Produced Water Management

Reducing Cost Through Evaporative Disposal

Produced Water Case Study

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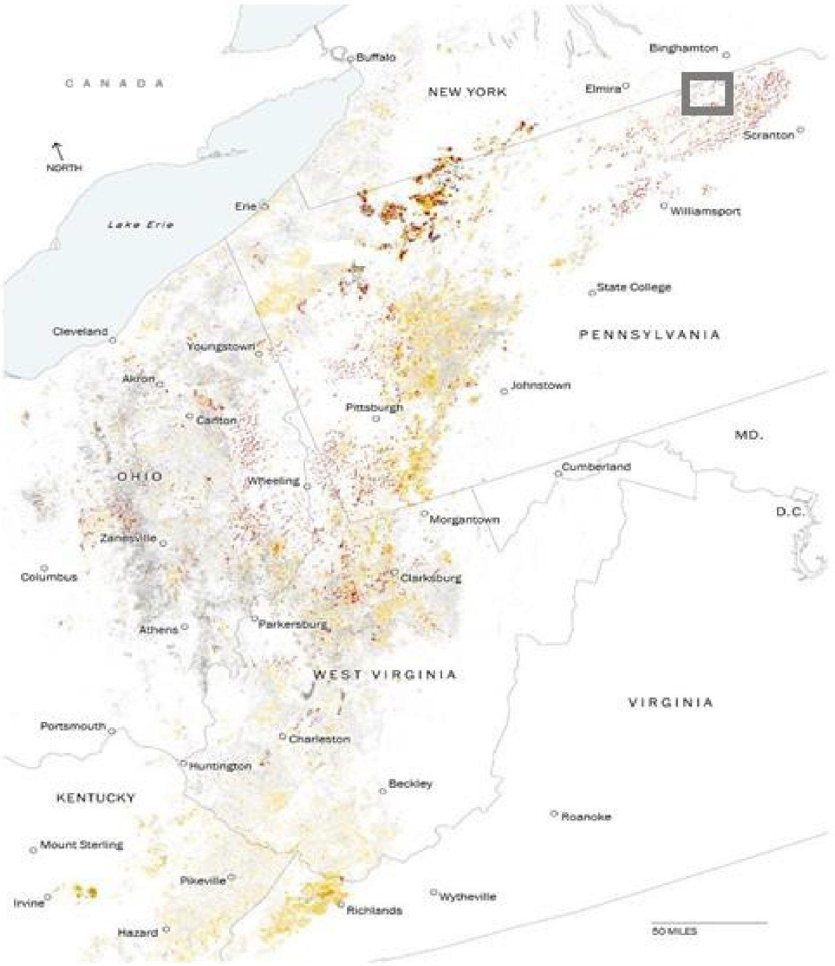
GRADIANT
ENERGY SERVICES

