



Well Construction Practices in the Marcellus

EPA: Technical Workshops for the Hydraulic Fracturing Study

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Agenda – Well Construction and Fresh Water

- Marcellus

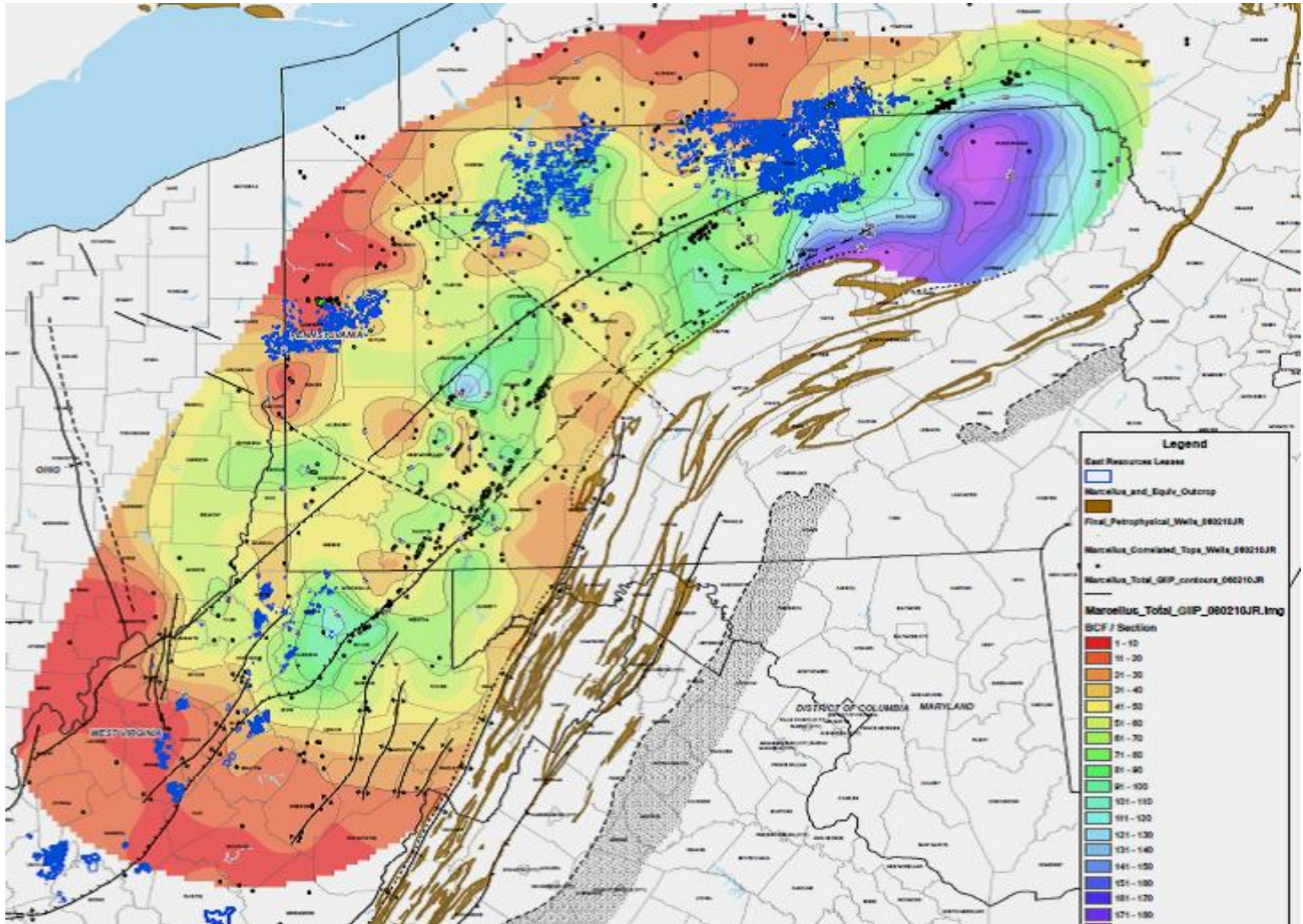
- Identifying Sources

- Protecting Sources
 - Hazard Avoidance

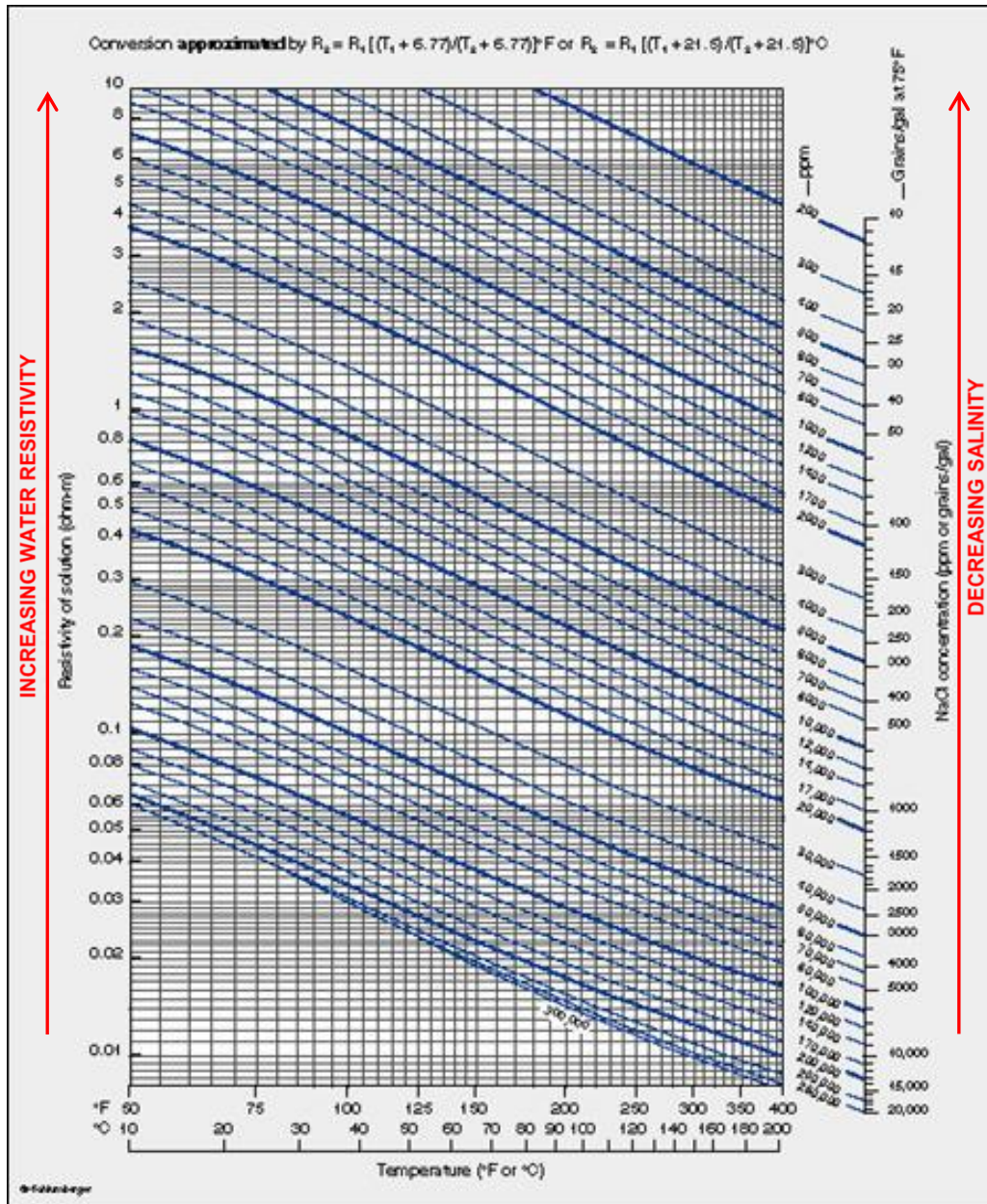
