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Characterizing Contaminant Flux at the Groundwater-Surface Water Interface

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Disclaimer

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Plan for Presentation

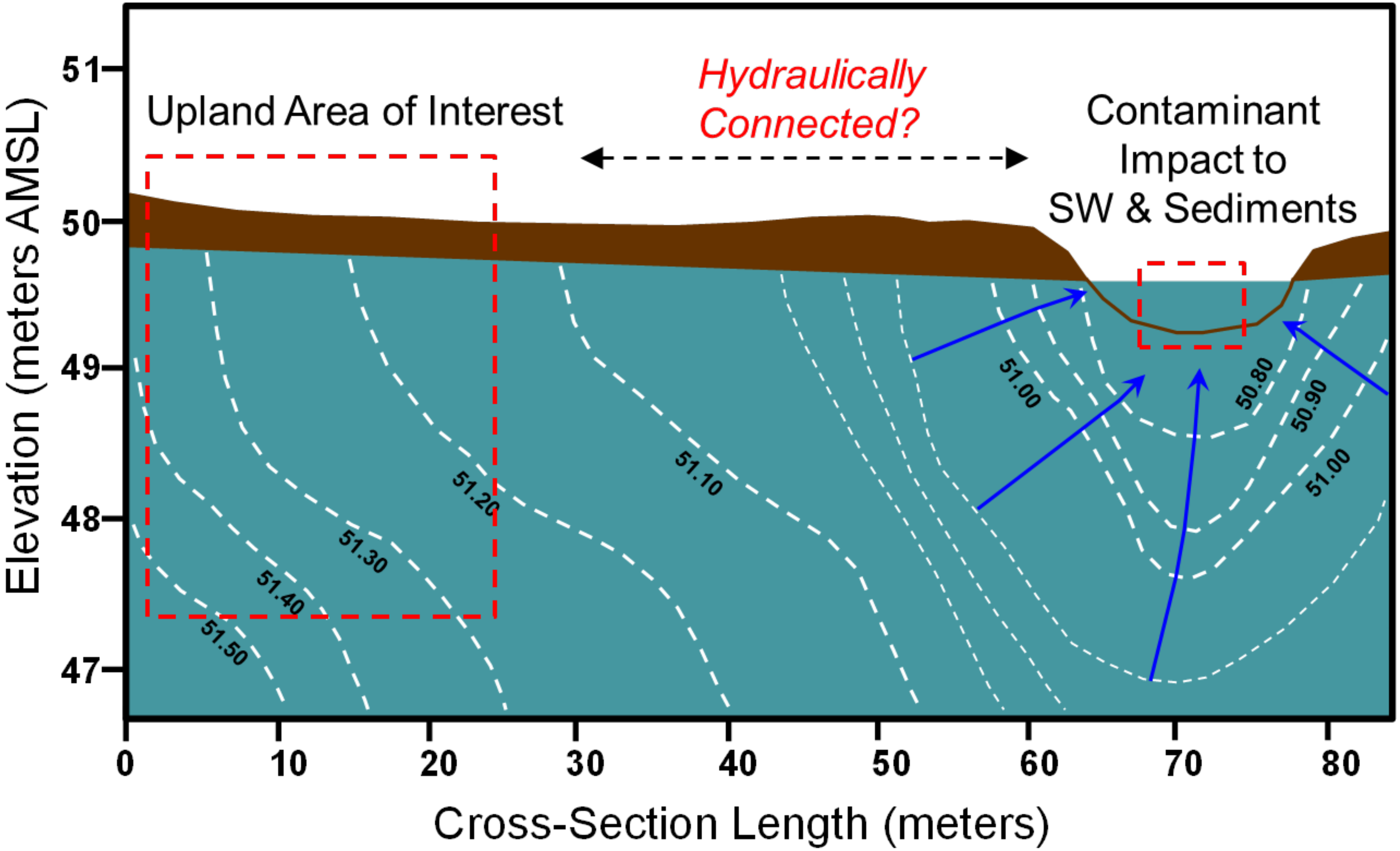
- Context for evaluating water and contaminant flux from upland groundwater to downgradient surface water bodies (CSM)
- Assessing hydraulic pathway from groundwater to surface water
- Assessing factors controlling contaminant flux to surface water

Conceptual Site Model

Understand Interaction Between GW & SW

- Water flux of GW and SW at interface will govern processes controlling contaminant fate
- Dominant chemical processes will be governed by the mass of contaminant and reactive constituents delivered to and mixed at the interface
- Net result of processes will likely vary in time (seasonal) and space (geology)

Conceptual Site Model



Conceptual Site Model

Effective CSMs - Site Hydrology Issues

- Hydraulic connection between contaminated GW and surface water body
  - Does it exist?
  - If so, is it continuous or episodic?
  - When connected, does the direction of water exchange vary?
- Questions need to be addressed to understand timing and location of contaminant discharge

