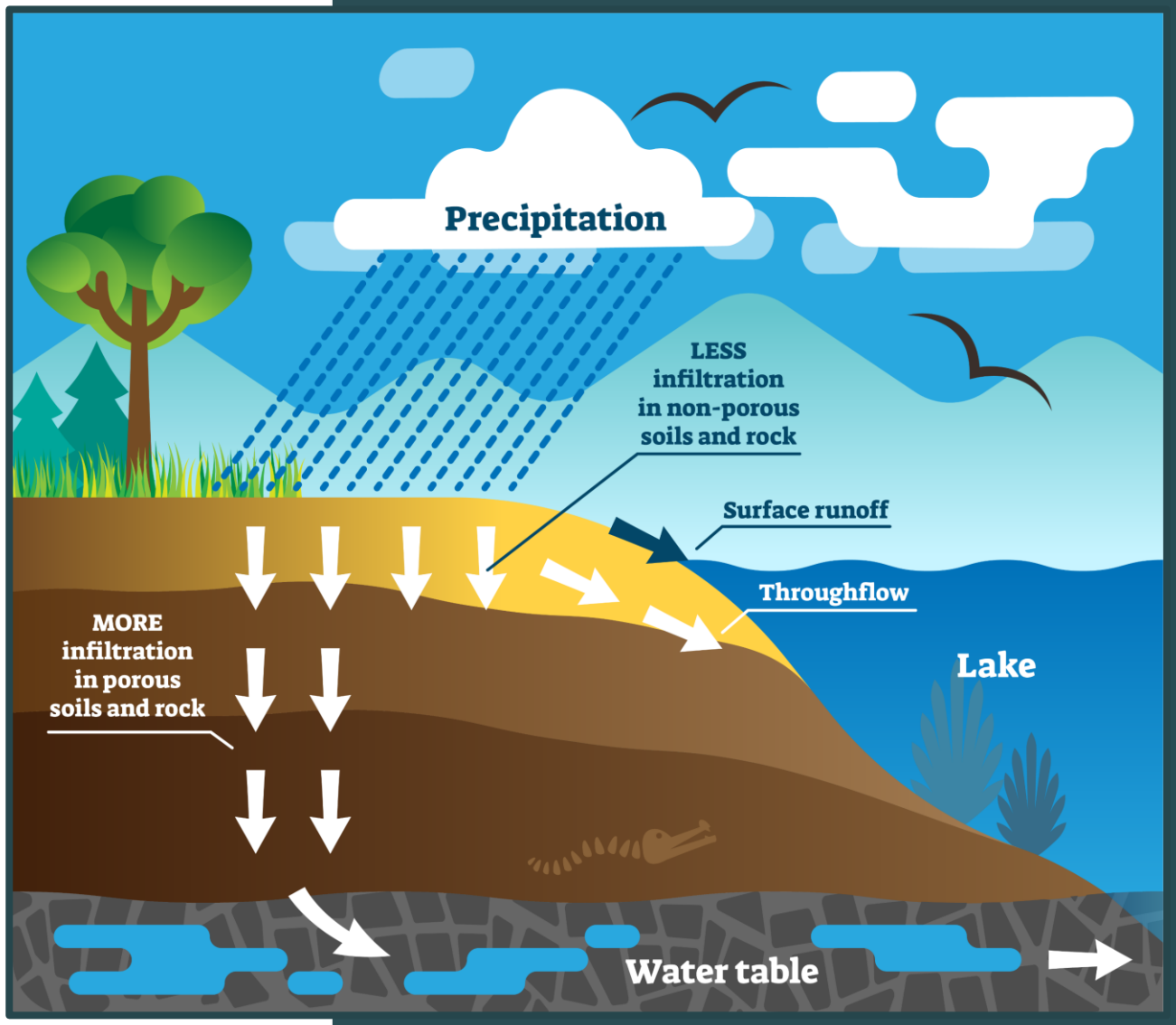
Groundwater Interactions

- Ideally, groundwater flow direction and quantity will be already modeled using MODFLOW
- However, that's often not the case
  - Have a general idea of a net loss or gain of groundwater



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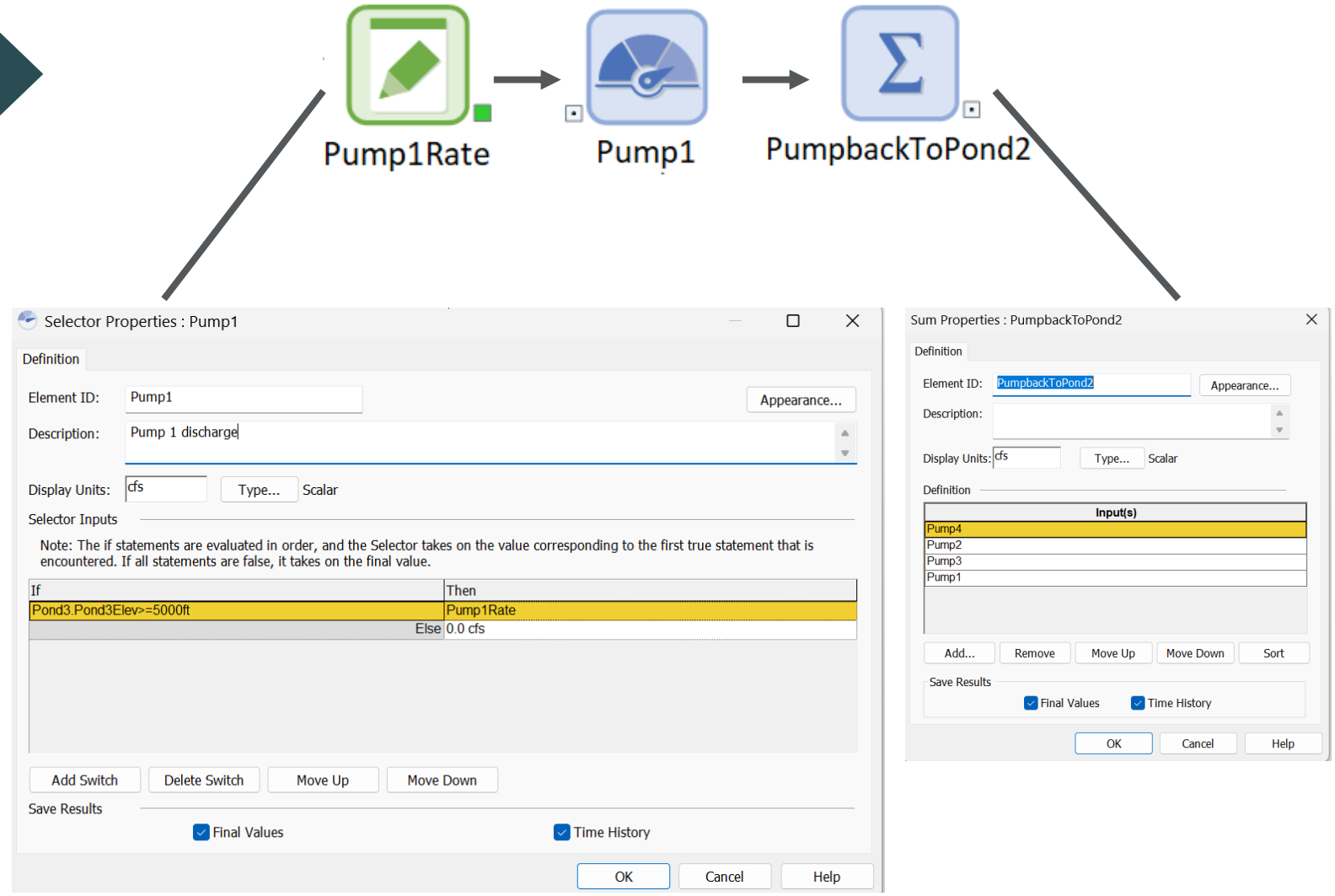
Operations

