Well Completion Methods for Aquifer Protection

By William E. Godsey, PG

Engineering Geologist - President

Geo Logic Environmental Services, LLC

Longview, Texas

bill.godsey@geologicenvironmental.com

903-753-8200

Introduction

- Appropriate environmental, hydrogeologic and regional geologic investigations coupled with proper well construction techniques can all but eliminate the potential for problems with adverse impact related to hydraulic fracturing.

Purpose

- The purpose of this presentation is to outline the tasks that can be undertaken concurrent with leasing, site acquisition, permitting and development of prospect areas to identify and mitigate potential pathways of frac fluids other than intended target zones.

Location

- Almost without exception, shale gas plays occur where existing oil and gas production, mining or known geologic structures are known. In many cases, these plays are now located in populated rural areas and urban settings where development and water supply wells are located.

Study Area

- The area selected for study is in East Texas where the Haynesville Shale extends into and under existing oil and gas fields and underlies extensive fresh water aquifers and lignite fields. There are also numerous gas storage fields, brine injection/disposal wells and complex geologic structures located in this area.

When to Conduct Due Diligence

- 1. Prospect is developed.
- 2. Land is leased.
- 3. Conduct due diligence investigation.
- 4. Casing and cementing program design.

Information Sources

- Records Research
- Well Log Review
- Published Reports
- Economic Data
- Public Records
- State Geologists
- University/College
- GIS Mapping
- Private Data Bases
- Regulatory Agency
- Surface Geology
- Groundwater/Soil
- Appraisal/Real Est.
- USGS/Fed. Agency

Aquifer Protection Investigation

- Identify all aquifers
- Determine base of usable quality water
- Locate municipal water supply wells and/or large irrigation wells
- Locate productive oil/gas intervals
- Isolate pressured or lost circulation zones

Illustrations Presented

- Oil and Gas Fields with Well Locations
- Stratigraphic Column
- Location Maps With Wells
- Major and Minor Aquifer Maps
- Alluvial Aquifer Maps
- Rural Water Supply Wells

Illustrations (continued)

- Well Log
- Municipal Water Supply Well Locations
- Lignite and Coal Map
- Casing and Cementing Criteria

What Tasks Needed to Complete An Appropriate Inquiry Into Potential Pathways?

- Determine Area of Well Bore Influence
  - Determine Regional Geologic Conditions
  - Indentify Hydrogeologic Setting
  - Locate Oil/Gas Fields/Mining Areas/Minerals
  - Municipal Water Supply Wells/Fields
  - Identify All Well Penetrations and Depths
  - Determine Status of Wells

Summary and Conclusions

Hydraulic fracturing can be conducted safely and aquifer protection can be provided when appropriate site investigation is conducted. Once aquifers and potential pathways of exposure are identified, casing and cementing programs can be developed to address specific applications. Geologic conditions vary from site to site and there are numerous frac methods to address the individual circumstances and assure aquifer protection.

Well Completion Methods for Aquifer Protection

William E. Godsey, PG
Geo Logic Environmental Services, LLC

The statements made during the workshop do not represent the views or opinions of EPA. The claims made by participants have not been verified or endorsed by EPA.

Introduction

Hydraulic fracturing of highly variable hydrocarbon producing geologic formations can be conducted safely and in an environmentally protective manner using well established petroleum industry standards. Geologic, environmental and engineering characteristics have utilized numerous fracturing media and techniques that are used in a variety of applications. The industry standards, in conjunction with appropriate due diligence and inquiry in the area of the targeted area for hydraulic fracturing, can result in successful well completions and groundwater protection.

Purpose

The purpose of this presentation is to outline how appropriate due diligence can be undertaken concurrent with leasing, site acquisition, permitting and development of prospect areas to identify and mitigate potential pathways of frac fluids other than intended target zones. Identification of potential pathways for fluids will allow for drilling, completion and hydraulic fracturing and can identify potential areas of concern and provide the engineering and design of the well bore construction team the opportunity to prevent negative consequences, regardless of the depth of the wells.

Location

This presentation is applicable to any location where hydraulic fracturing is conducted. Examples and illustrations are taken from the State of Texas where numerous geologic and geographic settings exist as does a long history of hydraulic fracturing throughout hundreds of oil and gas fields and the completion of tens of thousands of wells. Examples of aquifer diversity and extent are illustrated from Texas and Oklahoma.

Methods

The methods utilized in this presentation include literature review, personal interviews and experience as a state regulator, as an oil and gas operator, as a consultant to industry, local, federal and state government, water supply corporations, mining companies and legal entities as expert witness. Graphical representations taken from data published by state agencies were used to illustrate specific site circumstances.

