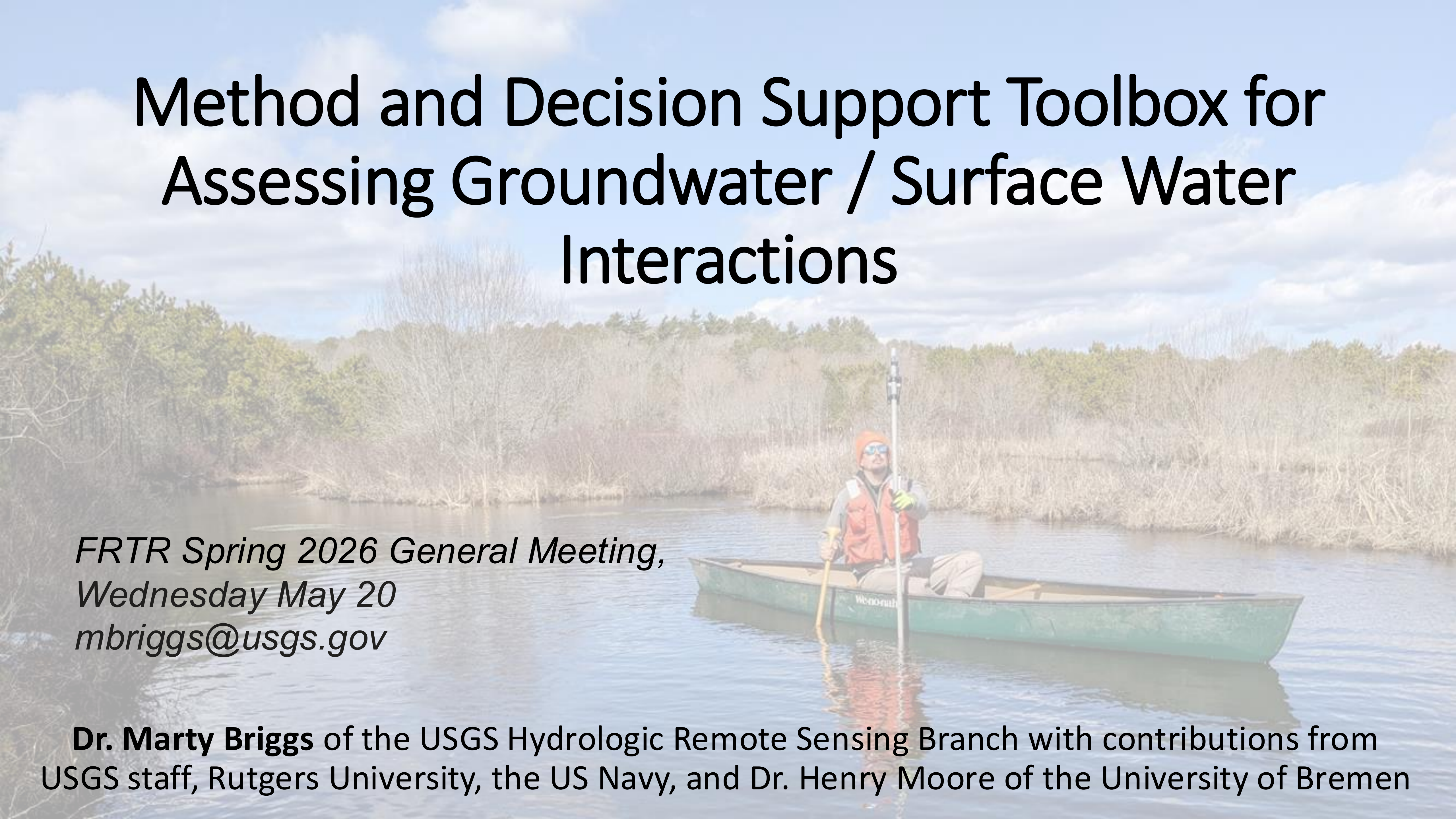


Method and Decision Support Toolbox for Assessing Groundwater / Surface Water Interactions

FRTR Spring 2026 General Meeting,
Wednesday May 20
mbriggs@usgs.gov

Dr. Marty Briggs of the USGS Hydrologic Remote Sensing Branch with contributions from USGS staff, Rutgers University, the US Navy, and Dr. Henry Moore of the University of Bremen

Funding and thank you

ESTCP

EPA

USGS Toxic Substances Hydrology Program

Also, the Air Force Civil Engineer Center for additional support, the
Town of Mashpee, MA for site access and road maintenance,
and field help from at least a dozen other people…

GW/SW Method Selection Tool

by Steven A. Hammett (USGS contractor); Frederick D. Day-Lewis (PNNL, corresponding author); Brett Trottier (USGS).

Corresponding Article Citation: "GW/SW-MST: A Groundwater/Surface-Water Method Selection Tool" by Hammett, Steven; Day-Lewis, Frederick; Trottier, Brett; Barlow, Paul; Briggs, Martin; Delin, Geoffrey; Harvey, Judson; Johnson, Carole; Lane Jr., John; Rosenberry, Donald; Werkema, Dale

Contact Info: USGS Hydrogeophysics Branch, hgb_help@usgs.gov

Last Updated: 1/27/2022 This program was designed to run in Microsoft Excel 2013 or later Excel versions.

Summary - The Groundwater/Surface-Water Method Selection Tool (GW/SW-MST) is designed to assist project scientists, and engineers in selecting data collection methods that (1) satisfy study goals, and (2) are feasible for application at a given site, based on site characteristics as entered by the user. The GW-SW MST uses a spreadsheet-based interface developed in MS Excel 2013.

Target Audience - The target audience for the Groundwater - Surface Water Method Selection Tool (GW/SW -MST) is the working technical professional with varied hydrological experience in performing studies of the interaction between groundwater and surface water through the exchange of water and chemicals.

Techniques illustrated include: (A) infrared aerial photography and imagery, (B) thermal profiling, (C) the use of temperature and specific-conductance probes, (D) dyes and tracers, (E) hydraulic potentiomanometers, (F) seepage meters, (G) well networks, (H) streamflow measurements. From Rosenberry, D.O., and LaBaugh, J.W., 2008. Field techniques for estimating water fluxes between surface water and ground water. U.S. Geological Survey Techniques and Methods 4-D2, 128 p.

Disclaimer - This software has been approved for release by the U.S. Geological Survey (USGS). Although the software has been subjected to rigorous review, the USGS reserves the right to update the software as needed pursuant to further analysis and review. No warranty, expressed or implied, is made by the USGS or the U.S. Government as to the functionality of the software and related material nor shall the fact of release constitute any such warranty. Furthermore, the software is released on condition that neither the USGS nor the U.S. Government shall be held liable for any damages resulting from its authorized or unauthorized use. Results at any one site may vary depending on the actual tools and acquisition settings used. We recommend that when making tool selections you read the manuals or consult the vendors for the range of operation for each tool. The tools shown in the appendix are for descriptive purposes only and do not constitute an endorsement of any particular brand or tool.

Acknowledgements - Development of this tool was supported by the U.S. Geological Survey (USGS) Toxic Substances Hydrology Program, and Water Availability and Use Science Program, and the U.S. Environmental Protection Agency (USEPA) through its Office of Research and Development via agreement DW-014-92497401 to the USGS. The second author's contribution to this work was partly supported by the Energy and Environment Mission Seed Program, under the Laboratory Directed Research and Development (LDRD) Program at Pacific Northwest National Laboratory (PNNL). Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Introduction | Directions for Using | Select Scenario Setting | Index | Stream or River GW-SW Matrix | Lake or Wetland GW-SW Matrix | Estuary or Coastal G

Ready | Accessibility: Investigate

- **Publicly available USGS software published *with a companion paper* in 2022**
- **Simple spreadsheet logic that cross references site characteristics with study goals to identify applicable methods (*and rule out others…)**
- **Framed around three general groups of hydrologic settings**
- **Covers 26 distinct physical, chemical, geophysical, and drone methods**
- **Updates underway now to explicitly include contaminant fate and transport study goals**

Time Domain Electromagnetic Induction (TDEM)

Measures: Electrical resistivity by observing transient decay of induced electromagnetic currents in subsurface material

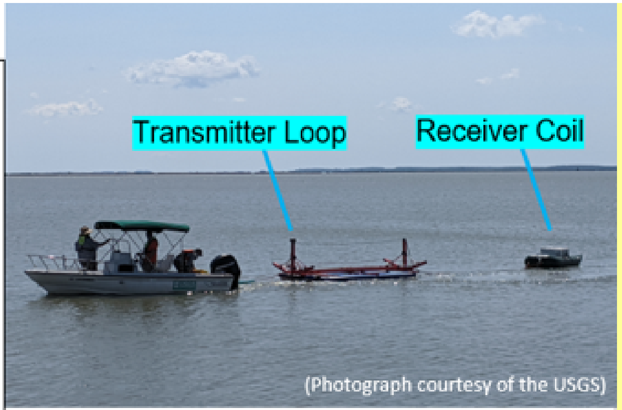
Provides:

- Location of lithology, bedrock, saturation, saline water, contaminant plumes, metallic ores, and other conductivity contrasts.

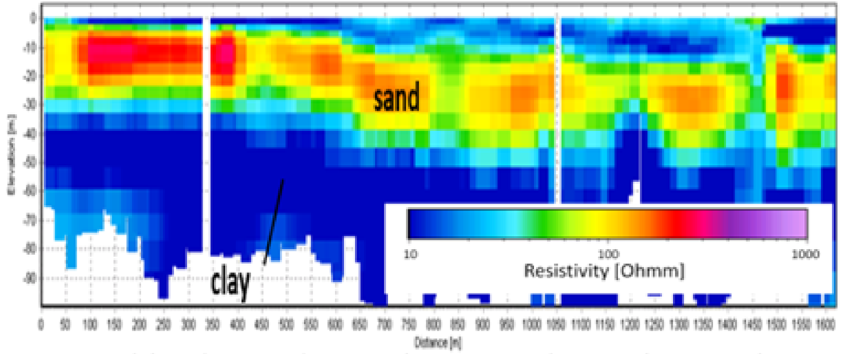
Details:

- TDEM surveys can be physically conducted with a stationary transmitter or a towed transmitter (terrain or waterborne) (Lane et al., 2020)
- TDEM over freshwater environments may be misleading. Best at identifying conductive water at depth (El-Kaliouby and Abdalla, 2015)
- Depth of investigation is dependent on the array size, transmitter moment, site conditions and frequencies used. Overall, depths potentially range from 40-400 meters
- Requires access and space for a square-array survey
- Not necessary to have direct electrical contact with the ground
- Necessary that inherent electrical conductivity contrast is significant
- Conducted on **land** or **water**

Cost Level: *Generally low – dependent on specific instrument/method used*



Boat towed TEM apparatus placed on inflatables to map submarine discharge zones on the Delaware River Basin. Best for investigating shallow depths (40-80 m). Towed TEM can also be performed on land with an ATV.

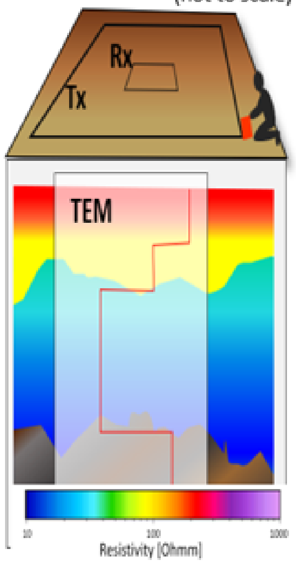


Inverted data showing relative conductivities in relation to distance and depth of investigation.

White et al., 2019

A stationary TDEM apparatus consists of a transmitter loop (Tx), a receiver (Rx) placed in the center of the Tx loop, and a console to record data and regulate current. This method provides a 1D snapshot of the subsurface, is more labor intensive and potentially more time consuming than a towed survey, and can survey depths of 100-400 m. Results show the conductivity structure of the subsurface, identifying horizontal conductivity interfaces.

(not to scale)



FDEM | TDEM | DCER | CRP | IP(TD) | SIP & IP(FD) | SP | GPR | Seismic Refraction | CSP | Paired Air and Water Temp | Vertical Bed Temp Pro

This example of a geophysical methods explanation slide features important context such as a photo of data collection and example data interpretation. Key references are mentioned and detailed on a summary slide.

Vertical Bed Temperature Profiling

Measures: Vertical temperature gradients and multi-depth temperature time series in saturated bed sediments

Provides:

- Point-in-time vertical water flux estimates (upward and downward) (Schmidt et al., 2007; Kurylyk et al., 2016 ; Irvine et al., 2019)
- Time series of vertical water flux estimates (upward and downward) (Gordon et al., 2012; Luce et al., 2013; Koch et al., 2016; Irvine et al., 2017)
- Time series of streambed scour and deposition and streambed thermal properties

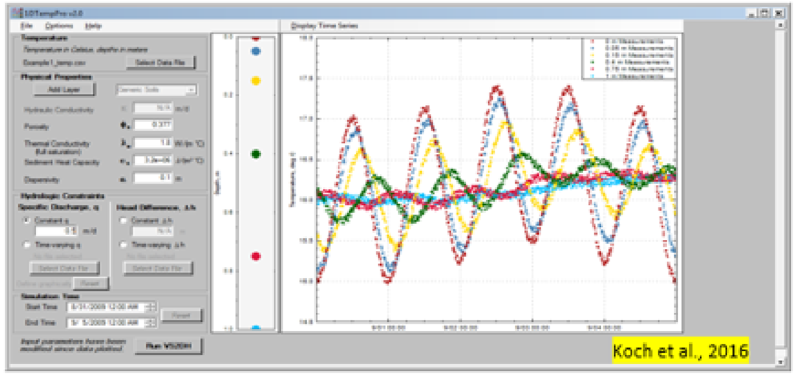
Details:

- Several sensor types ranging in size, structure, and operation including: individual self-logging thermistors, multiple thermistors attached to data logger, temperature profiling probes (TROD), fiber-optic high-resolution temperature sensors (HRTS)
- Typically less bed disturbance than caused by physical flux measurements
- Temperature-based vertical water flux based on the 1D advection-diffusion equation
- Automated vertical flux calculations are possible using a range of published software that are based on analytical (VFLUX, FAST) and numerical (1DTempPro, FLUX-BOT) models

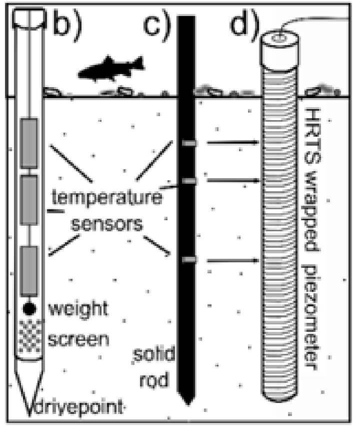
Cost Level: *Low*

(Photographs courtesy of USGS)

Options for protecting and spacing logging thermistors include commercial and homemade metal housings.



This example dataset displayed with 1DTempPro software shows approximately 5 days of streambed temperature at 6 streambed depths. Vertical water flux is optimized by fitting simulated to measured temperature at several depths.



Irvine et al., 2017

Schematic of several vertical temperature profilers including logging thermistors deployed in a piezometer (b), embedded in a solid metal or wood rod (c), and a wrapped high-resolution fiber-optic temperature sensor (HRTS).

Another example of vertical temperature profiling methods includes example analysis software.