Case Study

Background

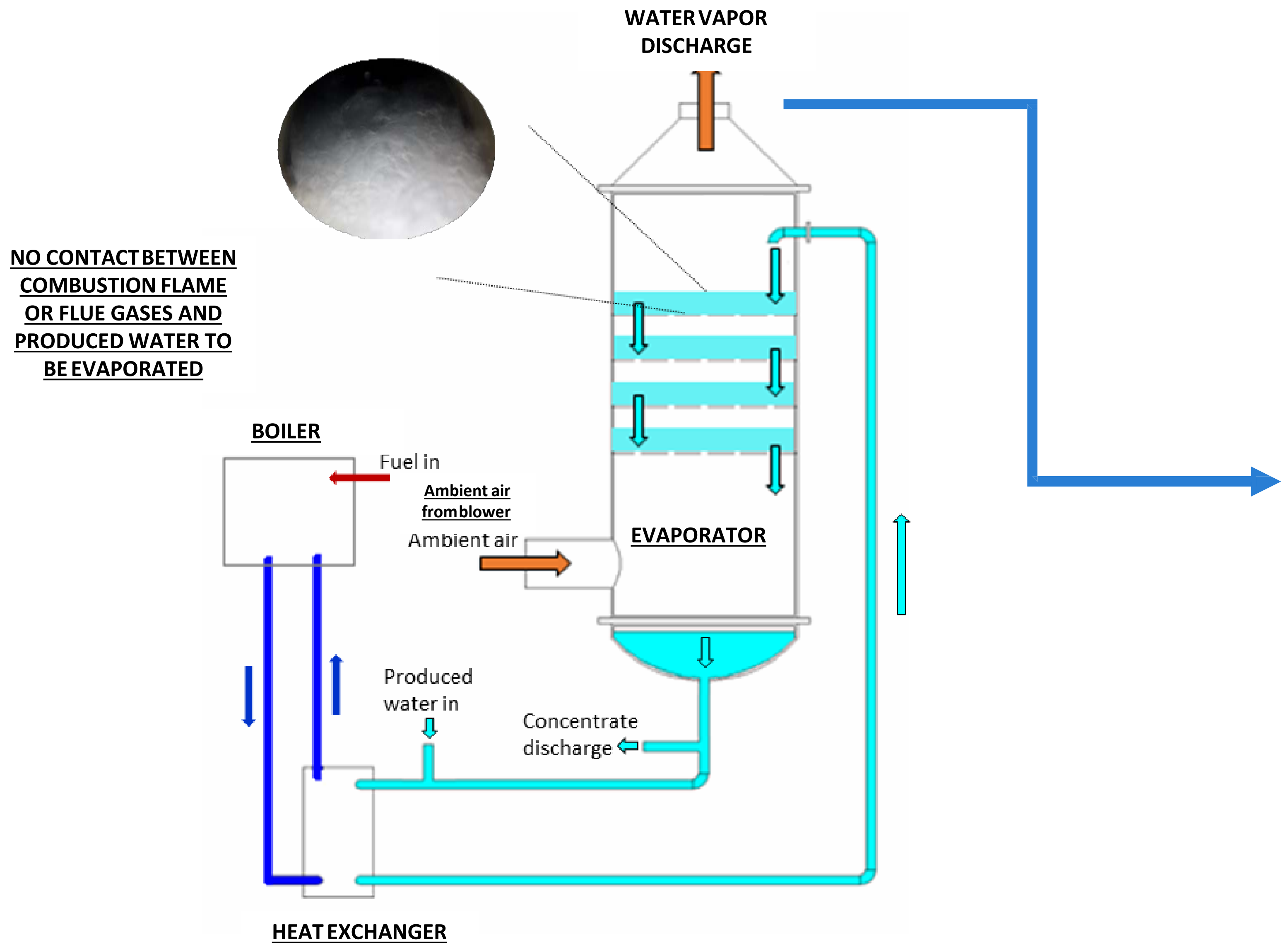
- Location : North East Marcellus
- Number of wells : >500 Wells
- Water Production : Most of the wells ~ 1 BPD
- Type : 45% of the wells - High TDS
- Flowback Phase : 0 – 2,500 BPD
- Frac Volume : 100 - 500K BPW
- Fracking : Fresh/Produced/Flowback
- Disposal Cost : $8 - 15/bbl

