Evaluating *in situ* remediation performance with the Geophysical Imaging of Flow and Transport (GIFT) system

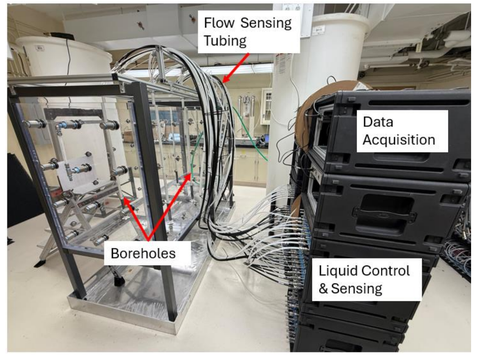
Dory Linneman, Chris Strickland, Tim Johnson, and Jon Thomle

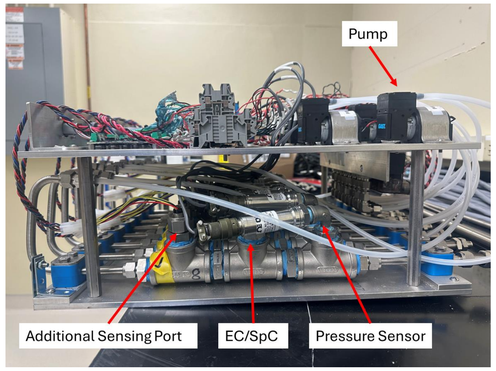
INTRODUCTION

The Geophysical Imaging of Flow and Transport (GIFT) system is an intermediate-scale laboratory experimental platform that provides a first-of-its kind capability to perform simultaneous geophysical tomographic imaging and multi-phase fluid (gas or liquids) sensing of *in situ* remediation performance within a meter-scale 3D surrogate for natural subsurface environments. Time-lapse tomographic imaging will improve quantification of flow and transport properties in heterogeneous unsaturated and saturated flow and contaminant transport conditions. Constraining these properties is essential to reducing uncertainty in predictions of contaminant fate and transport as well as monitoring long-term remedy performance.

IMAGING & SENSING CAPABILITY

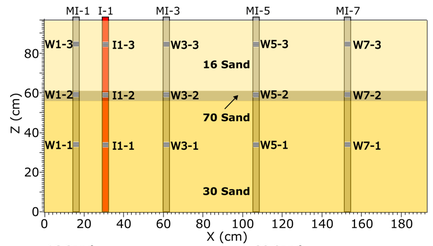
The GIFT system is a laboratory-scale tank testbed with inner dimensions of 193 x 74 x 97 cm. For the current campaign, GIFT is instrumented with eight monitoring boreholes and one injection borehole. Each monitoring borehole contains 10 electrical resistivity tomography (ERT) imaging electrodes and three fluid ports. The fluid ports are used to autonomously monitor fluid (gas/liquid) properties and can also be used for fluid injection and extraction.





Each fluid port is connected through tubing to a circulation pump with in-line sensors. The liquid circulation systems measure pressure and electrical conductivity, while the gas circulation systems measure pressure and O_2 %. The sensor configuration can easily be customized to suit the needs of an experiment. The internal components of the liquid sensing system are shown on the left.