- Pond levels or recirculation can often be modeled using “if statements”
- Particularly important if water should be conveyed at certain heights or volumes



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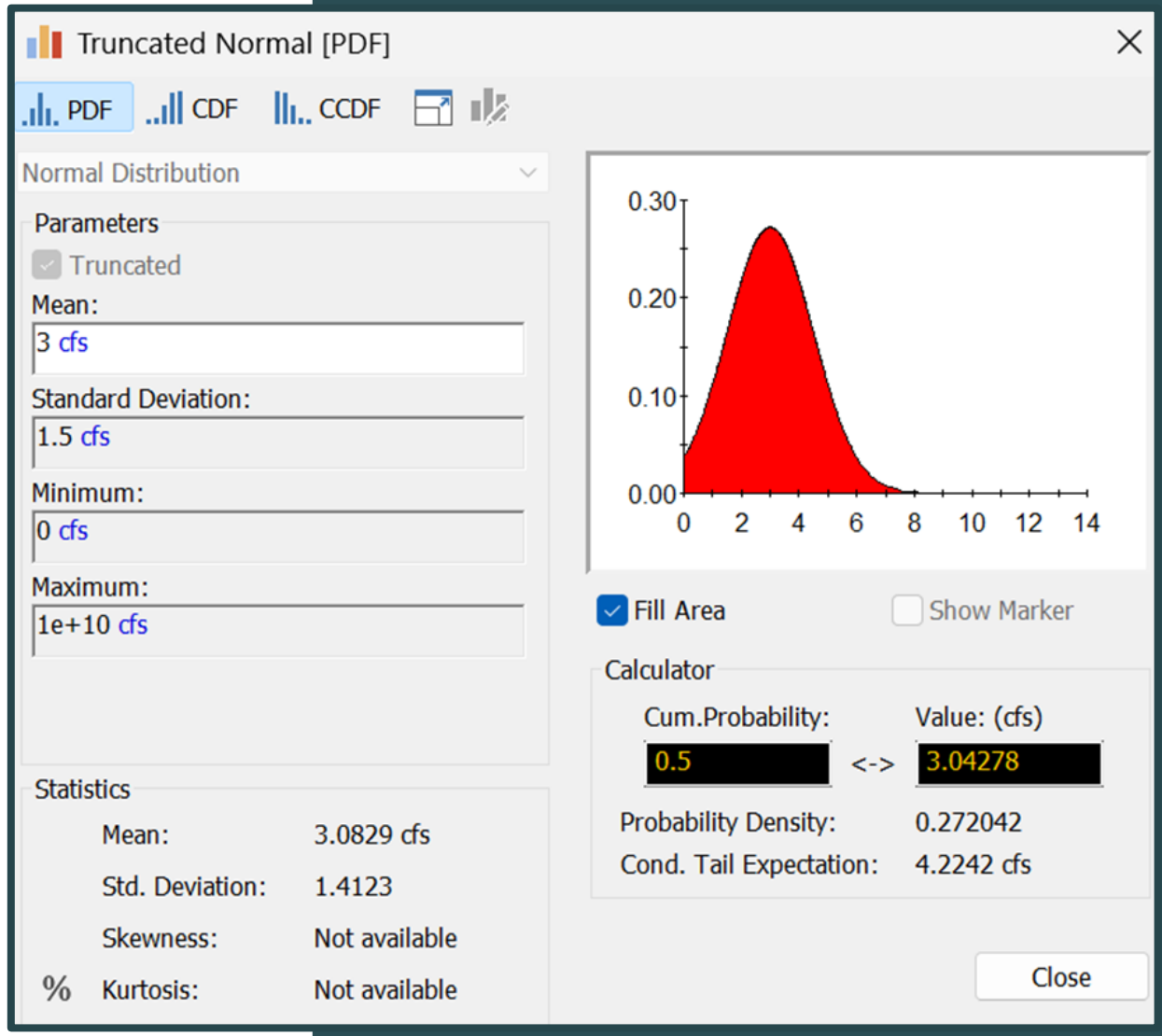
Estimating Unknowns

- Several unknowns existed prior to the development of the model, including
  - Groundwater flow and quantity
  - Seepage between ponds
  - Runoff from nearby hills/mountains
  - Recirculation rates
- Assumed a value for unmeasured variables based on reasonable estimates with a large range of uncertainty (50%)
  - Truncated at 0 cfs (GW gain)



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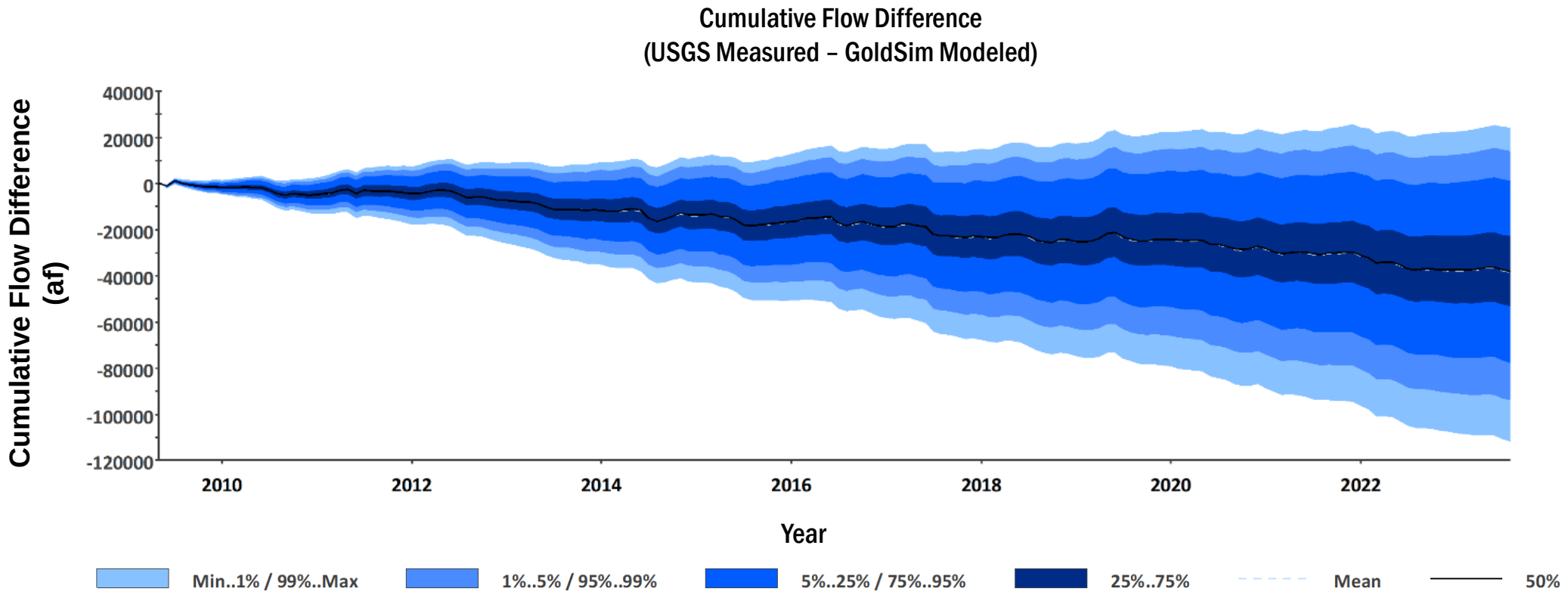
Sensitivity Analysis of Unknown Variables

- All data gaps with large uncertainties only contribute a total of 5% uncertainty to the total effluent flow



