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3-D Printing for Advanced Conceptual Site Models

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12 October 2018

Overview

- How do we currently visualize environmental data?
- How does 3-D printing fit into that toolbox?
- How does 3-D printing work?
- Case Studies
- Potential Applications for 3-D Printing
- Model Scope and Cost

What do we do with all of that data we collect?

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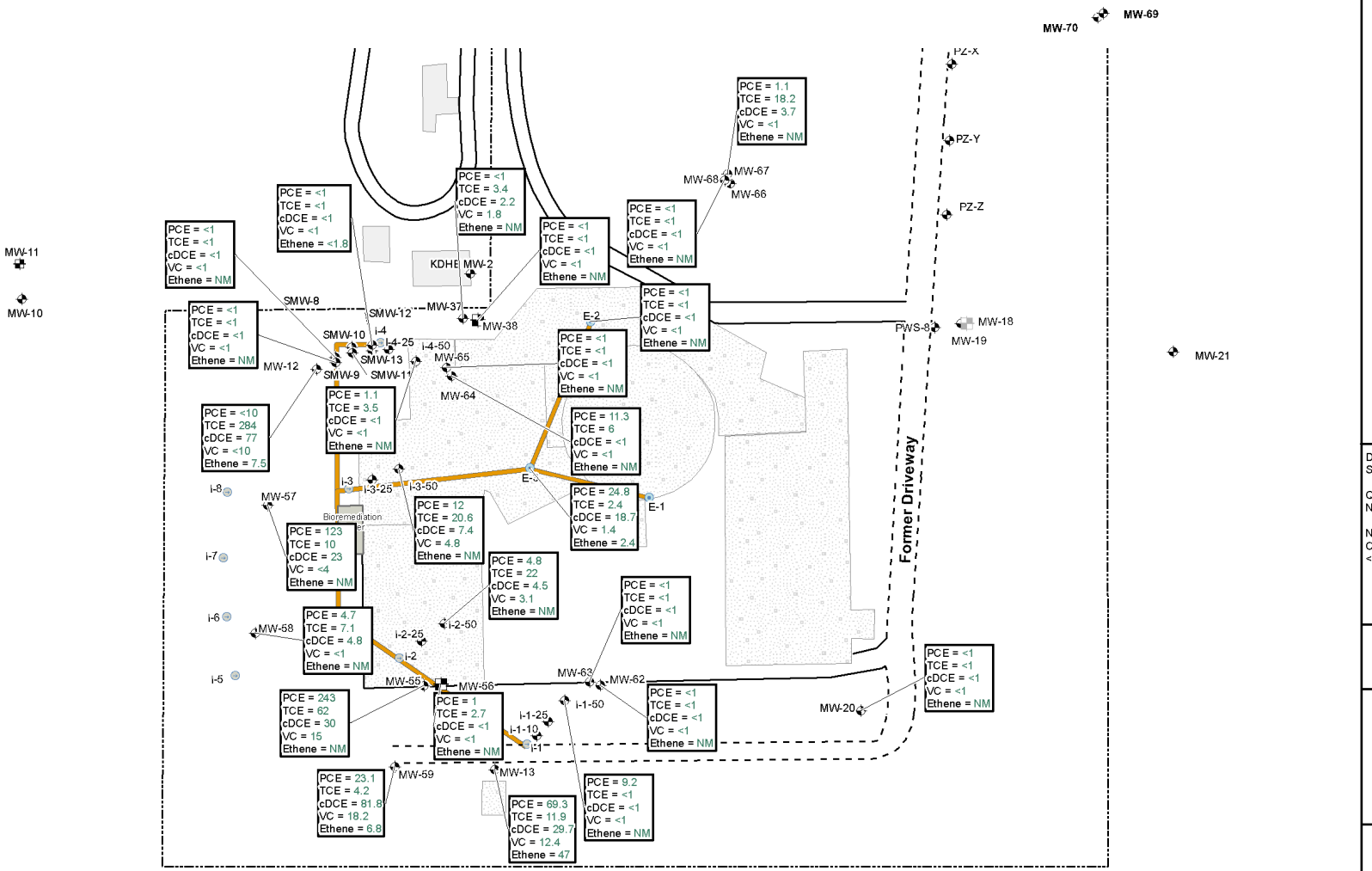
Post it (Groundwater)



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Legend

- Overburden Monitoring Well
- Bedrock Monitoring Well
- Decommissioned Bedrock Monitoring Well
- Injection Wells
- Extraction Wells
- Neighboring Site Structures
- Existing Concrete Pads
- Property Boundary
- Buried Piping for the Groundwater Recirculation System
- 54 April 2016 CVOC Concentrations

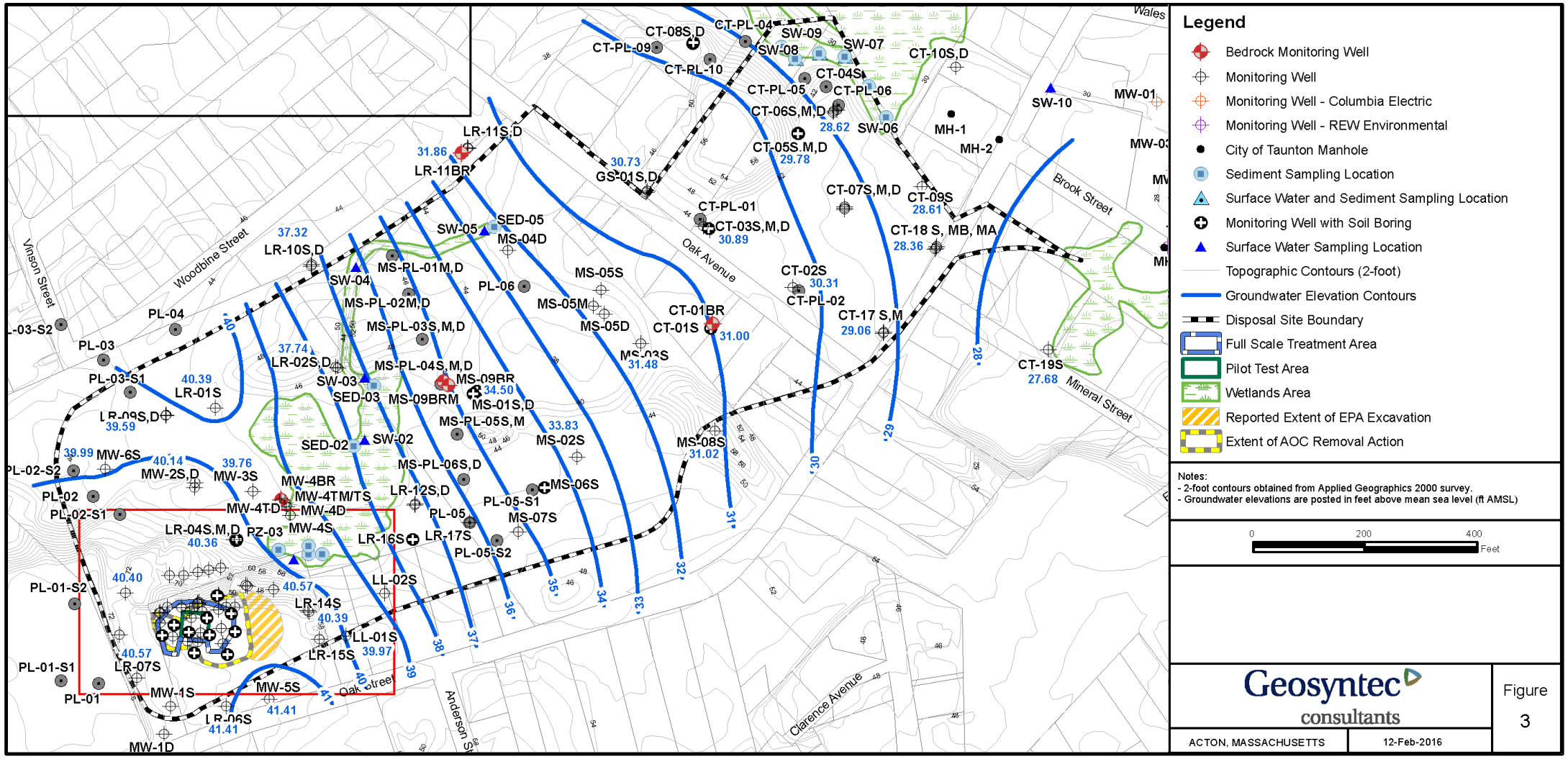
Definitions:
SR = Surrogate Recovery for these analyses were below method/laboratory control limits. Reported concentrations may be biased low.
QI = One or more qualifier mass ions did not meet method criteria.
NM = Not measured as part of the October 2014 or April 2015 sampling plan.

Notes:
Concentration = µg/L (micrograms per liter).
< = Less than laboratory reporting limit.

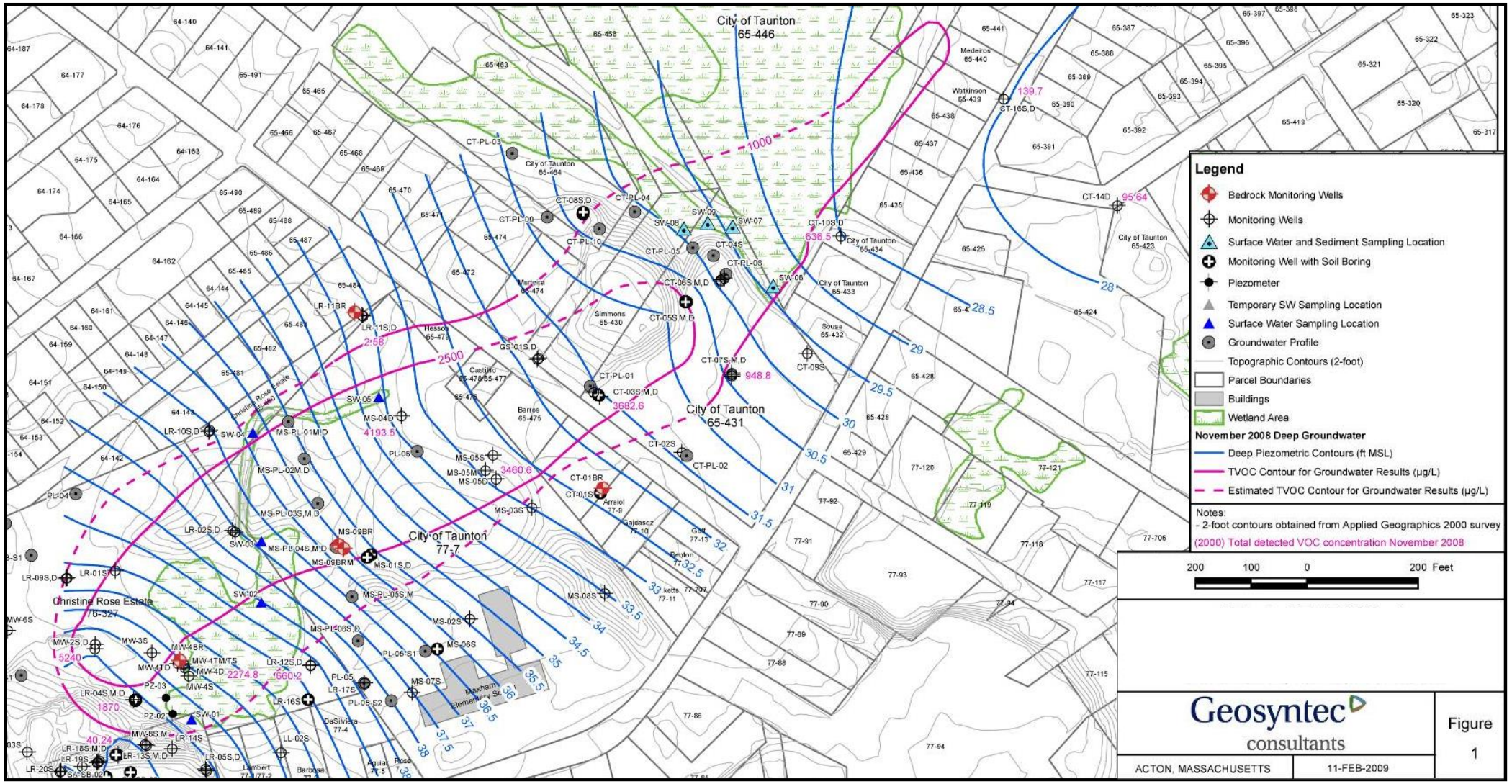
0 50 100 200 Feet

Figure 5

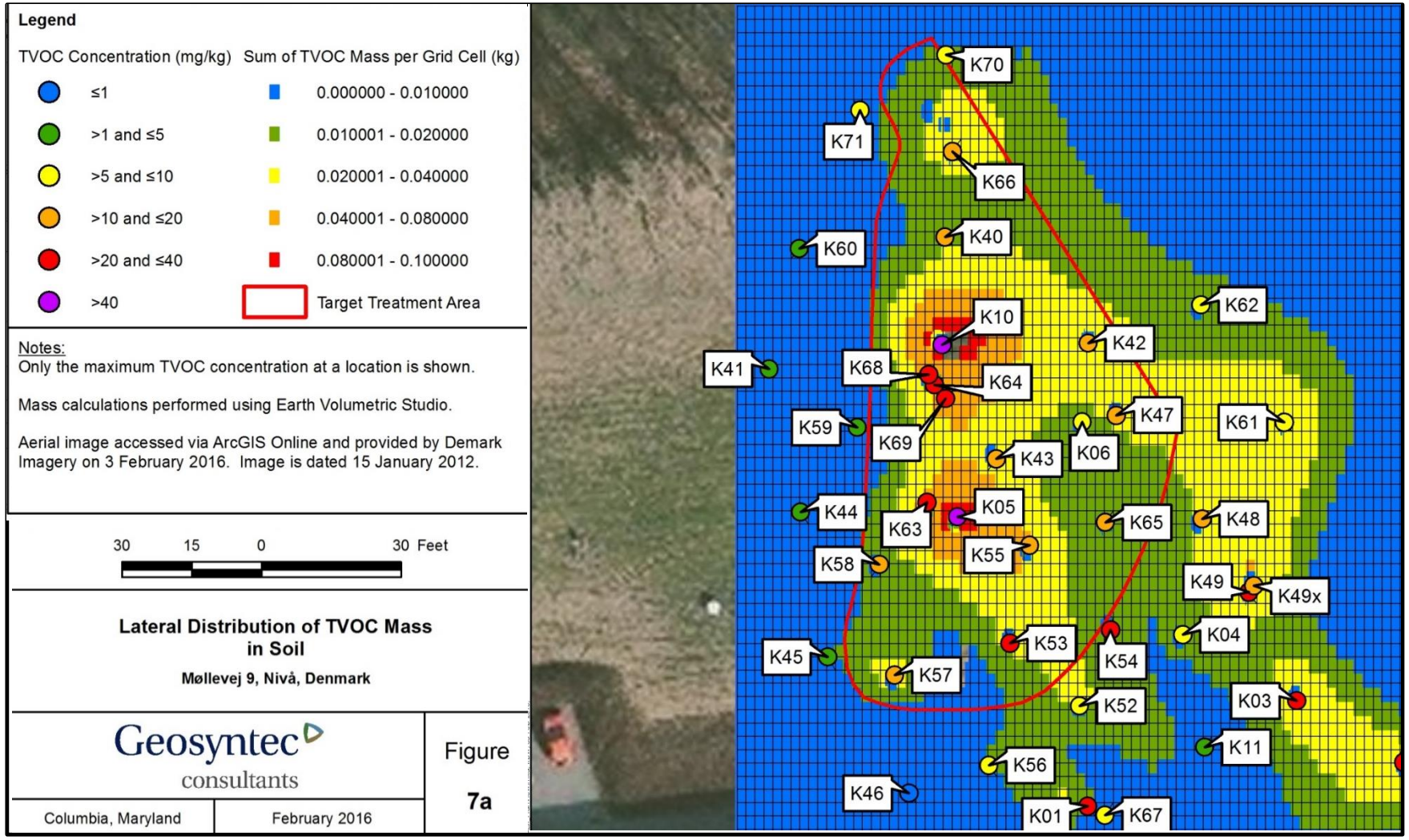
Contour it (Groundwater)



