Burrton Oil Field Chloride Plume Remedial Investigation & Alternatives Feasibility Study

Daniel Clement, P.G.

Kansas Water Office (KWO)

Presentation to Equus Walnut RAC and Kansas Water Authority

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Burrton Oil Field & Equus Beds Aquifer Brine Contamination Remedial Evaluation

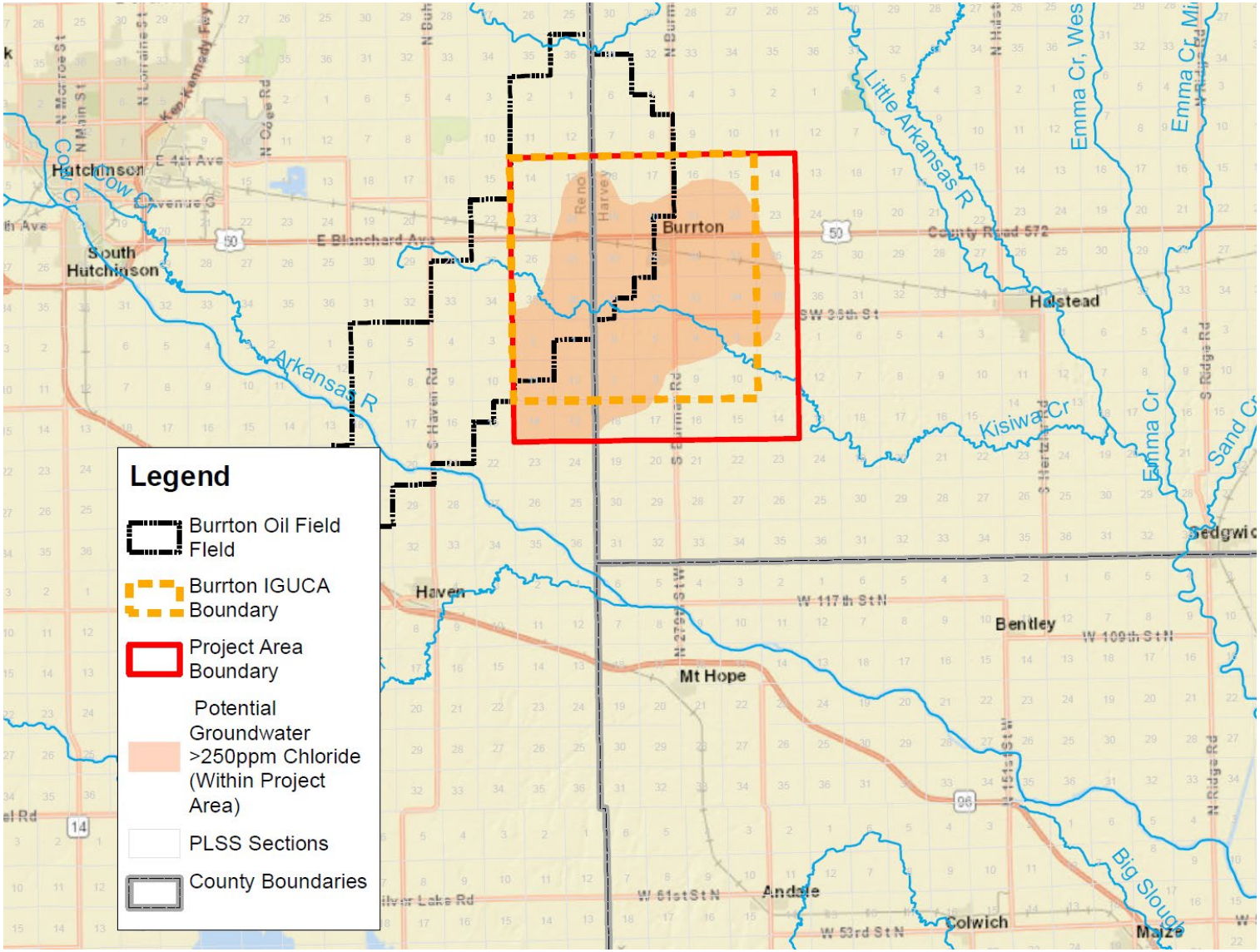
► Project Scope

- Review previous studies by KDHE, KCC, DWR, GMD, USGS, BOR
- Remedial Investigation Report - characterized the current state of the chloride plume and identified site alternatives for targeted remediation
- Feasibility Study Report - developed and evaluated remediation technology alternatives at each proposed site with opinions of probable cost

Burrton Oil Field Equus Beds Aquifer Brine Contamination Background

- A saltwater contamination plume near Burrton, KS was created between 1931 to 1943, when produced brine from oil field development escaped containment from surface storage ponds and seeped into the underlying Equus Beds Aquifer (96,000 mg/L)
- 1.9 million tons of salt entered the aquifer from the oil field brine loss (KGS) leading to the 36 square miles of the Burrton IGUCA. Current concentrations up to 1,600 mg/L.
- Chloride concentrations are in excess of useable standards for drinking water (250 mg/L), agricultural irrigation (~350mg/L), and most industrial applications.