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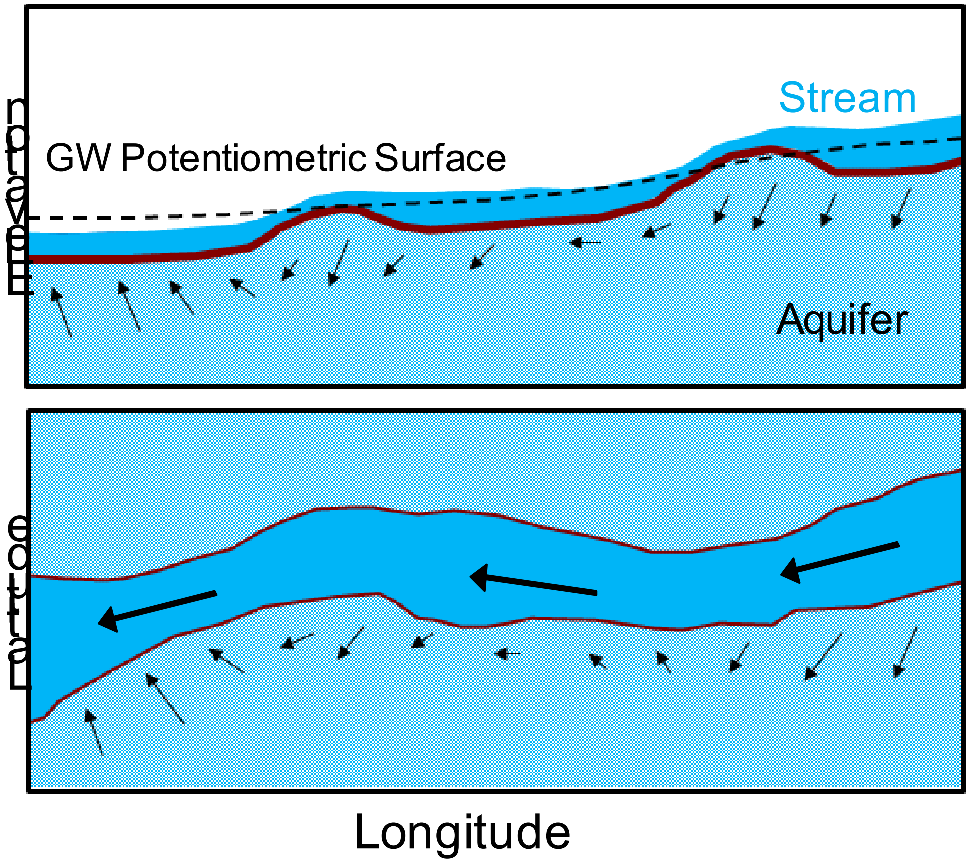
Conceptual Site Model



- Site topography and stream morphology influence GW flow direction and magnitude
- May need to characterize this spatial variability relative to GW plume dimension
- GW is not a static system, but may respond more slowly to changes in water budget (continuous logging)

