Environmental Costs of Managing Geological Brines Produced or Extracted During Energy Development

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Topics Addressed

- Energy systems that produce brines
- Composition of typical geological brines
- Water management options
- Environmental costs of water management

Sources of Geological Brines

- Produced and Flowback Water from Oil and Gas Operations
- Water Extracted from Deep Saline Aquifers used for Carbon Sequestration
- Spent Geofluid from Geopressured Geothermal Systems

Photo by John Veil

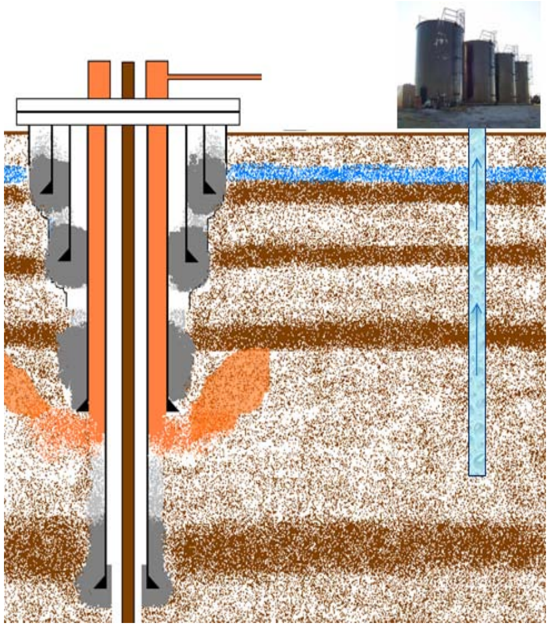
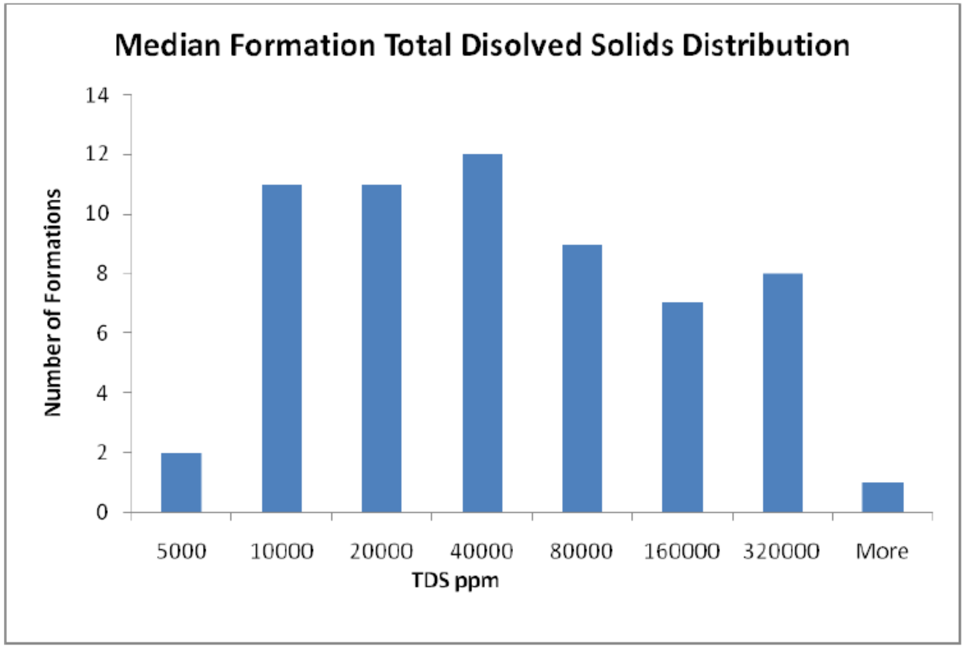