FDEM | TDEM | DCER | CRP | IP(TD) | SIP & IP(FD) | SP | GPR | Seismic Refraction | CSP | Paired Air and Water Temp | Vertical Bed Temp Pro

Ready | Accessibility: Investigate

Multi- and Hyperspectral Imaging Cameras

Measures: Specific electromagnetic spectrum wavelength bands

Provides:

- Time-specific snapshots of river corridor ground surface and vegetation light reflectance
- Vegetation vigor can indicate near-surface preferential GW/SW exchange pathways in arid regions (Pai et al., 2017)
- Vegetation stress can indicate saltwater intrusion in coastal areas and inland regions impacted by brine and contamination

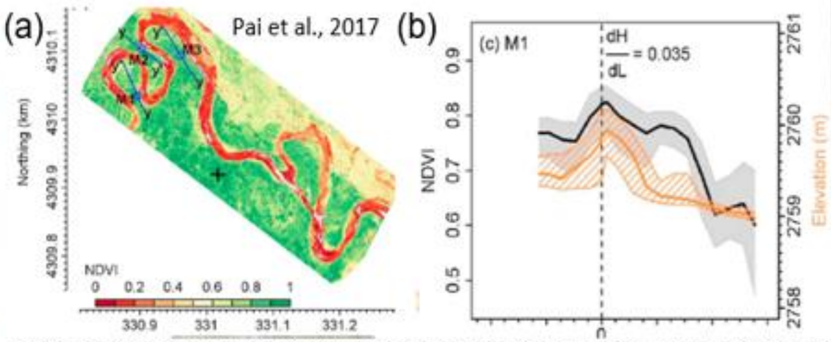
Details:

- Typically, multiple images are collected from an airborne or satellite platform with substantial overlap (i.e., >66%) and from multiple angles
- Data are processed using structure from motion-based software to derive orthomosaics ('ortho') and digital surface models
- Analysis such as Normalized Difference Vegetation Index (NDVI) act as a proxy for vegetation vigor

Cost Level: *Medium - High*

(Photograph courtesy of Cian Dawson, USGS)

Example of a small drone equipped with a multispectral camera. Similar data can also be collected from ground, aircraft, and satellite platforms depending on the combination of spatial coverage and spatial precision needed for the survey.



Multispectral imagery collected by a small drone along a stream reach in Colorado was used to map NDVI across meander bends with suspected preferential hyporheic exchange pathways (a). The change in NDVI and elevation across meander bend long axis was extracted to identify flowpaths as shown in (b).

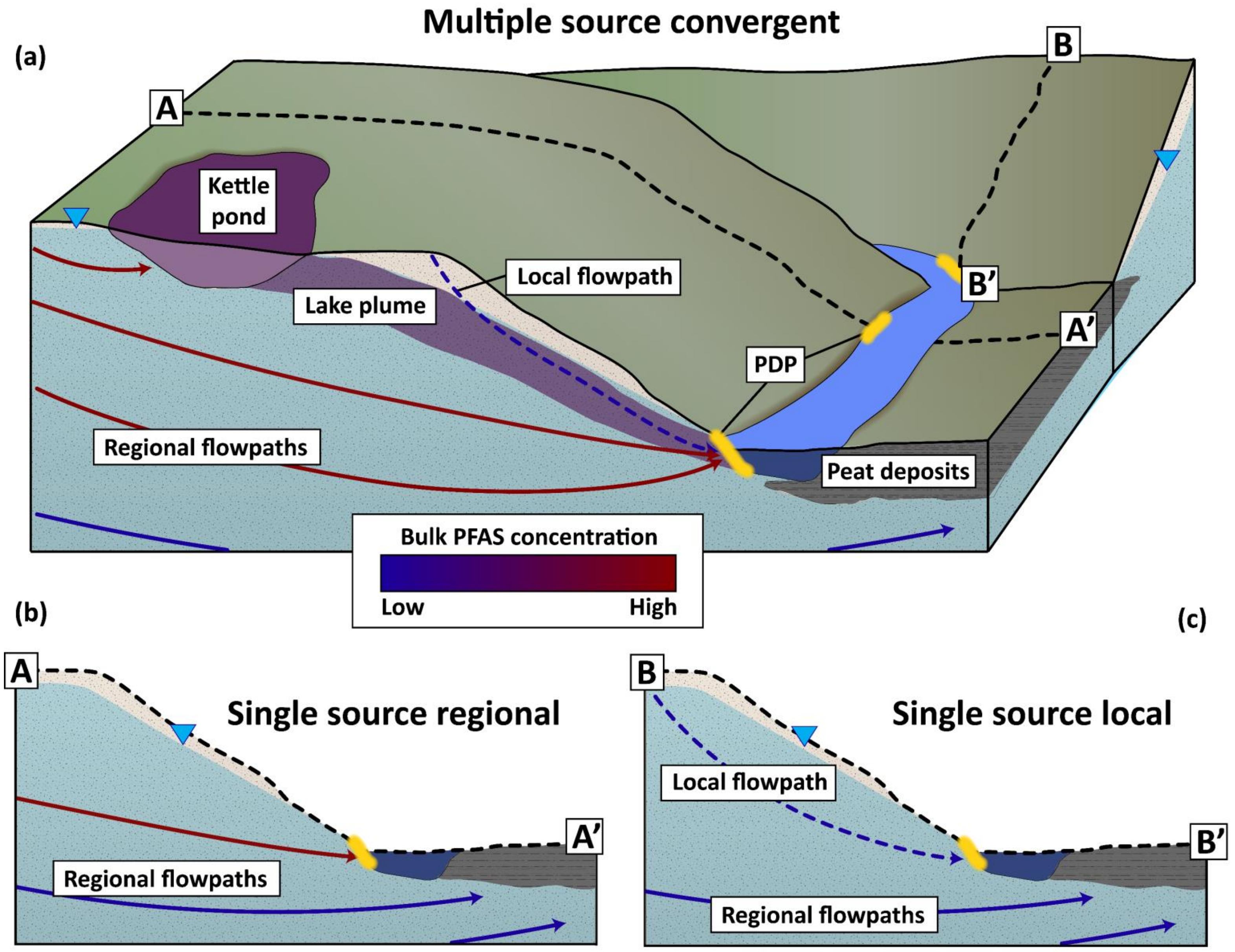
Multispectral data were collected by a small drone over the Palmyra Atoll National Wildlife Refuge to map vegetation type and stress that may be related to saltwater intrusion and preferential fresh groundwater discharge. These data are available at: https://doi.org/10.5066/F7Q81C0T

Finally, examples of several drone-based data types are shown along with published examples of their implementation.

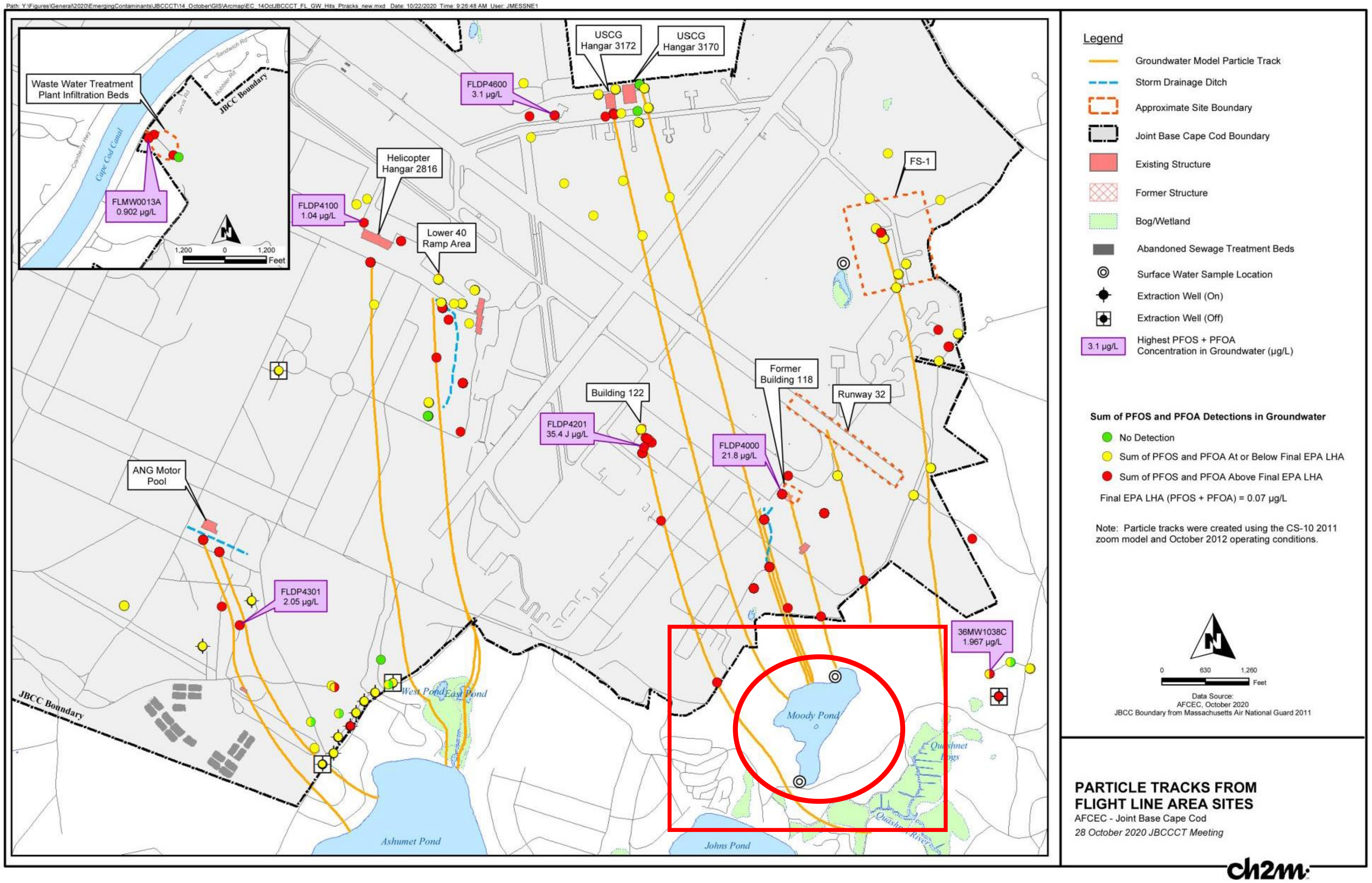
Chemical Hydrograph Separation | Injected Tracer Tests | Environmental Tracer Tests | GW Interface Tracer Tests | Thermal Imaging | Visible Light Ima

Ready | Accessibility: Investigate

Case Study Example: Cape Cod kettle lake, wetland, river system, all coupled via multiscale GW/SW exchange, with upland PFAS sources

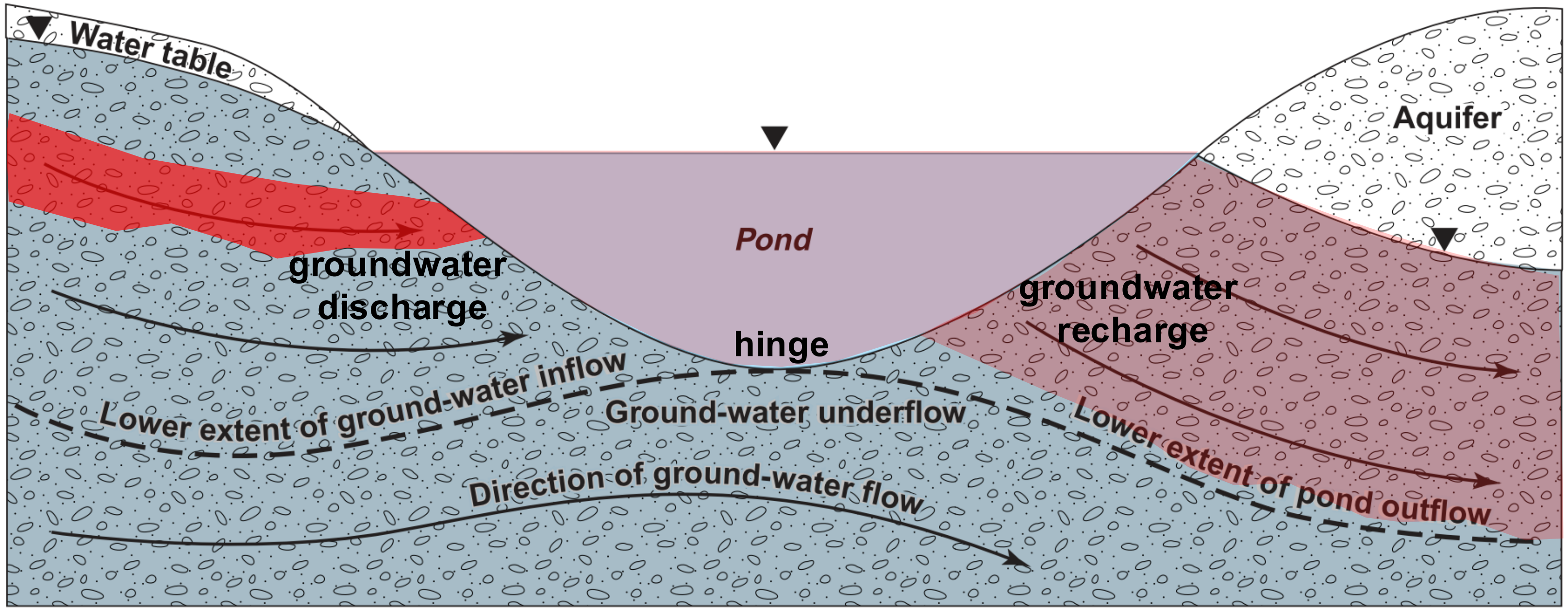


Known PFAS source areas across the Air Force Base to the North



PFAS exchanging with kettle lakes and later emerging at river seeps

Initial hypothesis: Preferential groundwater seepages down gradient from flow-through lakes will have bulk PFAS concentrations similar to lake water, rather than up gradient higher concentration source flowpaths. March 2022 sampling quickly indicated a much more complex 'source to seep' system….

