Treatment of Upstream Oil & Gas Wastewaters Prior to Disposal into a Class IID Well – Marcellus & Utica Shale Play

RUSSELL C. HUFFMYER
McKim & Creed, Inc.
Sewickley, PA

DAVID GROTTENTHALER
Self-Source Solutions
McDonald, PA

KEYWORDS: SWD, disposal, Marcellus, Utica, shale, play, treatment, chemical, conventional, non-conventional, gas, oil, O&G, drilling, completions, water, brine, Class IID, injection well, disposal well, well, unconventional, hydrofracturing, stimulation, proppant, friction reducer, gel.

ABSTRACT

In the upstream O&G sector, wastewater is generated during the drilling, completion, and production of conventional and non-conventional gas and oil wells. Throughout operations, there are methods for managing the wastewaters, which typically include recycle/reuse, evaporation/crystallization, and/or disposal into a Class IID disposal well. This paper will discuss the treatment of these wastewater streams prior to utilizing the method of disposal into a Class IID disposal well. These wastewater streams from the different phases in the life of the well contain varying amounts of suspended solids and parameters of concern that need to be adequately managed to avoid excessive solids management costs, concentration of normally occurring radioactive materials (NORM) or technologically-enhanced normally occurring radioactive material (TENORM), and reduction of capacity in the formation in which the wastewaters are disposed. Typical management methods include chemical addition and optimization of the facility design for suspended solids removal, both of which will be discussed in this paper through case studies at various operating facilities in the Marcellus and Utica shale plays.

INTRODUCTION

SECTORS OF OIL & GAS – In the upstream O&G sector, wastewater is generated during the drilling, completion, and production of conventional and non-conventional gas and oil wells. Throughout operations, there are methods for managing the wastewaters, which typically include recycle/reuse, evaporation/crystallization, and/or disposal into a Class IID disposal well. This paper will discuss the treatment of these wastewater streams, prior to utilizing the method of disposal into a Class IID disposal well.

The upstream sector is used to refer to the exploration and production of crude oil, natural gas, and natural gas liquids. Stages within the upstream industry include the search for underground, or underwater, oil and gas fields, the drilling of exploratory wells and if the wells are deemed economically viable, the operation of wells then will bring crude oil, liquids, and natural gas to the well's surface (Dover).

The midstream sector includes the processing, storing, transporting, and marketing of oil, natural gas, and natural gas liquids.

The downstream segment includes oil refineries, petrochemical plants, petroleum distribution outlets, retail outlets and natural gas distribution companies. The downstream sector touches consumers through thousands of products - from motor fuels to lubricants, and fertilizers to pharmaceuticals (Dover).

CONVENTIONAL VS. UNCONVENTIONAL – Regardless of how they are produced or the rock they come from, unconventional oil and natural gas wells are essentially the same as conventional wells. The term "unconventional" refers to the methods that are used, as well as the types of rock from which the oil and natural gas are produced.

Alberta Energy Resources refers to unconventional oil as tight oil, which is oil found in low-permeability rock including sandstone, siltstone, shale, and carbonates. Additionally, unconventional natural gas is referred to as tight gas, which is found in low-permeability rock, including sandstone, siltstones, and carbonates shale gas (AER, 2016).

DRILLING FLUID COMPOSITION – The drilling fluid chemistry is created specifically for each drilling operation. Additionally, it is changed during the operation due to bore hole depth and/or observed conditions. With that, there are three primary classifications to these fluids; water-based, oil-based, and synthetic-based; all of which are used throughout different shale plays due to regulations, operator preference, etc. (Rehm, 2012).
Water-based mud (WBM): A water-based mud system begins with water followed by the integration of clays and other chemicals to create a homogenous blend. The clay is usually a combination of native clays that are suspended in the fluid while drilling, or specific types of clay that are processed and sold as additives for the WBM system. The most common of these is bentonite, frequently referred to in the oilfield as "gel".
Oil-based mud (OBM): Oil-based mud can be a mud where the base fluid is a petroleum product such as diesel fuel. Oil-based muds are used for many reasons, some being increased lubricity, enhanced shale inhibition, greater cleaning abilities, and reduced fluid viscosity (Rehm, 2012).

Synthetic-based fluid or mud (SBM): Synthetic-based fluid is a material where the base fluid is synthetic oil. Synthetic based oils include vegetable esters, olefins, ethers, and other similar type products. These products are used much in the same way as oil-based fluids in the use of weighing agents (Rehm, 2012).