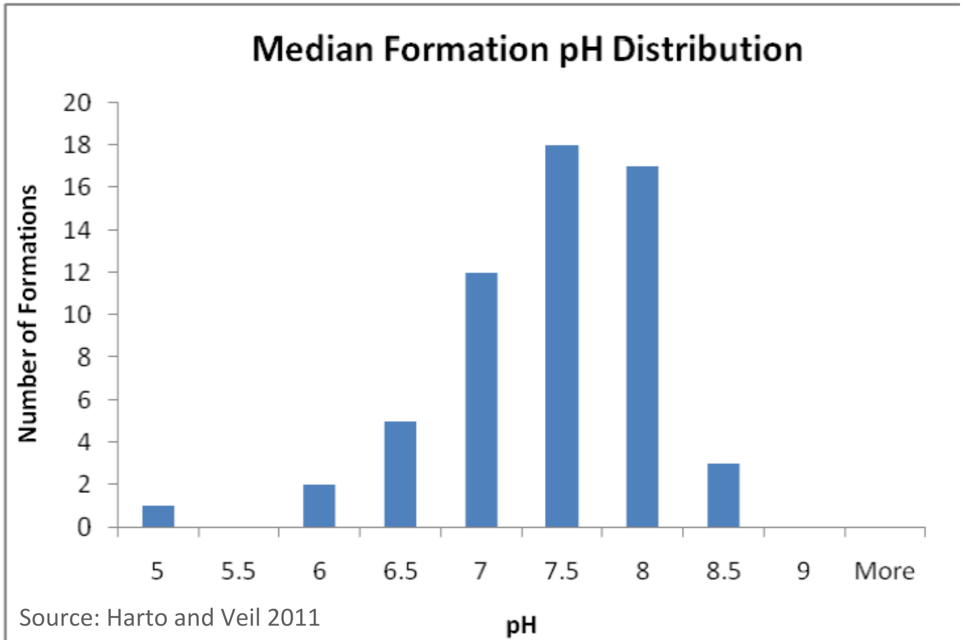
Diagram by John Veil

Photo by Corrie Clark

Water Composition

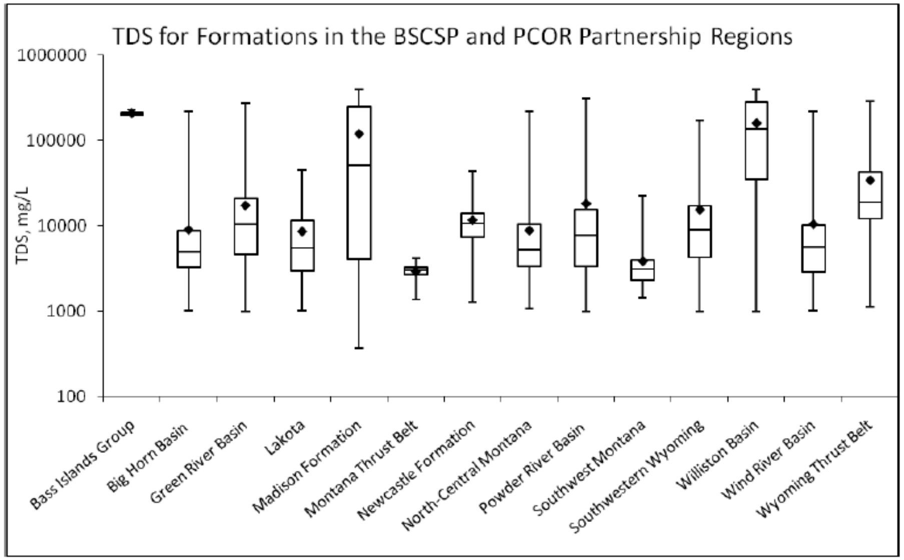
- Examples of the geochemical data
  - Formation TDS varies significantly by location
  - Formation pH ranges from slightly acidic to slightly basic
- Management solution must be targeted to unique local brine chemistry
- Note: data for geological formations of interest for carbon sequestration