Conceptual Site Model

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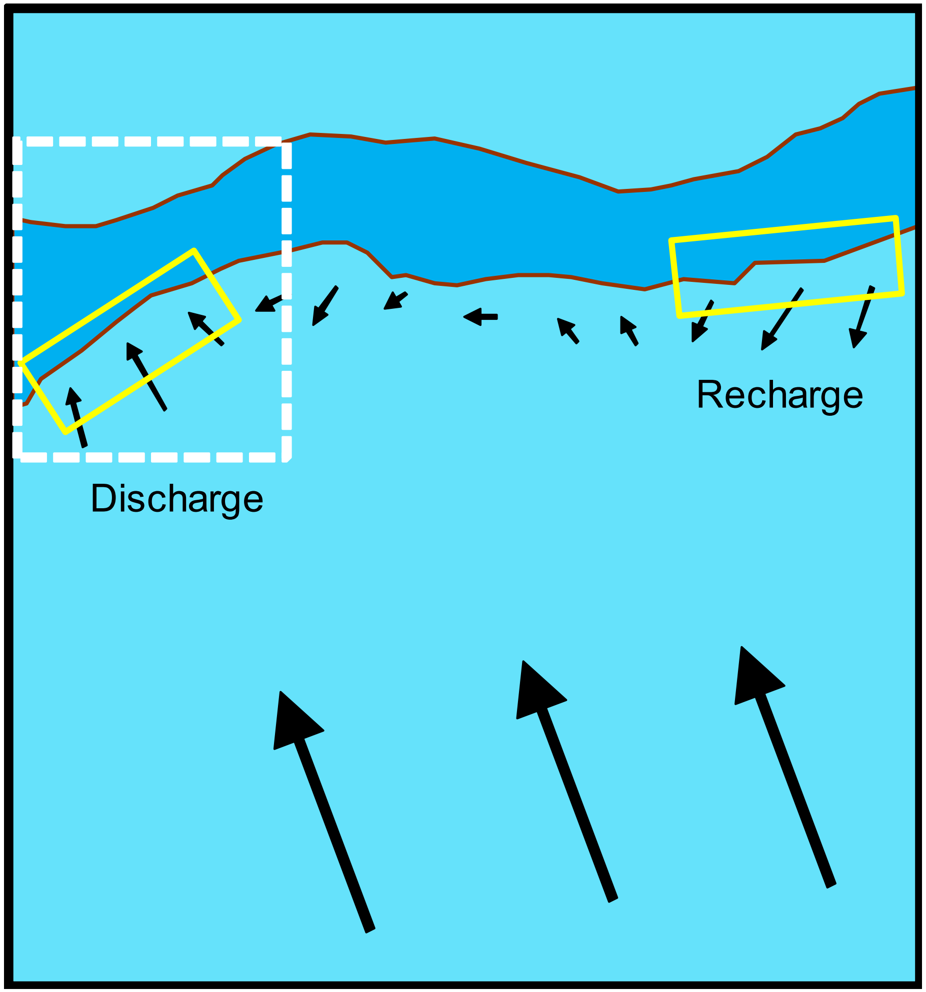
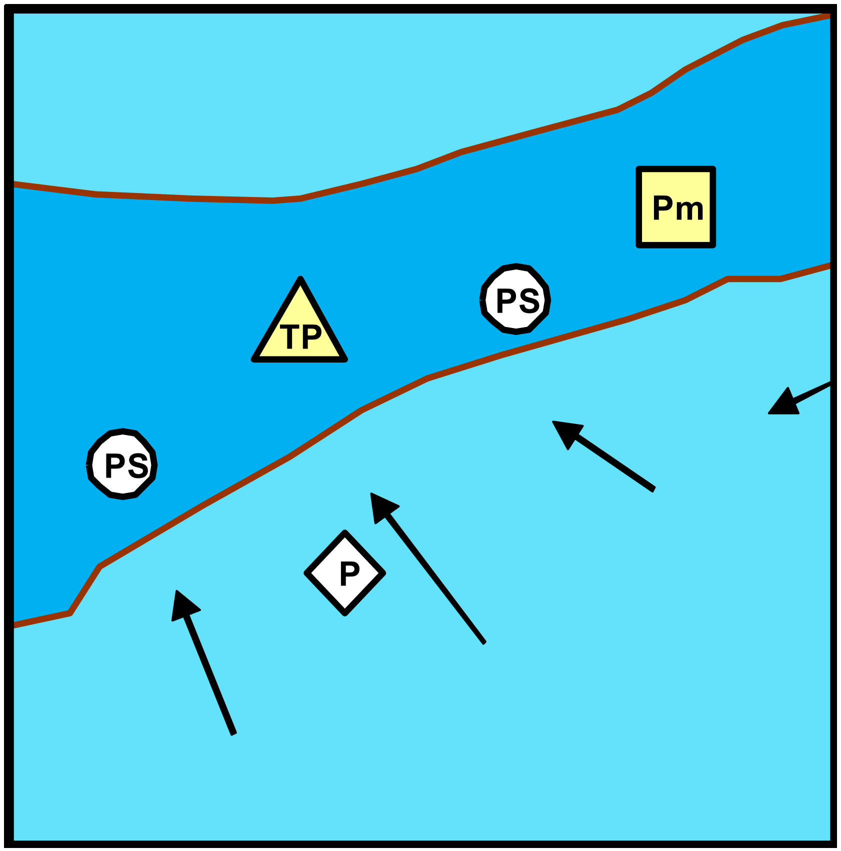
- An effective CSM depends on understanding contaminant transport from source area(s) to SW and dynamics at **GW-SW interface**
- Contaminant non-detects that occur along some assumed flow path could mean two things:
  - Contaminated GW does not reach SW
  - ***Monitoring location is not in the flow path***
- Hydrologic & chemical measurements across the GW-SW interface bridge upland GW-to-SW transport pathway

Assessing Hydrology



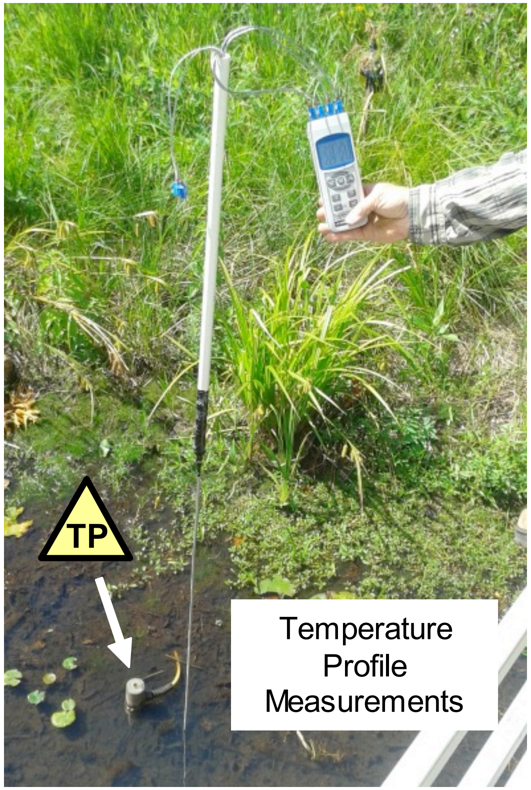
- Site topography and stream morphology influence GW flow direction and magnitude adjacent to surface water body
- Characterizing local flow field across GW-SW interface important for understanding dynamic processes governing water exchange & contaminant flux