FLOWBACK & BRINE – The definition used by the American Petroleum Institute (API): "Produced water is any of the many types of water produced from oil and gas wells"; the definition used by the Department of Energy (DOE): "Produced water is water trapped in underground formations that is brought to the surface along with oil or gas"; and a similar definition used by the American Water Works Association (AWWA): "Produced water is the combination of flowback and formation water that returns to the surface along with the oil and natural gas". Produced water can variously refer to formation water, a mixture of spent hydraulic fracturing fluid and formation water or returned hydraulic fracturing fluid.

Various definitions have been used for the term flowback. The American Petroleum Institute defined flowback as "the fracture fluids that return to the surface after a hydraulic fracture is completed," and the American Water Works Association used "fracturing fluids that return to the surface through the wellbore after hydraulic fracturing is complete". As mentioned above, flowback can also be defined as a process used to stimulate the well for production by allowing excess liquids and proppant to return to the surface (AER, 2016).

OPERATIONAL MANAGEMENT OF UPSTREAM WASTEWATERS

CLASS IID INJECTION WELL – Injection wells are used throughout the United States for oil and gas waste waters, as well as other waste waters that are typical to other industries. The type of fluid that is permissible to inject depends upon the class of the well, as shown in table one, and whether primacy is handled by the state government or the federal government. Class II wells fall into one of three categories, which consist of disposal wells, enhanced recovery wells, and hydrocarbon storage wells.

Table 1: Well Class Descriptions.

Class	Description	National Inventory
I	Inject hazardous wastes, industrial non-hazardous liquids, or municipal wastewater beneath the lowermost United States Drinking Water (USDW).	650
II	Inject brines and other fluids associated with oil and gas production, and hydrocarbons for storage.	151,000
III	Inject fluids associated with solution mining of minerals beneath the lowermost USDW.	21,000
IV	Inject hazardous or radioactive wastes into or above USDWs. Note: These wells are banned unless authorized under a federal or state groundwater remediation project.	24
V	All injection wells not included in Classes I – IV. In general, Class V wells inject non-hazardous fluids into or above USDWs	400,000 to 650,000

	and are typically shallow, on-site disposal systems. However, there are some deep Class V wells that inject below USDWs.	
VI	Inject Carbon Dioxide for long term storage, also known as Geologic Sequestration of CO_2.	6 to 10, by 2016

(ODNR, 2016)

Typical Class IID injection well facilities range from 2 to 3 acres at minimum and as much as 100 acres, which is dependent upon land availability, proposed well plan, surface facility construction, and existing environmental factors. A typical aboveground facility in the Marcellus and Utica shale play will consist of an unloading area for truck offloading, primary filtration, tank battery for storage and solids settling, chemical feed facilities and an injection pump system for injection into the well.

As new facilities are designed and constructed, injection well operators attempt to mitigate the operational challenges that are known to existing owners.

These challenges consist of the following;

1. Unwarranted wait times for water trucks at the facility
2. Excessive unload times for water trucks to unload into the system
3. Multiple filter replacements throughout a single unloading process
4. Transfer Pumps and Injection Pumps downtime
5. Large amounts of solids settlement in the storage tanks
6. Poor influent water characteristics reacting negatively in the well bore causing the surface injection pressure to rise, which will reduce disposal capacity
7. Poor Oil recovery
8. High static pressure on the well
9. Improper chemistry and chemical feed points

Although some of these challenges can be avoided, others cannot. An efficient maintenance team is valuable to have readily available to assist the facility operators to ensure minimal downtime for operations.

In the Marcellus and Utica region, rates at the injection facility vary between $2.50 per barrel and $4.50 per barrel, depending on the specific gravity of the water and market conditions. In addition to the cost to unload at the facility, the facility owner is required to pay a fee to the state and occasionally to the landowner, which is referred to as a royalty. Royalties range from a fixed fee to a specified percentage of the facility revenue.

RECYCLE / REUSE – Water is used in the hydrofracturing process to transport proppant (usually sand) with the aid of a friction reducer or gel viscosity builder. Reuse of flow back and production brines was not important in the past for conventional vertical wells due to the lower water volumes needed on these shorter well bores. Directional drilling and the hydrofracturing of horizontal laterals was a game changer when it came to frac water sources and reuse considerations. Millions of gallons of water are necessary to drill laterals, which now consist of multiple wells with longer laterals in the pad designs. Reusing the water that is flowing back from a nearby well or the production water from producing wells in the area, is now standard

practice in the Marcellus and Utica shale plays to conserve water, protect the environment, and to improve cost efficiency. Recycle systems need to provide reuse water that meets the E&P company's specifications for such parameters as pH, iron, chlorides, divalent cations (Ca^{++}, Mg^{++}, Ba^{++}, Sr^{++}), suspended solids, and bacteria.