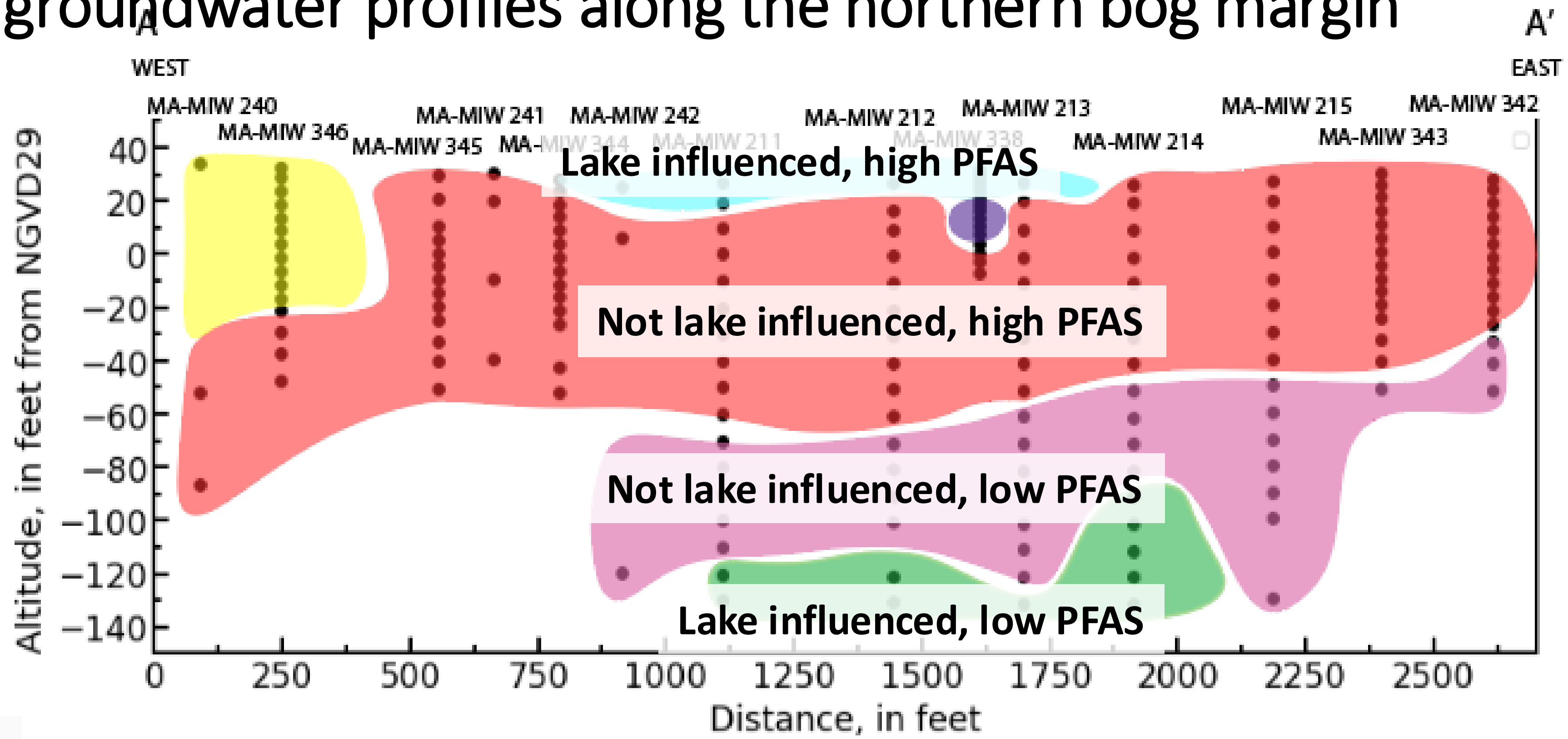


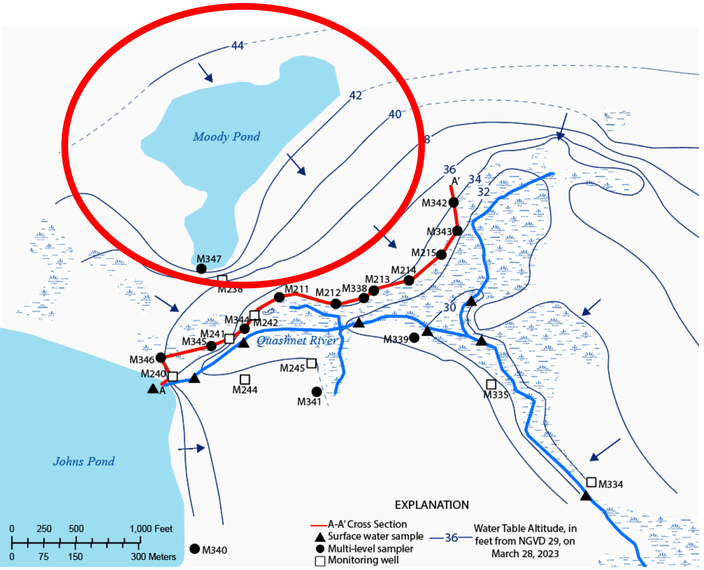
Modified from USGS Water-Resources Investigations Report 99-4174

High resolution groundwater profiles along the northern bog margin

Johns Pond

Air Force Base





Preliminary interpretation

MST input questions: mainly yes/no, related to the site and the study

#	Goals	
A	Identify zones of preferential (focused) GW exchange	Yes
B	Map geologic structure and other geologic attributes	Yes
C	Map thermal variability	Yes
D	Map high resolution topography	Yes
E	Map vegetation stress	No
F	Identify spatial variations in salinity (fluid conductivity) within the bed	Yes
G	Map bank seepage	Yes
H	Estimate gross GW/SW exchange gain/loss and other net changes for one or more sub reaches	Yes
I	Estimate hydraulic conductivity of bed material	Yes
J	Quantify GW/SW exchange (point measurement) flux through the bed	Yes
K	Long-term monitoring of exchange	Yes
L	Estimate rates of chemical reactions at groundwater interface	No
M	Estimate size of the hyporheic zone, water residence time, and rates of chemical reactions	Yes
N	Partition between hyporheic exchange and groundwater discharge fluxes across sediment bed	Yes

#	Project Site Parameters	
1	What is average depth of surface water in the area of data collection (m)?	<=1m
2	Are there currents?	Yes
3	Is strong upward flow thru the bed anticipated?	Yes
4	Is strong downward flow thru the bed anticipated?	No
5	Are there wind-driven waves?	No
6	Is there vegetation on the bottom?	No
7	Is the ground/bed armored or difficult to disturb?	No
8	Is multi-day deployment of instruments possible at the site?	Yes
9	What is the spatial scale of the area to be investigated?	Point to Reach
10	Can instruments be deployed by wading in the target area?	Yes
11	Can instruments be deployed by boat in the target area?	Yes
12	Does canopy/shading preclude GPS signal at the site?	No
13	Do local regulations (e.g. airfield nearby, etc.) preclude the use of a UAS at the site?	No
14	Do site conditions (e.g. overhead power lines, etc.) preclude the use of a UAS?	No
15	Is there cultural EM interference? (utilities, pipes, etc.)	No
16	Is there substantial gas within the bed?	No
17	What is the expected ground-water electrical conductivity (micro-S/cm)?	100
18	What is the expected surface-water electrical conductivity (micro-S/cm)?	100
19	What is the maximum GW/SW temperature contrast (degrees C)?	8

The MST output is based on the cross reference of study goals and project site parameters with the capabilities and challenges of 26 GW/SW exchange characterization methods.

MST output: Identification of suitable methods and contribution to goals

Fill in cells shaded aqua-blue (in column C). All other cells will be automatically updated.

#	Goals	
A	Identify zones of preferential (focused) GW exchange	Yes
B	Map geologic structure and other geologic attributes	Yes
C	Map thermal variability	Yes
D	Map high resolution topography	Yes
E	Map vegetation stress	No
F	Identify spatial variations in salinity (fluid conductivity) within the bed	Yes
G	Map bank seepage	Yes
H	Estimate gross GW/SW exchange gain/loss and other net changes for one or more sub reaches	Yes
I	Estimate hydraulic conductivity of bed material	Yes
J	Quantify GW/SW exchange (point measurement) flux through the bed	Yes
K	Long-term monitoring of exchange	Yes
L	Estimate rates of chemical reactions at groundwater interface	No
M	Estimate size of the hyporheic zone, water residence time, and rates of chemical reactions	Yes
N	Partition between hyporheic exchange and groundwater discharge fluxes across sediment bed	Yes

#	Project Site Parameters	
1	What is average depth of surface water in the area of data collection (m)?	<=1m
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15	Is there cultural EM interference? (utilities, pipes, etc.)	No
16	Is there substantial gas within the bed?	No
17	What is the expected ground-water electrical conductivity (micro-S/cm)?	100
18	What is the expected surface-water electrical conductivity (micro-S/cm)?	100
19	What is the maximum GW/SW temperature contrast (degrees C)?	8

Return to Select Scenario Setting

✓ Indicates method is potentially suitable
✗ Indicates method is not likely suitable
● Indicates method is likely appropriate/effective
○ Indicates method is not likely appropriate/effective

Note: If cell is Yellow then there is a qualifier comme

Methods	Suitable	Appropriate for Goals	Effectiveness at Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	Method made infeas 1	2
Ground-based Geophysical Methods																			
FDEM - Electromagnetic Induction (Frequency Domain)	✓	●	●		✓				✓	✓									
TDEM - Electromagnetic Induction (Time Domain)	✓	●	●		✓				✓	✓									
Direct Current (DC) Electrical Resistivity (ER)	✓	●	●	✓	✓				✓	✓						✓			
IP - Induced Polarization (Time Domain)	✓	●	●		✓														
SIP - Spectral Induced Polarization	✓	●	●		✓														
SP - Self- or Spontaneous- Potential	✓	●	●	✓						✓	✓								
GPR - Ground Penetrating Radar	✓	●	●		✓														
Seismic Refraction	✓	●	●		✓														
Waterborne Geophysical Methods																			
FDEM (Floating) - Electromagnetic Induction (Frequency Domain)	✓	●	●	✓	✓				✓							✓			
TDEM (Floating) - Electromagnetic Induction (Time Domain)	✓	●	●	✓	✓				✓							✓			
GPR (Floating) - Ground Penetrating Radar	✓	●	●	✓	✓														
CRP - Continuous Resistivity Profiling	✓	●	●	✓	✓				✓							✓			
IP - Induced Polarization (Time Domain)	✗	●	○		✓													✗	
SIP - Spectral Induced Polarization	✗	●	○		✓													✗	
SP - Self- or Spontaneous- Potential	✓	●	●	✓							✓								
CSP - Continuous Seismic Profiling	✗	●	○		✓													✗	
Temperature Methods																			
Paired Air and Water Temperature Logging	✓	●	●	✓		✓								✓					
Vertical Bed Temperature Profiling	✓	●	●	✓		✓				✓	✓	✓	✓	✓		✓	✓		
Spatial Bed Temperature Mapping	✓	●	●	✓		✓					✓		✓				✓		
FODTS - Fiber Optic Distributed Temperature Sensing	✓	●	●	✓		✓										✓	✓		
Hydraulic Methods																			
Seepage Meters	✓	●	●	✓					✓		✓	✓	✓						
Differential Stream Gaging/Seepage Runs	✓	●	●	✓							✓								
Darcy Fluxes	✓	●	●	✓						✓	✓	✓	✓						
Physical Hydrograph Separation	✓	●	●								✓			✓					
Chemical Hydrograph Separation	✓	●	●								✓			✓					
Chemical Tests																			
Injected Tracer Tests	✓	●	●	✓							✓		✓			✓	✓		
Environmental Tracer Tests	✓	●	●	✓					✓		✓		✓	✓		✓	✓		
Groundwater Interface Tracer Tests	✓	●	●	✓					✓				✓			✓	✓		
Remote Sensing Methods																			
Thermal Imaging	✓	●	●	✓		✓				✓									
Visible Light Imaging	✓	●	●		✓		✓			✓									
Multi- and Hyperspectral Imaging	✓	●	●	✓	✓		✓			✓									
LiDAR	✓	●	●		✓		✓												

#	Method Qualifier Comments for Goals
	Use of DCER necessitates waterproof cables and direct installation of electrodes into streambed.

Select Scenario Setting | Index | Stream or River GW-SW Matrix | Lake or Wetland GW-SW Matrix | Estuary or Coastal GW-SW Matrix | Method References | Resistivity-Conductivity Values | FDEM

MST output: Identification of suitable methods

Return to Select Scenario Setting

✓ Indicates method is potentially

✗ Indicates method is not likely su

Methods	Suitable	Appropriate for Goals	Effectiveness at Site
Ground-based Geophysical Methods			
FDEM - Electromagnetic Induction (Frequency Domain)	✓	●	●
TDEM - Electromagnetic Induction (Time Domain)	✓	●	●
Direct Current (DC) Electrical Resistivity (ER)	✓	●	●
IP - Induced Polarization (Time Domain)	✓	●	●
SIP - Spectral Induced Polarization	✓	●	●
SP - Self- or Spontaneous- Potential	✓	●	●
GPR - Ground Penetrating Radar	✓	●	●
Seismic Refraction	✓	●	●
Waterborne Geophysical Methods			
FDEM (Floating) - Electromagnetic Induction (Frequency Domain)	✓	●	●
TDEM (Floating) - Electromagnetic Induction (Time Domain)	✓	●	●
GPR (Floating) - Ground Penetrating Radar	✓	●	●
CRP - Continuous Resistivity Profiling	✓	●	●
IP - Induced Polarization (Time Domain)	✗	●	○
SIP - Spectral Induced Polarization	✗	●	○
SP - Self- or Spontaneous- Potential	✓	●	●
CSP - Continuous Seismic Profiling	✗	●	○
Temperature Methods			
Paired Air and Water Temperature Logging	✓	●	●
Vertical Bed Temperature Profiling	✓	●	●
Spatial Bed Temperature Mapping	✓	●	●
FODTS - Fiber Optic Distributed Temperature Sensing	✓	●	●
Hydraulic Methods			
Seepage Meters	✓	●	●
Differential Stream Gaging/Seepage Runs	✓	●	●
Darcy Fluxes	✓	●	●
Physical Hydrograph Separation	✓	●	●
Chemical Hydrograph Separation	✓	●	●
Chemical Tests			
Injected Tracer Tests	✓	●	●
Environmental Tracer Tests	✓	●	●
Groundwater Interface Tracer Tests	✓	●	●
Remote Sensing Methods			
Thermal Imaging	✓	●	●
Visible Light Imaging	✓	●	●
Multi- and Hyperspectral Imaging	✓	●	●
LiDAR	✓	●	●

Estuary or Coastal GW-SW Matrix

Clear output in 'radio button' format. For this example, all methods may be appropriate for the study goals, but a few are ruled out due to the site characteristics. Though a 'green check' at this stage is no guarantee of success. In reality, EM methods at the site, while the instruments functioned well, did not yield useful results as the electrical contrast between GW and SW was less than initially expected.

MST output: Identification of suitable methods

Method contributes to goal:														Method made infeasible by site parameter:							
A	B	C	D	E	F	G	H	I	J	K	L	M	N	1	2	3	4	5	6	7	8
	✓				✓	✓															
	✓				✓	✓															
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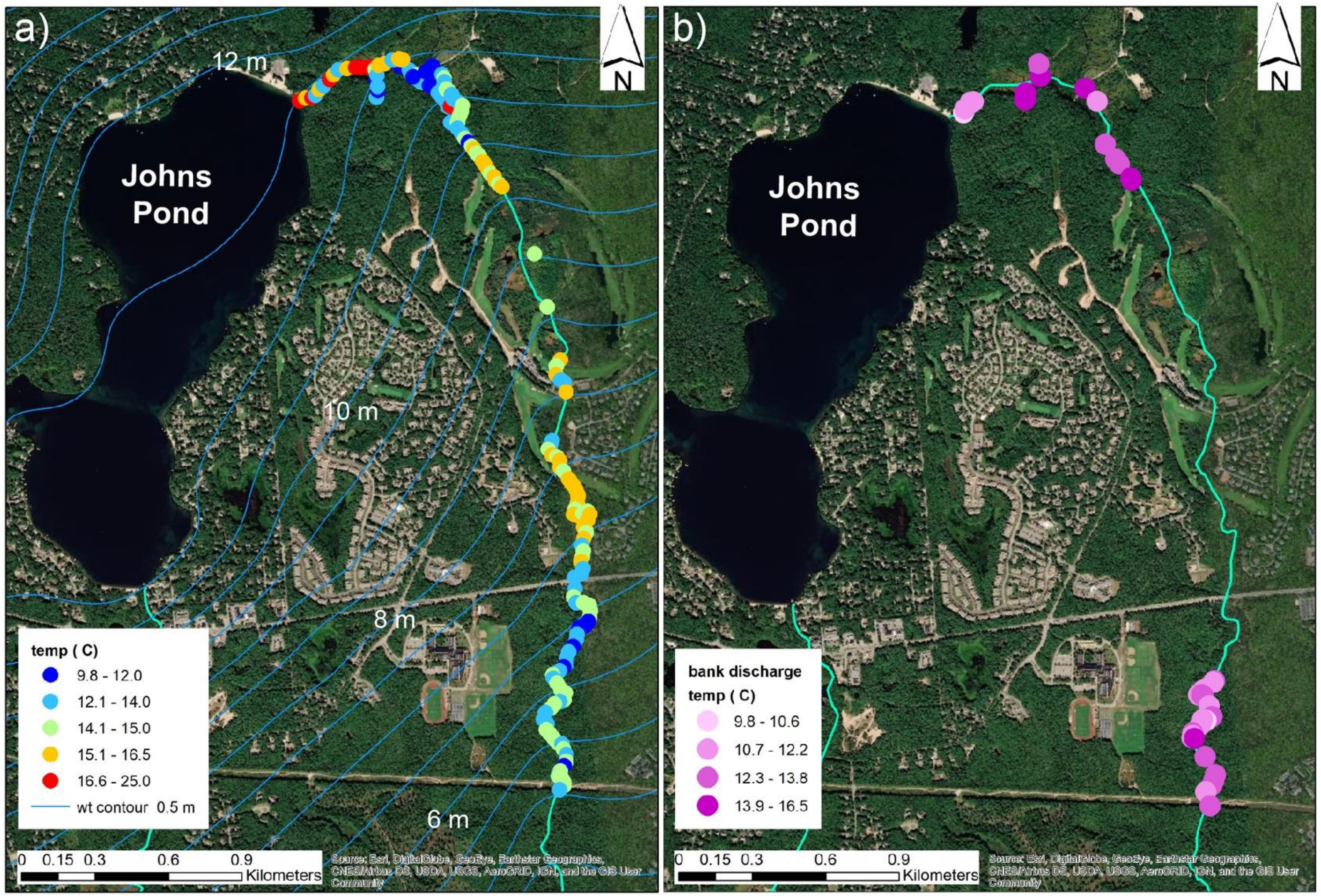
	✓		✓																		