Assessing Hydrology



- Hand-Deployed Devices
  - Piezometer (P)
  - Piezometer-Stilling Well (PS)
  - Temperature Profiler (TP)
  - Permeameter (Pm)
- Provide for assessment of the direction and magnitude of water exchange
- Logging sensors allow assessment of variability over time

Assessing Hydrology



Temperature Profile Measurements

Installation of Piezometer-Stilling Well & Temperature Profiler

Vertical Gradient Piezometer-Stilling Well

Assessing Hydrology

Develop Integrated Knowledge of GW-SW Interface

- Localized monitoring network used to understand dynamics of flow system with time (seasonal)
  - Horizontal gradient
  - Vertical gradient
  - Horizontal/vertical water flux
- Basis for comprehending processes controlling contaminant flux and fate at GW-SW interface
- Baseline analysis of system provides the basis for interpreting whether upgradient remedial actions are performing as desired

Factors Affecting Contaminant Transport

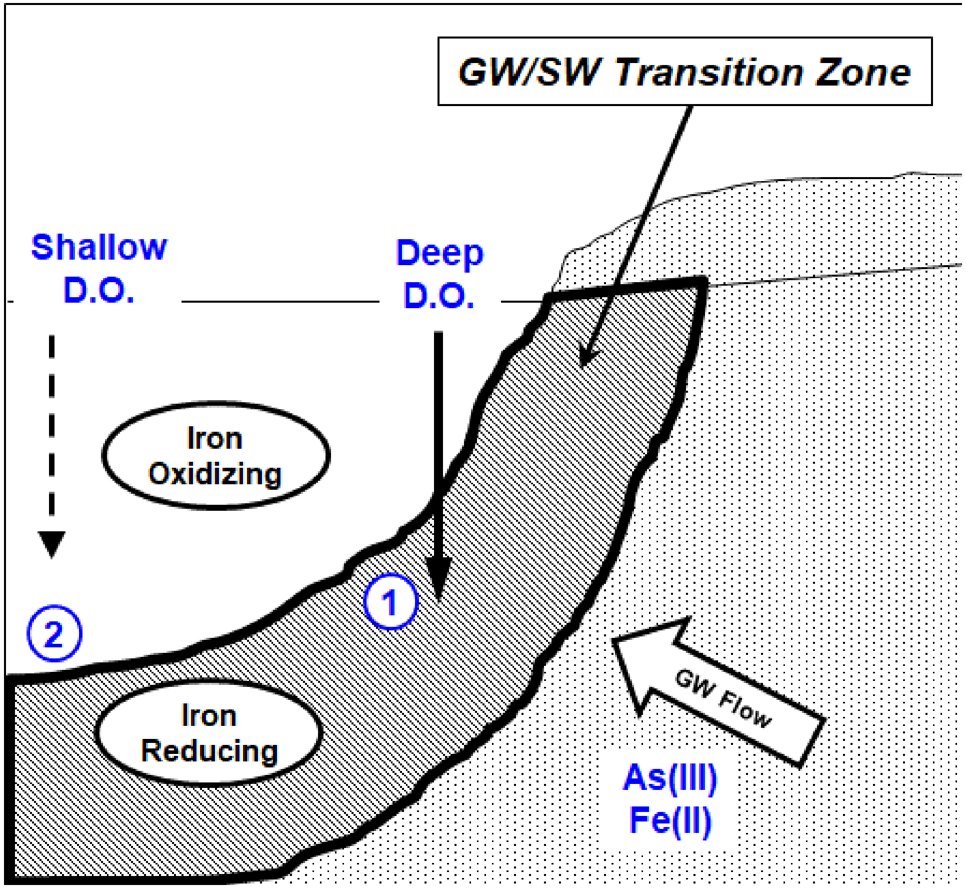
Inorganic Contaminant Properties & Mass Flux

- Contaminant properties influence types of processes active in controlling fate (adsorption, precipitation, chemical speciation)
- GW-SW interface is typically a zone with major changes in chemistry over distance due to mixing of reactive constituents delivered by GW and SW
- Contaminants with chemical fate sensitive to changes in pH and redox may show changing patterns with season
- Contaminants sequestered in sediments may become a secondary source of contaminant flux to SW

