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Making Projects Economic in a Low-Cost Environment While Improving Health, Environment and Safety in the Operations

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Abstract

Rather than drilling brand-new wells on previously undisturbed land to extract hydrocarbons, oil and gas companies are deepening existing shallow wellbores to reduce their overall environmental footprint, address safety concerns, and maximize capital returns.

First, environmental disturbance is reduced because no new well pads or roads are needed for field development, although some additional land reclamation may be needed. Second, many of these wellbores may be 30 years old or older, so mechanical integrity is extremely important for safeguarding both people and the environment. Several ways to reduce this risk will be discussed. Finally, the personnel utilized on these projects are cross-trained and gain not only operational experience, but also valuable knowledge of safety hazards and exposures. The tools and processes can be applied throughout drilling, completion, and artificial lift operations.

The first such project attempted by this operator was completed without any additional capital for land reclamation, without any recordable safety or environmental incidents, and with costs below authority for expenditure (AFE). Hydrocarbon production was also better than expected, and several more candidates have been identified for similar well deepening projects.

Introduction

In challenging market conditions, operators are exploring cost reduction ideas and processes to be able to maximize profitability of developing oil and gas fields while continuously improving health, environment, and safety (HES) aspects of their operations. Using a workover rig to deepen existing shallow wellbores to tap deeper zones was the method utilized to continue field development while minimizing environmental disturbance in the Permian Basin during a period of low commodities prices. Four wells were successfully deepened to the desired depth, hydraulically stimulated, and put on production after installing electrical submersible pumps (ESPs). There were no HES incidents during any of the operational phases of these deepening projects, and once completed, each well performed significantly higher than expected, with an average rate of return (ROR) greater than 60%.

Surface Construction Health, Environment and Safety Benefits

One of the main ways deepening wellbores has decreased surface disturbance is by eliminating much of the aboveground construction needed for a new well. The existing access roads to the well location, the well pad, and the current surface production lines can all be re-used in this kind of project. A typical drilling pad has the size of 330 ft by 410 ft, as shown below in Figure 1.

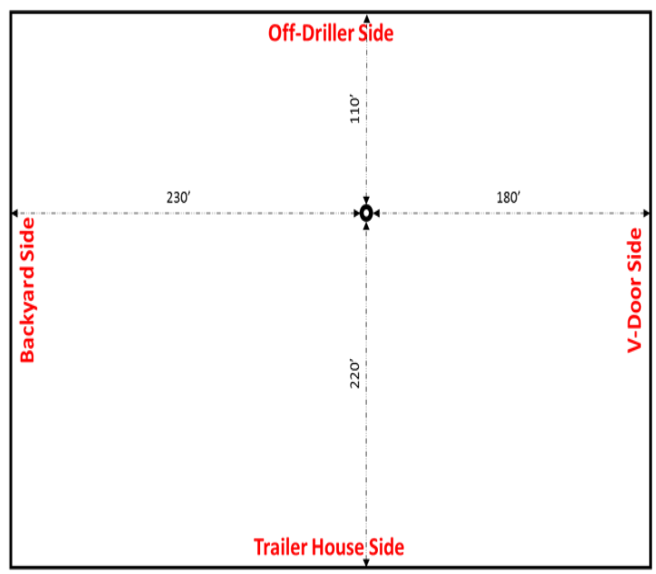

Figure 1 –Drilling rig pad layout

After the necessary surveying has been completed, the pad site needs to be leveled with a bulldozer and/or grader. A below-ground cellar is then excavated, and depending on the specific area, reserve pits and settling pits may be dug for water or drilling fluid returns. The existing surface lines are removed, and access roads are built for wellsite entry. Based on the U.S. Bureau of Land Management (BLM), access road construction in Wyoming averages 0.4 mile per well, with an average long-term 23.5 ft of total disturbance (1.14 acres surface disturbance per well).[1]

Combined with the pad and access roads, the existing surface pipelines can be re-used once the well is put on production. The average production pipeline is 0.4 miles in length with an average surface disturbance width of 30 ft (1.5 acres disturbance per average single-well pad).[1] For larger development projects, more disturbance can be caused with additional infrastructure, such as a communications site, power lines, compressor sites, central delivery points, stabilization plants, and ware yards.

