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3-D Printed Conceptual Site Models – Visualizing Geology and NAPL Distribution at a Superfund Site

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Background/Objectives. 3-D printing is an innovative tool for creating physical models of 3-D structures that exist solely in digital form. Over the last five years, the cost of desktop 3-D printers has decreased 10-fold, and printers are now widely available for less than $1,000 USD. The variety of materials available for 3-D printing has also expanded over the past few years and includes: acrylonitrile butadiene styrene (ABS), biodegradable polylactic acid (PLA), flexible polyurethane, and many others. The printing process starts with a digital 3-D mesh file. This file is processed using specialized 3-D printing software that "slices" the 3-D mesh files into discrete layers. A tool path is then generated for each layer, much like the tool path of a CNC machine. As the 3-D printer's extruder is moved along these tool paths, the print material is fed as a filament through a heated nozzle on the extruder and deposited as a sub-millimeter bead of melted plastic onto a glass plate to build the shape layer by layer. This additive manufacturing process is known as fused deposition modeling™ (FDM™) or fused filament fabrication (FFF). Here we present the use of a desktop FFF 3-D printer to create physical conceptual site models (CSMs) from two high-resolution site characterization datasets interpreted using environmental 3-D modeling software.

Approach/Activities. A low-cost desktop 3-D printer was used to create two modular desktop scale models. The first model was of the observed zero-valent iron (ZVI) distribution for a combined chlorinated solvent treatment utilizing chemical reduction and bioremediation. The second model was of the geology and distribution of NAPL at a Superfund site. Preparation of the 3-D mesh files for the ZVI distribution and NAPL models involved the use of existing 3-D models built in Environmental Visualization System (EVS) and EarthVision software packages, respectively. A workflow was developed to output shapes from each 3-D modeling software package and convert them to 3-D mesh files; these files were used to successfully print physical models using plastics of varying color and texture. The ZVI distribution model was designed to further our understanding of the CSM and support ongoing remediation efforts. The geology and NAPL model was used to communicate the CSM and proposed remediation approach for this site to a range of stakeholders; this large model measured approximately 55 cm by 28 cm by 15 cm in height.

Results/Lessons Learned. 3-D printing is a novel tool for communicating with stakeholders, clients, and regulatory agencies. Physical models are useful for visualizing complex environmental data in three dimensions. Applications for 3-D printing for environmental projects include: geologic block models, landfill scale models, topography, bathymetry for lakes and ponds, and complex 3-D CSMs for contaminated sites that can integrate: geology, hydrogeology, sources zones, and plumes. While the cost of 3-D printers and print materials are relatively low, the major cost driver for producing complex 3-D printed models is the effort spent building and processing the digital input files, managing the printing operations, and assembling/finishing the printed model components.