 - Zonal Isolation



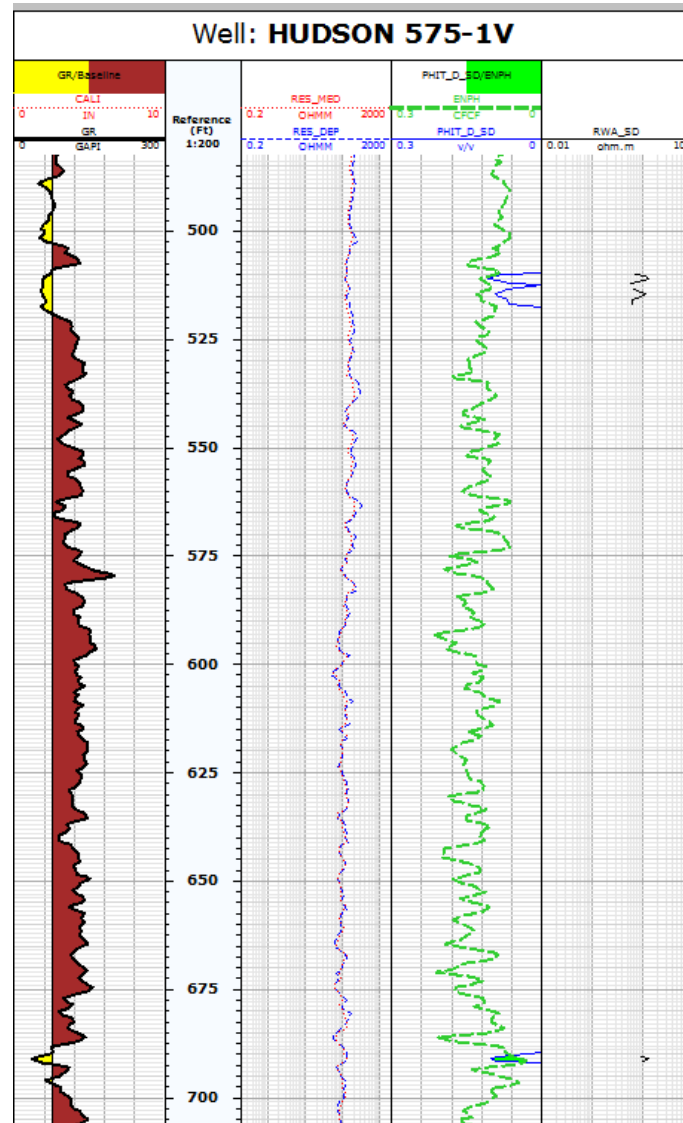
Marcellus Resource



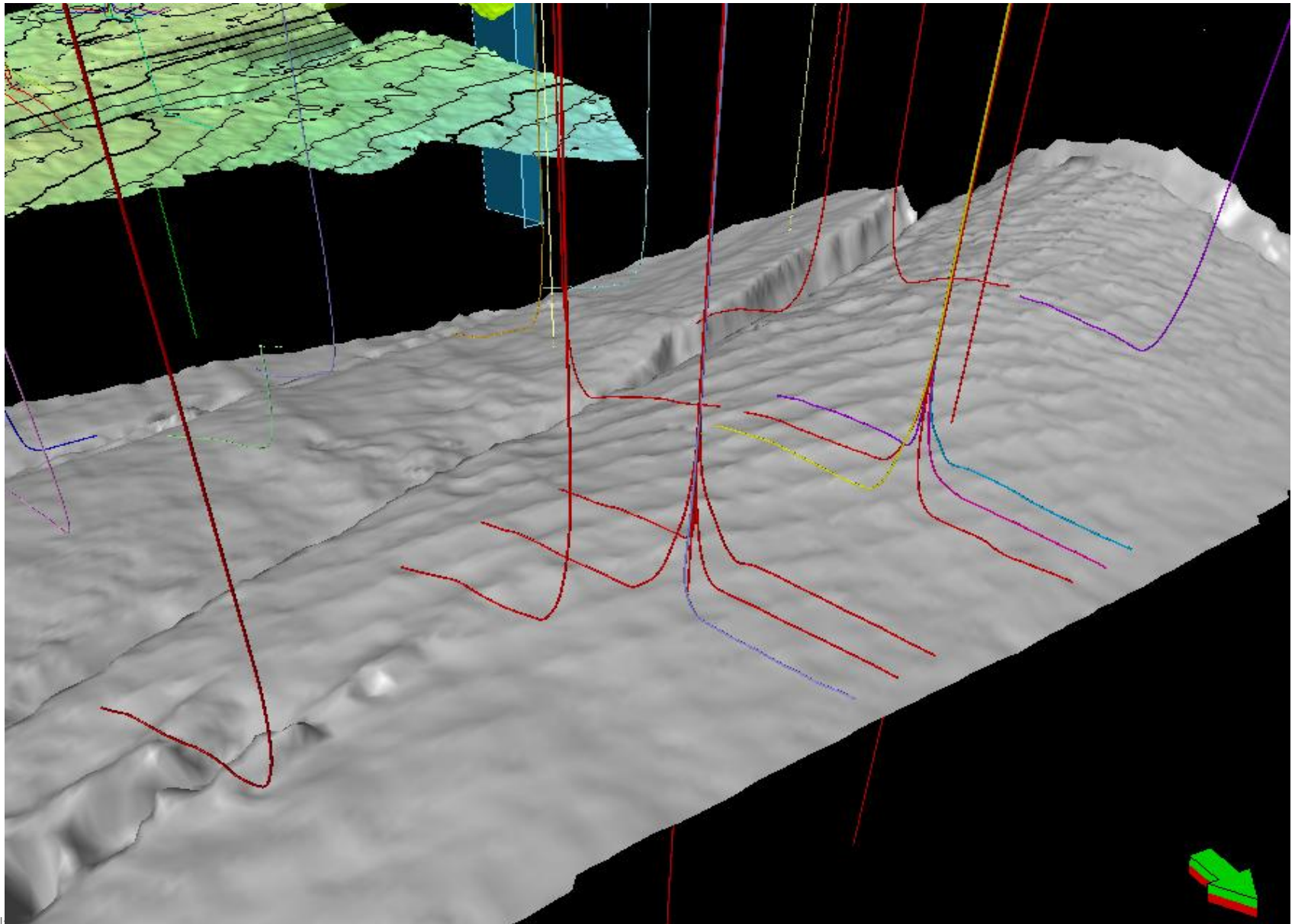
Water Salinity / Resistivity Relationship



