June 17, 2026

Diane Cutler
Idaho Department of Environmental Quality
1410 N. Hilton St.
Boise, ID 83706

Subject: Formal Public Comment on Proposed Rules: IDAPA 58.01.11 — Groundwater Quality Rule

Dear Ms. Cutler,

To support the statements made in our previous comment, we provide the following additional information.

We present, in *Transitioning From Time of Transport to Groundwater Vulnerability Index.pdf*, a structured explanation of the inadequacy of the current Time of Transport modeling approach for delineating source water areas.

Groundwater is monitored and consumed primarily through wells, for which Well Driller Reports are filed with the Department of Water Resources. The spatial density and distribution of these wells provide a compelling representation of subsurface conditions. We have converted over 1,300 well driller reports within the study area into a structured database using advanced Optical Character Recognition (OCR) technology at a nominal cost of $9.42. This technology continues to improve while declining in cost. The methodology and application are described in *OCR_Process.pdf*.

The resulting structured database has been modeled in three dimensions. We have reviewed this work with a highly qualified resource at the USGS, who is prepared to peer review the modeling logic as documented in *3D_Mesh_Stratigraphy_Modeling.pdf*.

Groundwater Protection Story.pdf presents renderings derived from the 3D model. All technologies used subsequent to OCR extraction are intentionally open source, royalty-free, and free of licensing requirements. While outside the scope of rulemaking, all modeling logic is documented and maintained in a publicly accessible repository.

Mr. Hall has collaborated with the Panhandle and Jefferson County health districts to map septic system density for incorporation into a modified DRASTIC groundwater vulnerability index. The results of this work are shown in *Jefferson Co with parcels_02_07_26.png* and *Sagle valley septic density 02_11_26.pdf*. *SagleDensity.png*, previously presented to DEQ in 2019, highlighted concerns regarding the protection of Southside Water & Sewer's source water in the context of permitted urban densities.

The current Time of Transport model does not account for observed subsurface conditions—specifically, permeable sand and gravel formations and aquifer depths ranging from approximately 40 to 100 feet, due to its apparent underlying assumption of nearly impermeable subsurface materials.

We understand that DEQ, through Jerry Mason, authored the wellhead protection ordinances currently in place but not implemented. This code is included in *WellheadProtection.pdf*. We urge the replacement of the existing wellhead protection framework with a groundwater vulnerability index–based approach applied to the area we previously defined as a "High-Demand Area." Time has proven that local governance cannot be relied upon to implement local governance, despite being provided excellent resources.

Sincerely,

Flint Hall and Jack Howard

Groundwater Tool

New source well – Artesian!



The four problems we recognize

- County land use decisions impact groundwater quality.
- Counties lack scientific and financial resources to manage groundwater quality.
- Groundwater impact by septic systems and urbanization is a current and growing threat.
- Complement existing legislature and agency responsibilities with proactive safeguards to groundwater quality.

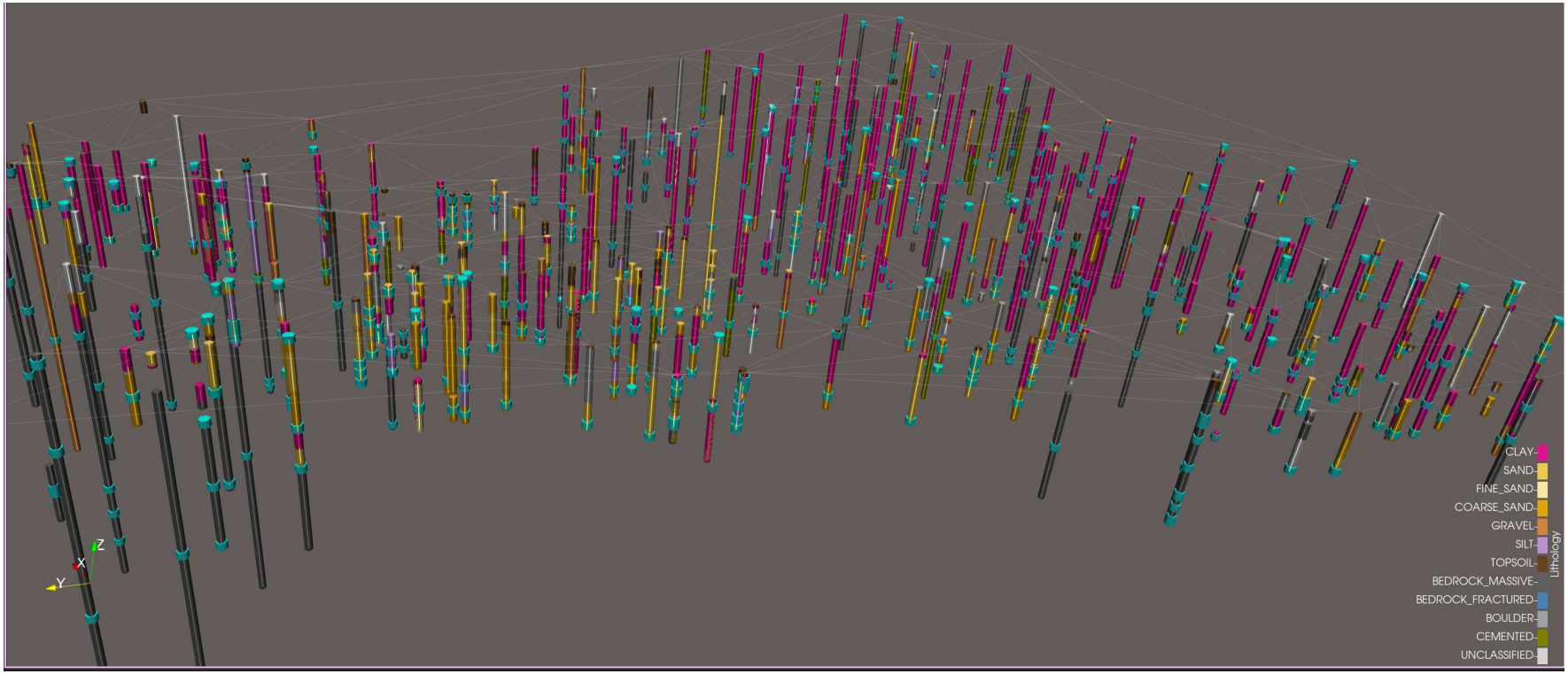
Core Ideas

- This initiative is data-driven, using proven methods to deliver insight needed for land use decisions.
  - Land use and groundwater is controversial and politically sensitive.
  - We need to collect data and determine its quality before all else.
- Leverage what has already been done, proven and readily available.
- With State agencies support, we are focused on Sagle with the mind's eye to be a template for any County in Idaho

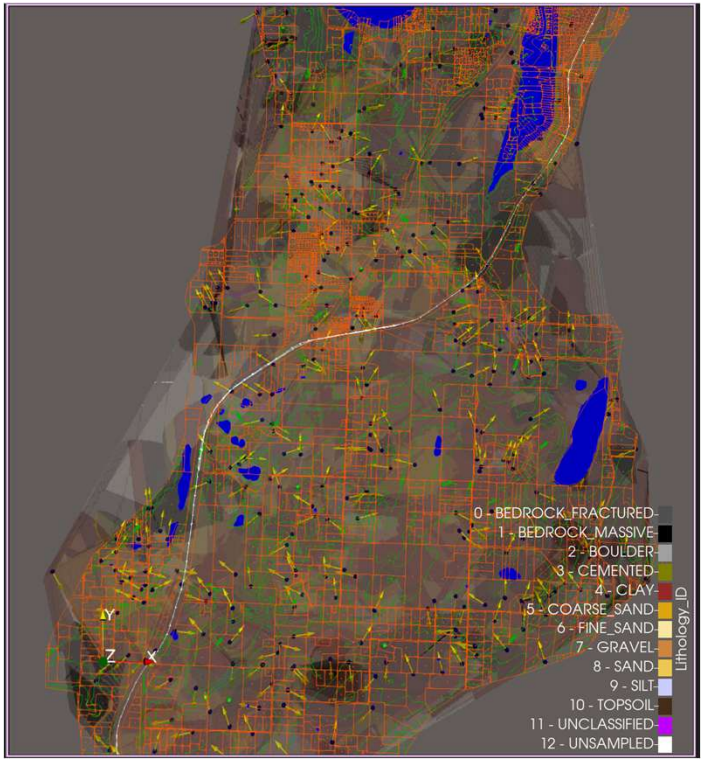
State Agencies and the County

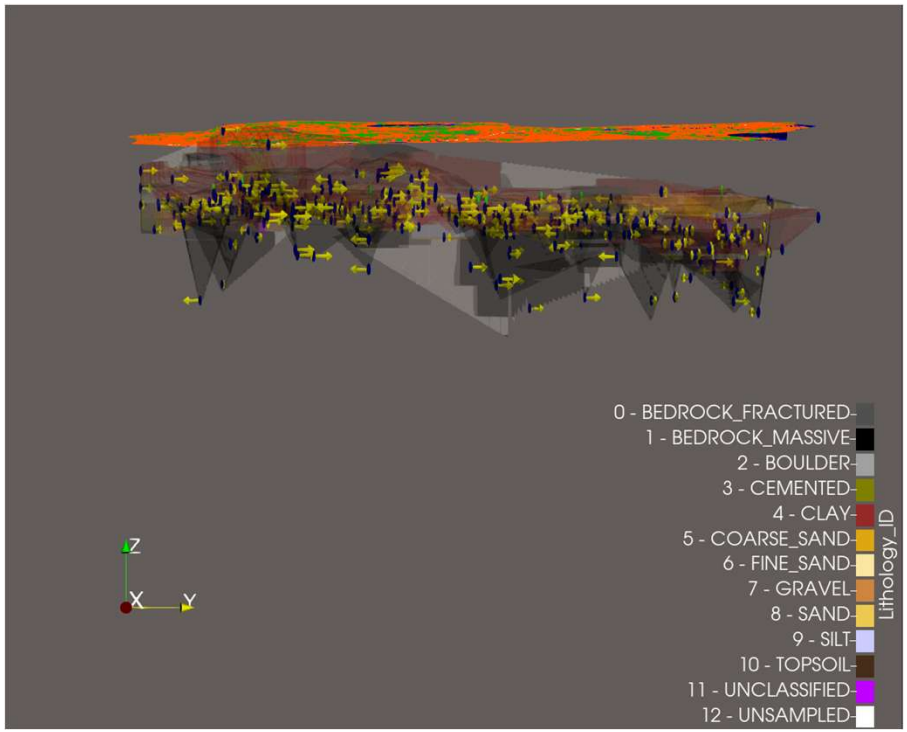
Authority	Planning Department	DEQ	IDWR
Land Use/Zoning Decisions	Yes	No	No
Environmental Permitting	No	Yes	No
Water Rights Permitting	No	No	Yes
Enforcement of Local Codes	Yes	No	No
Enforcement of State/Federal Environmental Laws	No	Yes	Yes (water rights and wate use statutes)
Can Overturn Other's Decision?	No	No (can enforce environmental laws on approved projects)	No (can curtail or regulat water use regardless land use approval)

