RockWare Consulting – A Case Study

In 2019, RockWare was contracted by a client directed by a state agency to help with the modeling and visualization of a groundwater contamination plume based on well data dating back to the mid-1980s. This project involved the creation of numerous contour maps, cross-sections, fence diagrams, volumetric computations, and animations depicting lithology, stratigraphy, hydraulic conductivities, groundwater pathways, and contaminant concentrations.

Initially, the project was based on incomplete historic data from multiple sources. In addition, data from groundwater monitoring wells was, and still is, being added to the project database on an ongoing basis. The challenge was to frequently create three-dimensional "snapshots" of the data in order to identify bad or missing historical data and to monitor the plume migration to facilitate the identification of optimal locations for additional monitor and recovery wells. In other words, the task was to repeatedly perform a complex series of steps involving modeling and visualizations as the data and the project dimensions continued to be changed.

To streamline the processing, the steps involved in automating the modeling and visualizations were added to a RockWorks Playlist (Figure 1). By doing so, all of the data could be re-processed with a single click every time the data was changed. These steps included the creation of;

- a series of base maps depicting major features, prohibited drilling boundaries, well locations, etc.,
- an upper constraining grid surface based on high-resolution LIDAR data,
- a 3D display of underground stormwater drainage pipes,
- a 3D terrain model (Figure 2A),
- 3D lithology and stratigraphy striplogs,
- a 3D bedrock surface model,
- a maximum water level surface model,
- a lithology block model (Figure 2B),
- a hydraulic conductivity model based on the lithology model,
- a BPI (Boolean Permeable/Impermeable) model based on the hydraulic conductivities,
- a truncated BPI model based on the maximum water level surface model,
- 25 annual contaminant (dioxane) models based on the time-based water samples and constrained by the BPI model,
- 25 annual 3D dioxane concentration striplogs,
- annual highest dioxane level grid models,
- depth to dioxane >7.2ppb, >280ppb, >1,900ppb grid models,
- production/remediation well location maps,
- annual 3D diagrams depicting 7.2, 280, and 1,900ppb isoshells,
- proposed monitor and recovery well maps,
- 3D lithologic fence diagrams (Figure 2C),
- 3D maximum ground water level fence diagrams,
- a 2D groundwater contamination animation from 1986 to 2019 (Figures 2D & 3),
- a 3D isoshell animation 1986-2020 (Figure 2E), and
- a 3D lithology cutaway animation.

As with any project, the lateral and vertical extents of the area changed as more data became available. In addition, the resolution (i.e., voxel dimensions) of the models also changed. These models were used to create cross-sections with superimposed borehole striplogs so that the client could QA/AC the data in an iterative fashion. This process was repeated until the client was satisfied with the quality of the data and the models. The addition of new data involved a similar iterative process.

A high-resolution LIDAR surface grid (Figure 2A) was used to constrain the upper extents of the models. A satellite image of the site was subsequently draped over the LIDAR-based surface grid (Figure 2D) to provide a better spatial understanding the of the plume extents.

An automated limiting-polygon tool was used to limit the annual contamination models based on the wells that were sampled during the associated time frame. For example, the extents of the 1990 model is smaller than the 1995 model because the 1990 model was based on fewer monitor wells.

102 Playlist Items (Item # 1) **Disable Bad Bore** ☑ ConvexHull_Flag calculation ☐ Enable Wells with ConvexHull_Flag = x ☑ 🌣 Set Project Dimensions Extract DEM from GeoTiff to Ground_Surface.rwgrd ☐ Create Base_Map_01.Rw2D (Satellite Image w/Bo Create Base Map 01 BW.Rw2D (B&W Satellite Imag ☑ Create Base_Map_02.Rw2D (Roads & Rivers added ☑ Load Downtown_Label.RwDat ✓ ∴ Create Base_Map_03a.Rw2D (Add Downtown_Label t ☑ Load Huron_River_Label.RwDa Create Base Map 03b,Rw2D (Add Huron River Label ☑ Load Allen_Creek_Drain_Label.RwDate ☑ 🖔 Create Base_Map_03c.Rw2D (Add Allen Creek Drain ✓

