Impacts of Oil Exploration and Production to Wetlands in Northeast Montana's Glaciated Terrains

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Sheridan County Oil Field Reclamation

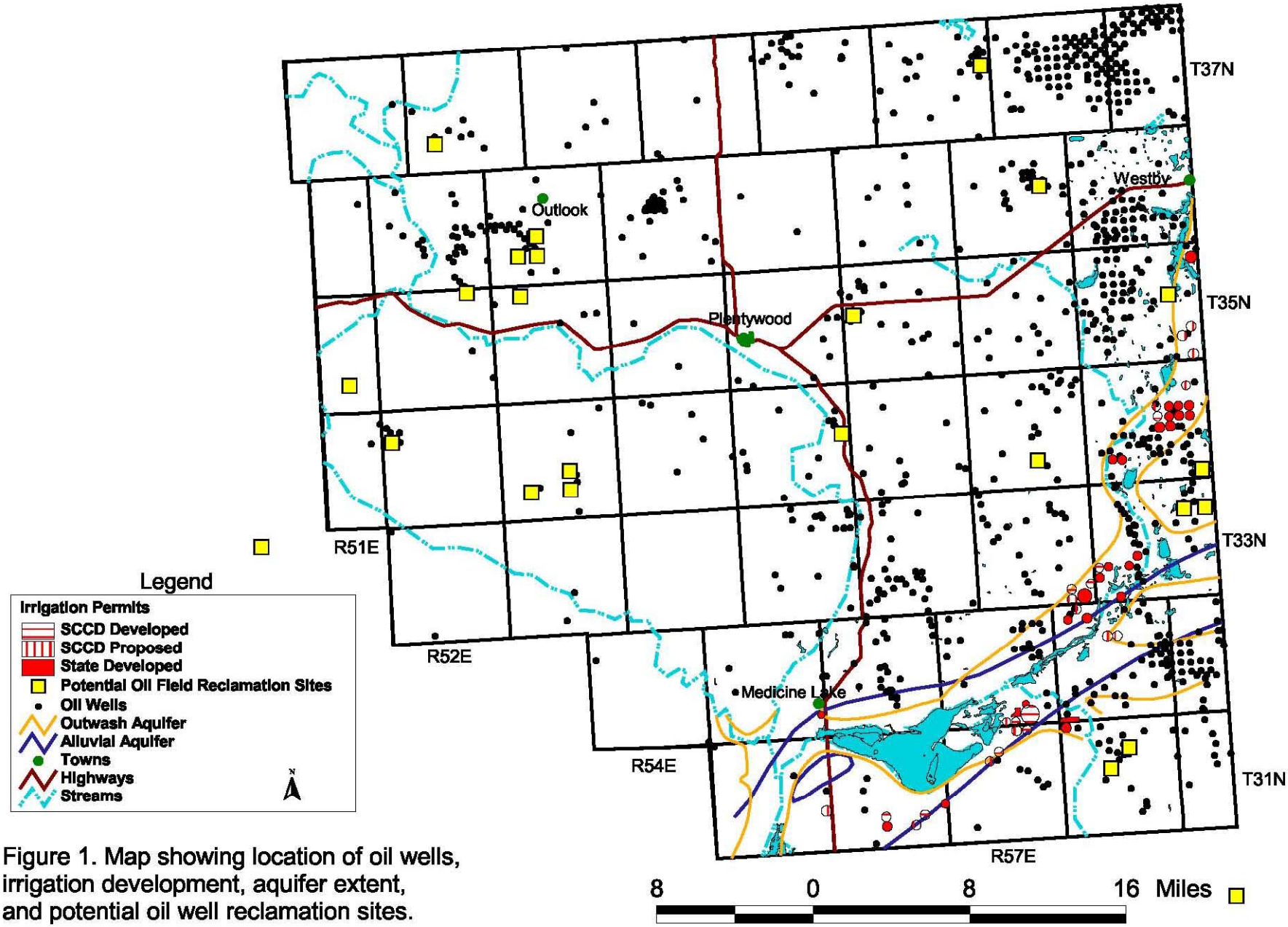
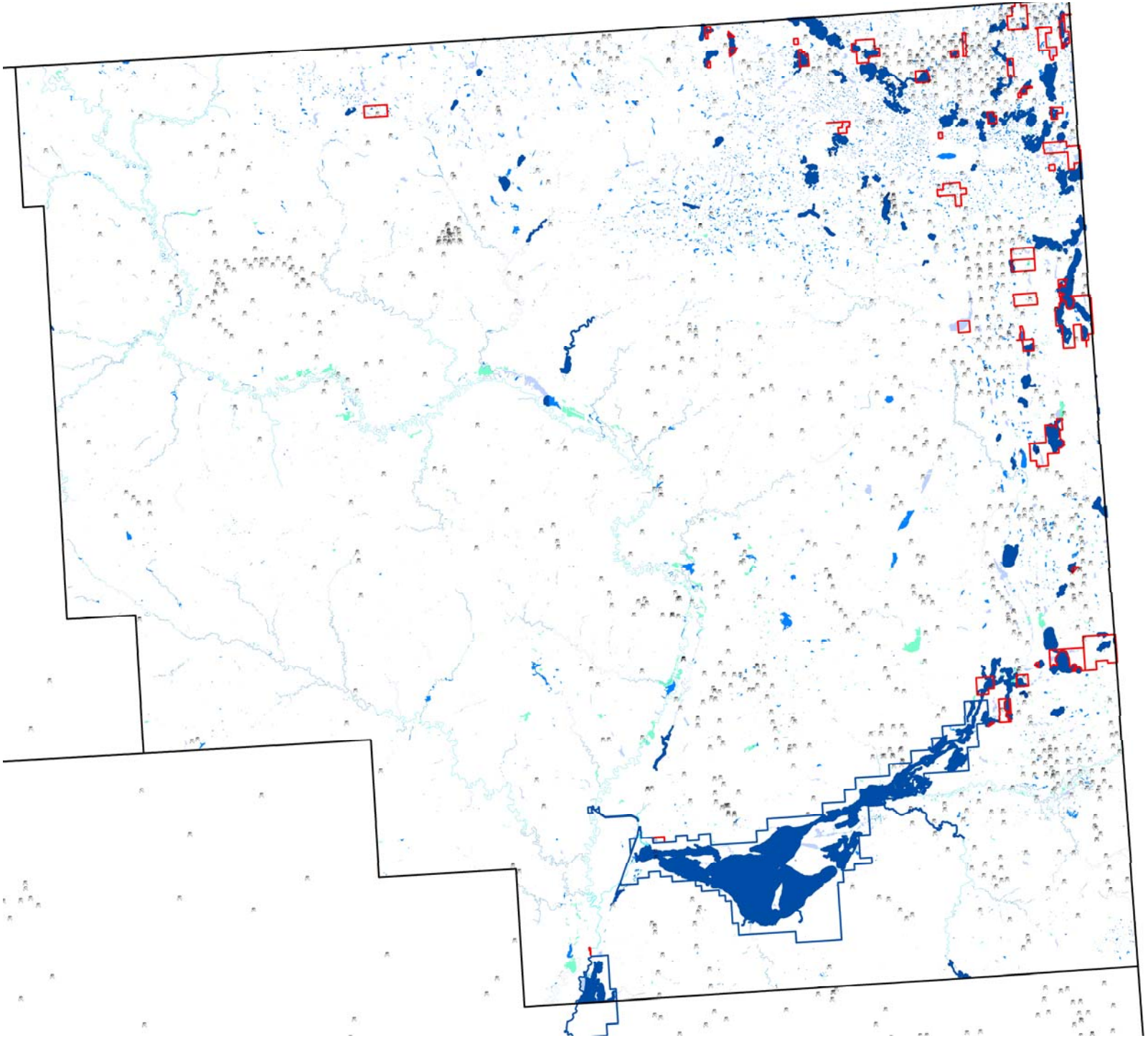
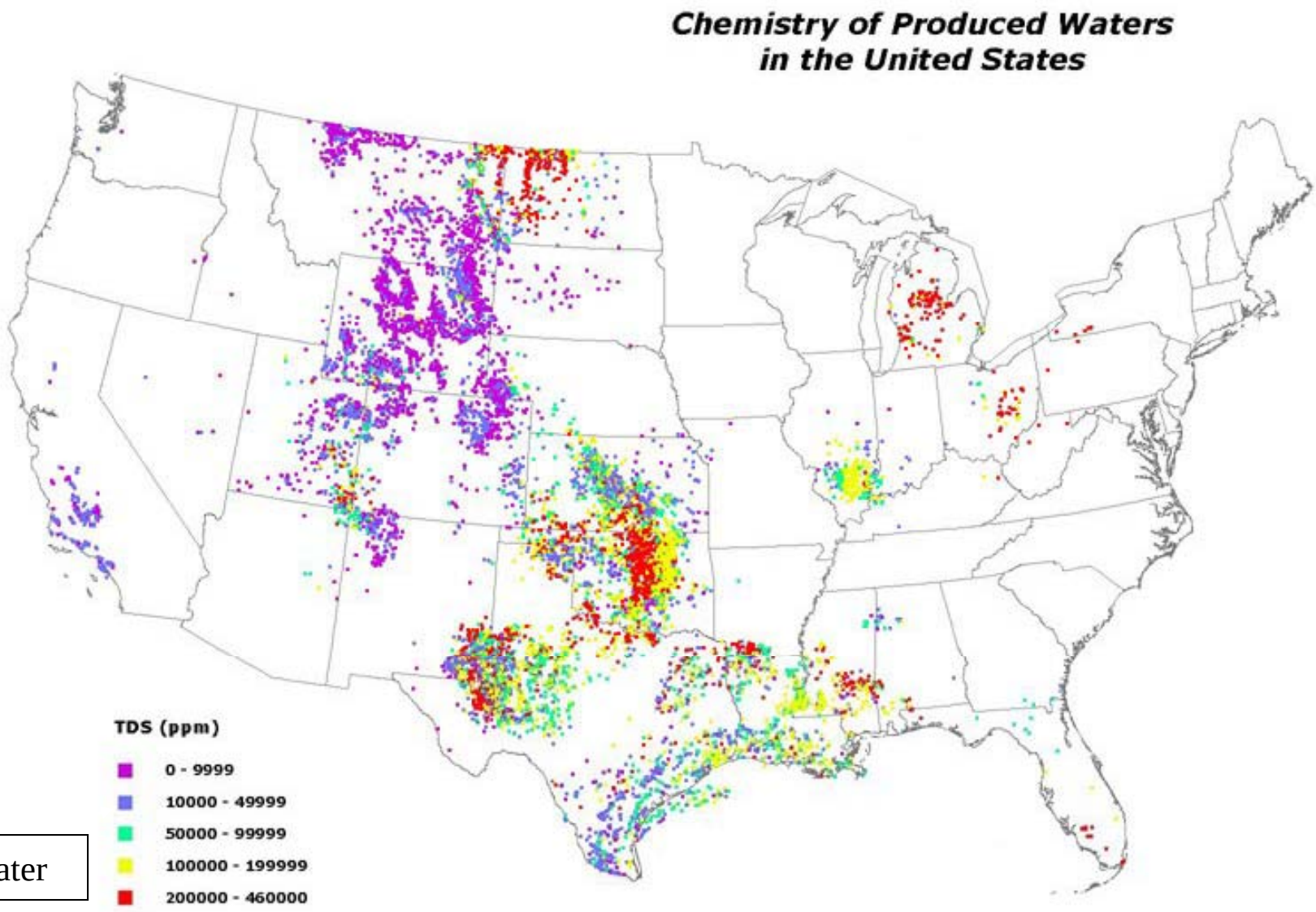


Figure 1. Map showing location of oil wells, irrigation development, aquifer extent, and potential oil well reclamation sites.



