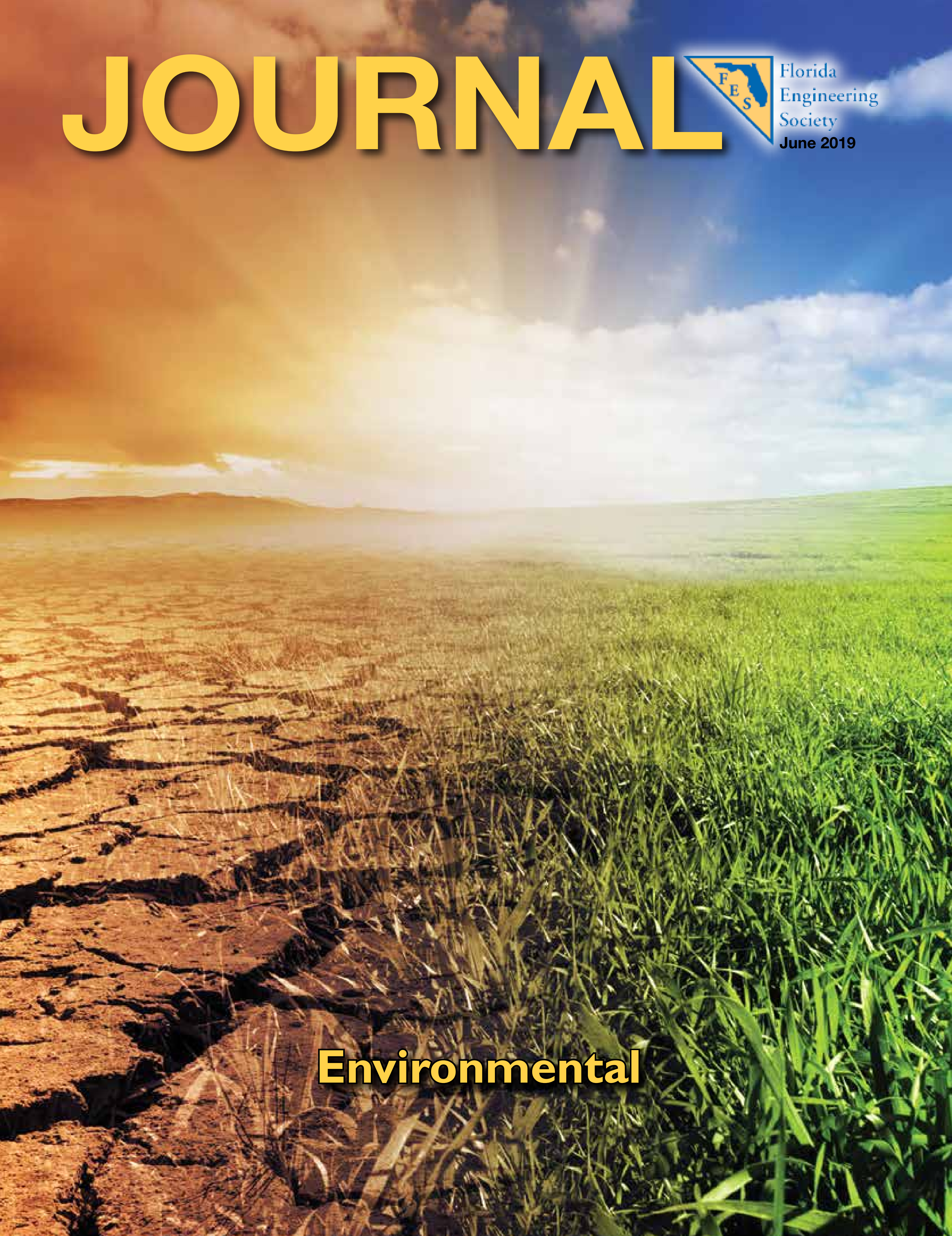
JOURNAL

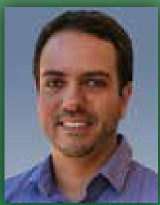
Florida Engineering Society
June 2019

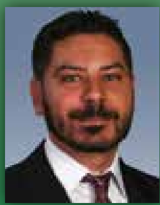


Environmental

Visualizing the Future

High Resolution Site Characterization techniques and Data Visualization Technologies help to support and refine conceptual site models for accelerated contamination assessment and remedy design and implementation.