Load Montgomery_Well_Label.RwDat Create Base_Map_03d.Rw2D (Add Montgomery Wel Create Base_Map_03e.Rw2D (Add Miller Ave Label to ✓ Maple_Road_Label.RwDat ☑ 🠪 Create Base_Map_03f.Rw2D (Add Maple Rd Label to F Create Base_Map_03g.Rw2D (Add M-14 Label to Base Create Base Map 03h.Rw2D (Add I-94 Label to Base 🗸 🗁 Load Gelman_Polygon.RwDat ☑ ② Create Base_Map_04.Rw2D (Gelman Polygon) ☑ ›› Create Base_Map_04a.Rw2D (Add Gelman Label to Ba ✓ Market Description For Polygon Probabilities For Polygon Probab ☑ Doad Prohibition_Zone_Label.RwDat ✓ ∴ Create Base_Map_05a.Rw2D (Add Prohibition Zone L.) ☑ 🗀 Load Prohibition_Zone_Polygon.RwDat ♥ 🤔 Create Base_Map_06.Rw2D (Add Gelman & Prohibi ✓ Market Description
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✓ Description
✓ Load Gelman_Polygon.RwDat Create Base_Map_07a.Rw2D (For Draping) By Adding ☑ Doad Prohibition_Zone_Polygon.RwDa ☑ Create Base_Map_07b.Rw2D (For Draping) By Adding ✓ Marchael Cage.Rw3D ▼ & Create Draped Image 1.Rw3D (Drape Satellite Image ✓ Ibad Gelman_Polygon.RwDat ☑ Load Prohibition_Zone_Polygon.RwDat ✓ ♥ Create Draped_Image_3.Rw3D (Add Prohibition Polyg □ Load Allen Creek Drain Data ✓ S Create Allen_Creek_Drain.rw3d ☑ Enable Wells with Lithology_Type = x (Including SIPs Enable Wells with Stratigraphy Type is not null Enable Wells with WaterLevel Flag not null ☑ III Create MWLS.RwGrd (2nd-Order Polynomial - Maxin ₩ i Truncate MWLS.RwGrd (Based on Ground Surface Mo **▽ =** Enable Wells with Lithology_Type = x Create Lithology Model ☑ 🚰 Create Permeability.RwMod 🗷 🛼 Create BPI.RwMod (Convert Permeability Model Mode ▼ # Truncate BPI.RwMod (Based on MWLS.RwGrd) Enable Wells with TData_Type = Create Annual Models.RwDat - 1 Hou ☑ III Diagnostic: Show 2020 Highest G-Value Grid **▼** Create 2020 Dioxane Logs.Rw3D ☑ 😘 Create 2020_Dioxane.Rw3D Compute Depths to 2020 Dioxane 7.2 ppb or Higher ▼ Compute Depths to 2020 Dioxane 280 ppb or Higher ☑ 1 Compute Depths to 2020 Dioxane 1,900 ppb or Hig ☑ Compute Depths to Largest 2020 Dioxane G-Values ☐ Enable Only Production Wells

☐ Enable Only Production Wells ☑ U Create Production_Wells.Rw3D Convert 2000 Model to 2000_IsoShells.Rw3D Convert 2005 Model to 2005 IsoShells.Rw3D

Convert 2011 Model to 2011_IsoShells.Rw3D
 Convert 2020 Model to 2020 IsoShells.Rw3d
 Convert 2020 Model to 2020 IsoShells.Rw3d