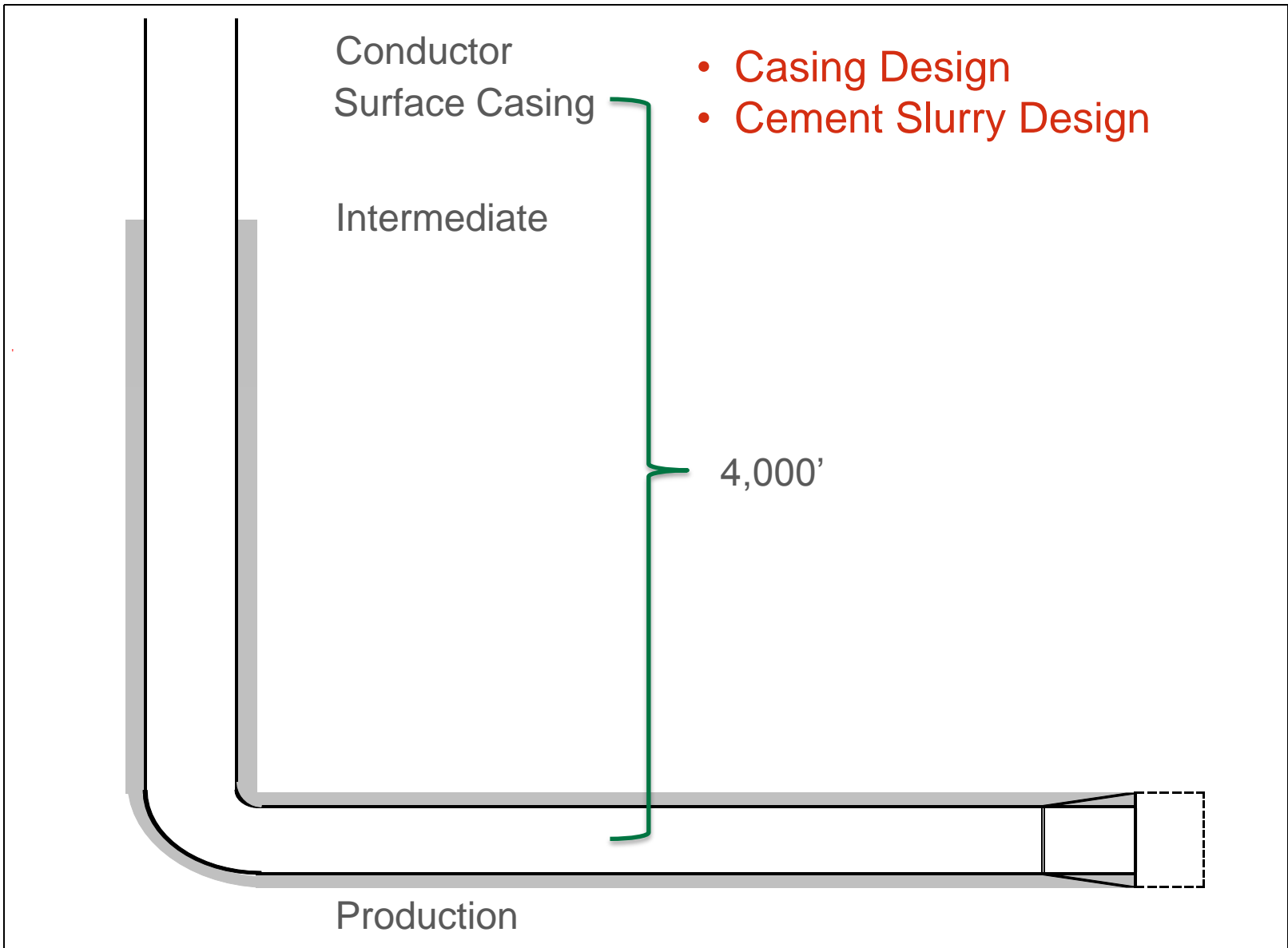
Evaluation



Formation Targeting



Horizontal Wellbore Construction



Shell's Well Construction Practices in the Marcellus Shale

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Introduction

This paper is about the well planning and construction techniques that Shell uses in the development of the Marcellus Shale to:

- Identify potential subsurface drinking water sources (private and municipal)
- Protect them through hazard avoidance (target zone planning) and zonal isolation

It will include location selection, directional planning, casing selection and design, cement slurry design, and integrity testing prior to fracture stimulation.