Potential hazards during the leveling and excavating/trenching process include damaging buried pipelines and cables, uneven ground causing bulldozers to roll over, and irritant and toxic plants, pollens, and other entrained materials.[2] As seen in Figure 2 below, the number of cases of injuries and illnesses with construction laborers is low, but ranks seventh highest in the rate of occurrence with 265 injuries per 10,000 full-time workers in 2015.[3]

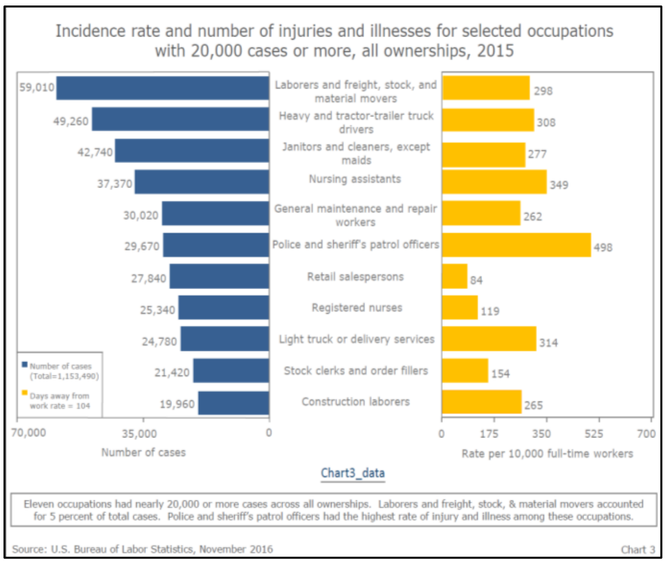

Figure 2 – Incident rate and number of injuries and illnesses for selected occupations with 20,000 cases or more, all ownerships, 2015[3]

Along with the construction laborers, tractor trailer trucks are utilized to haul caliche to build the well pad and roads, and flatbed trucks are used for hauling heavy equipment to perform the necessary leveling and excavation. The risk for injury for "heavy and tractor-trailer truck drivers" and "laborers and freight, stock, and material movers" is the highest of all occupations, with 49,260 and 59,010 injury cases in 2015, respectively, as shown in Figure 3.[3]

The overall reduction of surface disturbances also reduces sediment load and storm water runoff, protecting creeks and rivers. From Department of Environmental Conservation of New York State's Generic Environmental Impact Statement (GEIS), "spills or releases can occur as a result of tank ruptures, equipment or surface impoundment failures, overfills, vandalism, accidents (including vehicle collisions), ground fires, or improper operations. Spilled, leaked, or released fluids could flow to a surface water body or infiltrate the ground, reaching subsurface soils and aquifers." [4]

Drilling operators use reserve pits or a closed loop system to recycle all fluid during the drilling process. The system chosen is site- and drilling-specific. The closed loop system requires a larger drilling pad (caliche), whereas a reserve pit allows the drilling pad to be minimized. Oil and gas industry operators maintain high construction standards to help ensure the integrity and safe operations of reserve pits. The pits are lined to prevent contamination of the soil, and they are inspected daily to ensure any residual oil is removed.

Also, from the Department of Environmental Conservation of New York State's Generic Environmental Impact Statement (GEIS), "the fossil fuel-fired internal combustion engines used in transportation are a significant source of CO_2 emissions. Small quantities of CH_4 and N_2O are also emitted, based on fuel composition, combustion conditions, and post-combustion control technology. Estimating emissions from mobile sources is complex, requiring detailed information on the types of mobile sources, fuel types, vehicle fleet age, maintenance procedures, operating conditions and frequency, emissions controls, and fuel consumption." [4]