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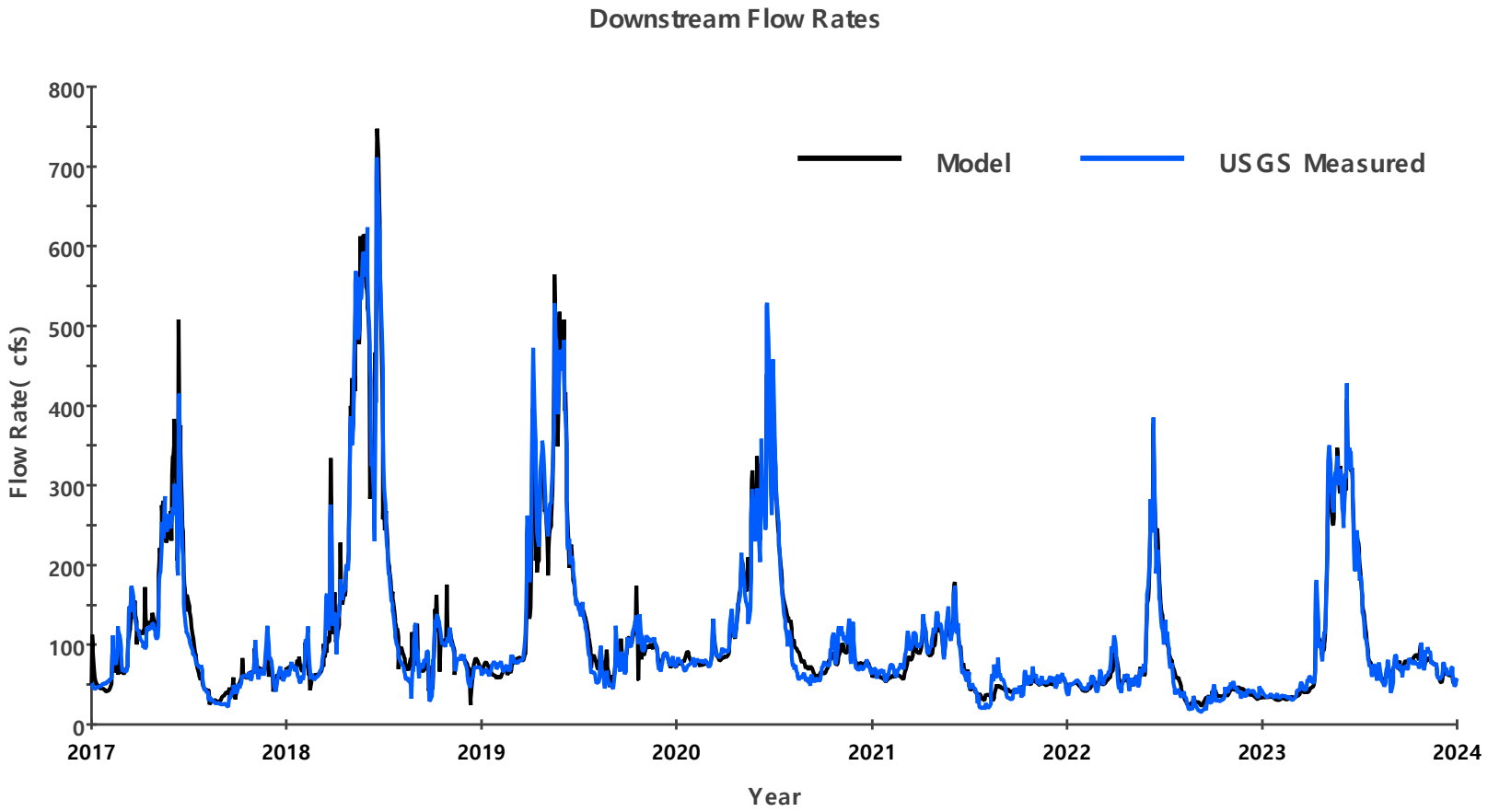
Model Performance

- Model effluent compared to USGS data shows the model can accurately reproduce conditions



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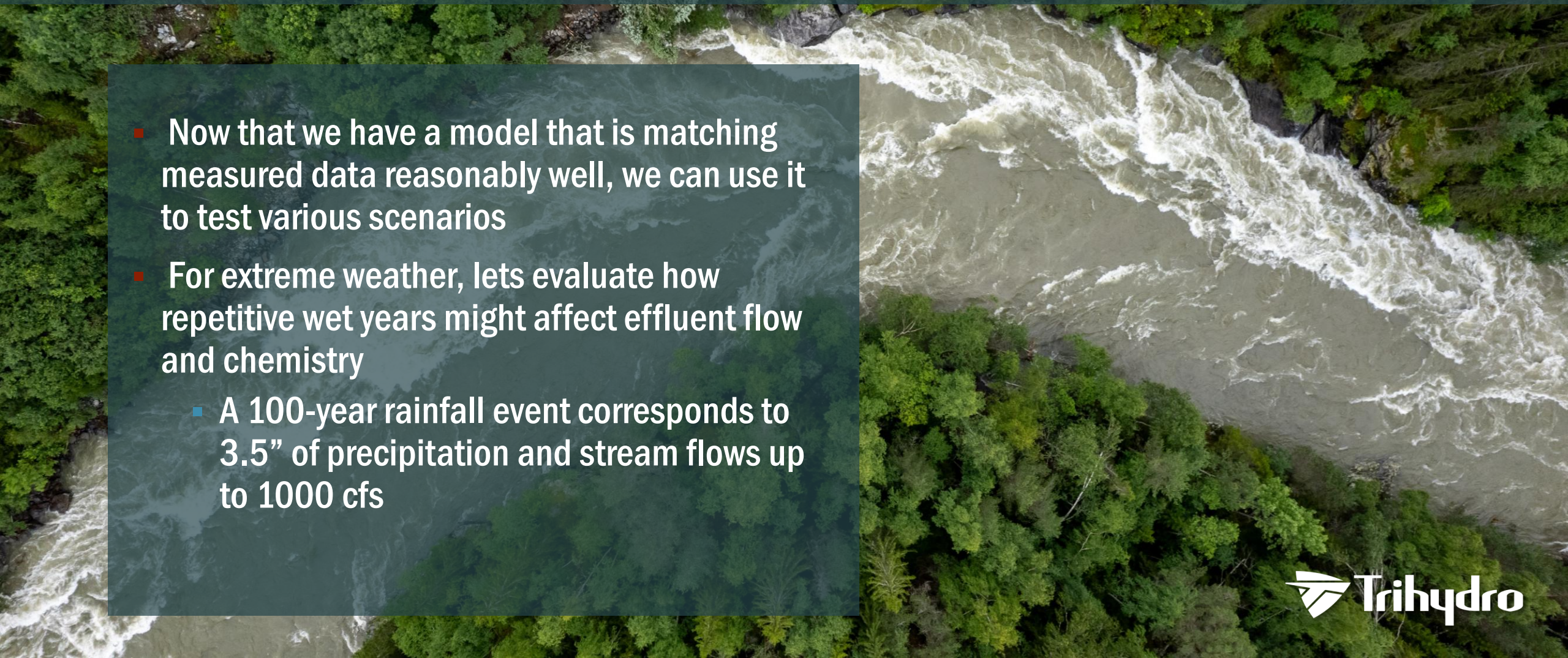
Testing Extreme Weather Scenarios



- Now that we have a model that is matching measured data reasonably well, we can use it to test various scenarios
- For extreme weather, lets evaluate how repetitive wet years might affect effluent flow and chemistry
  - A 100-year rainfall event corresponds to 3.5” of precipitation and stream flows up to 1000 cfs

