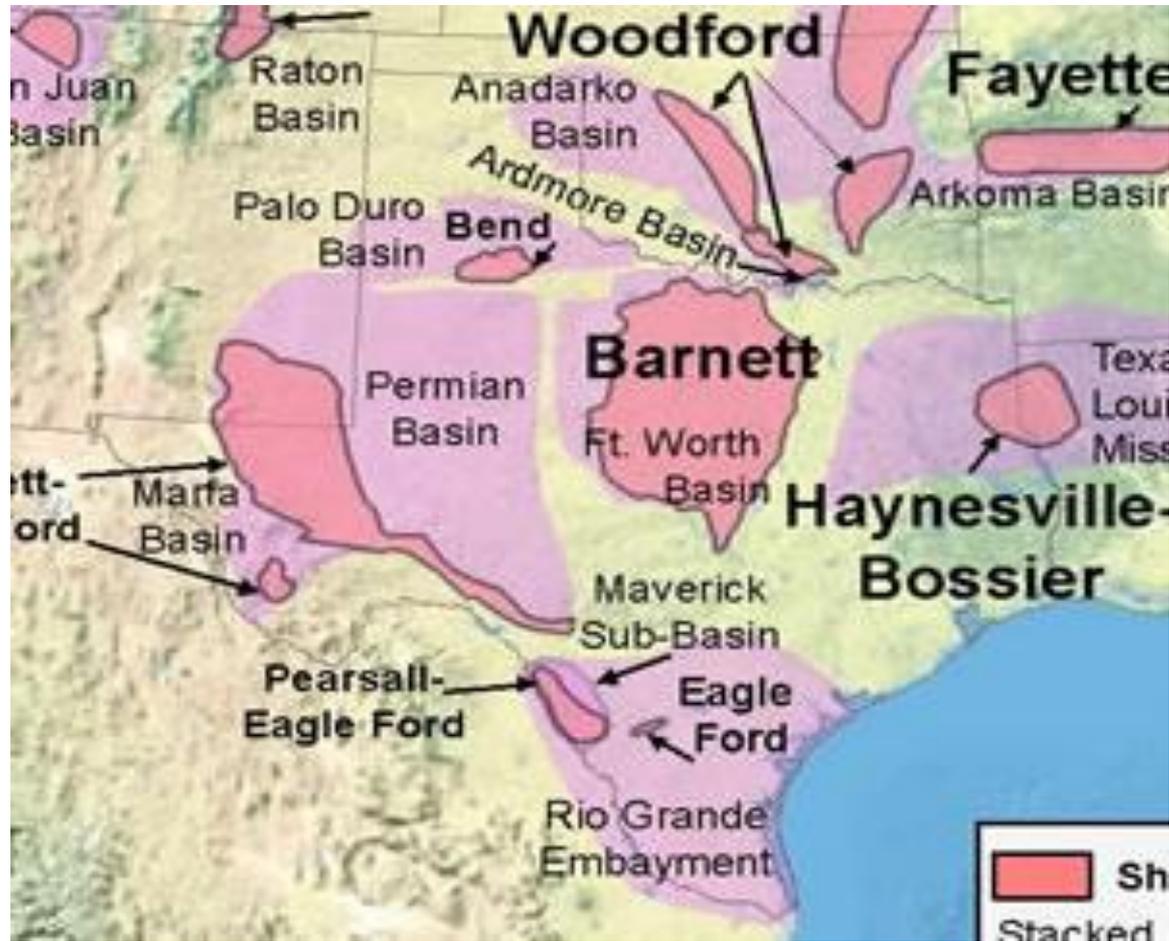


USEPA Workshops for Hydraulic Fracturing Study

Washington, D.C. March 10 and 11, 2011