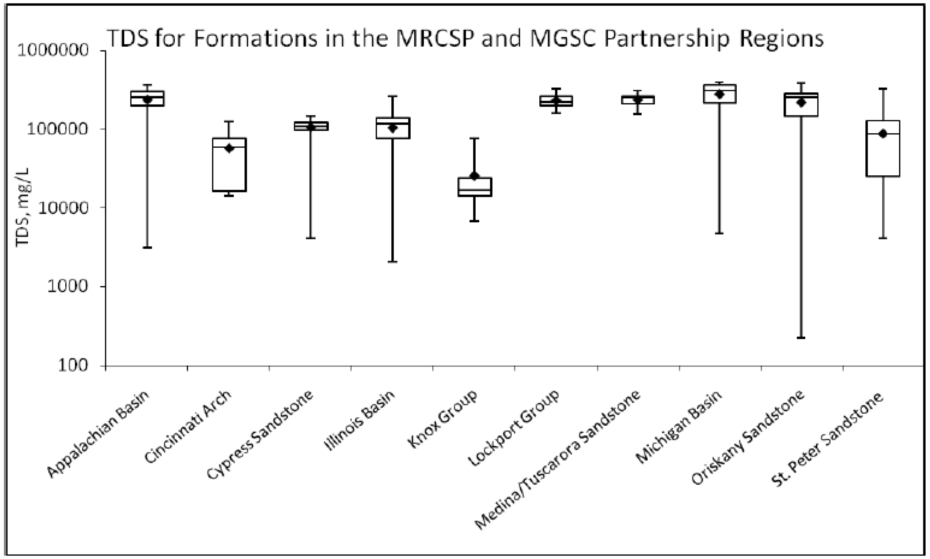


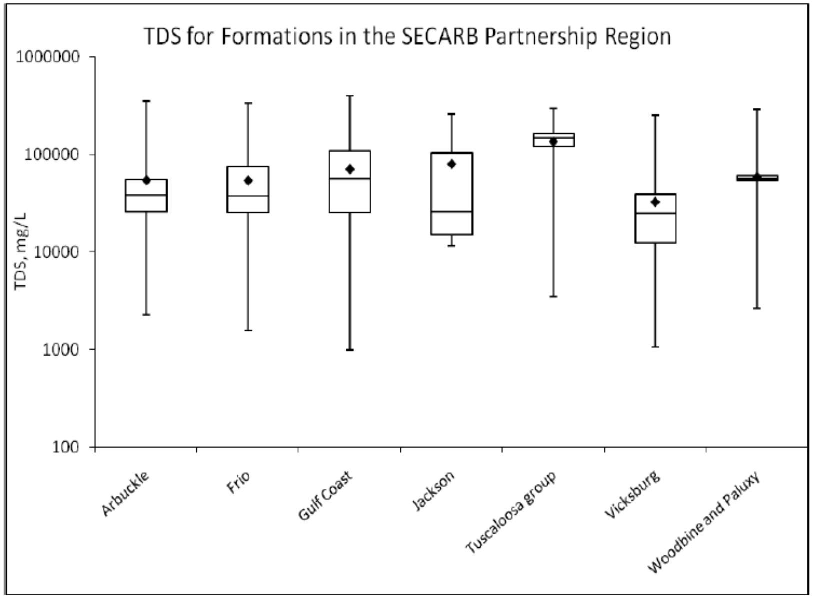


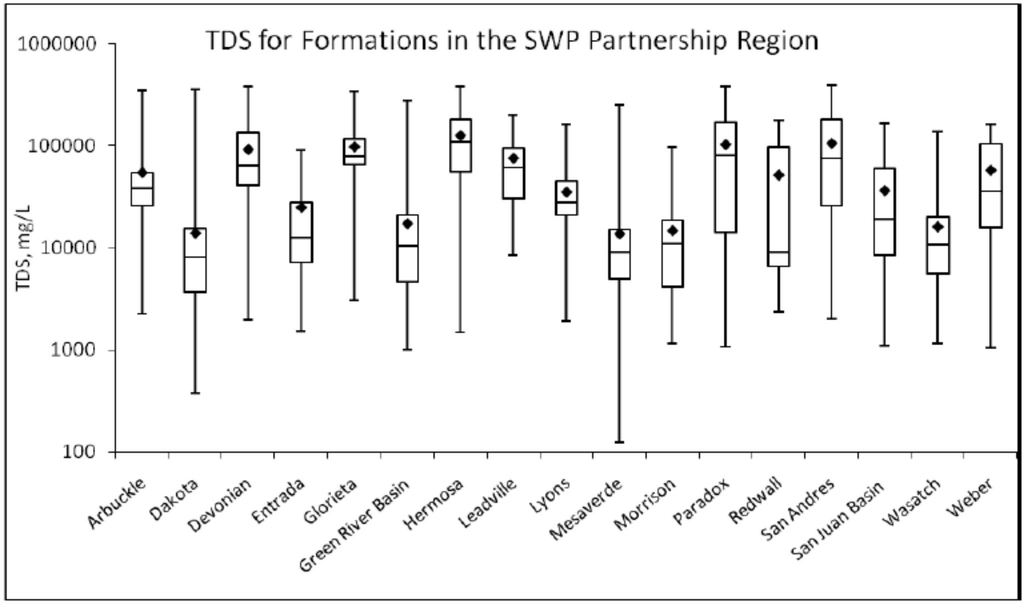
Source: Harto and Veil 2011

Variation in TDS Between Regions









Source: Harto and Veil 2011

Water Management Options

- Reuse
  - Use as is
    - Injection for recovering more oil
    - Hydraulic fracturing or drilling fluid
    - Enhanced geothermal systems makeup water
    - Injection for hydrological purposes
  - Use after treatment
    - Industrial
      - Cooling water
      - Dust control
    - Agricultural
      - Irrigation
      - Livestock
    - Drinking