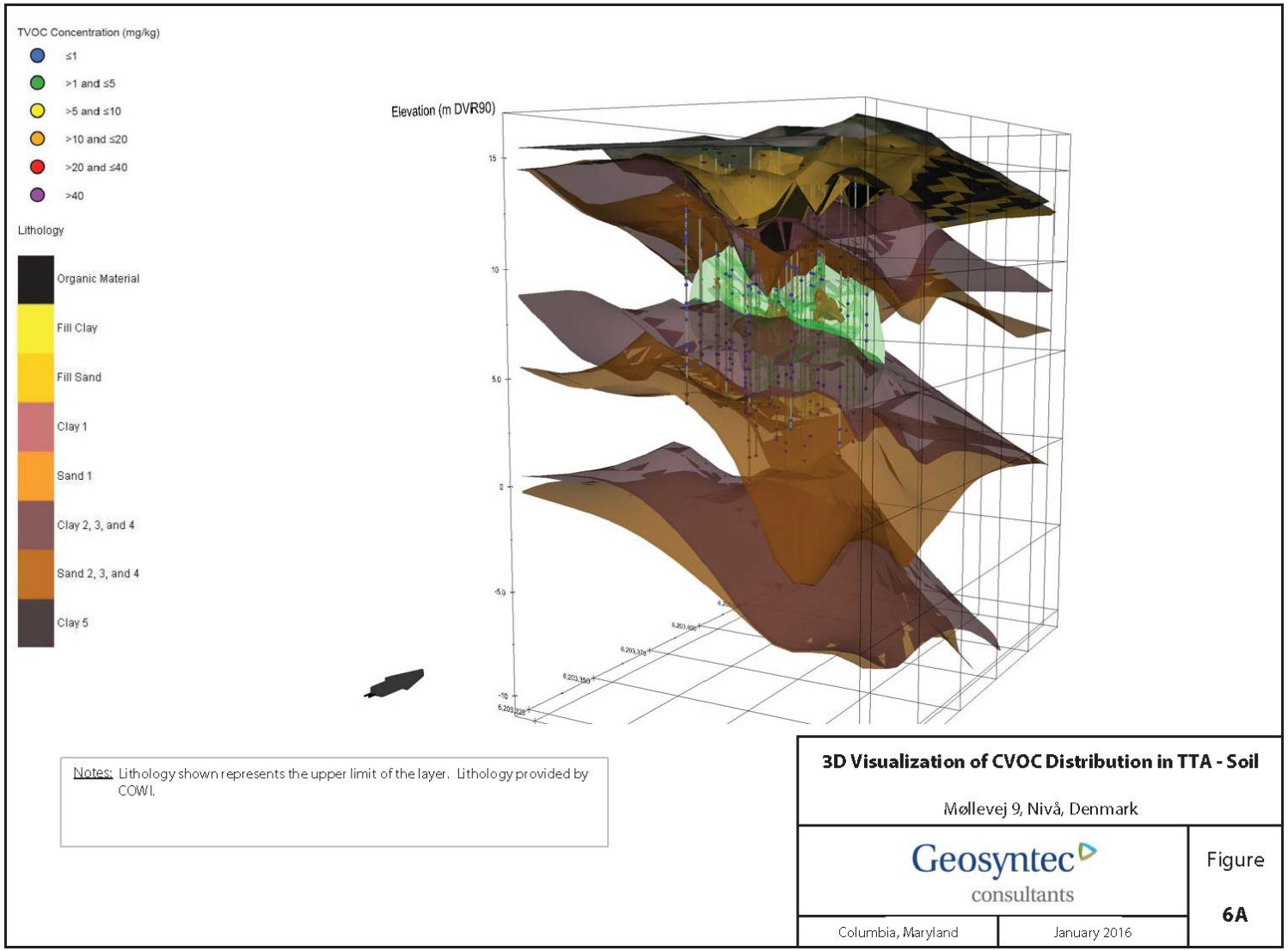
Contour it (Groundwater Concentrations)



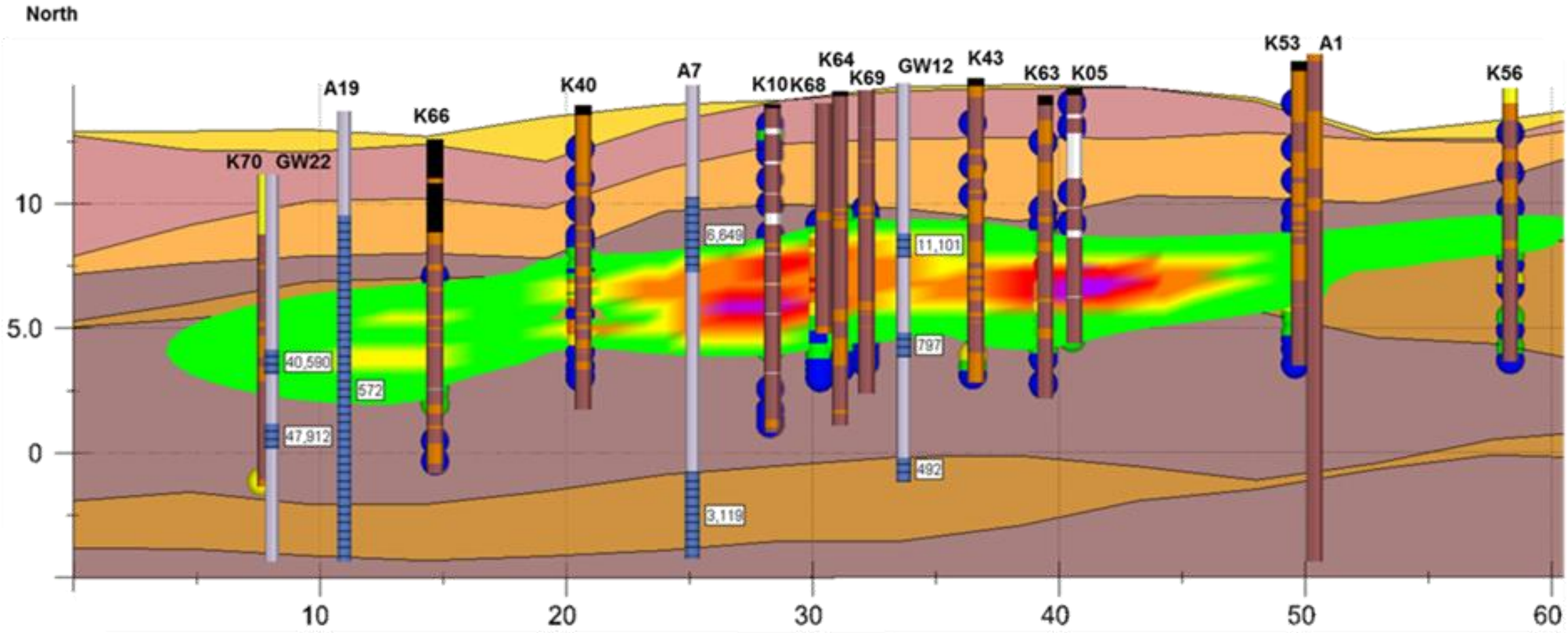
Interpolate it (Soil Concentrations)



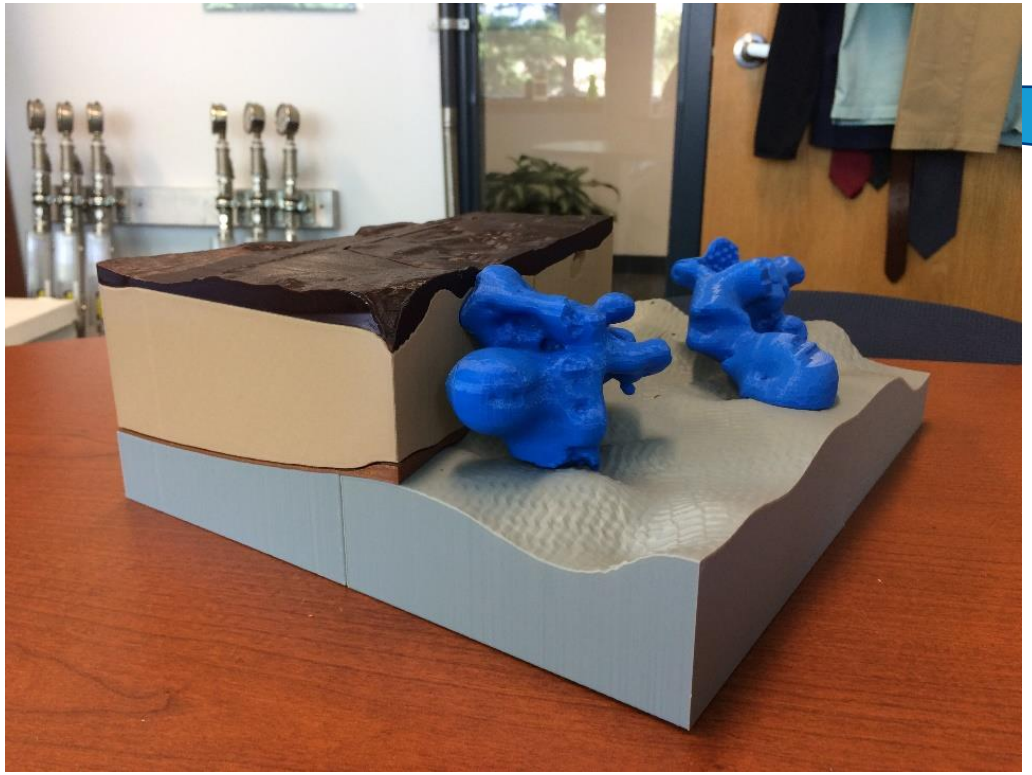
Model it in 3-D
(Soil Concentrations and Geology - EVS model)

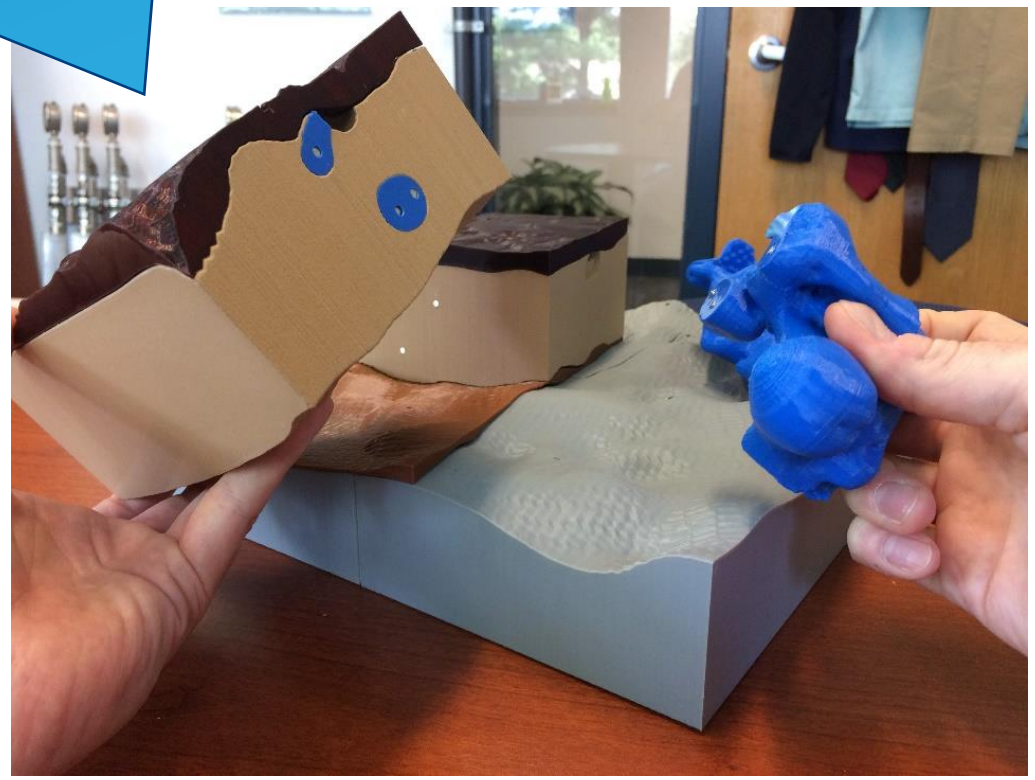


Slice it (Soil Concentrations and Geology)



Why is a 3-D Printed Model Better?





Why is a 3-D Printed Model Better?