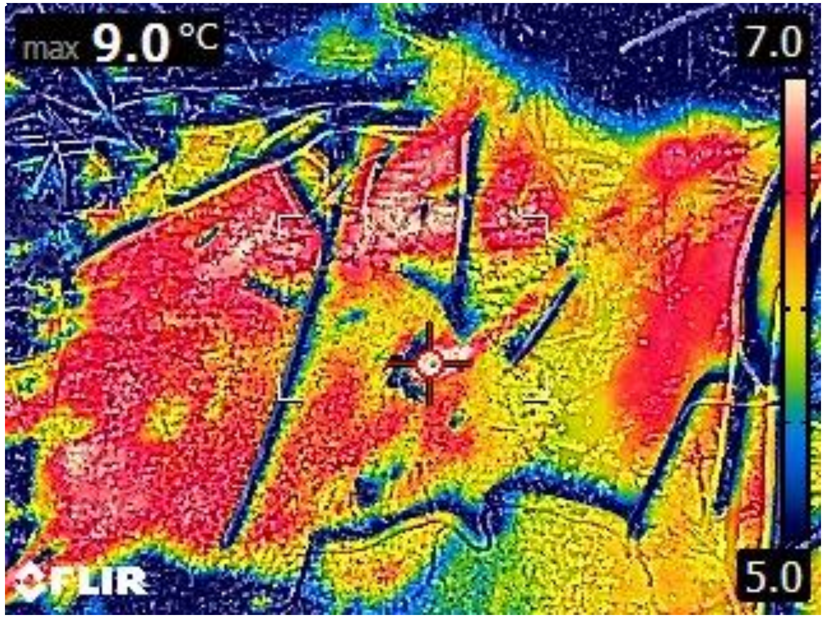
A matrix of goals and site parameters shows which specific methods are applicable to specific goals (with 'qualifiers' highlighted in yellow), and what site characteristics resulted in methods being ruled out. This level of detail can help with efficient project planning and provide justification for the possible need to pivot between methods.

Demonstration of data collected across methods at the field site: thermal



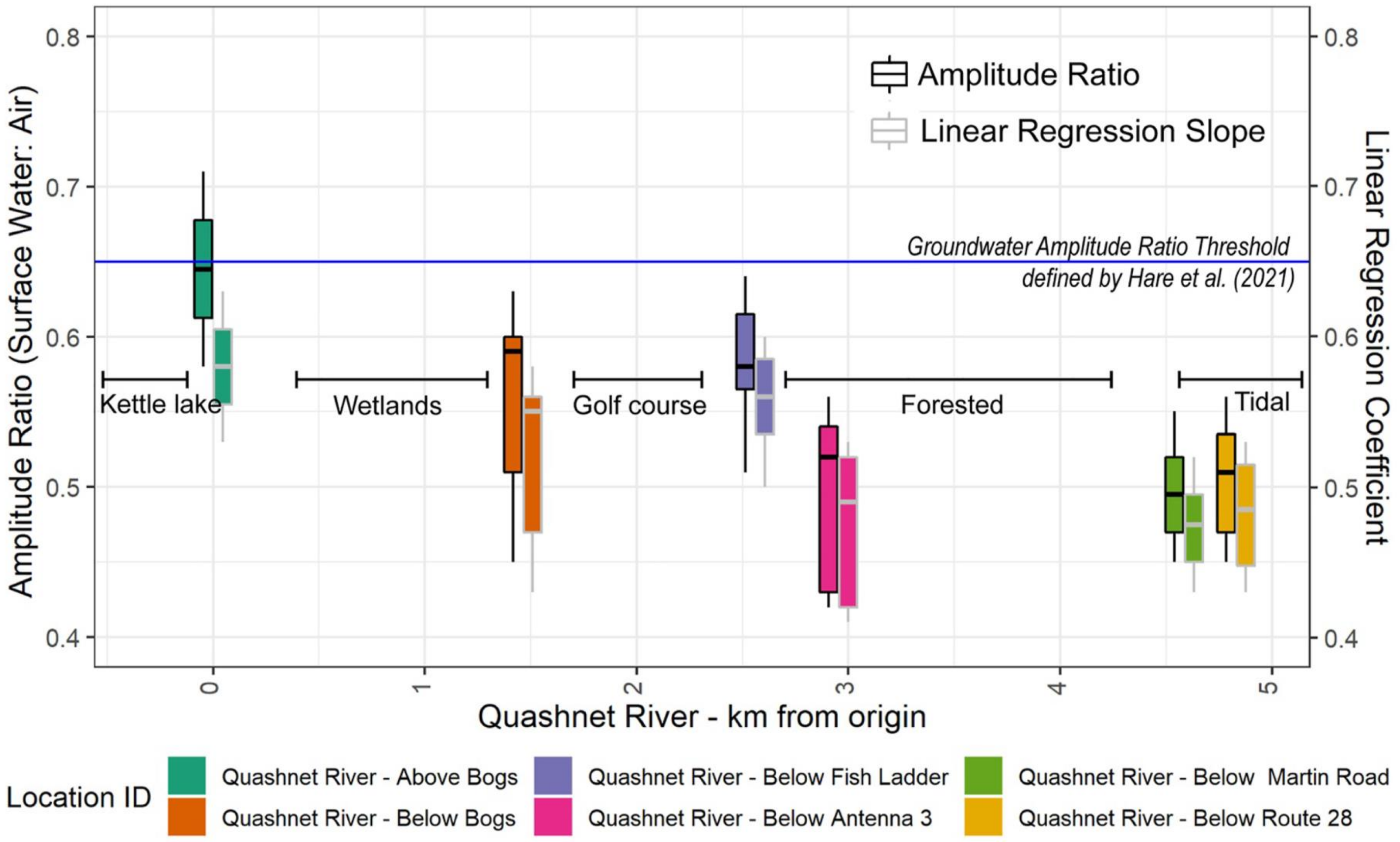
Snapshot-in-time a) direct bed temperature measurements and b) handheld thermal imaging both indicate clusters of discrete groundwater seepages in the wetland area to the north and in a natural valley section to the south, but little groundwater connectivity within a heavily modified golf course area.

Handheld thermal infrared pinpoints seeps



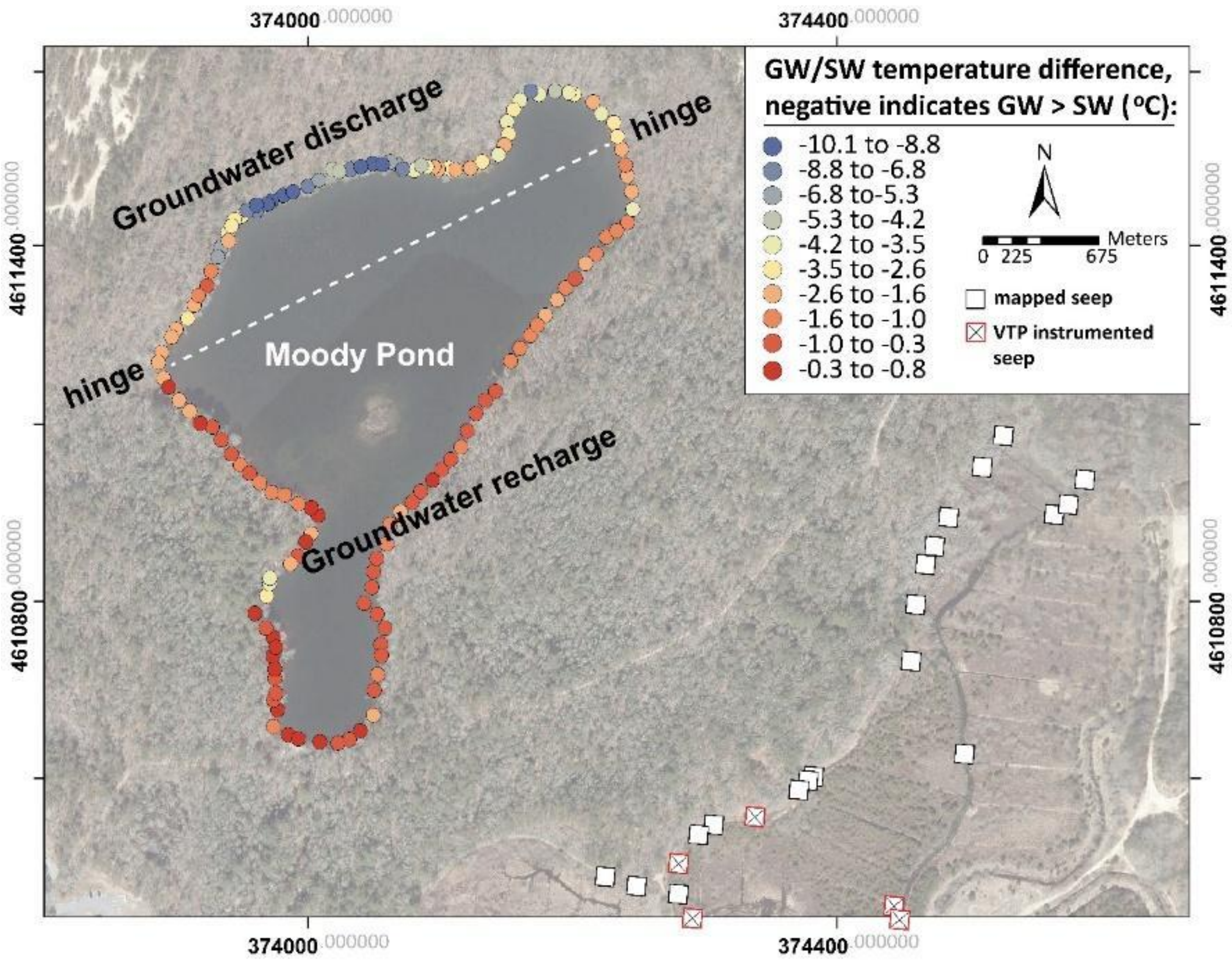
Direct temperature measurements and 'secondary' indicators also important (water cress, Fe deposition, sand boils)

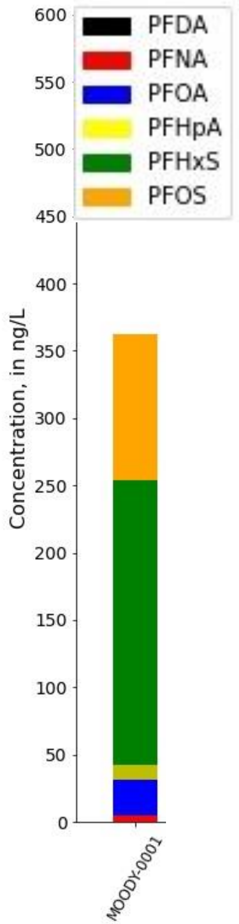
Paired air-water annual temperature signals and 'thermal sensitivity'



Air-water temperature relationships, based on at least several months of time series data at single locations, were used to map groundwater connected reaches at the km+ scale across seasons. The analysis metrics indicated strong groundwater connectivity along the river, focused to the wetland and natural valley areas.

Direct bed temperature measurements in the upgradient kettle lake

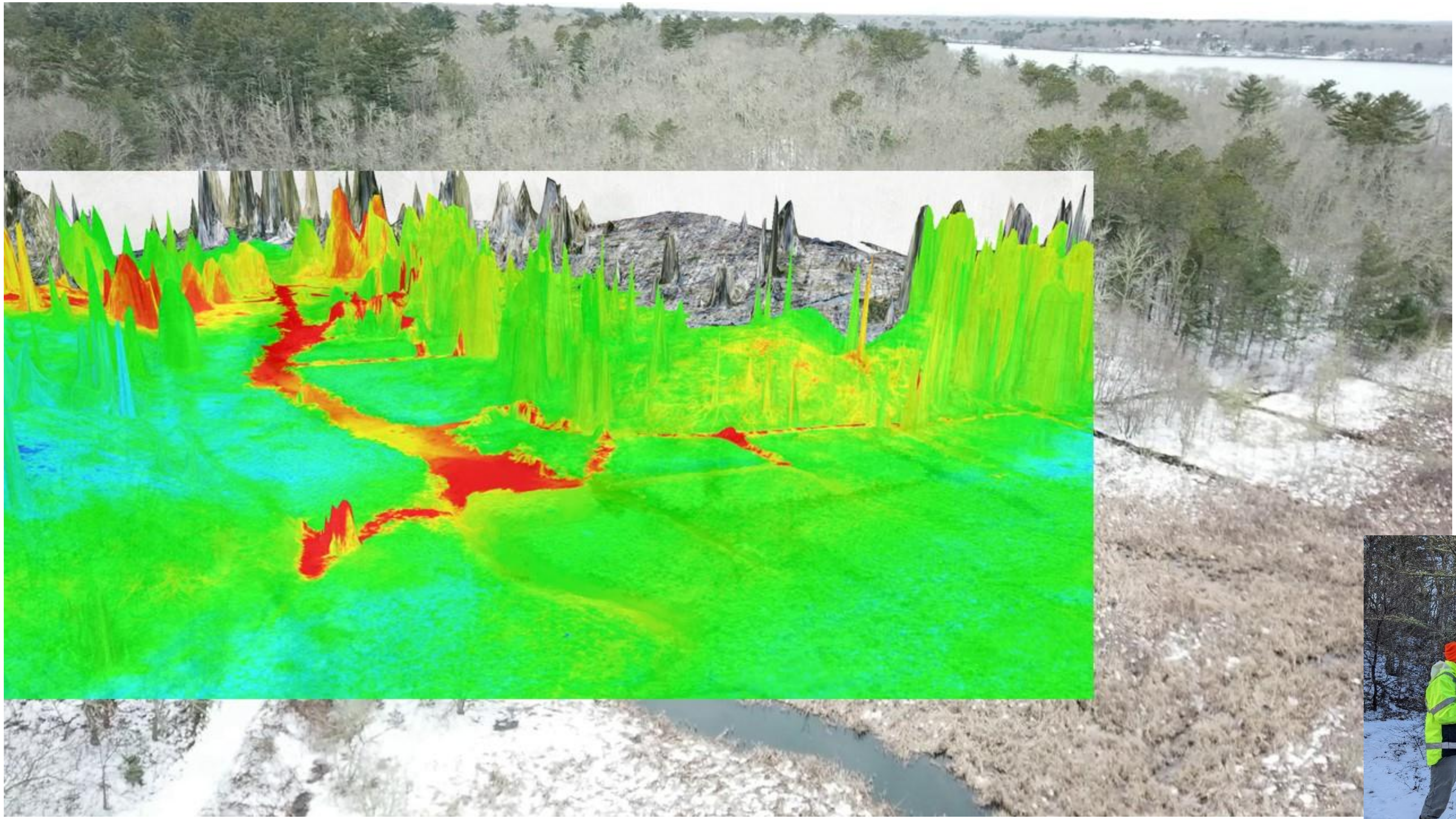




Snapshots of direct lakebed temperature collected along the shoreline were used to infer inflow and outflow regions in the groundwater flow-through kettle lake and guide PFAS sampling.