In 2008, an E&P company in the northeast Marcellus developed a strategy to reuse one hundred percent flow back, which was being stored for disposal. A conventional sedimentation system was used to improve the water quality. With that, the pH was adjusted with caustic soda to 8.5, which aided in iron/metals reduction. Sodium sulfate was used to help precipitate divalent cations, and the aluminum chlorhydrate and a coagulant aid were used to help remove the suspended solids. In that process, sodium hypochlorite was used as the microbiocide. In the end, the water quality did not interfere with the frac fluid design and the application was successful. Since 2008, a variety of technologies have been applied, as shown in figure one.

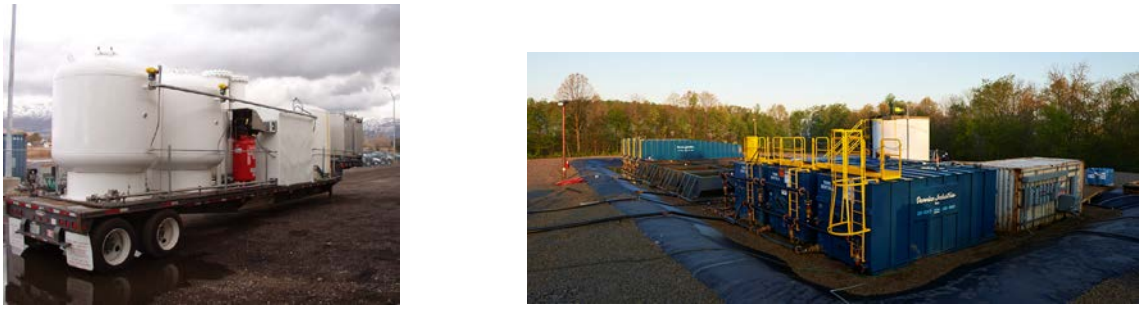

Figure 1: Equipment Examples of Simple Filtration and Precipitation.

Many operators are reusing water by blending the flowback water with a fresh or better water quality source, while others perform simple filtration and occasionally chlorination to improve the water quality. Many are employing electrocoagulation, filtration, and a variety of standard sedimentation systems. It is important to work with responsible and experienced groups to insure the safe reuse of flow back and production brines at costs that may be competitive to disposal through a Class IID disposal well. When reusing water, a qualified lab is essential for testing friction reduction, viscosity build/break, geochemical modeling, and microbiocide efficacy studies. These can help determine when the water quality could have a negative effect on the subsequent frac fluid design and/or well performance and confirm which technology allows for the lowest cost of operation.

EVAPORATION –Evaporation can concentrate the constituents that make the water source poor for reuse, allowing for lower volumes of waste water to be transported, thus lower transportation and disposal costs. Evaporation to ultimate crystallization can also result in benefits by reducing disposal costs and making crystals/salts that can be reused in other industries. There are several designs such as falling film, plate, or forced circulation evaporators. Technologies can include single or multiple effect evaporation and thermal or mechanical vapor recompression. In essence, the liquid is converted into a vapor and the process is more efficient as you raise the temperature of reaction. Many operators use a heat source to drive off distilled water, thus

concentrating the water volume down to one-fifth to one-twentieth of the original volume to save on transportation and disposal costs. Crystallization is the formation of a solid from a solution. This can provide benefits to the overall treatment cost, as many of the crystal by-products can be used in other markets.

TYPICAL DISPOSAL FACILITY DESIGN

PROCESS OVERVIEW – If the flowback and produced water cannot be reused it must be disposed in a saltwater disposal well, as shown in figure two. Most commonly, water trucks will utilize an unloading station and pumping system to dispose of water at a Class IID disposal facility. Facilities are designed to allow for a certain quantity of trucks to unload simultaneously to the tank battery. The truck unloading pumps deliver water to the tank battery through filter pots. The first gravity separation tank is typically a gun barrel tank which allows for hydrocarbons to float and solids to settle. Forward flow from the gun barrel tank overflows into the next settling tank and continues through to the last settling tank. Additionally, skim oil will overflow from the gun barrel tank into the skim oil tank. The clean water pump will pump water from the final settling tank through a finishing filter pot and into the final tank, most commonly referred to as the clean water tank. An injection pump will deliver water through a final cartridge filter before discharging into the disposal well.