Appropriate Due Diligence

In many cases, once the prospect is developed and the leases are taken, it is up to the drilling and completion departments of the companies to drill and complete the well. The engineers responsible for the casing and cementing of the well have numerous factors to consider for the proper design of the well. Not only does the well have to be designed properly for the target zone to be completed and stimulated, but other factors must also be assessed. Among the factors to consider are near surface conditions and well pad stability. Well pad stability and near surface wash out is usually managed by setting of conductor casing. The uppermost aquifer and base of usable quality drinking water must be isolated and protected. Fresh water intervals are usually protected by the surface casing. Pressurized zones, or formations which produce oil and gas, between the surface casing and the total depth of the well must be isolated, too. An intermediate casing can be used to provide additional fresh water protection or isolation of productive and/or pressurized zones.

Research by others has shown that the fracture influence in deep shale gas is limited to a few hundred feet from the well bore. Fracturing in shallow coal beds for methane is a separate mechanism[1] from deep shale gas fracturing; however, the investigation for potential pathways is the same.

Aquifer Identification

Beginning at the surface, inquiries as to the types of aquifers present and the use of these aquifers is advised. The classification and definition of groundwater varies from state to state. Therefore, it is crucial to understand, the nature and areal extent of the hydrogeologic conditions of the area. Not all freshwater-bearing aquifers are utilized. Some of the aquifers have objectionable characteristics such as high iron or sulfate concentrations which render an objectionable taste, unless treated before consumption. Identification of large capacity municipal supply wells is suggested as these wells generally supply a large number of people as opposed to a single family.

Some aquifers are so massive that the water quality changes with depth as does the use of the water. Some fresh water aquifers are even known to produce hydrocarbons naturally and the same formation can be so extensive as to have water quality become brackish-to-saline and produce oil and gas as well, such as the Wilcox Formation.

[1] While general HF operations are similar for coal beds and shale, the details differ for HF operations in these different geologic settings. For example, in the presence of typical fracturing fluids, coal tends to swell which reduces permeability through fractures and, therefore, reduces production. To control coal swelling, the approach to fracturing coal beds can include the use of different fracturing fluid mixtures or gas-based (nitrogen or carbon dioxide gas) fracturing fluids. Fracture design can also be different because coal has a distinct natural system of fractures (cleats and joints), can have different stress and strain regimes, and can require significant dewatering prior to gas production. (Explanation provided by The Cadmus Group)

Water Well Inventory

Determining the number, types and utilization of water wells in the area of a well being hydraulically fractured can be cumbersome if sometimes nearly impractical for a number of reasons. Experience has shown from investigations of water well complaints that there are a number of issues that repeatedly come forth. The issues include a lack of information by the well owner about the well construction and age of the well, the company or person that drilled the well or other pertinent information. In many cases, there are other factors such as poor well head protection, poor casing quality and a lack of sanitation around the well. Other problems include poor drainage around the well and close proximity to septic systems, especially in rural areas not serviced by sanitary sewer systems.

Identifying wells that could be potentially impacted by fluids from a hydraulically fractured well, should they escape would be beneficial for any investigation. In most cases it is practical only to identify large capacity municipal water supply wells prior to beginning drilling. This information is usually available from state agencies.

Adjacent Oil and Gas Fields

Some areas where hydraulic fracturing may take place will involve penetration through shallower oil and gas fields. Deeper penetrations may exist through zones where fracturing is to take place. In either situation, evaluation of potential pathways for migration should take place to avoid conditions where fluid migration may occur. These zones have been proven to be effectively isolated by casing and cement in numerous applications. Identification of producing zones that occur at depths shallower than the target zone and especially immediately above the target zone is advisable. Examination of penetrations through the target zone to assure appropriate isolation is suggested as well.

Areas where oil and gas exploration have taken place also contain previous well bores which have been plugged and abandoned or drilled as "dry holes." These well bores should be identified and evaluated as potential pathways prior to development of the target area. In most cases, these wells have been identified and are known by state regulators and are mapped accordingly.

Coal, Lignite and Other Mineral Resources

In numerous oil and gas producing areas, other mineral assemblages are also present. One of the most common mineral resources encountered is coal and lignite in near surface deposits. Both coal and lignite are known to produce methane naturally. When these mineral beds are highly fractured naturally and water moves through the units, minerals such as pyrite and other forms of iron and sulfur can form in the fractures giving the water an objectionable quality. Where these minerals are present in sufficient quantities, mining may have occurred in underground or near-surface operations. These activities should be noted when drilling in areas where coal and lignite resources are found. In some areas of Texas, drilling occurs in active mine areas and is compatible with mining activity.

Summary and Conclusions

Hydraulic fracturing can be conducted safely and aquifers can be protected when appropriate site investigation is conducted. There are many sources of information available for review. Once aquifers are identified and potential pathways for potential exposure are identified, appropriate casing and cementing designs can be implemented to address the specific site conditions. Hydraulic fracturing of geologic formations varies from region to region. Groundwater conditions and quality vary from region to region and protection/isolation techniques are available to address these variables. There are numerous approaches to hydraulic fracturing that involve various propping materials and delivery fluids. The key to successful hydraulic fracturing is identification of aquifers, location of potential pathways and appropriate casing and cementing programs to assure the frac materials remain in the target zone.