Borehole data – 1,338 wells

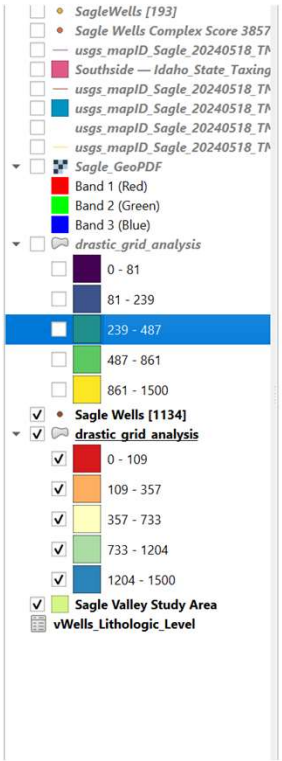


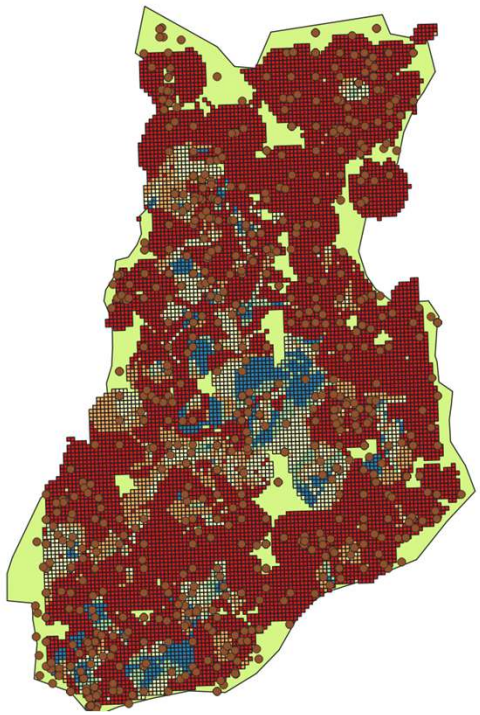
3D representation of borehole data





Translated into Planning Information





1.0 Summary

The Geo-Engine v4.0 is a computational framework designed to reconstruct subsurface stratigraphy and hydrogeologic surfaces in Sagle, Idaho. The engine consumes discrete borehole data from a SQL Server database to generate a 3D volumetric lithology model and 2D aquifer surfaces. The system employs Adaptive Inverse Distance Weighting (AIDW) to maintain horizontal continuity of alluvial deposits while preserving vertical stratigraphic transitions. Version 4.0 introduces localized groundwater flow vector calculation at well locations using neighbor-based plane fitting.

1.1 Computational Geometry and Volumetric Modeling

Traditional hydrogeologic visualizations often rely on polygonal meshing—specifically Triangulated Irregular Networks (TINs)—to represent surfaces like the water table or the top of a clay layer. However, these 2D surfaces do not account for the internal heterogeneity of the soil column. The 3D mesh facilitates visual and computational measurements of the borehole data to allow accurate 2D surfaces to be derived.

1.1.1 Voxel Discretization

The Geo-Engine utilizes a **voxel** (volume element) approach. A voxel is the 3D equivalent of a pixel, representing a discrete unit of volume within a regular grid.

- **Volumetric Meshing**: The engine populates a 3D matrix with lithology identifiers. This grid is then converted into an "Unstructured Grid" (VTU format) where each voxel is defined by eight coordinate points (vertices).
- **Comparison**: Unlike polygonal meshes which only define the outer boundary of a shape, a voxel-based volumetric mesh stores data *inside* the geometry, allowing for the calculation of mass, volume, and vertical averages at any (X, Y) coordinate.

1.1.2 Relevance to DRASTIC Vadose Zone Analysis

The primary utility of the volumetric model is to provide data for the **DRASTIC** groundwater vulnerability index, specifically the **Impact of the Vadose Zone (I)** and the **Soil Media (S)** parameters.

The "Vadose Zone" is the unsaturated layer between the ground surface and the water table. Because the engine computes a continuous vertical stack of voxels, users can perform a "vertical sum" or "weighted average" of the lithology types. This allows the system to:

1. Identify the exact thickness of restrictive layers (e.g., clay/silt).
2. Assign a weighted hydraulic conductivity score to the entire column.
3. Calculate the travel time of potential surface contaminants to the aquifer.

1.2 Data Synthesis and Stratigraphic Layers

The engine does not treat the subsurface as a single block; it organizes data into discrete vertical layers based on the SQL Server input.

- **Layer Stacking**: The engine constructs the stratigraphy by evaluating the relative position of lithologic contacts.
- **Z-Resolution Alignment**: By setting a high Z_RESOLUTION (1019), the engine ensures that thin layers—which would be "lost" or "merged" in a lower-resolution polygonal mesh—are preserved as distinct voxel layers.

```
SELECT
      max([Z_Top])
      ,min(z_bottom)
      ,max([Z_Top]) - min(z_bottom)
  FROM [water2025].[dbo].[v_Litho_Standardized]
```

Top Elev	Bottom Elev	Depth
2,547’	1,528’	1,019’

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2.0 Spatial Framework and Coordinate System

The model uses a single projected coordinate framework for all horizontal (X, Y) positioning. All spatial operations (grid generation, interpolation, masking, and visualization outputs) are performed within this unified projected space to ensure consistent distance calculations and stable surface generation across the study area.

Because the study area has a much larger horizontal footprint than vertical stratigraphic thickness, prior versions optionally applied vertical exaggeration to aid visualization. Vertical exaggeration is expected to be removed after data quality work has been completed. No vertical exaggeration would be represented by this:

Zscale = 1.0

This ensures that exported surfaces and volumes reflect true proportional geometry in the visualization environment.

2.1 Coordinate Reference System (CRS) Specification

- The engine is designed to operate on a **single, fixed projected CRS** for all internal computations and exported model geometry. This projection is required for the following reasons:
- **Linear Measurement Integrity:** The engine computes Euclidean distances for spatial weighting and neighborhood searches (e.g., adaptive inverse distance weighting). A projected CRS provides consistent linear distances, which is essential for reliable interpolation and surface generation.
- **Model Consistency:** A single projected CRS ensures that all inputs (borehole locations, derived surfaces, and output meshes) remain spatially aligned and comparable without additional transformation steps inside the engine.
- **Stable Resolution Control:** Using a consistent projected coordinate framework allows the engine's spatial resolution settings (voxel spacing and grid dimensions) to behave predictably across the study area.
- **Topographic Alignment**: The engine reprojects the Digital Elevation Model (DEM) used for the "Topography Stencil" to EPSG:2241 so that the ground surface aligns with the borehole collars.

2.2 Voxel Grid Specification

The subsurface volume is divided into a uniform grid of cells. The horizontal resolution is defined by VOXEL_SIZE (50.0 m), while the vertical resolution is defined by Z_RESOLUTION

(1019 slices). This density is required to resolve thin clay aquitards and sand lenses characteristic of the Sagle alluvial valley.

2.3 Elevation Accuracy

Elevation accuracy is of critical importance. Northing/Eastings were used to create latitude/longitude coordinates through the model's CRS and submitted to the USGS National Map - Elevation Point Query Service. The Elevation Point Query Service returns the elevation in international feet or meters for a specific latitude/longitude (NAD 1983) point from the USGS Elevation Service hosted at the NGTOC. Input parameters: x (longitude), y (latitude), units (Feet, Meters), output (XML, JSON). Latitude and longitude must be specified in decimal degrees with southern latitudes and western longitudes represented as negative values.[1]

3.0 Adaptive Interpolation Framework

The engine uses an Anisotropic Interpolation Framework to model geology between boreholes, assuming greater horizontal than vertical continuity—characteristic of glacial and fluvial depositional environments.[2]

3.1 Adaptive Inverse Distance Weighting (AIDW)

The engine calculates a local search radius (R) for each voxel based on the 95th percentile of the nearest-neighbor distances between wells. This ensures the search window scales with data density.

Within this radius, the engine calculates an interpolation power (p) that adjusts based on the local data density to prevent "bullseye" artifacts. The power p is derived as follows:

$$p = P_{\max}\text{-}(\mathrm{P}_{\max}\text{-}\mathrm{P}_{\min}) \cdot (\frac{\bar{d}}{R})$$

Where:

- $P_{\max}$: Maximum IDW power (4.0).
- $\mathrm{P}_{\min}$: Minimum IDW power (1.5).
- $\bar{d}$: Local average distance to the k-nearest neighbors.
- $\overline{R}$: Adaptive search radius.

[1] https://apps.nationalmap.gov/epqs/
[2] The adaptive inverse distance weighting method

A higher p value in high-density areas strictly honors local variability, while a lower p in sparse areas provides smoother transitions across larger gaps.

3.2 Voxel Classification (Election Logic)

The engine classifies each voxel using a winner-take-all approach, assigning lithology based on the weighted influence of the k nearest boreholes (neighbors) within the search radius in the horizontal (xy) plane.

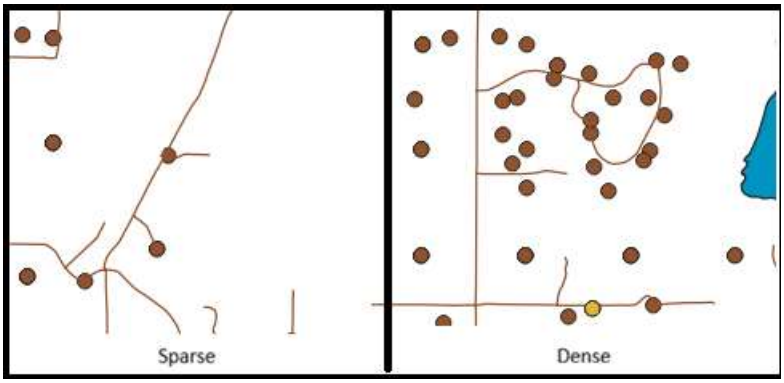


Figure 1 Sparse v Dense Well Neighbors

Each neighbor receives a weight w_i quantifying its influence on the voxel. In areas where each property has its own well, neighbor density is much higher compared to other areas in the study area.[3]

3.2.1 Weight Calculation Logic

For each of the k neighbors identified within the search radius, the engine assigns a weight (w) that quantifies that neighbor's influence on the voxel:

$$w = \frac{1}{d^p}$$

Where:

- w : The calculated weight (influence) of the borehole.
- $\boldsymbol{d}$: The 3D Euclidean distance between the centroid of the voxel and the specific borehole coordinate.
- p : The adaptive interpolation power (as defined in Section 3.1).

[3] https://pdfs.semanticscholar.org/a09c/5f2248ab8f47336fc91b3326530725371e74.pdf

3.2.2 Categorical Summation and Assignment

1. **Distance Calculation**: The engine uses a cKDTree to find the k-nearest neighbors and computes the distance d for each.
2. **Weight Summation**: Weights are grouped and summed by **Lithology ID**. For example, if three neighboring boreholes are "Sand" and one is "Clay," the cumulative weight for each category is calculated.
3. **Voxel Assignment**: The voxel is assigned to the Lithology ID with the highest cumulative weight.
4. **Confidence Check**: If the distance to the nearest neighbor exceeds the limit defined by the CONFIDENCE_THRESHOLD, the voxel is flagged as "UNSAMPLED" (ID 0). This prevents the model from "guessing" geology in regions where d is too large to provide a statistically significant interpretation.

4.0 Hydrogeologic Surface Modeling

The engine produces a 2D aquifer surface and localized flow vectors to characterize the groundwater environment.

4.1 Aquifer Pick Derivation

The engine identifies "Aquifer Picks" by selecting the deepest recorded water hit (minimum Z_{bottom} where water was indicated by the well driller) for each well. Wells with no water indicators are classified as "Dry Wells."

4.2 Dry Well Masking

To prevent the interpolation of an aquifer surface through known dry zones, the engine applies a masking utility. Any grid point within a calculated DRY_MASK_RADIUS of a dry well is assigned a NaN value, effectively removing it from the surface visualization.

