NAVFAC
Naval Facilities Engineering Systems Command

ENVIRONMENTAL RESTORATION

Groundwater to Surface Water Interface: Summary of Tools and Techniques (Part 2)

Introduction

Several physical, chemical, and biological processes combine to contribute to contaminant attenuation across the groundwater to surface water interface (GW-SWI). Understanding the site-specific conditions driving these processes at the GW-SWI can help to evaluate and control exposure pathways. This fact sheet summarizes the approach for identifying and assessing the GW-SWI and describes various tools that can be used.

Approach to Evaluating the GW-SWI

It is often a challenge to identify, verify, and evaluate the presence or absence of seeps in coastal and freshwater environments. There is a standard approach that can be applied as follows:

1) Characterize the constituents of concern (COCs) in the upland plume and see if the plume extends to the shoreline.
2) Evaluate the hydraulic conditions to see if there is a gradient toward the surface water and if there is evidence of communication between the upland and surface water systems (e.g., tidal fluctuations in monitoring wells).
3) Conduct a screening survey offshore from the upland area of concern (and down gradient) to identify potential discharge zones (e.g., with a Trident probe, fiber optic sensors, and/or visual observations).
4) Conduct porewater sampling in identified discharge zones at depths that are relevant to the exposure of risk endpoints (e.g., with Trident probe, push point, peepers, and/or passive samplers).
5) Characterize the discharge rates and contaminant flux as needed.

Tools and Techniques for Evaluating the GW-SWI

Several tools are available to determine the location of seeps, evaluate the physical, chemical, and biological conditions surrounding the interface, and to assess the flux across the GW-SWI. These tools can be used for performing preliminary screening, evaluating porewater quality, and measuring contaminant mass flux.

Table 1 summarizes a selection of tools and techniques that can be used to evaluate conditions at the GW-SWI. Many of the tools can be categorized as direct porewater samplers, while others are categorized as passive, diffusion-based samplers. Figure 1 shows an example of a device called an UltraSeep meter that can collect direct porewater samples. Figure 2 shows an example of a high-resolution passive profiler (HRPP). Other tools and analyses (as listed in Table 1) are especially useful in measuring attenuation mechanisms such as mixing, redox reactions, sorption, biotransformation, and/or dissolution. (Naval Facilities Engineering Systems Command [NAVFAC], 2017).

Figure 1. UltraSeep Meter *(Source: NAVFAC, 2017)*

Figure 2. HRPP *(Source: Environmental Security Technology Certification Program [ESTCP], in press)*

Table 2 provides specific Navy sites that have deployed combinations of these tools and recaps the outcomes. (NAVFAC, 2017; Battelle and Neptune, 2020, and NAVFAC, 2020).

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December 2020

Table 1. Tools and Techniques for Evaluating GW-SWI Conditions

Tool	Description
Mini-Piezometer	Identifies gaining and losing reaches of streams.
PushPoint Sampler	Measures contaminant concentrations in sediment porewater.
Trident Probe/Multi-Depth Trident Probe	Characterizes sediment porewater in coastal water bodies such as harbors and collects porewater samples for chemical analyses.
Peeper	Provides high resolution data at a single depth near the surface.
High Resolution Passive Profiler (HRPP)	Passively collects porewater/groundwater samples at multiple depths providing high resolution physical (bromine tracer used to measure vertical flow), chemical, and biological data for detailed concentration profiles.
UltraSeep Meter	Allows simultaneous measurement of groundwater and contaminant discharges; real-time measurement of temperature and conductivity; quantifies discharge rate and flux of chemical constituents across the GW-SWI.
Seepage Meter	Collects direct measurements of water flux across the GW-SWI.
Sediment Bed Passive Flux Meter	Measures porewater flux and contaminant mass flux across the GW-SWI.
Passive Flux Meter	Self-contained permeable unit inserted into a well.
Passive Samplers	Enables time-averaged measurements; less sensitive to daily fluctuations.
Differential Pressure Piezometer (DPZ)	Measures vertical hydraulic gradient between sediment porewater and surface water.
Fiber Optic Distributed Temperature Sensing	Direct contact temperature sensing technology to determine temperature difference between groundwater and surface water; used to delineate groundwater discharge locations.
Thermal Infrared Camera	Remote temperature sensing technology: thermal images differentiate groundwater discharge locations.
Traditional Sediment Coring	Allows characterization of observed sediment layers and collection of sediment samples for grain size and vertical and horizontal hydraulic conductivity, which can be used in calibrating groundwater models.
Friction Sound Probe	Infers sediment grain size by measuring the acoustic response as a probe with an imbedded microphone penetrates a sediment matrix.
Compound Specific Isotope Analysis (CSIA)	Measures the ratios of naturally-occurring stable isotopes in contaminants of interest to provide evidence of the extent of contaminant degradation.
Microbial Deoxyribonucleic Acid (DNA) Analysis	Analysis of microbial DNA to determine the species that are present.
In Situ Bioassay	Examines the toxicity of a medium by evaluating the effects of exposure to a variety of organisms. One example is the Sediment Eco-toxicity Assessment Ring (SEA Ring) developed by the Navy.
Tree Core Sampling	Inexpensive and rapid approach to screen for volatile organic compound (VOC) groundwater plumes discharging to shallow waters.
Visual Observation	Visual identification of seeps or springs, as well as sediment staining (iron and manganese staining) during low flow conditions after several days without precipitation. If the water body is tidal, the inspections should be performed during low tide conditions.