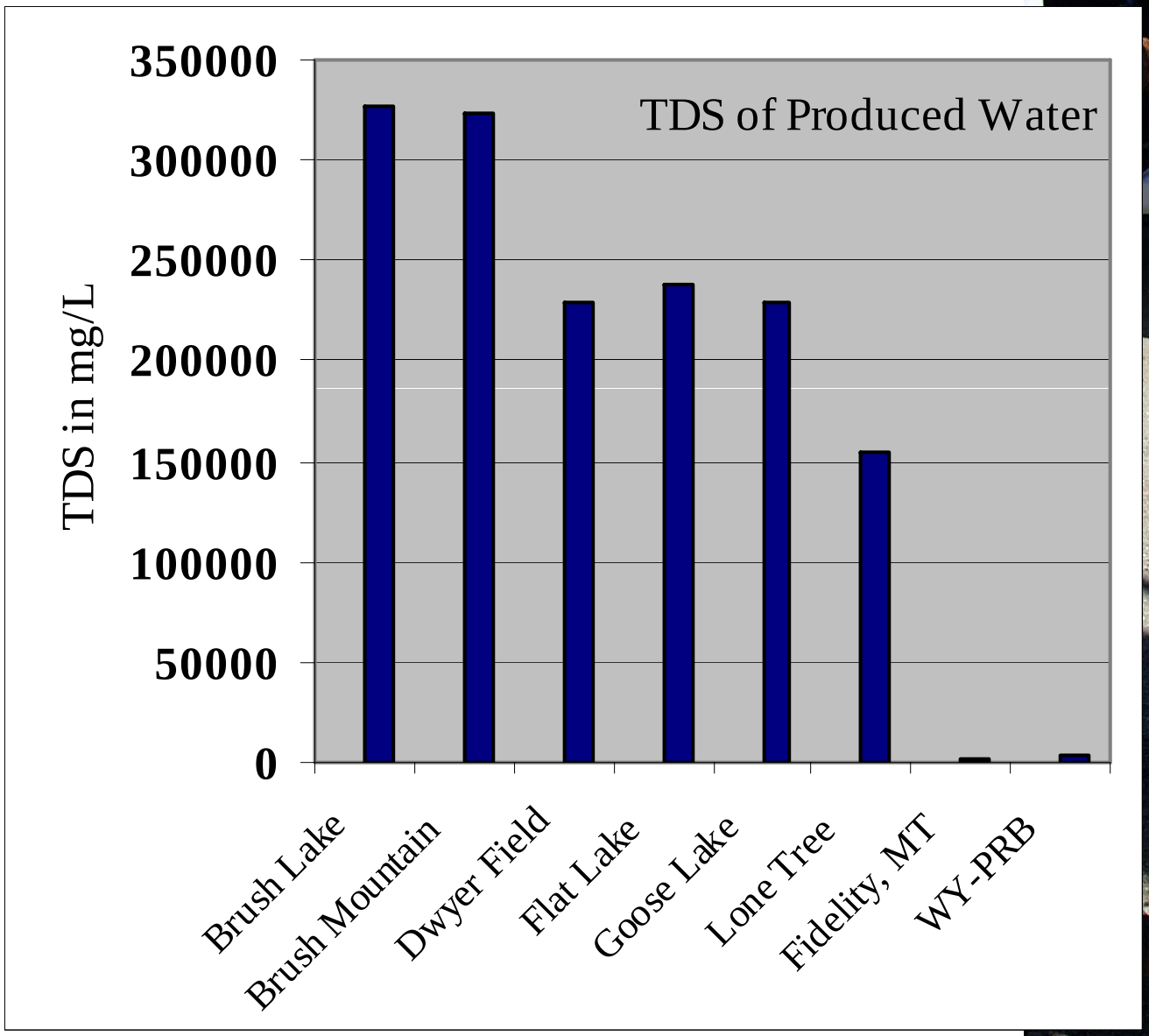
TDS of Produced Water from Oil and Gas Wells



Seawater

WHY IS THERE CONCERN?

- BRINES ARE 10 TIMES AS CONCENTRATED AS SEAWATER
- DOCUMENTED IMPACTS TO SOILS AND WATER RESOURCES
- COMPLEX SURFICIAL GEOLOGY LIMITS ABILITY TO PREDICT IMPACTS
- ONSITE DISPOSAL REMAINS A COMMON PRACTICE IN THIS PART OF THE WILLISTON BASIN


TDS of Produced Water
TDS in mg/L
350000
300000
250000
200000
150000
100000
50000
0
Brush Lake
Brush Mountain
Dwyer Field
Flat Lake
Goose Lake
Lone Tree
Fidelity, MT
WY-PRB

Injection well

Contaminant Pathways in the Williston Basin

Reserve Pits (Measure 150 ft x 60 ft x10 ft)

Each pit contains an estimated 52,000 to 1,000,000 gallons of drilling wastes, and 260 tons of NaCl salts

Pits were unlined until the late 1970s, and trenching occurred until the 1990s

Constituents of Concern

- **Saline produced waters (oil, trace elements, radionuclides, salt)**
- **Drilling fluid additives (barium sulfate, iron oxide, aluminum bisulfate, zinc carbonate, zinc chromate)**
- **Salt or oil based muds (250,000 ppm NaCl, diesel fuel, crude oil, fatty and organic acids and a variety of stabilizing agents)**
- **Drilling additives (iron lignosufonates, acrylic polymers, surfactants, organic amines, chlorophenols, formaldehydes**

Contaminant Pathways in the Williston Basin

Infiltration pits for produced water disposal

Produced waters sampled at reinjection sites contained barium, cadmium, chromium, lead, selenium, silver, and zinc

July, 1967

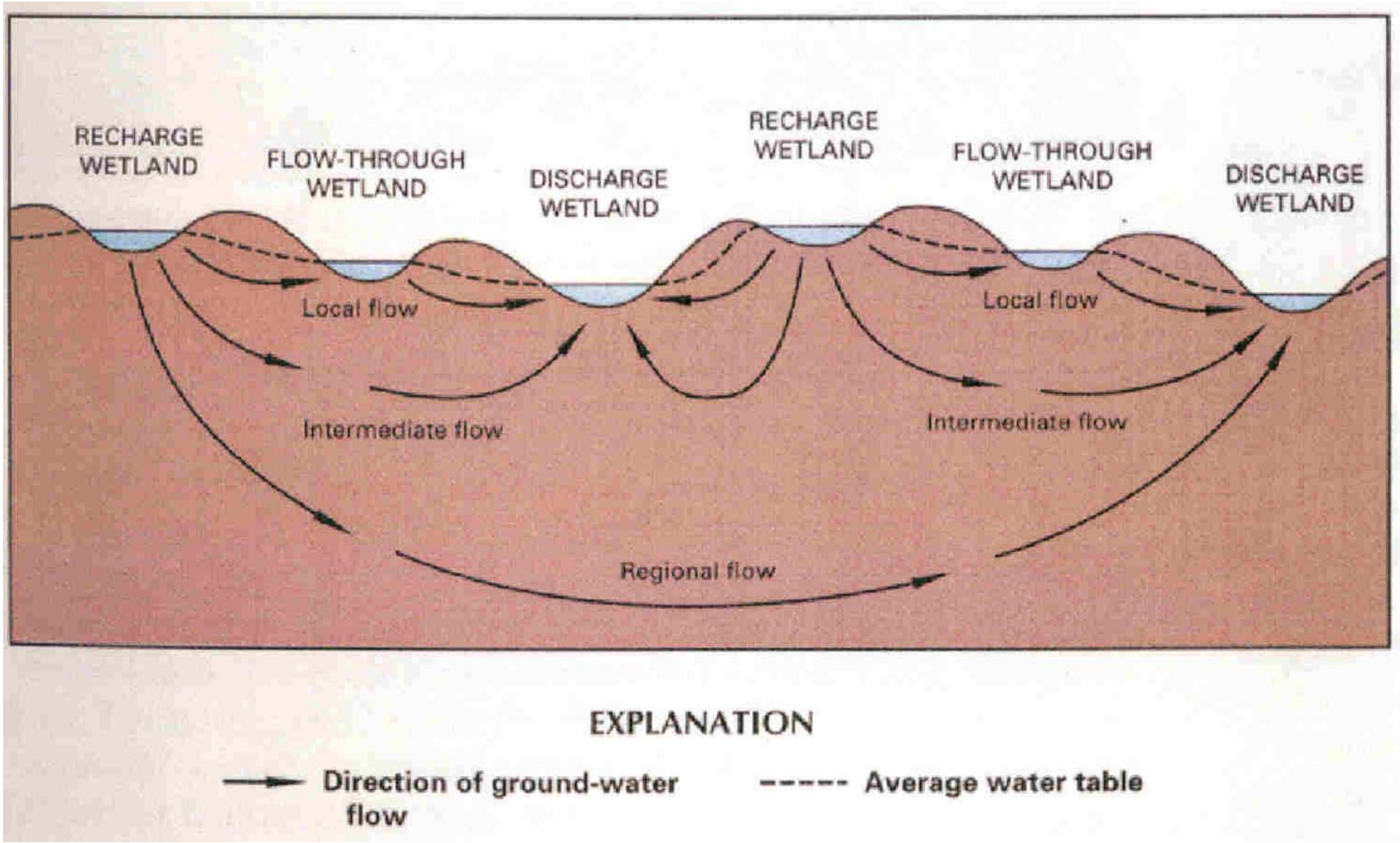
July, 1974

Infiltration pit location 2004

Contaminant Pathways in the Williston Basin

Flow lines and produced water lines

Natural geochemical diversity created by:
Groundwater flow path,
aquifer mineralogy, evaporation rates….