4.2.1 Flow Vector Calculation

Groundwater flow is computed at each aquifer-pick well using local plane fitting rather than grid-based gradients. For each well, the engine identifies the k -nearest wells with water and fits a plane:

$z = ax + by + c$

The flow vector (v) is derived from the slope of the plane:

- $v = -a$
- $v_y = -b$
- $v_z = 0$ (Flow is assumed horizontal for visualization)

4.2.2 Magnitude Derivation

The magnitude represents the steepness of the hydraulic gradient i, calculated as the resultant of the x and y slopes.

$$|\mathrm{v}| = \sqrt{a^2 + b^2}$$

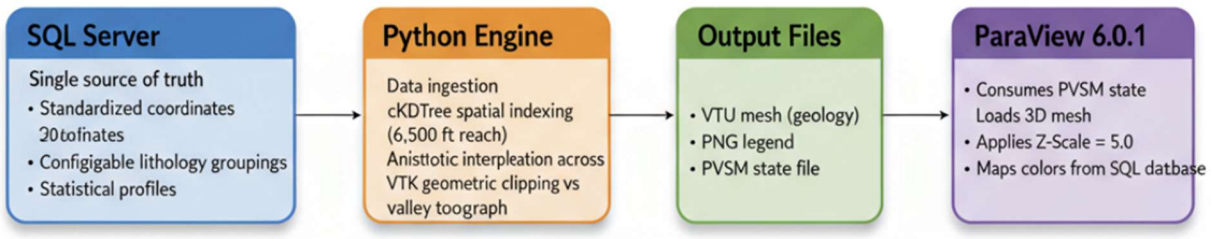
Where:

- |v| : The magnitude of the gradient.
- a: The solved coefficient for the x-axis.
- b: The solved coefficient for the y-axis.

In ParaView, this value scales the size of the flow arrows to visually indicate where the water table gradient is steepest, while arrow orientation shows the calculated direction of groundwater flow.

5.0 Technical Architecture

The system consists of four integrated layers:



1. **Relational Data Layer (SQL Server)**: The v_Litho_Standardized view standardizes borehole intervals. The LITHO_COLORS table describes DRASTIC group names and configures the colors used in 3D visual
2. **Python Processing Engine**:
    - Uses scipy.spatial.cKDTree for $O(log\ n)$ spatial querying.
    - Uses multiprocessing to distribute z-slice interpolation across CPU cores.
    - Performs plane fitting via numpy.linalg.lstsq.
3. **Geometric Transformation Layer (VTK)**:
    - Generates **VTU** files (Unstructured Grids) for 3D lithology.
    - Generates **VTI** files (Image Data) for 2D aquifer surfaces.
    - Generates **VTP** files (PolyData) for well points and flow vectors.
4. **Visualization (ParaView 6.0.1)**: Consumes the generated files and a Python state script to render the 3D model with applied Z-scaling and categorical color mapping.

6.0 Appendix A: Tuning Parameters and System Impact

The following parameters in geo_engine_v4.0.py control the computational load, the geometric fidelity of the subsurface reconstruction, and the statistical honesty of the 3D model.

6.1 Spatial Resolution Parameters

- **VOXEL_SIZE (Default: 50.0): Defines the horizontal (X, Y) dimensions of each voxel in feet.**
    - **Impact: Decreasing this value increases the total voxel count cubically. A 25.0 m voxel size quadruples the memory requirement and processing time compared to 50.0 m.**
- **Z_RESOLUTION (Calculated: 1019): Defines the number of vertical slices. By setting this to 1019, the engine achieves a 1:1 ratio with the study area's relief (2,547' to 1,528'), ensuring each voxel layer represents exactly one foot of elevation.**
    - **Impact: This avoids fractional slice artifacts and ensures that thin stratigraphic units (e.g., a 2-foot clay lens) are accurately resolved in the vertical stack.**

6.2 Interpolation and Masking Parameters

- **K_NEIGHBORS (Default: 12): The number of proximal boreholes used to calculate the lithology of a voxel and the local groundwater flow plane.**
    - **Impact: Higher values result in smoother transitions but may "blur" localized geological features by over-averaging categorical data. Lower values (e.g., 4) increase sensitivity to local data but may create "bullseye" artifacts where a single well dominates a large area.**
- **CONFIDENCE_THRESHOLD (Default: 0.02): The minimum cumulative weight required for a voxel to be rendered.**
    - **Impact: This serves as a "spatial honesty" filter. Higher values result in a more conservative model with more "holes" in areas of sparse data. Lowering this value allows the model to interpolate across larger distances, potentially over-extending geological interpretations.**
- **DRY_MASK_RADIUS: The distance around a "dry well" (no water recorded) where the aquifer surface is programmatically removed (assigned NaN).**

- **Automatic Calculation: By default, the engine sets this to the 95th percentile of nearest-neighbor distances (e.g., 2093.4 m) to ensure dry zones are appropriately represented in relation to well density.**
- **Manual Constraint: To constrain this to a fixed distance such as 500 meters, modify the compute_aquifer_surface function in the source code:**
  - ***Locate:* self.dry_mask_radius = np.percentile(d, 95)**
  - ***Replace with:* self.dry_mask_radius = 500.0**

6.3 Performance and Parallelization

- **multiprocessing.Pool: The engine distributes the 1,019 vertical slices across all available CPU cores. The impact of this setting is the total run time scales nearly linearly with the number of processor cores. Increasing Z_RESOLUTION without sufficient CPU overhead will significantly extend the "VTK GEN" phase of the log.**

7.0 Appendix B: Log Interpretation

When the engine calculates a mesh log entries are produced. This is a synopsis of the feedback provided by the engine.

Startup Sequence

- **2026-01-14 11:55:02,445 - common_init - INFO**: common_init.py loaded - gRPC warnings suppressed and utilities available
- **2026-01-14 11:55:02,534 - GeoCore - INFO**: Loaded 13 colors from SQL
- **2026-01-14 11:55:02,534 - GeoEngineV4.0 - INFO**: PIPELINE: Starting GeoEngine v4.0...
- **2026-01-14 11:55:02,534 - GeoEngineV4.0 - INFO**: SQL FETCH: Querying v_Litho_Standardized...
- **c:\DevGW\Groundwater\geo_engine_v4.0.py:571: UserWarning**: pandas only supports SQLAlchemy connectable (engine/connection) or database string URI or sqlite3 DBAPI2 connection. Other DBAPI2 objects are not tested. Please consider using SQLAlchemy. (Raw pandas warning on direct DBAPI connection; safe to ignore)
- **2026-01-14 11:55:02,661 - GeoEngineV4.0 - INFO**: SQL FETCH: Loaded 1383 intervals
- **2026-01-14 11:55:02,663 - GeoEngineV4.0 - INFO**: LITHOLOGY: Grid dims (nx,ny,nz)=(139,220,1019) radius=1162.8 ft grid_points=30,580

Repeated Module Loads

11:55:04-11:55:32: 16x repeated **common_init - INFO**: common_init.py loaded - gRPC warnings suppressed and utilities available. These fire from background threads/processes during grid kriging computations; this is normal behavior, not errors .

Kriging Runtime Warnings

Multiple at c:\DevGW\Groundwater\geo_engine_v4.0.py:165: RuntimeWarning: Mean of empty slice local_avg_dist = np.nanmean(np.where(valid_mask, d, np.nan), axis=1). AIDW interpolation hit grid cells with zero neighbors in search radius; engine assigns NaN (no data) and continues safely [table:RuntimeWarning].

VTK Model Generation

- **2026-01-14 11:55:37,674 - GeoEngineV4.0 - INFO**: VTK GEN: Converting to UnstructuredGrid... (Maps 3D NumPy voxel array to VTK vtkUnstructuredGrid object) [table:VTK GEN]
- **2026-01-14 11:55:38,084 - GeoEngineV4.0 - INFO**: VTK GEN: Applying Topography & Bottom Stencil... (Trims voxels above DEM surface or below deepest basement data) [table:VTK GEN]
- **2026-01-14 11:55:48,494 - GeoEngineV4.0 - INFO**: VTK GEN: Wrote C:\DevGW\Groundwater\sagle_v4_0114261155.vtu

Aquifer/Water Analysis

- **2026-01-14 11:55:48,584 - GeoEngineV4.0 - INFO**: WATER: Aquifer picks = 233 wells (deepest Y) (Found water_yes flag in 233 unique well locations from SQL data) [table:WATER]
- **2026-01-14 11:55:48,584 - GeoEngineV4.0 - INFO**: WATER: Dry wells = 5 wells (no water was encountered during the well drilling process, and no water volume was indicated)
- **2026-01-14 11:55:48,587 - GeoEngineV4.0 - INFO**: WATER: Aquifer AIDW radius = 500.0 m (Fixed search radius for 95% data coverage interpolation) [table:WATER]
- **c:\DevGW\Groundwater\geo_engine_v4.0.py:299: RuntimeWarning**: Mean of empty slice (Same AIDW empty-neighbor handling for aquifer surface) [table:RuntimeWarning]
- **2026-01-14 11:55:48,614 - GeoEngineV4.0 - INFO**: WATER: Dry-well mask radius = 500.0 m

File Exports

- **Aquifer surface VTI → aquifer_surface_0114261155.vti**
- **Deepest_Water_Hits → deepest_water_hits_0114261155.vtp** (points=233 verts=233) [table:EXPORT]
- **Dry_Wells → dry_wells_0114261155.vtp** (points=5 verts=5)
- **Flow vectors at wells → flow_at_wells_0114261155.vtp** (points=233 verts=233; 2D gradient glyphs per well) [table:EXPORT]

Pipeline Complete

2026-01-14 11:55:48,654 - GeoEngineV4.0 - INFO: PIPELINE: Complete. Dry mask radius used = 500.0 ft. All outputs ready in C:\DevGW\Groundwater\ for ParaView .

8.0 Appendix C: ParaView Integration (workstation_macro.py)

The script generates a secondary Python script, workstation_macro.py, specifically for ParaView.

8.1 Environmental Decoupling

The primary engine runs in standard Python. ParaView has its own internal rendering engine. The macro acts as the bridge so they talk to each other.

8.2 Dynamic Color Mapping and State Automation

Users do not need to manually configure legends or assign colors. The LITHO_COLORS SQL table is the single source of truth.

- **Automated Colors:** The engine pulls the exact RGB colors from SQL and forces ParaView to use them.
- **Automated Layers:** To prevent visual clutter, the macro pre-builds a hidden Threshold layer for every specific soil type. You can simply click the eye icon to instantly isolate "Sandy Gravel".
- **Flow Arrows:** The macro automatically scales the 3D groundwater arrows based on the calculated FLOW_GLYPH_SCALE_FACTOR.

8.3 Contextual Map Integration

To provide immediate geographical context, the macro automatically loads static maps alongside the 3D geology.

- **Surfaces:** Contours, Roads, and Hydrography are draped directly over the ground.
- **2025 Cads:** Parcel boundaries are loaded strictly as a **Wireframe** so you can see property lines without hiding the geology underneath.
- **Z-Scaling:** The macro automatically stretches the maps to match whatever Vertical Exaggeration (Z_SCALE) you applied to the 3D grid.

8.4 Repeatability

By generating this macro, the engine ensures that a peer reviewer sees the exact same representation of the data every single time the model is opened, completely eliminating human error in the visual setup.