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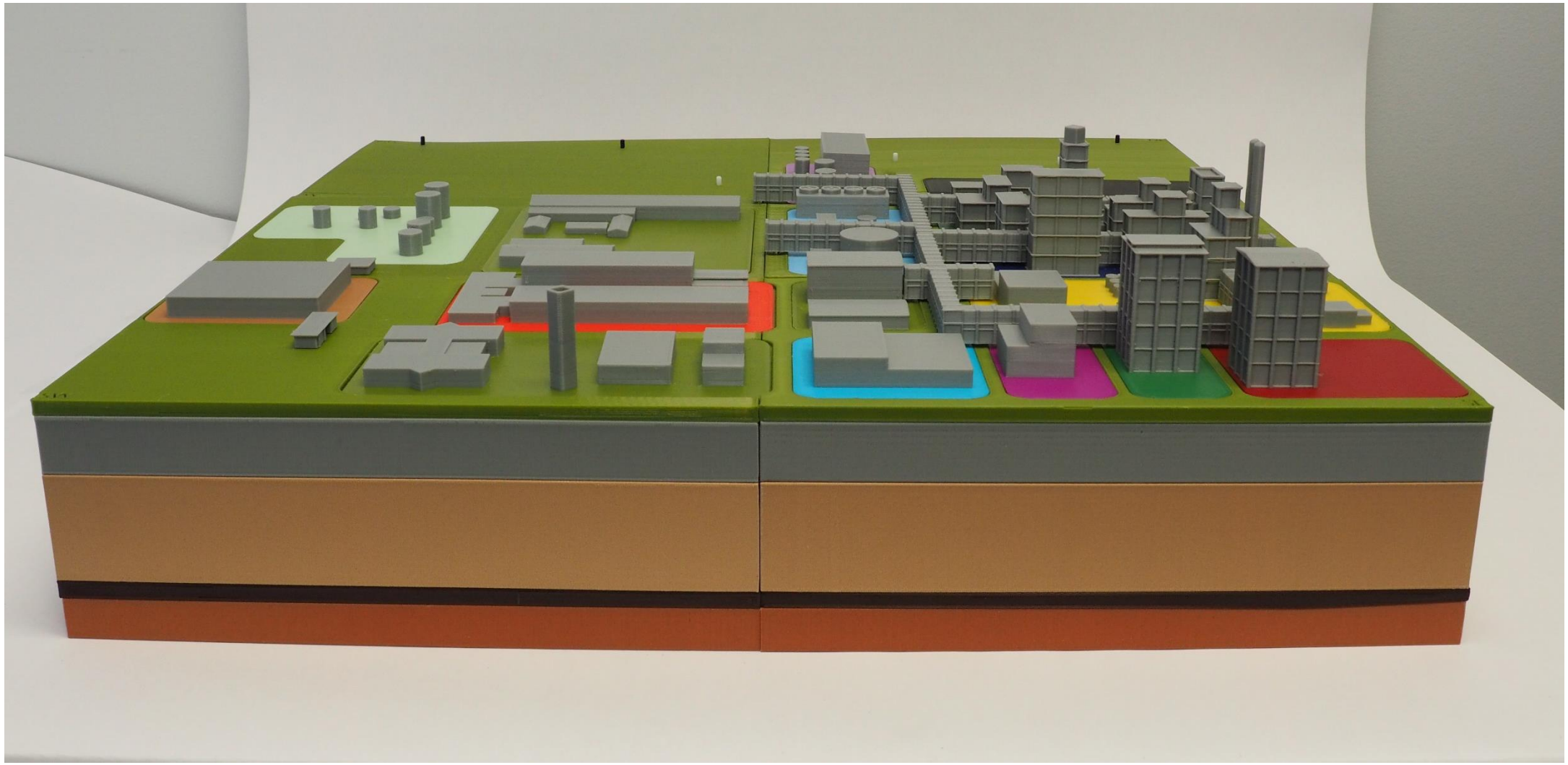

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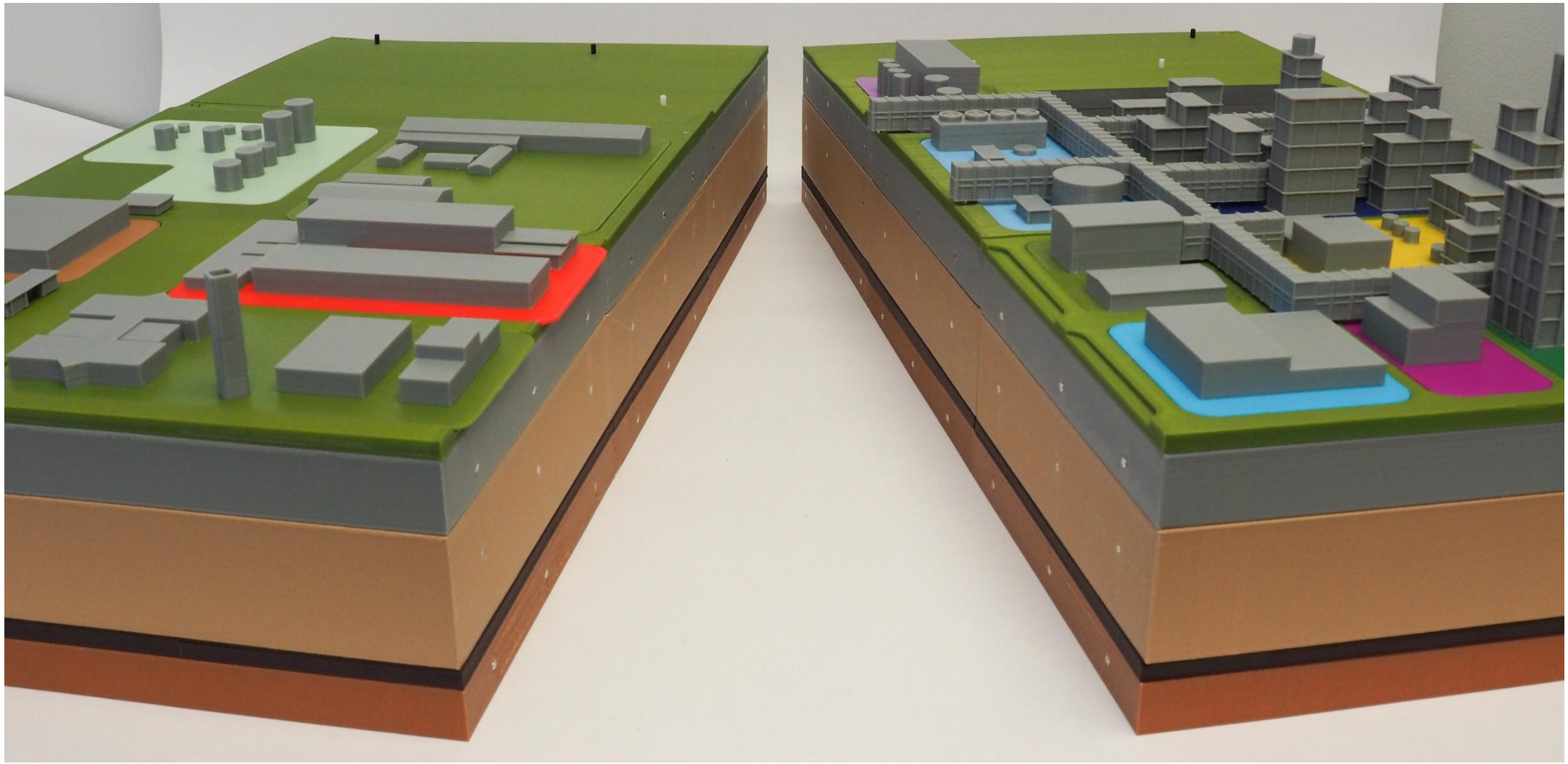

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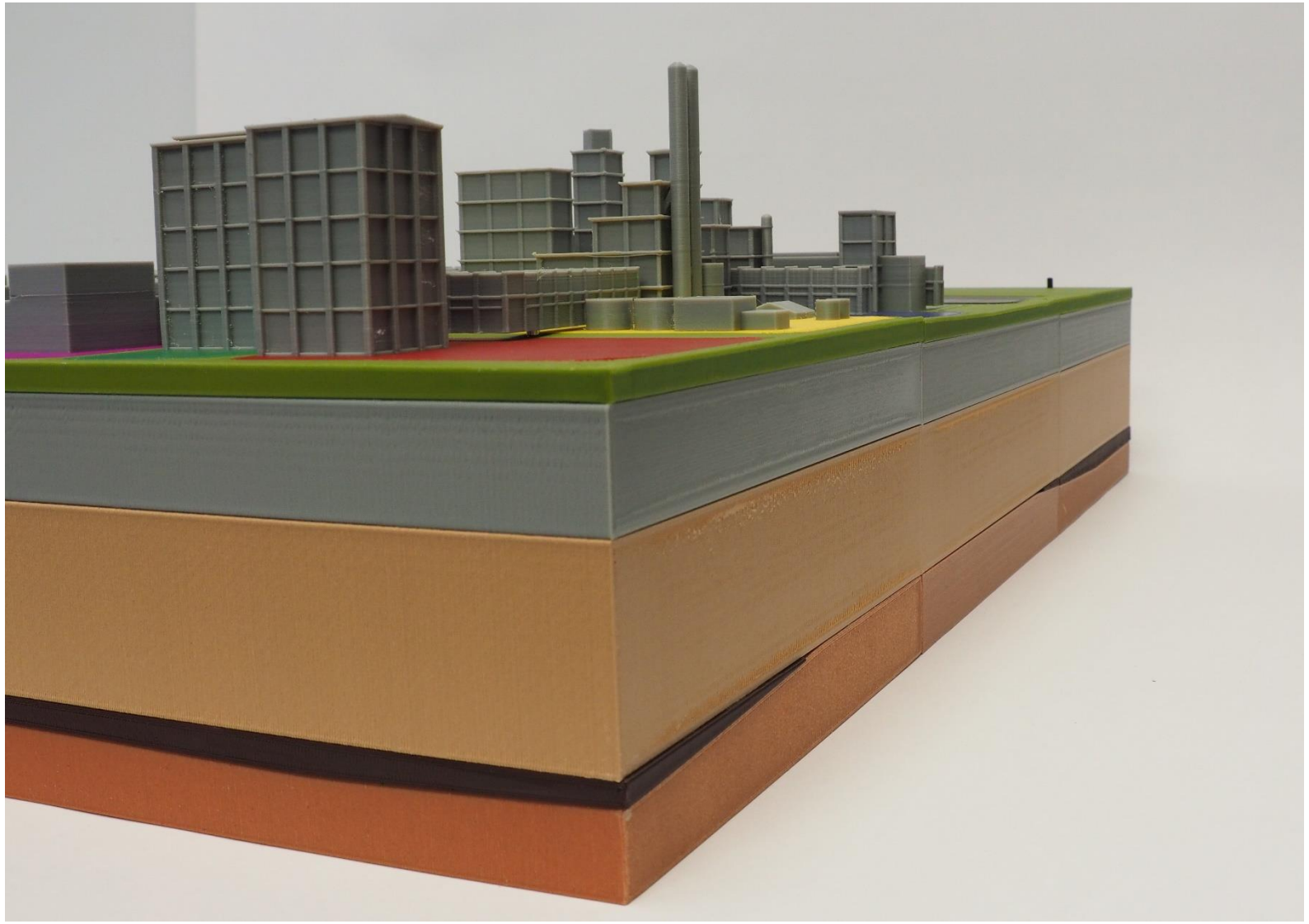

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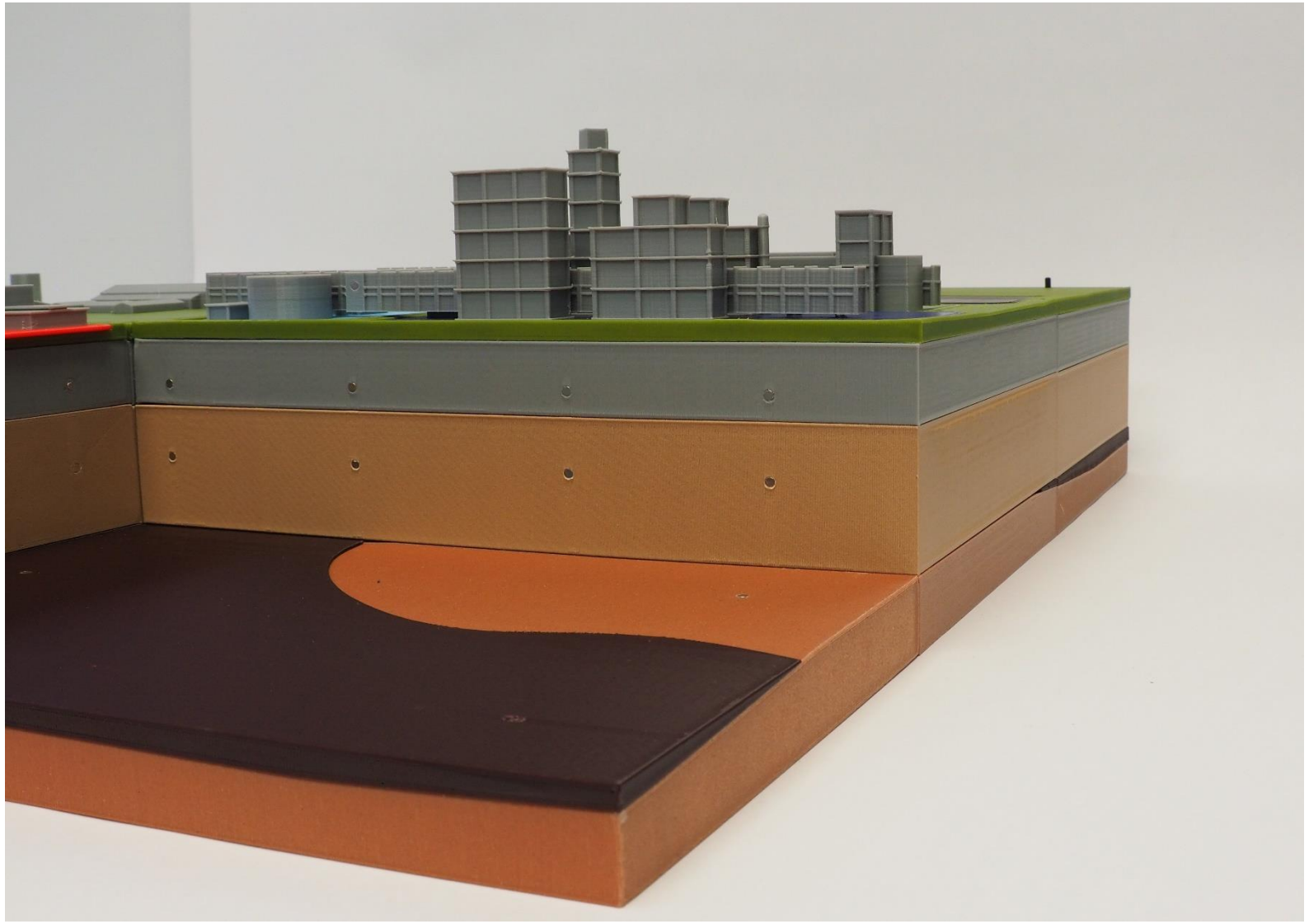