Assessment Methods

- Produced water contamination index
- NORM surveys
- EM-31 Soil Conductivity Surveys
- Groundwater sampling in identified plumes
- Hydrocarbon sampling and plume delineation
- Toxicity Testing
- Invertebrate sampling and identification

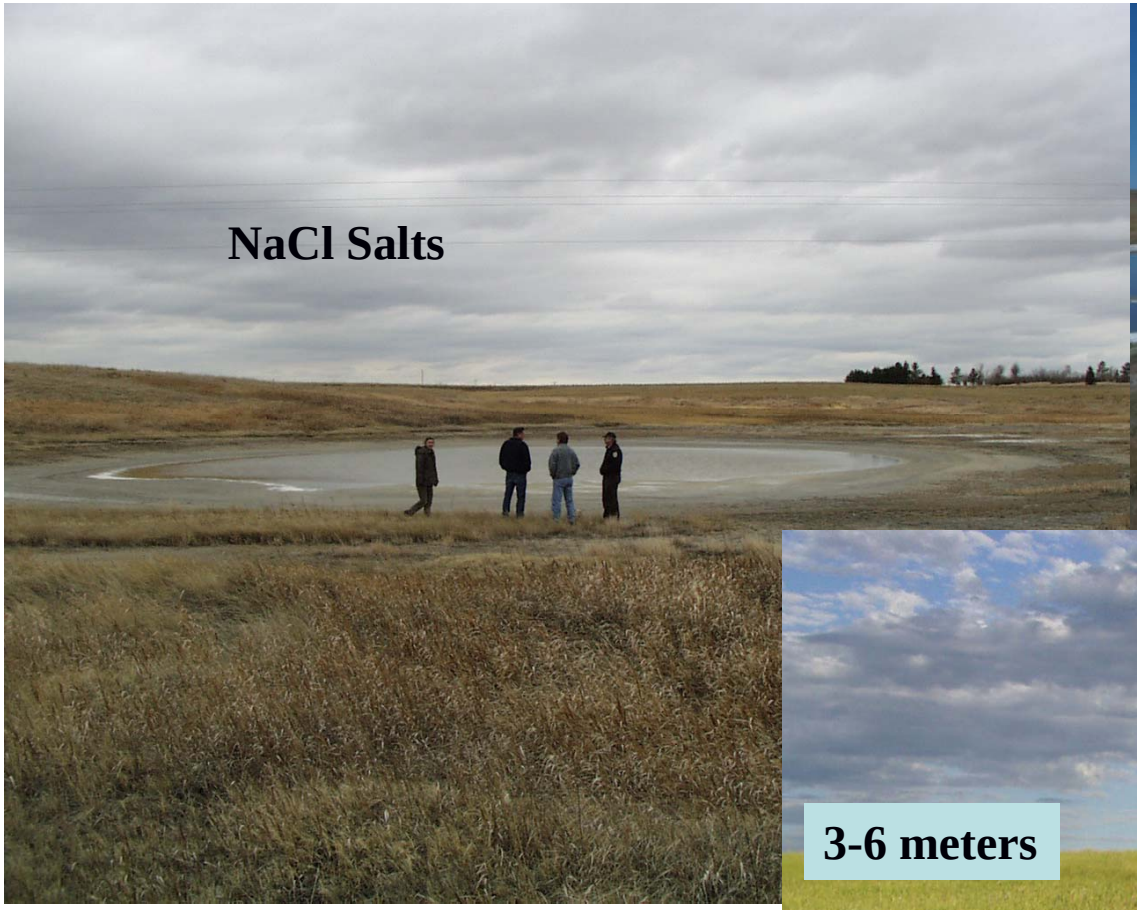
Produced Water Contamination Index

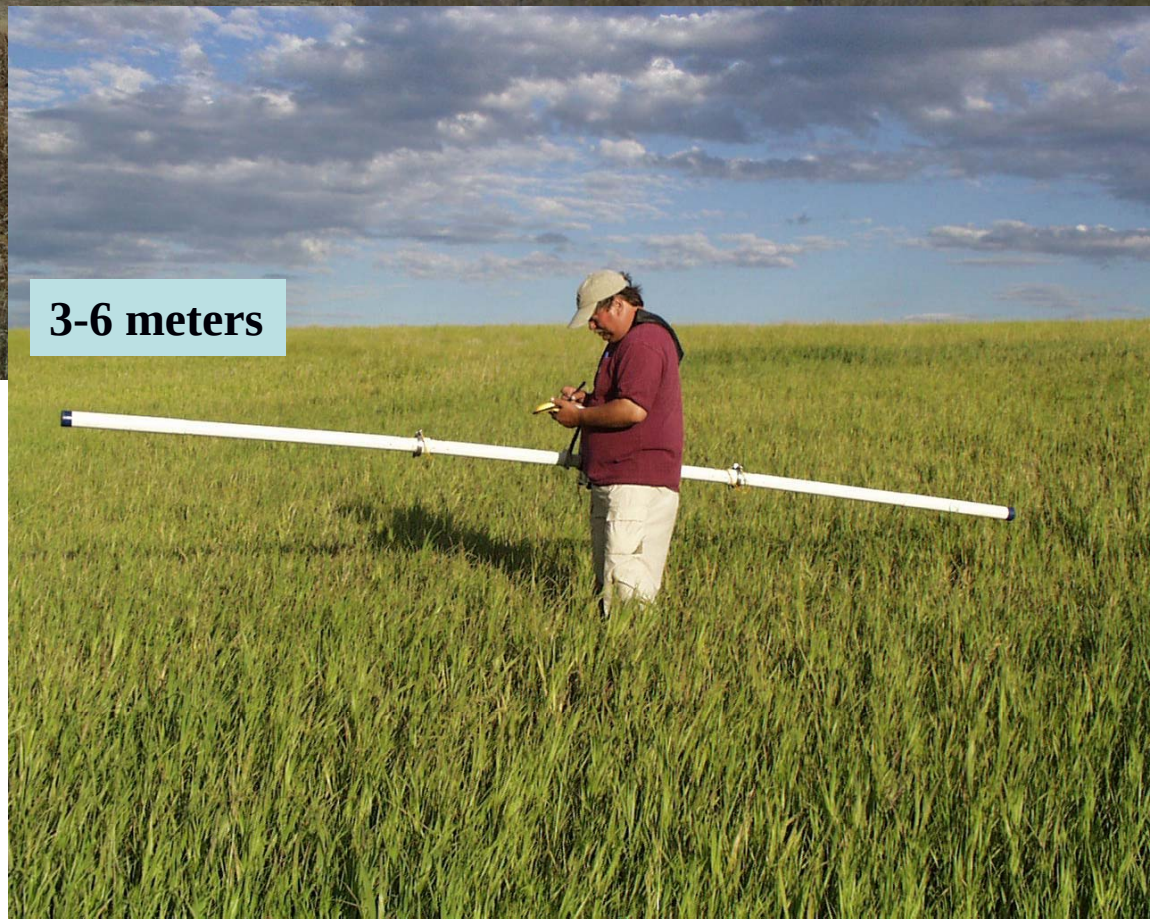
SC µs/cm:Cl mg/L >0.034 Produced water impacts

Surface water samples collected from 80 wetlands and lakes

50 % revealed impacts from produced water

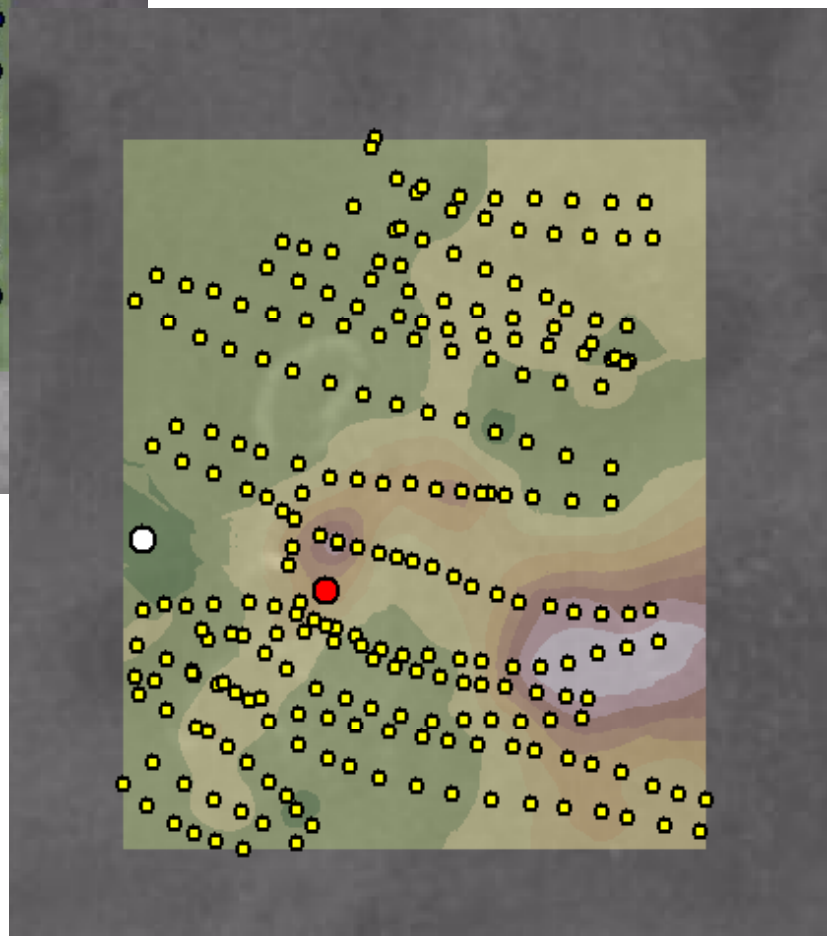
WPA/NWR	Site	SC µs/cm	Cl mg/L	CI
Parry	PAR1	4902	53	0.0108
Parry	PAR1E	4680	53	0.0113
Parry	PAR2	55185	1547	0.0280
Parry	PAR3	4351	61	0.0140
Parry	PAR3	5928	84	0.0142
Parry	PAR4	2669	27	0.0101
Parry	PAR4	3396	30.5	0.0090
Rabenberg	RABE1	22480	8362	0.3720
Rabenberg	RABE2A	4130	953	0.2308
Rabenberg	RABE2	5150	1485	0.2883
Rabenberg	RABE3	4011	908	0.2264
Rabenberg	RABE3A	2731	650	0.2380
Rabenberg	RABE4	8658	3145	0.3632
Rabenberg	RABE5	7509	2420	0.3223
Rabenberg	RABE5	8126	2690	0.3310
Rabenberg	RABE5+	8437	2908	0.3447
Rabenberg	RABE6	8812	2614	0.2966