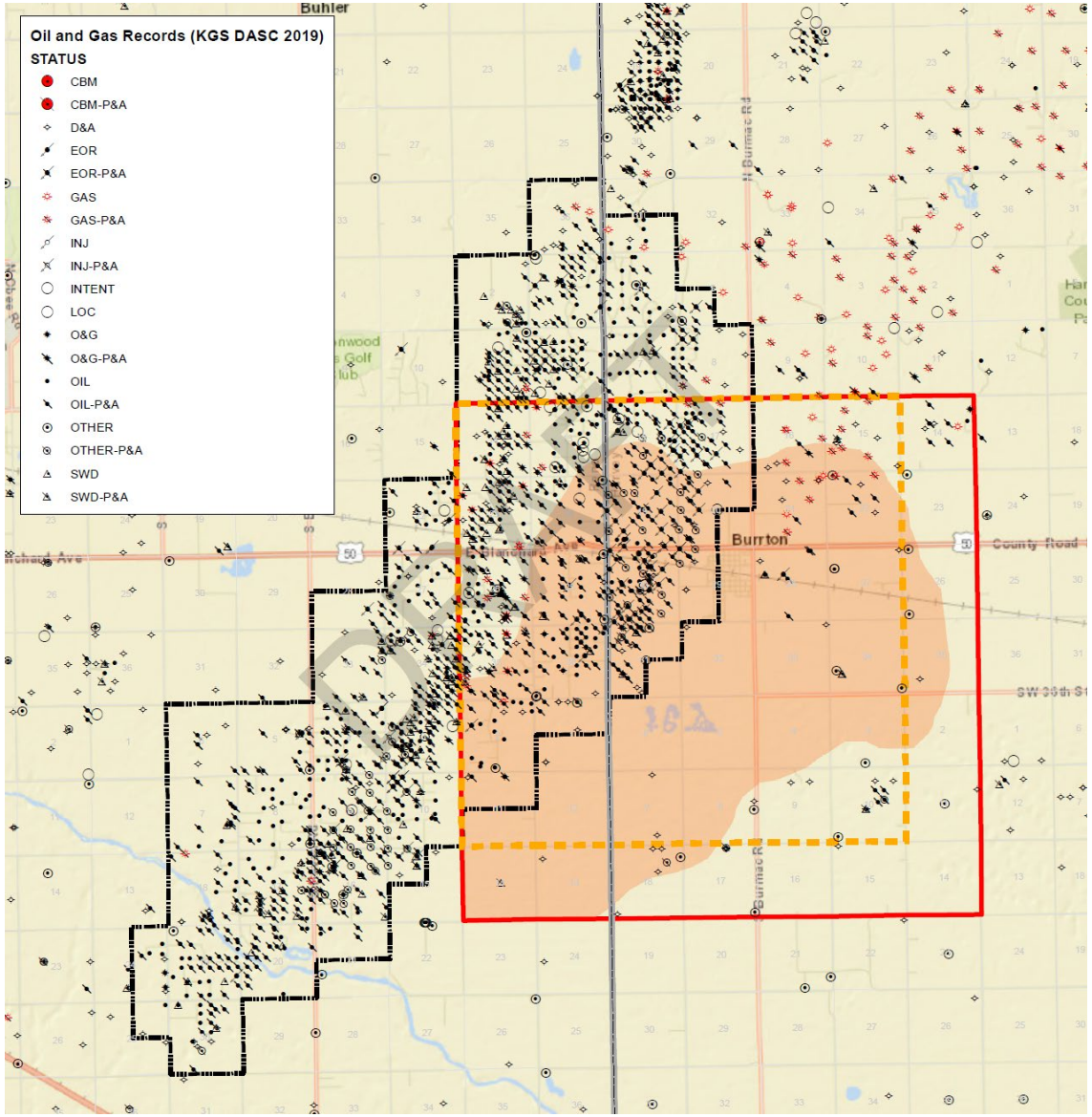
Burrton Oil Field Brine Plume Location



Burrton Oil Field

Legend

- Project Area Boundary
- Areas with Potential Groundwater >250ppm Chloride (Within Project Area)
- Burrton IGUCA Boundary
- Burrton Oil Field Field
- PLSS Sections
- County Boundaries



Brine Plume – Upper Aquifer ~65 feet deep

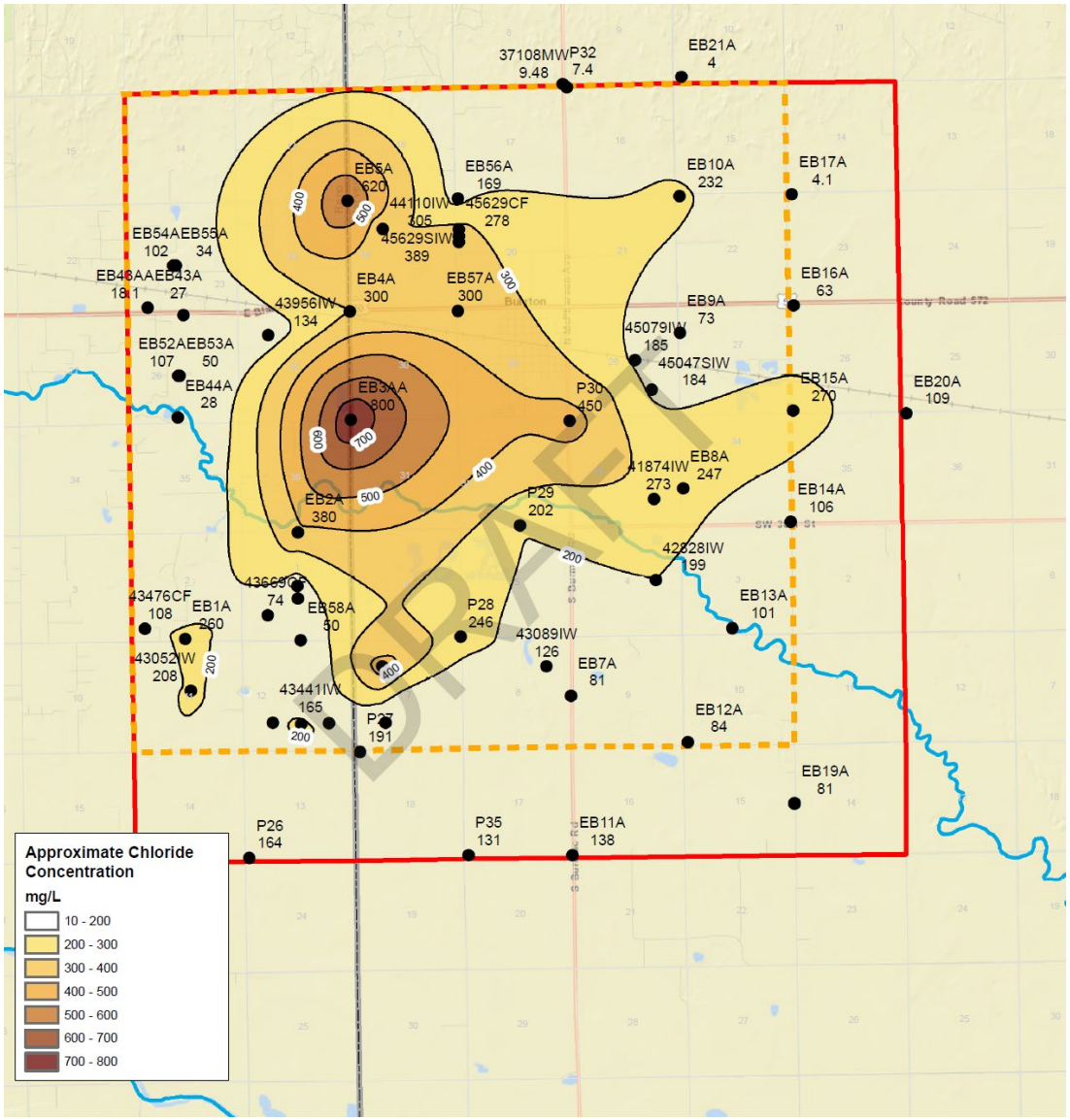
Legend

- Observed Chloride Concentrations 2018 (mg/L)
- Chloride Concentration Contours (mg/L)
- Burrton IGUCA Boundary
- Project Area Boundary
- PLSS Sections

Approximate Chloride Concentration

mg/L

- 10 - 200
- 200 - 300
- 300 - 400
- 400 - 500
- 500 - 600
- 600 - 700
- 700 - 800



