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Key Issues Associated with Produced and Recycled Water Handling in the Shale Plays

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Produced Water Society

Produced Water Challenges for the Permian Operations / Midland September 2017

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Produced Water and the Shale

- Used for Drilling
- Used for Hydraulic Fracturing
- Flowback from newly fractured wells as Produced Water
- It is estimated there are 10 Barrels of water to handle for every barrel of oil produced
- Some recycled and some disposed of in Saltwater Disposal Wells (SWD)
- Average water use in oil and gas zones per well 5 MM gallons per well
  - Varies between oil and gas zones
  - Varies between different plays
- Water Commoditization and Management will be the Focus for Cost reduction

Water Management

- Source of Water for the Shale
  - Treated City Water
  - Aquifer and Fresh Water
  - Recycled Produced Water
- Disposal and handling of up to 1 Trillion Gallons of water
- Require an effective management strategy to recycle
  - Storage and handling infrastructure
  - Water Quality accepted for HF
  - Level of Salinity accepted for HF water
- Over 50% of the well's operation cost is due to water management

Estimated cost was over $ 12.5 Billion and 20 Billion across the different US major plays in 2015 and 2016 respectively for utilizing and handling the water

The Focus on Cost

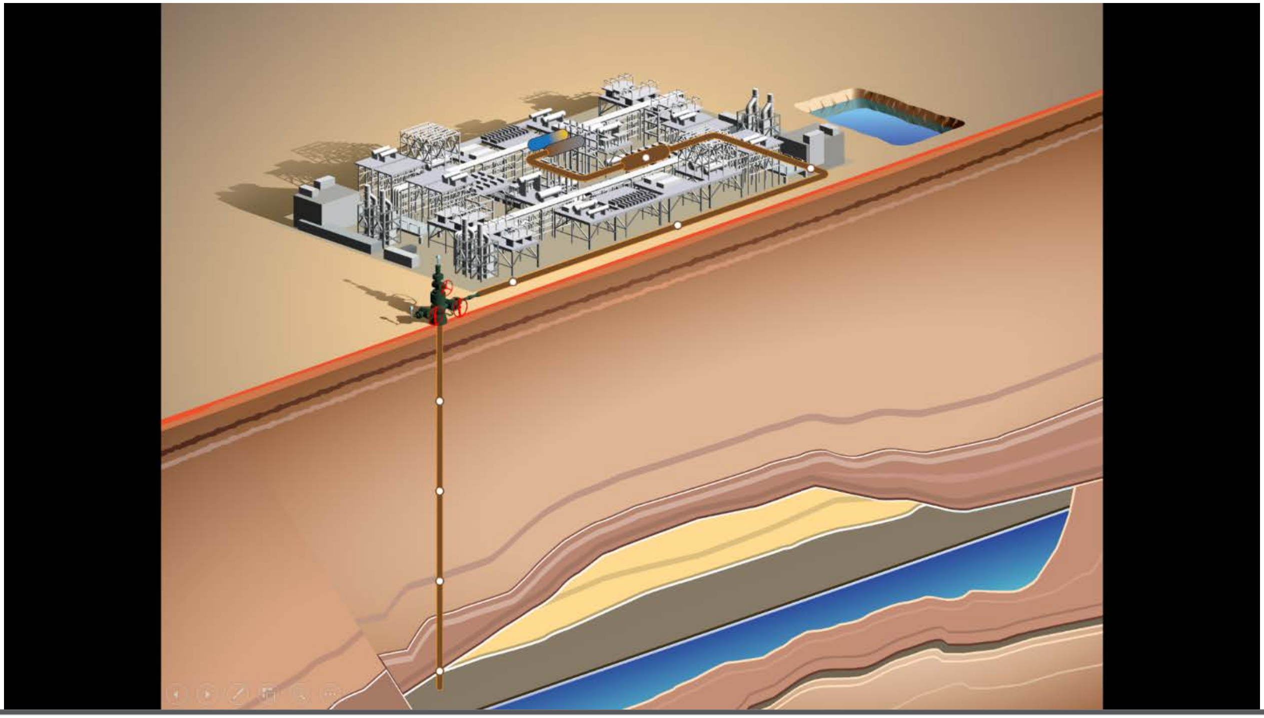
• Breakdown on Cost

- **Disposal and Hauling (63% of the cost)**
- **Storage (9% of the cost)**
- **Transfer (6.5% of the cost)**
- **Services for the Flowback (6.2% of the cost)**
- **Sourcing (6.2% of the cost)**
- **Treatment (9.0% of the cost include cost of pre-treatment for HF)**