Soil Conductivity Surveys

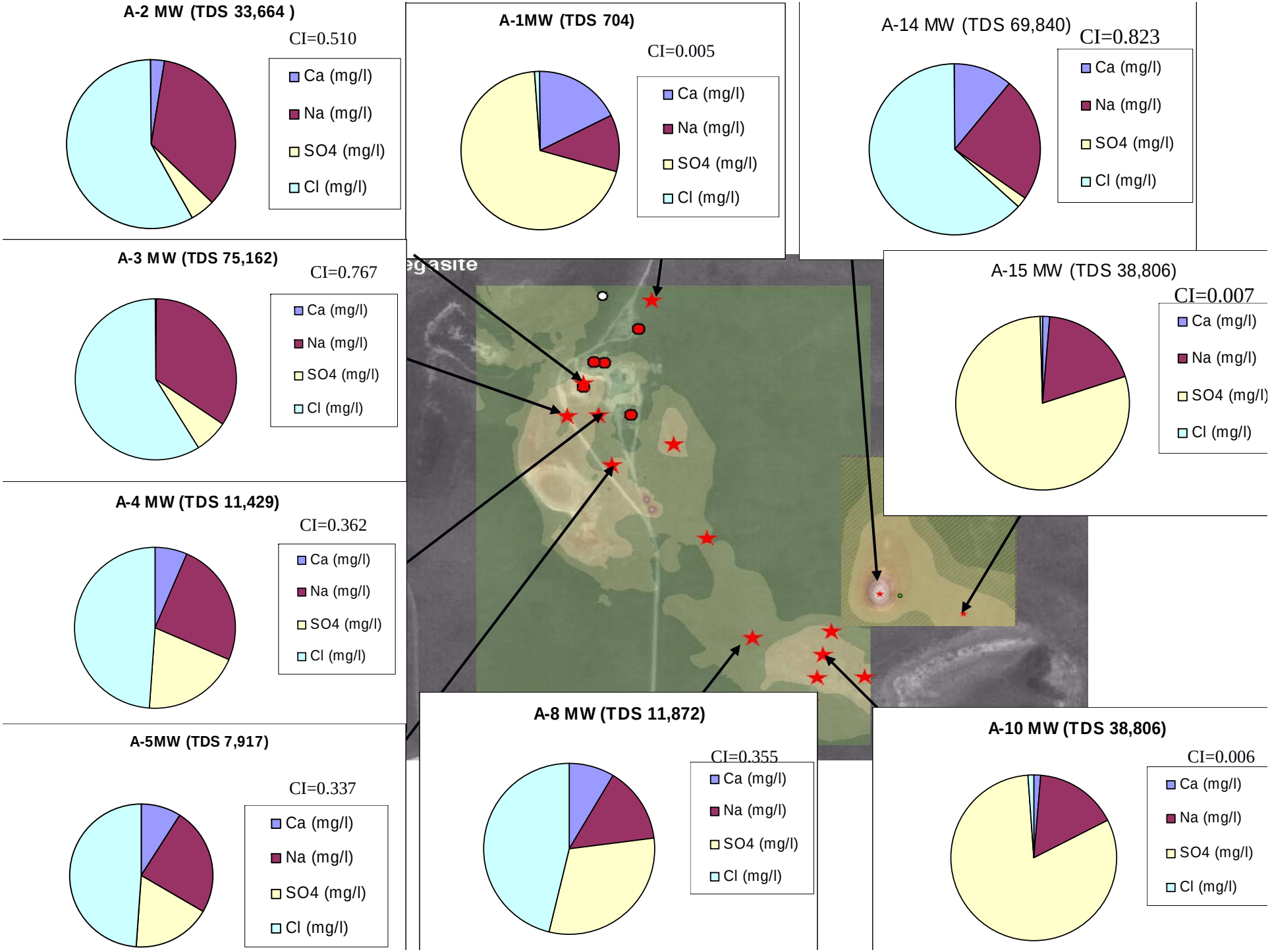
- Conducted using an EM-31 and a Trimble GeoXT
- Completed on 30 sites, on or near Service owned land
- Plumes delineated at all but one survey location

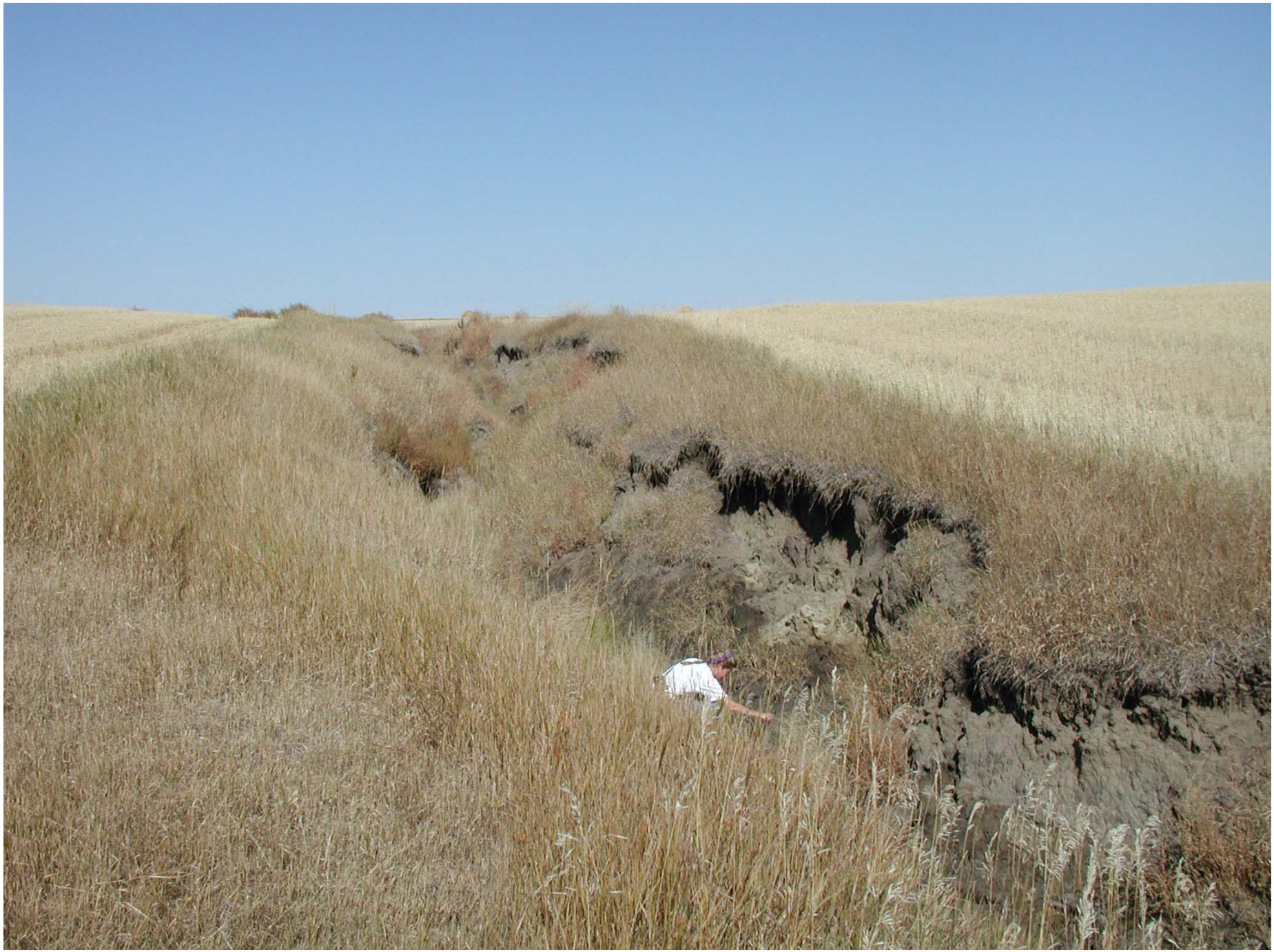


- Trimble files containing EM-31 data were used to create plume maps utilizing Kreiging
- Maps created by HAPET
- Monitoring well locations selected based on plume maps

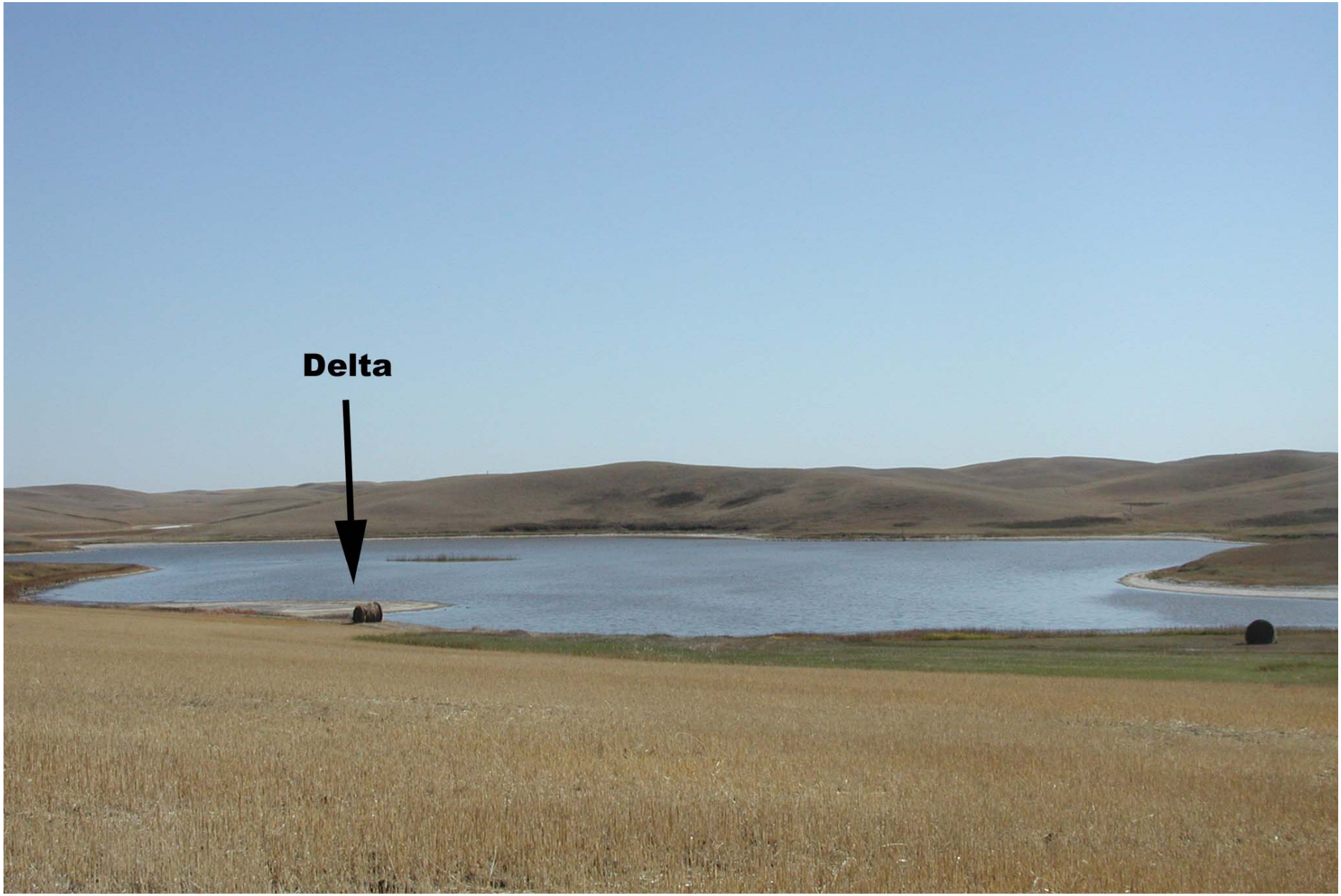
Installation of Monitoring wells

- 33 wells established on 6 WPAs and 2 ML NWR locations
- Sampled for major ions, trace element, and TPH


A-2 MW (TDS 33,664)
CI=0.510
Ca (mg/l)
Na (mg/l)
SO4 (mg/l)
Cl (mg/l)
A-1MW (TDS 704)
CI=0.005
Ca (mg/l)
Na (mg/l)
SO4 (mg/l)
Cl (mg/l)
A-14 MW (TDS 69,840)
CI=0.823
Ca (mg/l)
Na (mg/l)
SO4 (mg/l)
Cl (mg/l)
A-3 MW (TDS 75,162)
CI=0.767
Ca (mg/l)
Na (mg/l)
SO4 (mg/l)
Cl (mg/l)
A-15 MW (TDS 38,806)
CI=0.007
Ca (mg/l)
Na (mg/l)
SO4 (mg/l)
Cl (mg/l)
A-4 MW (TDS 11,429)
CI=0.362
Ca (mg/l)
Na (mg/l)
SO4 (mg/l)
Cl (mg/l)
A-5MW (TDS 7,917)
CI=0.337
Ca (mg/l)
Na (mg/l)
SO4 (mg/l)
Cl (mg/l)
A-8 MW (TDS 11,872)
CI=0.355
Ca (mg/l)
Na (mg/l)
SO4 (mg/l)
Cl (mg/l)
A-10 MW (TDS 38,806)
CI=0.006
Ca (mg/l)
Na (mg/l)
SO4 (mg/l)
Cl (mg/l)



Trench eroded across wheat field caused by oil field brine seepage



Wetland below trench. Note delta.

