PROJECT ID:
591

Locating and Quantifying Groundwater Surface Water Connections Using Distributed Temperature Sensing

DTS deployment. (Photo Credit: SelkerMetrics)

OBJECTIVE

The objective of this study is to demonstrate the capability of a distributed temperature sensing (DTS) system to provide high resolution identification of seepage locations at a relevant Navy site.

PROBLEM STATEMENT

The identification and migration of contaminated groundwater into surface water is a priority among Remedial Program Managers (RPM). Traditional sampling methods to identify and quantify groundwater seepage involve measurements at a few discrete locations. These methods provide limited information because seepage may occur to varying degrees over a large area. Better methods that provide more complete data are needed to improve the characterization of groundwater movement and associated contaminant transport, to support remedial decision making.

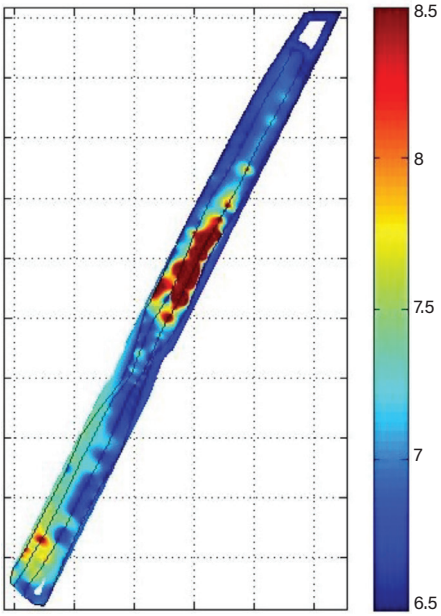
DESCRIPTION

Temperature differences have been used extensively as tracers to track groundwater-to-surface water discharge—areas of differential temperature indicate groundwater discharge zones. Fiber optic DTS technology uses the relationship between temperature and scattered light in a fiber optic cable to measure temperatures continuously.

The cable may be several kilometers in length, allowing continuous measurement at thousands of locations.

Analytical tools allow for the processing of these data into a detailed view of temperature differential (representing groundwater seepage) through time, including variations with tide level, precipitation events and/or pumping. Groundwater flux rates (velocity) and scouring and deposition of sediments may also be estimated. This project includes a field demonstration of DTS at an appropriate Navy site and a laboratory study designed to validate the seepage rate estimates derived from the DTS temperature measurements.

For the field demonstration, the DTS cable will be buried a few centimeters below the sediment water interface in soft sediment. It will be deployed in a grid pattern to cover the area of interest. Once installed, the fiber will be connected to an instrument that measures temperature along the cable and logs the data, allowing users to identify seeps over large areas and through time. Once data collection is complete, the raw DTS data will be calibrated, and statistical and geospatial analytical techniques will be employed to identify locations along the cable which correspond to potential seepage.



Example DTS results showing locations of relatively warm groundwater seeps. (Graphic Credit: SelkerMetrics)

The DTS study will be followed by a different seep investigation method for comparison with DTS results. Then, seepage rate estimates based on DTS temperature measurements will be validated with a benchtop experiment.

RETURN ON INVESTMENT

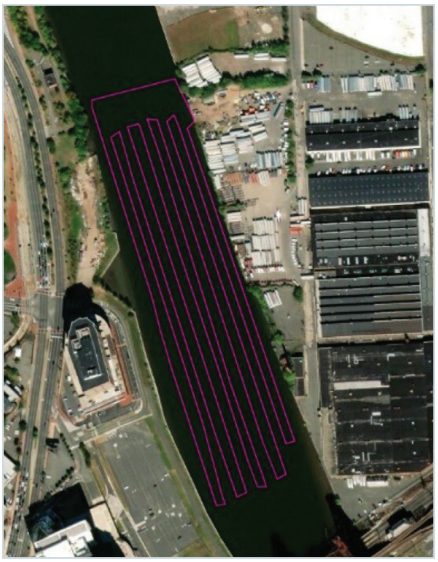
Over two decades, commercial clients have found that DTS supports cost-effective progress with sites, and it is likely Department of Defense sites will recognize similar cost savings with better information about seep location and flow rates.

For example, at a site where capping is under consideration, portions of the site may be found to have little or no groundwater seepage and thus require little or no capping. Capping costs are site specific but can range from $100,000/acre (thin sand cap) to over $1,000,000/acre (multilayer armored reactive cap), helping to illustrate a benefit of focusing remedial efforts based on DTS study results.

Submersible plow used to bury DTS cable below sediment surface. (Photo Credit: SelkerMetrics)

NAVY BENEFITS

Use of the fiber optic DTS technology provides several potential benefits to the Navy. First, it is the only technology providing high-resolution identification of seeps across a large area. This validates and improves groundwater and contaminant transport models. It pinpoints areas of concern and rules out areas with very low or no seepage. For example, a recent 50-acre DTS study found seeps occurring in less than 5 percent of the site area. This high-resolution data can increase cost effectiveness of follow-up investigations and provide regulators increased confidence that the site is well characterized.



Example DTS deployment pattern.
(Photo Credit: SelkerMetrics)

Secondly, as mentioned above, DTS may eliminate the need for capping at a site. Also, DTS provides a better picture of natural recovery, potentially reducing or eliminating the need for cap armoring.

Finally, DTS is easier and less invasive to apply than other methods. The DTS optic cable is installed only a few inches below the sediment-water interface, unlike other devices that are driven deeper into the sediment and may require divers. This decreases the affects to benthic habitat and reduces the likelihood of resuspending contaminated sediment.

TRANSITION DESCRIPTION

DTS technology is commercially available and being employed by a variety of users nationwide. After successful demonstration, it may be readily deployed across multiple sites. The project team will use multiple technology transfer mechanisms to integrate the technology with end users in the Navy and Base Realignment and Closure. These include distribution of the final report to RPMs with sediments sites, two site visits to two locations of particular concern, discussion with two Naval Facilities Engineering Systems Command work groups, presentations at conferences and potential inclusion on remediation training seminars.

CONTACT

For more specific information about this project, contact the Principal Investigator at 805-982-1258.

ABOUT THE NESDI PROGRAM

The Navy Environmental Sustainability Development to Integration (NESDI) program is the Navy's environmental research and development, demonstration and validation (6.4) program, sponsored by the Chief of Naval Operations, Energy and Environmental Readiness Division (OPNAV N45) and managed by the Naval Facilities Engineering Systems Command (NAVFAC) out of the Engineering and Expeditionary Warfare Center (EXWC) in Port Hueneme, CA.

The mission of the program is to provide solutions by demonstrating, validating and integrating innovative technologies, processes, materials, and filling knowledge gaps to minimize operational environmental risks, constraints and costs while ensuring Fleet readiness and lethality. The program accomplishes this mission through the evaluation of cost-effective technologies, processes, materials and knowledge that enhance environmental readiness of naval shore activities and ensure they can be integrated into weapons system acquisition programs.

The program is the Navy's complement to the Department of Defense's Environmental Security Technology Certification Program which conducts demonstration and validation of technologies important to the tri-Services, U.S. Environmental Protection Agency and Department of Energy.

For more information, visit the NESDI program web site at www.navfac.navy.mil/nesdi or contact Ken Kaempffe, the NESDI Program Manager at 805-982-4893, DSN: 551-4893 or ken.kaempffe@navy.mil.