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In the field of contamination assessment and remediation, every site decision begins with the Conceptual Site Model (CSM). The state of Florida's regulations for Contaminated Site Cleanup Criteria defines the CSM as a written and/or graphic representation of the physical, chemical and biological processes that affect the transport, migration and actual or potential exposure to contamination in all affected media to human and ecological receptors. The CSM is used to develop and refine the extent of site assessment, remedial alternative selection and design, cleanup progress and optimization, and support overall risk management decisions. Accordingly, the site data collected and associated data quality objectives, along with the techniques utilized to present the data to a varied audience of stakeholders that may include responsible parties, regulatory agencies, and the general public, are critical components to the overall success of a project.

For complex sites, achieving this level of understanding can be difficult, with faulty or incomplete CSMs causing delayed site assessment completion and/or prolonged site remediation. Fortunately, there are continually evolving concepts and innovative tools that can assist with the formation or visualization of the CSM, contaminant fate and transport and ultimately, to successful and cost-effective site assessment and cleanup. The use of High Resolution Site Characterization (HRSC) techniques, can be complemented with 3-dimensional (3D) models to provide a robust amount of data within an easy to understand illustration of contaminant behavior.

HRSC is a set of strategies and techniques that use scale-appropriate measurement and sample density to define contaminant distributions, and the physical context in which they reside, with greater certainty, supporting faster and more effective site cleanup.

HRSC often involves the use of in-situ site assessment tools such as a Membrane Interface Probes (MIP) and Hydraulic Profiling Tools (HPT) that allow for real-time evaluation of contaminant concentrations and hydrogeologic information. The robust data set generated using HRSC concepts correlates well with the use of 3D visualization software, including Earth Volumetric Studio (EVS). The preparation of 3D models in both still and motion picture formats allow for an ease of understanding that is more difficult to achieve from traditional plan view figures, cross-sectional figures, and large tables of data. The use of HRSC coupled with 3D visualization technologies can be used for source assessment, site assessment planning, and remediation optimization, as described in the case studies below.

Implementation of HRSC techniques with 3D visualization modeling was incorporated into supplemental assessment activities at a Superfund Site in Southeastern Florida to more accurately define a dissolved sodium plume in groundwater that resulted from a historical process water softening system discharge. The investigation included data collection from 50 locations using Direct Push Technology (DPT), with groundwater profiling conducted along six transects. A total of 168 discrete groundwater samples were analyzed in the field via the use of a sodium ion-specific electrode, to complement the existing traditional network of monitoring wells. To assist in the evaluation of the sodium plume behavior, a 3D EVS model was generated, with correlating lithologic data (**Figure 1**). This made it possible to determine that a residual source was not present and that 80% of the sodium plume was concentrated on top of a semi-permeable confining layer. Moreover, the historical monitoring well data, when further analyzed using Monitoring and Remediation Optimization System (MAROS) software, represented that the center of mass had migrated below a downgradient wetland and surface water body and had reached stability in concentration trends. Through