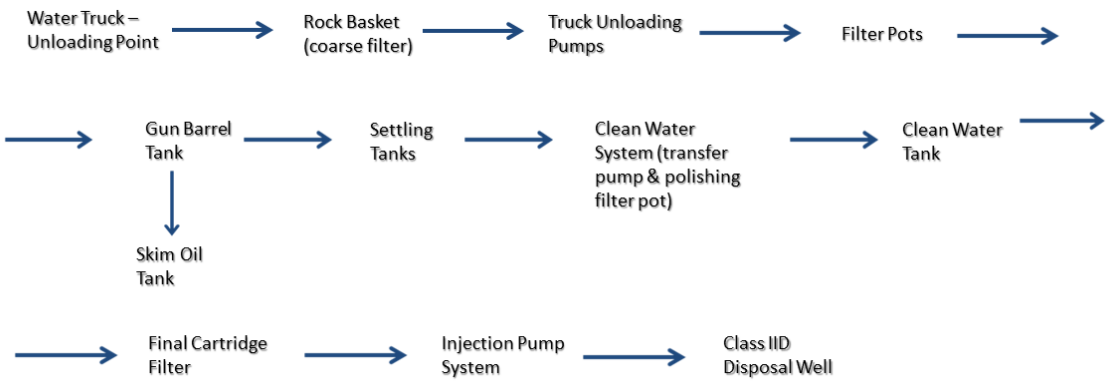

Figure 2: Process Flow Diagram of a Typical Saltwater Disposal Well Facility.

Truck Unloading Pumps – Trucks will connect to the truck unloading system to be pumped to the gun barrel tank using a horizontal centrifugal pump. Each pump suction line typically includes a coarse filter to remove any major obstructions from the fluid, and each pump discharge commonly includes a filter pot to reduce suspended solids in the system. For times when the Truck Unloading Pumps are out of service, a second truck connection is included to allow the trucks to unload directly into the system via the on-truck pumping system if the permanently installed unloading pumps are out of service to keep the system operational. Each filter pot typically includes a differential pressure transmitter that will alert the operator when the filters need changed out. The truck unloading area is typically designed on a concrete pad with trench drains connected to a concrete sump, which includes a submersible pump, to pump any captured rainwater or spilled product into the gun barrel tank.

Gun Barrel Tank, Skim Oil Tank, and Slop Tank – In most cases, the truck unloading pumps discharge to the gun barrel tank, as shown in figure three, for oil/water separation. The water enters the inlet flume section at the top of the tank. The oil and water travel downward through a downcomer pipe and are dispersed by a spreader plate. Free water remains in the lower section and the oil travels upward. Clean oil at the top flows over the oil outlet to the skim oil tank by isolating flow to the downstream settling tank and raising the volume in the gun barrel tank to allow discharge to the skim oil tank.

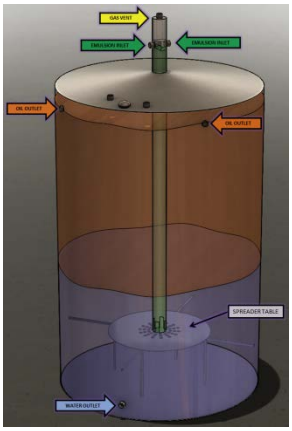

Figure 3: Diagram of a Typical Gun Barrel Tank. (Petrosmith, 2016)

Settling Tanks – From the gun barrel tank, the flowback water flows by gravity to settling tanks in series to settle solids. The level in the tanks will be controlled by the amount of flow received from the truck unloading pumps (routed through the overflow of the gun barrel tank) and the flow rate of the clean water pump.

Clean Water System – From the settling tanks, the treated water will be pumped through a polishing filter pot and into the clean water tank. At that point, the injection pump will take suction from the Clean Water Tank. Additionally, a final cartridge filter is commonly included on the suction line prior to injection into the well.

SUBSURFACE WELL BORE DESIGN & COMPLETION METHODS – With the design of the subsurface well bore, the operator will need to consult with a geologist in order to understand the depths and porosities of the formations available. Once the targeted formation is understood, the consulting geologist will develop a well bore design per the standards of the respective well class (i.e. I, II, III, IV, V, & VI).