Well Driller Report Extraction

In support of the Groundwater Overlay Protection Proposal for Bonner County Idaho

By: Jack Howard, Chair, Groundwater Protection Overlay technical committee

November 26, 2025

This process employs the latest technologies

- Well Driller Reports are complex documents that challenge the best Optical Character Reading (OCR) technologies.
- This process evaluated 9 different technologies before settling on Microsoft Azure.
- The structure of this solution facilitates the use of different technologies with the least impact possible.

	well_id	level_number	bore_diameter	from_ft	to_ft	level_remarks	water_yes	water_no
1	893859	2	10	0	2	Top Soil		X
2	893859	3	10	2	23	Sand & Gravel		X
3	893859	4	10	23	59	Fine Sand	X	
4	893859	5	8	59	130	Fine Sand 20 gpm	X	
5	893859	6	8	130	140	Cemented Sand & Gravel		x
6	893859	7	8	140	165	Gravel w/ Clay Lens	X	
7	893859	8	8	165	178	Clay w/ Gravel		X ××
8	89385			178	273	Cemented Sand & Gravel		X
9	89385			273	280	Sand & Gravvel w/ 8 gpm	x	
10	89385			280	290	Clay		XX
11	89385			290	305	Black & Purple Shale		
12	89385			305	328	Green Shale w/ 3 gpm	××	
13	893859	14	888	328	400	Purple & Green Shale	X	
14	893859	15				360' - 30 gpm		
15	893859	16				380' - 67 gpm		

Google OCR AI's fatal bug:
Check marks are scramabled and more added for good measure.

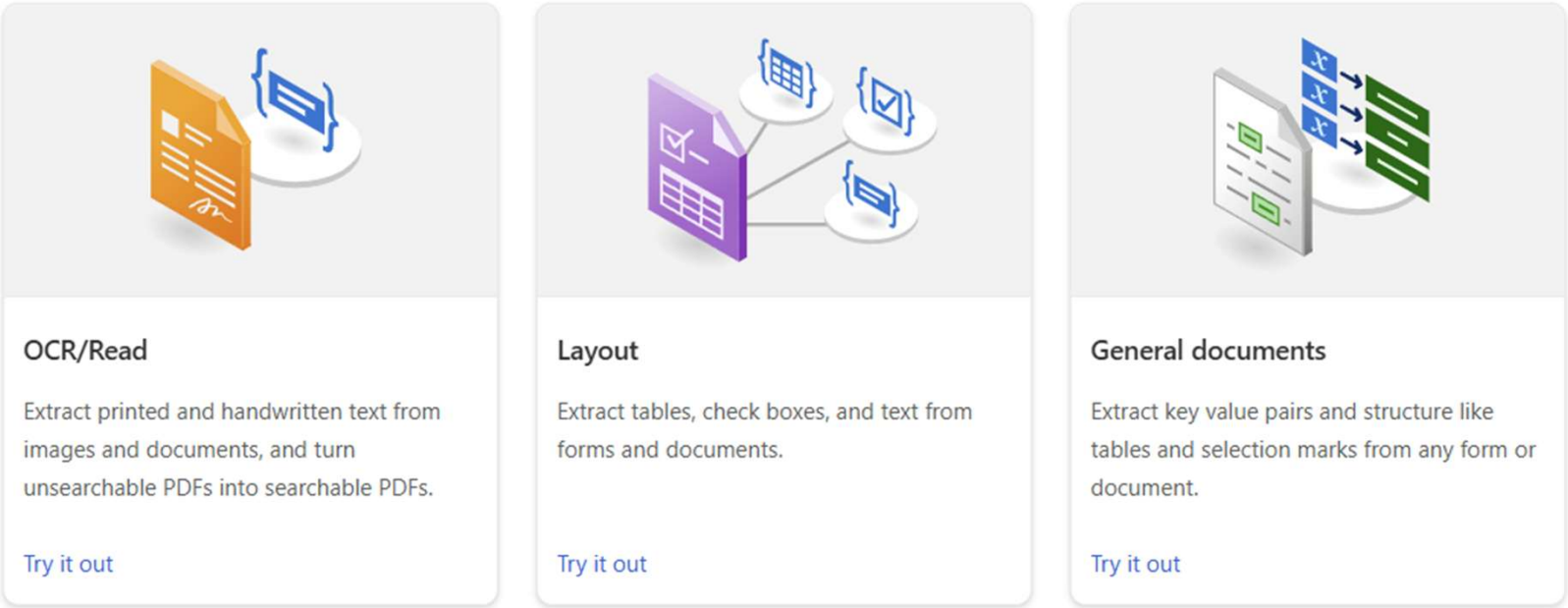
...this is impossible to resolve

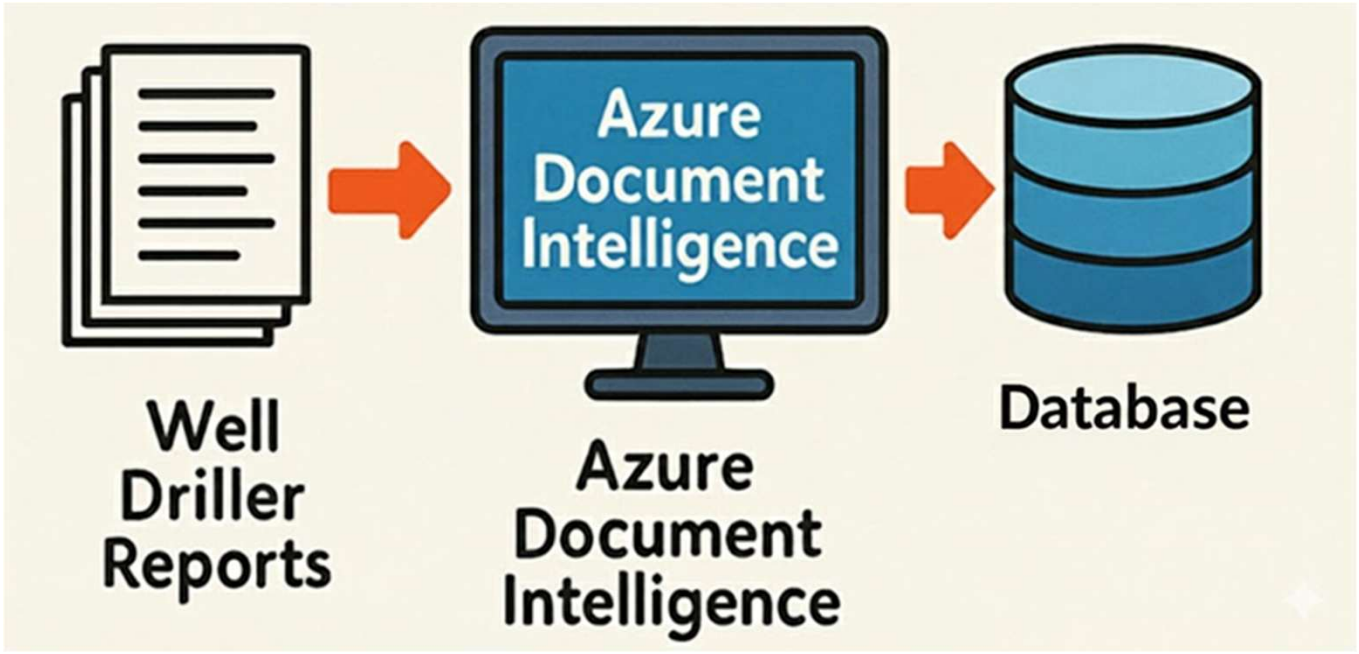
Microsoft Azure Document Intelligence

- Azure offers three OCR services – hint: one works better than the others

Document analysis

Extract text, tables, structure, key-value pairs, and named entities from documents.



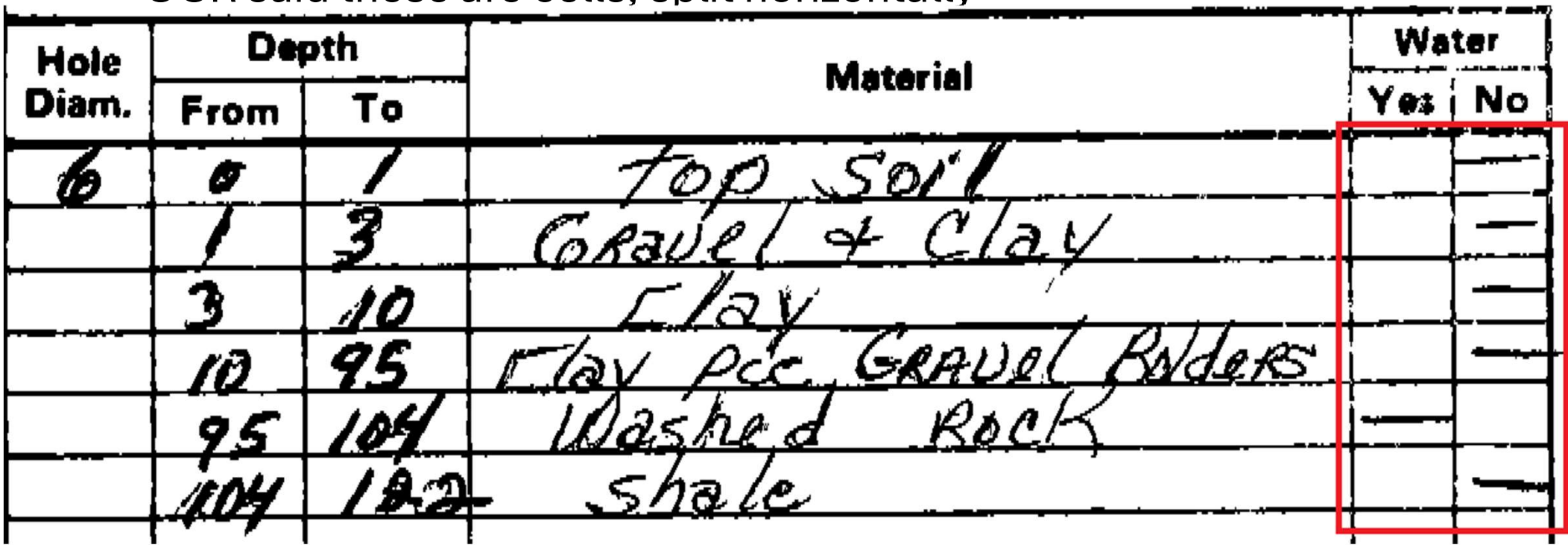


Python programs move PDFs through the process

Types of Problems Encountered

Very cunning check marks

- OCR said these are cells, split horizontally



Hole Diam.	Depth From	Depth To	Material	Water Yes	Water No
6	0	1	Top Soil		—
	1	3	Gravel & Clay		—
	3	10	Clay		—
	10	95	Clay pcc Gravel Bolders		—
	95	104	Washed Rock	—	
	104	122	Shale		—

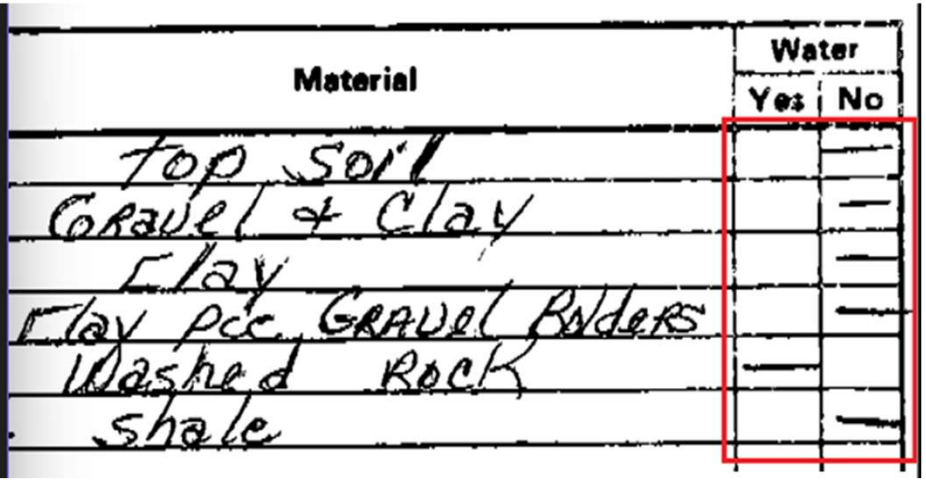
Deep Check logic

- Python finds no water yes/no, opens the form and looks for itself.
- Pixels in cells on the form finds the answer