Table 2. Example Applications at Navy Sites

Site	Site Type	COCs	Tools Used	Outcome
Operable Unit 4, Naval Training Center (NTC), Orlando, Florida	Coastal	PCE and its degradation products	• Trident Probe • UltraSeep • Piezometers	• Identified areas of groundwater discharge using the Trident Probe. Detectable levels of VOCs were measured in the subsurface or surface water in the areas of groundwater discharge. The results were consistent with those from shallow piezometers. • Quantified groundwater discharge rates and VOC discharge concentrations using the UltraSeep meter in two discharge zones. The results were consistent with those from shallow piezometers. • Demonstrated how discharge of VOCs to Druid Lake are regulated by physical and chemical attenuation, along with the effects of localized mixing in the lake itself.
Site 99 Quantico Embayment, Marine Corps Base Quantico, Virginia	Freshwater with slight salinity fluctuations	PCBs and DDx	• Trident Probe • Passive Samplers	• Collected groundwater 18 inches below the sediment surface using the Trident probe. The groundwater was analyzed for PCBs and DDx. The probe was also used to identify and sample seeps to evaluate if groundwater discharging from beneath a landfill is impacting an adjacent watershed. • Deployed polyethylene devices (PEDs) to sample the top 6 inches of porewater and the overlying water. The data allowed for calculation of the diffusive COC flux. The PEDs showed that no upward flux of contaminated groundwater was observed meaning that the cap is performing well. • Showed 30 to 200 times lower DDx and PCB concentrations, respectively, in the surface water than predicted based on the calculated diffusive flux from porewater to surface water, possibly due to tidal flushing.
Site 07 Calf Pasture Point, Davisville, Rhode Island	Saltwater, embayment	Chlorinated VOCs	• Trident Probe • UltraSeep Meters • DPZs • HRPPs • Sediment Coring • Groundwater Monitoring • SEAWAT Modeling • CSIA • Microbial DNA Analysis	• Combined Trident probes with quick turn-around-time chemistry testing to assess the location of the contaminated groundwater discharge areas into the bay; the assessment was based on conductivity and temperature difference, as well as chlorinated VOC results. • Used UltraSeep meters to measure seepage velocity of upwelling groundwater and DPZs to measure the hydraulic head for SEAWAT modeling. • Deployed HRPPs to collect high-resolution porewater samples for chlorinated VOC, anion, and dissolved gas analyses. Microbial DNA and CSIA samples were also collected with HRPPs. • Collected sediment cores for testing the grain size, porosity, and permeability, which were later used in SEAWAT modeling. • Collected groundwater samples to establish the chlorinated VOC concentrations in the source water. • Showed significant attenuation of chlorinated VOCs occurs in the top parts of the sediment. The observed attenuation was significantly greater than physical dilution only. Microbial analyses confirmed the presence of bacteria capable of reductive dechlorination of chlorinated VOCs.

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