CLEAR LAKE AQUIFER WATER RESERVATION

SHERIDAN COUNTY CD GROUNDWATER RESERVATION INCREASES OPPORTUNITIES FOR PRODUCERS

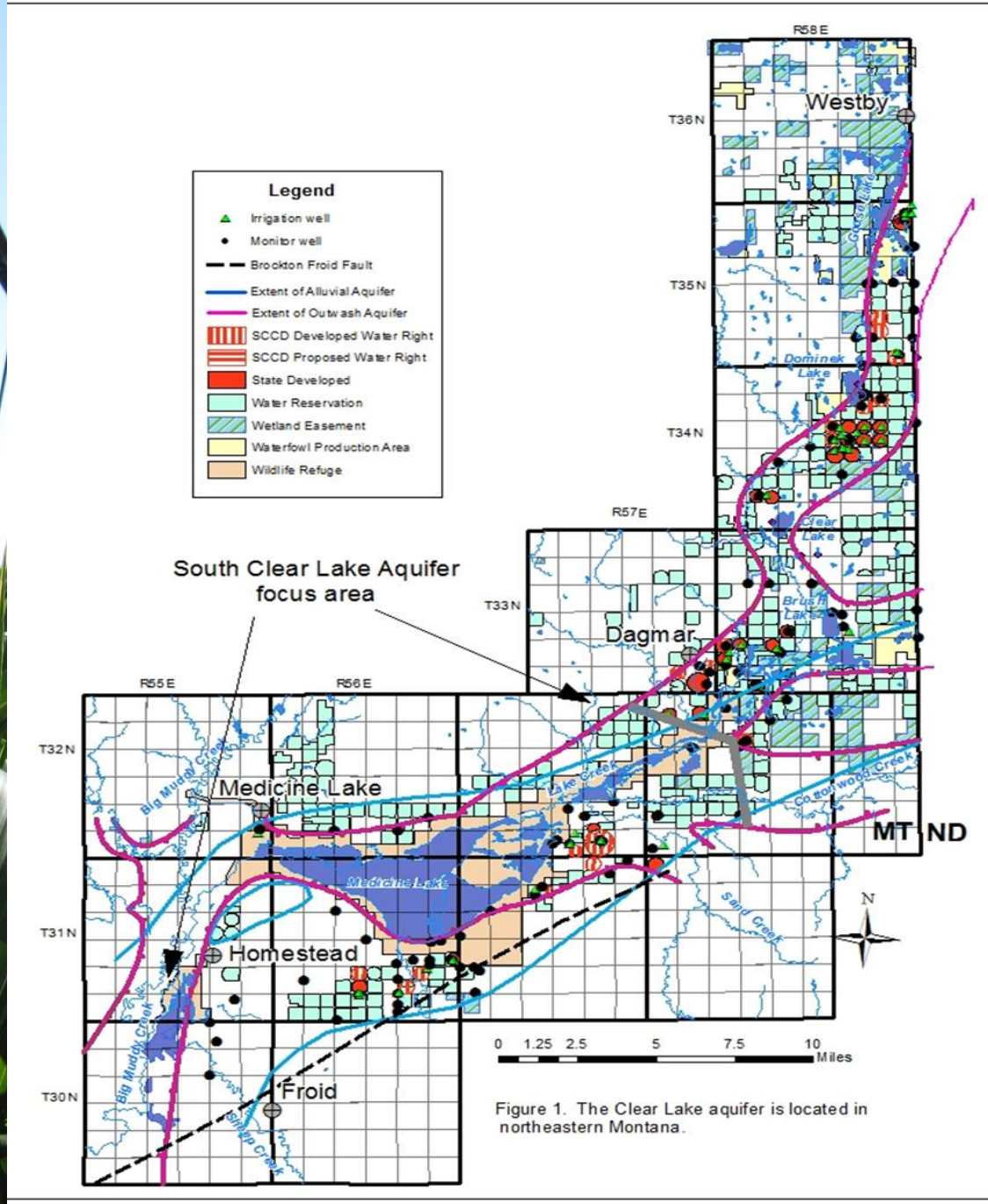
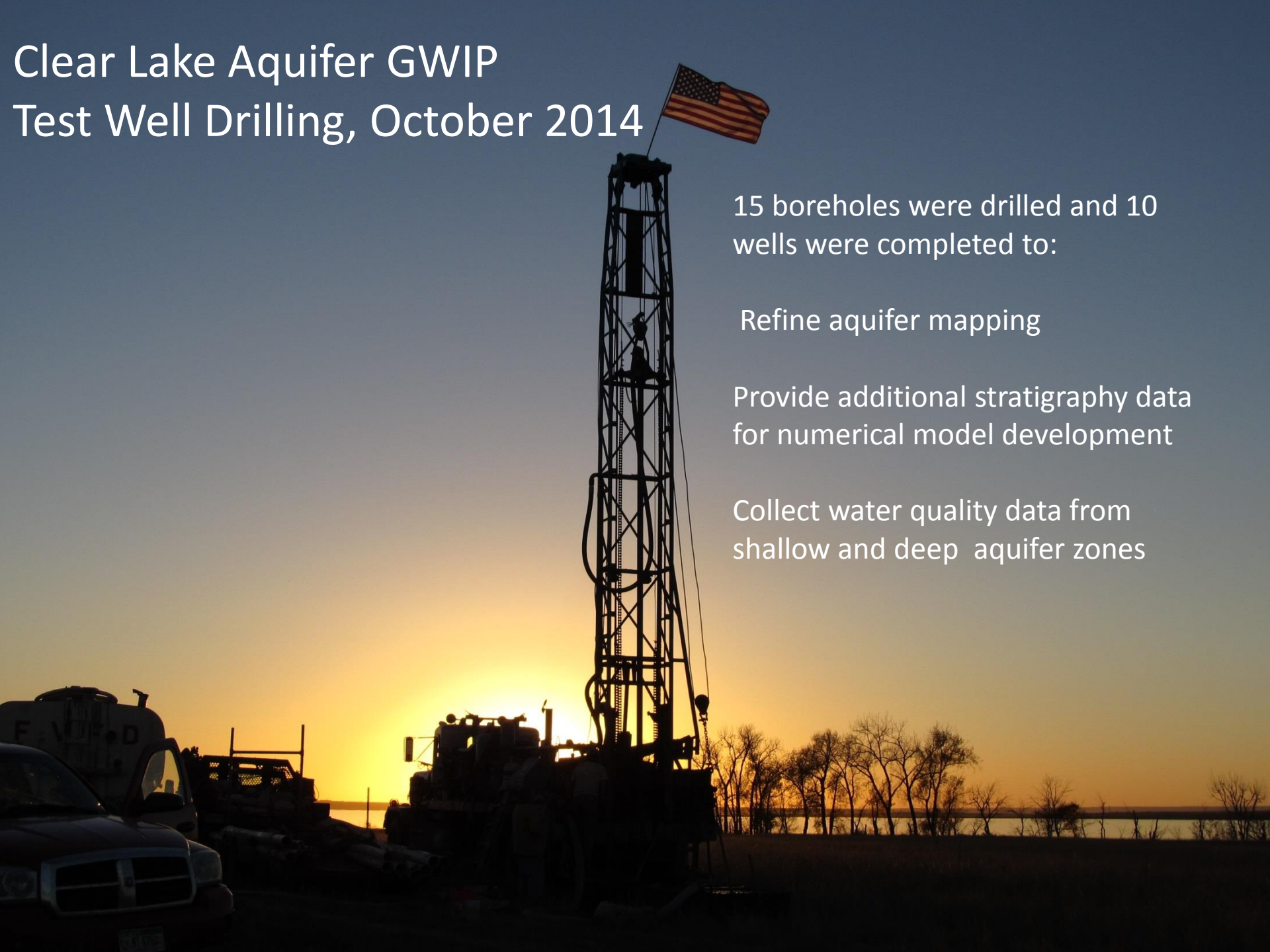