Well Construction & Operations Overview



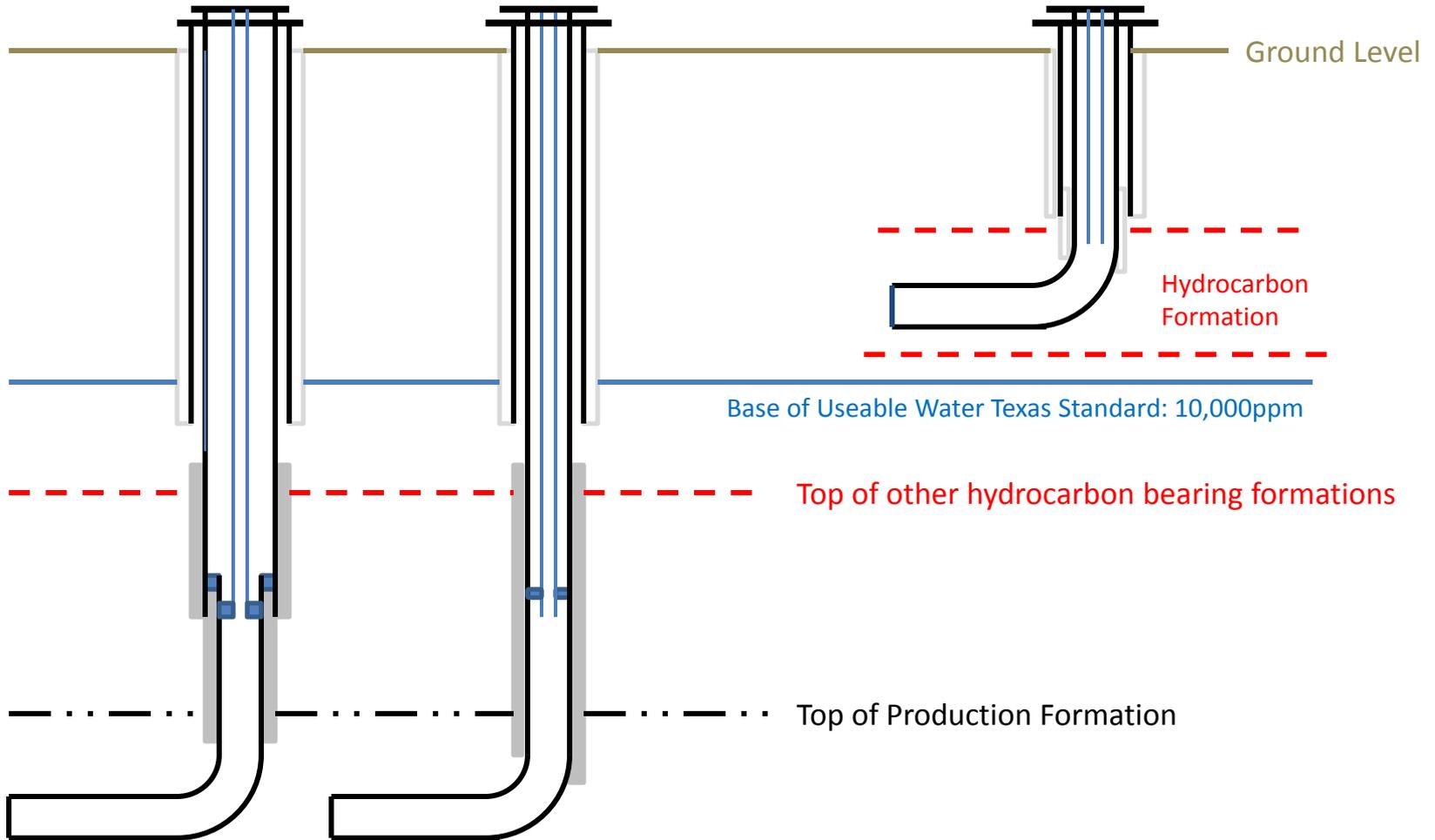
Bob Whiteside, P.E.