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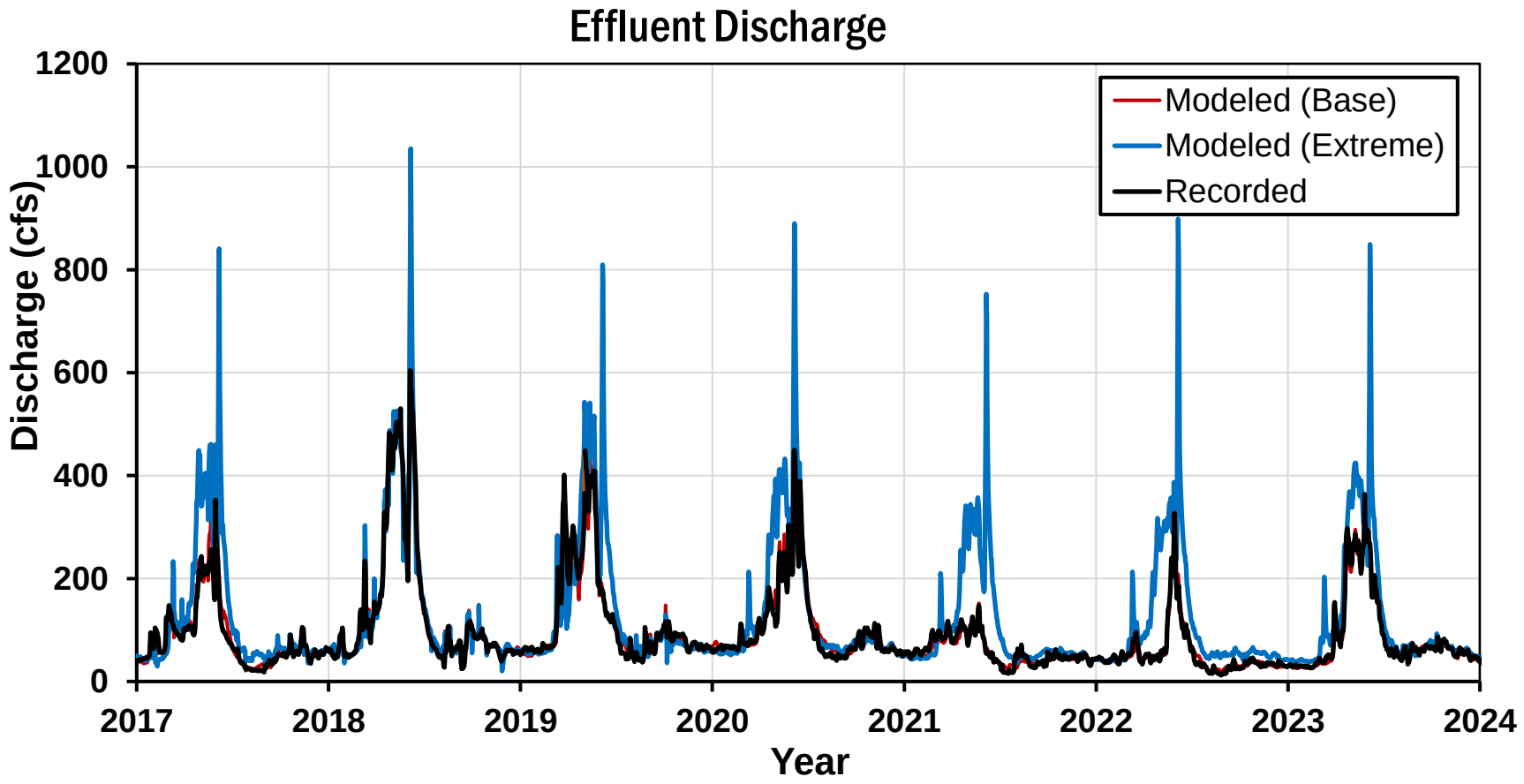
Testing Extreme Weather Scenarios
Effluent Discharge

- A 100-year precipitation (3.5”) and streamflow event (1000 cfs)



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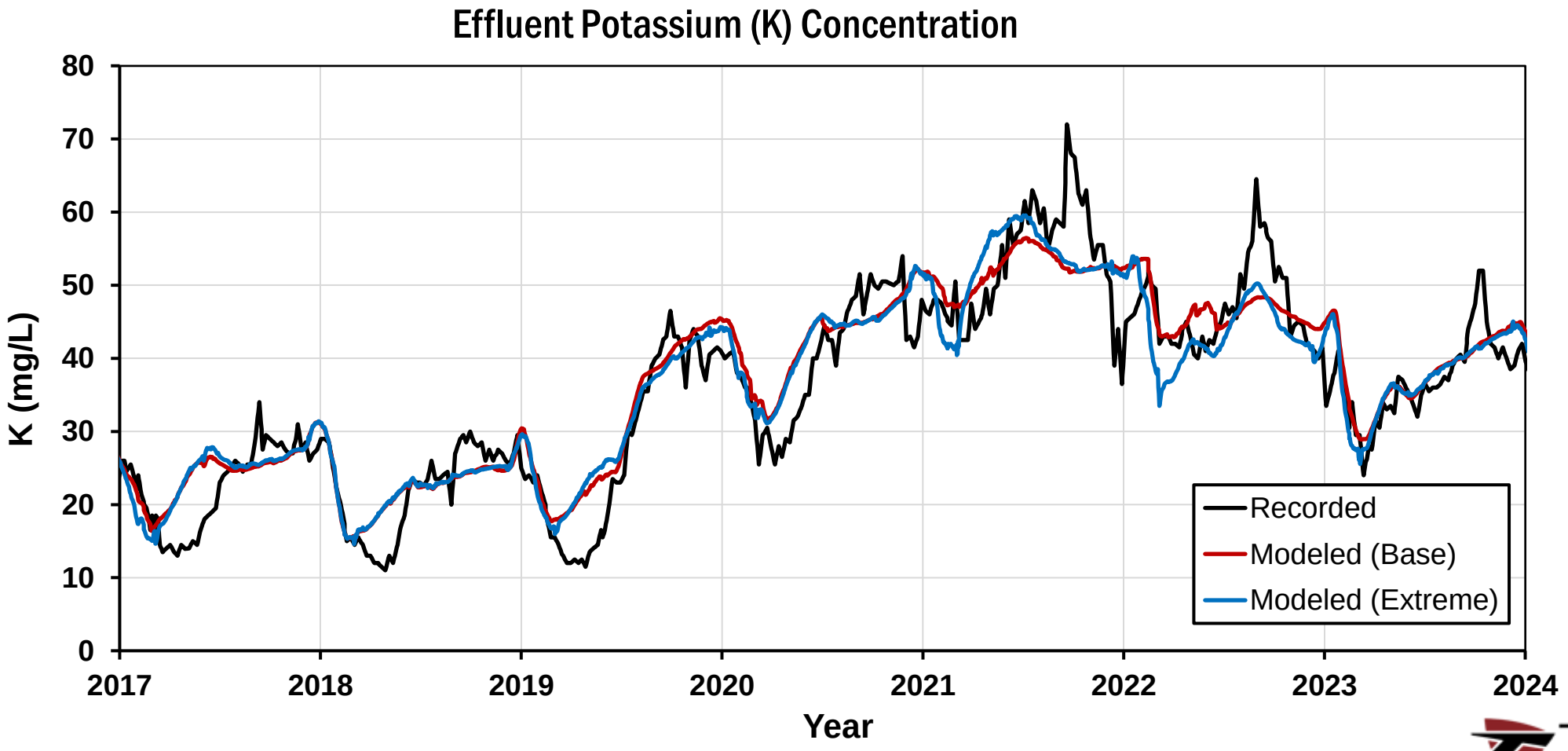
Testing Extreme Weather Scenarios
Potassium