During the process of developing the well bore design, the operator will need to determine the preferred borehole size, materials of construction, vendor selection, and completion methodology. The operator will need to determine the preferred borehole size, as this will relate to the size of injection tubing the well will be capable of handling. When determining the tubing size, it is good practice to define the materials of construction as it pertains to lining the injection tubing and the packer. Plastic lined steel tubing is often used to minimize corrosion from the oxygenated saline solution. If the operator decides to line the tubing and packer, the inside

diameter of the injection tubing will be decreased. In regards to disposal well construction, the operator will pick whether to use a perforated design, an open-hole design, or other, as shown in figure four. The most commonly used method for new Class IID wells that are drilled into deeper formations is the open-hole completion. This completion style increases the injectable interval thus giving the operator a larger selection of formations to inject water.

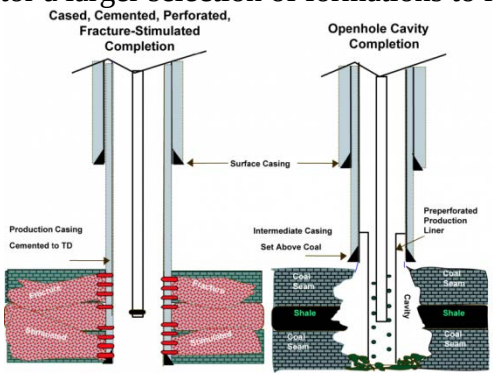

Figure 4: Example of Perforated Completion and Openhole Completion Methods for Production Wells. (PetroWiki, 2016)

EXAMINATION OF FORMATIONAL WATER CHEMISTRY

When operating a Class IID disposal well, it is essential that the operator have a thorough understanding of the water quality being received. This information will provide direction for treatment considerations, safe handling, and overall treatment costs. Daily composite sampling is recommended for water quality issues of concern, such as pH, conductivity, divalent cations, bacteria, natural gas liquid and dissolved and suspended solids concentration. This will assist with the correct filter selection and optimize the treatment chemical selection and dosages.

The use of a qualified lab and experienced treatment chemical representatives will maintain a more efficient system and allow for treatment approaches to maximize the injectivity profile of the water, allowing for higher pumping rates at lower pressures, and a residue-free formation. Examination of the water quality should include an analysis of the anions and cations of concern, pH, viscosity, and scaling calculations. Beyond testing standard water parameters, the operator should be aware and have chemicals on-site to reduce the water viscosity when that situation arises. Geochemical modeling using the water quality provides the impact on the formation of certain scaling species, and provides treatment chemical selection and loading to mitigate these issues. Microbiocide efficacy studies should be conducted to confirm which biocide at what dosage will control the microorganisms associated with the influent to the Class IID facility.

TREATMENT PROGRAM DESIGNS

Class IID disposal well operators strive to improve the business model to pump maximum amounts of water at pressures which are under the permitted pressure setpoints to minimize facility downtime. Disposal of flow back and production brines present several challenges for the operator, which relate to scaling/deposition, bacteria, and higher water viscosity. Injectivity profile, which is the ability to inject the water underground at lower pressure, is optimized when the appropriate treatment chemistries and dosages are being employed. Whether a Class IID disposal well is of open hole or of perforated design, the formation that the water is being

pumped into needs to be maintained as residue free. The porosity of the formation allows for deep well disposal of flow back and production brines and maintains permeability helping the operator achieve these goals. As usual, economics come into consideration, which is attributed to lower pressure and higher gallons per minute disposal rates, which will save the operator on labor, utilities, filter change out, and maintenance costs. With that, this section of the paper will explore pretreatment technologies and considerations that could benefit the Class IID disposal well facility owner.

DIVALENT CATION PRECIPIATION CONTROL – Divalent cation (Ca++, Mg++, Ba++, Sr++) reduction is worth consideration as calcium carbonate ($CaCO_3$) and barium sulfate ($BaSO_4$) and other scaling species can have a significant negative impact on the injectivity profile of a wastewater for deep well injection. Controlled precipitation of the divalent cation of choice can be performed with conventional commodity chemicals, such as adding sodium sulfate to the wastewater to precipitate/reduce the barium as barium sulfate. With that, the following economics need to be explored to answer several questions:

1. Will divalent cation removal reduce the overall treatment costs?
2. Will the tank bottom clean out or filter change out offset savings?
3. Is occasional acidizing in the formation a better option?
4. Are there viable and affordable scale-control chemicals that will maintain the injectivity profile without divalent cation removal?