Background

The Marcellus Shale is a laterally contiguous shale deposit that covers parts of Pennsylvania, West Virginia, Ohio, New York, and Virginia. This shale has been proven to contain commercially viable natural gas resources and thus has entered the development phase of a hydrocarbon resource. As part of the development technique, hydraulic fracturing is utilized to enable production of natural gas at commercial rates. This technique allows for high conductivity fractures to be created, or natural fractures to be supplemented, that allow higher flow surface areas to connect to a wellbore. In order for fracturing operations to commence a wellbore must be drilled to the appropriate location with the appropriate equipment to allow integrity and control during the fracturing operation.

Drinking Water Source Identification

The process for the identification of sub-surface drinking water sources starts when a well location to be drilled has been identified. This process begins with a spatial and title review to identify offsetting land owners or potential users of sub-surface water for consumption or other use. Once the spatial and title review have been completed a survey is conducted, via registered mail, to determine if people within 1,000' of the proposed drilling location have sub-surface water source wells. If sub-surface water wells are present then information about the depth of the well is gathered. Additionally a request to conduct a base line survey (Table 2), including gathering a sample, is requested from the owner or user of the sub-surface water well.

Well Directional Planning

The directional planning of oil and gas wells are undertaken to hit subsurface targets and avoid subsurface hazards that could compromise the integrity of the wellbore or the ability to reach the final objective. There are two basic approaches that are used to identify hazards, the first is

by geologic interpretation and the second is by seismic interpretation. Geologic interpretation uses the latest data available to continually improve the model. The basic inputs are surface data, including topography and outcrop information. As information on new wells is gathered this model is improved to grow the understanding and improve future interpretations. The seismic interpretation is based on the acquisition of seismic data, or the acoustic response of subsurface features to a surface event. Examples, not all inclusive, of subsurface hazards to potentially avoid when performing directional planning would be faults, shallow gas, and shallow water flows.

Zonal Isolation

Zonal isolation is generally accomplished through the use of steel casing that is cemented in place for the purpose of structure and annular isolation. The steel casing is typically designed for the anticipated operating loads to which it will be exposed, including running, future well construction activities (including hydraulic fracturing operations), and production operations. The annular area outside the steel casing is cemented to support the pipe and help control some of the loads (e.g. buckling). The cement is also used to control flow in the pipe annulus. The cement is engineered for specific properties, including but not limited to, set up time, compressive strength, and viscosity.

Conclusion

All of the practices represented in this paper are built on a back bone of Health, Safety, Security, and Environmental (HSSE) management. These practices comply with regulations and incorporate best industry practices. Hazard identification and management are core to the sustainability of our operations. At Shell, safety is a deeply held value that is demonstrated by our pursuit of “Goal Zero”, or the goal to have a zero incident work environment.

Table 2. Parameters analyzed during baseline water survey

Test	Holding Time (with Preservative)
pH (Lab)	Immediate
Alkalinity	14 days
Chloride	28 days
Hardness	6 months
Sulfate	28 days
Total Dissolved Solids (TDS)	14 days
Total Suspended Solids (TSS)	7 Days
MBAS/Surfactants	48 hours
Nitrate-Nitrogen	
Turbidity	Immediate
Specific conductance	
Barium	6 months
Calcium	
Iron	6 months
Magnesium	6 months
Potassium	6 months
Sodium	6 months
Arsenic	6 months
Cadmium	6 months
Chromium	6 months
Lead	6 months
Mercury	28 days
Selenium	6 months
Silver	6 months
Bromide	
Strontium	
Oil and grease	28 days
Benzene	14 days
Toluene	14 days
Ethylbenzene	14 days
Xylene	14 days
Ethylene glycol	
Total coliform	
E. coli	
Fecal coliforms	
pH (Field)	
Methane (% in atmosphere; well head space)	
Methane (% of LEL; well head space)	
Methane (in water)	7 days
Ethane	7 days
Propane	