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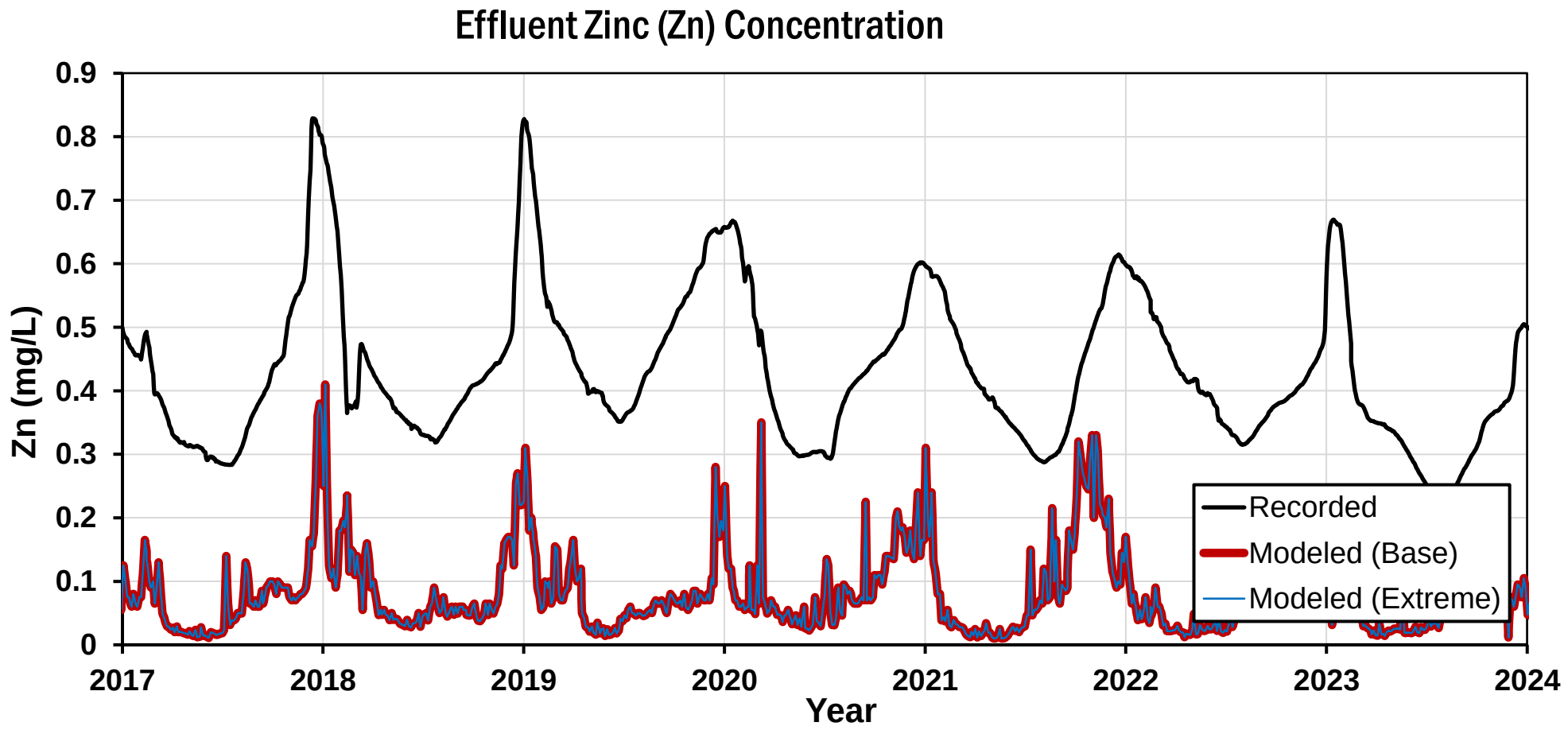
Testing Extreme Weather Scenarios

Zinc



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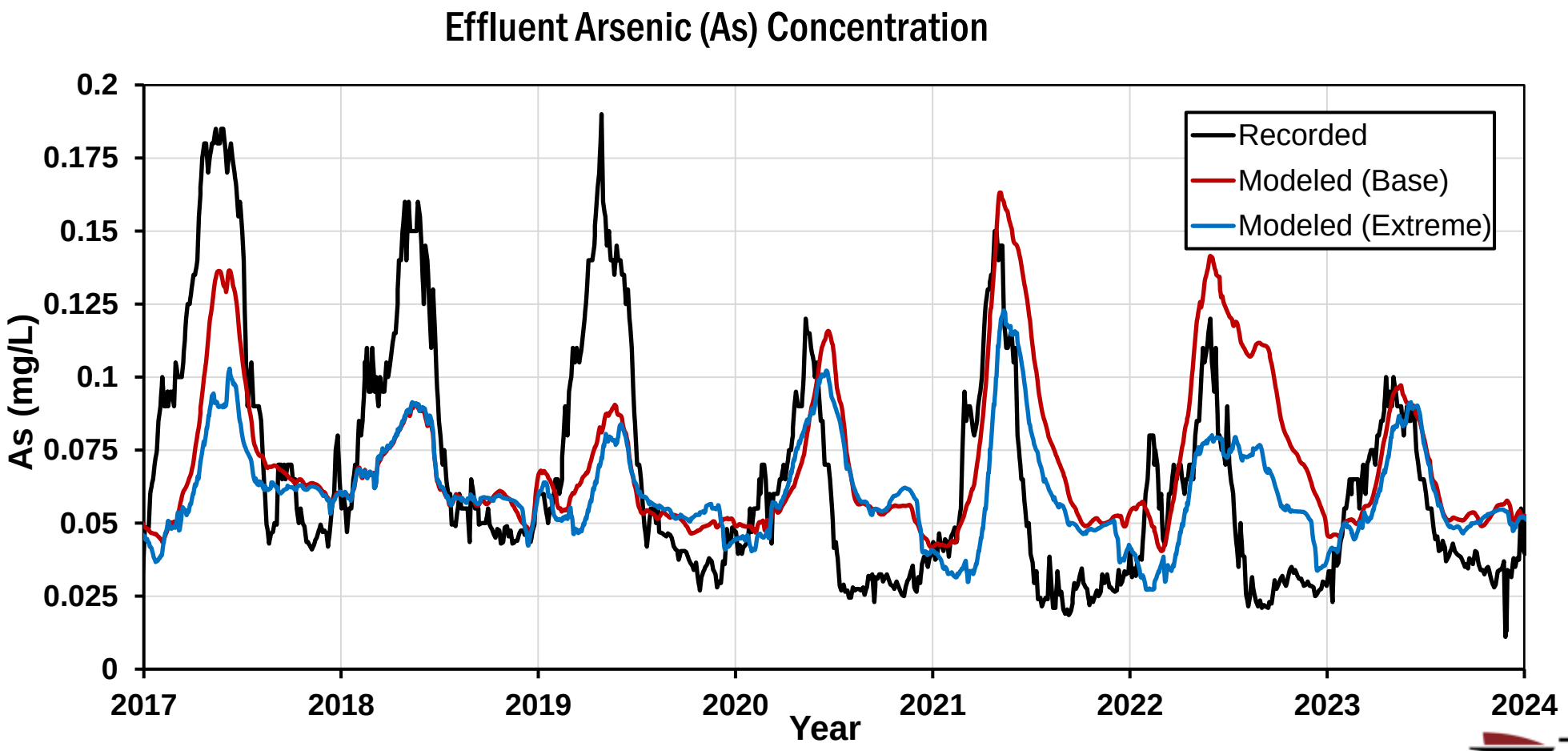
Base Flow Conditions
Arsenic