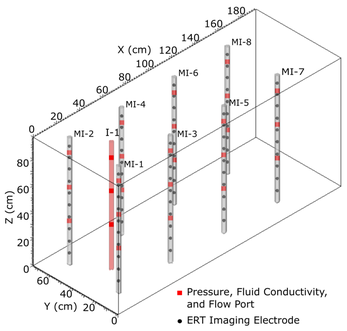
EXPERIMENTAL SETUP



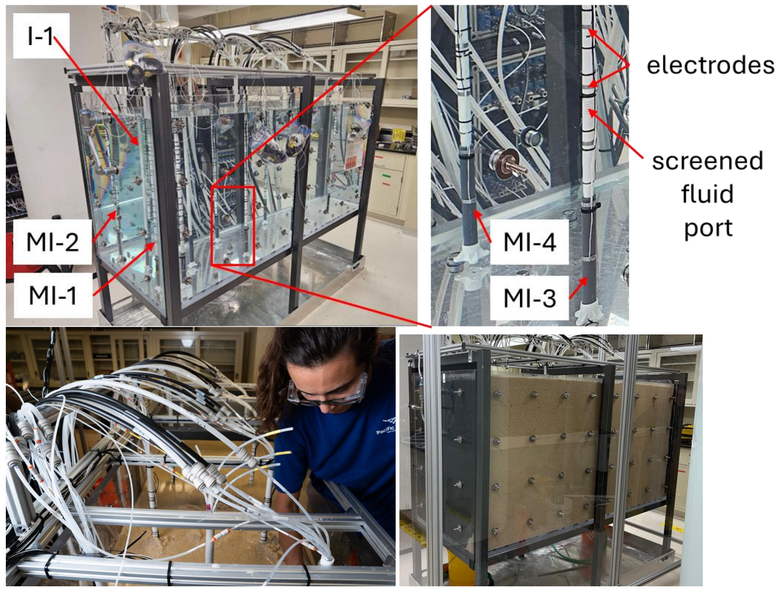
16 Sand
permeability: 7e-11 m^2
hydraulic conductivity: 605 m/d
porosity: 0.4

30 Sand
permeability: 4e-11 m^2
hydraulic conductivity: 343 m/d
porosity: 0.4

70 Sand
permeability: 2e-12 m^2
hydraulic conductivity: 18 m/d
porosity: 0.4



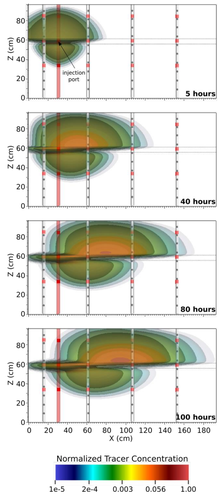
Cross-sectional (left) with sediment hydraulic property profile and oblique (right) diagrammatic views of the GIFT system. Eight monitoring boreholes (MI-1 through MI-8) are instrumented with fluid ports and ERT electrodes. The injection well (I-1) is instrumented only with fluid ports.



Top: Photograph of GIFT tank and instrumentation during testing of the fluid sensing and control system. Several boreholes are annotated, with a closeup view of boreholes MI-3 and MI-4 highlighting electrodes and fluid ports. Bottom: Photographs of GIFT tank during (left) and after (right) sediment packing.

PLANNED EXPERIMENTS & NUMERICAL MODELING

Initial tracer transport experiments and numerical simulations will inform design of an injection and extraction scheme aimed at optimizing treatment of the low-permeability zone with a DV-1 amendment (calcium polysulfide or polyphosphate). Post delivery, the GIFT tank will be continuously monitored by the ERT system for image changes in bulk electrical conductivity and chargeability associated with amendment reactions.



PFLOTRAN simulation of tracer migration given the hydrogeologic properties of the packed testbed.

The insights gained from GIFT experiments will enable the development and validation of innovative tools and methodologies for managing vadose zone contamination. The GIFT system allows for cost effective laboratory-scale testing of subsurface environments that include many of the complexities present in real-world settings, advancing the mission of the U.S. Department of Energy.

U.S. DEPARTMENT of ENERGY
BATTELLE
PNNL is operated by Battelle for the U.S. Department of Energy
REMPLEX CENTER FOR THE REMEDIATION OF COMPLEX SITES @PNNL
DEEP VADOSE ZONE PROGRAM @PNNL
10/27/2025 |
Pacific Northwest NATIONAL LABORATORY
www.pnnl.gov
This work was prepared by the Deep Vadose Zone – Applied Field Research Initiative at Pacific Northwest National Laboratory, funded by the U.S. Department of Energy, Hanford Field Office.