Source: USFWS

Water Management Options

Treatment Technologies for TDS/Salt Removal

Photo by John Veil

Membrane Processes

Photo by Chris Harto

Thermal Treatement

Photo by John Veil

Water Management Options

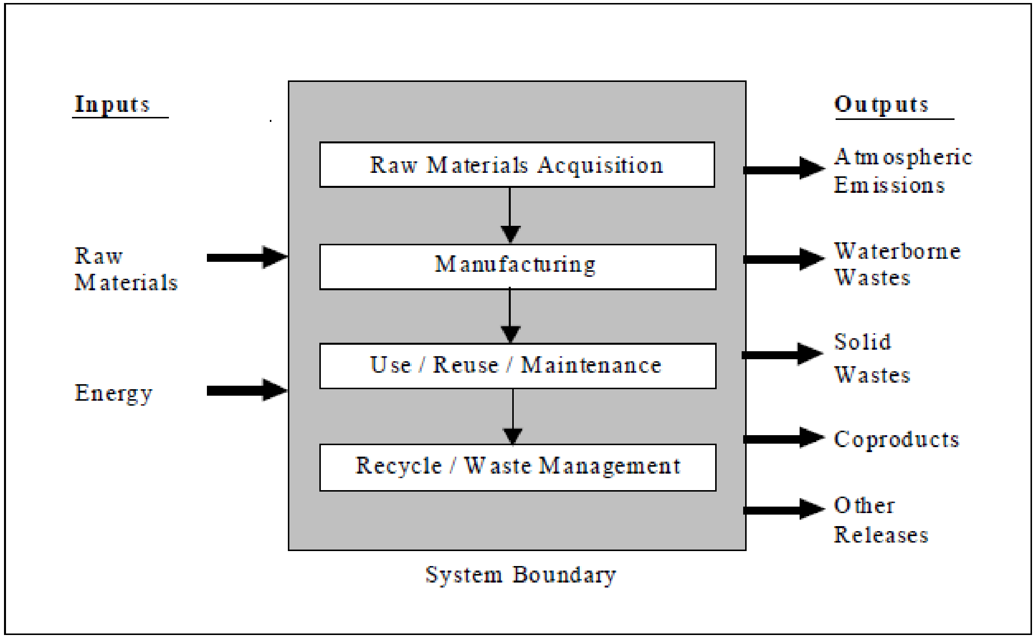
- Disposal of Extracted Water
  - Injection to non-hydrocarbon producing formation (UIC class II)
  - Evaporation

Photo by John Veil

Photo by John Veil

Balancing Environmental Costs and Benefits

- When selecting a water management you must weight the costs and benefits of the alternatives
- Hybrid life cycle assessment (LCA) approach used to compare
  - Energy consumption
  - GHG emissions
  - Net water savings



Source: EPA 2006

Hybrid Life Cycle Assessment

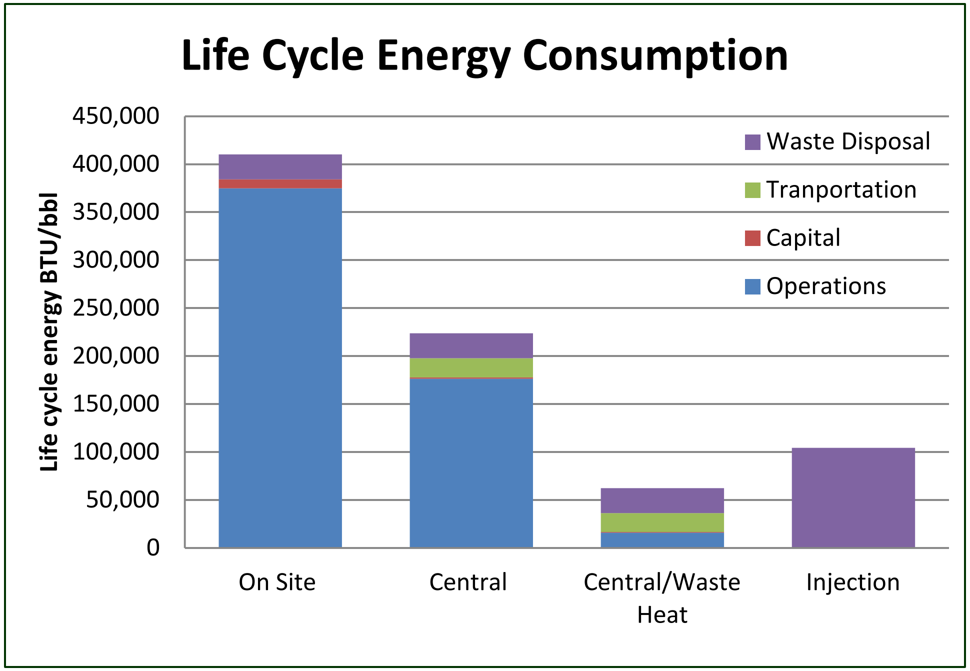
- Combines process based LCA approach with economic input-output LCA approach (EIOLCA).
- Process approach
  - Ideal for well characterized processes
  - Requires lots of specific data
  - Suffers from cut-off error
- EIOLCA approach
  - Suitable for more general processes
  - Only requires capital costs
  - Suffers from aggregation error
- Process approach utilized for direct process inputs
- EIOLCA approach used to consider capital equipment impacts