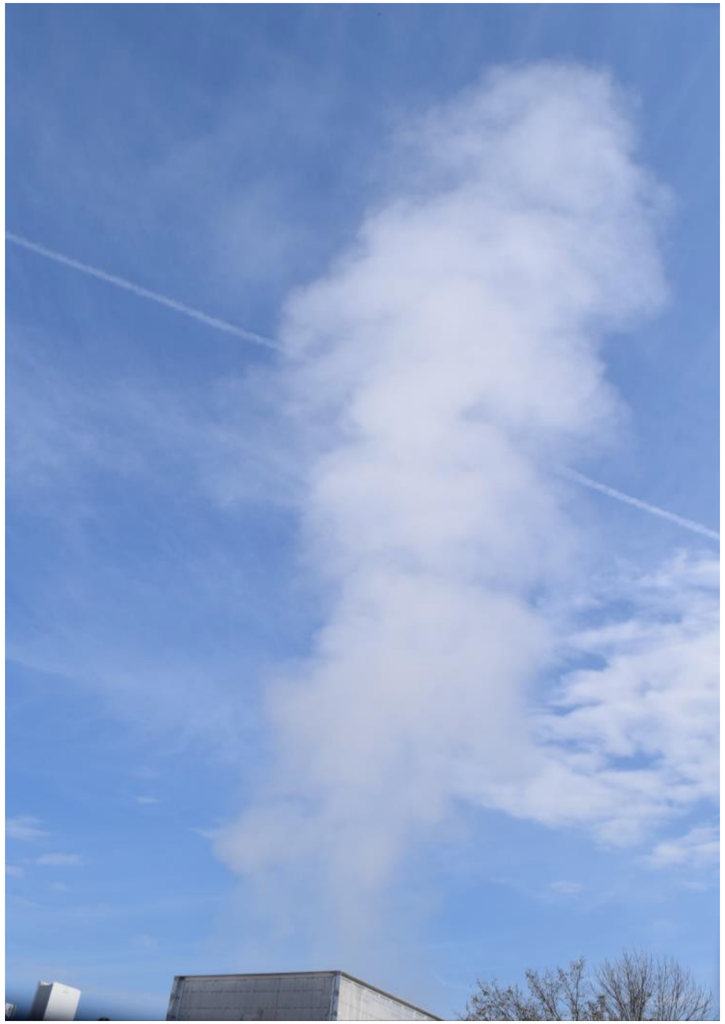


Objective : Reducing Water Disposal Costs

Technology - Carrier Gas Concentrator (CGCTM)

Alternative to Expensive Trucking, Salt Water Disposal or Evaporation Ponds





CGC Design

Evaporation Capacity : 500 BPD

Footprint : 60’ X 70’
CIP Process and Boiler pump system
Influent, Recirculation and Effluent pump system
CGC Bubble column
Natural Gas Boiler and Air compressor

Interconnecting piping and power leads

Influent Water TDS

Variable

Operating Conditions

Top Brine Temp:	200 F
Air flow:	4,000 scfm
Thermal Consumption:	0.5 Mcf/bbl

Effluent Water

200,000-250,000 ppm

Technology - Carrier Gas Concentrator (CGC™)

Features for Cost Savings:

- **Compact :**
  - Multi-stage bubble column humidification
  - High heat and mass transfer rates
- **Automated :**
  - Proprietary control algorithm
- **Minimal Pretreatment :**
  - Robust internal design
- **Lower Energy Consumption :**
  - High energy effectiveness because of efficient multi-stage design
- **Lower emissions**
  - No direct contact
- **Reliability :**
  - Developed out of MIT
  - Lab tested for over 5 years
  - Commercially operated in the oilfield using various produced waters over 2 years

Application:

- Greenfield development
- Disposal constrained regions
- High trucking costs
- Enhancing evaporation pond or SWD capacity

Technology - Carrier Gas Concentrator (CGC™)

- **Permitting:**
  - PA DEP
  - Air Emissions (TPY)
- **Spills:**
  - Handled as per operator's SOP. No major potential due to
    - Lower volume
    - Nature of process – Automated
- **Influent and Effluent Testing on site:**
  - Stack Testing
- **Waste : Heavy Brine**
  - Can be made a ZLD process
- **Potential Impacts – Methanol**