Oilfield brine seep near Redstone. Source is near powerlines above the seep.

OIL-FIELD BRINE PLUMES IN SHALLOW GROUND WATER, SHERIDAN COUNTY, MONTANA: SIXTEEN YEARS LATER

Goose Lake Field Hydrogeology

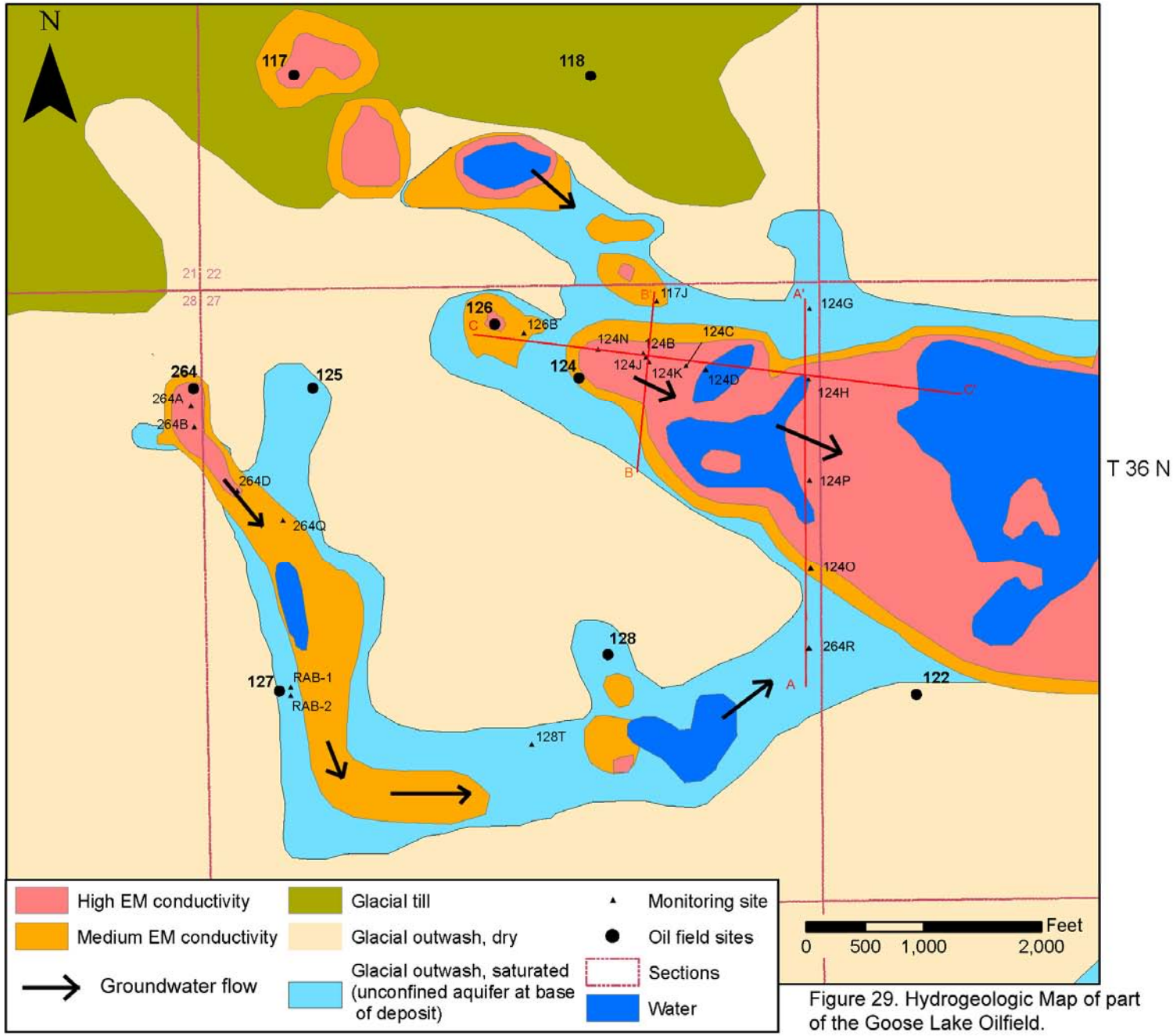


Figure 29. Hydrogeologic Map of part of the Goose Lake Oilfield.

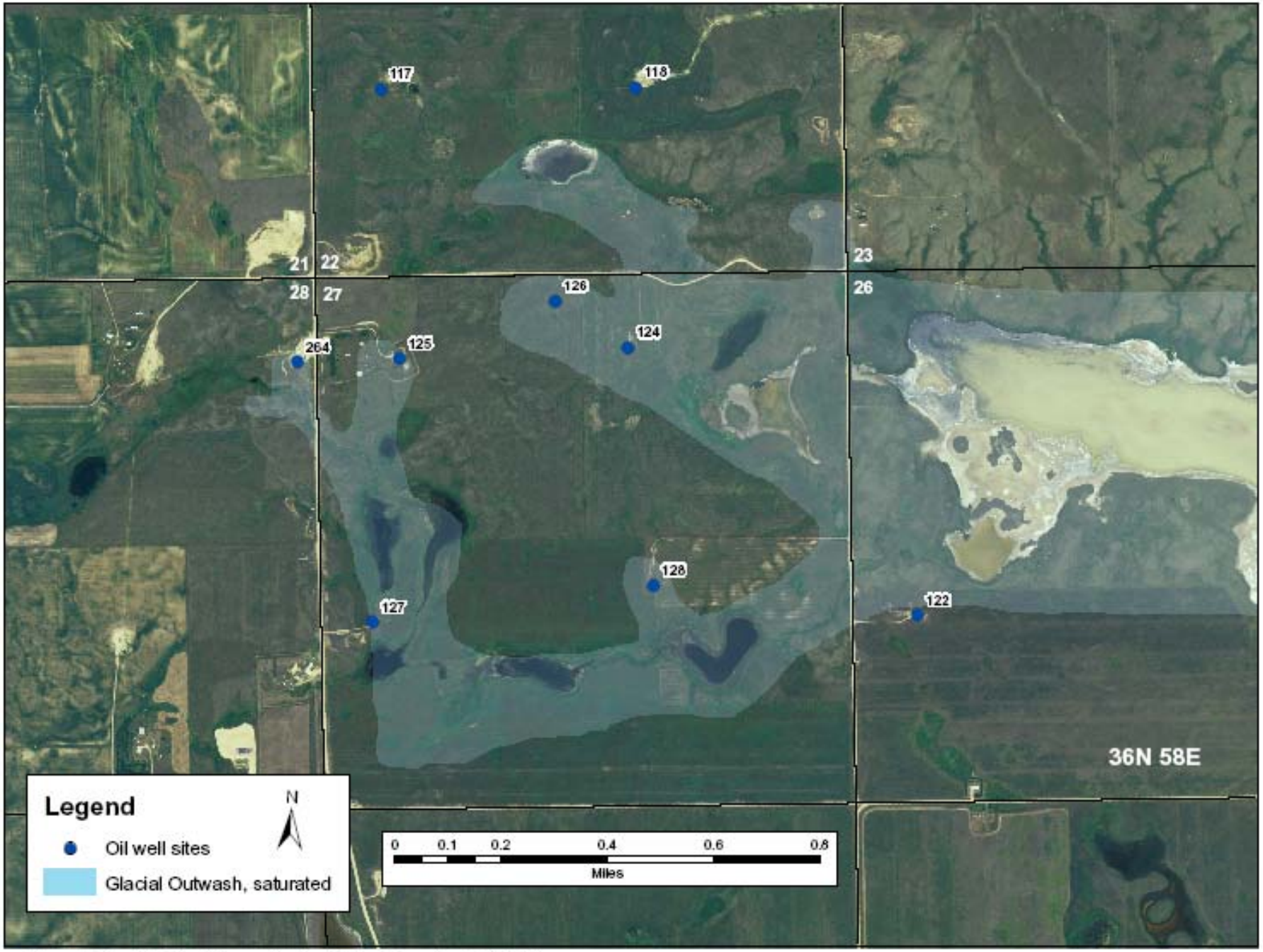
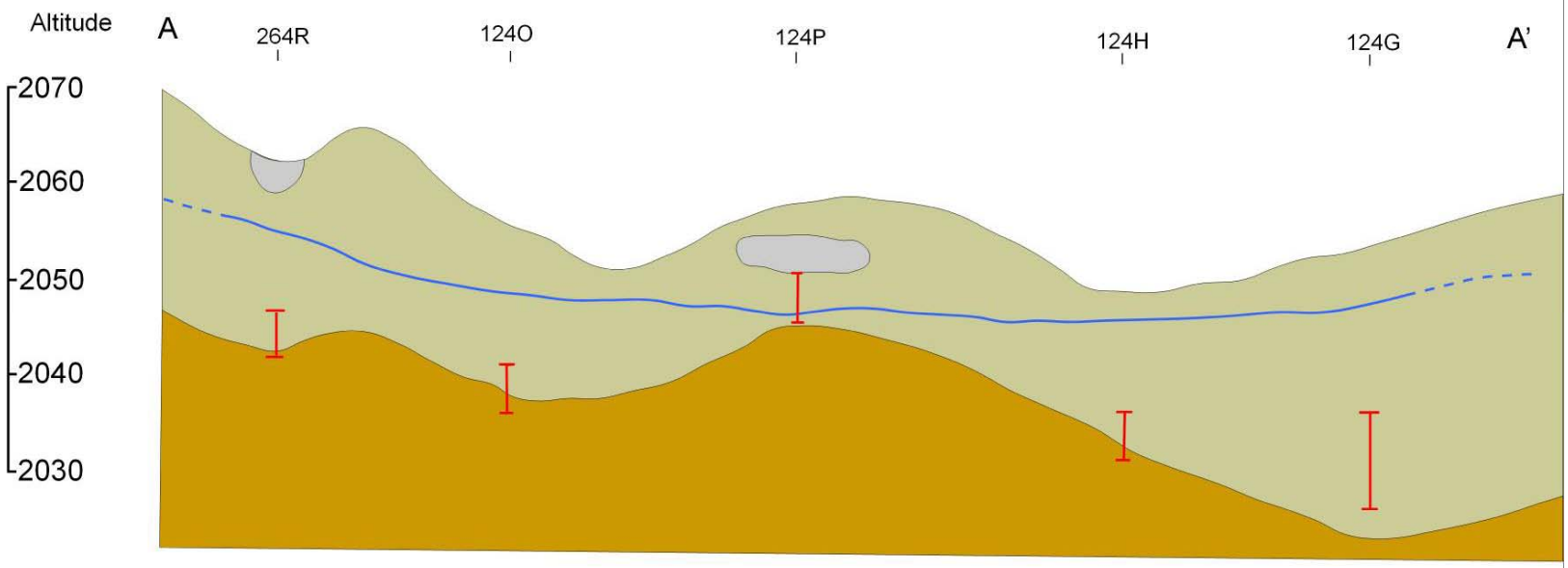


Figure 30. Aerial orthophotograph of part of the Goose Lake Oilfield.