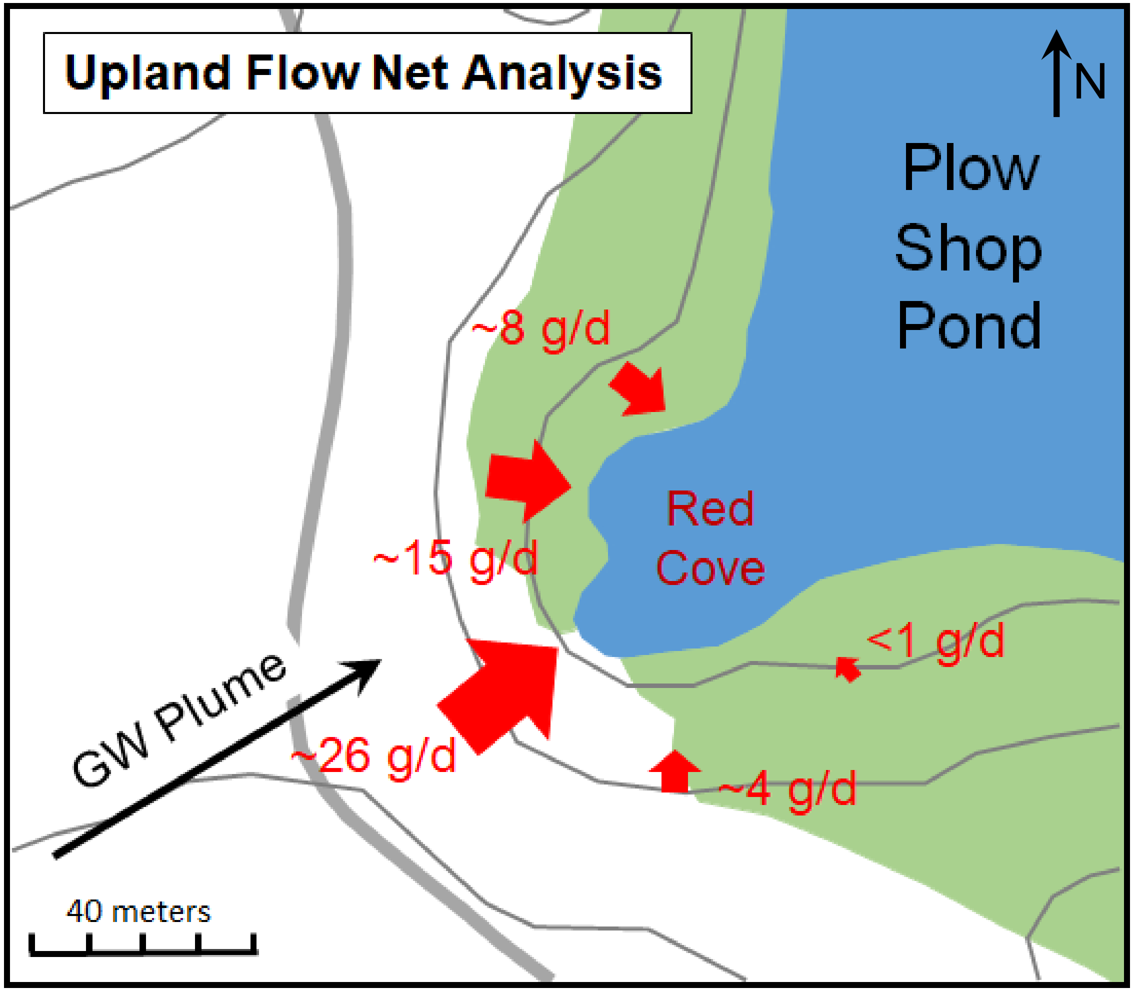
Factors Affecting Contaminant Transport

Reduced GW Plume

- SW body with varying water depth in which oxygen reaches sediments in shallow locations but not deep
- Oxidation & attenuation of Fe and As in sediments for shallow depths
- Unhindered transport of As into SW for deeper depths



Case Study



- Arsenic plume flowing from landfill toward cove
- Nested piezometers used to evaluate magnitude & distribution of arsenic flux