Case Study : Set-up

Saturated Brine

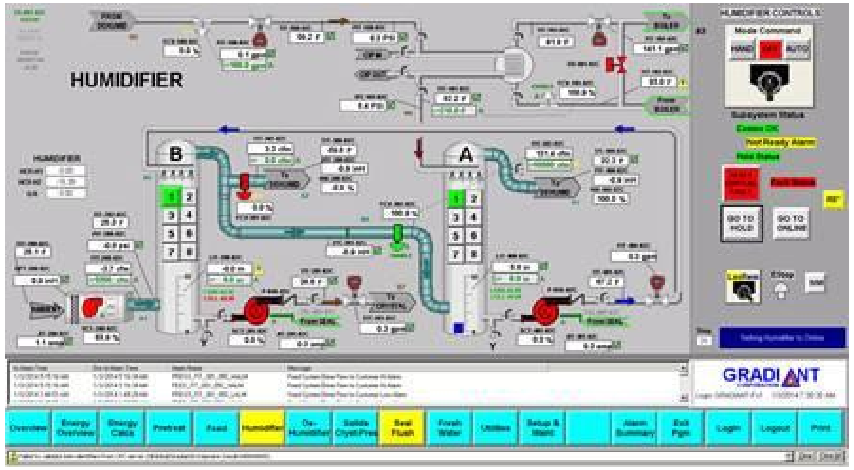
Heat Source

CGC

Water Vapor

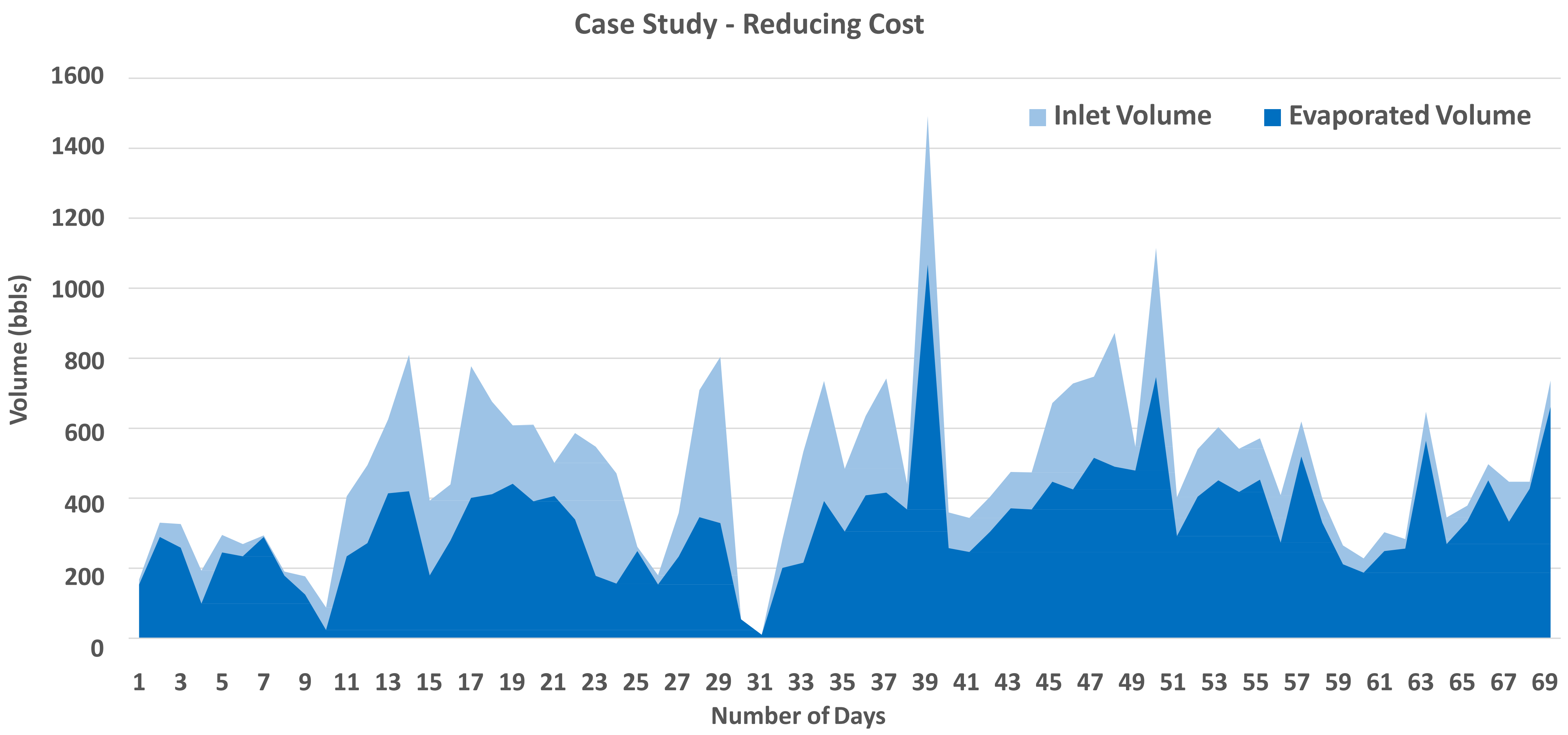
Basic Filtration
Single
Antiscalant

Produced
Water
Wellhead
Or Trucking