When considering divalent cationic ion removal in the form of settled solids, one must sample the settled sludges to determine if there is a concentration of the NORM / TENORM characteristics of the sludge. One should contact a certified radiation safety officer for appropriate sampling and analyses to gain information to mitigate these issues.

CORROSION CONTROL – Many salt water disposal well facility owners consider the use of corrosion inhibitors as part of the treatment program design. Most owners choose to use fiberglass or chloride resistant paints for tank interiors. The use of many conventional corrosion inhibitors such as phosphate and phosphonates are not cost effective as they often times will complex with the water chemistries and suspended solids in the waste water, rendering them ineffective.

IRON CONTROL – Depending upon the production formation, ferrous iron and ferric iron concentrations can be considerable in well flow back and produced brines. The particulate iron can compromise the waste water injectivity profile and potentially impede formation permeability. Iron control can be improved with the use of low-cost acid or spent acid from an acidizing job, chelants, or chemistries outlined in US Patents 8,871,691 “Methods of treating flowback water from a subterranean formation” (Grottenthaler) and 9,034,805 “Fluid treatment systems, compositions and methods for metal ion stabilization in aqueous solutions” (Blauch).

MICROBIOLOGICAL CONTROL – There are many species of aerobic and anaerobic bacteria in flow back and production brines. The population and species can proliferate as many of these water sources are stored in pits and working tanks for long periods of time before they are transported to a Class IID disposal well. Aerobic slime-forming bacteria present challenges not

only in the formation where the water is being discharged, but in the pumping and filtration systems within the disposal well tank farm and filtration processes. Acid-producing bacteria can increase corrosion rates throughout the disposal well system and piping. The use of oxidizing or nonoxidizing biocides must be considered to minimize maintenance within the Class IID disposal well system and to keep the well formation residue free.

APPLICATION OF TREATMENT PROGRAMS

INHIBITORS – Many disposal wells in basins throughout the United States have found a benefit of using proper scale and deposit-control programs to improve the injectivity profile of the waste water. There are numerous scale/deposit considerations and many effective treatment chemicals that would provide a more residue-free formation. A brief discussion of recommendations will allow for properly sampling of the waste waters that would come to a Class IID disposal well and provide some of the data management calculations that could be used to select the correct inhibitor, frequency of feed, and optimized dosages.

The influent water to the facility can be flow back, production brines, pit water, containment water, drilling fluids, and other sources of liquids from the well pad. It is best to meet with the manager of the waste water source(s) to gain an understanding as to which production wells, pits, and flow back sources will be provided.

Due to the variability of influent water sources, it is suggested that occasional composite sampling be performed and to have an analysis performed at a qualified lab. Once a range of influent water parameters has been established, one can begin to understand the potential for scaling/deposition tendencies and types. A simple test to see if $CaCO_3$ might be of concern is to run a Langelier Index (a web based calculator is available on many sites). The operator will need to know the water pH, total alkalinity, total dissolved solids (TDS), calcium, and temperature. For informational purposes, indices that are positive are scale forming, and indices that are negative will show your water source to be corrosive. A more sophisticated approach is to use computer modeling that will use the water analysis data and look at the propensity for a variety of different scales to deposit. (AWT, 2016)

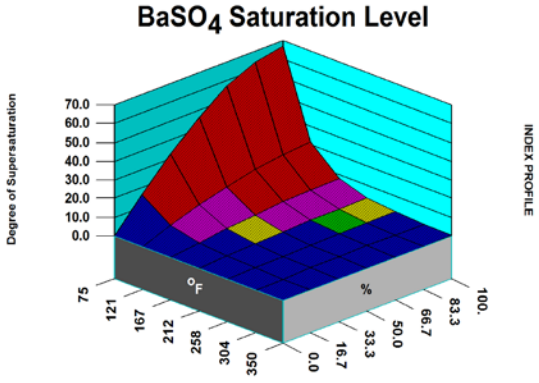

Figure 5: Saturation Profile for $BaSO_4$.

This program is designed for downhole well analysis, and uses the water analysis to calculate degree of supersaturation while considering temperature and formation water percent, as shown in figure five. One can choose from a list of standard scale inhibitors to see which chemistries are best for the specific application.