Case Study

Picture of cove from north shore

Picture at central cove from boat next to contaminated seepage area

Case Study

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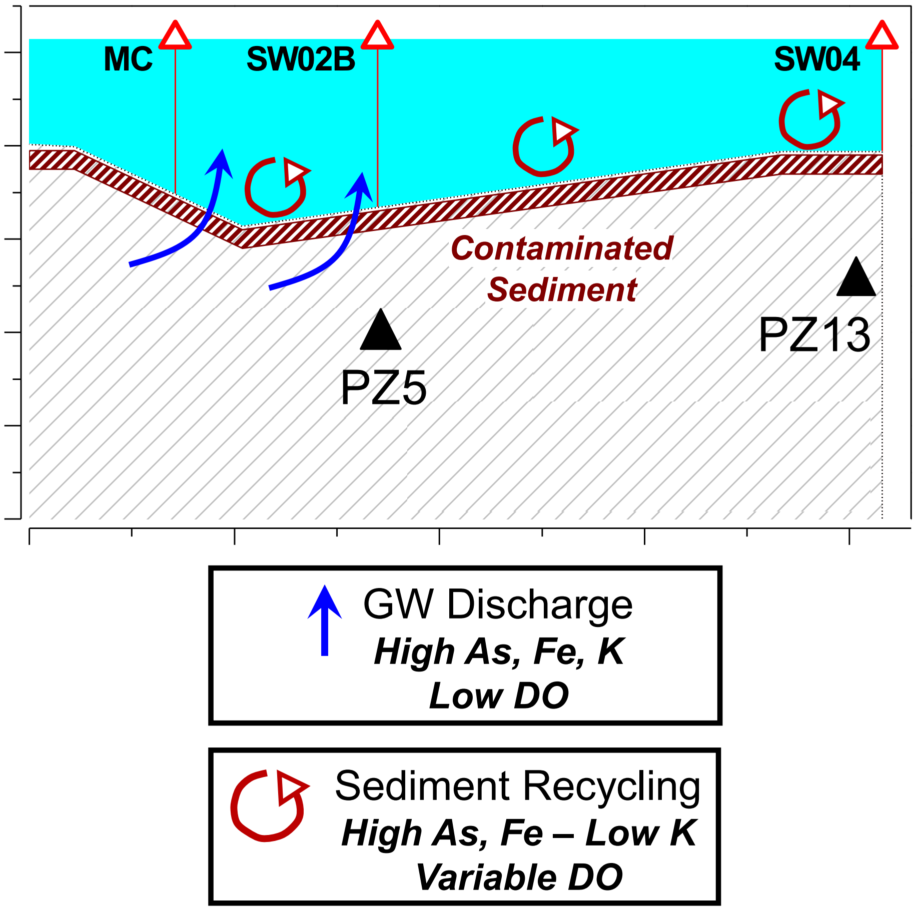
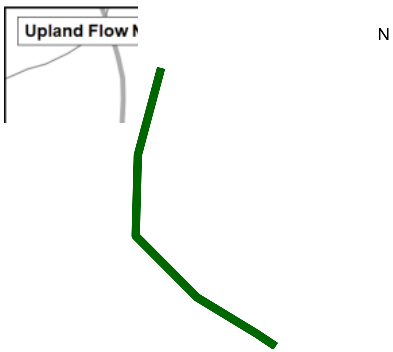
What influences SW concentrations?



- Sediment arsenic concentrations variable within cove – correlate with iron
- PZ5 location shows sustained discharge with plume chemistry signature in deep SW
- PZ13 in location of low discharge & no plume chemistry signature in deep SW