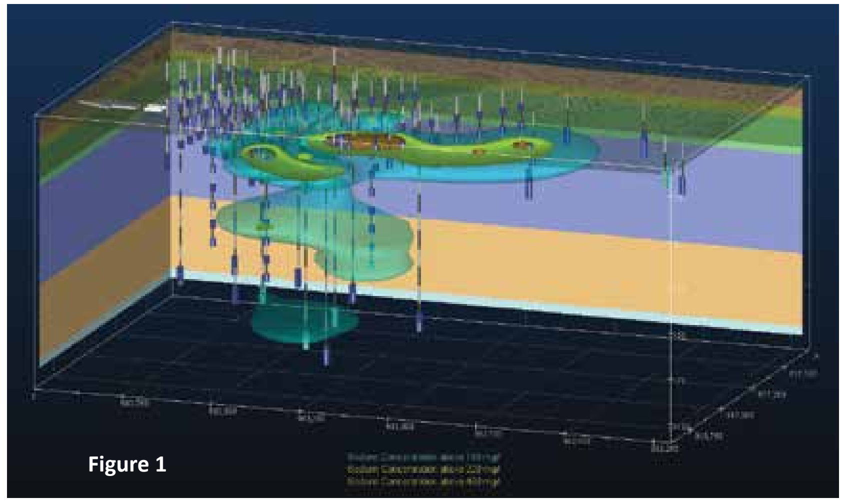
Figure 1

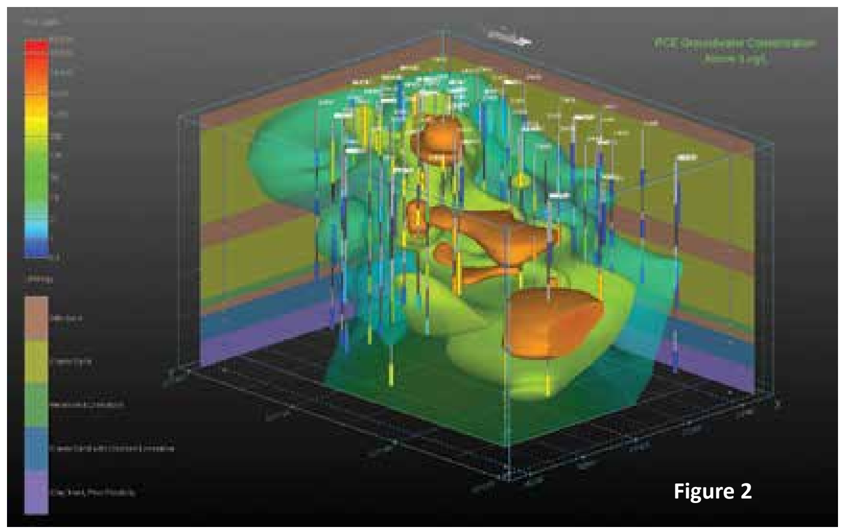
Figure 2

the use of HRSC tools and 3D modeling, it was concluded that natural attenuation of the sodium plume was a viable remedy versus continued costly active groundwater remedy due to its distribution, dynamics, and lack of any ongoing source material.

At a former drycleaning facility in North Florida, the use of 3D Visualization was instrumental in the preparation of a supplemental site assessment work plan. Based on the site history and traditional site assessment activities previously conducted, the release(s) of chlorinated solvents at the facility was evident, with significant soil and groundwater impacts observed driven by a source that is characteristic of potential non-aqueous phase liquid (NAPL) onsite. Despite previously conducted DPT groundwater profiling at varying depths and installation of 46 monitoring wells, the extent of groundwater impacts had

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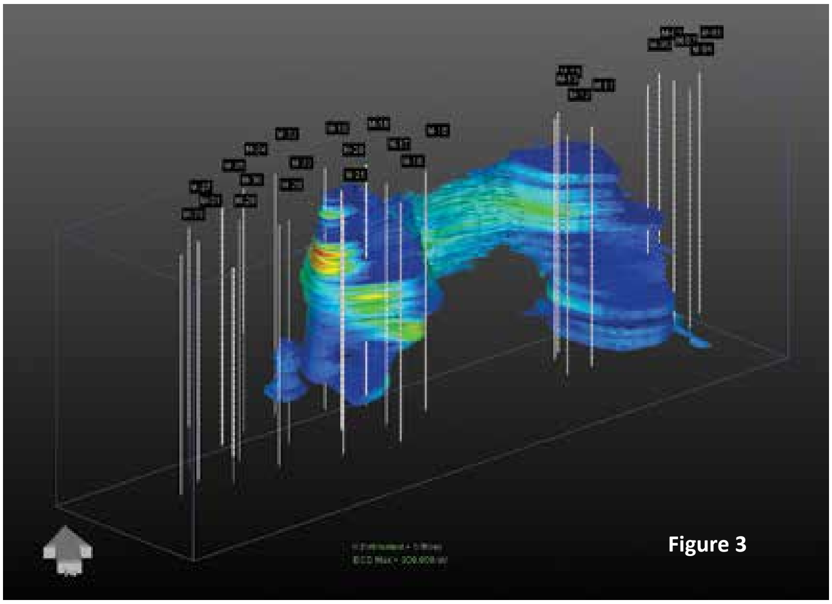