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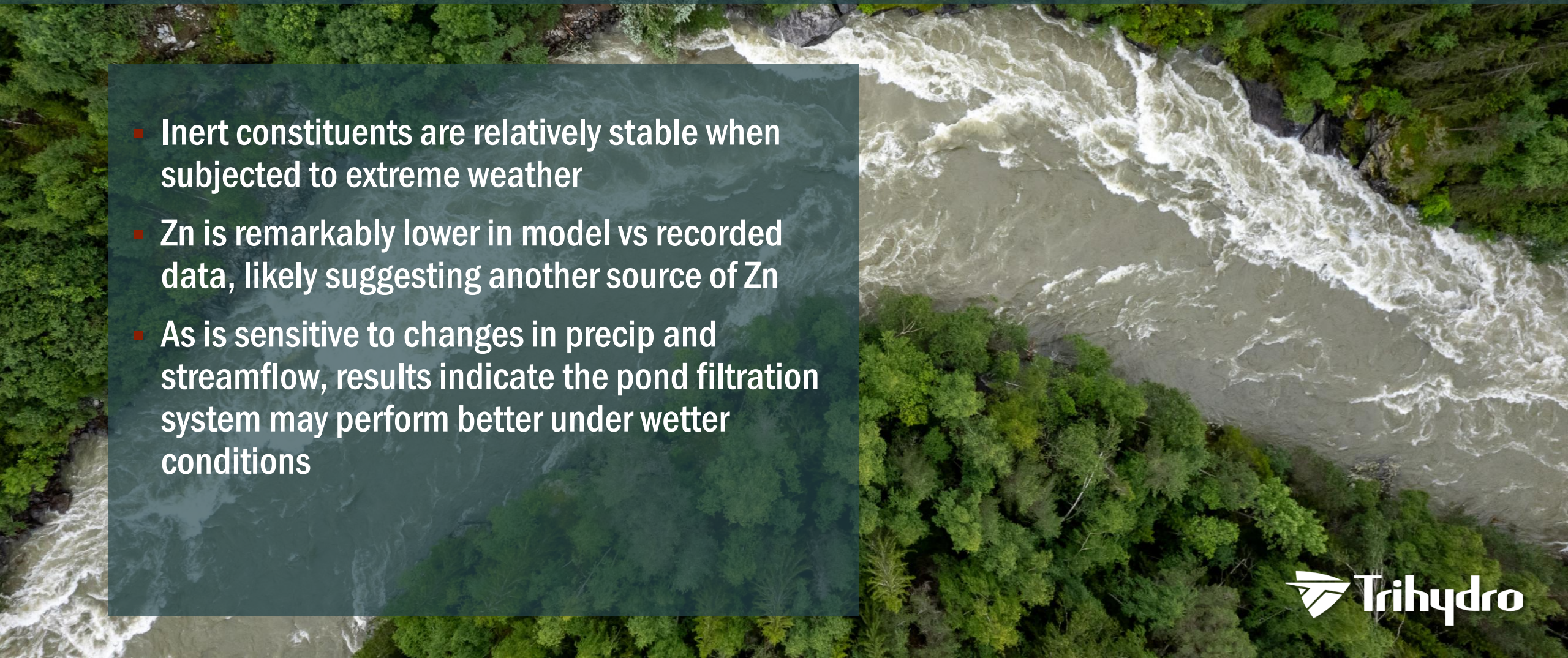
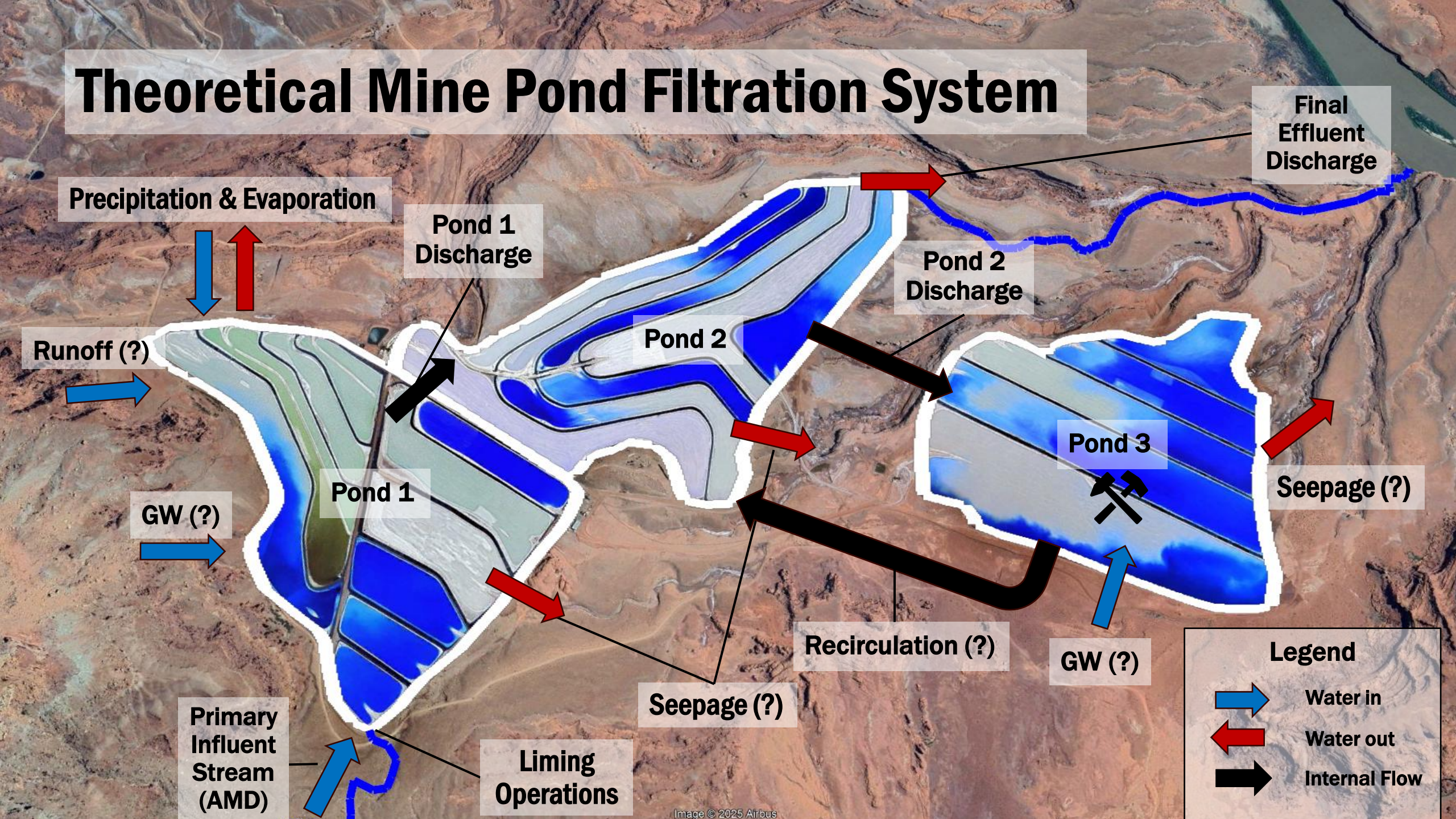
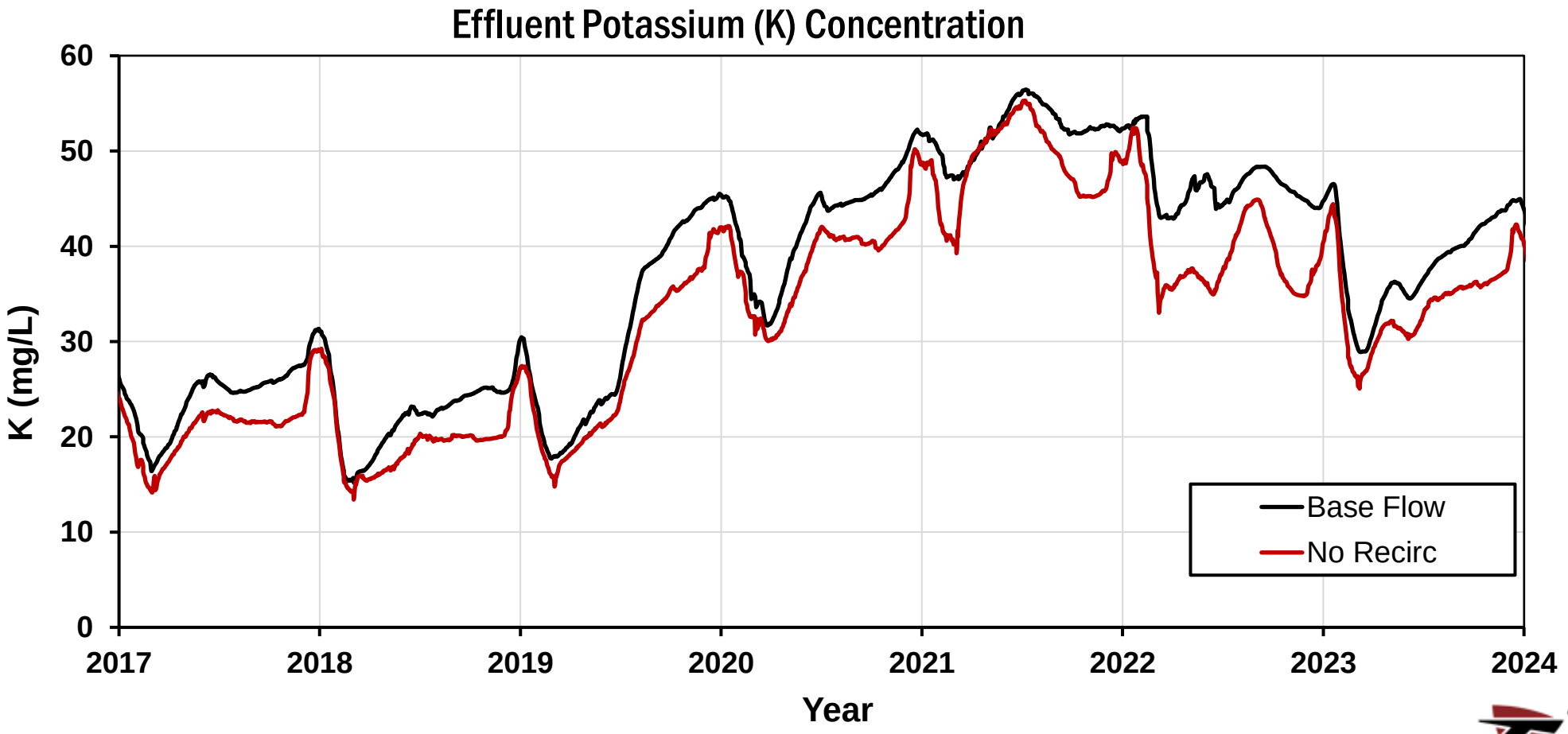
Conclusions