Cross Section A - A'



Lithologic Units

- Silt and clay
- Sand and gravel
- Pebbly clay till

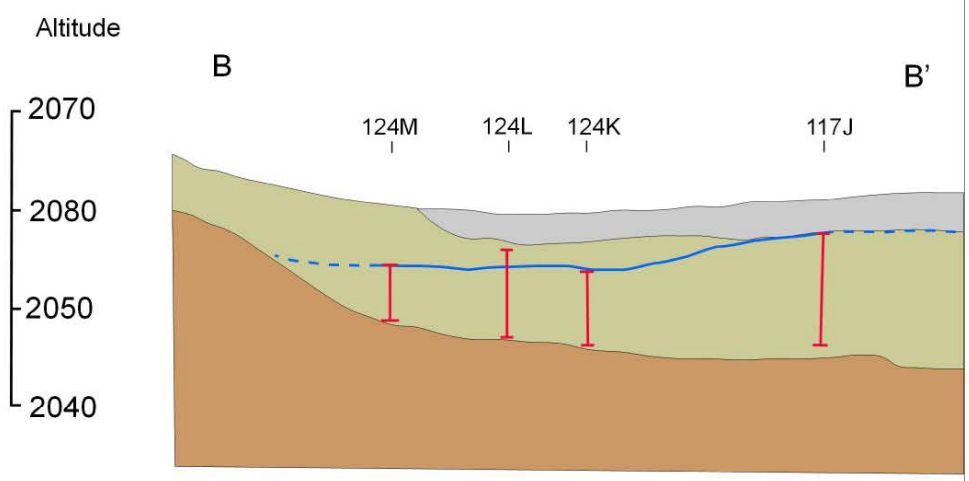
Hydrologic Symbols

- Water table (dashed where inferred)
- Lake or pond
- Screened Interval

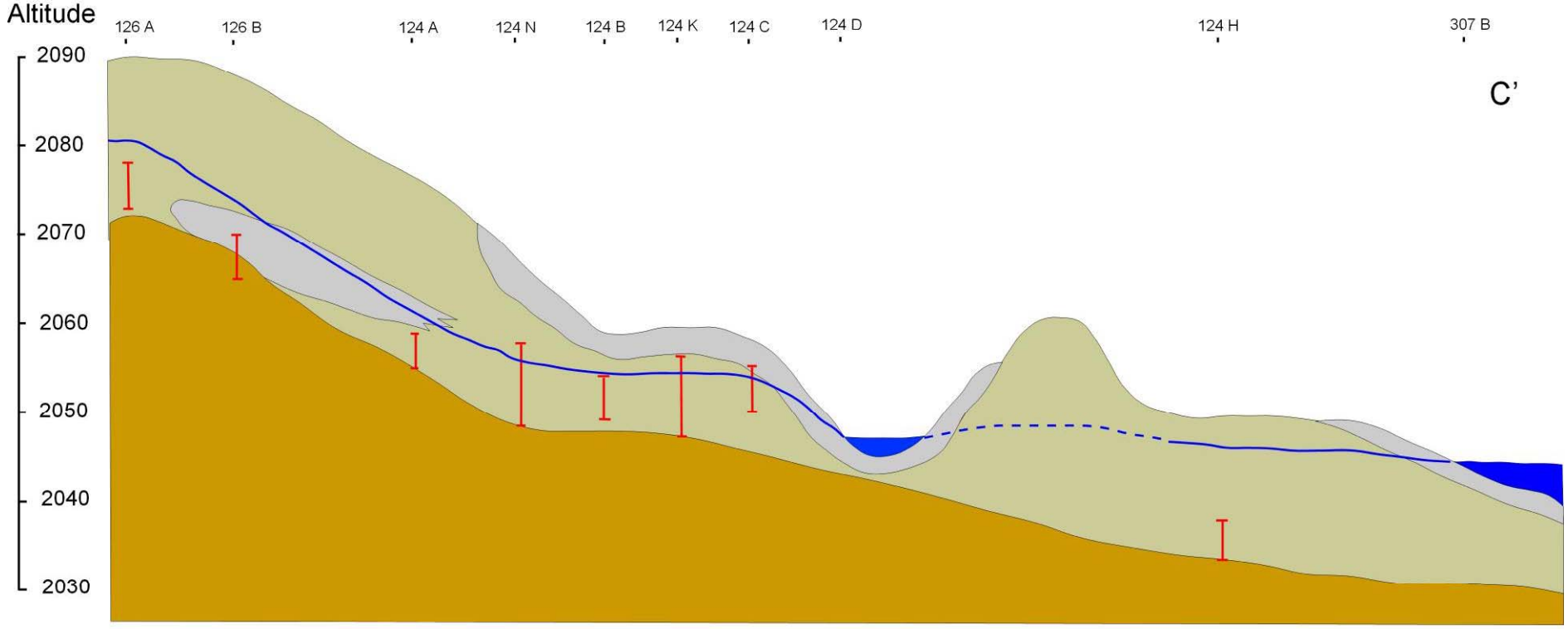
Horizontal Scale

0 500ft

Cross Section B -B'



Cross Section C - C’



Explanation

Lithologic Units

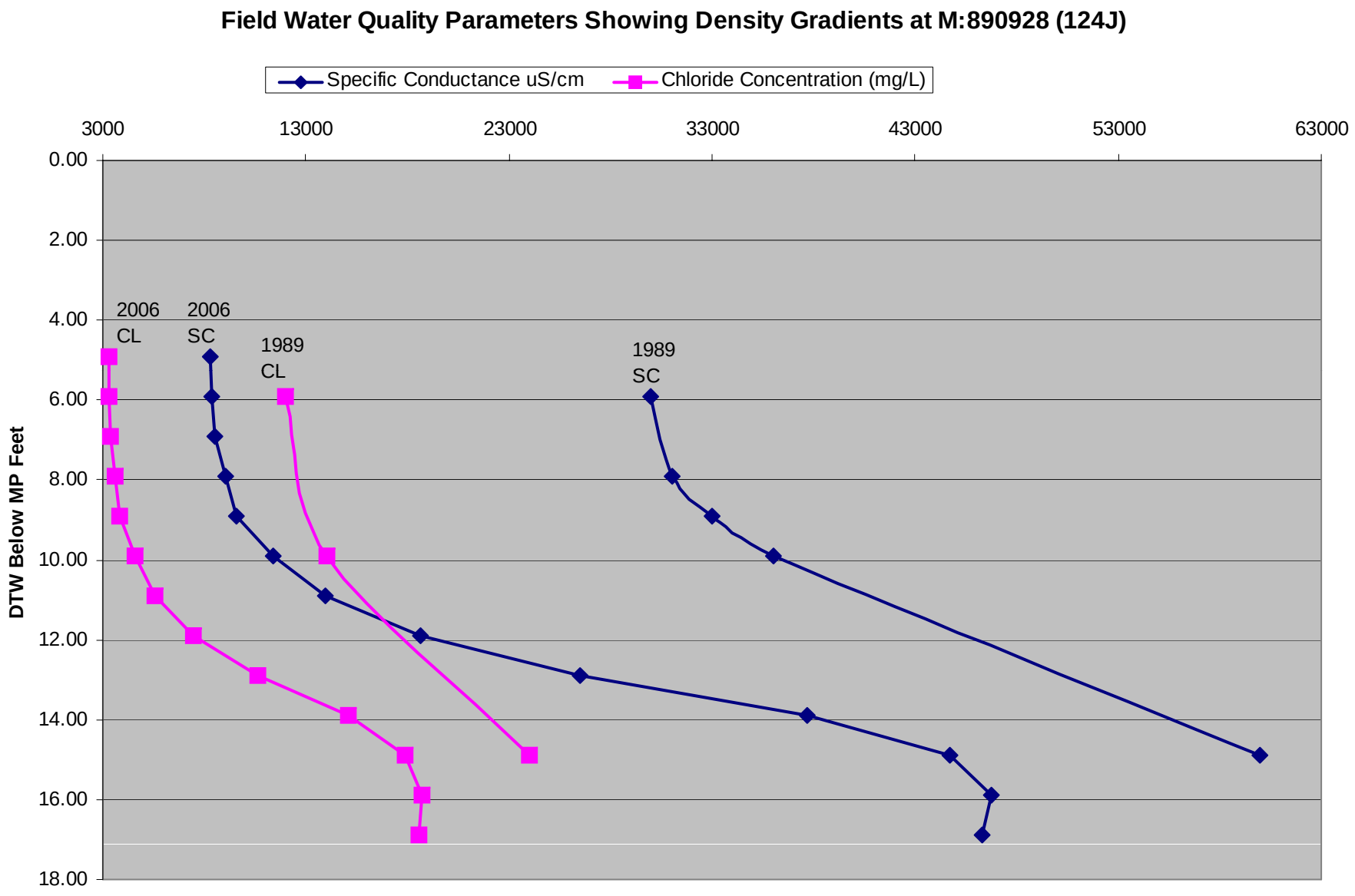
- Silt and Clay
- Sand and gravel
- Pebbly clay till

Hydrologic Symbols

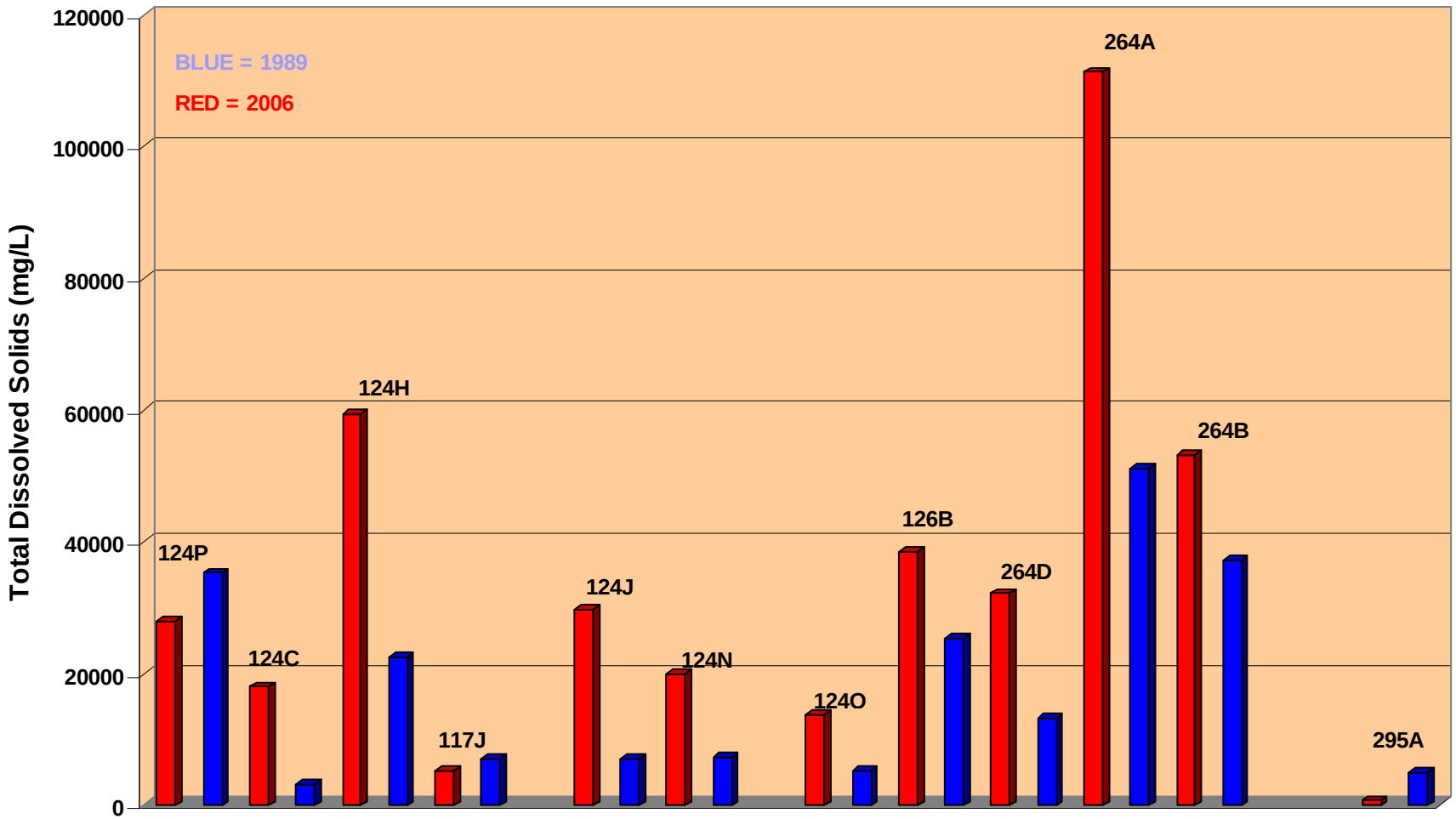
- Water table (dashed where infered)
- Lake or pond
- Screened Interval