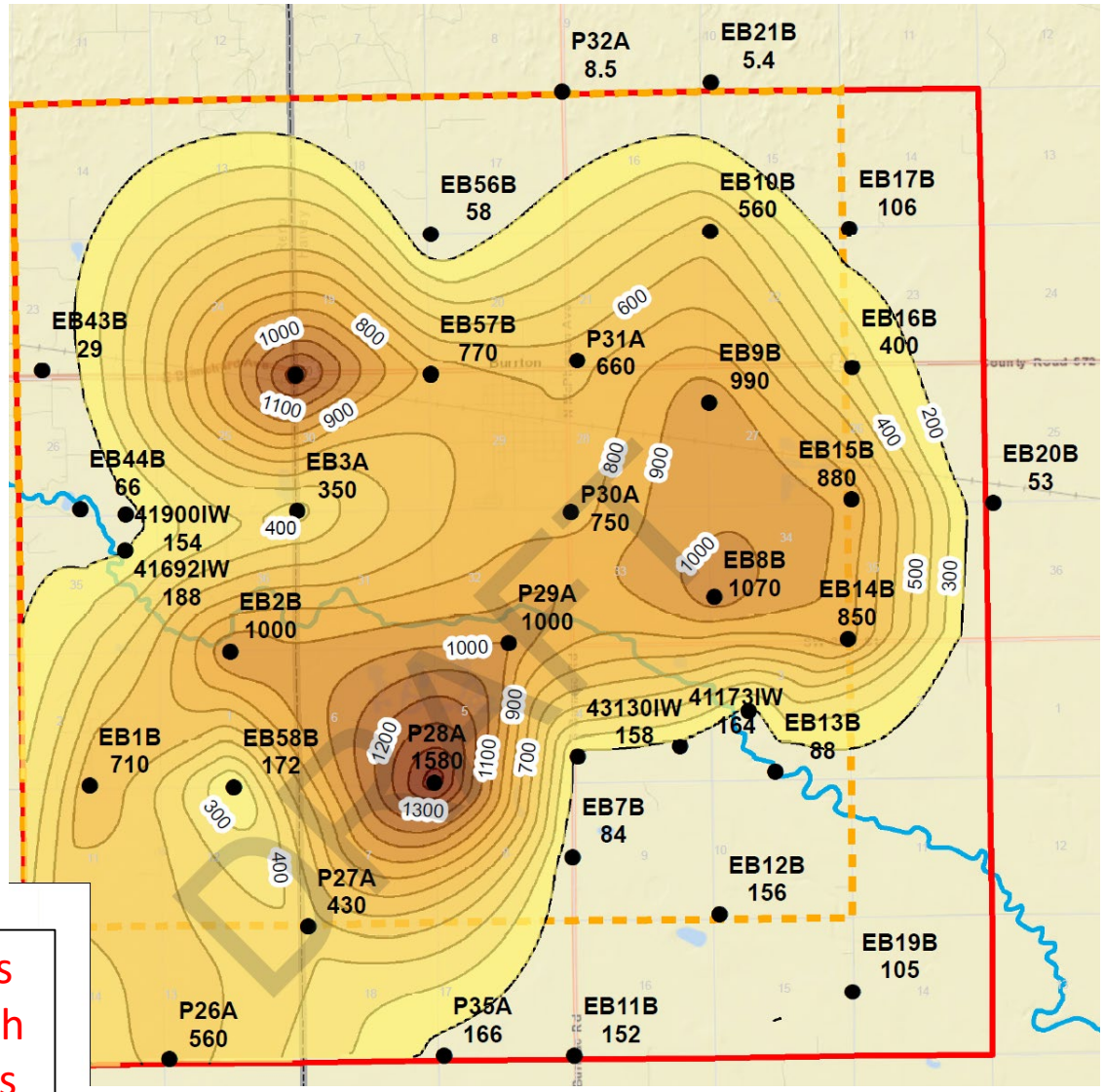
Brine Plume – Middle Aquifer ~65 to 175 feet deep

Legend

- Observed Chloride Concentrations 2018 (mg/L)
- Chloride Concentration Contours (mg/L)
- Burrton IGUCA Boundary
- Project Area Boundary
- PLSS Sections

Approximate Chloride Concentration (mg/L)

- 10 - 200
- 200 - 300
- 300 - 400
- 400 - 500
- 500 - 600
- 600 - 700
- 700 - 800
- 800 - 900
- 900 - 1,000
- 1,000 - 1,100
- 1,100 - 1,200
- 1,200 - 1,300
- 1,300 - 1,400
- 1,400 - 1,500
- 1,500 - 1,600



Arkansas River High Chlorides

Brine Plume – Lower Aquifer 175 to 285 feet deep

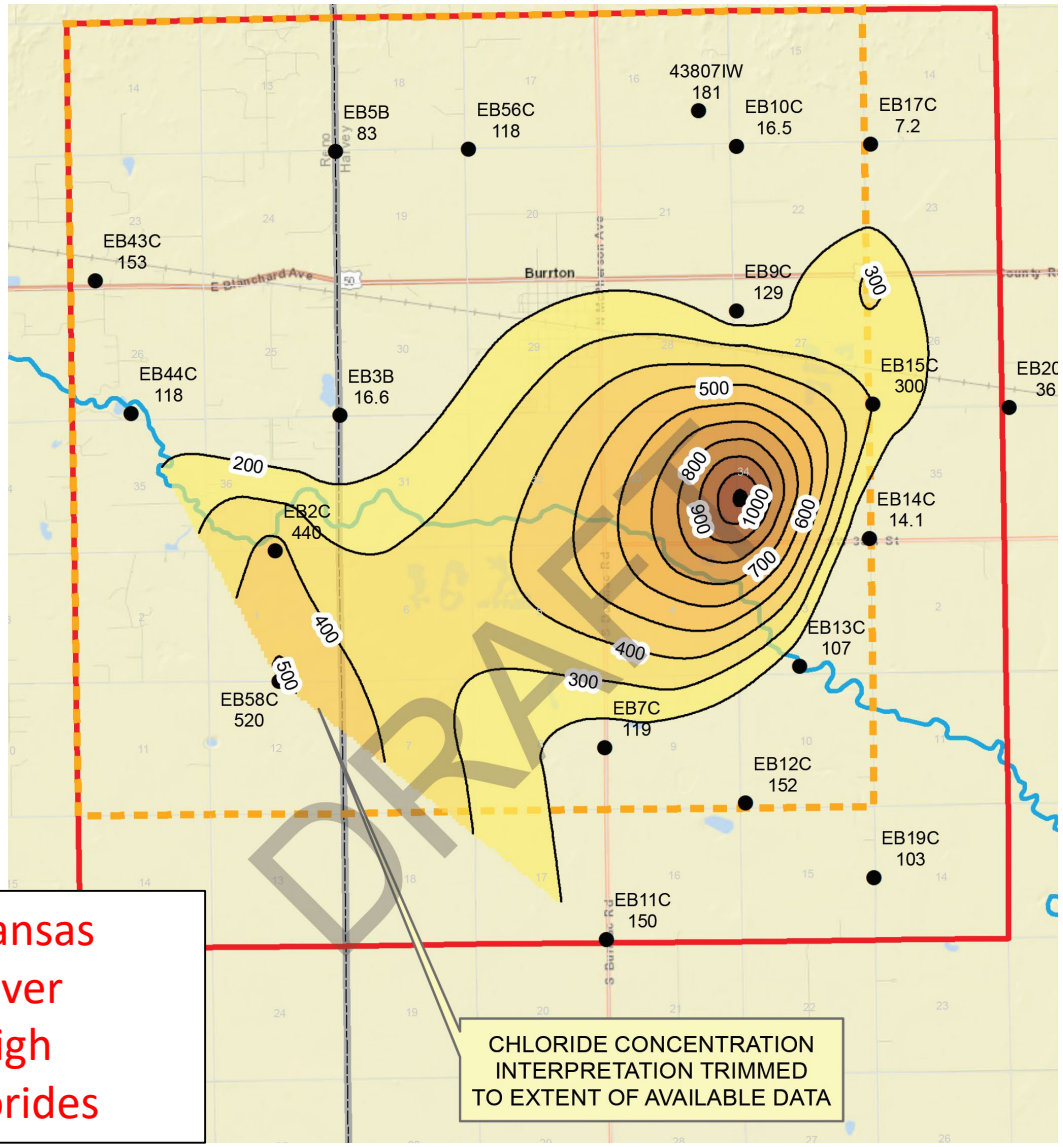
Legend

- Observed Chloride Concentrations 2018 (mg/L)
- Chloride Concentration Contours (mg/L)
- Burrton IGUCA Boundary
- Project Area Boundary
- PLSS Sections

Approximate Chloride Concentration

mg/L

- 10-200
- 200-300
- 300-400
- 400-500
- 500-600
- 600-700
- 700-800
- 800-900
- 900-1000
- 1000-1100
- 1100-1200