Other Key factors in the cost have not been taken into consideration although can add / contribute significantly to the overall cost on the top of the estimated cost

• The Hidden Cost of the PW Cost Equation

- The consequence of poor water treatment through the whole life cycle, is failures and maintenance of wells and surface equipment
- **($5K-$30K per well per year) and (surface equipment ??)**



Failures

- **Failures that can be directly contributed to the poor water quality / treatment both the tubing and surface equipment**

- **Solids in the system**

- **Separation efficiency**

- **Corrosion Failures**

- **Scale deposit failures**

- **Bacteria**

- **Hydrogen Sulphide**

Typical cost of using chemicals to control some of the above issues plus other flow assurance issues can be ($ 1.00 - $10.00 per BOE)

Water Life Cycle Holistic Approach

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Drilling and HF

Production and Processing

Flow assurance and Treatment

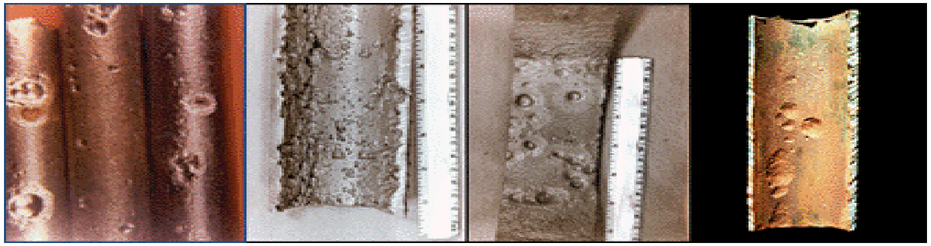
Handling and Storage

Reuse and Recycle

What are the Challenges

It requires to have an integrated and holistic approach to deal with water treatment and overall integrity and flow assurance issues

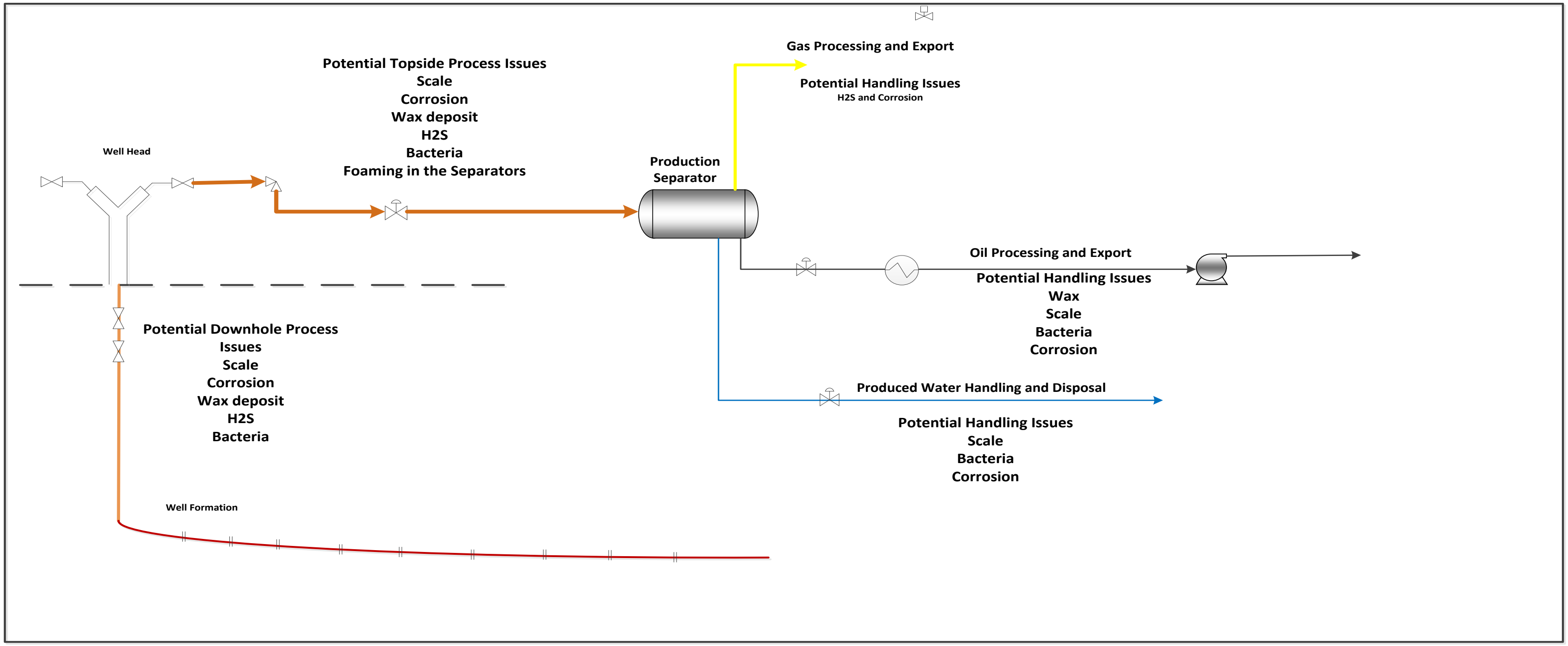
- Define key system Integrity issues
- Impact on the water quality
- Define the common risks associated with the integrity issues and water quality
- Source of risks
- Means to mitigate the risks and to achieve a common objective for both
- Effectiveness in controlling the risks
- Room for improvements



