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INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

Proper Investigative Techniques for Shallow Bedrock

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INTRODUCTION

There are several standard assumptions commonly used to predict contaminant behavior in porous media:

- Subsurface sediments are relatively flat lying strata and continuous across the study area,
- Groundwater flows in predictable directions,
- Perched groundwater is not directly connected to the water table,
- Groundwater flows toward the nearest stream, and
- Contamination will flow with the groundwater.

When encountering bedrock at a shallow depth (less than 25 feet below ground surface, ft.-bgs), these assumptions may not accurately represent site conditions and direct transport of contaminated materials should be included in the conceptual site model (CSM). If bedrock is greater than 25 ft.-bgs, contamination is usually specific to a limited set of contaminants such as chlorinated solvents and manufactured gas plant (MGP) residuals and presents special considerations and challenges beyond what is presented in this document. The document addresses the data collection and investigation methods used to evaluate contaminant fate and transport along the interface between unconsolidated sediments and shallow bedrock.

Shallow Bedrock

Investigations in some areas of Indiana can include bedrock that is very close to the surface. When refusal is encountered, it is common to stop drilling, take samples, and set a well. In doing this, a very important preferential pathway for contaminant migration is potentially overlooked. Without the additional overburden, shallow bedrock is more susceptible to weathering and interconnection with unconsolidated sediments. Groundwater will flow within the weathered bedrock surface until deeper un-weathered material is encountered or the water table intersects the land surface (seeps).

Should bedrock be shallow enough, installation of a well in the overlying unconsolidated materials may not be possible. In this case, installation in the weathered bedrock (not necessarily karst) may be needed. The top of the well screen should be at a minimum six feet bgs to allow for:

- 2 feet of filter pack above the top of the well screen (USEPA 2013),
- 2 feet of bentonite grout (USEPA 2013) , and
- 2 feet of concrete for the surface pad (USEPA 2013).

If a well is installed closer than six feet to the surface, there is a possibility that surface water could enter the well (potential preferential pathway).

Bedrock surface mapping:

If the available soil boring data is insufficient to develop a bedrock surface map, a series of probe points can be advanced (usually on a grid pattern) until refusal. The depths of refusal are mapped and, if present, the "low spot" on the bedrock surface can be located. Soil samples should be collected from the identified low spots. Since sediments along the bedrock surface can become entrained in water flowing along this surface, soil sampling in areas with shallow bedrock is needed to evaluate the migration of contaminated soil particles. If high levels of soil contamination are identified in the "low spot", there is a reasonable probability that contaminated groundwater may be flowing along the bedrock surface.

Geophysical Survey:

If traditional soil boring data fails to provide the data needed to develop a bedrock surface map, geophysical mapping of the bedrock surface is another option (a work plan outlining the survey with supporting data should be provided to IDEM for review). Geophysics can provide data to both locate potential "problem areas" where bedrock mapping should be focused, and allow accurate extrapolation of data between borings. Examples of land-based geophysical methods include:

- Electromagnetics (EM) and Electric Imaging (EI),
- Spontaneous Potential (SP),
- Microgravity,
- Seismic Refraction, Reflection, and Surface Wave Analysis, and
- Ground Penetrating Radar (GPR).

These techniques work best when there is little to no near-surface interference (sometimes called cultural interference). Types of near-surface interference can include, but are not limited to:

- Utility corridors,
- Fill materials,
- Reinforced concrete, and
- Above ground, metallic objects (i.e. fences, railroads, power lines).

If there is significant near surface interference, geophysical investigation results can be misleading and traditional soil borings will produce better results. Prior to conducting any geophysical surveys, it is recommended that IDEM is included in

preliminary decision making to determine if such an investigation is reasonable and/or necessary to complete site characterization.