- **Texas World Operations, Inc** – President
UIC Class I Engineering and Consulting
40 Years of Experience Drilling, Completion and Compliance, Technical Delegate to UIC Reg-Neg
- **Signa Engineering Corp** - Sr. Drilling Consultant
International Drilling Engineers and Consultants
- **Cheyenne Petroleum Company**
Project Manager/Drilling Engineer
Oil and Gas Production

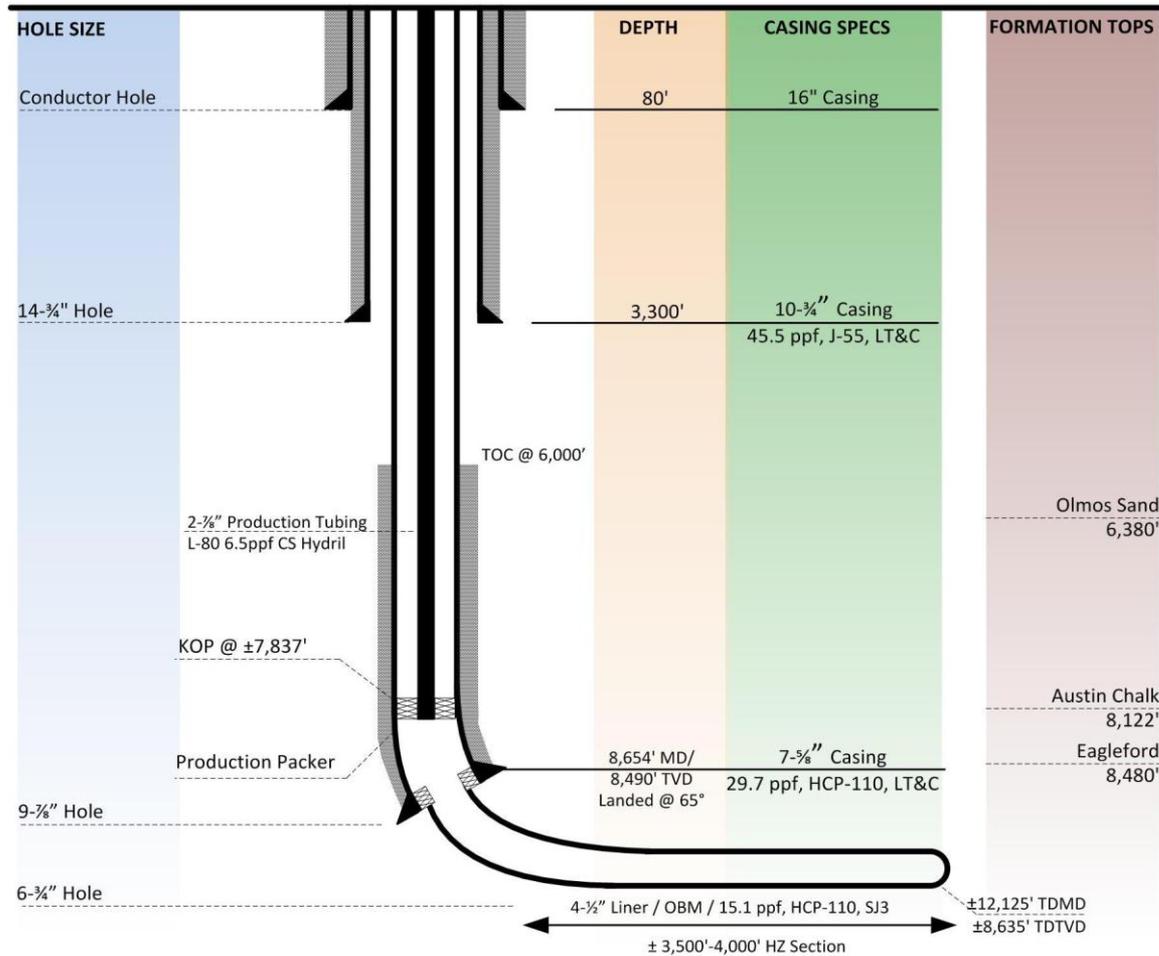
Case 1
Intermediate
Casing

Class 2
No Intermediate
Casing

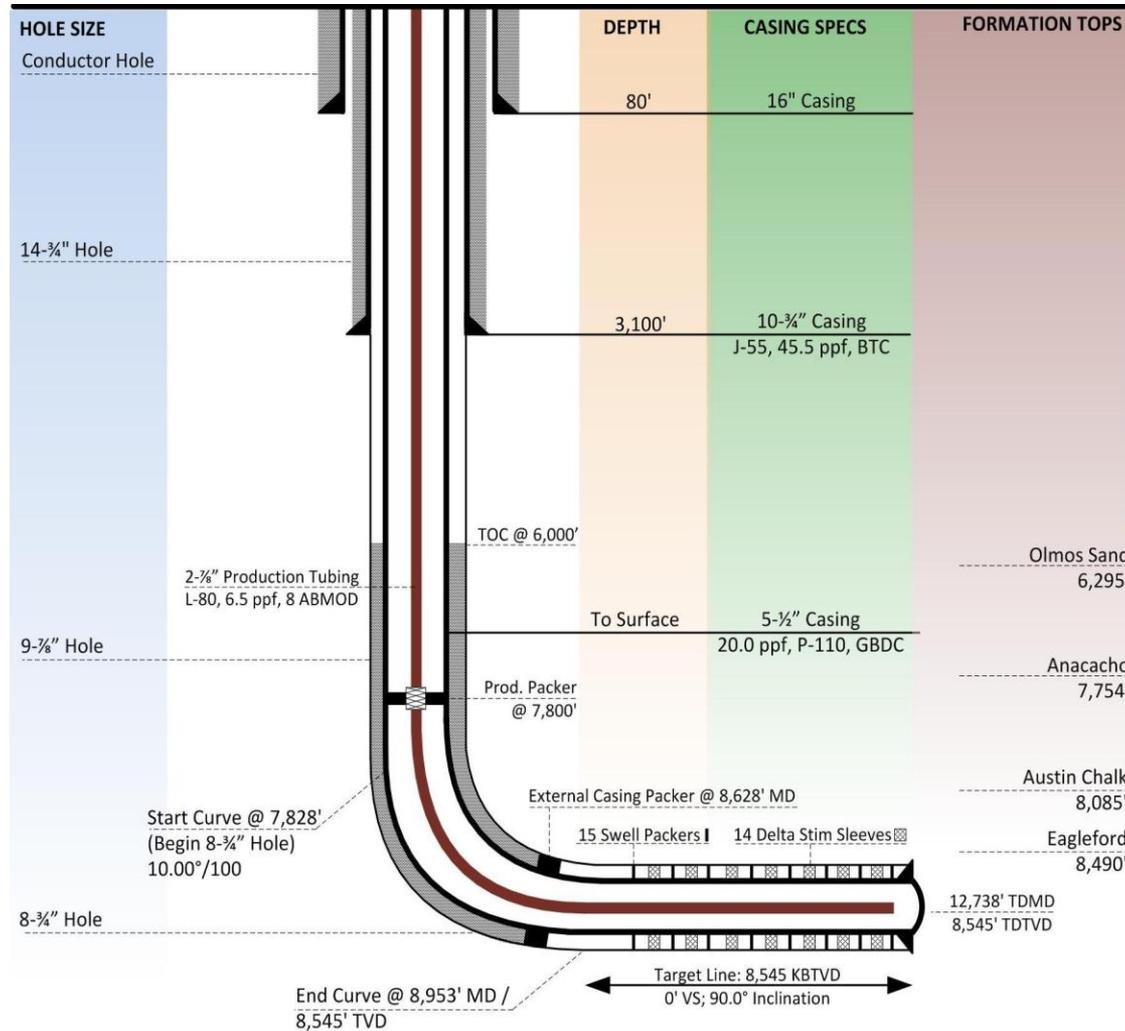
Class 3
Production Zone
Above the UIC Standard