100 % No issues found Ln: 1 Ch: 1 SPC

Results Messages

	from_ft	level_remarks	water_yes	water_no
1	1	gravel & clay		Y
2	3	clay		Y
3	10	clay pac gravel balders		Y
4	95	washed rock	Y	
5	4.04	shale		Y



The use of ditto is pervasive

```
        ,[bore_diameter]
        ,[from_ft]
        ,[level_remarks]
        ,[water_yes]
        ,[water_no]
    FROM [water2025].[dbo].[lithologic_level_stage]
    WHERE well_id =270041D


    --from_ft = '93' and to_ft = '130';
```

100 % | 1 | 0 | Ln: 8 | Ch: 25 | SPC | CRLF

Results | Messages

	well_id	bore_diameter	from_ft	level_remarks	water_yes	water_no
1	270041	6	0	fill	Y	
2	270041	6	2	5mail gravel + clay		Y
3	270041	6	66	boulders		Y
4	270041	6	21	clay + gravel water seep	Y	
5	270041	6	93	clay + boulders		Y
6	270041	6	130	clay * gravel	Y	
7	270041	6	144	boulders y clay	Y	
8	270041	6	166	gravel + clay	Y	
9	270041	6	180	clay		Y

Query executed successfully. | WSH (15.0 RTM) | WSH\jwhow (64) | water2025 | 00:00:00 | 9 rows

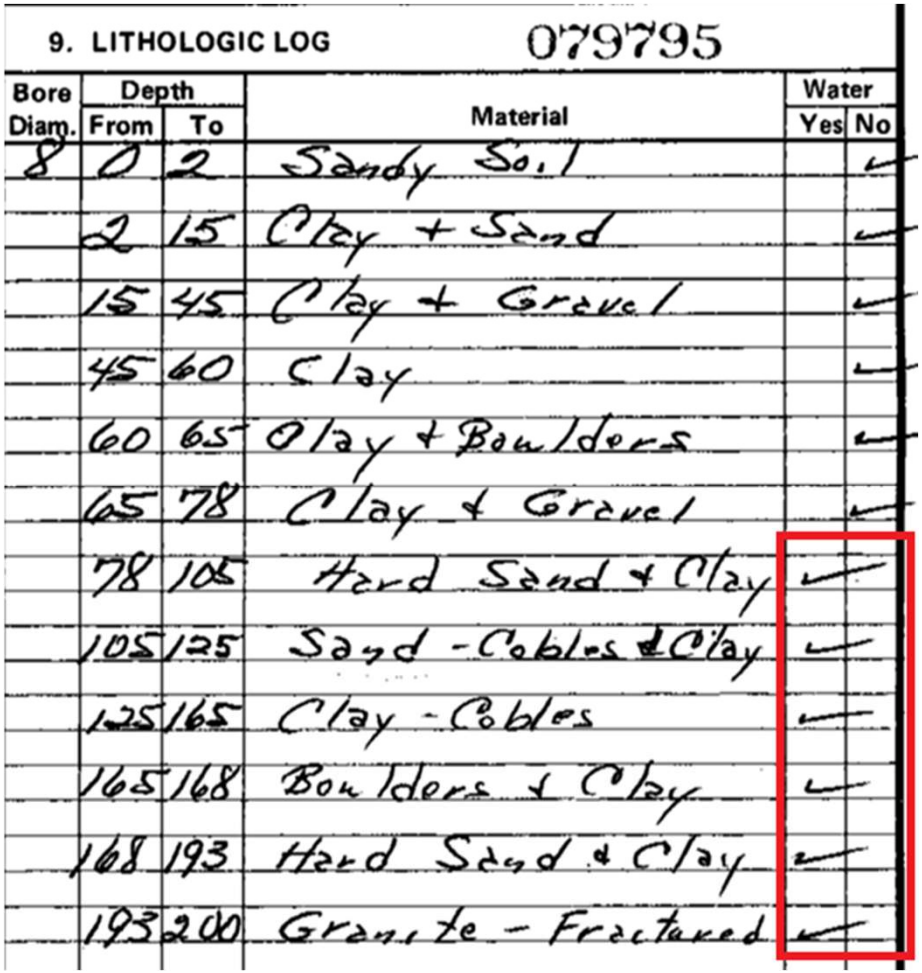
LITHOLOGIC LOG

Depth From	Depth To	Material	Water Yes	Water No
0	2	FILL		
2	66	SMALL GRAVEL + CLAY		X
66	71	BOULDERS		X
71	93	CLAY + GRAVEL WATER SEEP	X	
93	130	" + BOULDERS		X
130	144	" + GRAVEL	X	
144	166	BOULDERS + CLAY	X	
166	180	GRAVEL + "	X	
180	185	CLAY		X

Handwritten ✓

- Overlapping checkmarks
- Which is it?

  If Yes and No, then Yes



9. LITHOLOGIC LOG 079795

Bore Diam.	Depth From	Depth To	Material	Water Yes	Water No
8	0	2	Sandy Soil		✓
	2	15	Clay + Sand		✓
	15	45	Clay + Gravel		✓
	45	60	Clay		✓
	60	65	Clay + Boulders		✓
	65	78	Clay + Gravel		✓
	78	105	Hard Sand + Clay	✓	
	105	125	Sand - Cobles & Clay	✓	
	125	165	Clay - Cobles	✓	
	165	168	Boulders + Clay	✓	
	168	193	Hard Sand & Clay	✓	
	193	200	Granite - Fractured	✓	

SQLQuery48.s...H\jwhow (53))* | SQLQuery47....\jwhow (64))*

```
SELECT well_id
      ,[bore_diameter]
      ,[from_ft]
      ,[to_ft]
      ,[level_remarks]
      ,[water_yes]
      ,[water_no]
  FROM [water2025].[dbo].[lithologic_level_stage
  WHERE well_id = 268573
```

100 % | No issues found | Ln: 8 | Ch: 48 | SPC | CRLF

Results | Messages

	bore_diameter	from_ft	to_ft	level_remarks	water_yes	water_
1	8	0	2	Sandy Soil		Y
2	8	2	15	Clay + Sand		Y
3	8	15	45.	Clay + Gravel.		Y
4	8	45	60	Clay		Y
5	8	60	65	Olay + Boulders		Y
6	8	65	78	Clay & Gravel		Y
7	8	78	105	Hard Sandy Clay	Y	
8	8	105	125	Sand - Cables I Clay	Y	
9	8	175	165	Clay - Cables	Y	
10	8	16.5	168	Boulders & Clay	Y	
11	8	168	193	Hard Sandy Clay	Y	

Query executed successfully. | WSH (15.0 RTM) | WSH\jwhow (64) | water2025 | 00:00:00 | 13 rows

9. LITHOLOGIC LOG 079795

Bore Diam.	Depth From	Depth To	Material	Water Yes	Water No
8	0	2	Sandy Soil		✓
	2	15	Clay + Sand		✓
	15	45	Clay + Gravel		✓
	45	60	Clay		✓
	60	65	Olay + Boulders		✓
	65	78	Clay + Gravel		✓
	78	105	Hard Sand + Clay	✓	
	105	125	Sand - Cables & Clay	✓	
	125	165	Clay - Cables	✓	
	165	168	Boulders + Clay	✓	
	168	193	Hard Sand & Clay	✓	
	193	200	Granite - Fractured	✓	

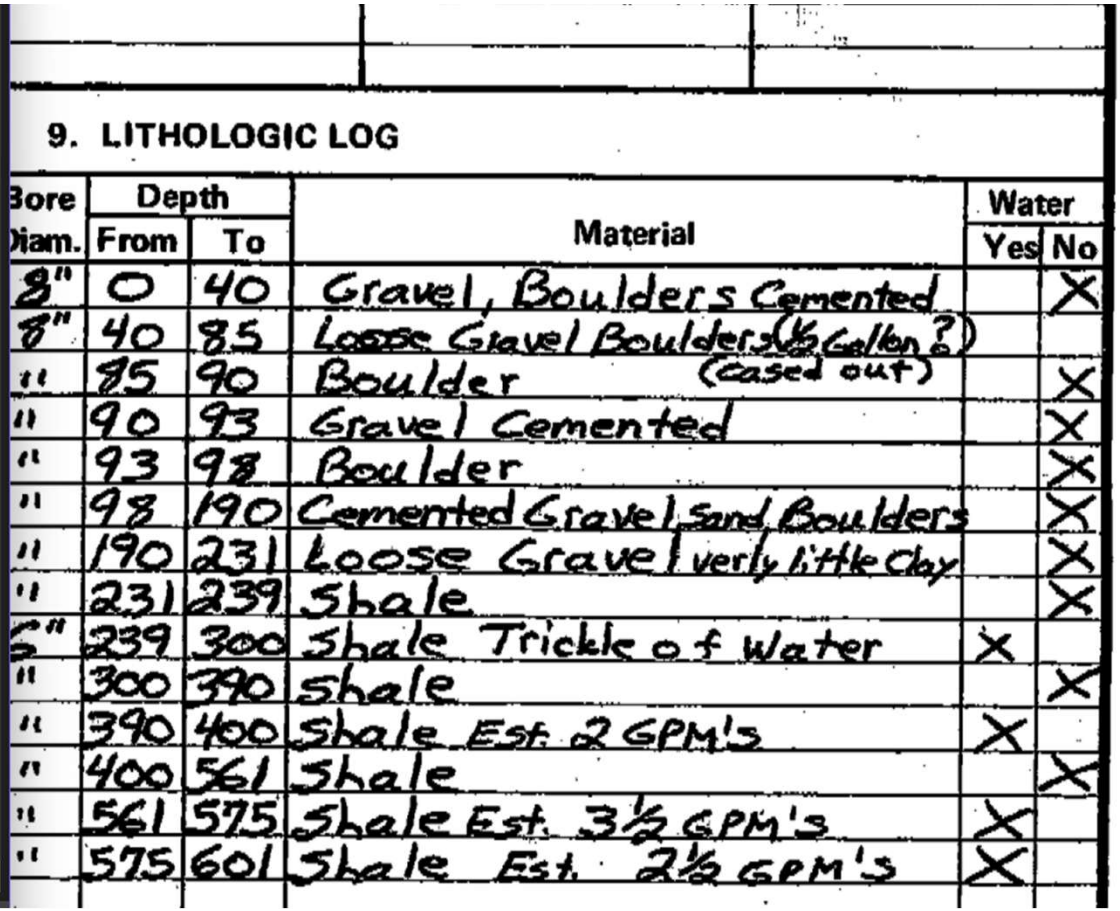
The latest version solved rows dropping randomly