What are the Challenges

There is a lack of full understanding of the fundamental issues and gaps in knowledge associated with water quality and failures

- **Hence effective treatment can't be achieved**
- **Cost control is not effective**



Corrosion Control downhole and surface

- Understanding the factors that influence the corrosion process
- How much it is influenced by the produced fluid?
- How much it is influenced by external factors?
- Using correct samples for analysis
- Using the correct methodology to measure the level of the corrosive gases (H_2S , CO_2 and Oxygen) in the relevant phases
- The influence of Bacteria related corrosion (MIC)
- Using the optimum location for sampling
- Applying the correct monitoring strategy with all the wells

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Bacteria Control

- Understanding the sources of bacteria
- How much it is influenced by the produced fluid?
- How much it is influenced by external factors?
- Using correct samples for analysis
- Using the correct methodology to determine the effectiveness of current treatment regime
- Using the optimum location for sampling
- Applying representative and correct monitoring strategy

Understanding Scale ad Salt Issues

- Deposit caused by changes in operating conditions downhole
  - Pressure
  - Temperature
  - Evaporation
  - Poor compatibility of the processed waters
- To quantify the problem and provide optimum solution
  - Having the correct water sample and composition / chemistry
  - Normalizing the water chemistry
  - Correct well pressure and temperature data

The Gaps

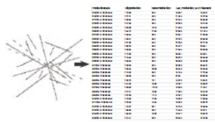
- Data mining and analysis
- Interpretation and Mapping

- Monitoring

Key Elements for Improvements

Find practical cost effective means to establish full understanding of the risk

- Monitoring
    - Currently are we doing enough monitoring
- What and how to monitor
    - Large number of producing wells
    - Different fluid properties
    - Consistency of the data gathered
    - Frac fluid factor / communication between wells
    - External water treatment factor
- How to use the gather monitoring data
    - Collating all the data together and useful tools for data mining
- Water characterization data required to improve water handling