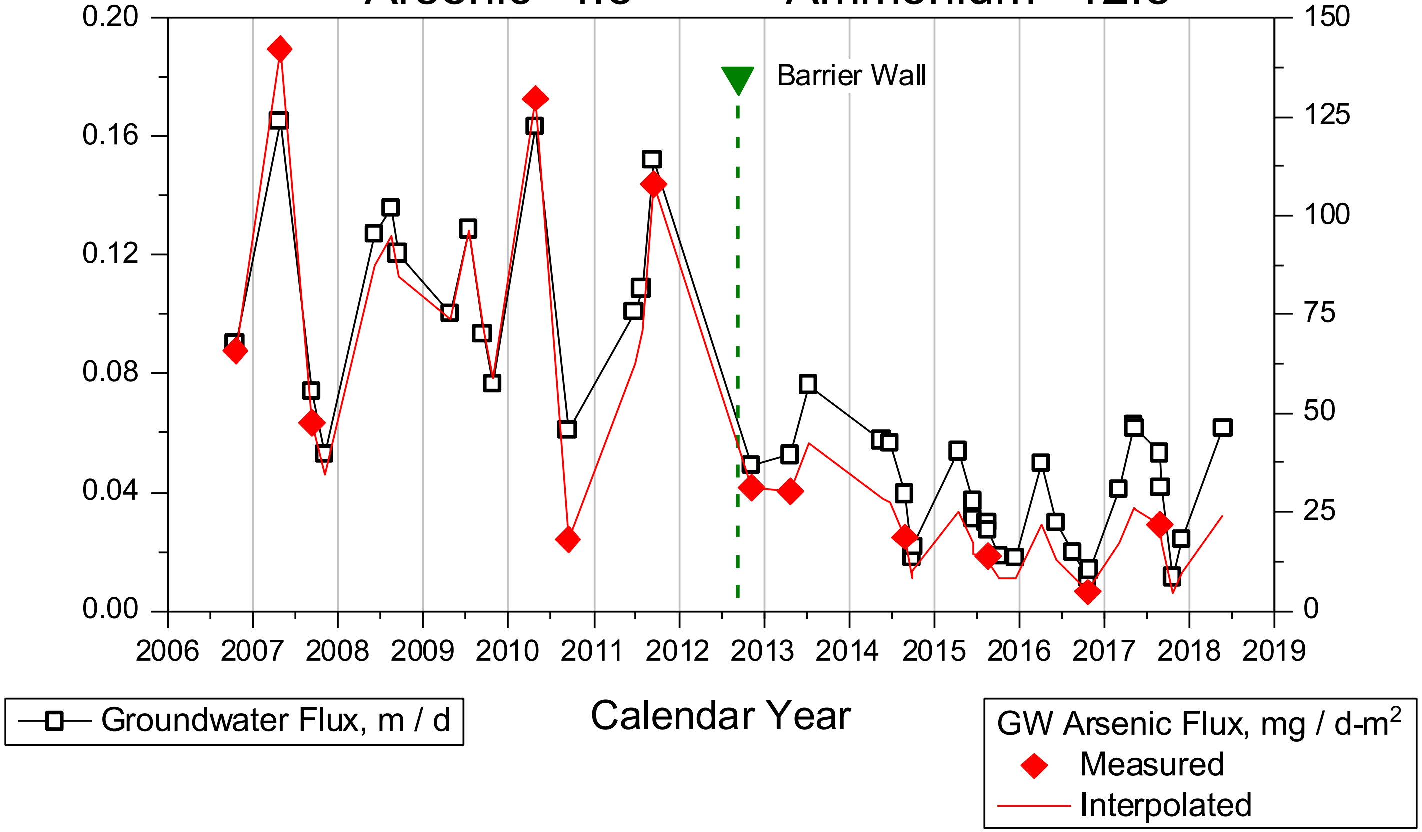
Case Study

Upland GW



Median Flux Reduction Factors

Flow	2.9	Barium	7.6
Arsenic	4.3	Ammonium	12.8



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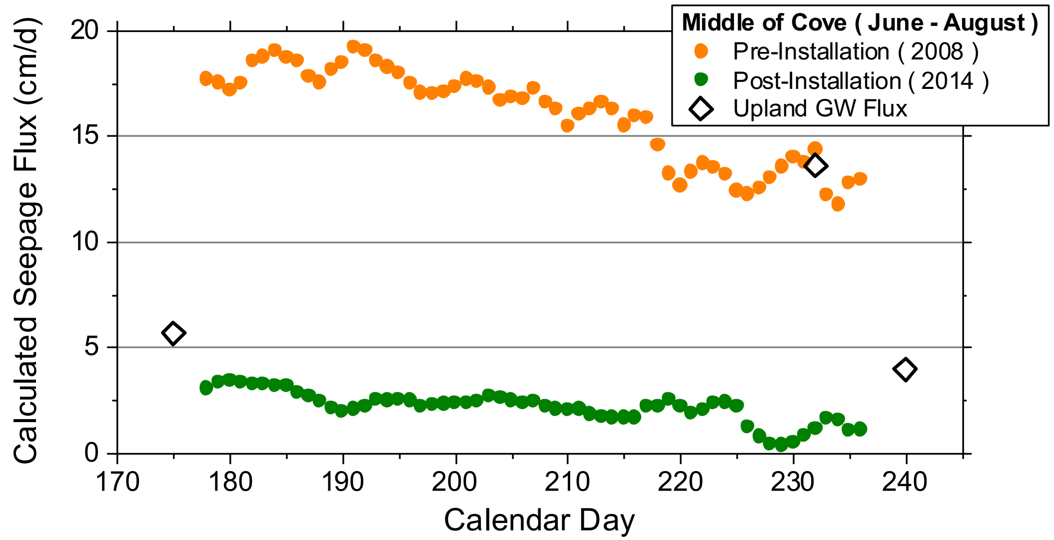
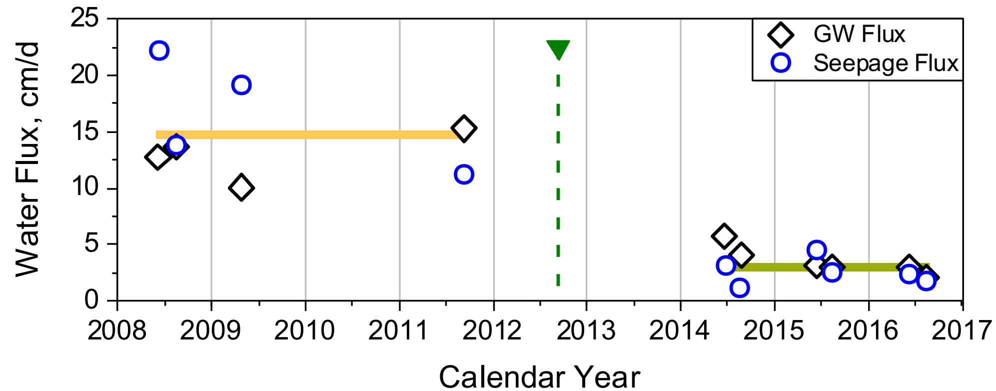
Case Study