Figure 1. The Clear Lake aquifer is located in northeastern Montana.

Clear Lake Aquifer GWIP
Test Well Drilling, October 2014

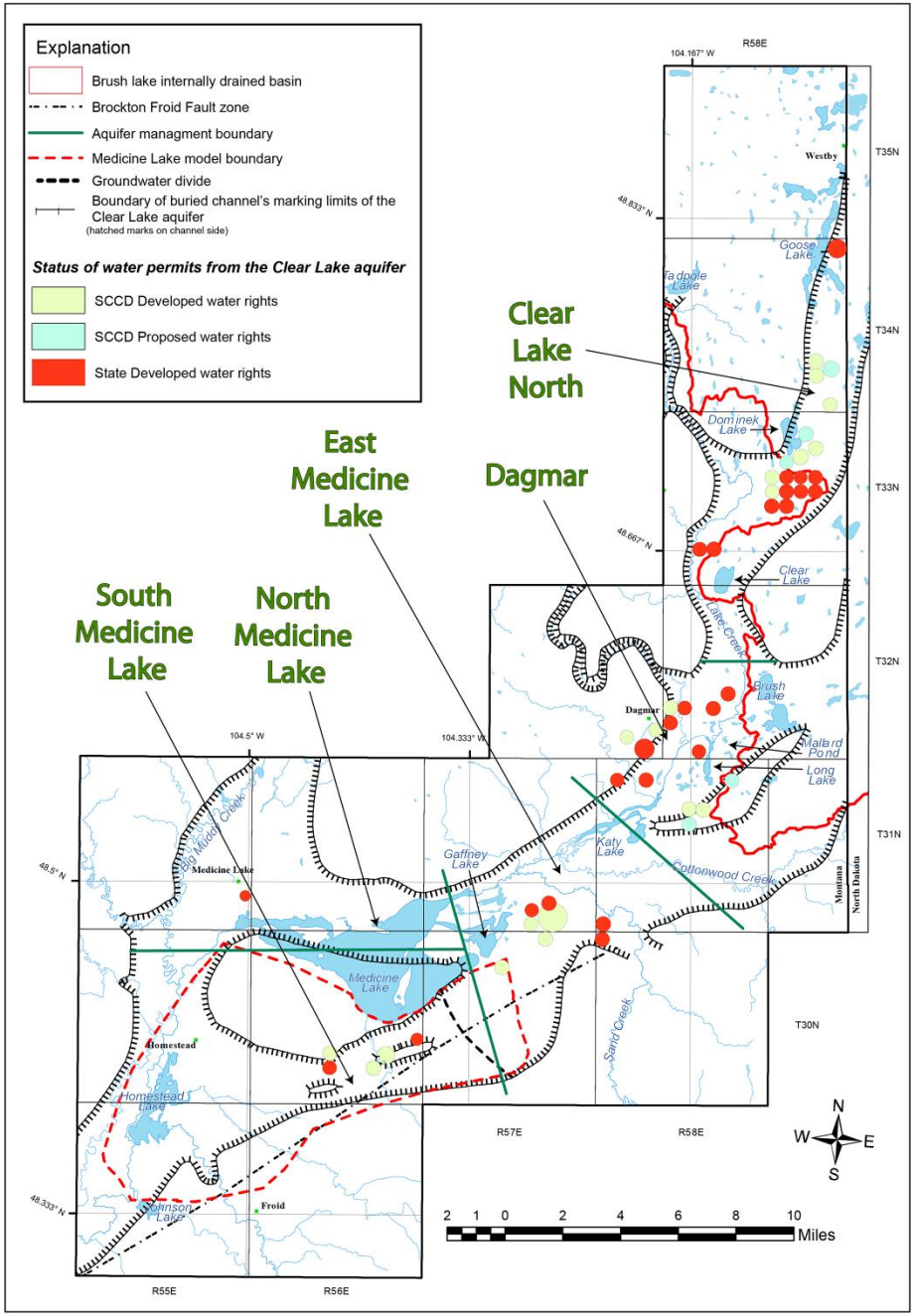


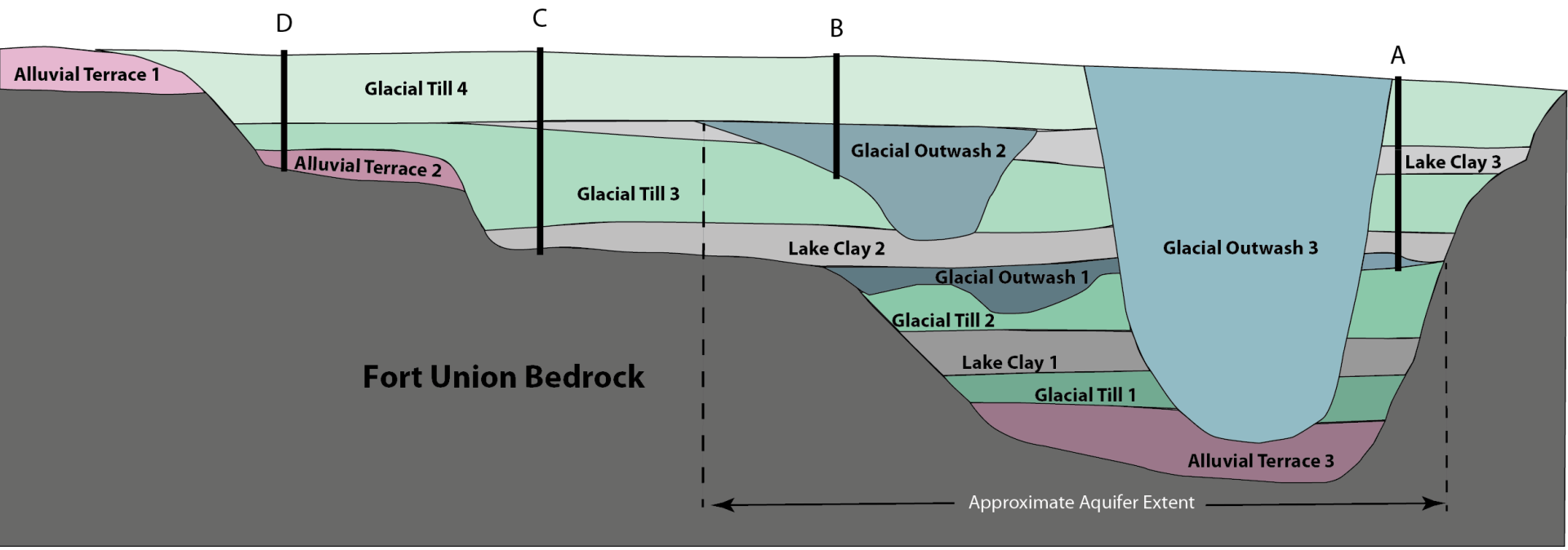
15 boreholes were drilled and 10 wells were completed to:

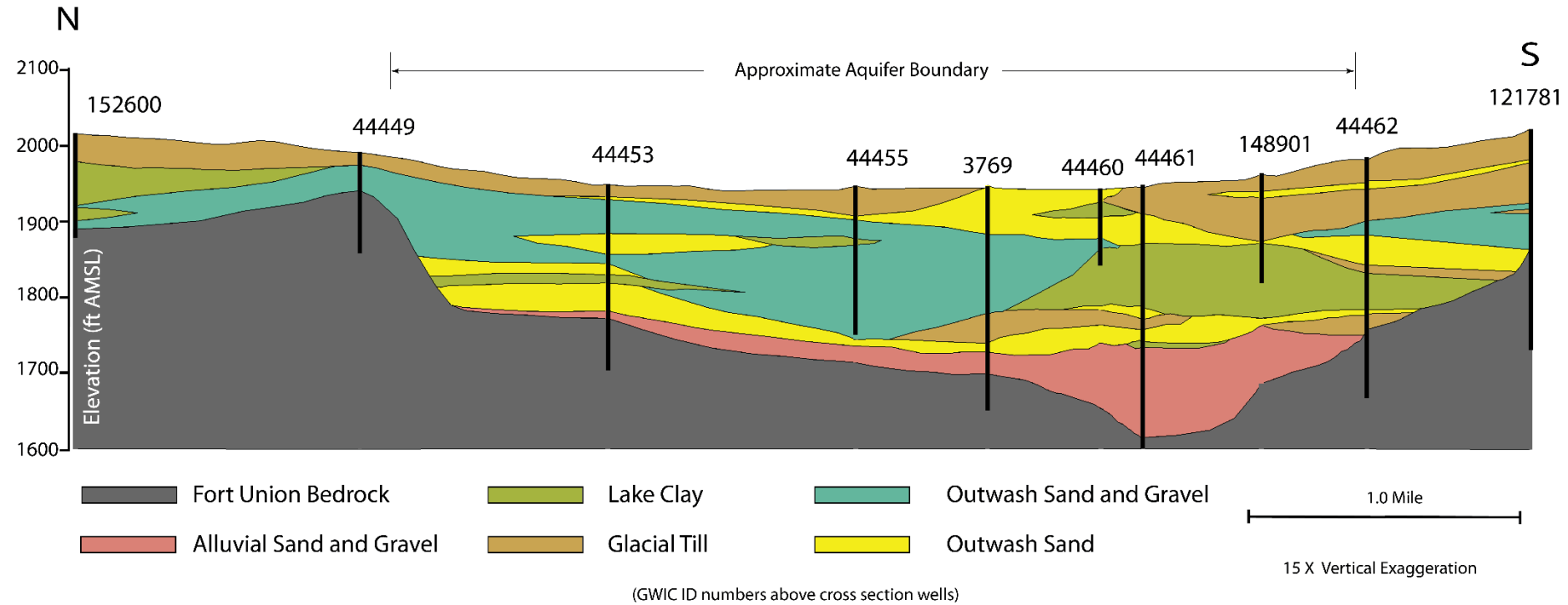
Refine aquifer mapping

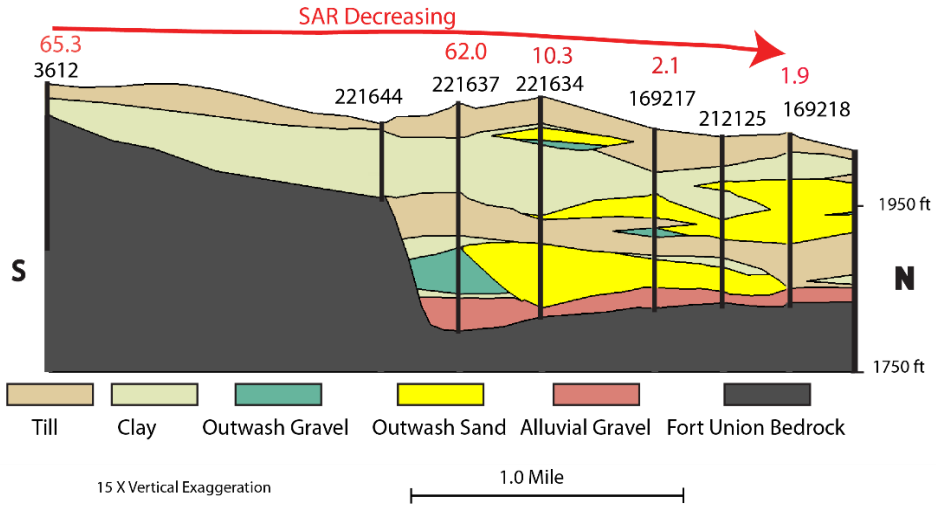
Provide additional stratigraphy data for numerical model development