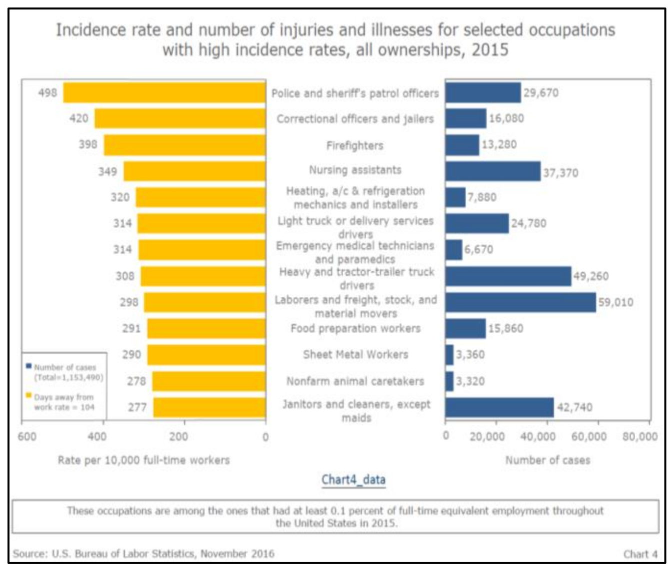

Figure 3 – Incident rate and number of injuries and illnesses for selected occupations with high incident rates, all ownerships, 2015 [3]

Though minor, noise is also present during the well site construction. Bulldozers, backhoes, flatbed trucks, and other types of construction equipment used for building of the well site all emit noise. It is estimated that it takes 10-45 truckloads to construct a pad and access road for a well.[4] The surrounding habitat may be affected by the additional noise.

Although there was a decrease in drilling activity in 2015 due to a challenging market, drilling activity is increasing in 2016 and in the future, based on the number of drilling permits issued (see Figure 4)[5]. With so many pipelines and wells already in place, building additional roads, pads, and pipelines has become more complex, therefore increasing risk to HES.

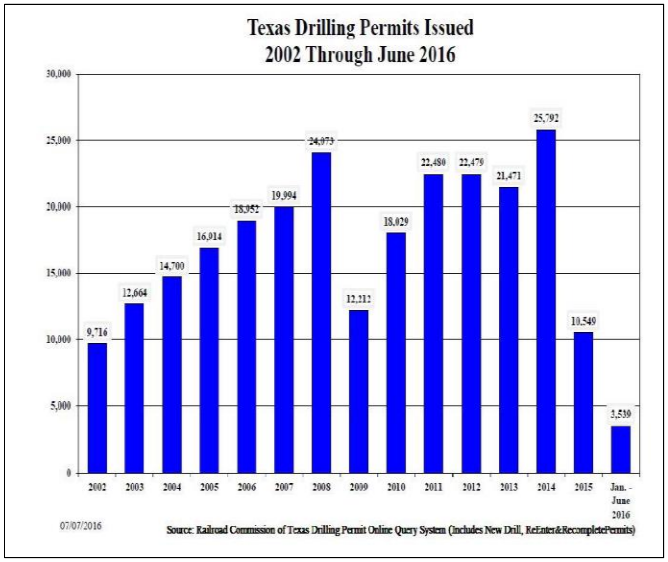

Figure 4 – Texas drilling permits issued, 2002 through June 2016 [5]

Surface Construction Economic Benefits

Along with decreased impact on safety and the environment, deepening existing wells greatly reduces well construction costs. Staking and building costs averaged 48% of the total drilling preparation phase cost.

The access roads to the location, well pad, underground cellar, and surface lines can be re-used at no additional expense to the operator. In addition to the cost savings, there is also a time benefit, as the well construction process is no longer part of the critical path of drilling a well.

Mechanical Integrity HES Impact

Mechanical integrity benefits include improved well reliability, reduction in well failures, improved well maintenance consistency and efficiency, reduced operating costs, and compliance with government regulations.

Over time with constant exposure to reservoir fluids, solids, and gases, the existing well begins losing its integrity, leading to various wellbore failures. Figure 5 shows corrosion results of an ultrasonic imager (USI) log that was run inside the production casing of well that has been producing for more than 30 years on beam lift. The red curves in the far right track show the minimal thickness values with a scale of 0.1 to 0.5 in. As shown in Figure 5, the casing has significant wear throughout the 25-ft interval, as the curves reflect to the left and at times reflect off the track. The wear is also shown on the discoloration of the third track, and the tool can be deemed to be reading accurately as the tool remained centered throughout the run, as shown by the red curve in the first track.

The rate at which a well loses its mechanical integrity is dependent on many variables associated with the well, such as reservoir fluids and gases, pressures, temperatures, well design in place, lift types, precipitate buildup, well age, deviation, etc. Although the well in Figure 5 has been producing through tubing inside the production casing, it is evident that pipe will corrode and lose its mechanical integrity over time.