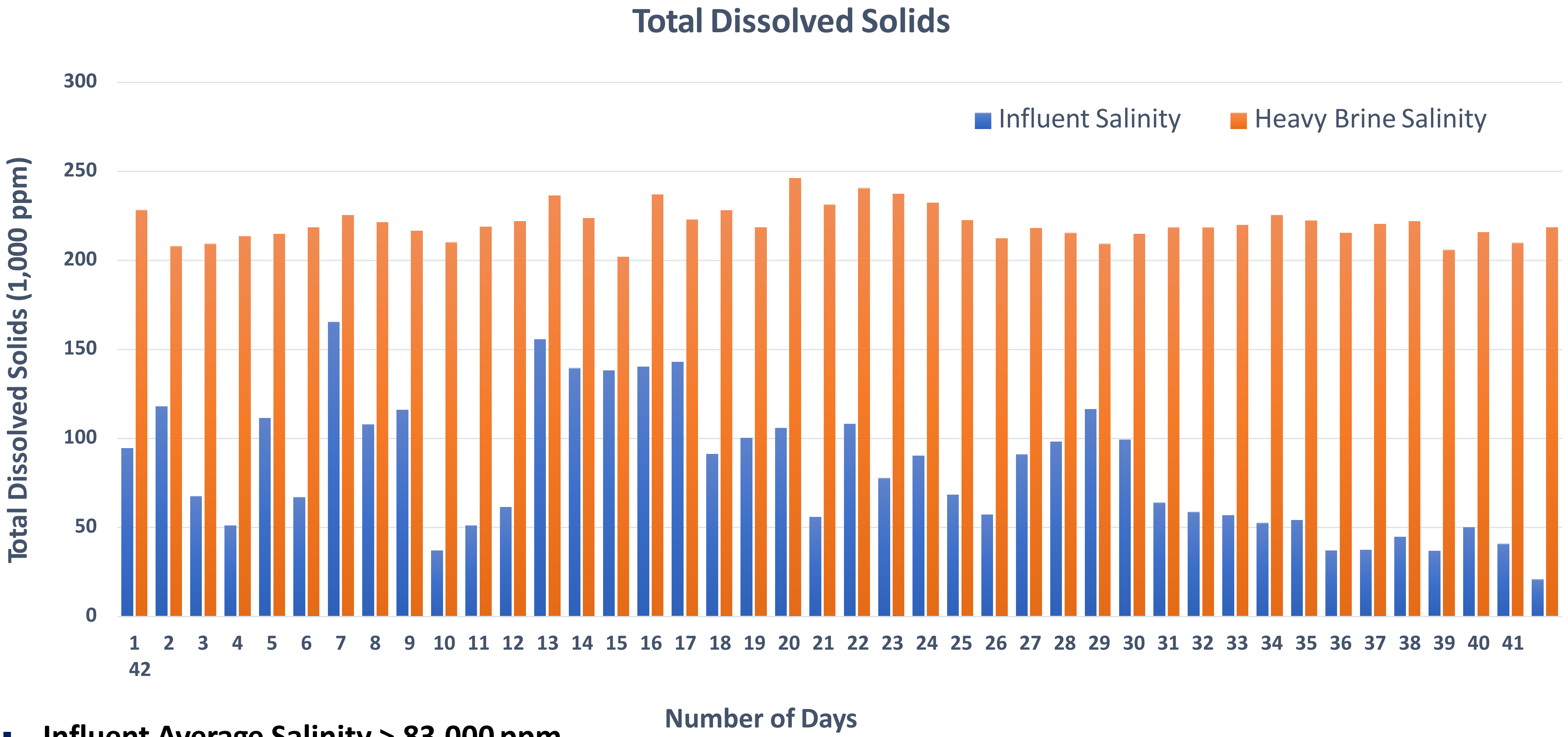


SCADA Connectivity

Case Study : Reducing Trucking Cost Through Evaporation



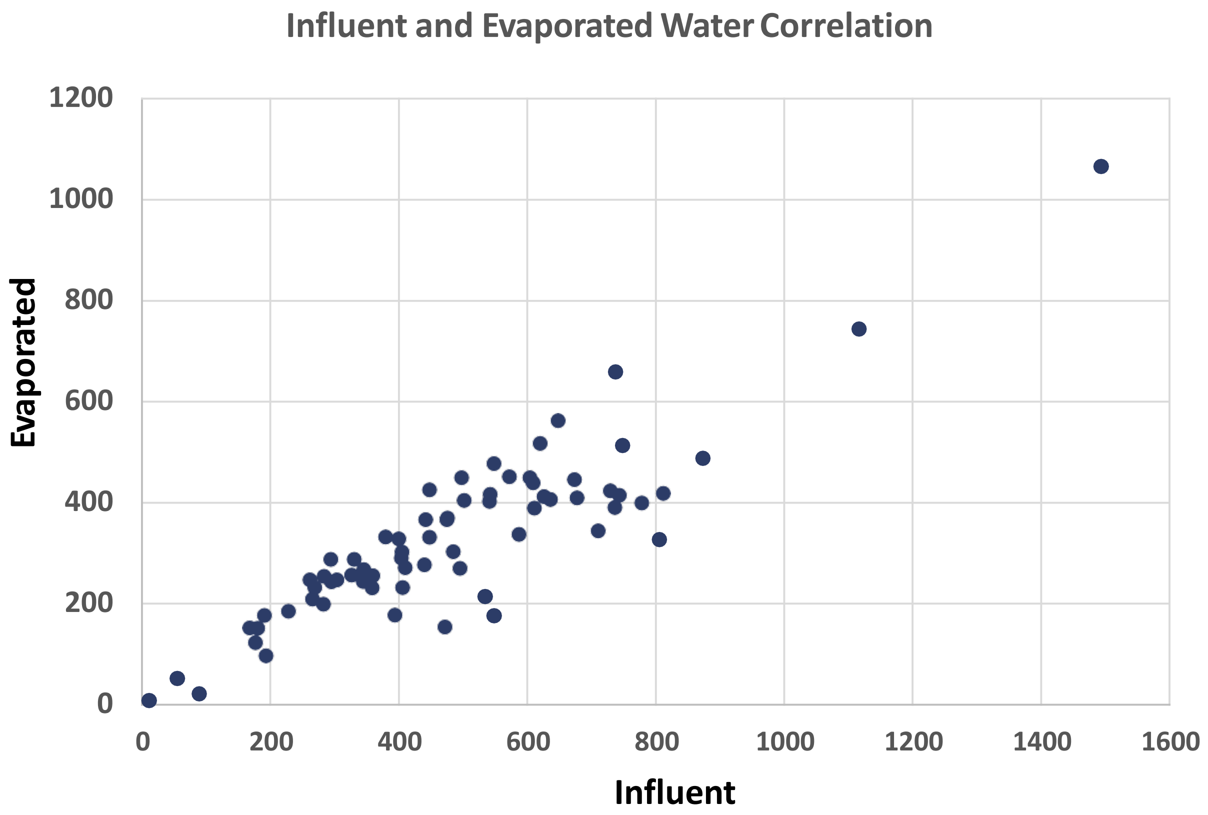
Case Study



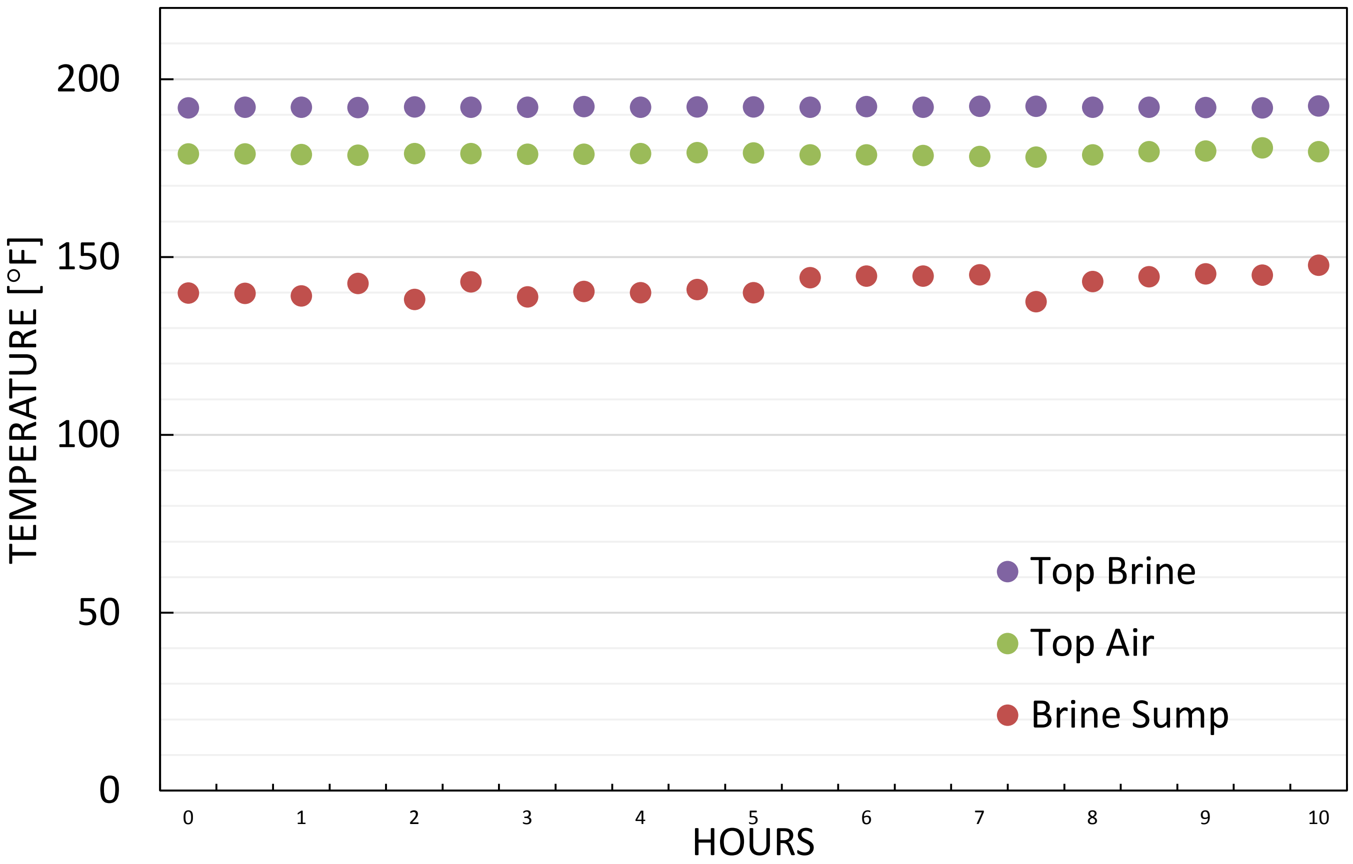
- **Influent Average Salinity > 83,000 ppm**
- **Generated Heavy Brine Salinity > 221,000 ppm**

Case Study : Reducing Trucking Cost Through Evaporation

- **45% Cost savings compared to trucking**
- Consistent Operation – Water Evaporated
  - Influent
  - Evaporated water
- Clean vapor
- Robust System : Varying Influent TDS
- Minimal Pre - Treatment
- Ambient Pressure
- Low Operational Temperature
- Operated November ’16 – February ’17
  - Winterization