100 % | No issues found | Ln: 9 | Ch: 6 | SPC | CRLF

Results | Messages

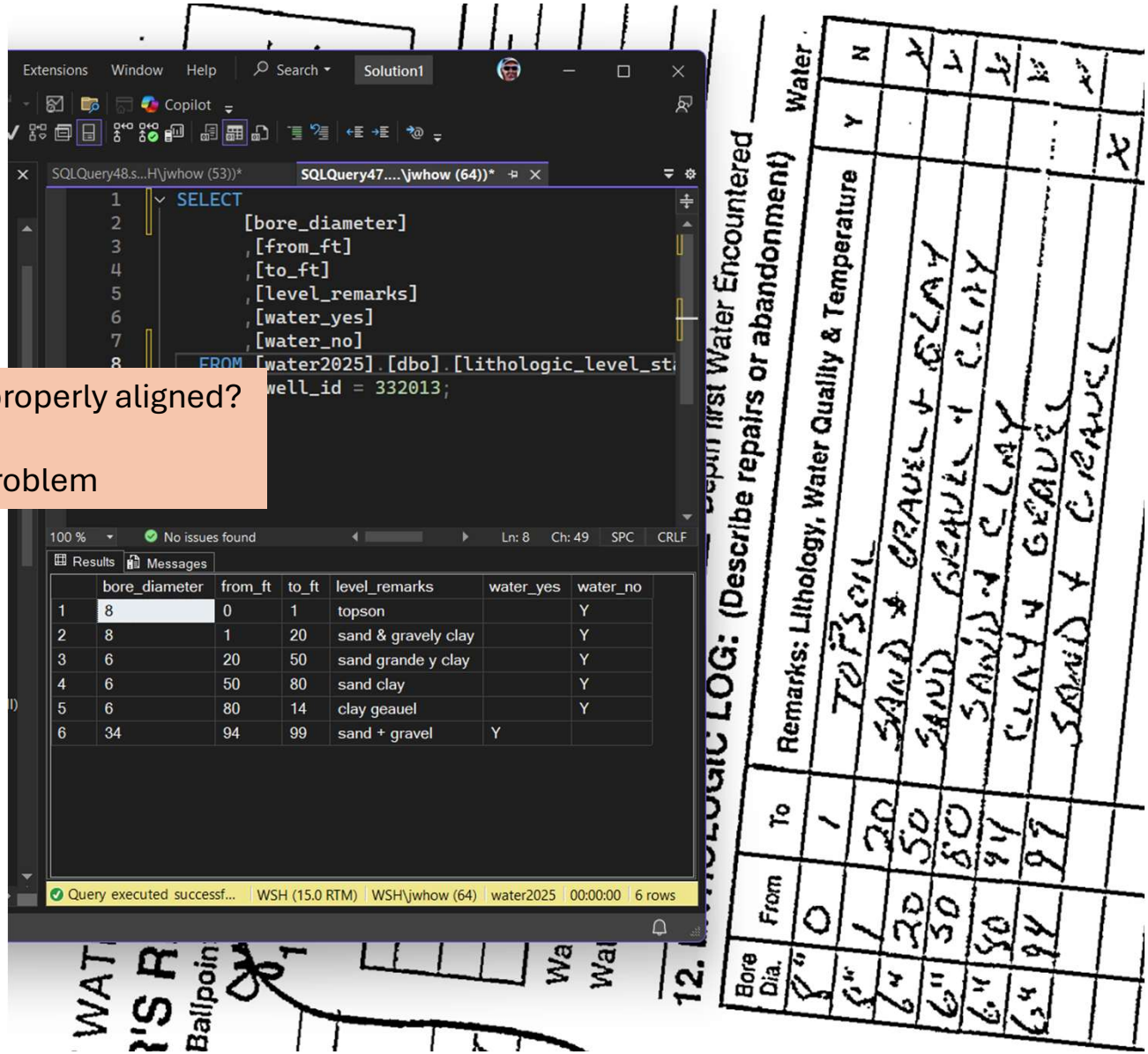
	bore_diameter	from_ft	to_ft	level_remarks	water_yes	water_no
1	NULL	0	40	Gravel, Boulders Cemented		Y
2	0	40	85	Loose Gravel Boulders ('s callon ?)		Y
3	11	85	90	Boulder (Case' out)		Y
4	11	90	93	Gravel Cemented		Y
5	11	93	98	Boulder		Y
6	11	98	190	Cemented Gravel Sand Boulders		Y
7	11	190	231	Loose Gravel very little Clay		Y
8	11	231	239	Shale		Y
9	6	239	300	Shale Trickle of Water	Y	
10	11	300	390	Shale		Y
11	11	390	400	Shale Est 2 6PM'S	Y	
12	11	400	561	Shale		Y
13	11	561	575	Shale Est. 3 1/ 6PM'S	Y	
14	11	575	601	Shale Est 2's 6PM's	Y	

Query executed successfully. | WSH (15.0 RTM) | WSH\jwhow (64) | water2025 | 00:00:00 | 14 rows



9. LITHOLOGIC LOG

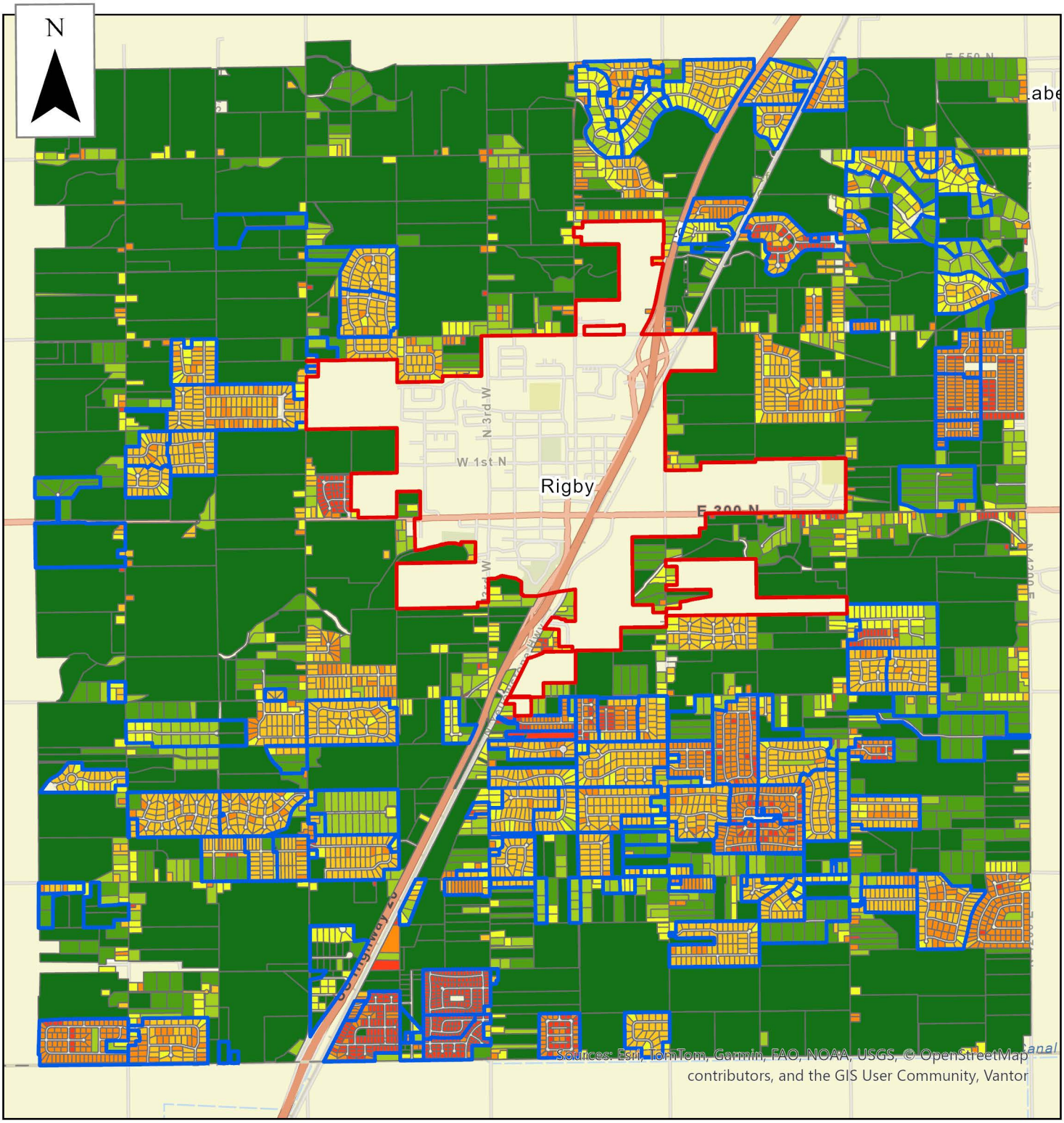
Bore Diam.	Depth From	Depth To	Material	Water Yes	Water No
8"	0	40	Gravel, Boulders Cemented		X
8"	40	85	Loose Gravel Boulders (½ Gallon ?)		
"	85	90	Boulder (Cased out)		X
"	90	93	Gravel Cemented		X
"	93	98	Boulder		X
"	98	190	Cemented Gravel Sand Boulders		X
"	190	231	Loose Gravel very little Clay		X
"	231	239	Shale		X
6"	239	300	Shale Trickle of Water	X	
"	300	390	Shale		X
"	390	400	Shale Est. 2 GPM's	X	
"	400	561	Shale		X
"	561	575	Shale Est. 3½ GPM's	X	
"	575	601	Shale Est. 2½ GPM's	X	


Not properly aligned?
No problem
Extensions Window Help Search Solution1
Copilot
SQLQuery48.s...H\jwhow (53))*
SQLQuery47....\jwhow (64))*
SELECT
[bore_diameter]
,[from_ft]
,[to_ft]
,[level_remarks]
,[water_yes]
,[water_no]
FROM [water2025].[dbo].[lithologic_level_st
well_id = 332013;
100 % No issues found Ln: 8 Ch: 49 SPC CRLF
Results Messages
bore_diameter from_ft to_ft level_remarks water_yes water_no
1 8 0 1 topson Y
2 8 1 20 sand & gravely clay Y
3 6 20 50 sand grande y clay Y
4 6 50 80 sand clay Y
5 6 80 14 clay geauel Y
6 34 94 99 sand + gravel Y
Query executed successf... WSH (15.0 RTM) WSH\jwhow (64) water2025 00:00:00 6 rows
Depth first Water Encountered
Water
Bore Dia.
From
To
Remarks: Lithology, Water Quality & Temperature
Y
N

Recap

- Total Cost: $ 9.42 for 1,226 PDFs
- Python is open source, (free) and all modules employed have no licensing costs or restrictions
- All reports have Azure data, regardless of current state.

form_type	current_state	report_count
ABANDONMENT_REPORT	ROUTED_BAD	21
	OCR_FAILED	3
AUTHORIZATION_TO_ABANDON	ROUTED_BAD	3
EMAIL	ROUTED_BAD	2
LITHOLOGIC_LOG	OCR_JSON_INGESTED	869
APPLICATION_FOR_DRILLING_PERMIT	ROUTED_BAD	9
DATE_OF_INSPECTION	ROUTED_BAD	7
OTHER	ROUTED_BAD	2
START_CARD	ROUTED_BAD	288
WELL_LOG_AND_REPORT	OCR_JSON_INGESTED	23