□ ==== CREATE MEGA-DIAGRAM ===

□ Enable Only Proposed Monitoring Wells
 □ Load Proposed_Monitor_Wells.RwDat

☐ ② Create Proposed_Monitor_Wells.rw3d

□ Enable Only Proposed Recovery Wells
 □ Load Proposed_Recovery_Wells.RwDate

Create Proposed_Recovery_Wells.rw3d

✓

Create Clipped_MWLS.RwGrd

✓ Create NS_Lithology_Fence_Panels.rw3d

✓ Create NS_Ground_Surface_Fence_Panels.Rw3D

Create NS_MWLS_Fence_Panels.Rw3D

Create NS_MWLS_Fence_Panels.Rw3D

Create EW_Lithology_Fence_Panels.rw3d

□ Create EW_Ground_Surface_Fence_Panels.Rw3D

Create EW_MWLS_Fence_Panels.Rw3D

Create Base_Image.rw3d

✓ ☑ Load MegaDiagram_Input.rwda

☑ 🥌 Create MegaDiagram.rw3d

✓ Datasheet: Annual_Models

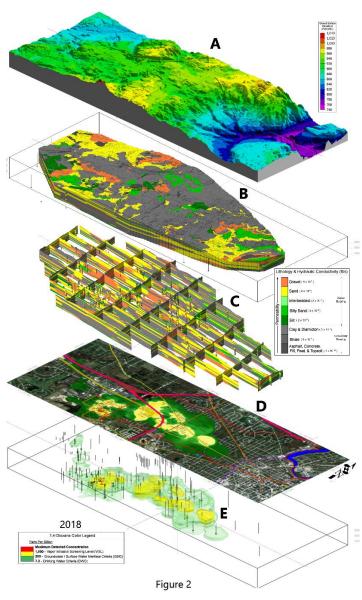
□ === CREATE ANIMATIONS ===

▼ Create Contour_Animation.mp4 - 41 Minutes

☐ Create IsoShell_Animation.mp4 - 5.5 Hours (10 frame)
☐ W Create 2020_Dioxane_Rotation.mp4 - 1 Hour

© Create Lithology_Reveal.mp4 - 41 Minutes

PROCESS PLAYLIST



2016H.png

2017H.png

Hydraulic conductivities were assigned to each of the lithology types in order to create a hydraulic conductivity model. This model was then filtered to create a Boolean (true/false) model which was subsequently used to constrain the annual contamination models.

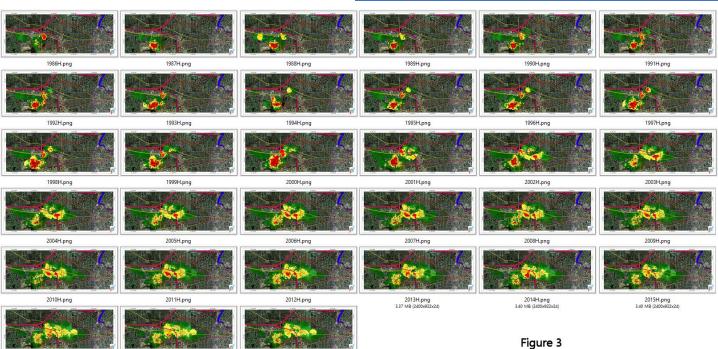
A maximum water level surface was created to serve as an upper confining surface for the geochemical modeling. Bedrock data, as determined by a seismic survey and a handful of wells, was also supplied by the client to act as a lower confining surface.

Tables and graphs were created to show the annual changes in the contaminant volumetrics based on three cutoff levels; 7.2ppb for drinking water, 280ppb for groundwater/surface water, and 1,900ppb for vapor intrusion screening level. These graphs provided a quantitative, non-spatial alternative to the time-based 3D animations in terms of showing the historical dissipation of the contamination.

Over the course of the project additional items (e.g., adding sub-sites) were added to the Playlist resulting in a list that currently contains over 248 different items. The playlist was crucial in both time management and QA/QC. Instead of having to go through each individual step as data was updated, the workflow now only consisted of updating the data and running the playlist.

Based on this case study as well as other consulting projects, the benefits of the RockWorks Playlist capability include;

- **self-documenting automation** that eliminates the tedium and errorprone repetition of opening, adjusting, and executing individual program menus,
- an audit trail that can be used to refresh a user's memory,
- a detailed record of all steps, algorithms used, and other menu settings suitable for use during the discovery process during litigation,
- a **turn-key deliverable** to clients (such as ours) who want to be able to process future data,
- a **strategy for processing other sites** without being forced to start from scratch, and
- a tool that can be used by **entry-level geoscientists** that was designed by senior-level geologists.



2018H.png