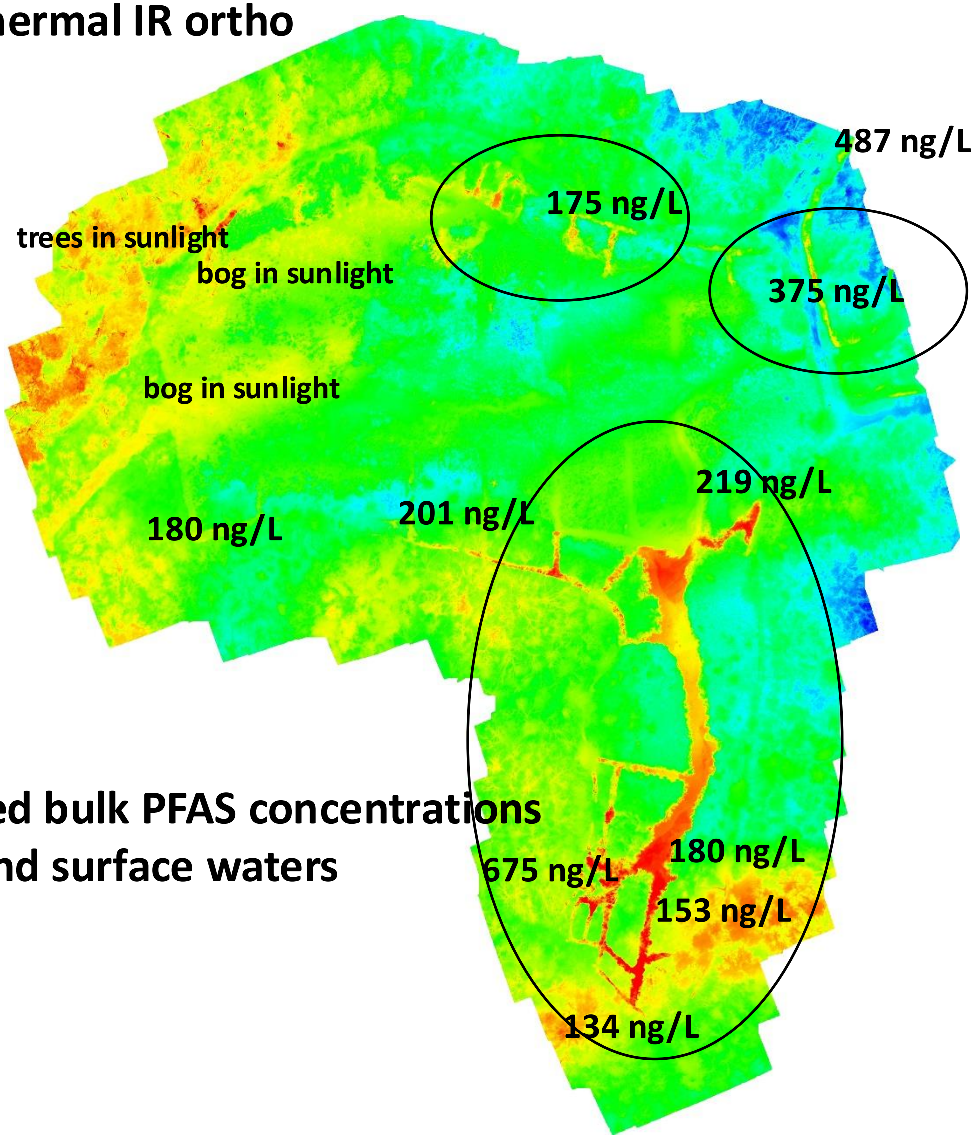
Rey et al. in

Thermal and terrain mapping with drones



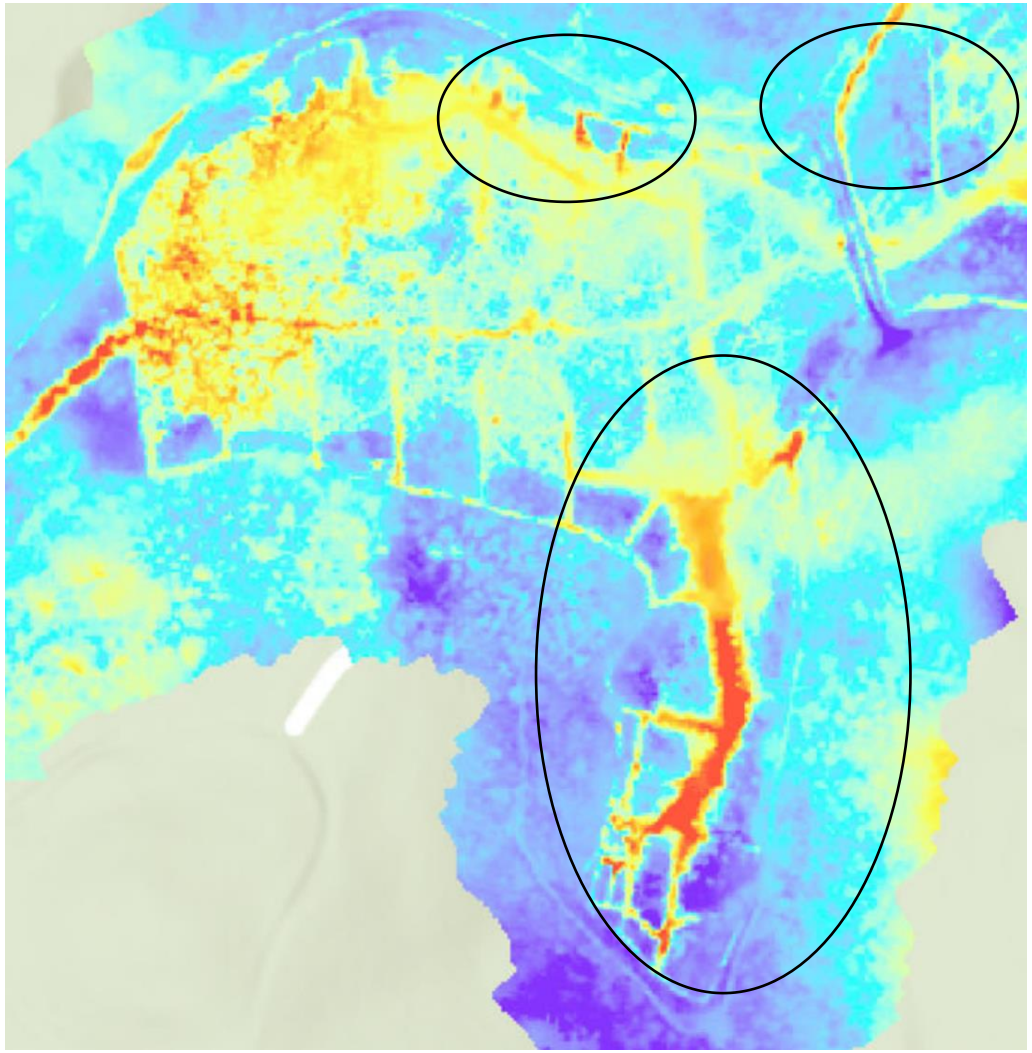
Thermal mapping with drones over time, used to guide sampling

Winter 2022 drone thermal IR ortho



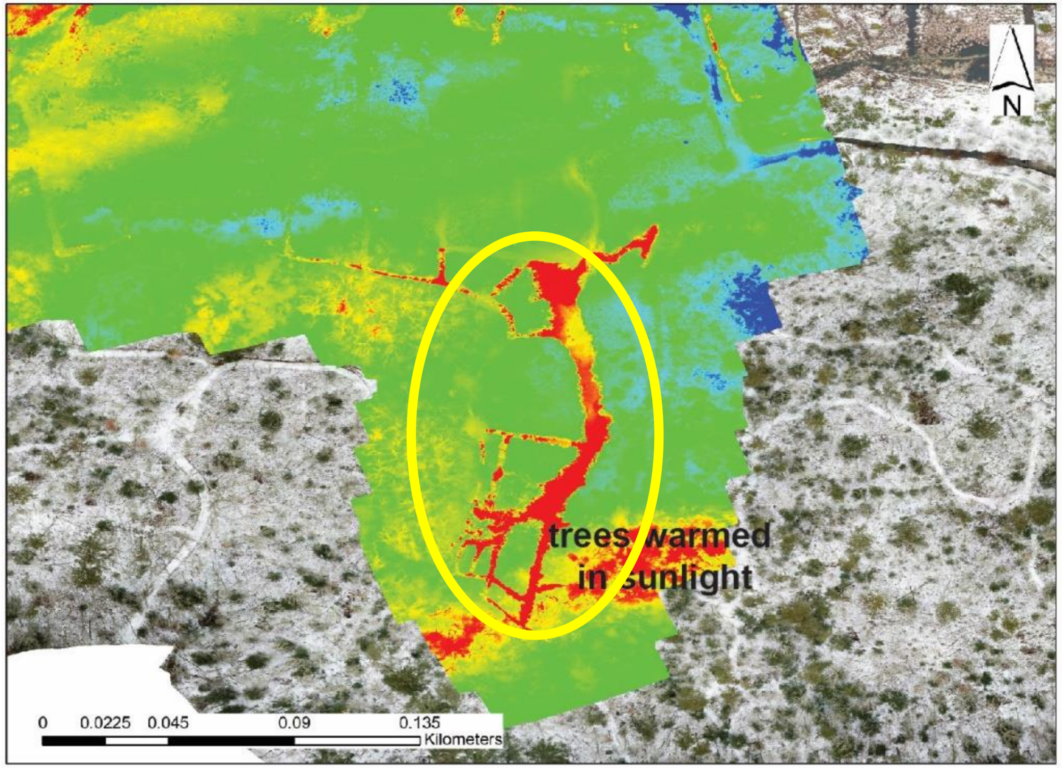
March 2022 measured bulk PFAS concentrations at seeps and surface waters

Winter 2019 drone thermal IR ortho

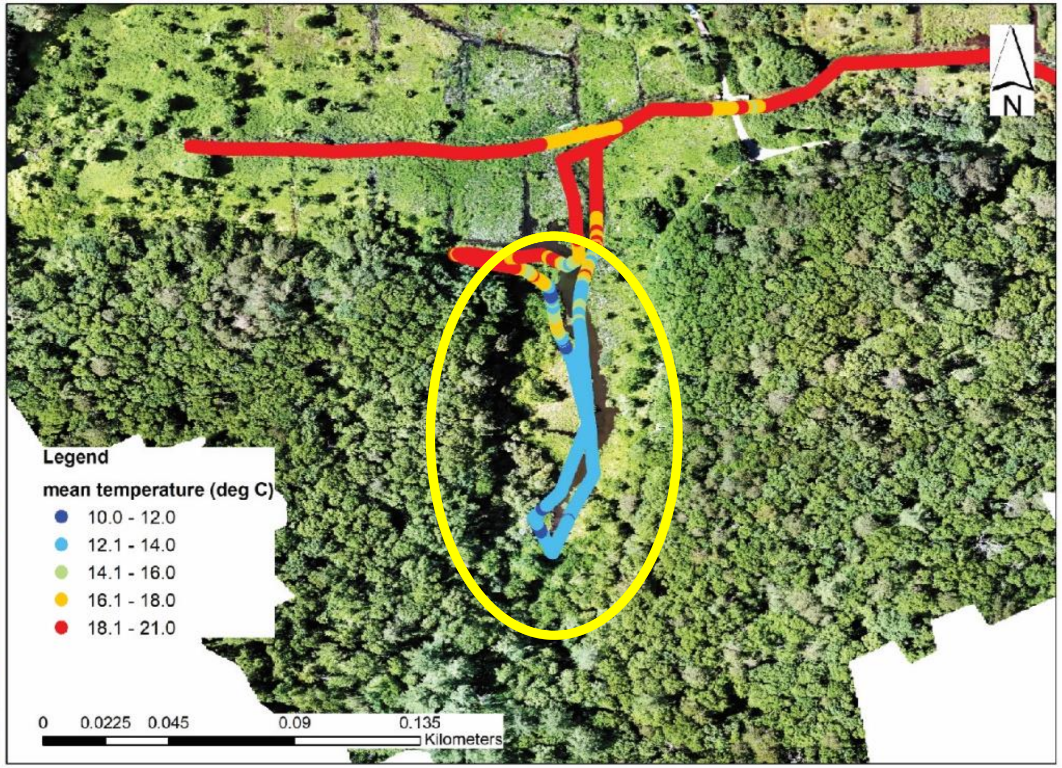


Preliminary data

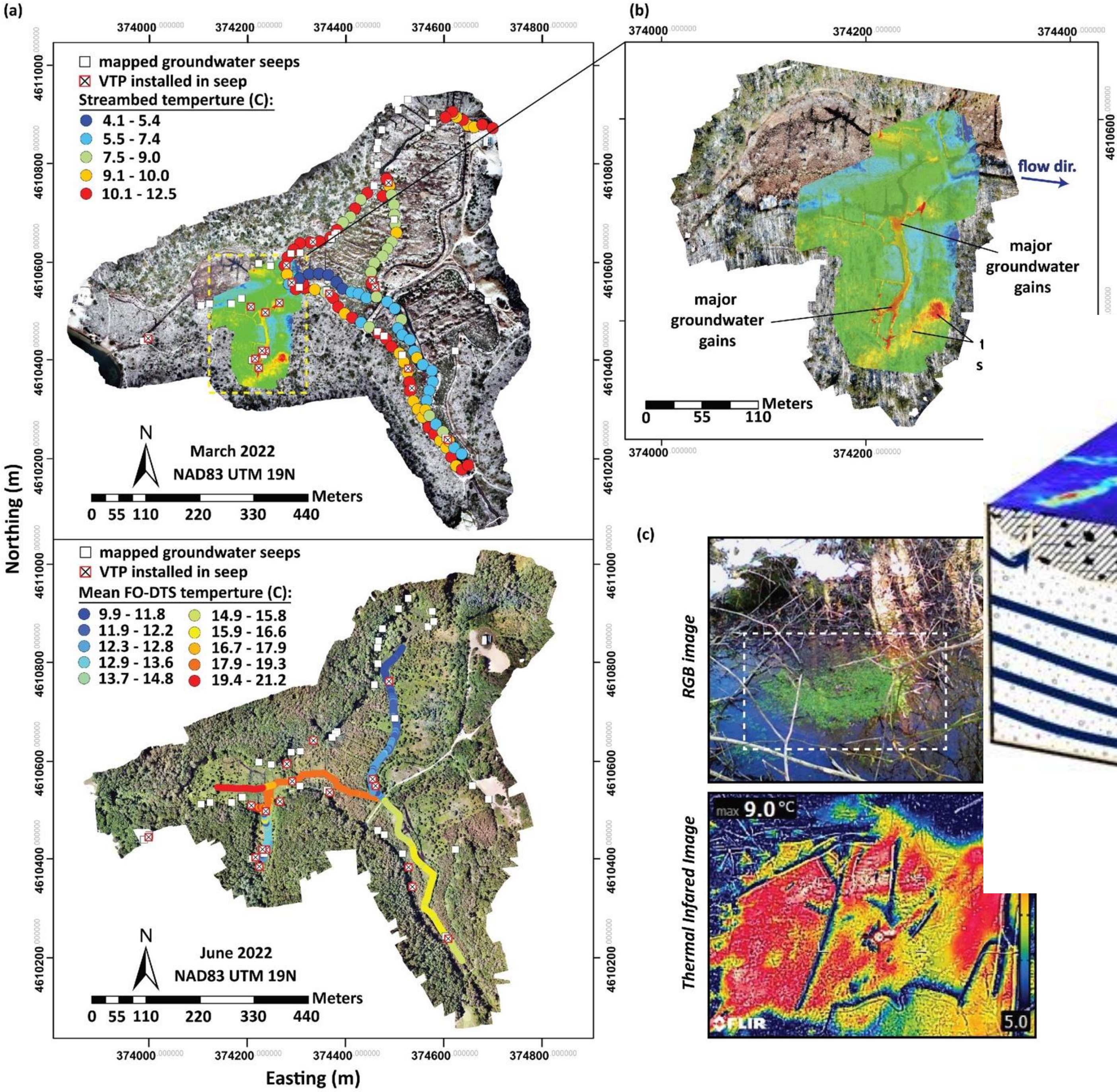
Combined the drone infrared data with fiber-optic distributed temperature sensing to pinpoint areas to sample at the sub-m scale