0 0.25 0.5 1 Miles

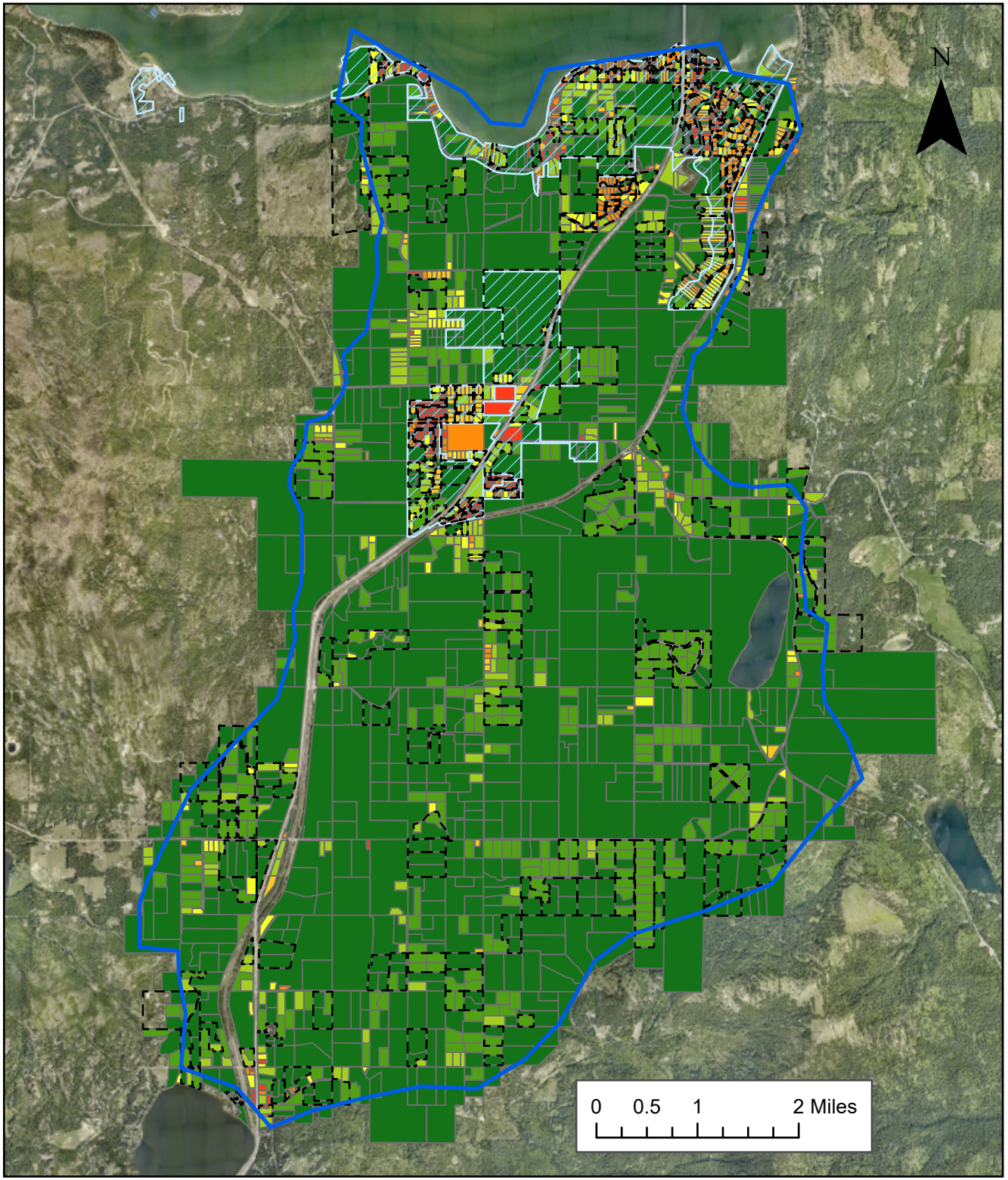
Legend

- Rigby City Limits
- subdivisions outside of rigby

Septic Loading (GPD/Acre)

load_acre

- <50
- 50 - 75
- 75 - 150
- 150 - 250
- 250 - 300
- 300 - 500
- 500 - 1212.90



Sagle Valley Groundwater Study Area

Legend

- Sagle Study area
- sagle_valley_subdivision
- Water and Sewer Districts

Septic Loading

load_acre (GPD)

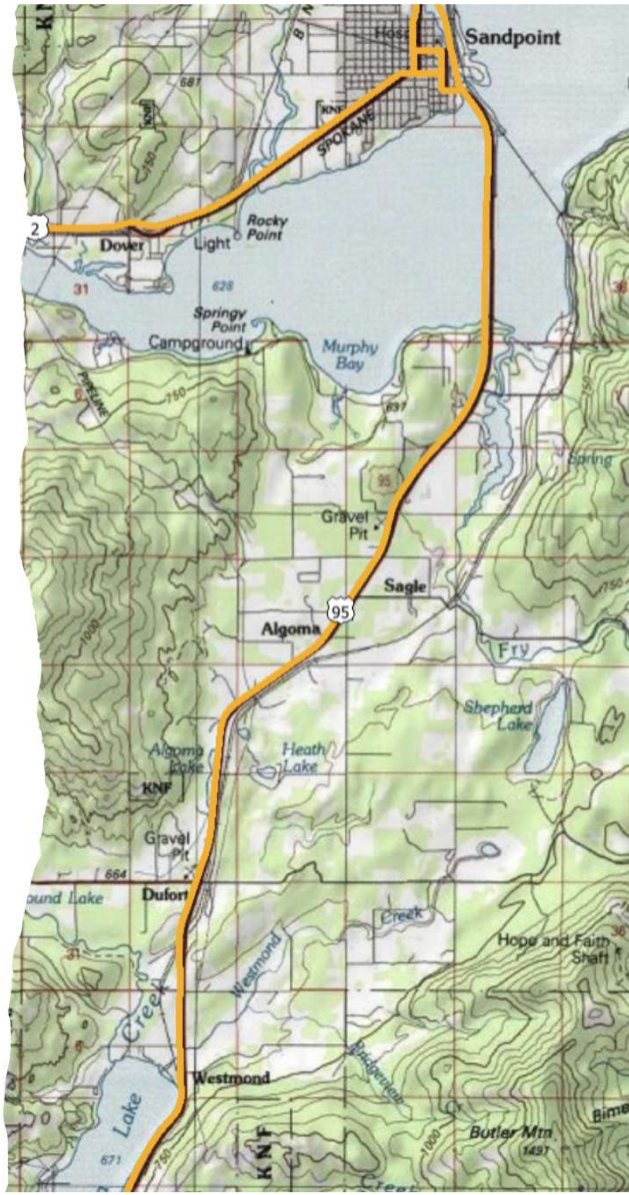
- <50
- 50 - 75
- 75 - 150
- 150 - 250
- 250 - 300
- 300 - 500
- 500 - 1873



Predicting groundwater vulnerability to contamination

Sagle is an unincorporated area South of Sandpoint, Idaho in Bonner County

Over 1,337 Private and Municipal wells have been drilled in this area.



Source water protection

The Safe Drinking Water Act, 1986 and 1996 amendments, provided a structure for protecting public drinking water sources.

The Idaho Department of Environmental Quality is responsible for implementing Source Water Protection.

- **Source Water Protection**:
  - Proactive plans designed to prevent degradation of drinking water sources
- **Requires:**
  - Delineating (mapping) Sources
  - Identifying potential contaminants
  - Determining susceptibility to contamination
  - Developing and implementing management strategies

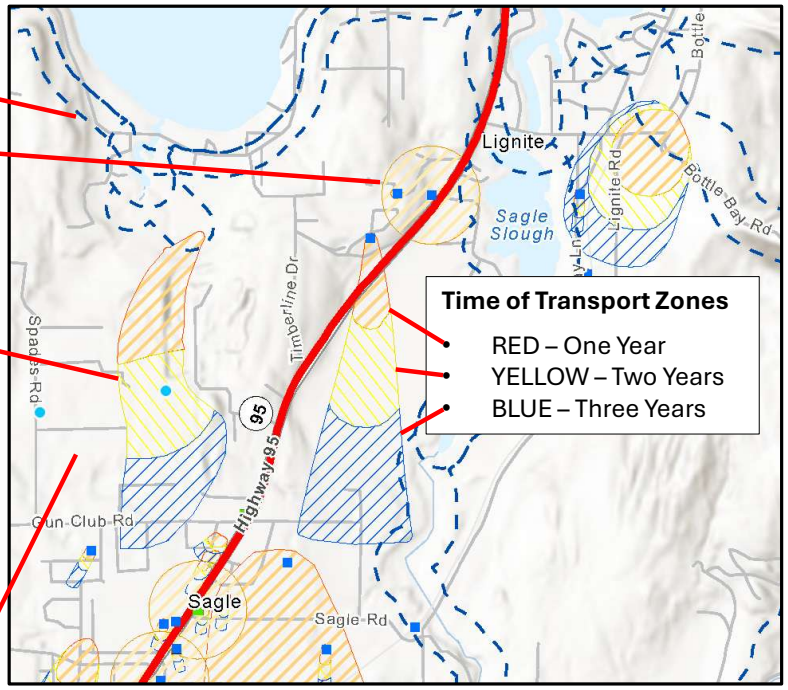
Delineating Drinking Water Sources

Sources to protect are identified by:

- Setback from surface water source (50-200 ft)
- Fixed radius (1000 ft radius)
- Modeled Capture zone (Well Head Analytical Element Model – WhAEM))

- **Requires:**
  - Delineating (mapping) Sources
  - Identifying potential contaminants
  - Determining susceptibility to contamination
  - Developing and implementing management strategies
- **Protection:**
  - These zones were incorporated into ordinance to guide allowed land use in proximity to source wells.

Areas outside of delineated sources are not assessed



WhAEM: Scientifically grounded, simplified in Practice

- WhAEM is a single-layer, steady-state analytical element groundwater model for determining groundwater flow.
- Single values for hydraulic properties (hydraulic conductivity, aquifer thickness, areal recharge, and porosity are used)
- The model is calibrated to a limited number of recorded water levels.
- Adjustments were made to account for pumping, recharge, and soil/rock water-flow properties until the model's water levels matched the actual measured levels.
- The model treats each well separately because each has its own boundary, so the effects of multiple wells are not combined.

We need for a more comprehensive approach

Key Gaps in Current Methods

- WhAEM's simplified assumptions leave subsurface variability, development impacts, and spatial hydrogeologic factors unaddressed.

What Is Needed

- A method that integrates multiple hydrogeologic parameters to map estimated groundwater vulnerability in an area.

The Solution

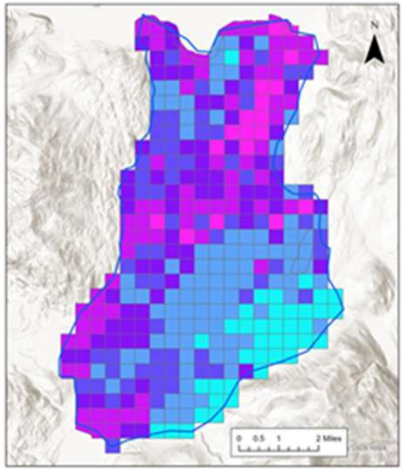
- A Groundwater Vulnerability Index (GVI) provides a spatial, data-driven framework to assess cumulative contamination risk.

Groundwater Vulnerability Index

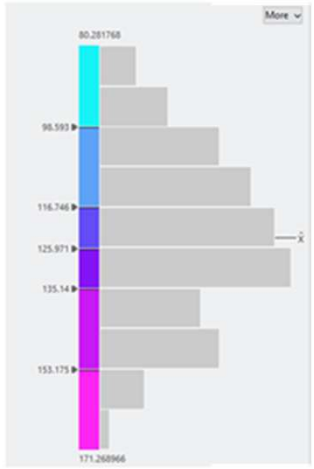
- Maps the risk of surface contaminants percolating into the groundwater system using spatial and hydrogeologic data.
- DRASTIC, Developed jointly by the US Environmental Protection Agency (EPA) and the National Water Well Association in 1985 serves as the most widely used framework in the U.S.
- Proven Reliability: A foundational tool used for decades in groundwater protection and planning across Idaho and worldwide.
- Use of an index is a fundamental approach to groundwater planning and protection, used extensively in Idaho and worldwide for decades.

Bridge WhAEM to GVI

GVI Map



Histogram of GVI values



We propose adopting Groundwater Vulnerability Index values to land use in the same manner as ToT Zone is.