Arkansas River High Chlorides

CHLORIDE CONCENTRATION INTERPRETATION TRIMMED TO EXTENT OF AVAILABLE DATA

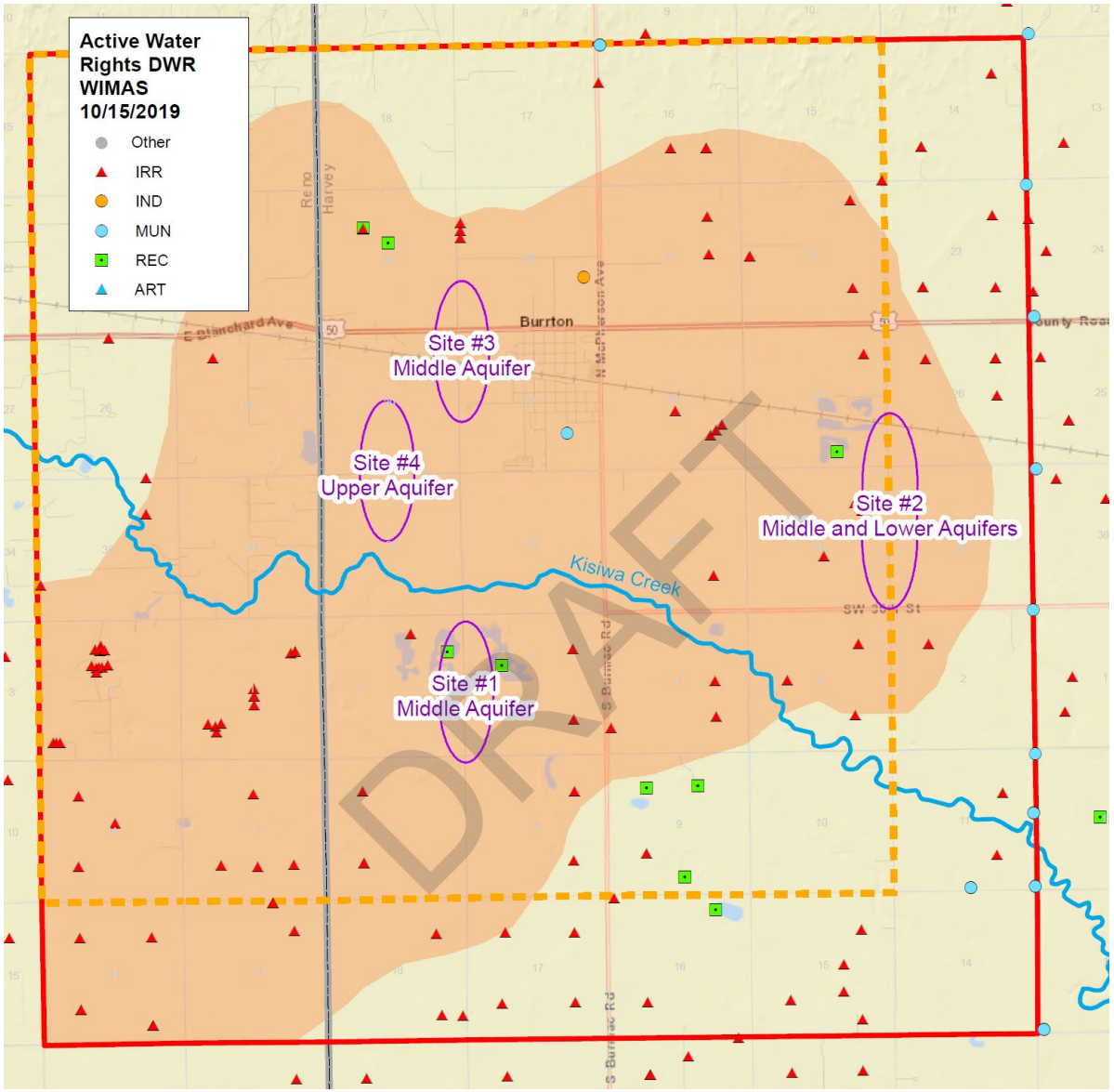
Remedial Strategy

- Restoration of the entire project area is not currently feasible (~1.9 million tons of salt)
  - *Large amount of groundwater would need to be pumped and remediated or disposed*
  - *Pumping a large amount of groundwater induces natural chlorides into the area from the Arkansas River*
- Recommended Approach - target areas with highest concentrations using remediation well contaminant removal before further migration and dispersion (>1,000 mg/L)

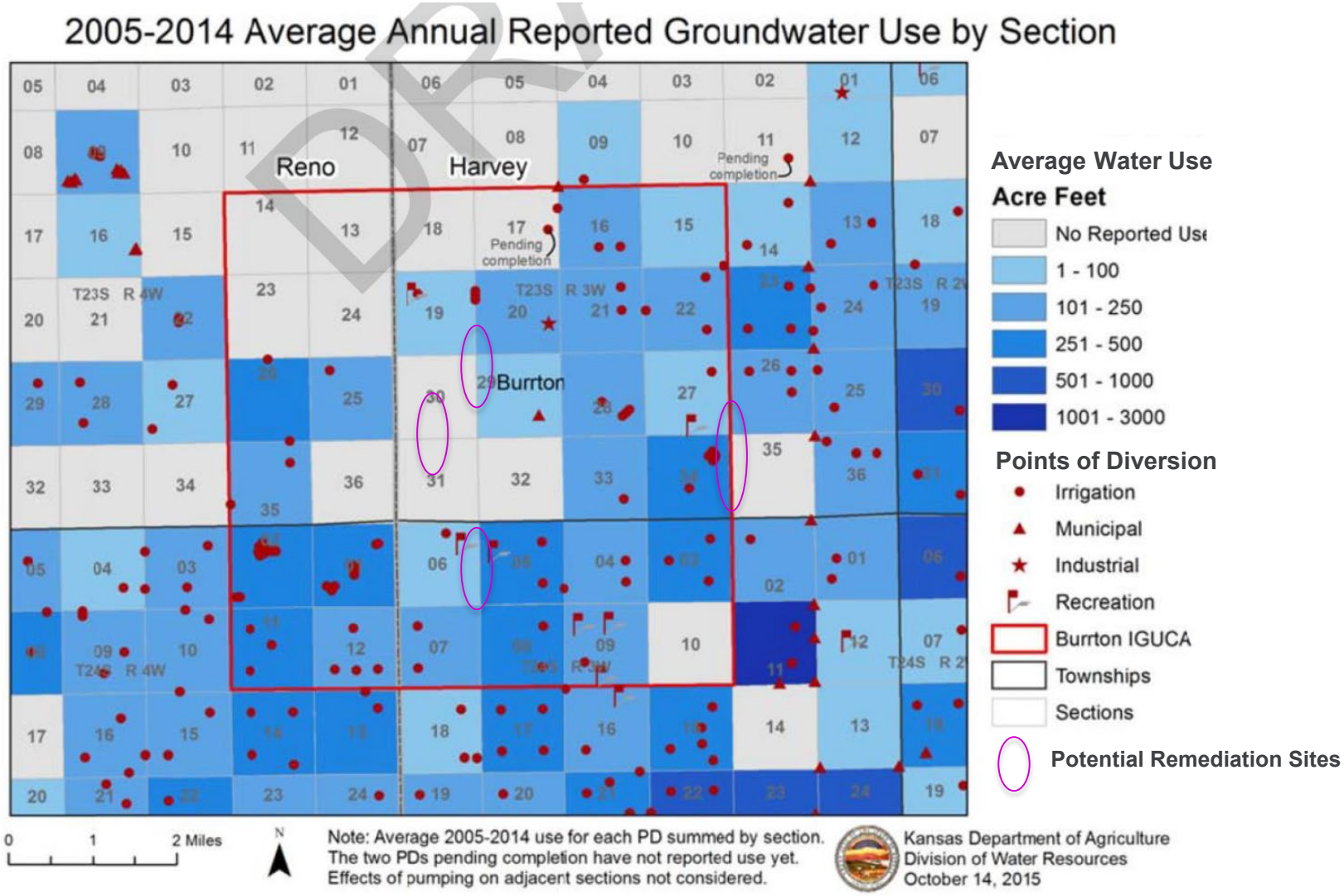
Potential Remediation Sites

Legend

- Potential Remediation Sites
- Potential Groundwater >250ppm Chloride (Within Project Area)
- Burrton IGUCA Boundary
- Project Area Boundary
- PLSS Sections