Groundwater Sampling:
If bedrock mapping identifies any "low spots", monitoring wells can be installed so that the screens intersect the interface between the unconsolidated materials and the bedrock surface where the transport of entrained contaminated sediments is occurring. At least one monitoring well should be installed in each of the "low spots" identified on the bedrock surface map. These wells are installed to monitor water flowing along the bedrock surface. One of the most difficult aspects of sampling this type of groundwater is when to sample. Water flowing along the bedrock surface is dependent on rainfall. Since water flow along the bedrock surface may be affected by precipitation events, samples need to be collected during non-storm and storm flow conditions. Non-storm flow conditions are when there is less than 0.25-inch of rain in a 24-hour period (termed base flow conditions). Storm flow conditions are during any precipitation event greater than 0.75-inch of rain in a 24-hour period.

Special Cases and Other Considerations

Pinnacle Reefs of Northeastern Indiana
Pinnacle reefs can add an element of uncertainty during investigations conducted in this region. These bedrock structures can be extremely porous and should be generally investigated like karst.

Devonian Shales of Indiana
Investigators need to know if the site under investigation is located in an area where Devonian Shales are present. Bedrock investigation in areas with Devonian Shales is conducted in the same manner as other shallow bedrock except for contaminant sampling. The Devonian Shales of Indiana (very common in southern Indiana) are organic rich shales (geologists refer to these types of shale as oil shales) that can provide anomalous SVOC and metals concentrations. It is also possible the soils directly above these shales will also have a high organic content.

Karst Bedrock
Contamination in karst does not follow many of the fate and transport assumptions presented in this document. Please consult with IDEM Science Services Branch for a site-specific plan to address these situations. Please see IDEM's Technical Guidance Document entitled "*Proper Investigative Techniques in Karst*" for more information.

Fractured Bedrock
Fractured bedrock presents substantially different and more complex contaminant flow behaviors. The Interstate Technology and Regulatory

Council (ITRC) has developed a document entitled "*Characterization and Remediation in Fractured Rocks*" that details the methods and techniques to commonly used to investigate fractured bedrock.

SUMMARY AND CONCLUSIONS

Staff assembled the information contained in this document from sites in Indiana and staff experiences. This document provides a basic outline for investigating shallow bedrock. More in-depth evaluations should be discussed on a site-specific basis. An understanding of the nature of not only the materials associated with shallow bedrock, but also how groundwater interacts with those materials is needed to develop an accurate CSM. When shallow bedrock is present, a successful remedial approach may involve a combination of remediation methods. Elements of a remedial measure can include, but are not limited to: excavation, in-situ chemical oxidation, vapor extraction, bioremediation, pump & treat, source removal (free phase contamination), or use of Environmental Restrictive Covenants (ERCs).

Further Information

If you have any additional information regarding this subject or any questions about the evaluation, please contact IDEM's Office of Land Quality, Science Services Branch at (317) 232-3215. IDEM's TEG will update this technical guidance document periodically or upon receipt of new information.

REFERENCES

Davis, S.N., 1988, Sandstones and Shales, in Back, William, Rosenchein, J.S., and Seaber, P.R., eds., Hydrogeology: Bolder Colorado., Geological Society of America, The Geology of North America, v. O-2, p. 323-332.

Heath, R.C., Hydrogeologic Setting of Regions, in Back, William, Rosenchein, J.S., and Seaber, P.R., eds., Hydrogeology: Bolder Colorado., Geological Society of America, The Geology of North America, v. O-2, p. 15-23.

Pinsak, A.P., Shaver, R.H.; 1964; Indiana Geological Survey (IGS), Bulletin #32, 87 Pages.

Shaver, R.H.; 1978; Indiana Geological Survey (IGS), Special Report # 15, 36 Pages.

USEPA. 1988. Application of dye-tracing techniques for determining solute-transport characteristics of ground water in karst terranes.

USEPA. 2013, Design and Installation of Monitoring Wells January 29, 2013, SESDGUID-101-R1, https://www.epa.gov/sites/production/files/2016-01/documents/design_and_installation_of_monitoring_wells.pdf