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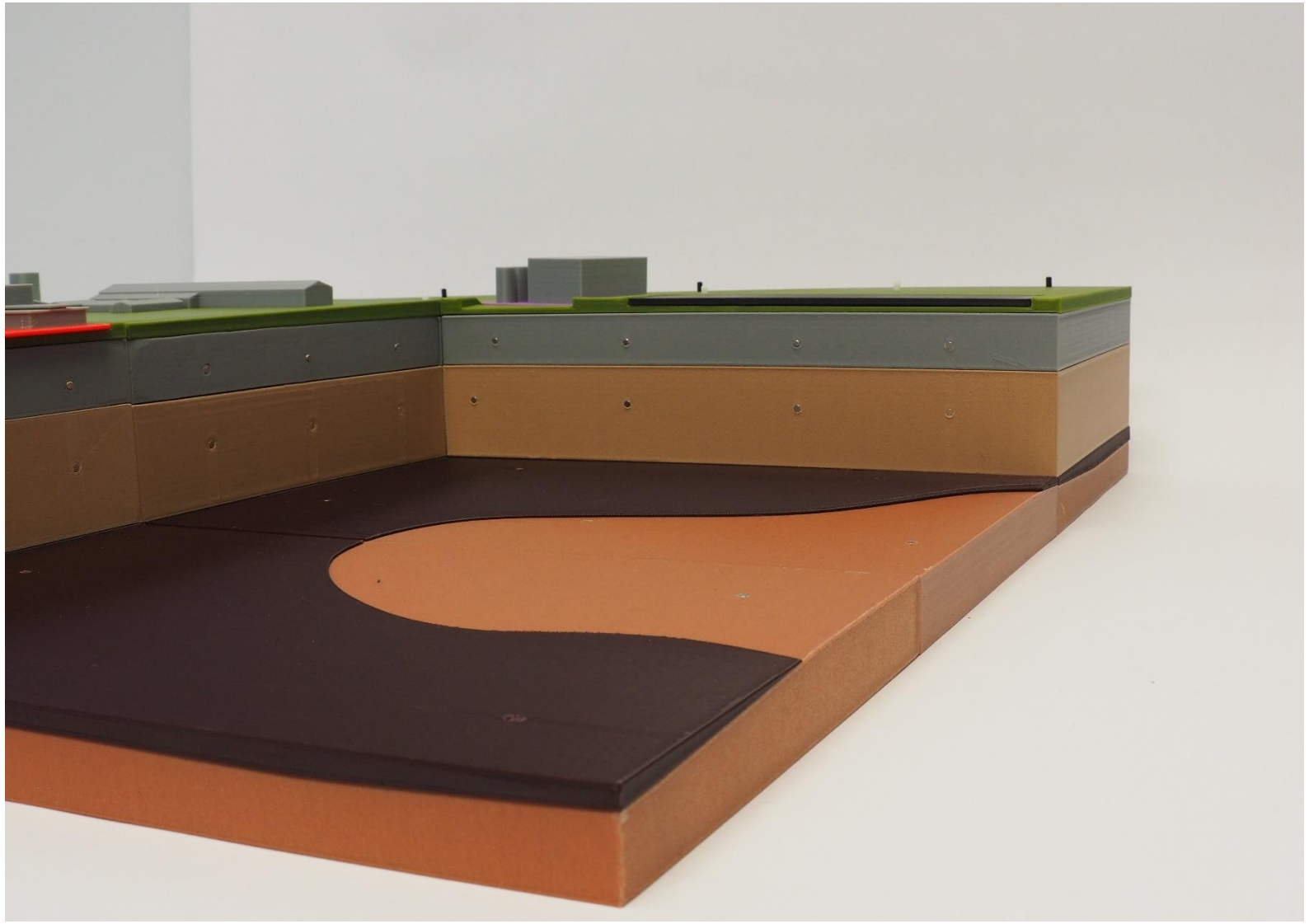

Introduction to 3-D Printing

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- 3-D printing uses additive manufacturing to create physical models from digital 3-D structures.
- Printer costs range from $500 to $50,000+.
- Raw materials range from $20-$100/kg.
- 3-D printing services are becoming widely available for rapid prototyping and small-scale manufacturing.
- Visualizing environmental data and site geology is a novel application for 3-D printing.
- Geosyntec has been using 3-D printing since 2013.

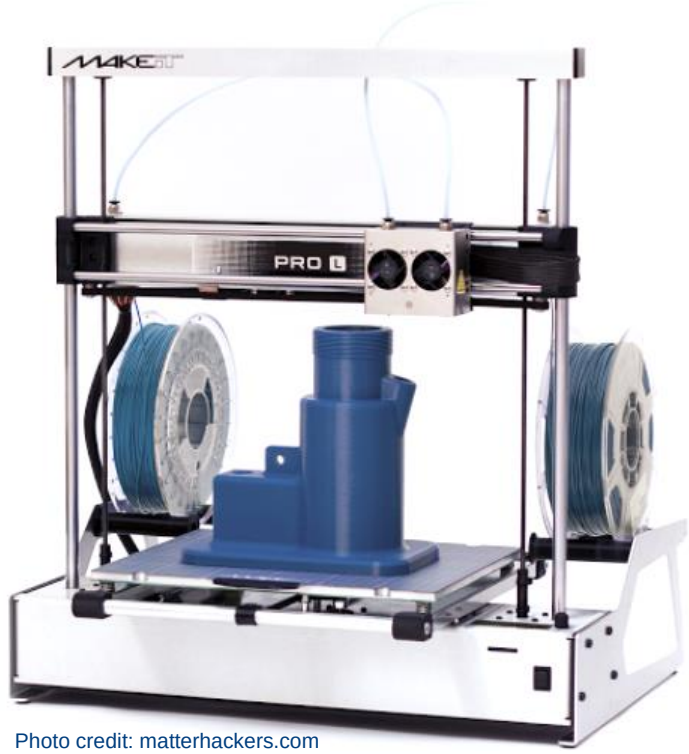

Photo credit: matterhackers.com

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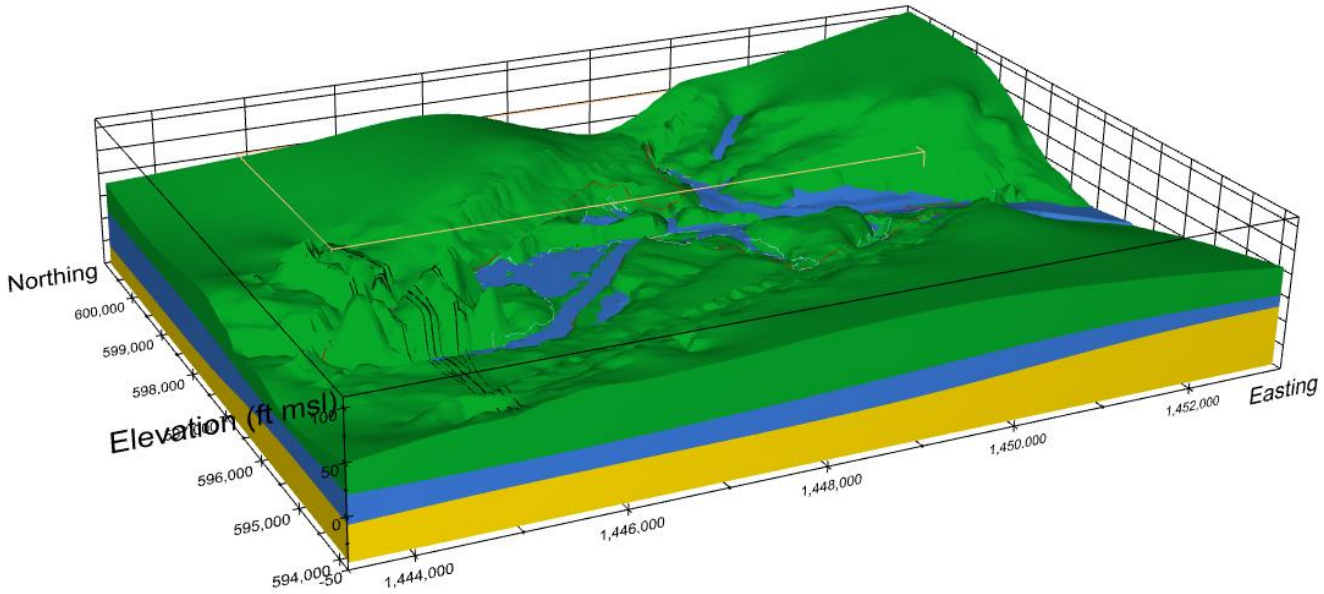
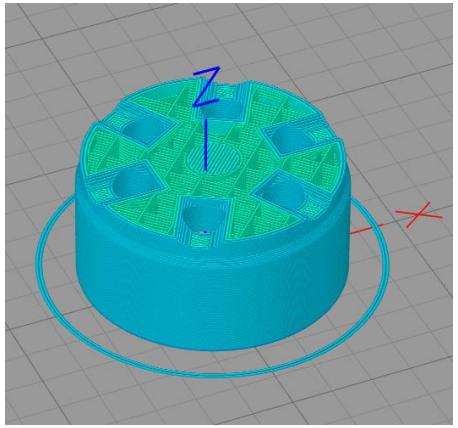
Digital 3-D models can be created in many software packages:

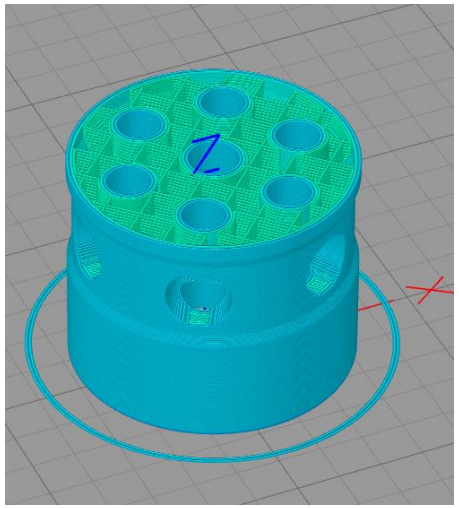
- AutoCAD
- EVS
- EarthVision
- Blender
- Rhino

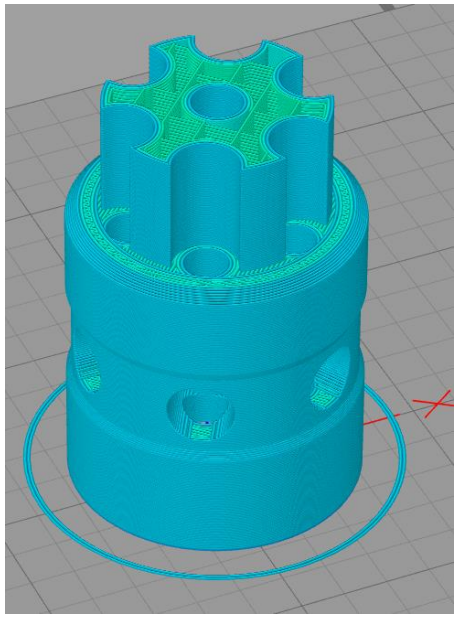


Converting a digital 3-D model to a physical model requires the following steps:

- Convert your 3-D model to file format used for 3-D printing (.stl file)
- Process (or “slice”) the model into the file that printer uses to create the shape







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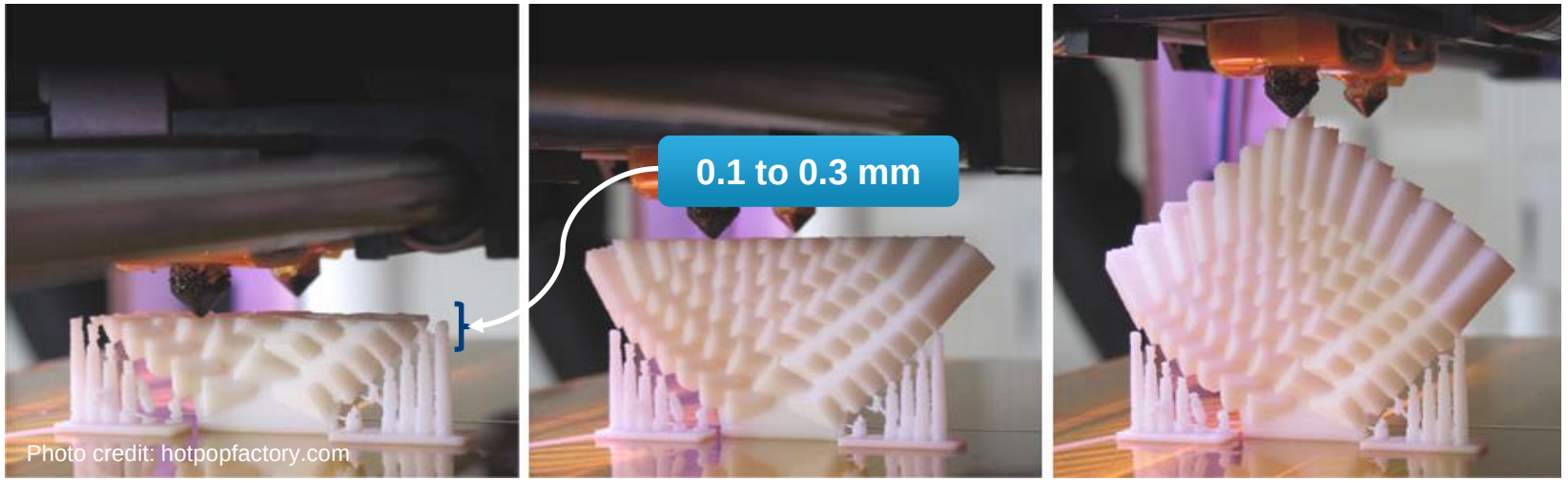
Converting a digital 3-D model to a physical model requires the following steps:

- Select material and color (ABS, PLA, Nylon, Flexible polyurethane, and many more)
- Print!

Printer builds model in layers (slices) from the bottom up.



Post-Process/Finish the model:

- Trimming
- Sanding/polishing
- Acetone washing (smoothing)

How did we get started? DPT Jet Injection Tool

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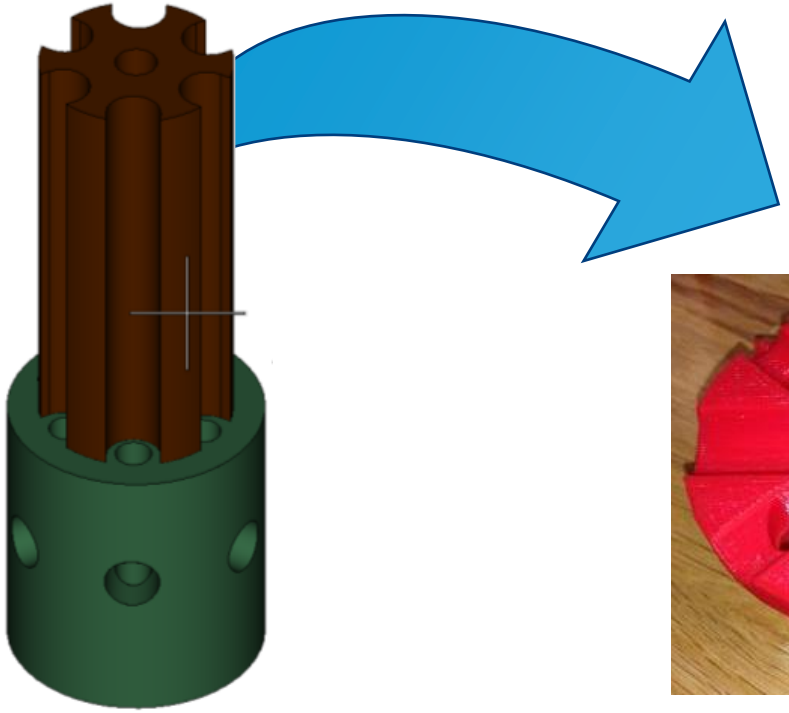
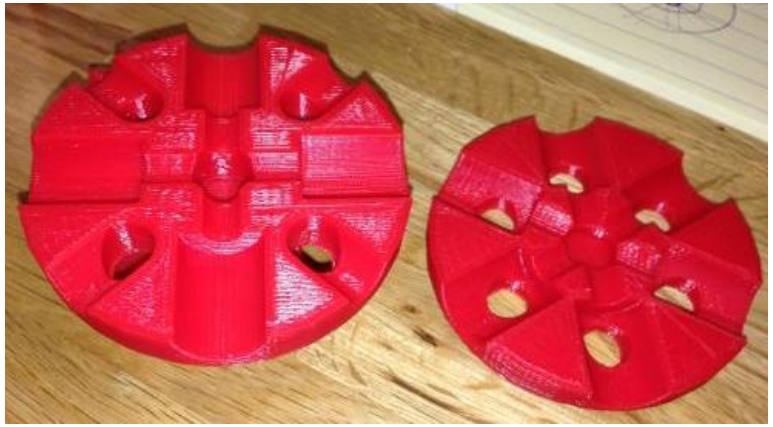
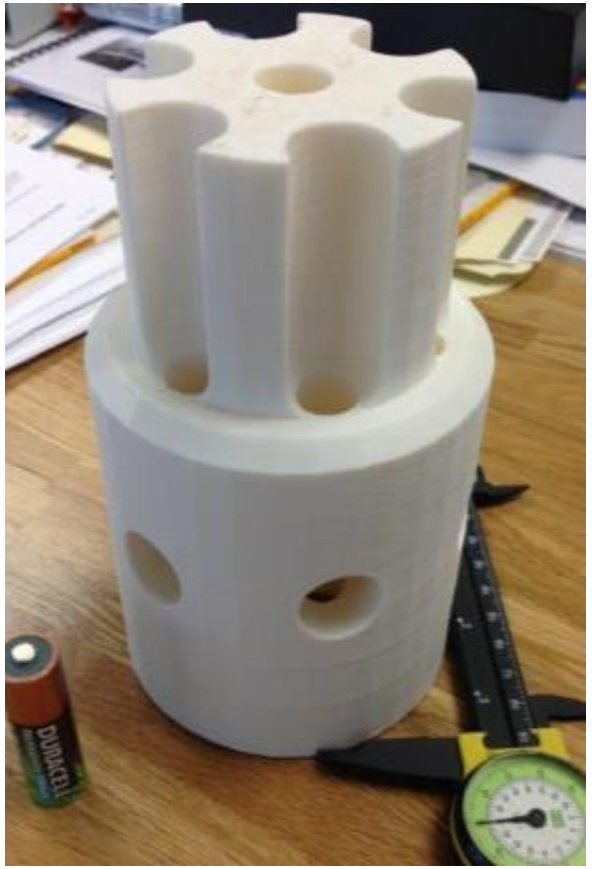
Digital 3-D Model (created in AutoCAD)