MICROBIOCIDES – Class IID disposal wells can often times benefit with the administration of a proper biocide program. It is suggested that a lab in your area should not only be able to do the bacteria testing, but also perform a microbiocide efficacy study. This will provide for using the appropriate sterile containers for sample collection and for storing them at the proper temperature for transport to the lab. The species of primary concern are Total Aerobic Bacteria (TAB), Sulfate Reducing Bacteria (SRB), and Acid Producing Bacteria (APB). Most Class IID facilities select biocides and loadings to maintain the TAB population at $<10^4$ cfu/ml and the SRB and APB counts at $<10^2$ cfu/ml.

A proper microbiocide efficacy test would evaluate an oxidizing biocide (sodium hypochlorite) and several industry effective nonoxidizing products such as glutaraldehyde, DBNPA, Dazomet, TTPC and others. Select the program that would be the most effective and at the lowest cost. Occasional on-site testing should be conducted to keep the system and the injection formation clean and provide information to make proper dosage adjustments. Microbiocide feed should be proportional to flow and fed at the truck unloading piping. This is most effective to keep your entire system clean, minimize filter change out, and facility downtime.

EMULSION BREAKERS – Emulsion breakers can be considered and cost justified when the influent waste water contains more than 2% oil with most of it emulsified, which is very rare in the Marcellus and Utica shale plays. Injection of the appropriate emulsion breaker will allow for better capture, and generally better oil quality within the skimmer, gun barrel, or a supernatant on the tanks.

GELS – On occasion, a Class IID disposal well can receive flow back with a high concentration of friction reducer (FR) or guar gel that had been used during hydrofracturing and would cause the water to be high in viscosity. High water viscosity would cause the disposal well system to have pumping problems and filter change out issues. It would be prudent to keep powdered citric acid for FR viscosity reduction and some persulfate breaker for unexpected gel loadings on location to mitigate issues associated with high-viscosity waste waters. Many operators use 50 micron bag filters or a specific gravity meter at the truck unloading location to prevent the high-viscosity products from entering the system. These procedures would also assist with the prevention of drilling fluids/muds from entering the Class IID system.

CASE STUDY #1 – UTICA SHALE REGION

The following is a case study on a Class IID disposal well in central Ohio. The facility processes 3,000 barrels per day and the influent consists of primarily production brines from conventional wells and Utica unconventional well flow back.

The operator was experiencing:

- High pumping pressures

- High static pressure
- Line replacement due to corrosion
- Numerous filter change outs daily
- Poor oil recovery
- Microbiological issues

A survey was conducted and samples of the system water and deposition product were collected for analysis. Samples of the fouled filter media were collected as well for evaluation. The operator was feeding a scale inhibitor and slug feeding a microbiocide. A microbiocide efficacy study was conducted with the biocide being administered and several other products that are effective biocides on oilfield waste water. Inspection of the chemical storage and feed points was also documented.

The water analysis parameters were within the normal ranges for a combination of flow back and production brine. Chlorides were 107,000 mg/L (as Cl^-) and the resulting total dissolved solids were 156,078 mg/L. Total iron was 82.8 mg/L (as Fe), calcium was 18,903 mg/L (as Ca^{++}) and total alkalinity was 245 mg/L (as $CaCO_3$). Geochemical modeling resulted in the potential for carbonate, sulfate, and iron based scales. Evaluation of the scale control on location showed that it was a low concentration liquid containing phosphonate only.

The control water sample without biocide in the microbiocide efficacy study yielded a moderate total aerobic bacteria count at 10^4 cfu/ml and a low sulfate reducing bacteria count at 10^1 cfu/ml. The acid producing bacteria was very high at $>10^6$ cfu/ml.

Based upon the findings the following conclusions were determined:

- The process would benefit from a multi-component scale control program to address carbonate, sulfate, and iron related scaling species
- The biocide that the facility was using was a proper selection, but the slug feeding of inadequate dosages, needed to be corrected
- The current scale inhibitor was not only inappropriate chemistry but was being applied at an ineffective feed point. Both the scale inhibitor (with a methanol carrier) and biocide were being added to the receiving tank above a 1’ – 2’ oil layer

Corrective actions:

- A multi-component scale inhibitor was implemented and the feed point was extended below the oil layer on the receiving tank and feed rates were set to be effective against carbonate, sulfate, and iron based scales associated with the influent water parameters
- The biocide feed was automated and dosage adjustment based upon routine testing was implemented
- The water is now sampled frequently and adjustment are made to the scale control and microbiocide programs
- Filter change out has been reduced
- Tubing replacements are no longer are necessary
- Pumping pressures have been reduced

This case study is for a Class IID disposal well in northeast Ohio that receives Marcellus flow back and production brines and some produced water from conventional wells in the area. The facility processes 1,500 barrels per day. This facility is typical of many in the northeast United States where there were several years in the past where no treatment chemicals were used to prevent scale, deposition and/or biofouling within the system and into the formation that received the water.