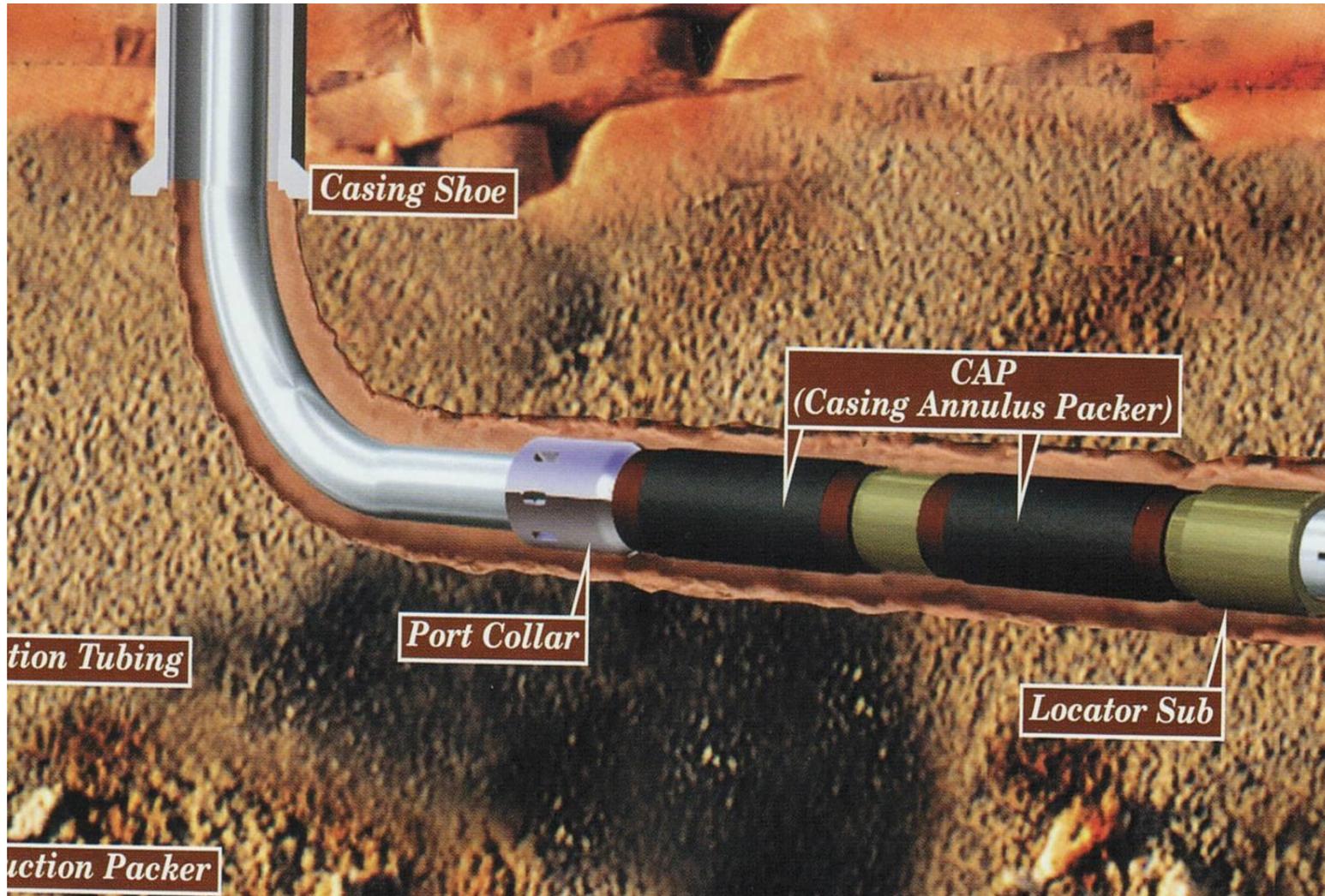
Standard Eagle Ford Well with an Intermediate Casing



Standard Eagle Ford Well without Intermediate Casing



Annulus or External Casing Packer Courtesy of TAM International



Swell Packer

Courtesy of Halliburton



Overview of the Well Construction Sessions

Bob Whiteside, P.E.