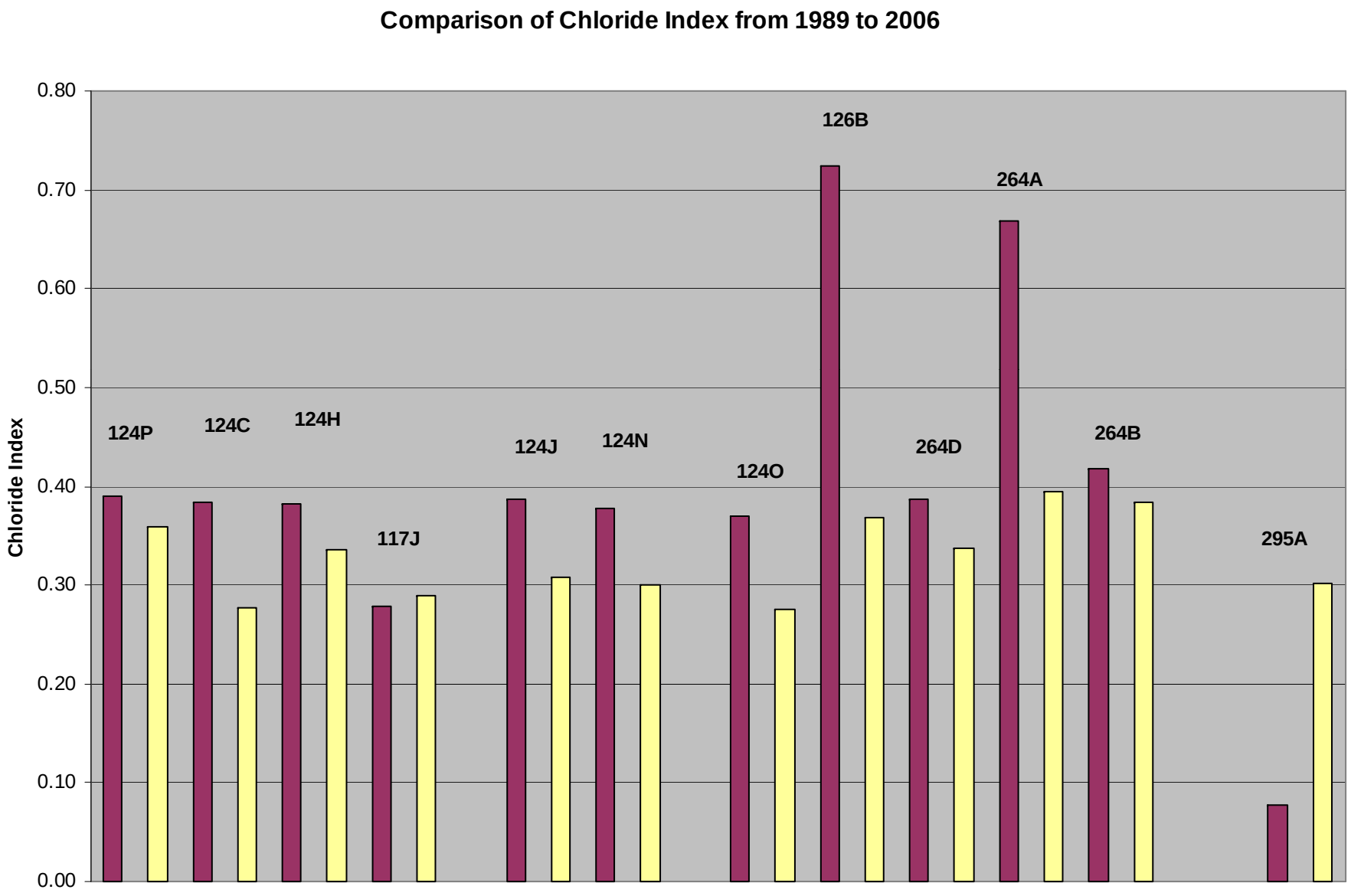
Horizontal Scale

0 500 ft


Field Water Quality Parameters Showing Density Gradients at M:890928 (124J)
Specific Conductance uS/cm
Chloride Concentration (mg/L)
3000
13000
23000
33000
43000
53000
63000
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
DTW Below MP Feet
2006 CL
2006 SC
1989 CL
1989 SC

Comparison of Total Dissolved Solids from 1989 to 2006




Comparison of Chloride Index from 1989 to 2006
Chloride Index
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
124P
124C
124H
117J
124J
124N
124O
126B
264D
264A
264B
295A

Goose Lake Field Hydrogeology

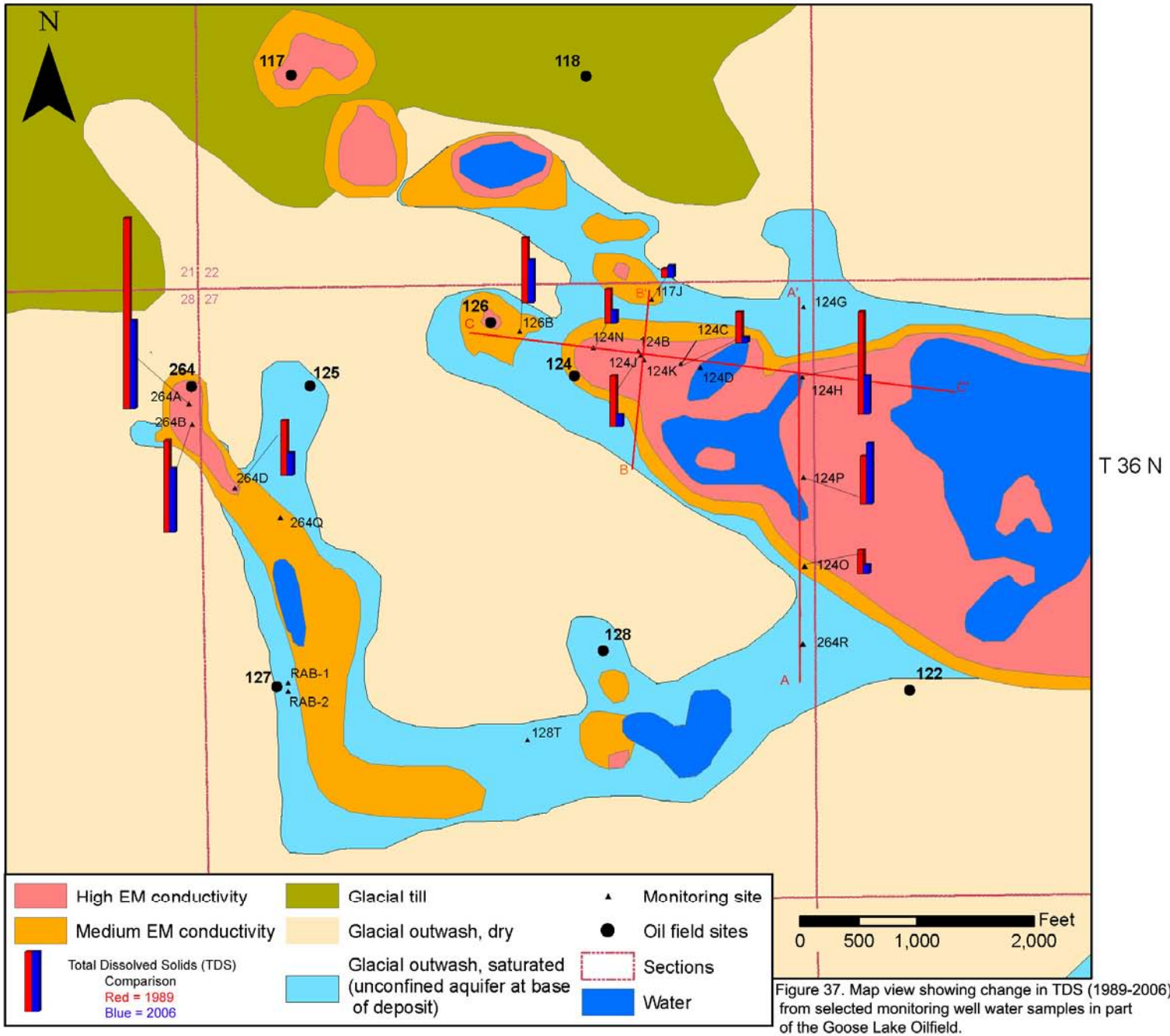


Figure 37. Map view showing change in TDS (1989-2006) from selected monitoring well water samples in part of the Goose Lake Oilfield.