3-D Printed Physical Models





Case Study #1 - Distribution of ZVI in Clay Till

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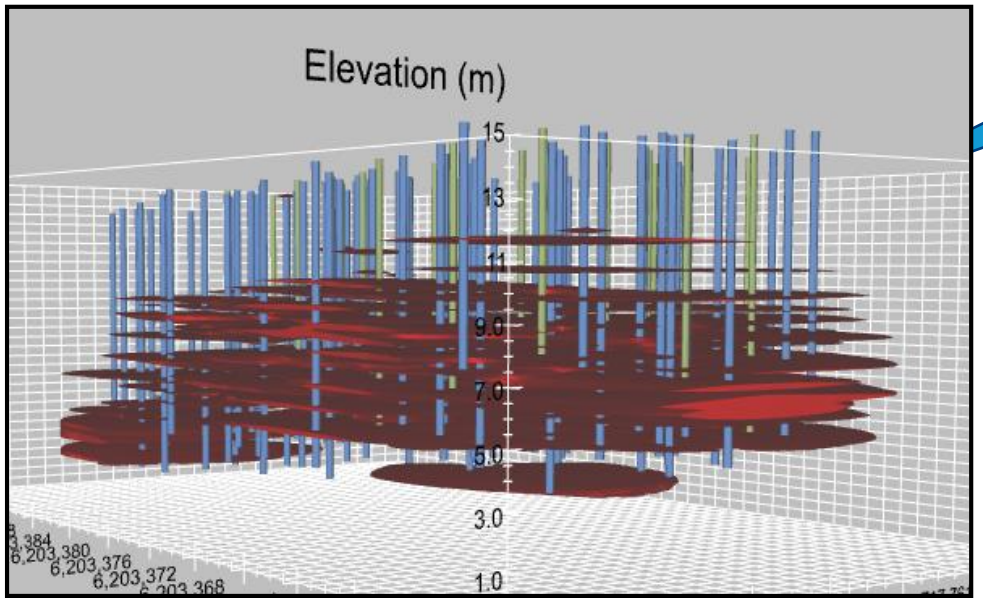

Virtual 3-D Model (created in EVS)

3-D Printed Model

Case Study #1 - Distribution of ZVI in Clay Till

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3-D Printed Model

3-D printed model shows distribution of zero-valent iron (ZVI) layers emplaced in clay using jet injection.

Case Study #2 - NAPL and Geology Model – Superfund Site

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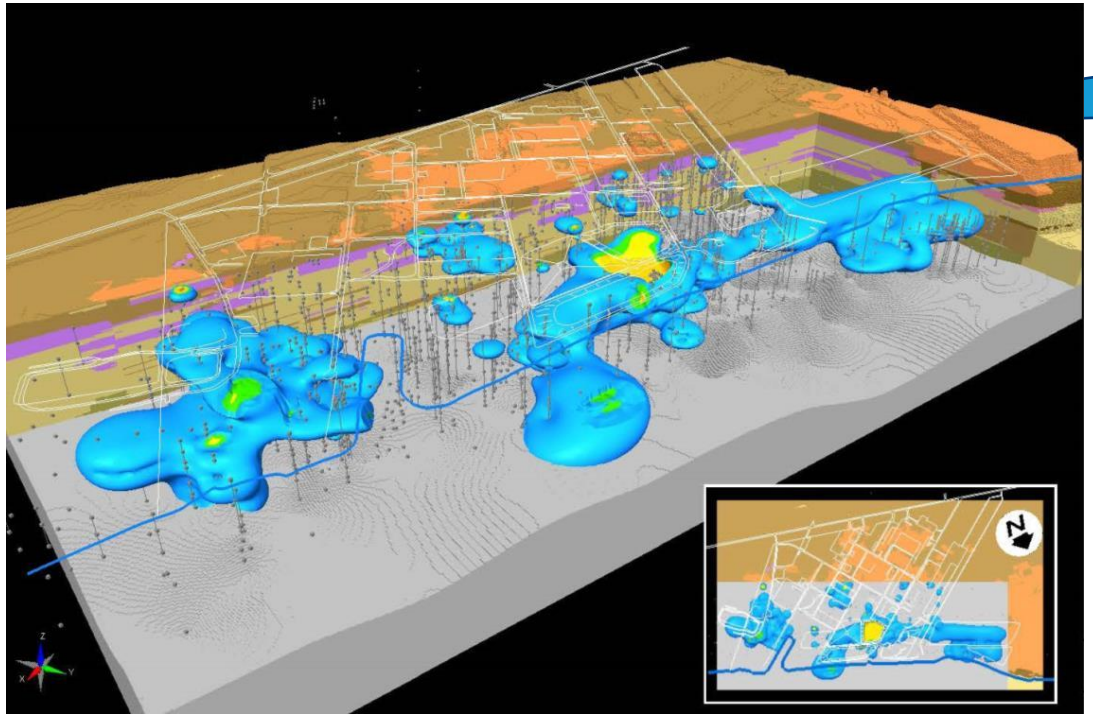

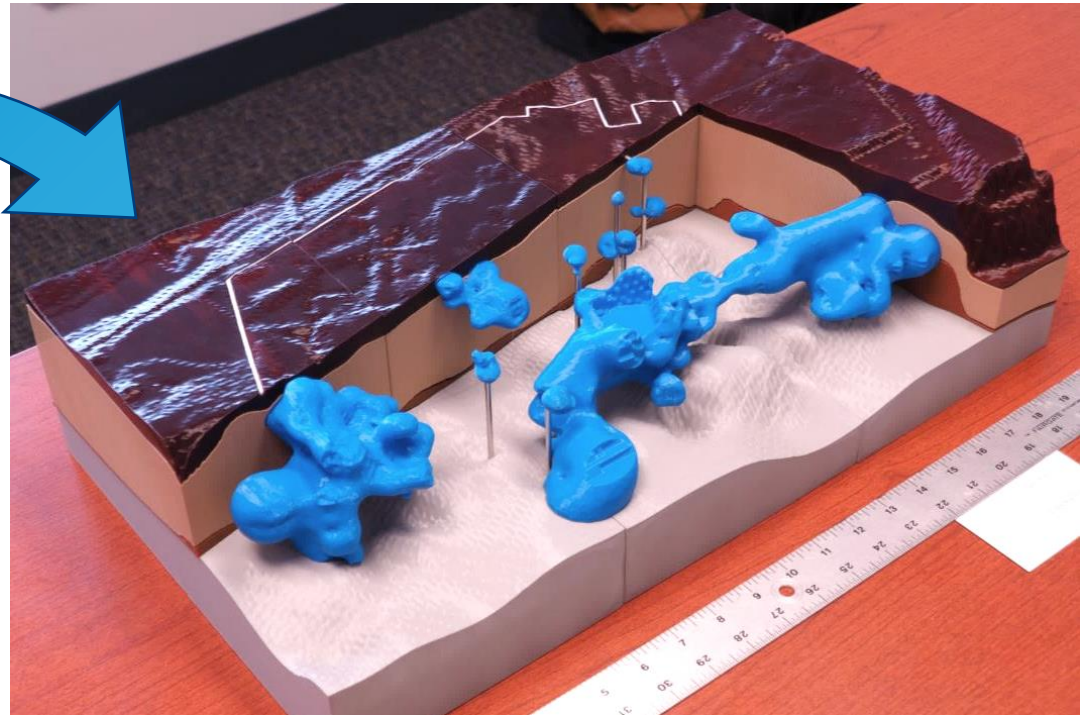

Virtual 3-D Model

3-D Printed Desktop Model

Case Study #2 - NAPL and Geology Model – Superfund Site

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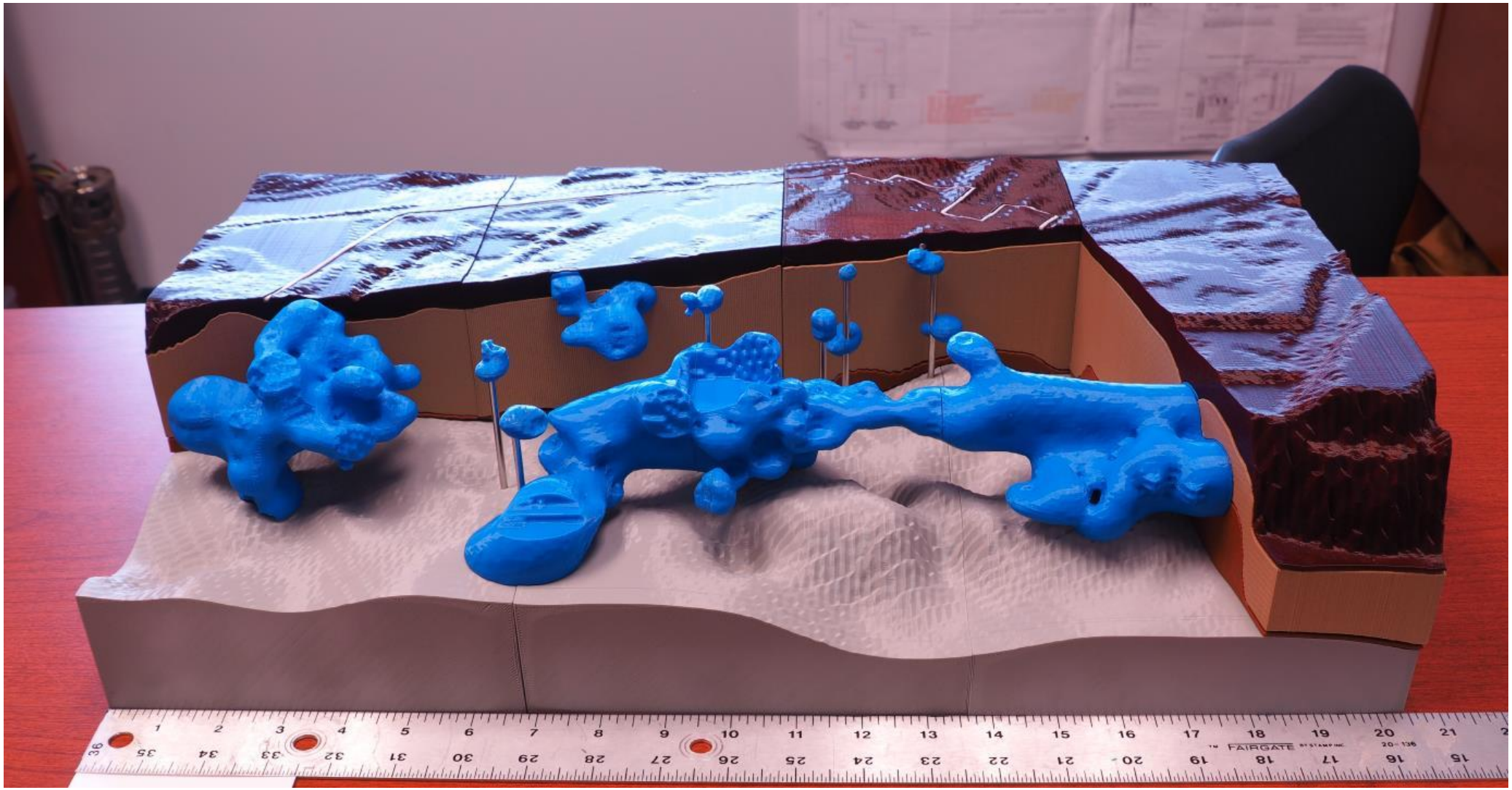