GW-SW Interface

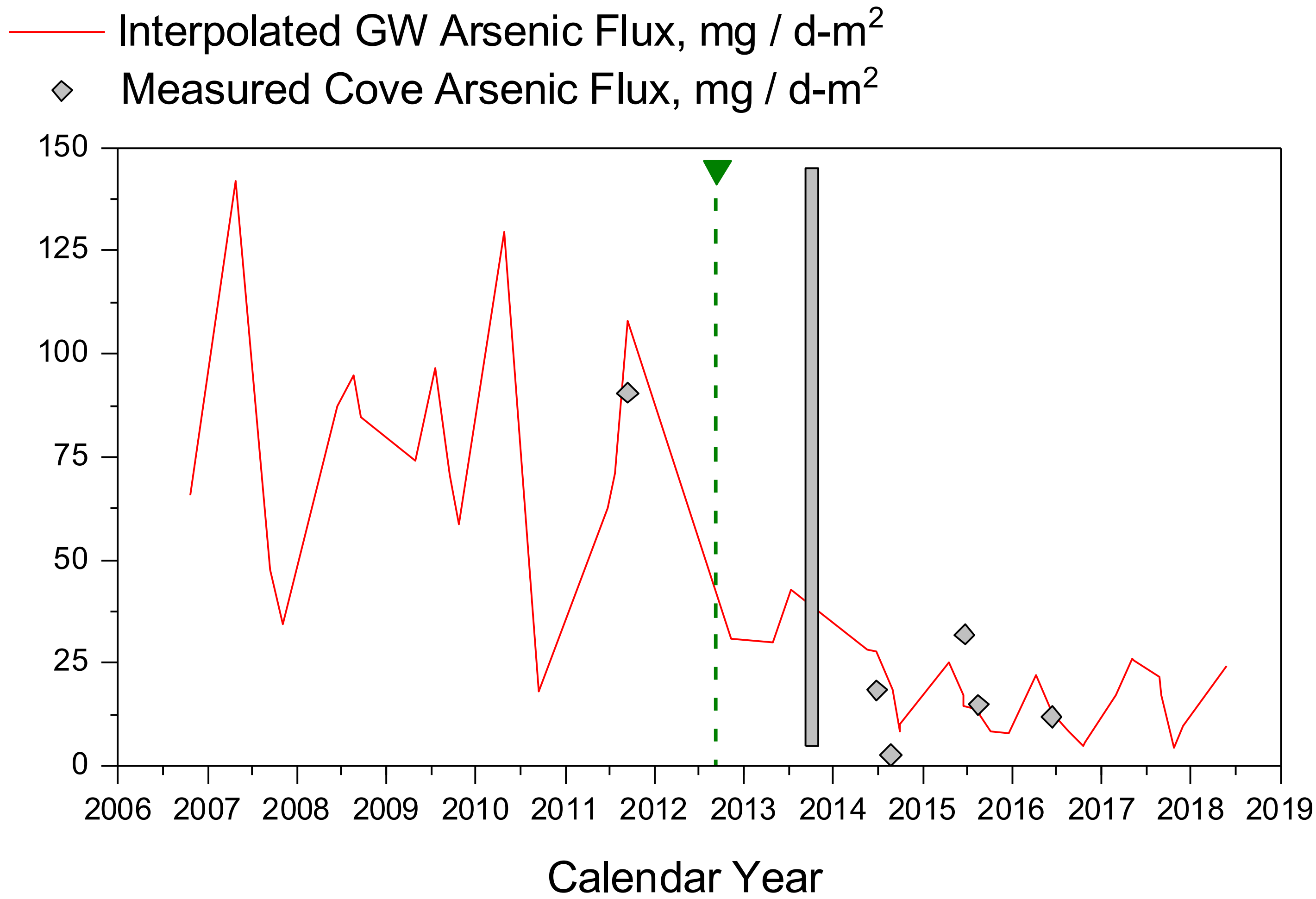
Sediment Temperature Profile Method



Comparison over entire monitoring period…



Case Study



Interpolated GW Arsenic Flux, mg / d-m^2
Measured Cove Arsenic Flux, mg / d-m^2
150
125
100
75
50
25
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Calendar Year

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Case Study

BEFORE

AFTER

Outcome

- GW plume diverted away from cove by hydraulic barrier
- Performance metric of GW contaminant flux reduction was realized and could be assessed in multiple ways
- Episodic exceedances of AWQC (As) during late Summer / early Fall, but…
- Spring fish nest building observed immediately after remedy and continues (2014-2018)

Closing Remarks

- Methods to assess GW flow and seepage flux are relatively easy to implement and provide flexibility to monitor the GW-SW interface
- Knowledge of water flux dynamics improves understanding of processes controlling contaminant fate
- Comprehension of baseline contaminant flux dynamics across the GW-SW interface are critical to assessing response to upland remediation

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