Goose Lake Field Hydrogeology

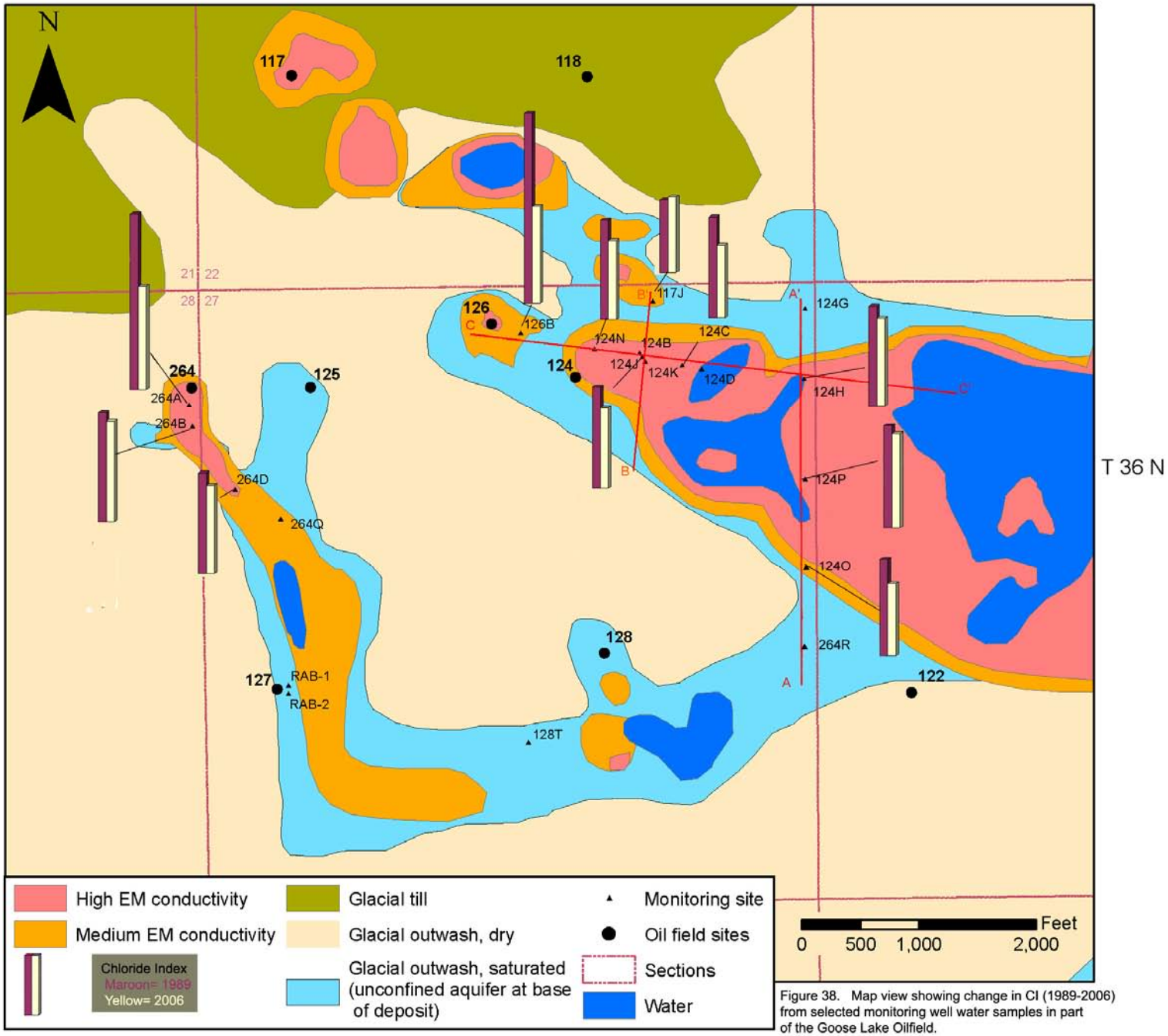
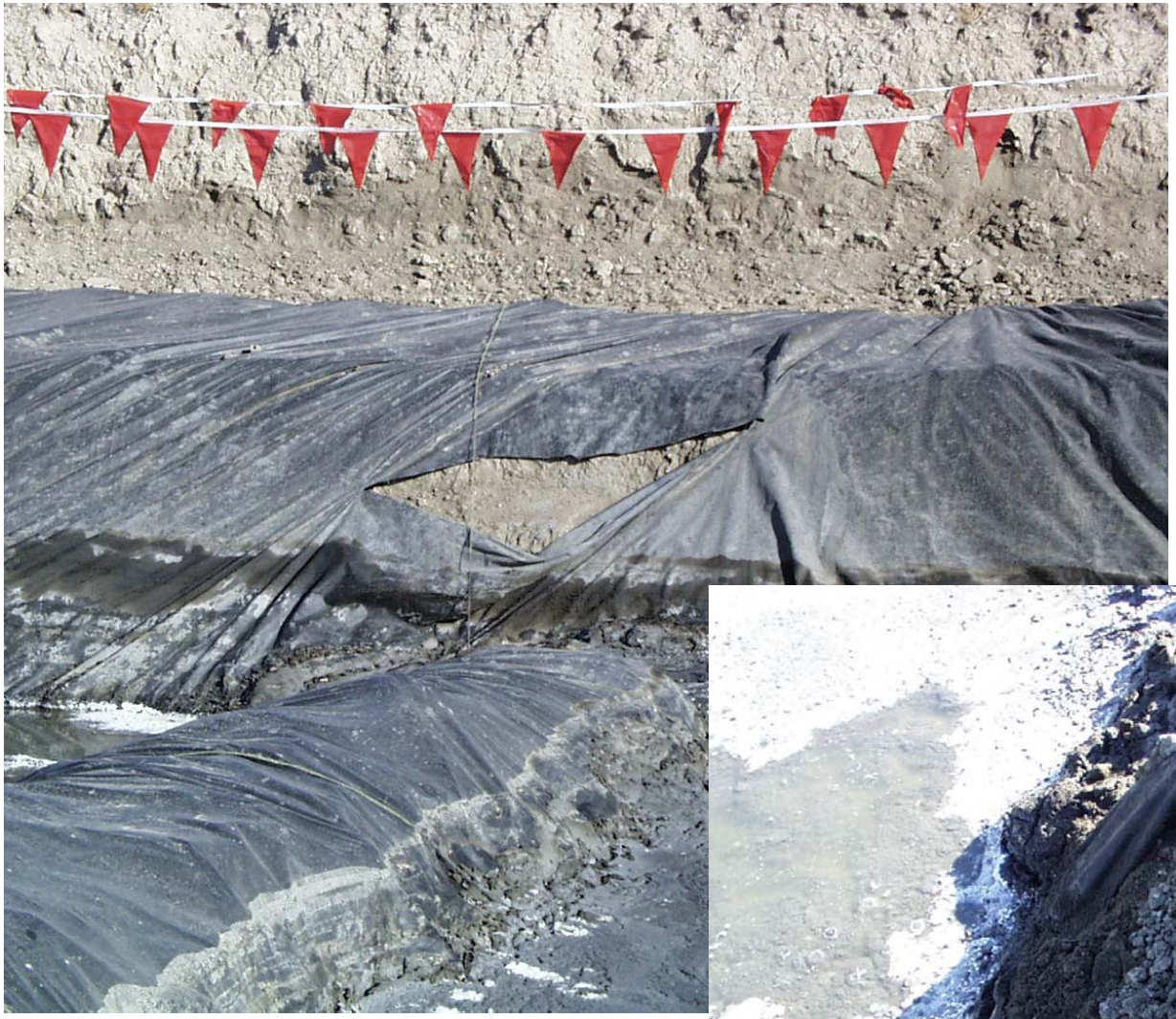


Figure 38. Map view showing change in Cl (1989-2006) from selected monitoring well water samples in part of the Goose Lake Oilfield.



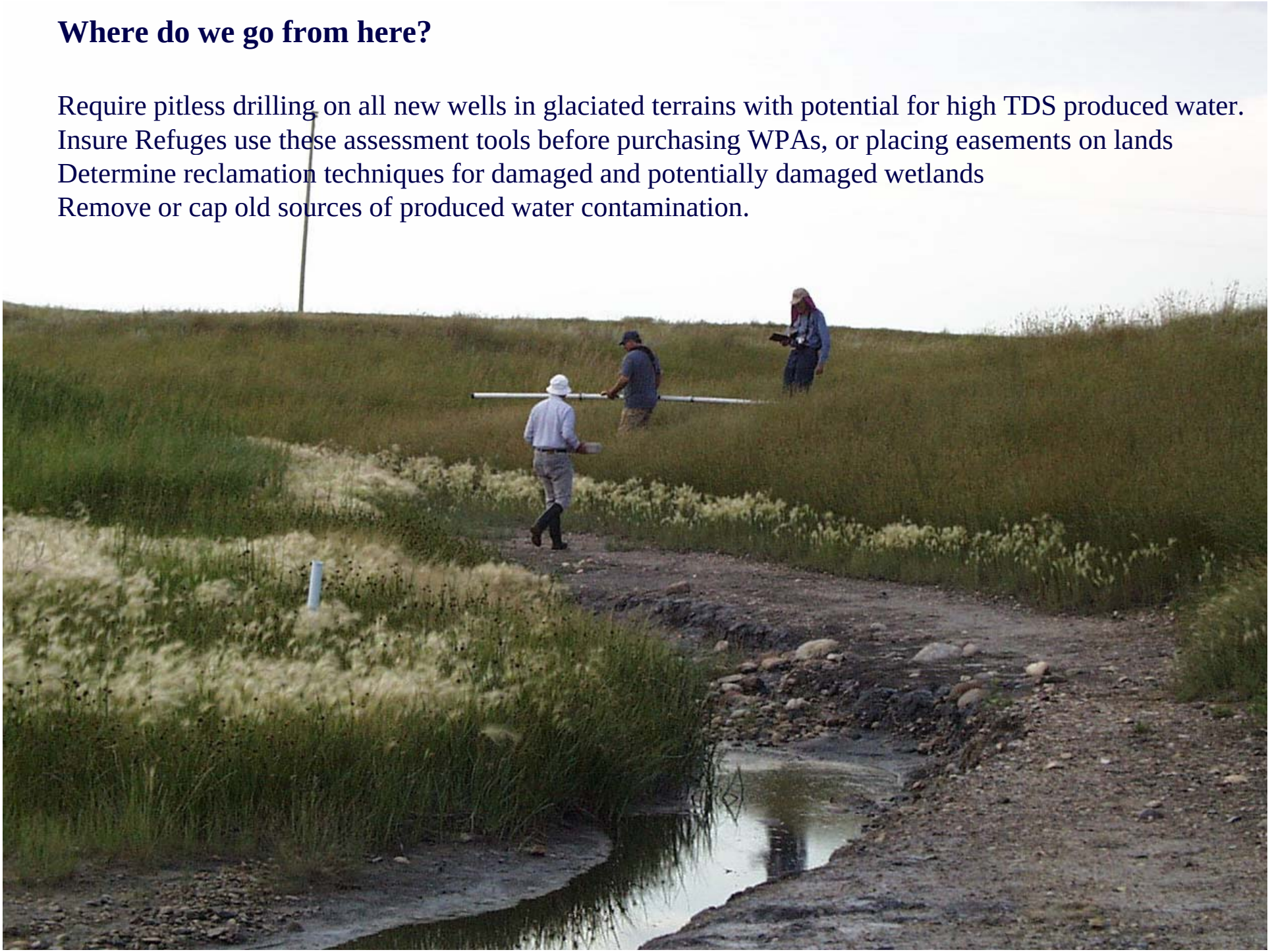
Pitless drilling possible

Required in Alaska, Alberta, Saskatchewan*

Several companies use pitless drilling exclusively

Where do we go from here?

Require pitless drilling on all new wells in glaciated terrains with potential for high TDS produced water.
Insure Refuges use these assessment tools before purchasing WPAs, or placing easements on lands
Determine reclamation techniques for damaged and potentially damaged wetlands
Remove or cap old sources of produced water contamination.



This project was made possible by the funding, expertise, and support of the following agencies:

U.S. Fish and Wildlife Service
Division of Environmental Quality
Medicine Lake National Wildlife Refuge Complex
HAPET Office, Bismarck, North Dakota
Montana Board of Oil and Gas Conservation Commission
Montana Bureau of Mines and Geology in cooperation with the Sheridan County Conservation District
Montana State University
University of Wyoming
U.S. Environmental Protection Agency
Region VIII Montana Office, Helena, MT
Office of Enforcement, Compliance, and Environmental Justice's
Legal Enforcement Program, Denver, Colorado
U.S. Geological Survey, Denver, Colorado