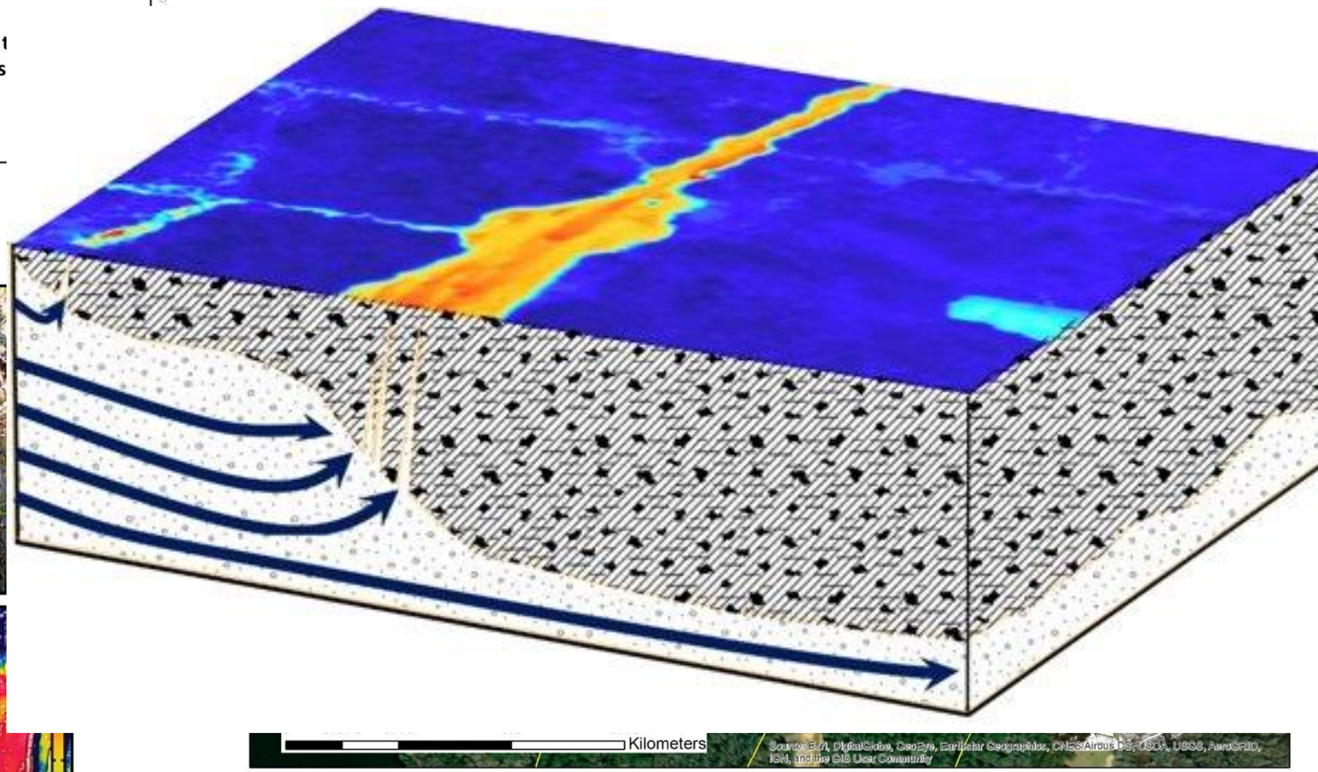
March drone infrared data of extensive warm groundwater discharge in winter, complicated by early AM sunlight on trees.



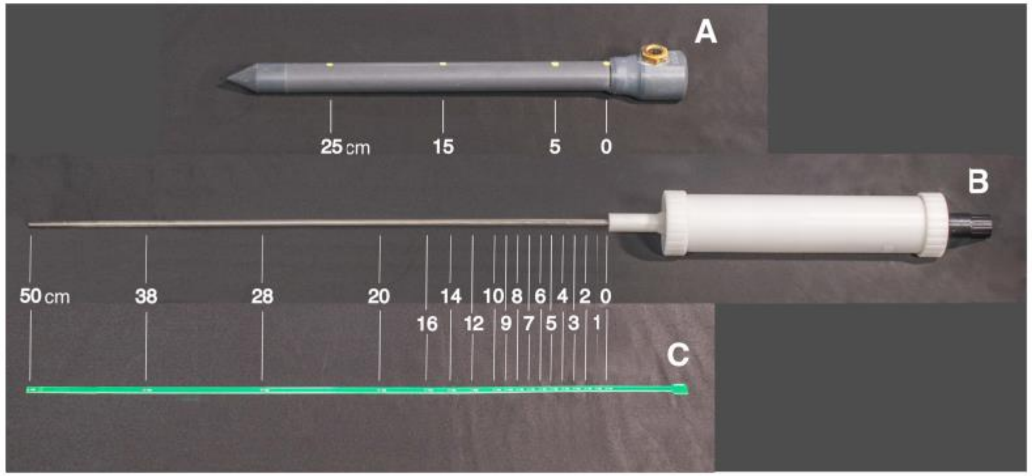
June fiber-optic temperature data of extensive cool groundwater discharge, with embedded coldest anomalies, directing the chemical sampling and in-situ flux measurements.

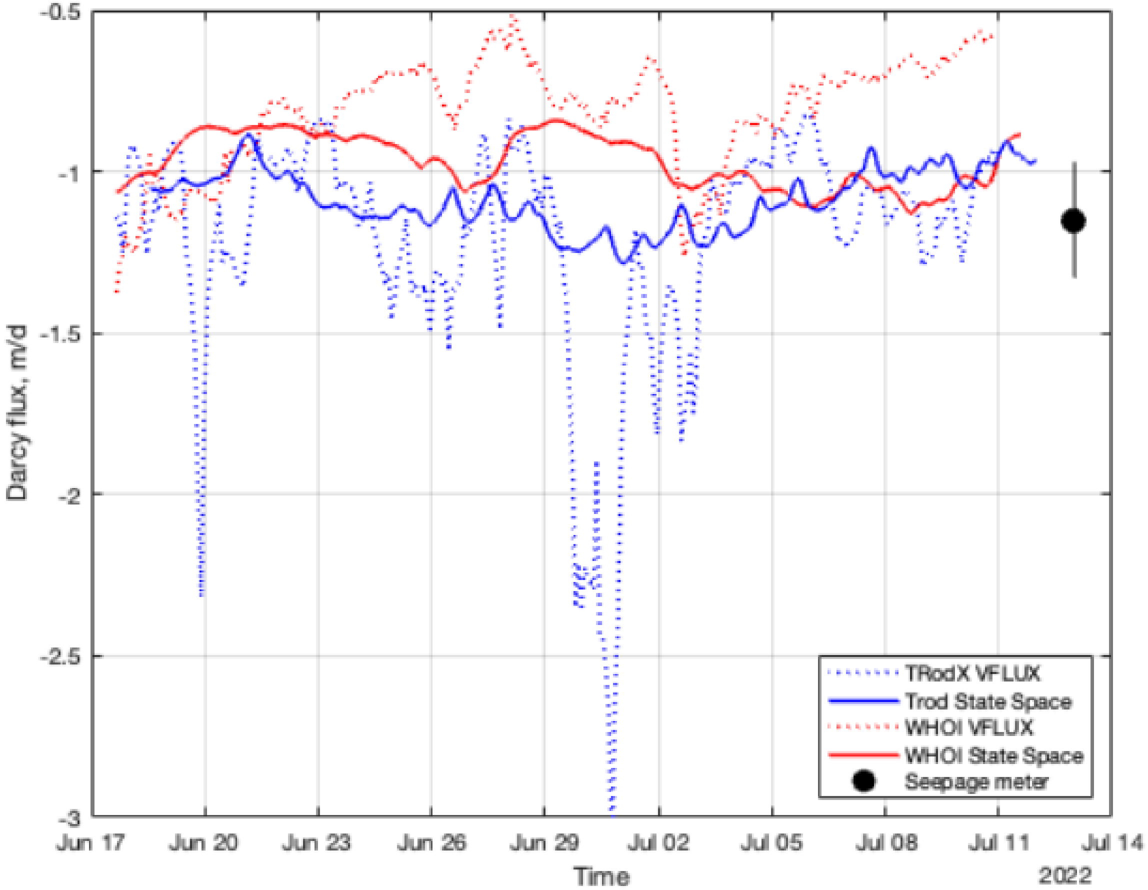


Heat tracing methods yield interpreted map of preferential groundwater seeps

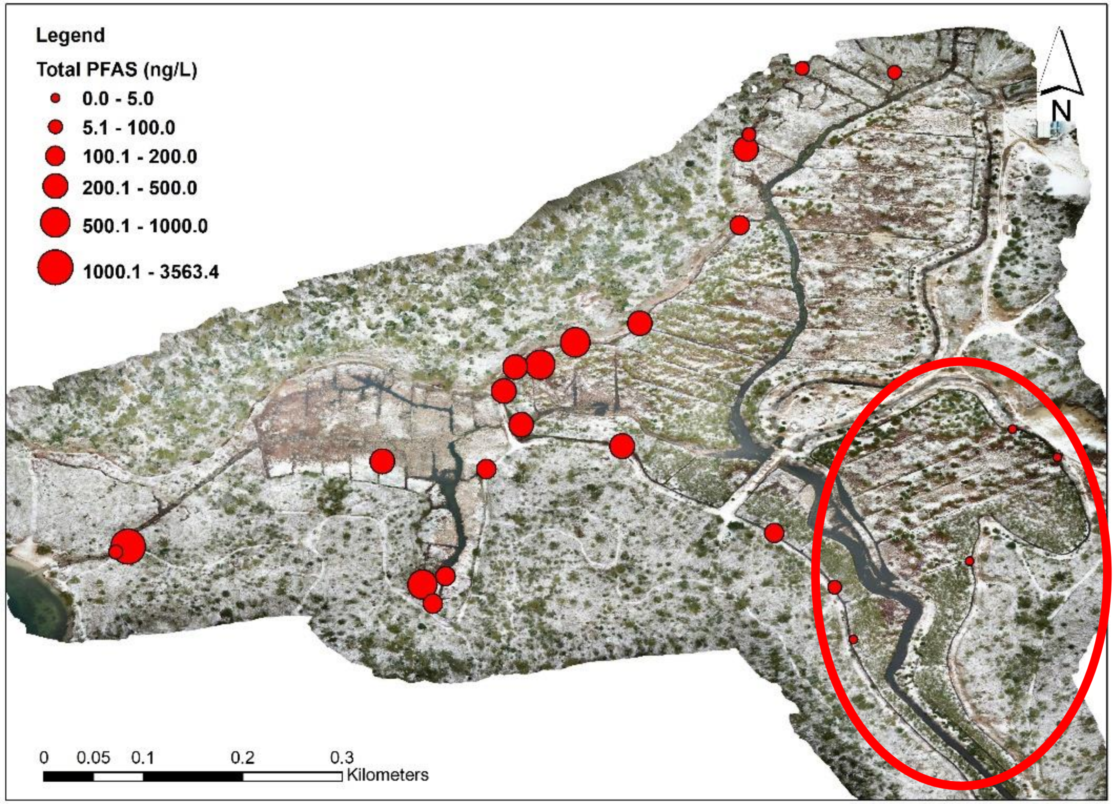


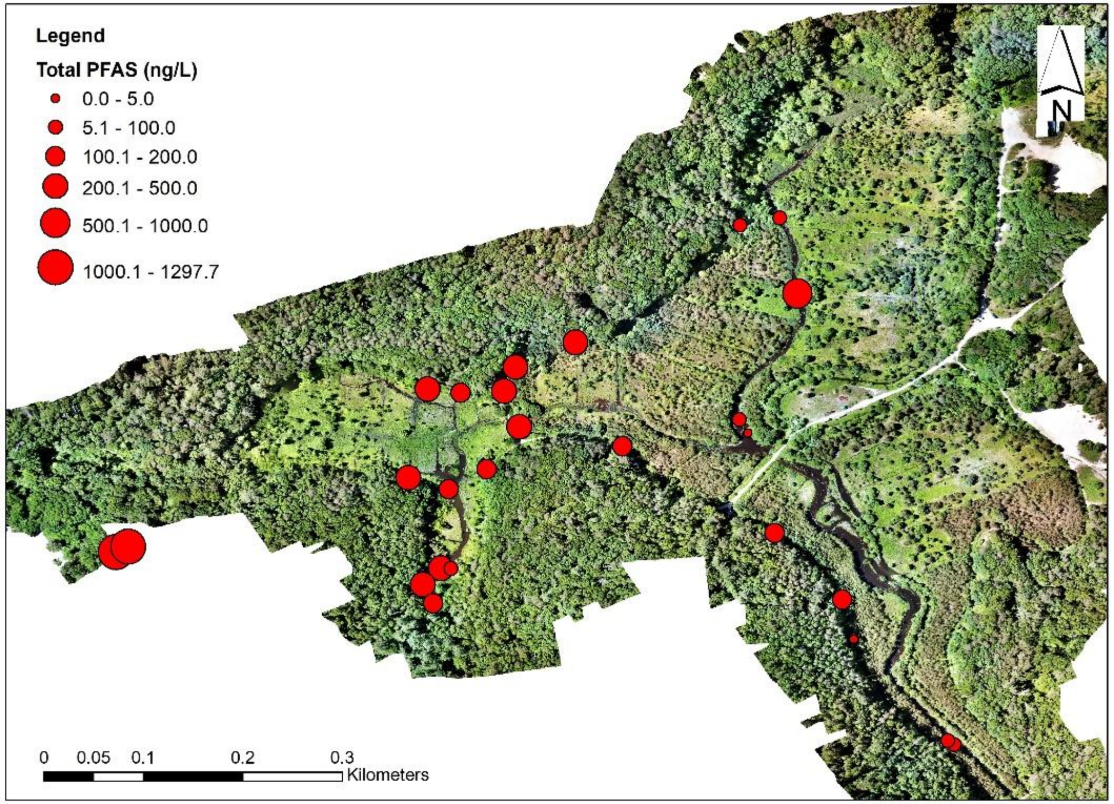
Estimating vertical discharge flux at the seep locations