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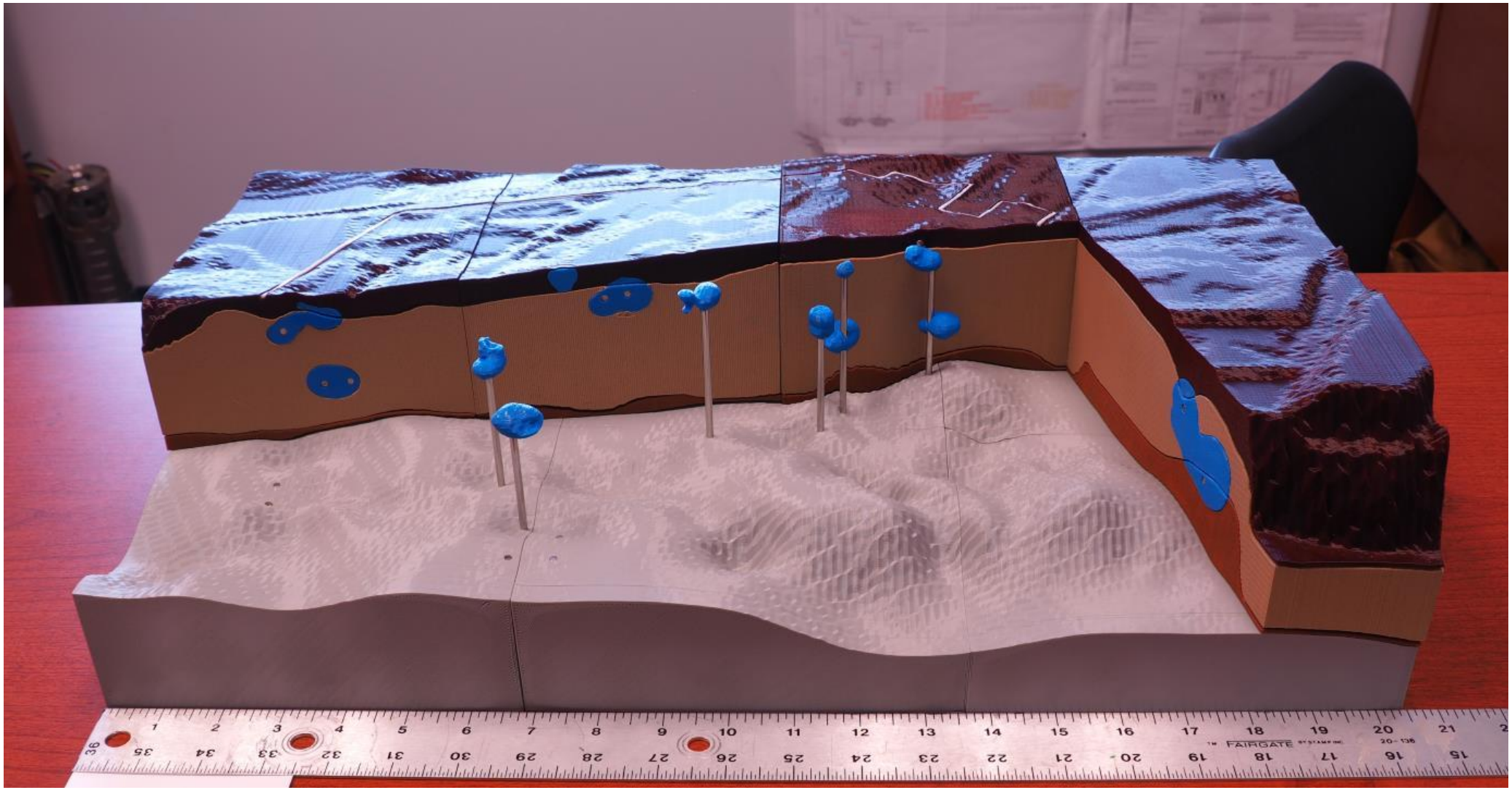

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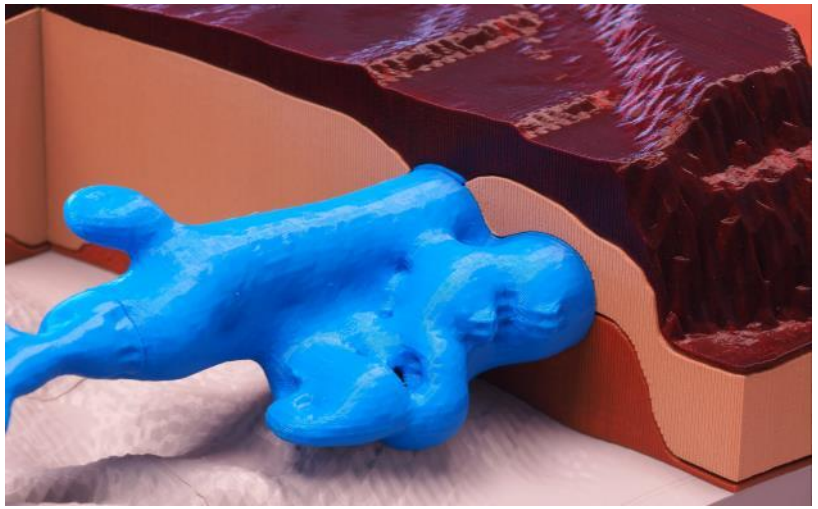

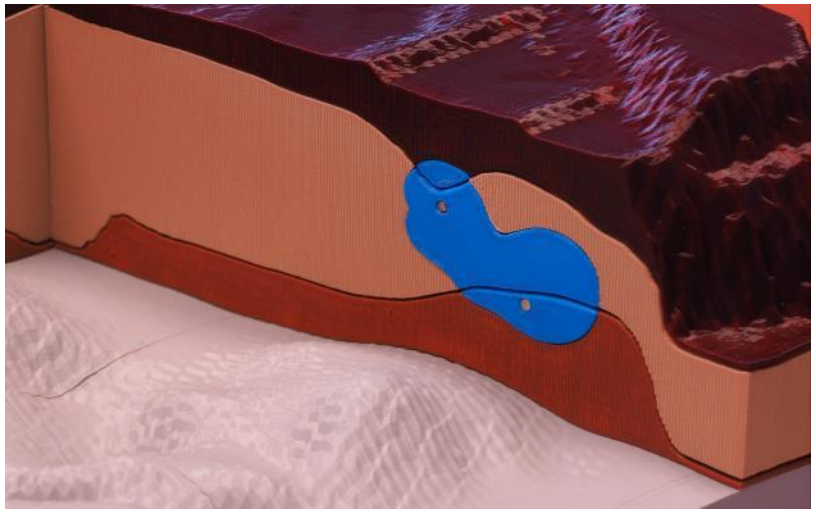

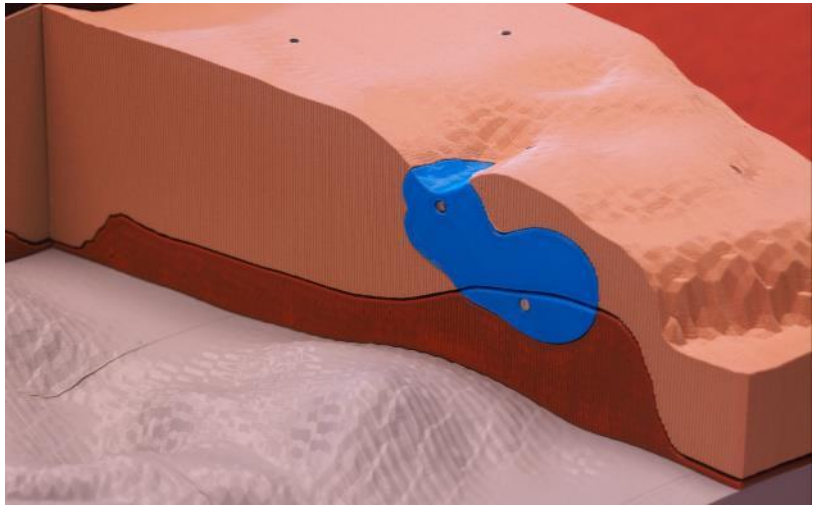

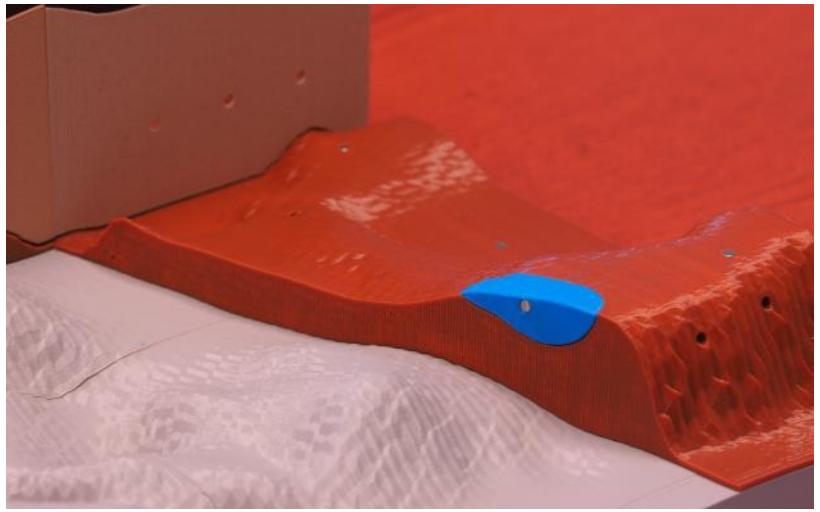

Case Study #3 - Landfill Scale Model

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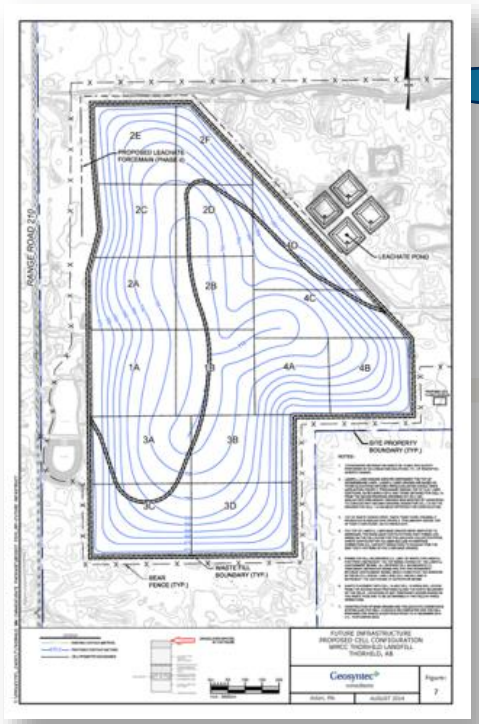
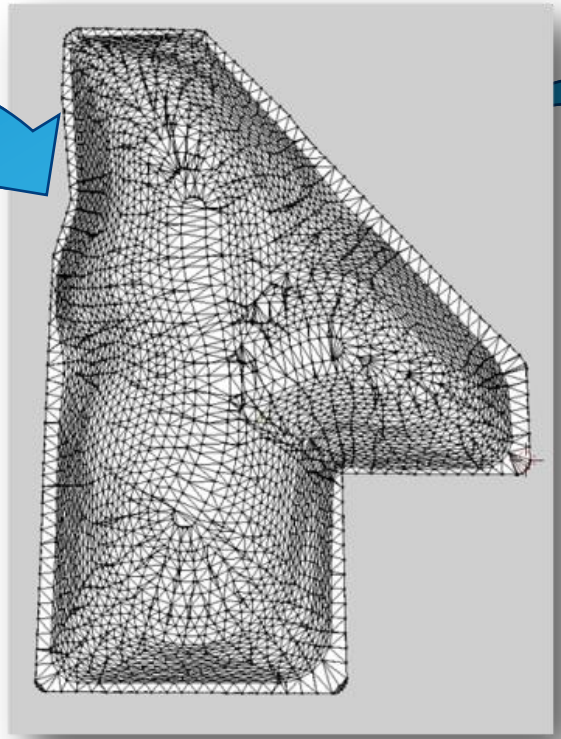
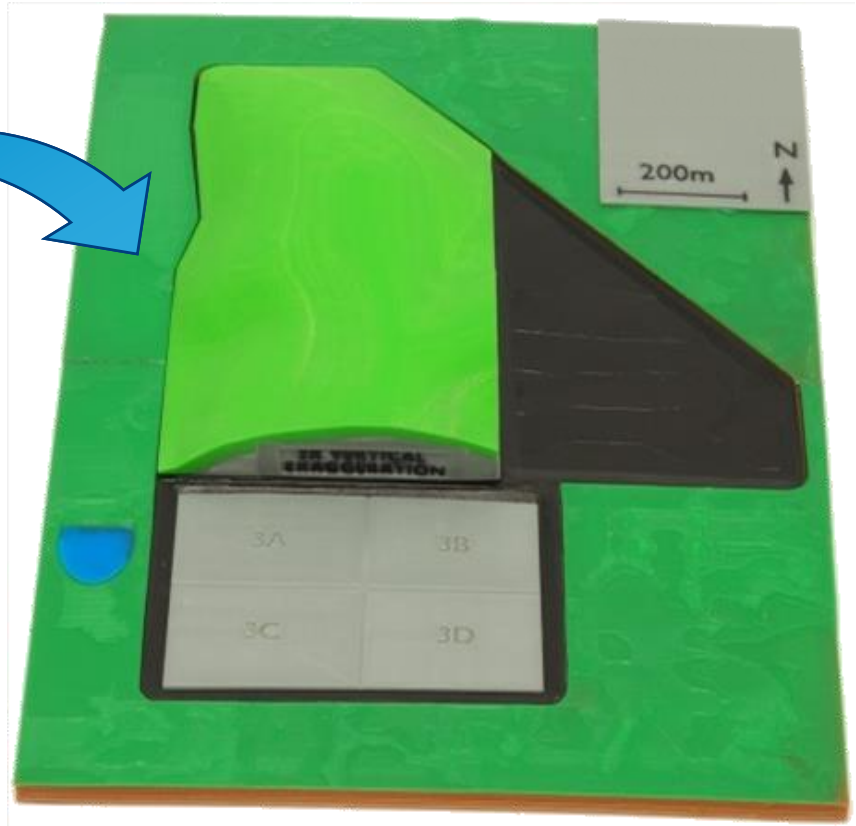
3-D Surface (AutoCAD)



3-D Mesh (.stl)



3-D Printed Scale Model



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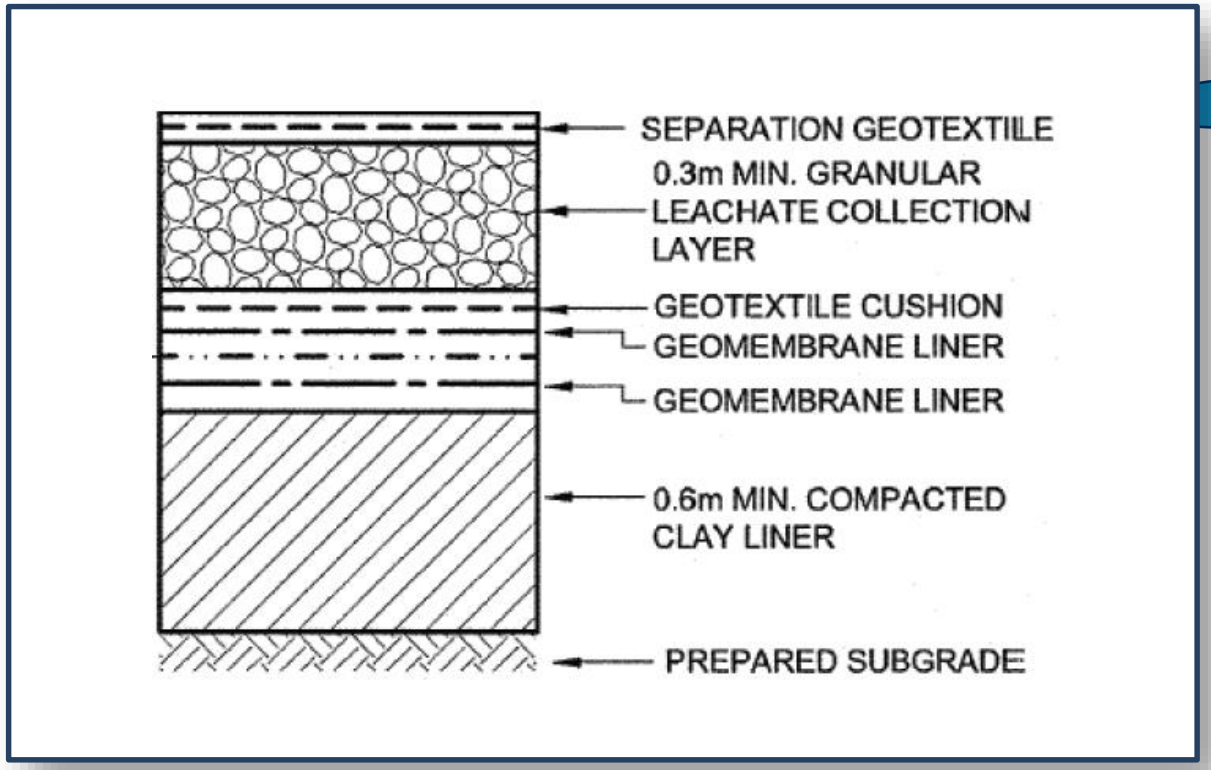