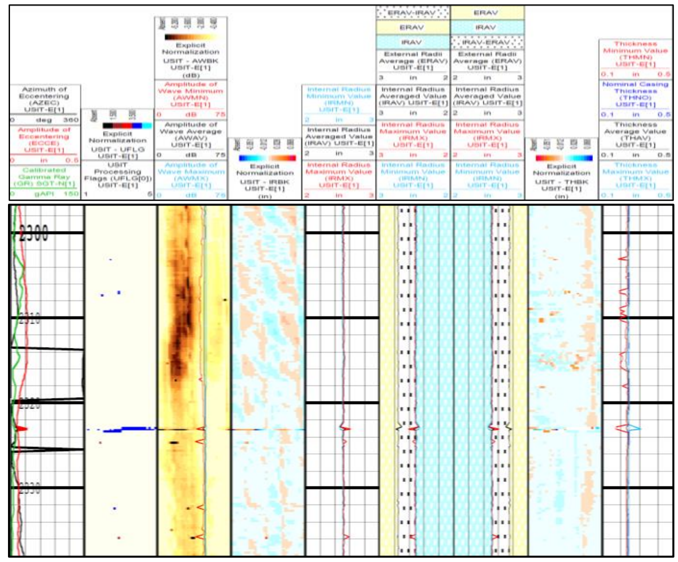

Figure 5 – Ultra Sonic Imager (USI) log (source: Schlumberger)

A USI log was run in four wells that have been producing for over 30 years through tubing with beam lift. The wells have been treated with chemicals throughout their life, and tubing and/or rods were replaced as needed. Even with proper maintenance and a string of pipe separating the production fluids and gases from the production casing, the production casing still had an average wall loss of 34%. Table 1 shows the wall loss for the four wells with corrosion exceeding 30% on each well.

Table 1 – Production Casing Wall Loss with Well's Age

	Well A	Well B	Well C	Well D	Average
Well Age	33	33	32	34	33
Wall Loss, %	35	32	33	36	34

With time, the wall loss may be high enough that a hole or a leak could develop. An example of how a leak could contaminate the fresh water table is shown in Figure 6. A well with leaks in the casing that is in contact with a fugitive brine zone and a fresh water zone may contaminate the fresh water zone and therefore a nearby active water well. Older wells require higher amount of maintenance due to loss in well integrity over time. Oil and gas operators utilize the latest technology to detect leaks and maintain overall well integrity.

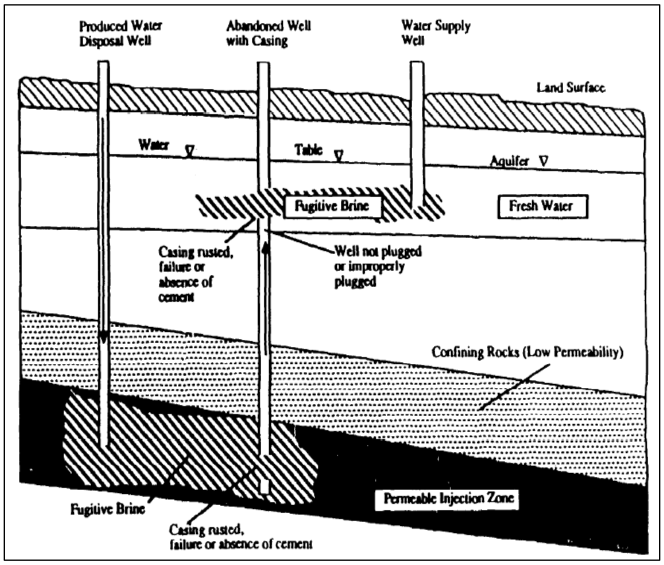

Figure 6 – Schematic diagram of contamination of an aquifer with brine[6]

Mechanical integrity failures are costly to repair and in rare instances may even cause uncontrollable releases or blowouts. There were 104 blowouts in 2015 in the state of Texas.[7]

With each deepening, a new casing string is installed and cemented, then new lift equipment is installed and the well is put on production. The existing production casing now has two strings of pipe separating it from the reservoir fluids. In addition, the wellheads are replaced with new wellheads rated to the designed stimulation needs.