- Inert constituents are relatively stable when subjected to extreme weather
- Zn is remarkably lower in model vs recorded data, likely suggesting another source of Zn
- As is sensitive to changes in precip and streamflow, results indicate the pond filtration system may perform better under wetter conditions




Theoretical Mine Pond Filtration System
Final Effluent Discharge
Precipitation & Evaporation
Pond 1 Discharge
Pond 2 Discharge
Runoff (?)
Pond 2
Pond 3
Pond 1
GW (?)
Seepage (?)
Recirculation (?)
GW (?)
Seepage (?)
Primary Influent Stream (AMD)
Liming Operations
Image © 2025 Airbus
Legend
Water in
Water out
Internal Flow

Operational Changes
Potassium



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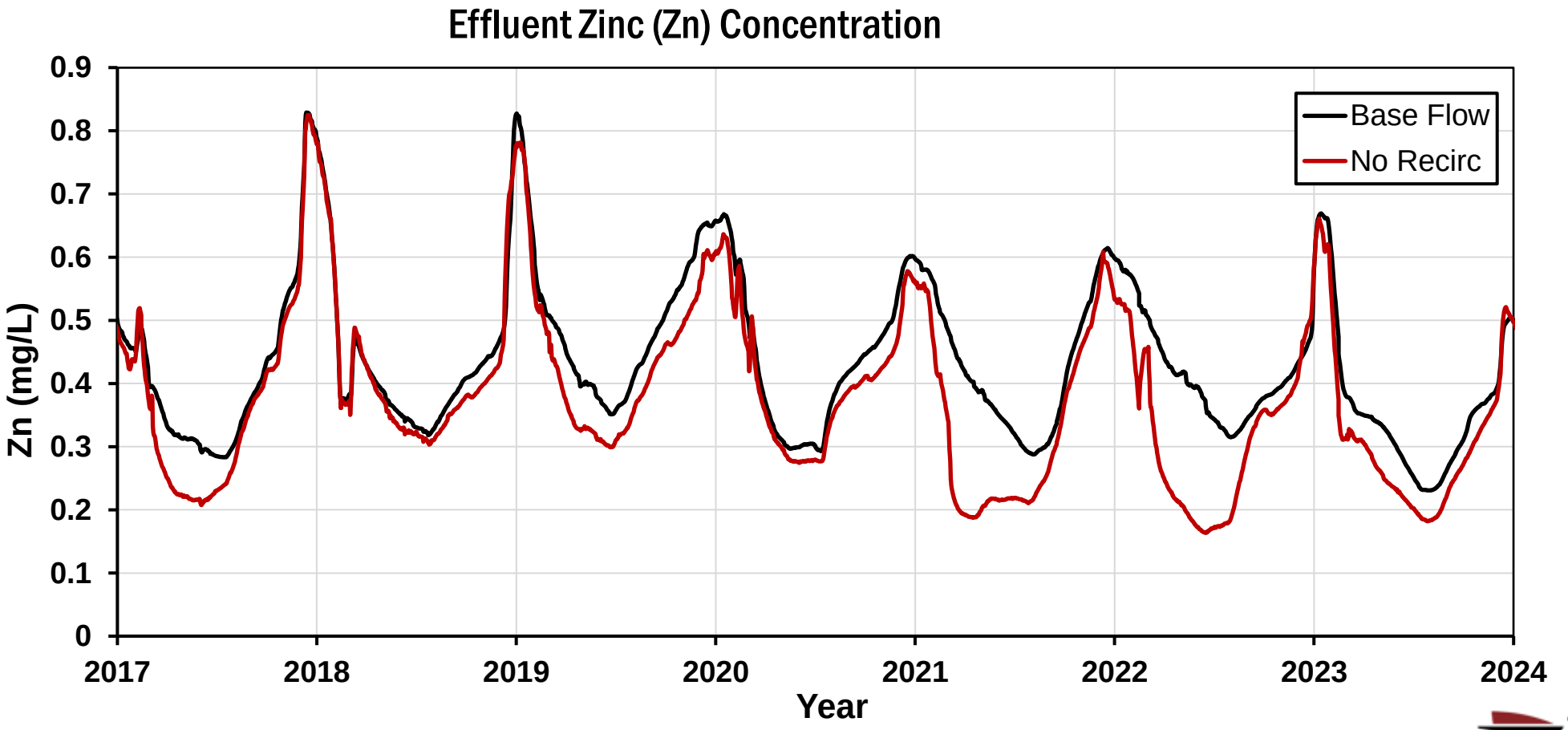
Extreme Weather Scenarios
Zinc