Typical Base Lining System

3-D Printed Block Model

Case Study #3 - Landfill Scale Model

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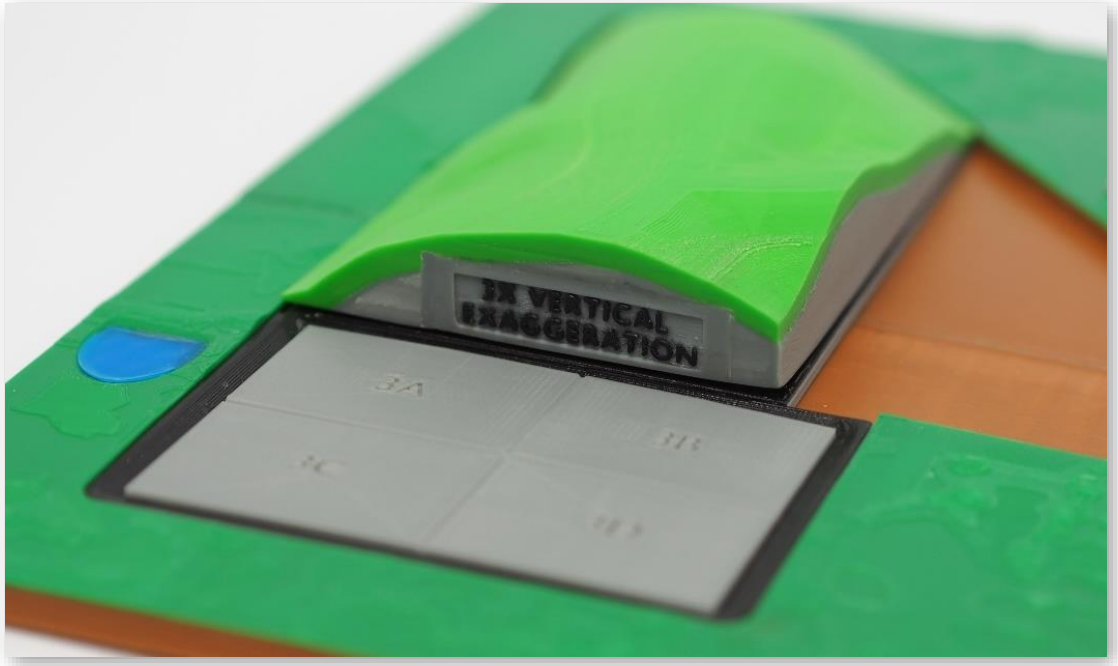
Scale Model:
Final Grades and Site Topography



Block Model:
Liner System Detail

Case Study #4 - Tabletop Model - Chemical Facility in Brazil

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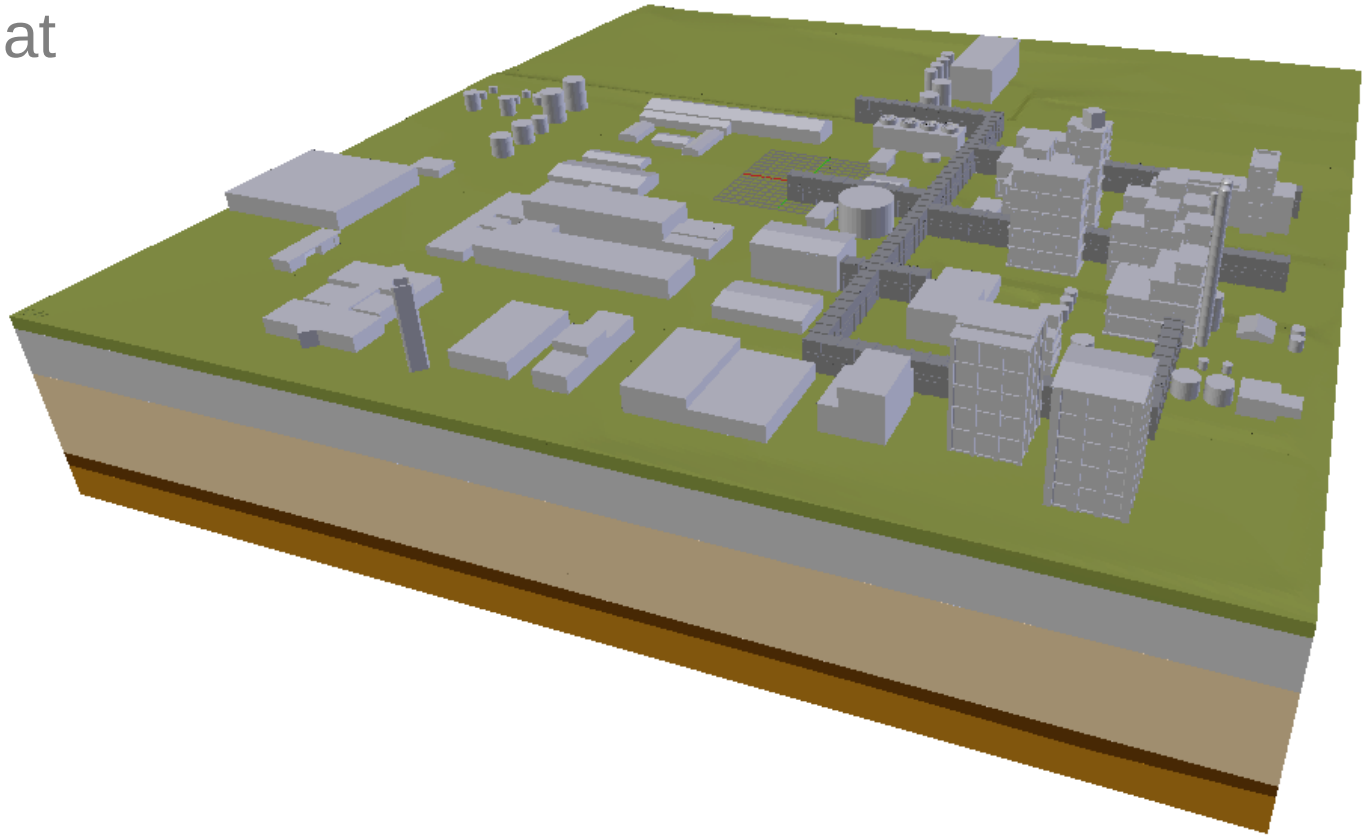
2 ft x 2 ft desktop model showing geologic layers and buildings at chemical plant in Brazil



Case Study #4 - Tabletop Model - Chemical Facility in Brazil

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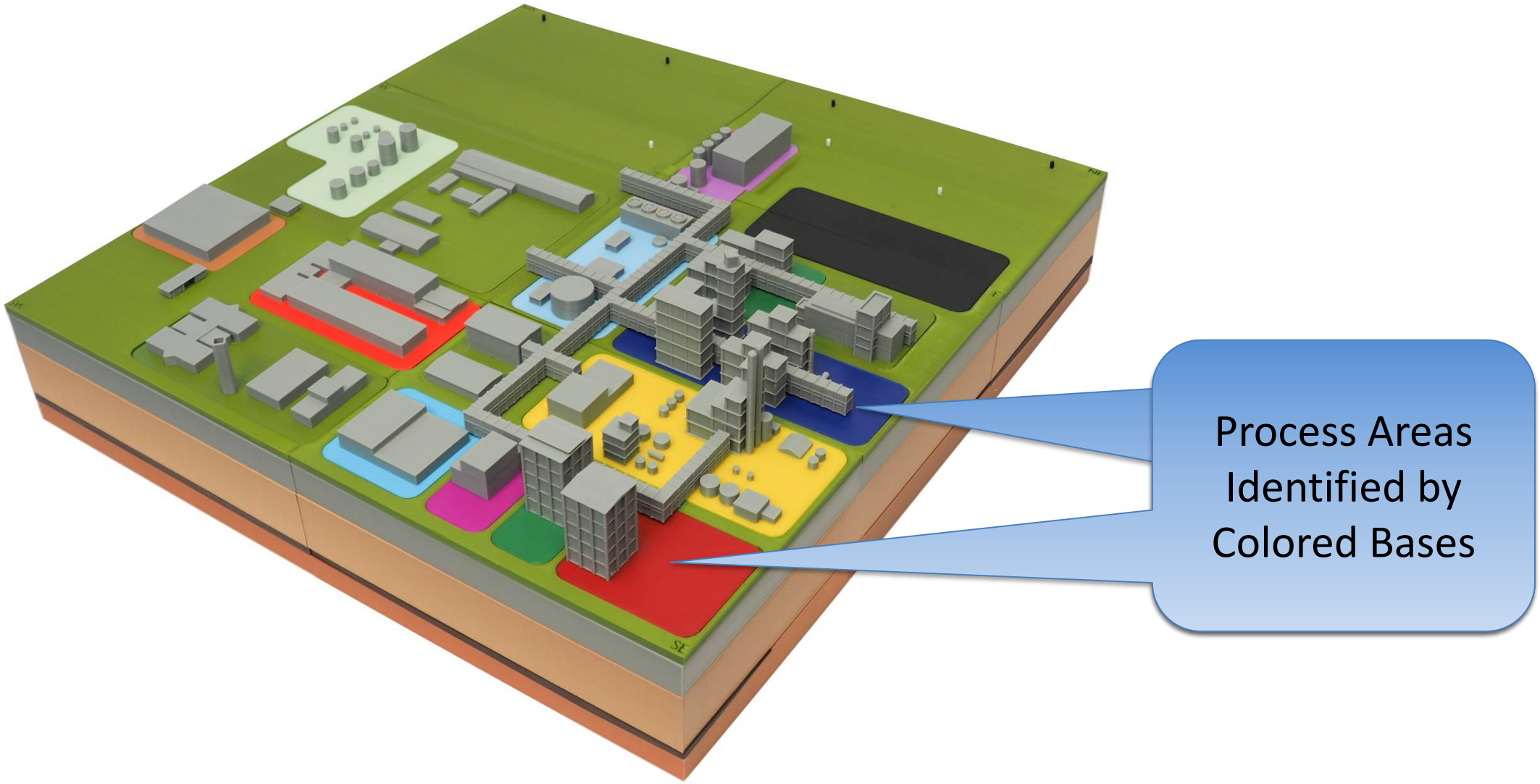

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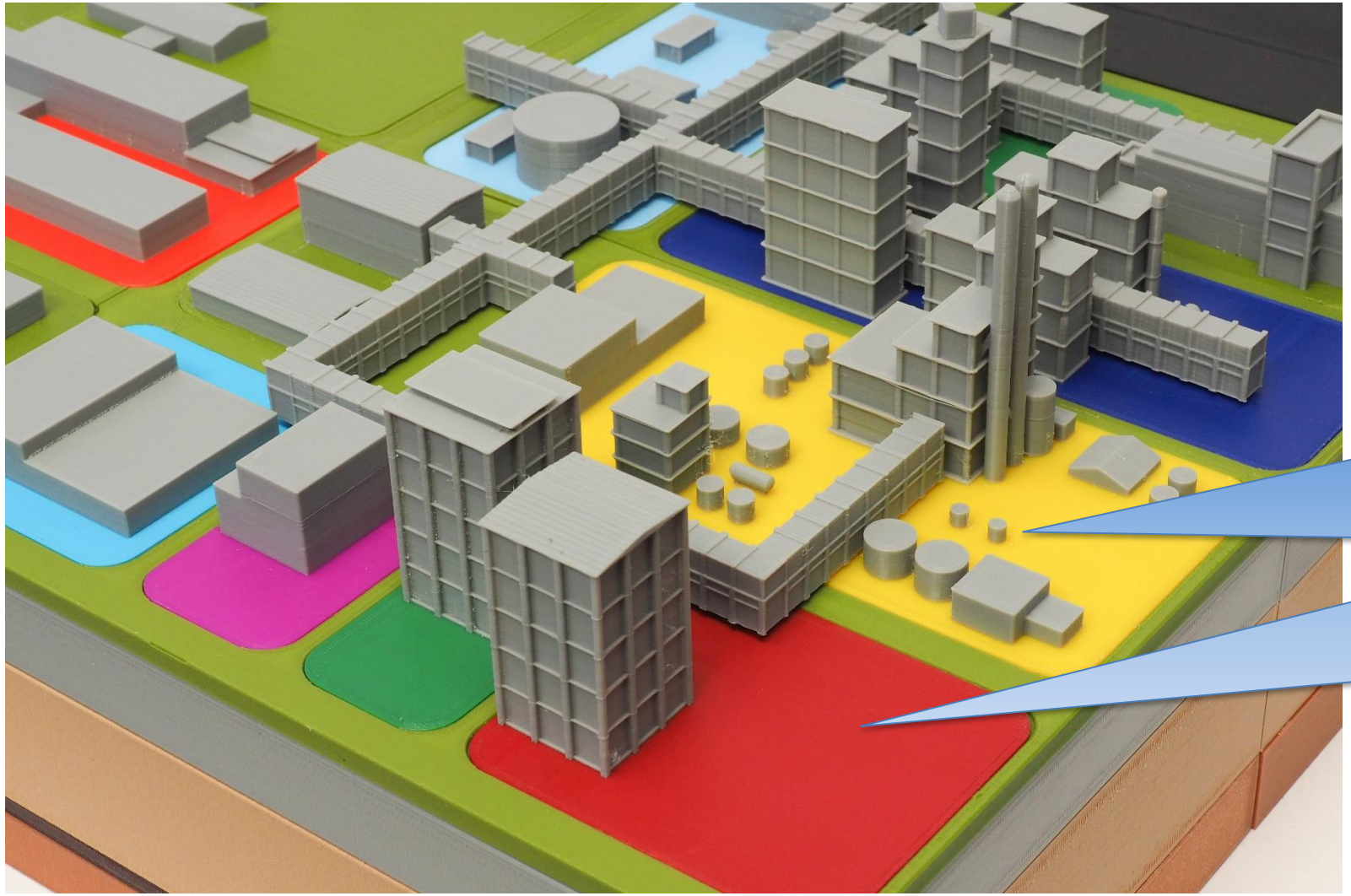