Putting PFAS concentrations and GW/SW exchange flux together

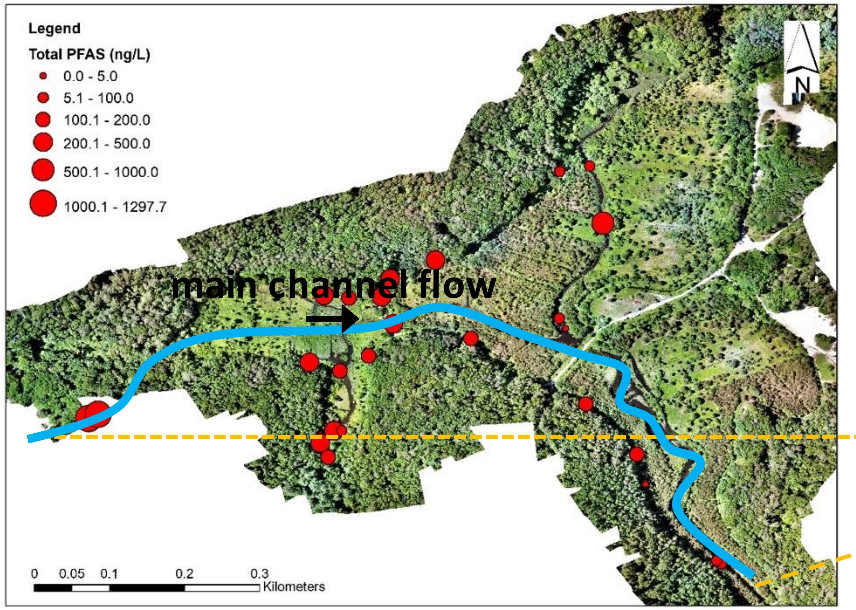


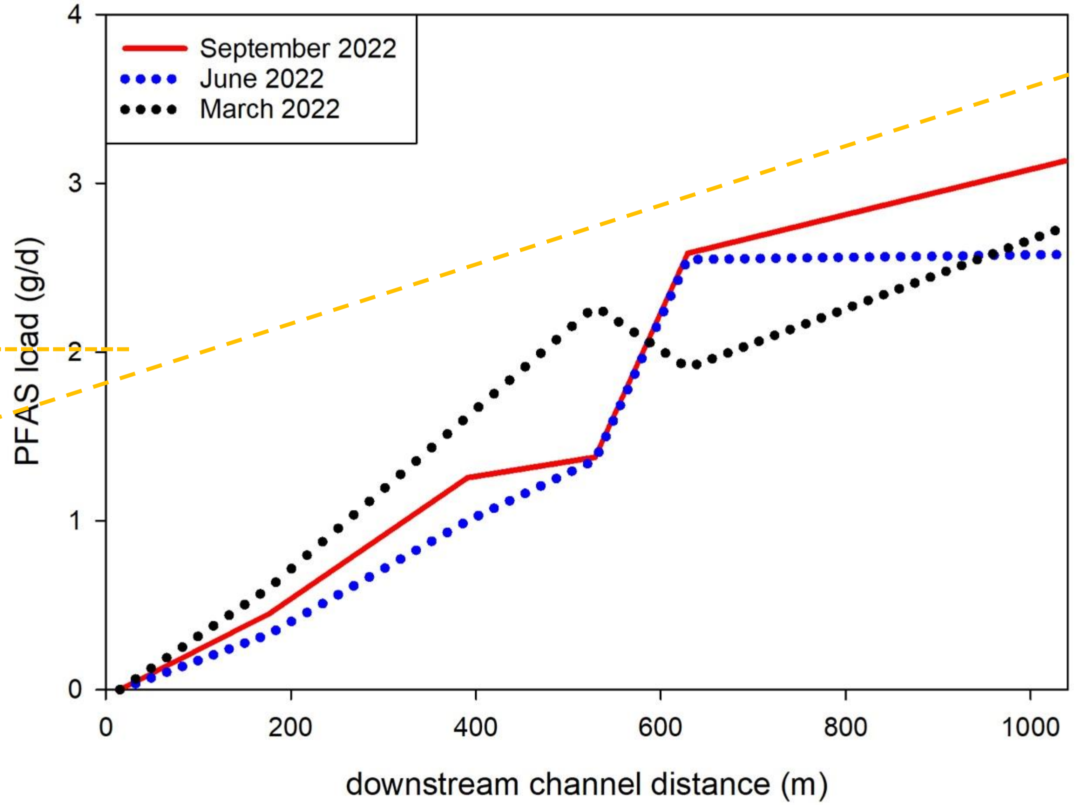


Evidence of local hillslope groundwater discharge with little to no PFAS, down gradient of the Base.

Although individual seeps show dynamic temporal PFAS fluxes, net PFAS loading to the river similar from winter to fall, 2022

Johns Pond outflow →





Correct for pond outflow PFAS loading

Stream disconnected from pond by fall following summer drought

Similar net loading of total PFAS from groundwater to main channel across seasons

GW/SW Method Selection Tool

by Steven A. Hammett (USGS contractor); Frederick D. Day-Lewis (PNNL, corresponding author); Brett Trottier (USGS).

Corresponding Article Citation: "GW/SW-MST: A Groundwater/Surface-Water Method Selection Tool" by Hammett, Steven; Day-Lewis, Frederick; Trottier, Brett; Barlow, Paul; Briggs, Martin; Delin, Geoffrey; Harvey, Judson; Johnson, Carole; Lane Jr., John; Rosenberry, Donald; Werkema, Dale

Contact Info: USGS Hydrogeophysics Branch, hgb_help@usgs.gov

Last Updated: 1/27/2022 This program was designed to run in Microsoft Excel 2013 or later Excel versions.

Summary - The Groundwater/Surface-Water Method Selection Tool (GW/SW-MST) is designed to assist project scientists, and engineers in selecting data collection methods that (1) satisfy study goals, and (2) are feasible for application at a given site, based on site characteristics as entered by the user. The GW-SW MST uses a spreadsheet-based interface developed in MS Excel 2013.

Target Audience - The target audience for the Groundwater - Surface Water Method Selection Tool (GW/SW -MST) is the working technical professional with varied hydrological experience in performing studies of the interaction between groundwater and surface water through the exchange of water and chemicals.

Stream or River GW-SW Matrix | Lake or Wetland GW-SW Matrix | Estuary or Coastal GW-SW Matrix

that when making tool selections you read the manuals or consult the vendors for the range of operation for each tool. The tools shown in the appendix are for descriptive purposes only and do not constitute an endorsement of any particular brand or tool.

streamflow measurements. From Rosenberry, D.O., and LaBaugh, J.W., 2008. Field techniques for estimating water fluxes between surface water and ground water. U.S. Geological Survey Techniques and Methods 4-D2, 128 p.

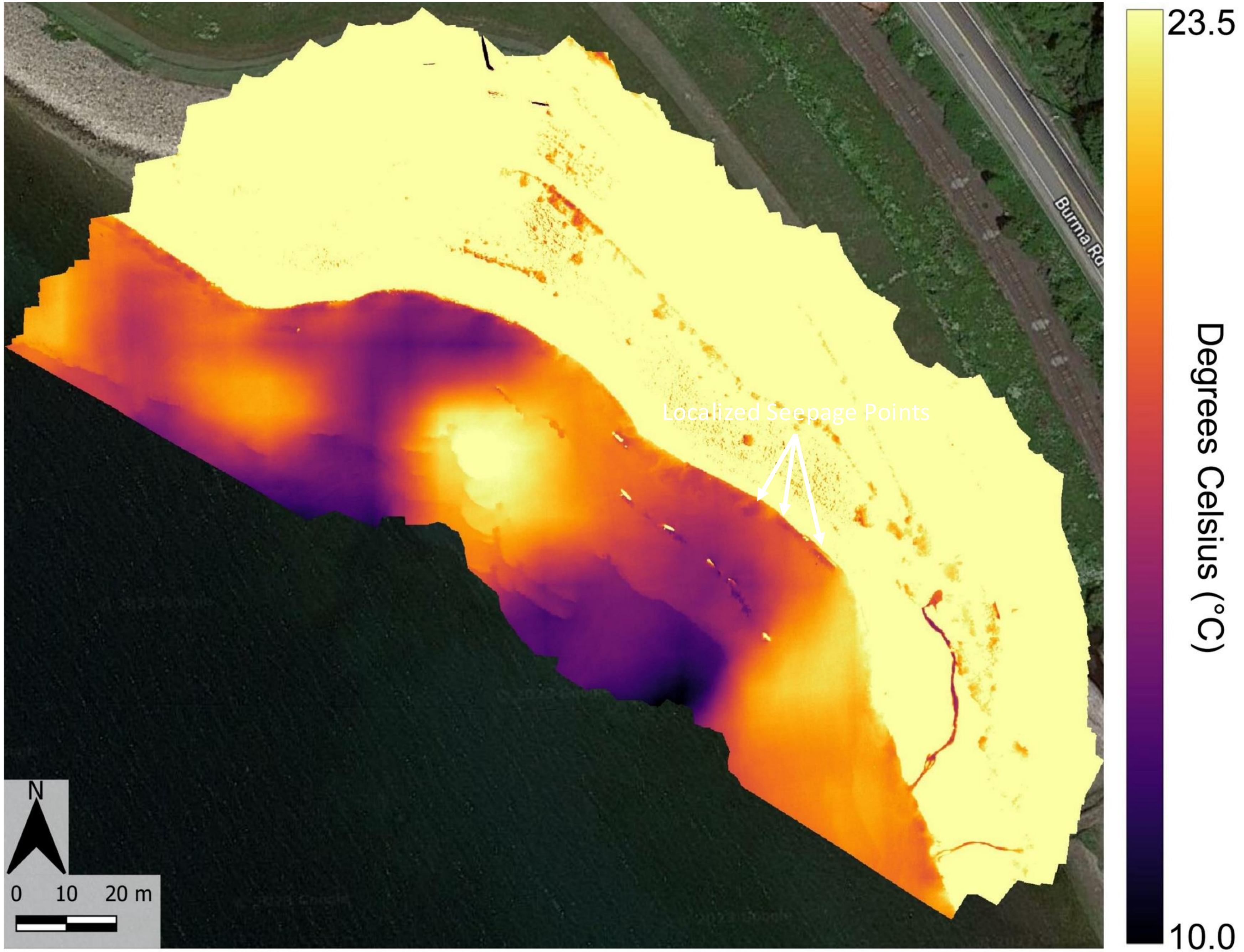
Acknowledgements - Development of this tool was supported by the U.S. Geological Survey (USGS) Toxic Substances Hydrology Program, and Water Availability and Use Science Program, and the U.S. Environmental Protection Agency (USEPA) through its Office of Research and Development via agreement DW-014-92497401 to the USGS. The second author's contribution to this work was partly supported by the Energy and Environment Mission Seed Program, under the Laboratory Directed Research and Development (LDRD) Program at Pacific Northwest National Laboratory (PNNL). Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

So, what's up with the tabs for different hydrologic settings??

Introduction | Directions for Using | Select Scenario Setting | Index | Stream or River GW-SW Matrix | Lake or Wetland GW-SW Matrix | Estuary or Coastal GW-SW Matrix | Method References

Ready | Accessibility: Investigate

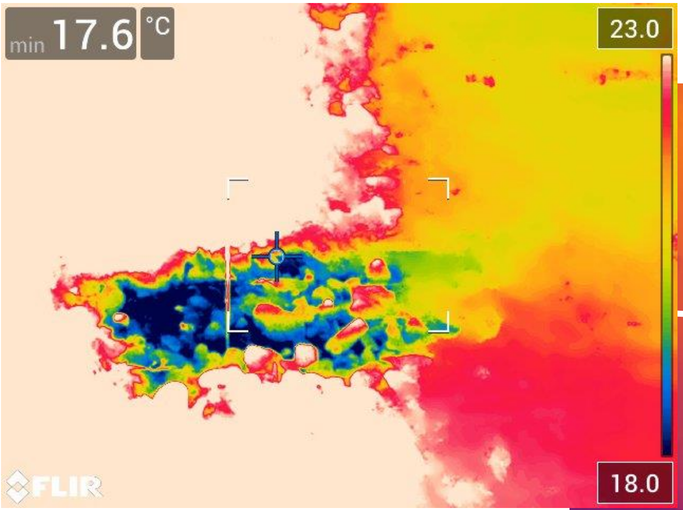
Why would coastal settings be so different?



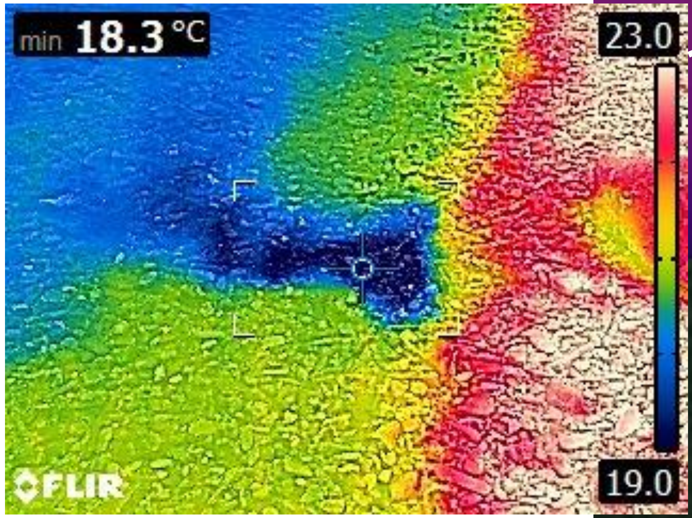
'Skin' surface temperature was mapped over the site using drone-based TIR imagery with focused anomalies indicating cooler groundwater entering the bay during the summer. Some apparent cold areas may be due to dynamic tidal exchange which occurred during the survey.

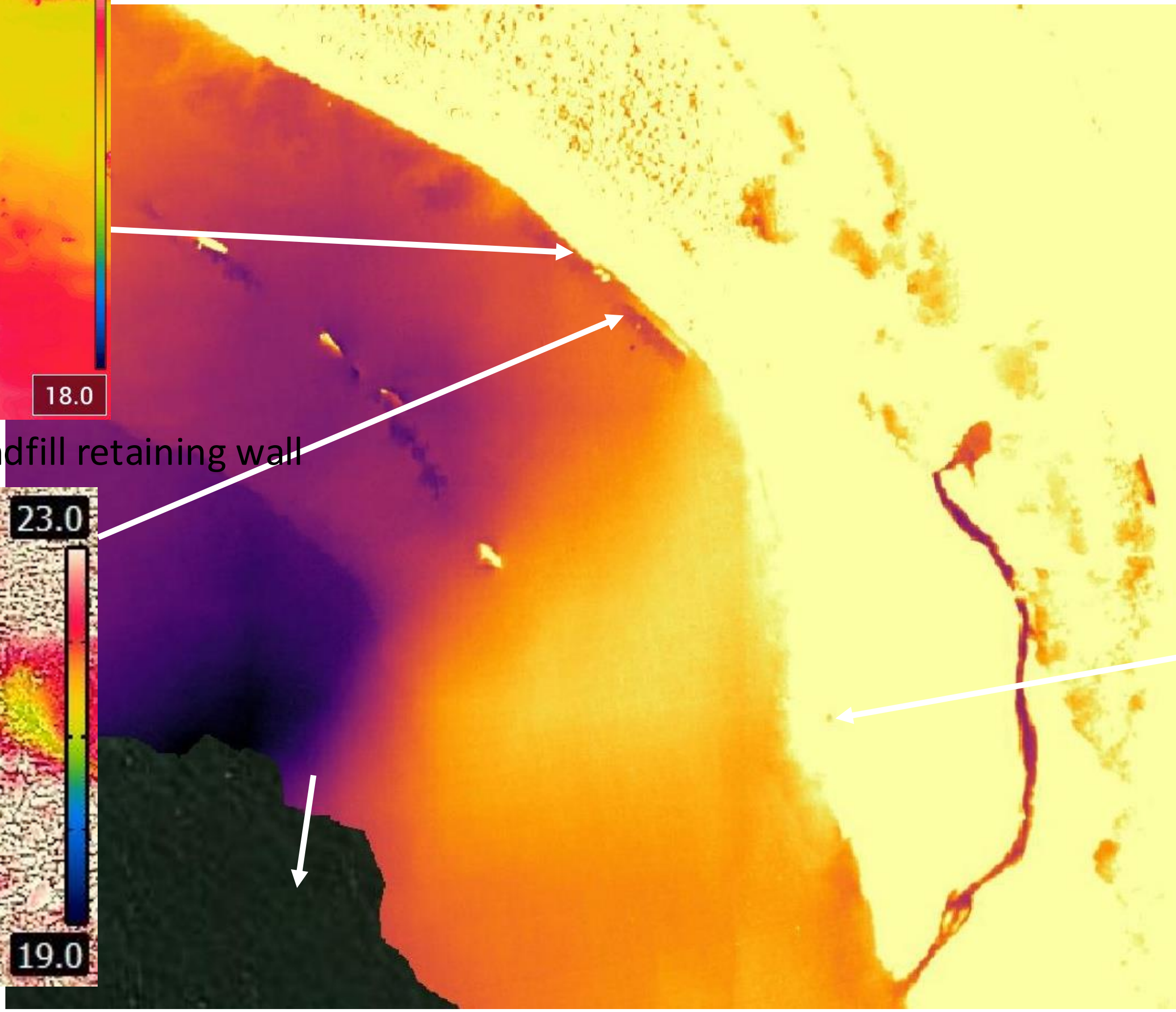
Tidal exchange obscures seepage influence in orthos