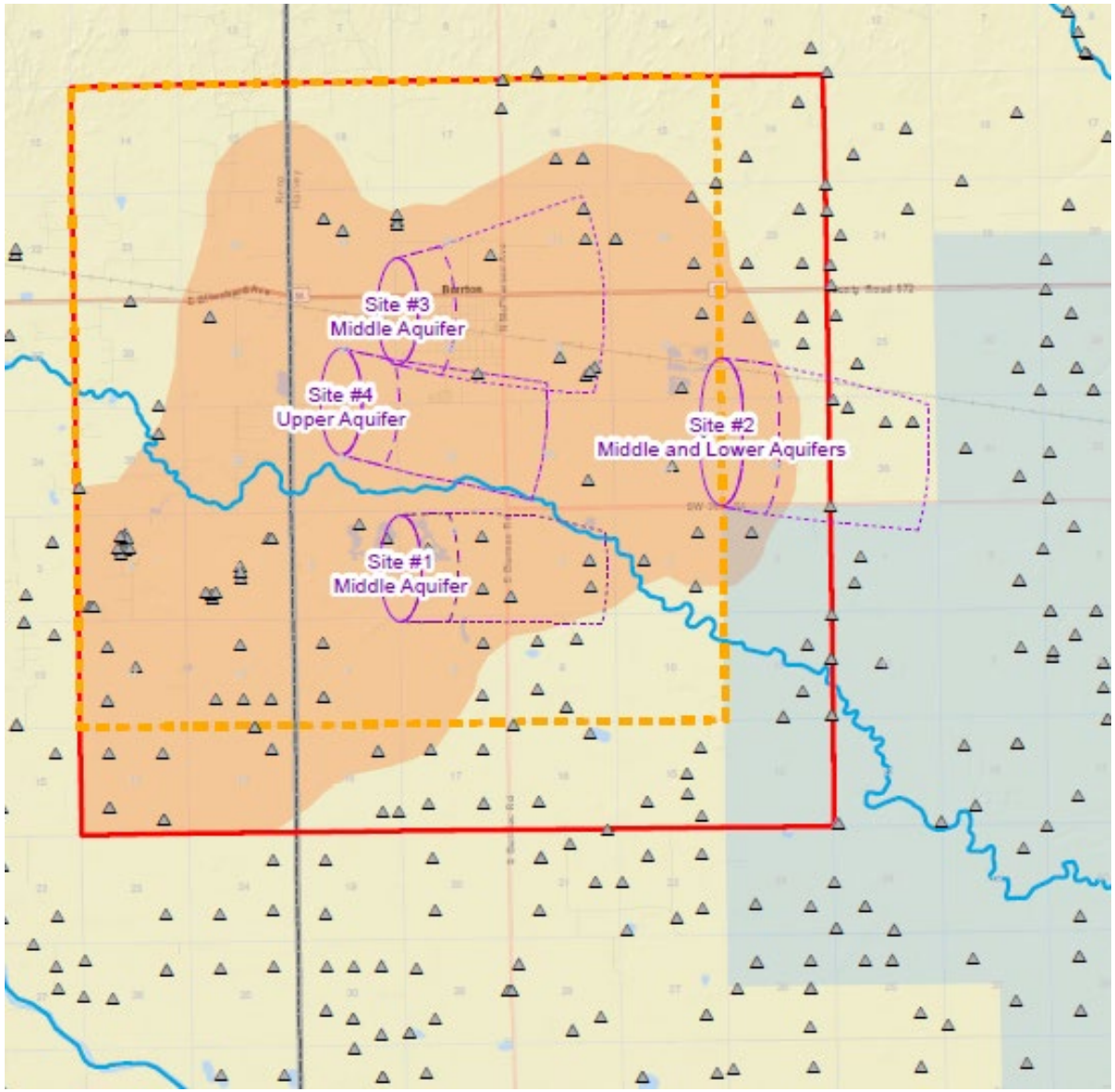
Burrton IGUCA Area Water Use



Potential Remediation Site Locations

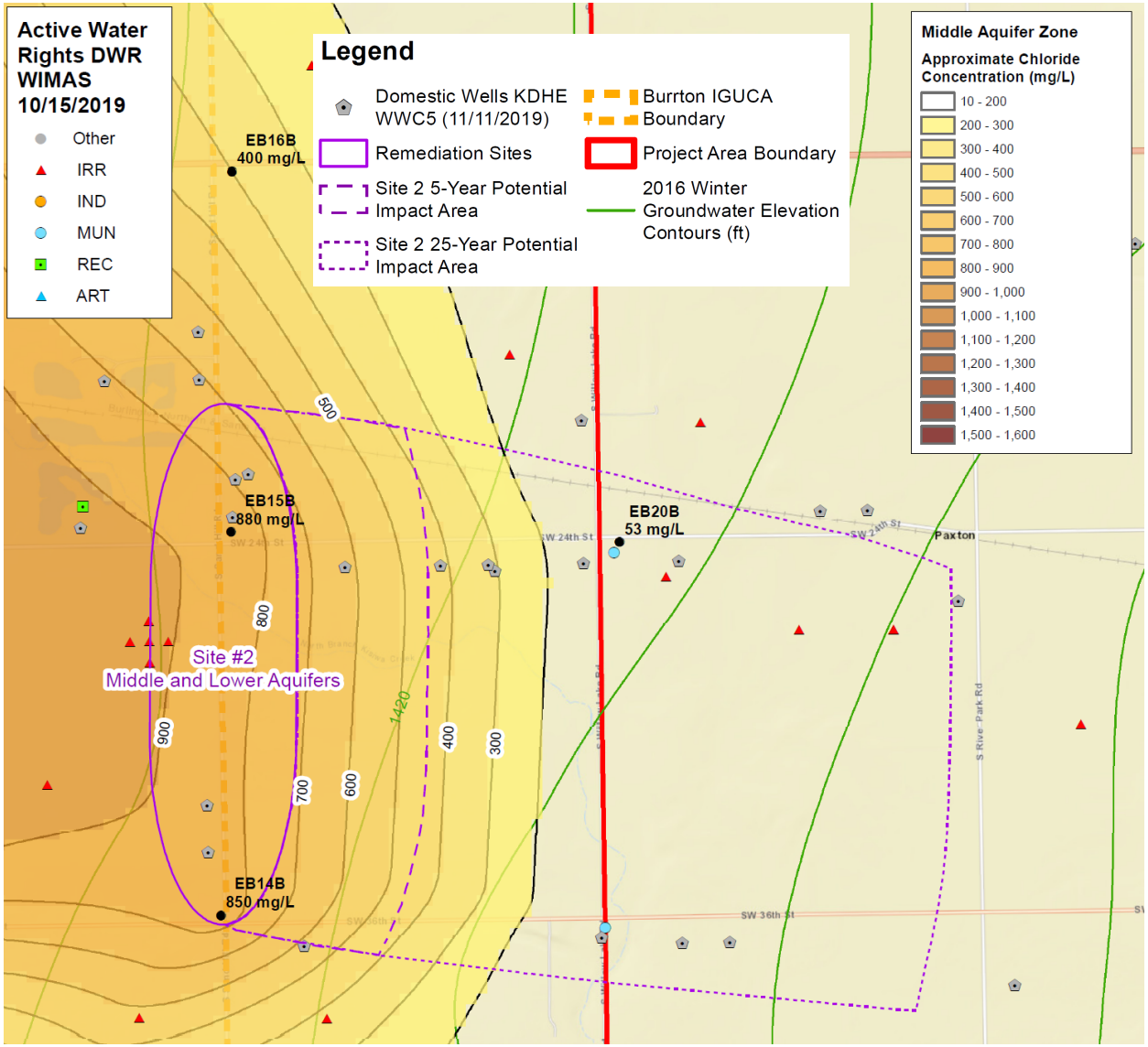
Legend

- Project Area Boundary
- Areas with Potential Groundwater >250ppm Chloride (Within Project Area)
- Burrton IGUCA Boundary
- 5-Year Potential Impact Areas
- 25-Year Potential Impact Areas
- Remediation Sites
- Wichita Wellfield Area (USGS)
- Active Water Rights DWR WIMAS 10/15/2019



Projected Impact / Benefit Area – Site 2 Example

- Without action migration of ~1ft/day
- 5-year projection
- 25-year projection
- Area of potential benefit from remediation



Potential Remediation Sites – Pumping Rates

- Flow rates ~600 gpm at each individual identified site estimated for capture of upgradient plume
- 2 to 3 Remediation Wells required for alternatives and concept evaluation

Table 4-1: Remediation Well Rates and Projected Radius of Influence

Well Pumping Rate (GPM)	Radius of Influence (feet)
100	150
200	400
300	900
400	1,400
500	1,800

Calculated radius of influence based on 2 feet of drawdown at 30 days of constant pumping at indicated rate

Evaluated Remediation Alternatives

- No Action
- Evaporation Ponds
- Blending
- Deep Well Disposal
- Treatment

Evaluated Remediation Alternatives

► No Action Alternative

- The baseline alternative for the Burrton chloride plume would be no action which would result in continued plume migration to the east and southeast (~1 foot per day).

- Chlorides will also continue to spread laterally and downward within the aquifer increasing the total impacted area