Process Areas Identified by Colored Bases

Case Study #4 - Tabletop Model - Chemical Facility in Brazil

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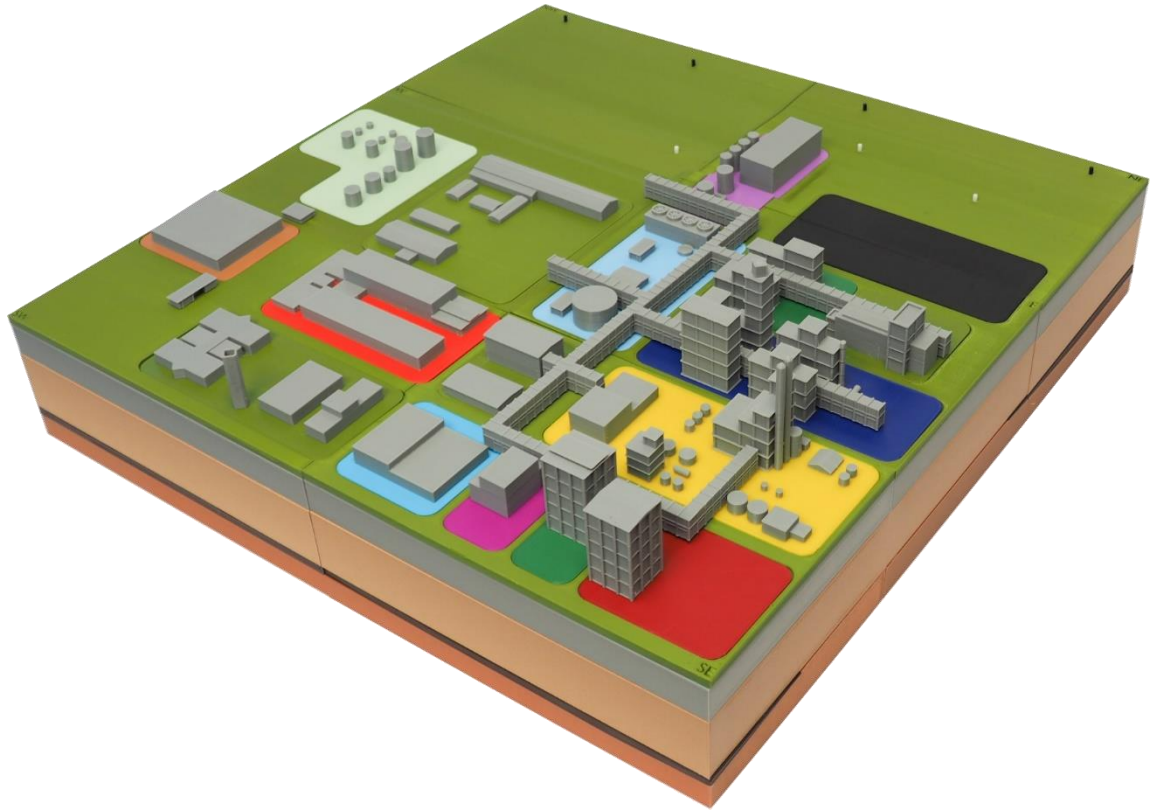

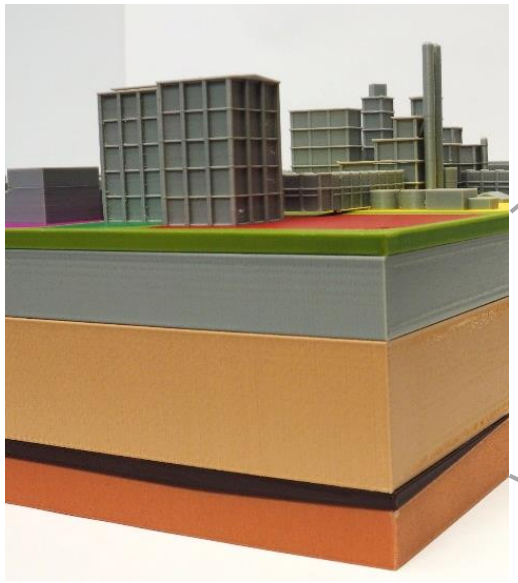

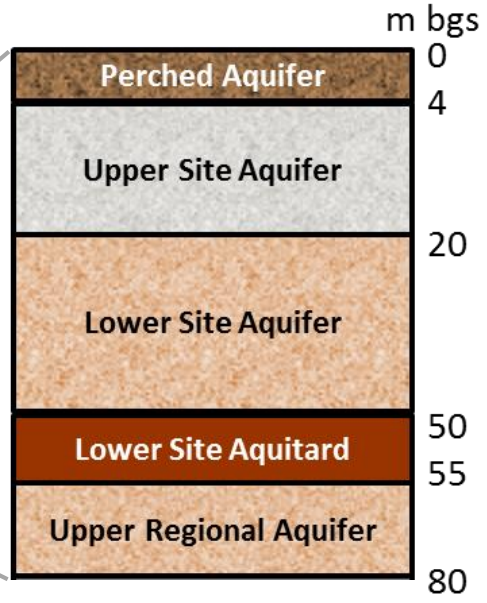

Case Study #4 - Tabletop Model - Chemical Facility in Brazil

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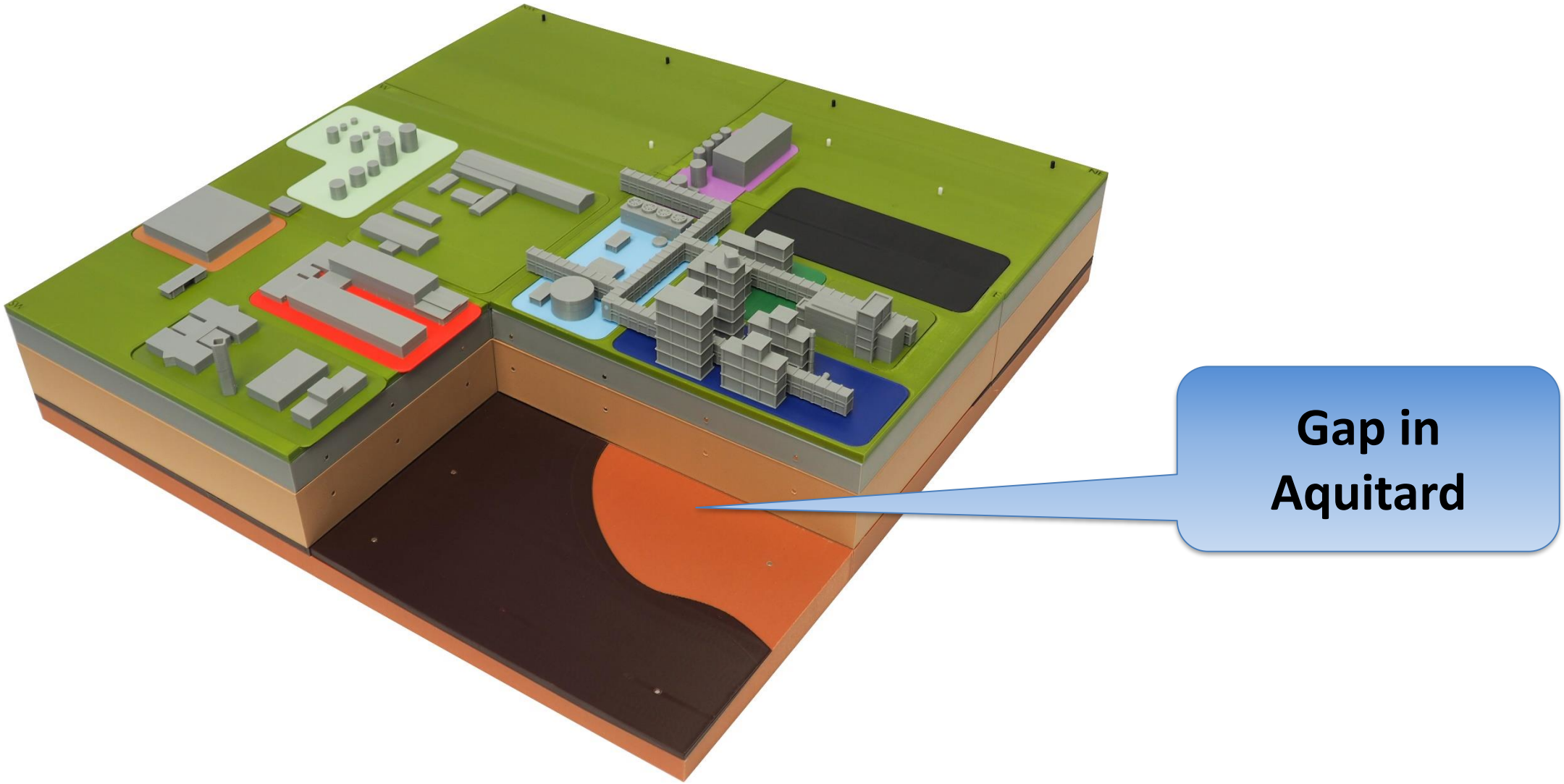

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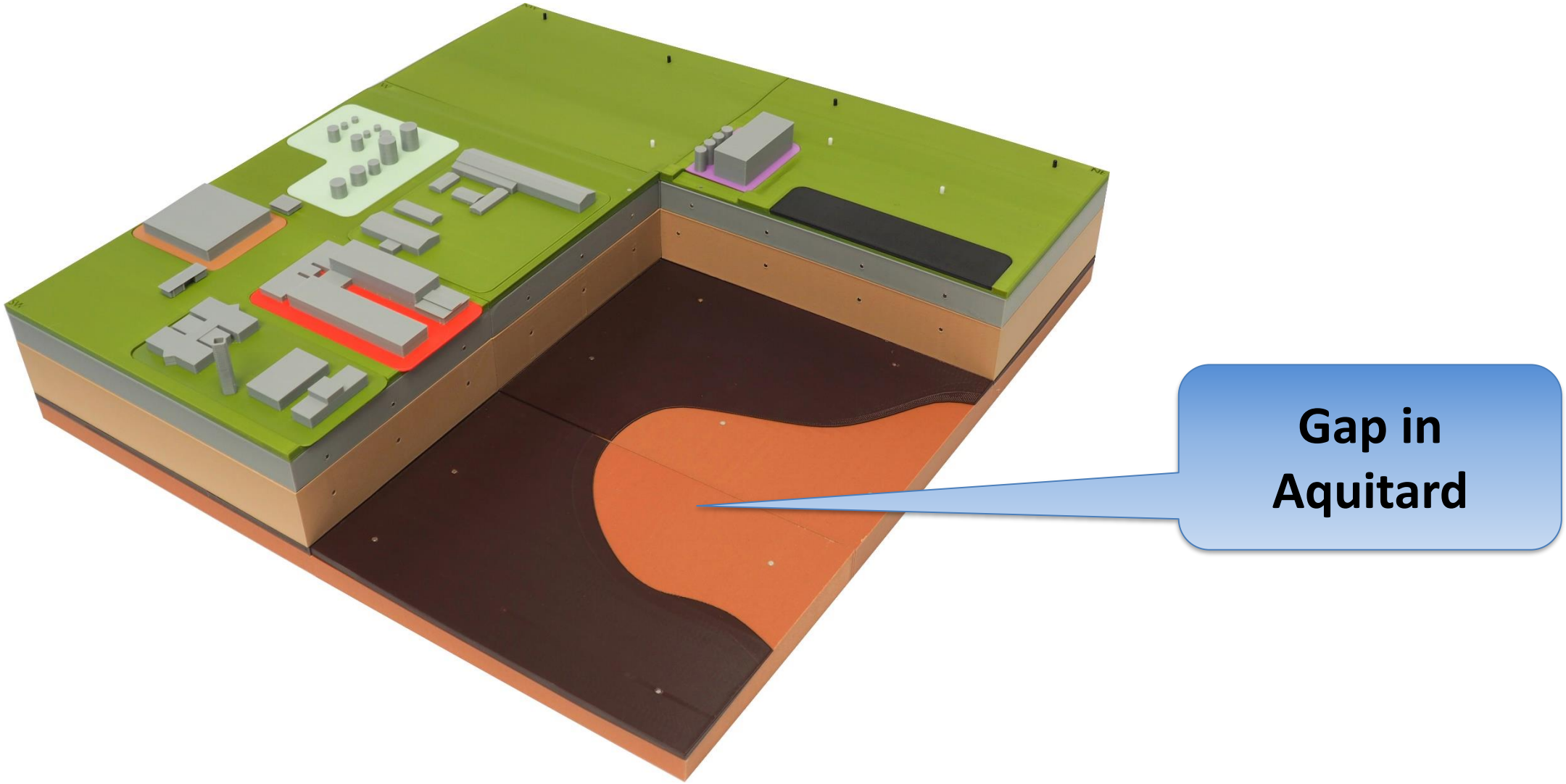

Potential Applications for 3-D Printing

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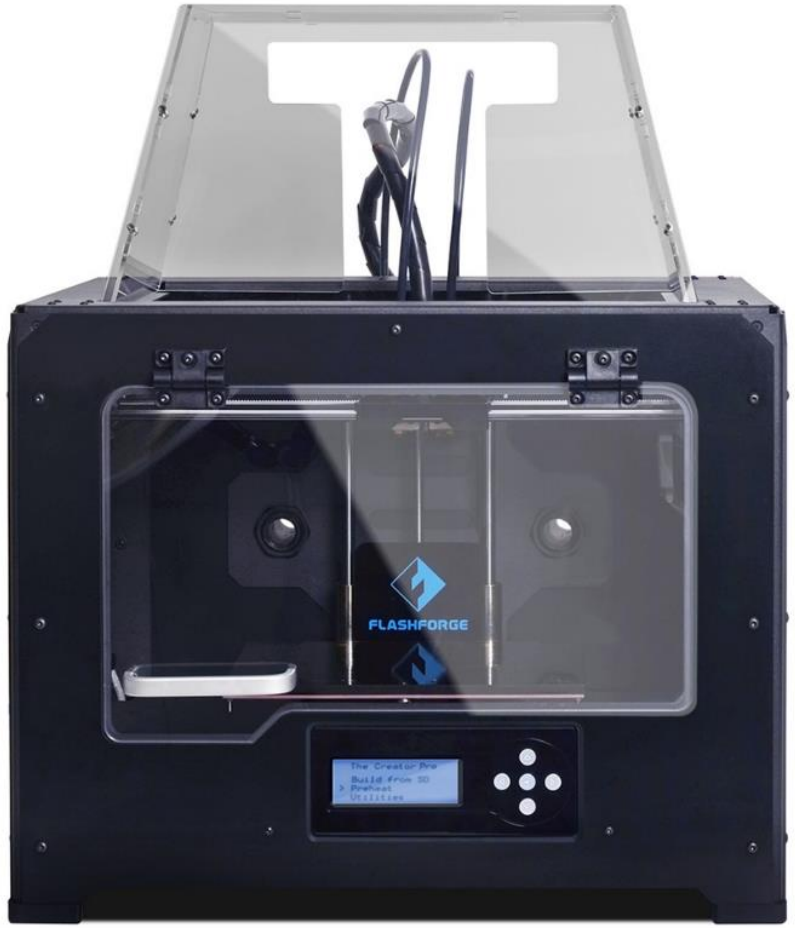
- **Litigation Support** – Communicating with jurors or other non-technical participants in lawsuits.
- **Client/Regulatory Communications** – Communicate conceptual site models and remediation achievements to clients and regulators.
- **Stakeholder/Public Meetings** – Facilitate meetings with stakeholders, including PRPs and community groups.

Model Scope and Cost

- Develop EVS Models Geared Toward 3-D Printing
- Convert/Print Existing Digital 3-D Models
- Model Costs Range from $5k to $50k+ based on size and complexity



Questions?

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