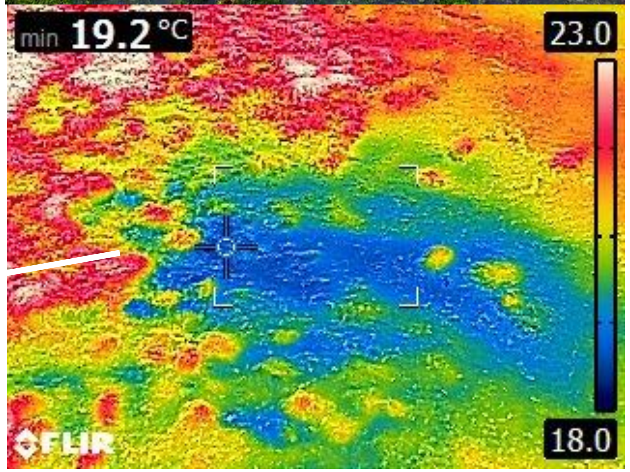
Handheld thermal IR imaging pinpointed highly focused discharge points at low tide in a similar region to FODTS.



groundwater seeps near end of landfill retaining wall

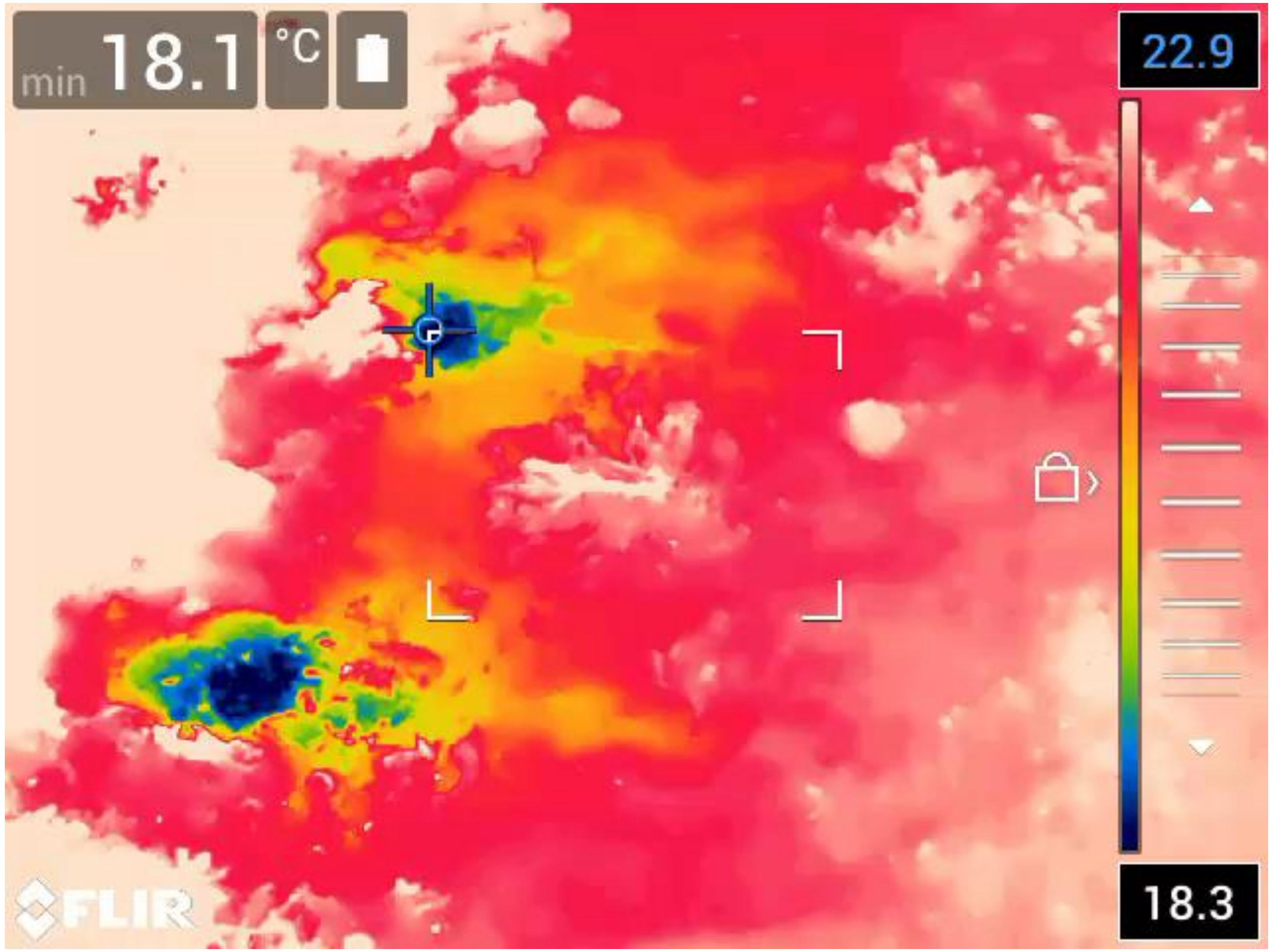






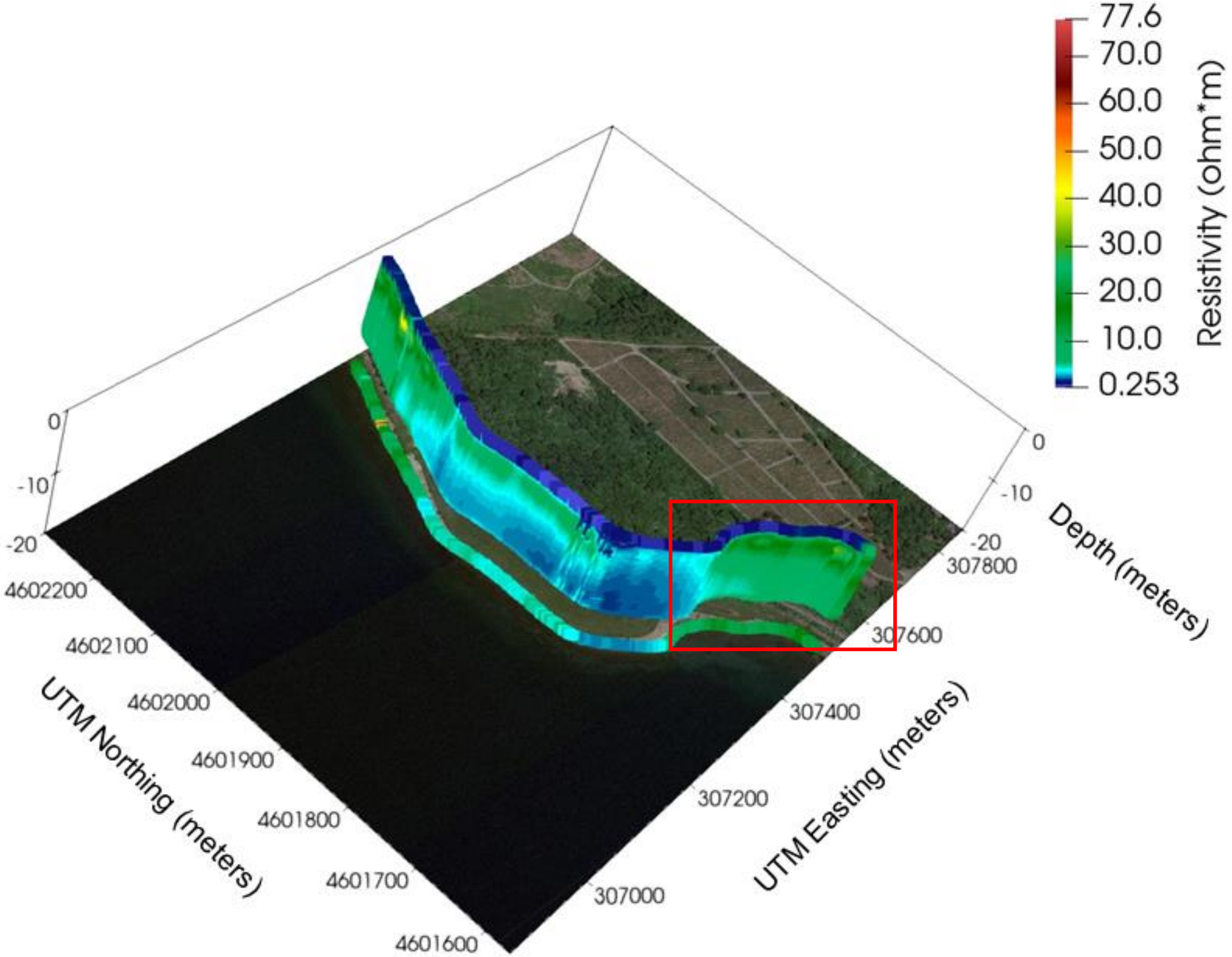
‘short circuit’ seepage from
tributary channel
(likely not groundwater)

Tidal pumping!

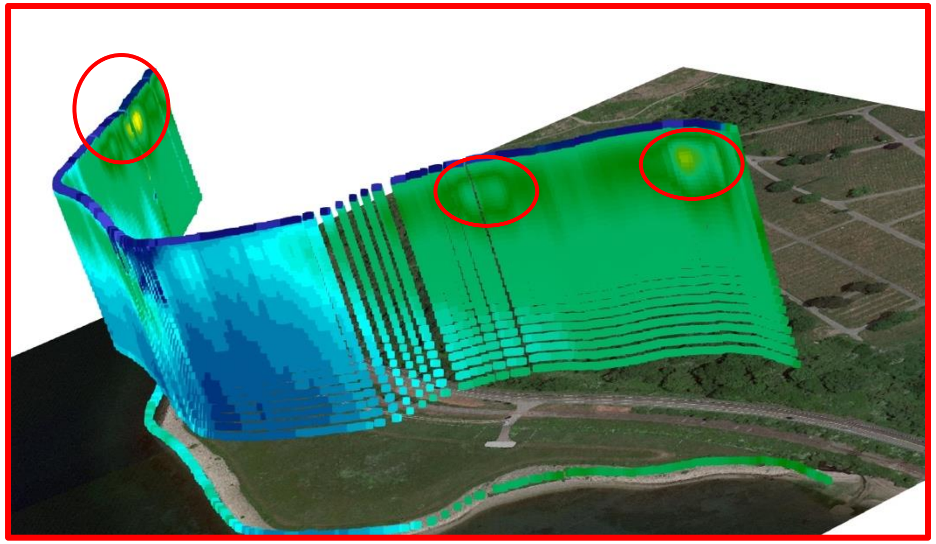


Handheld thermal IR video demonstrates dynamic mixing of discharge with surface water and the potential for tidal pumping to influence discharge rates.

Towed electrical resistivity survey: EC contrast!

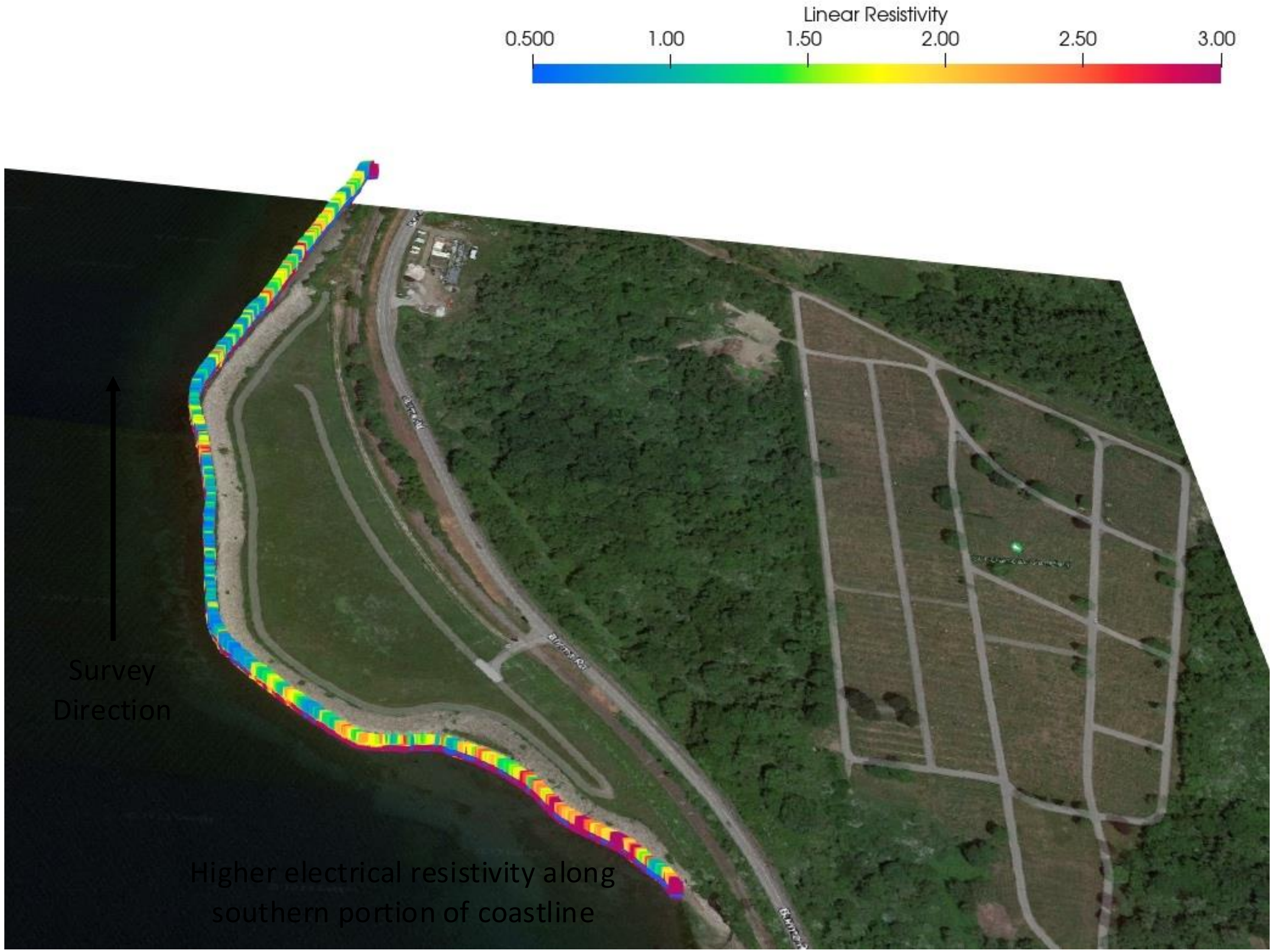


- Identifying groundwater seepage zones through more resistive electrical signatures with depth



Higher resistivity along southern portion of coastline, with localized points ~3-5m depth

Floating EM survey: EC contrast!



- Investigating electrical resistivity with depth (~3m) to highlight contrasts between resistive (yellow/red) groundwater entering conductive (blue/green) bay water.

GW/SW MST wrap-up

- The GW/SW methods selection tool (MST) can be run on the front end of project planning when only general site conditions and study goals are available to help with with project scoping and cost estimates
- As local data are collected, the MST input can be refined for more specific guidance, and the methods description slides can be consulted for important example references and analysis software
- While based on relatively simple spreadsheet logic, the MST harnesses the shared knowledge of ***10 USGS/EPA subject matter experts***

https://water.usgs.gov/water-resources/software/GW-SW-MST/

Groundwater

Methods Note/

GW/SW-MST: A Groundwater/Surface-Water Method Selection Tool

by Steven Hammett[1], Frederick D. Day-Lewis[2,3,4], Brett Trottier[1], Paul M. Barlow[5], Martin A. Briggs[1], Geoffrey Delin[6], Judson W. Harvey[7], Carole D. Johnson[1], John W. Lane Jr[1], Donald O. Rosenberry[8], and Dale D. Werkema[9]