Evaluated Remediation Alternatives

- **Evaporation Alternative**
  - Shallow evaporation lagoons with low permeable Clay or HDPE liners
  - >500 acres of evaporation lagoon area required
  - Not Currently Feasible
    - Land intensive
    - Secondary risk of re-contamination of the aquifer, evaporation is not considered a feasible option.

Pump and Blend Alternative – Low Feasibility

Table 3-1: Blending Parameters

	Site 1	Site 2	Site 3	Site 4
Chloride concentration in remediation water (mg/L)	1300	800	1100	650
Chloride concentration in nearby low-chloride zone (mg/L)	100	50	30	50
Remediation water flow (gpm)	600	600	600	600
Required low-chloride flow (gpm) to attain blended chloride concentration of 250 mg/L	4200	1650	2318	1200
Total blended flow (gpm)	4800	2250	2918	1800
Required number of low-chloride wells, assuming 200 gpm each	21	9	12	6
Required low-chloride flow (gpm) to attain blended chloride concentration of 150 mg/L	13,800	3,900	4,750	3,000
Total blended flow (gpm)	14,400*	4,500	5,350	3,600
Required number of low-chloride wells, assuming 200 gpm each	69	20	24	15
Approximate distance to low-chloride wells (miles)	1.5	2.0	2.5	2.0

* Exceeds the estimated 8,000 gpm limit for pumping out of the Equus Beds Aquifer for remediation purposes before pulling high-chloride water from the Arkansas River into the aquifer.

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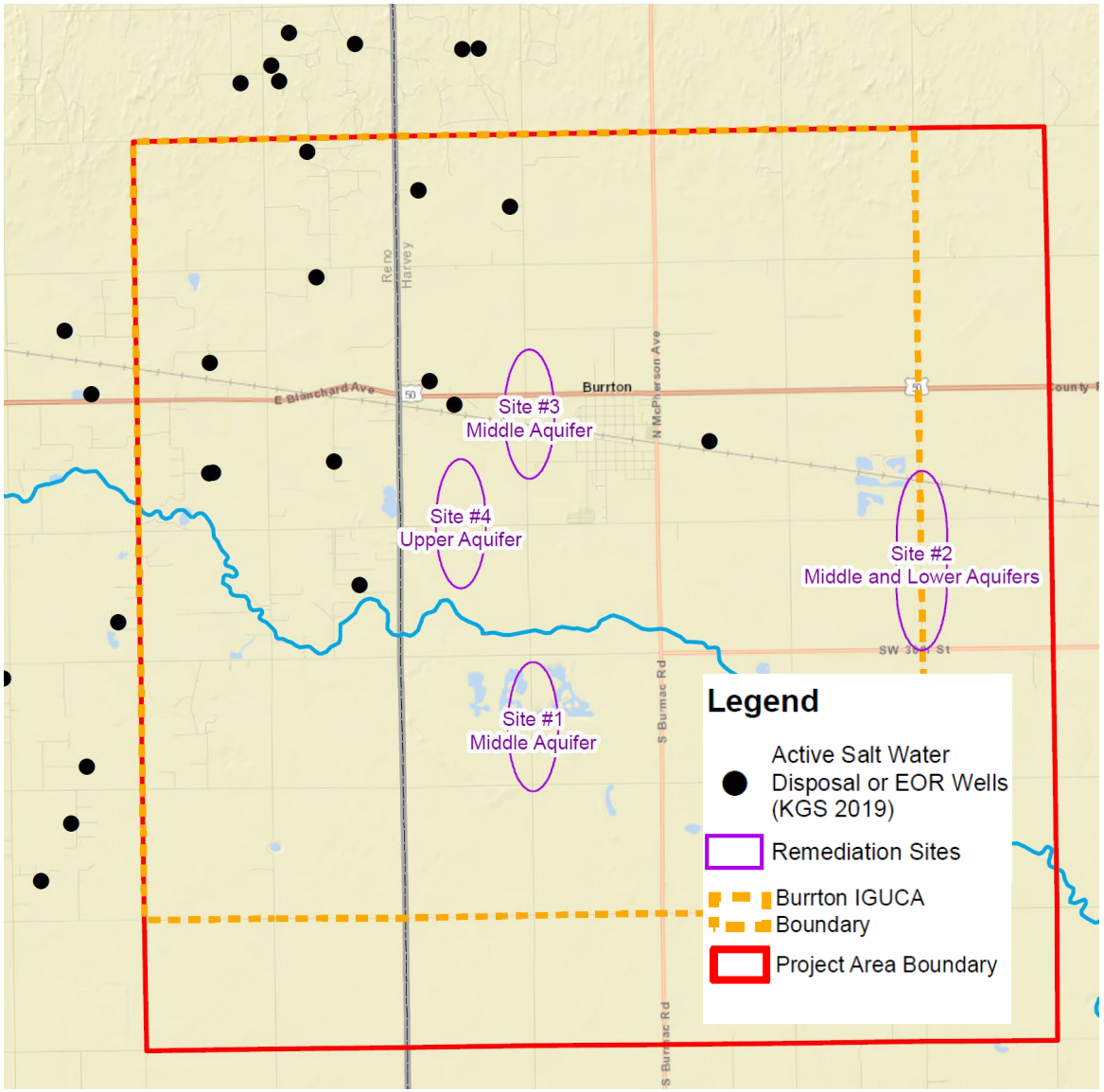
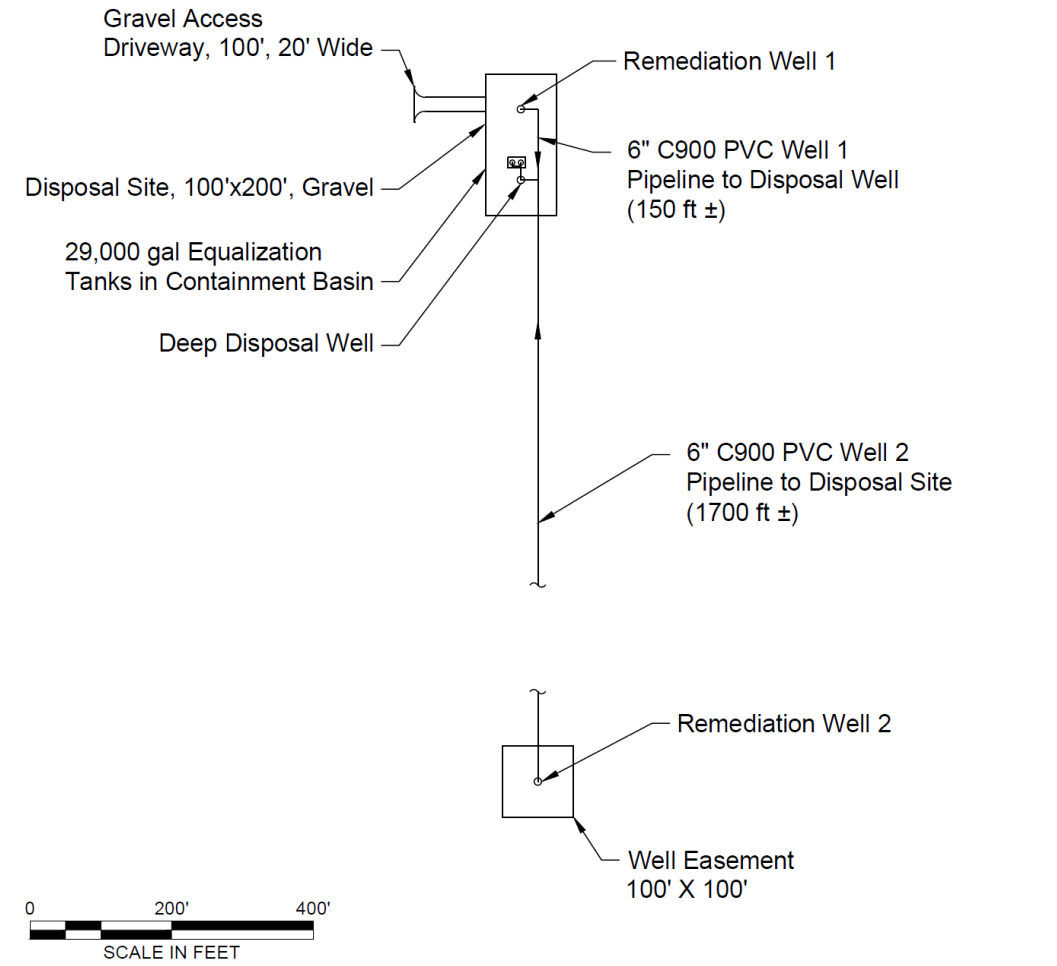
Pump to Deep Well Disposal Alternative