Correlation to Vulnerability Tiers

GVI score	Relative Risk	ToT Zone
80-89	Lowest	III (outer vulnerability)
89-98		
98-107	Lower	III
107-117		II (intermediate)
117-126	Low-moderate	II (intermediate)
126-135	Moderate-increasing	
135-144	Increasing Risk	1B (inner vulnerability)
144-153		
153-162	Greatest Risk	1A (site tier)
162-171		

Conclusion

- WhAEM provided a useful starting point but relies on simplified assumptions, neglects spatial impacts from factors controlling infiltration, and does not provide for an assessment of cumulative impact.
- A GVI is a data-driven framework integrating multiple hydrogeologic parameters addressing a cumulative susceptibility to contamination. Potential contaminant sources can then be spatially assessed.
- Bridging WhAEM's time-of-travel zones with GVI vulnerability tiers enables informed land use protection decisions.
- This integrated approach strengthens required source water protection assessment and supports sustainable land use planning in Bonner County and beyond.

SUBCHAPTER 5.3 – WELLHEAD PROTECTION OVERLAY DISTRICT

12-530: PURPOSE OF DISTRICT:
The wellhead protection overlay district is established for the purpose of protecting public water supply wells or springs from contamination by land use activities occurring or which may occur within the delineated recharge areas for such wells or springs. (Ord. 501, 11-18-2008)

12-531: ESTABLISHMENT OF OVERLAY DISTRICT; APPLICABILITY:
There is hereby created a wellhead protection overlay district within Bonner County, the boundaries of which shall be established by the procedures and according to the criteria set forth in this subchapter. The provisions of this subchapter shall only be applicable within a properly established wellhead protection overlay district; provided, further, that no existing lawful use shall be affected by this title, but such uses will be governed by subchapter 3.4 of this title, nonconforming uses and structures, as amended. The requirements of this subchapter shall be deemed to be cumulative and supplementary to those of any underlying zone district. Whenever a conflict between the provisions of this subchapter and the underlying zone district exist, the more stringent requirements shall apply. (Ord. 501, 11-18-2008)

12-532: ELIGIBILITY FOR OVERLAY DISTRICT:
For the purposes of this subchapter, a wellhead protection overlay district shall only be established where a direct relationship exists between the overlay district and a well or spring serving a public water system which serves ten (10) or more connections or twenty five (25) or more of the same persons for at least six (6) months of the year, whether such public water system is publicly or privately owned or operated. (Ord. 501, 11-18-2008)

12-533: APPLICANTS FOR OVERLAY DISTRICT:
The following persons or entities may apply for lands to be designated as a wellhead protection overlay district:

A. The owner of any well as set forth at section 12-532 of this subchapter; or

B. Any incorporated municipality, water district, water and sewer district, recreational water district or homeowners' association which is the primary user of any well as set forth at section 12-532 of this subchapter. (Ord. 501, 11-18-2008)

12-534: ZONE BOUNDARIES FOR SCIENTIFICALLY ESTABLISHED WELLHEAD PROTECTION OVERLAY DISTRICT:
Scientific studies conducted by hydrogeologists, licensed geologists or licensed professional engineers shall be provided, and such studies shall include, but are not limited to, calculations and modeling to include zone III mixing water flow, transmissivities, effective porosity, regional and local hydraulic gradients, depth to saturated zones, aquifer saturated zones, aquifer saturated thickness, boundary conditions, degree of confinement and recharge areas as appropriate to develop time of travel boundaries. The United States environmental protection agency methodology, "Wellhead Protection Area (WHPA) Delineation Code, Version 2.1", by Blandford and Huyakorn, April 1992, or equivalent, shall be used for calculating and modeling time of travel boundaries. The following shall constitute the boundaries for the wellhead protection overlay district:

TABLE 5-2

OVERLAY DISTRICT BOUNDARIES

Zone	Criteria And Thresholds	Methods

Zone IA	Minimum distance of 100 feet for wells and/or springs	Fixed radius
Zone IB	2 year time of travel	Calculated/modeled boundary
Zone II	5 year time of travel	Calculated/modeled boundary
Zone III	10 year time of travel	Calculated/modeled boundary

(Ord. 501, 11-18-2008)

12-535: USE TABLE:
The following table 5-3 identifies uses of special concern in the wellhead protection overlay district. Uses identified with a "C" are conditional, and uses not identified as conditional are prohibited. Uses listed in table 5-3 are subject to either the standards set forth in this subchapter or to the standards set forth in the underlying zone, whichever is more stringent. Uses not listed in table 5-3 are subject to the standards set forth in the underlying zone. Standards associated with particular uses are identified by numbers and are listed below the table.

TABLE 5-3

USES IN THE WELLHEAD PROTECTION OVERLAY DISTRICT

Use	**Overlay District**			
	IA	**IB**	**II**	**III**
Use	**Overlay District**			
	IA	**IB**	**II**	**III**
Residential Uses:				
Dwelling, multi-family		C	C	C
Mobile home parks		C	C	C
Residential care or assisted living facility		C	C	C
Commercial Uses:				
Animal establishments		C	C	C
Convalescent center		C	C	C
Farm equipment sales and service		C	C	C
Hotels/motels		C	C	C
Miscellaneous commercial uses (1, 2)				C
Racetracks		C	C	C
Repair services, boat and motor, minor		C	C	C
Resorts, commercial		C	C	C
Resorts, private		C	C	C
Storage of hazardous materials, above or belowground (1)			C	C

Vehicle sales and service, mechanical repair shops		C	C	C
Industrial Uses:				
Industrial and manufacturing			C	C
Junkyards/wrecking yards				
Manufacturing of explosives		C	C	C
Manufacturing of hazardous materials (1)				
Sawmills, shingle or planing mills, woodworking plants		C	C	C
Slaughterhouses, meat processing or rendering plants		C	C	C
Public Uses:				
Airports		C	C	C
Cemeteries				
Golf courses		C	C	C
Heliports		C	C	C
Hospitals and clinics		C	C	C
Injection wells for waste products				
Public utility complex facility		C	C	C
Recreational facilities		C	C	C
Recreational vehicle parks and campgrounds		C	C	C
Sanitary landfills				
Sewage treatment or storage, 2-9 dwelling units or capacity of less than 2,500 gallons per day		C	C	C
Sewage treatment or storage, 10 or more dwelling units or capacity of 2,500 gallons or more per day				C
Solid waste collection facilities		C	C	C
Stormwater drain fields, impoundments, infiltration beds or injection wells			C	C
Resource Based Uses:				
Agribusiness activities (1)		C	C	C
Commercial land application of agricultural wastes (2)			C	C
Commercial land application of effluent, sludge or septage (2)				C
Commercial surface impoundments of agricultural, commercial or industrial wastes (2)		C	C	C

Confined animal feeding operation				
Fur farms, commercial		C	C	C
Mining			C	C
Rock crushing operations			C	C

Standards:

1. Where fuel, chemicals, fertilizer, solvents, pesticides, waste oils and other similar petroleum products or byproducts, leachates or other detrimental materials and/or wastewater discharge pose a proximate threat to groundwater as determined by the Panhandle health district and/or state of Idaho.

2. "Commercial", for purposes of this section, shall be defined as "activities designed for the market; relating to commerce; viewed with regard to profit; or supported by advertisement", excluding "home occupations", as defined in section 12-808 of this title.

(Ord. 501, 11-18-2008)

12-536: SPECIAL REQUIREMENTS AND RESTRICTIONS WITHIN DISTRICT:

A. Within an established wellhead protection overlay district, and subject to the provisions of this subchapter, the performance and conditional use standards listed in subchapter 2.2 and chapter 4 of this title, respectively, and the requirements of the underlying zone district, the following uses are prohibited or require conditional use permit issuance. Uses not listed within this section that are listed as permitted uses within the underlying zone district are subject to the provisions of that district, together with the performance standards listed in chapter 4 of this title. Uses not listed within this section that are listed as conditional uses within the underlying zone district are subject to the provisions of that district, together with the performance and conditional use standards listed in subchapter 2.2 and chapter 4 of this title, respectively.

B. In addition to the performance and conditional use standards listed in subchapter 2.2 and chapter 4 of this title, respectively, and the requirements of the underlying zone district, uses requiring conditional use permit issuance are subject the following:

1. Prior to conditional use permit issuance, the applicant shall demonstrate to the satisfaction of the Panhandle health district and/or state of Idaho pursuant to applicable standards and appropriate practices that, where applicable, fuel, chemicals, fertilizer, solvents, pesticides, waste oils and other similar petroleum products or byproducts, leachates or other detrimental materials and/or wastewater discharge shall not pose a proximate threat to groundwater. The applicant shall provide to the planning department written verification from the Panhandle health district and/or state of Idaho confirming implementation of Panhandle health district and/or state of Idaho requirements.

C. Where all "urban services", as defined in section 12-821 of this title, are not available, the minimum lot or parcel size for divisions of land within an established wellhead protection overlay district shall be five (5) acres. Exception: cluster lots in a conservation subdivision may be less than five (5) acres, provided the overall subdivision density does not exceed one dwelling unit per five (5) acres. (Ord. 501, 11-18-2008)

12-537: APPLICATION FOR WELLHEAD PROTECTION OVERLAY DISTRICT; CONTENTS:

An application for wellhead protection overlay district shall include all of the items required for zone changes in subchapter 2.1 of this title, and shall be accompanied by the fee for a zone change as set forth at section 12-265 of this title, and shall additionally include:

A. The names of the applicants and documentation that the applicants meet the criteria set forth at section 12-533 of this subchapter;

B. The scientific study completed for the proposed wellhead protection area, meeting the requirements of section 12-534 of this subchapter, and additional copies of said study as determined by the planning director;

C. A map at a scale of one inch to four hundred feet (1" = 400'), showing the proposed boundaries of zones IA, IB, II and III, as appropriate, and depicting individual lots or parcels, property ownership, and existing zoning within the boundaries;

D. A map at a scale of one inch to four hundred feet (1" = 400'), showing the proposed boundaries of zones IA, IB, II and III, as appropriate, and depicting lot or parcel boundaries, and significant features to include, but not limited to, existing wells (identifying any public water supply wells); existing springs; existing roads; existing gravel pits or other mining operations; existing above or belowground fuel storage tanks; and any existing land uses which may constitute a significant, potential contamination source for groundwaters.

E. A public information/public awareness plan specifying how and when the applicant will notify landowners within the wellhead protection overlay district of ways to promote groundwater protection.

F. A management plan identifying high risk activities that may pose a proximate threat to groundwater and ways to mitigate those threats.

G. A contingency plan identifying an alternate water source for the applicant and the method of procuring that source, financially and technically, in the event of closure of the subject well or spring.

H. A program establishing, at a minimum, annual subject well or spring water testing; voluntary water testing of private wells located within the established overlay district; and a method of notifying at minimum landowners within the wellhead protection overlay district of testing results.

I. Written documentation verifying that the applicant has invited public participation from, at a minimum, landowners within the wellhead protection overlay district. (Ord. 501, 11-18-2008)

12-538: PROCEDURE:
The procedure for the addition of a wellhead protection overlay district shall be as set forth for zone changes generally in this title. (Ord. 501, 11-18-2008)

12-539: STANDARDS:
In addition to the standards for zone changes generally, as set forth in this title, the following standards shall be applicable to any application for a wellhead protection overlay district:

A. There is a need to protect and preserve clean drinking water supplies for current and future residents.

B. There is a potential for groundwater contamination of current and potential land uses within the proposed overlay district.

C. There is not a potential for significant loss of use of properties not owned by the applicant through the restrictions imposed by the proposed overlay district.

D. There are reliable data upon which the zone district boundaries have been proposed. (Ord. 501, 11-18-2008)

12-540: WATERSHED PROTECTION OVERLAY:
(Reserved) (Ord. 501, 11-18-2008)


Algoma