Although the industry has developed and implemented many proactive solutions for mitigating HES impacts from mechanical integrity failures, hydrocarbon and chemical spills continue to be an ongoing challenge with aging wells in the oil and gas industry.

Mechanical Integrity Economic Benefits

Along with the savings associated with utilizing the existing surface layout and infrastructure, deepening wellbores also has a downhole savings associated with it. The conductor and surface casing have already been drilled, cased and cemented. The conductor and surface interval typically account for over one-third of the total drilling cost of a vertical well. Having an existing surface section also benefits operations, because a workover rig that has limited working capabilities can be used to deepen the wellbore instead of the larger drilling rig that is needed to drill and case the larger diameter surface hole. The daily rate of a workover rig is about 50% lower than for a larger drilling rig.

In addition to the cost savings with utilizing a workover rig, there is also an environmental benefit. The workover rig has a smaller footprint, takes less transportation to rig up, has a lower HP, and therefore emits less noise and emissions to the atmosphere.

Having pre-existing production casing adds another barrier between the well's production fluids and gases from the drilled formation and allows for the deepening sections to be drilled with cheap, fresh-water mud, as the salt section has been cased and cemented with the existing production casing. With deepening projects, 75% of the reserves of a new well are added with 60% of the total cost.

Some existing vertical wells are utilized to hold leases and mineral rights. When a well fails, there are typically time constraints to start a workover on the well to put it in back on production. Instead of incurring the P&A cost for the well and drilling a new well, the existing well could be deepened to maintain the lease and mineral rights and boost production for the subject field.

Cross-Training of Personnel Benefits

The exploration and production technical workforce in the oil and natural gas industry is estimated to be about 494,200 workers. Demand for domestic workers in the oil and gas industry will remain strong for the foreseeable future. This demand is primarily driven by recent technological advances in drilling and completion of unconventional reservoirs, advancements in oil sands development, and stronger commodity prices. Similar to the U.S. national trends, baby boomers that currently make up one-third of the existing oil and gas workforce will retire within the next decade. There are concerns within the business, academic, and technical communities about the ability to adequately replace the knowledge of the retiring workforce.[8]

Cross-training personnel is one way to help alleviate the lack of experienced personnel in the oil and gas industry for the future. During a deepening project, the well site manager (WSM) is exposed to multiple operations, increasing the person's technical, operational, and HES knowledge. The well needs to be prepared for deepening first, so the existing lift equipment needs to be pulled out of the well. Next, the existing casing needs to been cleaned and tested, and the existing perforations need to be sealed off before deepening can begin. After the well has been successfully prepared, the drilling operations can begin. The well is deepened and casing is run and cemented, and necessary well logs obtained. After the drilling phase, the hydraulic fracturing equipment will move in to perforate and stimulate the newly drilled hole. Once completed, the well is cleaned out and artificial lift is installed so the well can be put on production.

Cross-training creates an organization of "T-shaped" individuals who have a deep expertise in one area and a working understanding across disciplines, which gives them insight into the overall objective and goal. Having T-shaped individuals in an organization gives the company durability and flexibility, as it helps ensure that the business won't suffer if an essential team member quits or takes a vacation. Organizations are better equipped to recover quickly from disruptions and handle transitions smoothly. The workforce is more agile through cross-training, and teamwork is increased as employees have a chance to build new relationships with people they might otherwise never contact. This will help the team work more effectively and increase employees' understanding of the big picture.[9]

Since the same WSMs are managing the preparation, drilling, completion, and lift installation operations, there is constant oversight on the well process. Gaps in handovers between the different operations is no longer a concern, and field personnel have one focal contact to avoid any confusion. The WSMs are exposed to many HES risks with each operation and are able to build their HES knowledge to be utilized on other projects and train other personnel inside and outside the company.

Summary

Deepening existing wellbores has health, environment, and safety benefits while adding economic value. Surface disturbance is reduced because no new well pads or roads are needed for field development. Mechanical integrity of the well is increased, alleviating some of the health and safety risks associated with downhole failures. The personnel involved in wellbore deepening projects are cross-trained and better positioned for the company in the future. Deepening projects add 75% of the reserves of a new well with 60% of the total cost.

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