- Use of an existing deep disposal well?
  - Well Condition
  - New pipeline containing high chloride water
  - Long term use agreement
  - Permitting Limitations
  - Designed Injection Rate



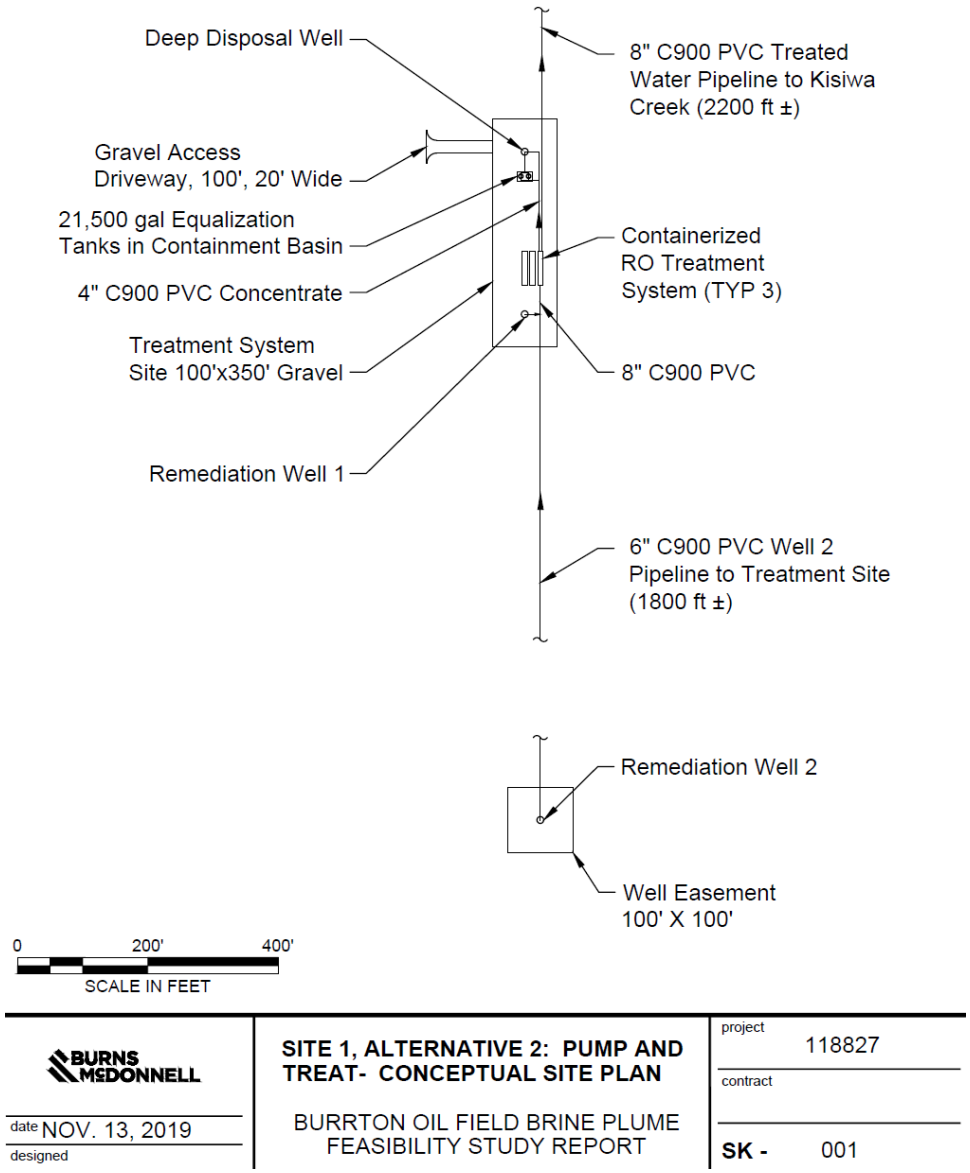
Deep Well Disposal Alternative (Site 1 Example)

- New Class I, II, or V Disposal Well
- 2 - Remediation Wells
- Equalization Tanks
- Transmission Pipeline from Remediation Wells
- Easement Acquisition



Pump & Treat Alternative (Site 1 Example)

- Containerized Reverse Osmosis
- New Class I, II, or V Disposal Well to handle waste stream
- 2 Remediation Wells
- Equalization Tanks
- Transmission Pipeline to Kisiwa Creek or beneficial use
- Easement Acquisition