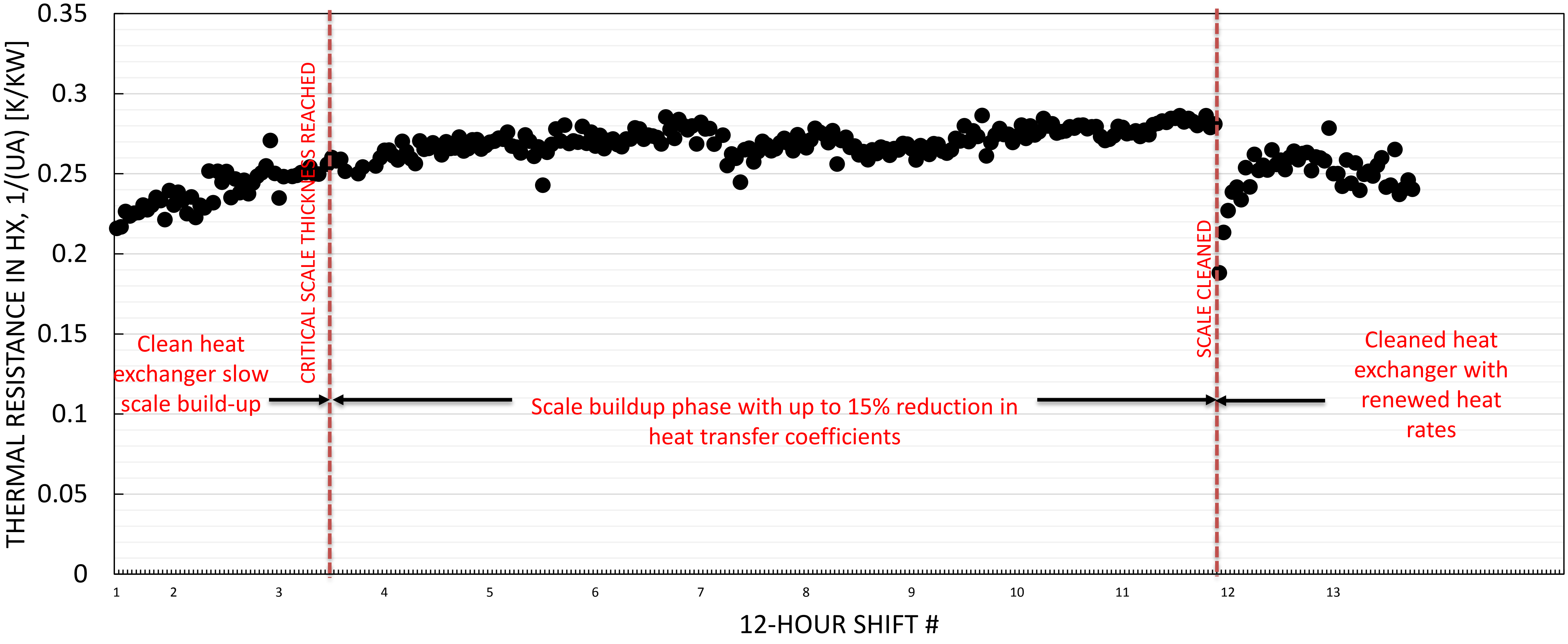


Temperature Profile of System



- Temperature profile throughout column is monitored ensure consistent performance
- For smooth operation, consistent temperatures are a crucial parameter
- Ensures consistent production and energy usage
- Data points show a 30 minute average during steady state operation

Scale accumulation on HX plate



Lessons Learnt/Challenges

- Emissions
  - Source or Centralized
  - VOC’s – Air Stripper
    - Modelling
  - Methanol
- Water Chemistry
  - Defoamers, Gas Hydrate Inhibitors
- Stack Testing
  - Cost
- Natural Gas
  - Availability
- Regulations
  - PM 10, PM 2.5
  - TPY

Acknowledgements

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Q&A