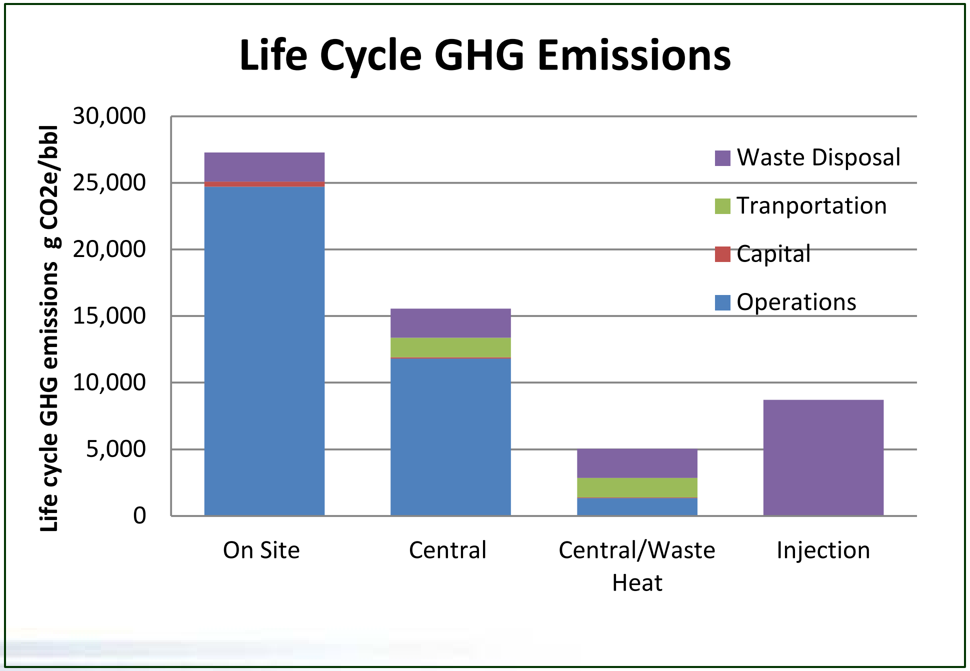
Example Scenario: Marcellus Shale

- Analysis for a single well in Marcellus Shale
- 4 options considered
  - Thermal treatment on site
  - Thermal treatment at centralized facility
  - Thermal treatment at centralized facility utilizing waste heat
  - Transport to UIC injection well
- Key Scenario Parameters
  - Transportation distance (0, 30, 150 miles for on site, centralized facility, injection)
  - All transportation by truck
  - Concentrate disposed of through UIC class II injection in Ohio

Results

- Higher efficiency of central location outweighs the energy for transportation for energy and GHG
- Thermal treatment more energy intensive than injection unless waste heat used
- Net water savings
  - Treatment system returns 0.66 bbl of clean water for every 1 bbl treated
- Other considerations
  - Availability
  - # of truck trips
  - costs





Further study in progress

- Management options will be included for further study
  - Reuse without treatment for TDS
  - Treatment to remove TDS
    - At least one reverse osmosis system
    - At least two thermal treatment systems
  - Disposal
    - Deep well injection
    - Evaporation
- Consider alternative transportation parameters
  - Truck vs. Pipeline
  - Transportation distance
- Explore impact of water quality (TDS)

Final Thoughts

- A number of energy development activities can result in the production of large quantities of salty water.
- Managing these brines can be a challenging, but must be done in environmentally responsible manner.
- When selecting the best management practices a number of factors should be considered in addition to cost.
- LCA is one useful tool for comparing the environmental footprint of competing options.