Opinion of Probable Cost

- Each site will have the costs of additional hydrogeologic and water quality characterization
  - Costs for hydrogeologic investigation (pump testing and well siting)
  - Comprehensive water quality testing
  - 12 monitoring wells, (2” up to 175’ for monitoring)
- Overall Contingency – 30%
- Engineering Costs – 15%
- General Contractor Conditions
  - Bonds, Insurance, etc

Opinion of Probable Cost

Table 4-5: Alternatives Opinion of Probable Cost

Site Alternative	Alternative 1: Pump for Deep Well Disposal	Alternative 2: Pump and Treat
Site 1	$5,300,000	$13,100,000
Site 2	$5,300,000	$14,000,000
Site 3	$5,300,000	$13,900,000
Site 4	$5,300,000	$13,100,000

Table 4-6: Alternatives Opinion of Probable O&M Cost

Item	Alternative 1: Pump for Deep Well Disposal	Alternative 2: Pump and Treat
Annual O&M Cost	$103,000	$470,000
20-Year Present Value of O&M Costs*	$1,200,000	$5,400,000
Total Life Cycle Cost (Capital plus Present Value of O&M):		
Site 1	$6,500,000	$18,500,000
Site 2	$6,500,000	$19,400,000
Site 3	$6,500,000	$19,300,000
Site 4	$6,500,000	$18,500,000

* Assuming a discount rate of 6 percent.

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Site Alternatives Comparison

Table 5-1: Site Alternatives Comparison

Parameter	Site 1	Site 2	Site 3	Site 4
Aquifer Zone Targeted for Remediation	Middle	Middle	Middle	Upper
Domestic Wells Downgradient from Capture Zone (25 Years)	14	9	38	3
Water Rights Downgradient from Capture Zone (25 Years)	7	3	4	0
Aquifer zone for completion	Middle	Middle	Middle	Upper
Chloride concentration based on nearby monitoring wells	1,000 to 1,600 mg/L	800 to 1,000 mg/L	800 to 1,400 mg/L	600 to 800 mg/L
Anticipated chloride concentration in pumped remediation water*	1,000 to 1,300 mg/L	650 to 800 mg/L	650 to 1,100 mg/L	500 to 650 mg/L
Chloride removed (initial, assuming upper end of concentration range)	1,700 tons/year	1,100 tons/year	1,400 tons/year	900 tons/year
Number of remediation wells required	2	2	2	3
Distance between remediation wells	1,800 ft	1,800 ft	1,800 ft	800 ft
Width of zone of capture	3,600 ft	3,600 ft	3,600 ft	2,400 ft
Remediation flow for initial implementation	600 gpm total, 300 gpm per well	600 gpm total, 300 gpm per well	600 gpm total, 300 gpm per well	600 gpm total, 200 gpm per well
Nearby wells and water rights potentially subject to net pumping effect	Several	Several	Few	Few

* The anticipated chloride concentration in the pumped remediation water is less than that in the nearby monitoring wells because water from less contaminated zones of the aquifer is anticipated to cause some dilution during pumping.

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Preliminary Steps Prior to Remediation

- Acquisition of water quality and flow data for Kisiwa Creek to check the viability of using creek water for blending or as a point of discharge
- Installation of additional monitoring wells and water quality testing across the entire project site, and at proposed remediation sites
- A pre-design hydrogeologic investigation (site specific pump testing to refine remediation well yields and aquifer characteristics). Both quantity and quality will refine costs.
- Preliminary permitting evaluations from State and local regulatory agencies
- Identify potential beneficial uses of water
- Begin identifying potential remediation system operational responsibilities

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Remediation Alternatives Comparison

Table 5-2: Remediation Alternatives Comparison

Parameter	No Action	Alternative 1: Deep Well Disposal	Alternative 2: Treatment
Downgradient Domestic Wells Affected by Plume (25 Years)	Up to 38 depending on site	Reduced number affected and/or reduced concentrations	Reduced number affected and/or reduced concentrations
Downgradient Water Rights Affected by Plume (25 Years)	Up to 7 depending on site	Reduced number affected and/or reduced concentrations	Reduced number affected and/or reduced concentrations
Regulatory and Permitting Requirements	• IGUCA remains in effect and is periodically updated • GMD2 oversight	• IGUCA remains in effect and is periodically updated • GMD2 oversight • DWR water right application • KDHE BER permit • 600 gpm disposal well permitted through KDHE (Class I) or KCC (Class II) with monthly reporting	• IGUCA remains in effect and is periodically updated • GMD2 oversight • DWR water right application • KDHE BER permit • 140± gpm disposal well permitted through KDHE (Class I) or KCC (Class II) with monthly reporting • NPDES permit for Kisiwa Creek outfall with periodic reporting
Availability of Remediation Water for Use	No effect, water remains in aquifer	Unavailable, water is removed from hydrologic cycle	460± gpm available for use or discharge

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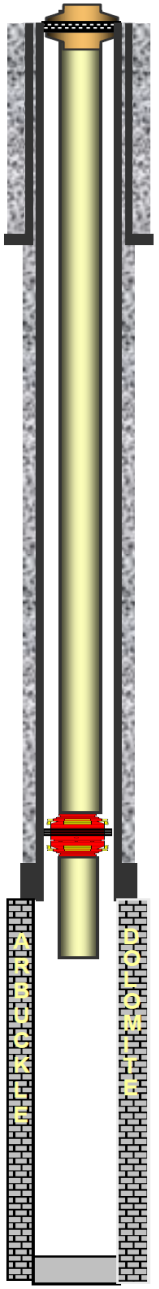
Remediation Alternatives Comparison

Table 5-2: Remediation Alternatives Comparison

Parameter	No Action	Alternative 1: Deep Well Disposal	Alternative 2: Treatment
Potential net pumping effect	None	Possible, especially with Sites 1 and 2	Possible, especially with Sites 1 and 2
Waste Stream Injected for Deep Well Disposal	None	600 gpm	140± gpm
Energy Consumption	None	170,000 kWh/year	1,030,000 kWh/year
Space required, property or easements	None	3.0 ac	Site 1: 9.5 ac Site 2: 17.0 ac Site 3: 16.5 ac Site 4: 9.5 ac
Visible Infrastructure	None	Disposal equalization tanks and an electrical panel with shade structure near each remediation well	Disposal equalization tanks, electrical building, three treatment system containers, electrical panel with shade structure near off-site remediation well, and outfall structure at Kisiwa Creek

Deep Disposal Well Class I UIC Construction Example



1 Wellhead

2 Surface Casing
13.375" Steel Cemented

3 Well Casing
8.625" Steel Cemented

5 Packer

4 Injection Tubing 5.50"
6 Tailpipe 5.50"

Top Arbuckle Formation
~3900'
Base Arbuckle Formation
~4550"

7 Plug Back

8 Total Depth

Potential Remediation Sites

Table 3-1: Site Alternatives Count of Downgradient Water Users (25 Years)

Parameter	Site 1	Site 2	Site 3	Site 4
Aquifer Zone Targeted for Remediation	Middle	Middle	Middle	Upper
Downgradient Wells from full width of "hot spot" that could ultimately be targeted for remediation:				
Downgradient Domestic Wells	27	16	47	11
Downgradient Water Rights	7	7	6	1
Downgradient Wells from initial 600 gpm remediation project capture zone*:				
Downgradient Domestic Wells	14	9	38	3
Downgradient Water Rights	7	3	4	0

* The exact number of downgradient wells could vary based on exact locations chosen for the remediation wells.