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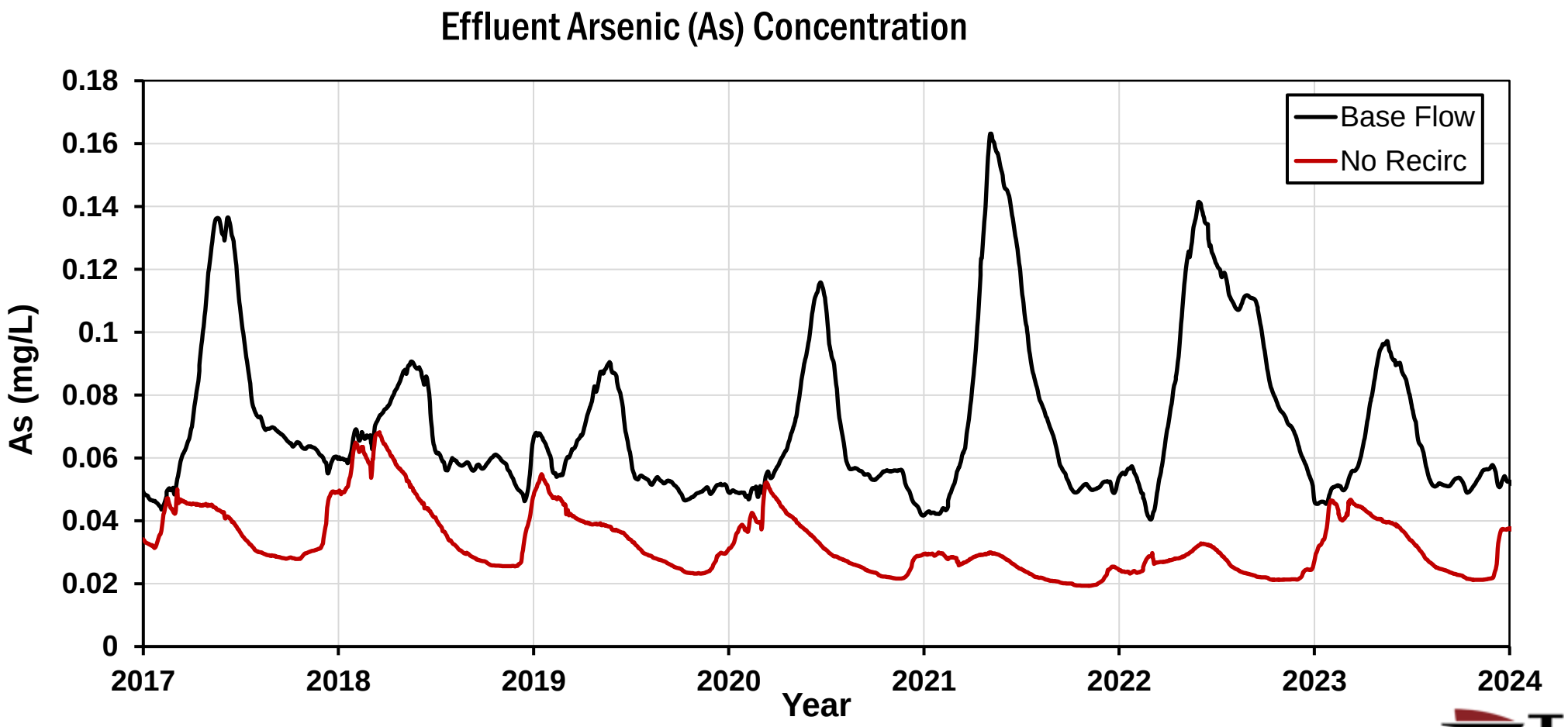
Operational Changes
Arsenic



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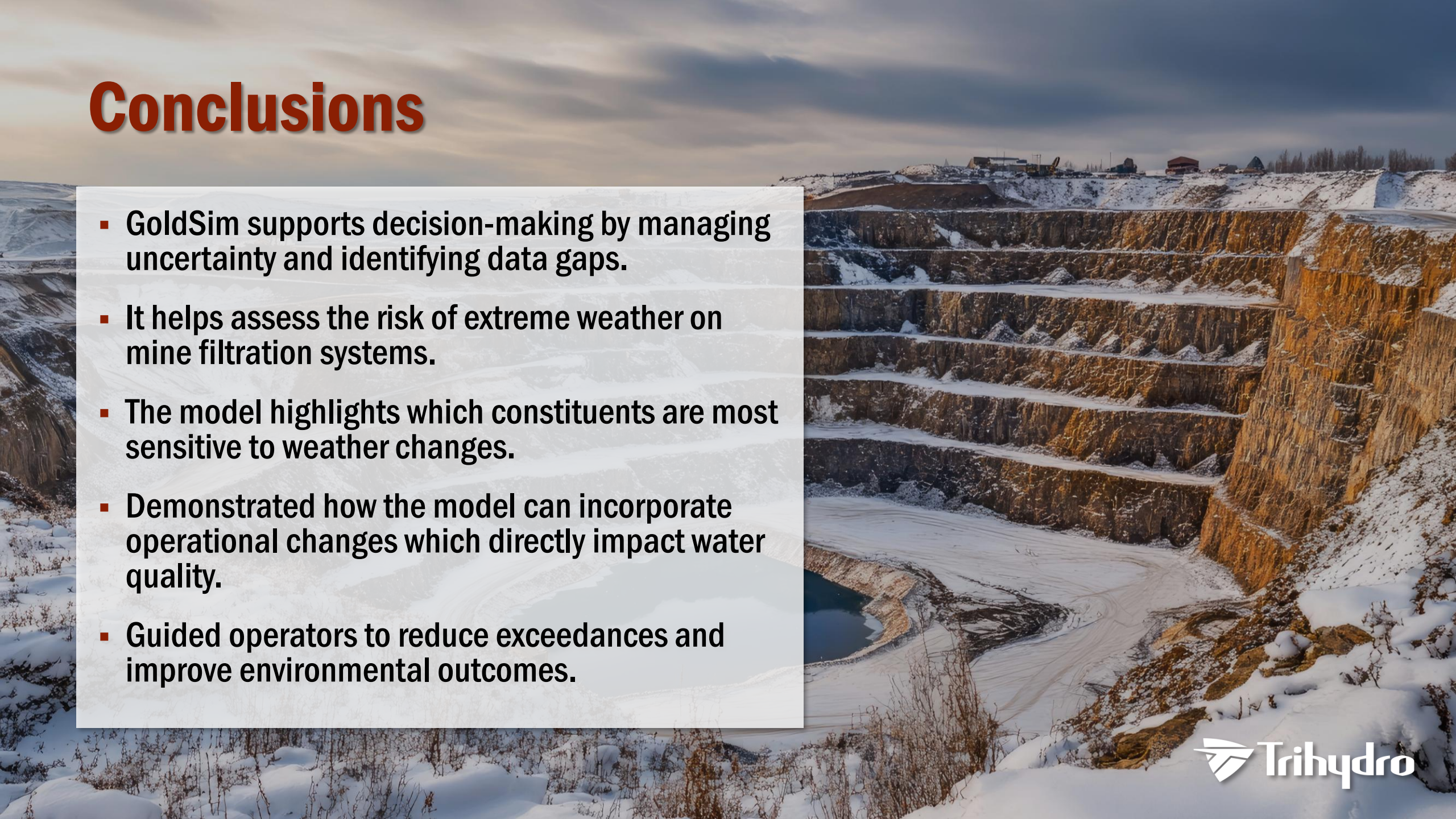
Operational Changes

Conclusions

- Removing recirculation created a uniform decrease in all constituents.
- If recirculation was removed from the system, key elements of concern such as As could be greatly decreased.

Conclusions

- GoldSim supports decision-making by managing uncertainty and identifying data gaps.
- It helps assess the risk of extreme weather on mine filtration systems.
- The model highlights which constituents are most sensitive to weather changes.
- Demonstrated how the model can incorporate operational changes which directly impact water quality.
- Guided operators to reduce exceedances and improve environmental outcomes.



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QUESTIONS

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