Texas World Operations/Signa Engineer Corp

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

The extraction of hydrocarbons from shale and other low permeability formations using hydraulic fracturing technology has led to the development of many new oil and gas reserves and many new environmental questions. Newspaper and television reports highlight water contamination cases, wildlife losses and surface water incidents on what seems like a daily basis. Environmental agencies, defenders of the environment, academicians and oil and gas professions are all searching for answers.

A portion of the of problem lies within the definitions and the terms of what is considered ground water and/or underground sources of drinking water. The Underground Injection Control Regulations (40 CRF 140-148) dealt with the same issues by defining a USDW as any formation containing water with less than 10,000 mg/l Total Dissolved Solids. While the UIC regulations deal with very limited numbers and specific type of wells, the oil and gas industry extracts hydrocarbons from where they are located within the subsurface. While most production wells are well above the USDW definition, a growing number of wells exist within the lower salinity formations. Some examples are wells in Wyoming which produce from formations containing 5000 mg/l TDS or coal methane wells located in formations that have much lower TDS's.

Eight presenters will give papers dealing with a range of topics which include regulatory concerns, well completion methods, casing design, cementing practices and testing methods. The session is constructed to give the listener a sense of what is currently being done within the oil and gas industry to protect ground water and introduce so of the latest techniques to enhance protection of human health and the environment. After each three presentation set, a question and answer period will follow. All participants in the workshop are encouraged to ask questions and seek answers during those times.

Well Settings in Texas

Well completion can be easily broken into three primary categories:

- Case 1: Wells that have surface casings cemented at depths containing waters greater than 10,000 mg/l TDS with intermediate casing set deeper
- Case 2: Wells that have surface casing cemented at depths containing waters greater than 10,000 mg/l TDS with no intermediate casing.

Case 3: Wells whose surface casings are cemented at depths less than 10,000 mg/l TDS

Case 1 Well Considerations

The deeper wells incorporate traditional designs and completions, which are adequate for ground water protection. Groundwater in the Class 1 scenario is protected by multiple layers of casing and cement. When standard API, SPE and industry standards are incorporated into the well design; little, if any, additional consideration is required to adequately protect groundwater.

In Texas, the Railroad Commission of Texas (RRC) prescribes the method of cementing, the number of centralizers, the excess quantity of cement required and other design considerations. The minimum and maximum depth the surface casing must be set at is prescribed by the Texas Commission on Environmental Quality (TCEQ). Operators are required, by law, to apply for and receive a drilling permit from the RRC and a letter entitled "Depth of Usable-Quality Water to Be Protected" issued by the TCEQ Surface Casing Team, Waste Permits Division before drilling can begin.

After the surface casing is cemented and generally 5 to 10 feet of new borehole has been drilled, a Formation Integrity Test (FIT) is performed. The FIT is a hydrostatic pressure test that is designed to determine if the surface casing cement job has adequate strength to drill further and if the formation in which the casing is terminated has sufficient strength to withstand any pressure event that might occur while drilling. If the wellbore passes the FIT, the well can safely be drilled deeper.

Once drilling has progressed through geological formations which lack sufficient strength to withstand expected production pressures or are too weak to support further drilling operations, an intermediate casing is set and cemented in place. Generally only the lower sections of these casings are cemented. Texas regulations require intermediate casing to be cemented from the bottom of the casing to a height above ... *hydrocarbon or geothermal resource fluids* ... (TAC, Title 16, Part I, 3, §3.7). The intermediate casing and cement provides additional layers to protect groundwater and decreases the probability of hydraulically fracturing into groundwater formations.

Case 2 Well Considerations

The shallower wells only have cemented surface casing covering the TCEQ-described useable water. Therefore, additional design elements have been added to reduce risk and avoid ground water incidents.