Figure 3

Figure 4

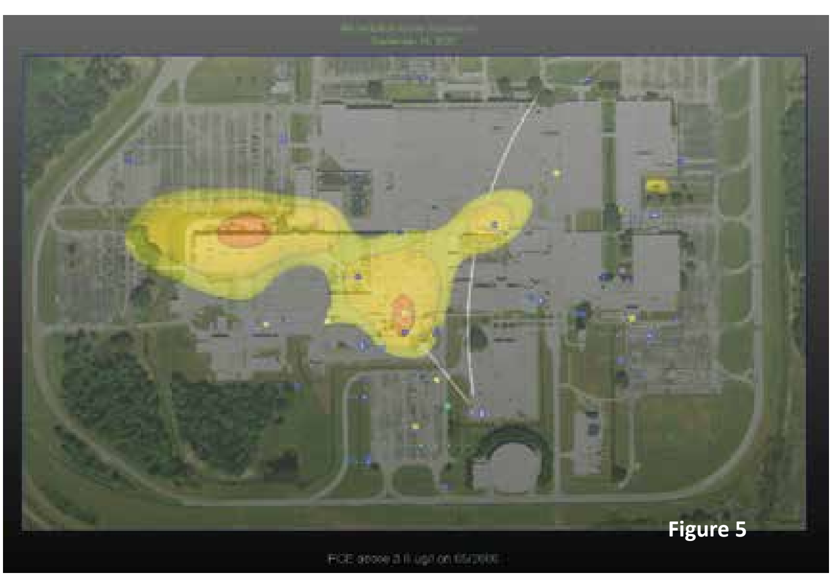

Figure 5

not been fully delineated. Generation of a 3D model to visualize the existing CSM (**Figure 2**) was essential to understanding the behavior and known extents of the drycleaning solvent plume and its associated daughter products, identifying transport characteristics correlated by lithologic information, and identification of data gaps to optimize the scope of work for future site assessment activities. Based on the findings from the 3D visualization of historical data, recommendations were provided for supplemental assessment using membrane interface and hydraulic profiling (MiHPT) techniques, along with DPT groundwater profiling tools to guide the installation of additional monitoring wells at key locations within an area of approximately 50 acres to delineate the horizontal and vertical extents of contamination, and refine future remedial strategies.

During remedial investigation work at a site in Central Florida, MiHPT techniques were utilized to assist in optimizing the design of a bioremediation injection system. A total of 31 MiHPT borings were advanced across the site, with the results analyzed using the EVS 3D modeling software (**Figure 3 and 4**). The 3D model facilitated better visualization of the correlation between high contaminant concentrations and intervals of high hydraulic conductivity, thereby identifying optimal locations and intervals for bioremediation stimulant injections, ultimately resulting in avoided costs for additional stimulant and implementation for unnecessary injection intervals.

The EVS model can also be used to visualize the behavior of a plume contaminant over a specified time domain, allowing another perspective in the evaluation of remedial system effectiveness and providing key data in the decision-making process for modification or optimization of remedial system operations. At a site in Central Florida impacted by chlorinated solvents (namely trichloroethene [TCE] and trichloroethane [TCA]), operation

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of a groundwater extraction and treatment system was conducted between 2000 and 2016, with groundwater quality analyzed over time. A time domain EVS model (**Figures 5, 6** and **7**) was prepared and utilized to better understand the extent of Floridan Aquifer contaminant exceedances and to evaluate potential sources, as well as to evaluate the remedial system effectiveness following an optimization effort conducted in 2013-2014.

The use of HRSC and 3D visualization techniques can help to improve CSM formulation and allow for better interpretation of contaminated site characteristics over traditional techniques. The resulting information can be used to expedite and more cost-effectively complete contaminant assessment and cleanup projects, and present this information in a meaningful way to practitioners, regulators, and the layperson alike.

Figure 6

Figure 7

About the Authors:

Fabio Fortes, EI is an Environmental Engineer with 6 years of experience in site assessment and remediation of industrial and residential contaminated sites with skills in Remediation Design, Geographic Information System (GIS) and 3D visualization modeling. He is a registered Engineer Intern (EI) in the state of Florida and Professional Engineer from Sao Paulo, Brazil. Fabio has a degree in Environmental Engineering from the Federal University of Itajuba, Brazil and is currently pursuing a Master's Degree in Civil Engineering at the University of South Florida with anticipated graduation in 2019. Currently, he works at HSW Engineering Inc. in their Tampa Office.

Nicholas Barnes, PE, is an environmental engineer at HSW Engineering Inc. with 13 years of experience in the assessment and remediation of environmental contamination. He has extensive experience in the evaluation and selection of remedial action cleanup strategies for a range of contaminants.