The Implementation

- **Easily said than done but it is achievable**
- **Potentially can reduce the recycle volume of water handling and consequently reduce the overall cost**
  - **Disposal and Hauling (63% of the cost)**
  - **Storage (9% of the cost)**
  - **Transfer (6.5% of the cost)**
  - **Services for the Flowback (6.2% of the cost)**
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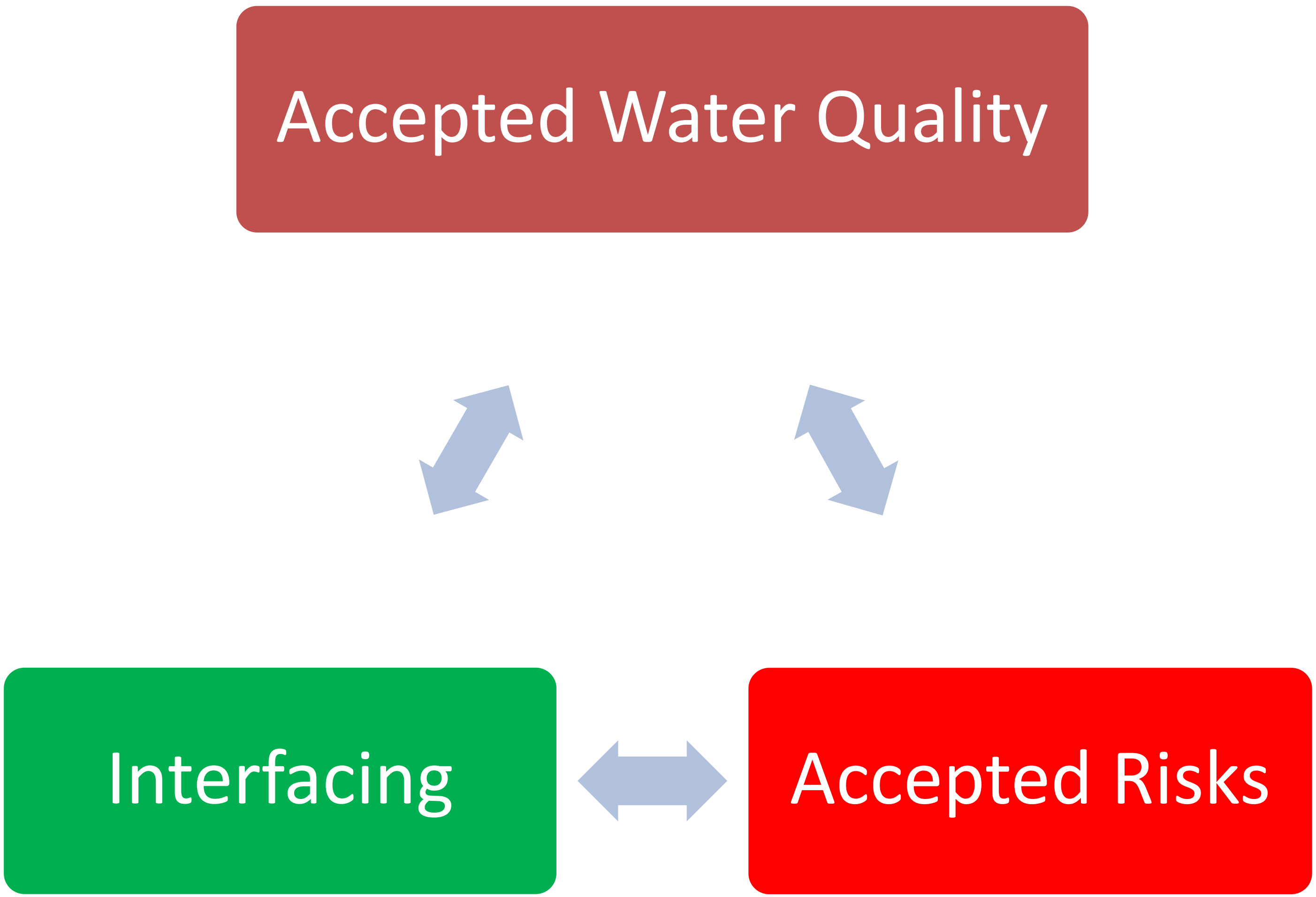
The Goals



Conclusions

- Assess the different risk in operation of the wells and production facilities
- Define the risk using modelling tools and system monitoring
- What can we accept for water quality for Frac Operation
- Compatibility of Frac Water with the chemicals used
- Integrate the produced water treatment together with all aspects of flow assurance issues and treatment
- Introduce effective monitoring program

Conclusions

- Well data correlation / mining and evaluation
- Mapping the different integrity issues in the system
- Develop the methodology to determine effectiveness of chemical treatment
- Define critical water characterization data
- Establish KPI’s for system improvements
- Utilize the correct technology with the optimum configuration
- The ultimate objective increase the recycle of the produced water

Have we got Easy Answer to the Produced Water Issue