An initial survey of the system yielded:

- The operator was using a manual drum pump and putting a coffee can of scale control into the filter pot ahead of the truck coupling to the influent line. The pump from the truck carried the waste water and scale control chemical into the receiving tank.
- The facility received multiple waste water sources in a variety of tanker sizes
- There was no on-going biocide feed. The operator would occasionally use store bought bleach, particularly in the summer when they received a lot of "black water with an oily smell"
- The operator would need to shut down and acidize the well frequently

Water samples were collected form several of the trucks throughout the week and kept in a cooler. Sterile containers were also used to collect samples from several trucks for a microbiocide efficacy study.

Based upon the data from the lab analyses, the following was determined:

- Influent flowback water to the facility was high in calcium, total alkalinity, Total Aerobic Bacteria (TAB) and Sulfate Reducing Bacteria (SRB)
- Iron levels in the ferric form averaged near 100 mg/L

The operator was reluctant to spend much money to automate scale control feed and to start consistently using a biocide. The following was accomplished to improve the system conditions:

- A slug dosage chart was made and plastic beakers with accurate measurement were provided for the operator. Therefore, they would use the chart when different tanker sizes arrived to properly dose the scale control program.
- Concentrated sodium hypochlorite (bleach) was sourced form a local commodity supplier. This allowed the Class IID to feed a more concentrated product for microbiological control and keep treatment costs at a minimum.
- Operator training, more accurate scale control loading, and a more concentrated biocide has led to lower pumping pressures and acidizing the system has not occurred in the past year.

CONCLUSION

Dependent upon the wastewater streams and the varying amounts of suspended solids, there are a variety of wastewater treatment schemes to choose. Each saltwater disposal well has the tendency to react differently to the different treatment structures, so it is imperative to perform a technical evaluation by a qualified consultant. In addition, the evaluation of disposal methods will vary depending on the shale play, O&G operator, and the optics of the public.

REFERNCES

AWT web site Water Treatment Rules of Thumb, Myths - French Creek Software. 10 June 2016. <http://www.frenchcreeksoftware.com/awt2003/AWT2003PAPER.PDF>

Blauch, M.; Grottenthaler, D; Rey, P; Rey, S; Seyman, M. (2015). Patent Identifier No. US9034805 B2. Location: United States.

CBM Well Drilling and Completion. PetroWiki, 2016. 15 July 2016. <http://petrowiki.org/CBM_well_drilling_and_completion>

Class II Oil and Gas Related Injection Wells. US Environmental Protection Agency, n.d. 9 June 2016. <https://www.epa.gov/uic/class-ii-oil-and-gas-related-injection-wells>

Defining Upstream Oil & Gas. A Dover Company, n.d. 15 June 2016. <http://www.psgdover.com/en/oil-and-gas/oil-gas-market-overview/oil-gas-upstream>

General Information About Injection Wells. US Environmental Protection Agency, n.d. Web. 9 June 2016. <https://www.epa.gov/uic/general-information-about-injection-wells>

Grottenthaler, D; Rey, P; Rey, S (2014). Patent Identifier No. US8871691 B2. Location: United States.

Huffmyer, R; Van Gehuchten, J (2013). Recovering Valuable Byproducts from Oil and Gas Wastes, International Water Conference, 3 – 4

Injection Well Classifications. Ohio Department of Natural Resources, 2016. 11 June 2016. < http://oilandgas.ohiodnr.gov/industry/underground-injection-control>

Oilfield Storage Tanks. Petrosmith, 2016. 15 July 2016. <http://petrosmith.com/wp-content/uploads/2014/07/Gunbarrel-Tank.png>

Rehm, B; Haghshenas, A; Paknejad, A; Al-Yami, A; Hughes, J; Schubert, J (2012). Underbalanced Drilling - Limits and Extremes, *Gulf Publishing Company*, 198-230.

What is Unconventional Oil and Gas? Alberta Energy Resources, 2016. Web. 7 June 2016. https://www.aer.ca/about-aer/spotlight-on/unconventional-regulatory-framework/what-is-unconventional-oil-and-gas