These wells have traditional surface casing and cementing designs. In some cases, enhanced ground water protection is achieved by means of an external casing packer (ECP). An ECP is an

inflatable packer consisting of an inflation bladder, a deformable set of steel slats and an outer rubber covering. The ECP is screwed onto the bottom of the surface casing and run in the hole with the casing. Once the casing is set at its maximum depth, cement is pumped through the casing, around the outside of the casing, up the annulus and eventually exits the top of the wellbore. At the end of the cement column being pumped down the inside of the casing is a wiper plug to separate the cement from the displacement fluid. The wiper plug activates the inflation ports within the ECP body which allows fluid and pressure to enter and inflate the packer. Once the packer is inflated, a permanent mechanical seal is formed between the bottom of the casing and wellbore in the confining layer below the aquifer.

Examination of bond logs within the Eagle Ford field has shown a number of wells with “gas cut” cement. When gas is entrained in the cement slurry during emplacement, channeling and contamination of the slurry can result in poor bonding. Hydraulic fracturing pressures can further degrade the cement column and, in extreme cases, impact the cement behind the surface casing. Incorporating an inflatable ECP in the production casing is one way to reduce the risk to ground water. The packer is inserted into the production casing with a mechanical port collar immediately above the packer. The ECP placed so that it will inflate and seal at the junction of the production formation and the formation above. The ECP is inflated by means of a tool run on a workstring. After inflating the packer, the port collar is opened to allow the annulus between the wellbore and the casing to be cemented.

Case 3 Well Considerations

The Case 3 wells are located in or adjacent to useable ground water (under any definition). Therefore, there is no way to protect useable ground water. The only thing that can be done is a comprehensive ground water study of all existing water wells in the area that are at a depth within 500 feet of the top of the production zone. A full suite of tests should be performed by a certified lab for metals, salts, and organics before any drilling or fracturing is performed. If the ground water is already contaminated by natural causes, an aquifer exemption should be issued.

Follow up testing should be required after fracturing activities. An area of review of approximately 3 miles should be a minimum with all water wells tested. If municipal water wells are involved, a reasonable "off-limits" distance should be applied (approximately 5 mile radius). The regulators and the operators should look closely at performing smaller frac jobs to limit height and more stages to limit fracture growth. The nearest water wells should be sampled within 50 to 60 days of the frac activity to determine impact and on a quarterly basis for a period of no less than 2 years. If water quality parameters in the water wells do not change, the operator should be safe in the assumption that impacts to the aquifer have not occurred as result of hydraulic fracturing. If any of the water quality parameters have changed, the state regulatory program may want to reconsider the value of the aquifer or require the operator to provide water from other sources.

Oil and gas production is always a matter of economics. If the operators feel there is no penalty,

then they will drill shallow wells to make easy money. The real question is: "Do we need shallow production or do we save water resources?" In many cases, shallow wells may be profitable because the natural concentrations of salts, metals or other compounds are already elevated. Shale plays are growing in number every day. Do we have to produce all of them just because we can? The only true evaluation is the value of the hydrocarbon versus the value of the water. Currently operators are not really being forced to make those decisions but that does not mean they shouldn't be forced to. With today's gas prices and an increasing gas supply, I believe that wells that produce gas with oil should be rated as more valuable to the energy market than just a well that produces "cheap gas" which may endanger the environment.

The Texas definition for "useable-quality water" is the same as Ohio and the UIC definition for underground source of drinking water (USDW) – ground water with 10,000 ppm TDS or less must be protected. Under those restrictions, it will generally be better for the operators to drill deeper and the ground water is no longer an issue.

Conclusion

Very few, if any, incidents of ground water contamination have been reported from the wells listed as Case 1 and Case 2. These wells generally are inherently safe because of the depth of useable water protected by surface casing and cement. Inexpensive enhancements can be added where the depth to useable waters is relatively close.

Case 3 wells pose a different challenge to the drilling engineer and the regulator. These wells can be made safe by careful planning, additional geological study, and close attention to fracture procedures. However, each well field must be considered on an individual basis. Texas uses the "aquifer exemption" regulations to determine if drilling and production from these fields can be conducted in a manner which is protective of human health and the environment.