Collect water quality data from shallow and deep aquifer zones

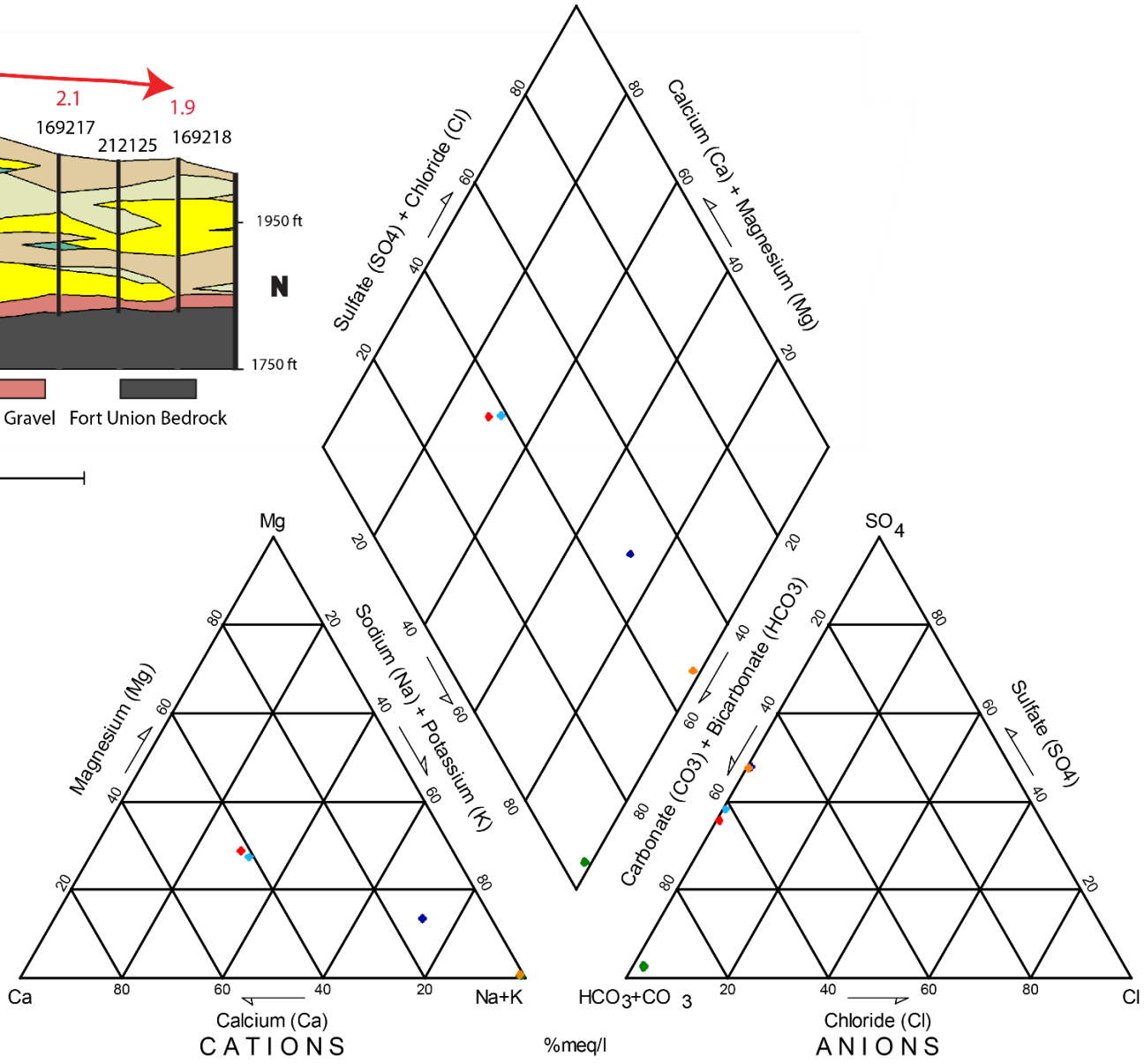

Explanation
Brush lake internally drained basin
Brockton Froid Fault zone
Aquifer managment boundary
Medicine Lake model boundary
Groundwater divide
Boundary of buried channel's marking limits of the Clear Lake aquifer
(hatched marks on channel side)
Status of water permits from the Clear Lake aquifer
SCCD Developed water rights
SCCD Proposed water rights
State Developed water rights
Clear Lake North
East Medicine Lake
Dagmar
South Medicine Lake
North Medicine Lake
R58E
104.167° W
T35N
T34N
T33N
T32N
T31N
T30N
48.833° N
48.667° N
48.5° N
48.333° N
104.5° W
104.333° W
R55E
R56E
R57E
R58E
Westby
Goose Lake
Tadpole Lake
Dominek Lake
Clear Lake
Lake Creek
Brush Lake
Dagmar
Mallard Pond
Long Lake
Big Muddy Creek
Medicine Lake
Gaffney Lake
Katy Lake
Cottonwood Creek
Medicine Lake
Homestead
Homestead Lake
Johnson Lake
Froid
Sand Creek
Montana
North Dakota
N
W
E
S
2 1 0 2 4 6 8 10
Miles


D
C
B
A
Alluvial Terrace 1
Glacial Till 4
Alluvial Terrace 2
Glacial Till 3
Glacial Outwash 2
Lake Clay 3
Lake Clay 2
Glacial Outwash 3
Glacial Outwash 1
Glacial Till 2
Lake Clay 1
Glacial Till 1
Alluvial Terrace 3
Fort Union Bedrock
Approximate Aquifer Extent

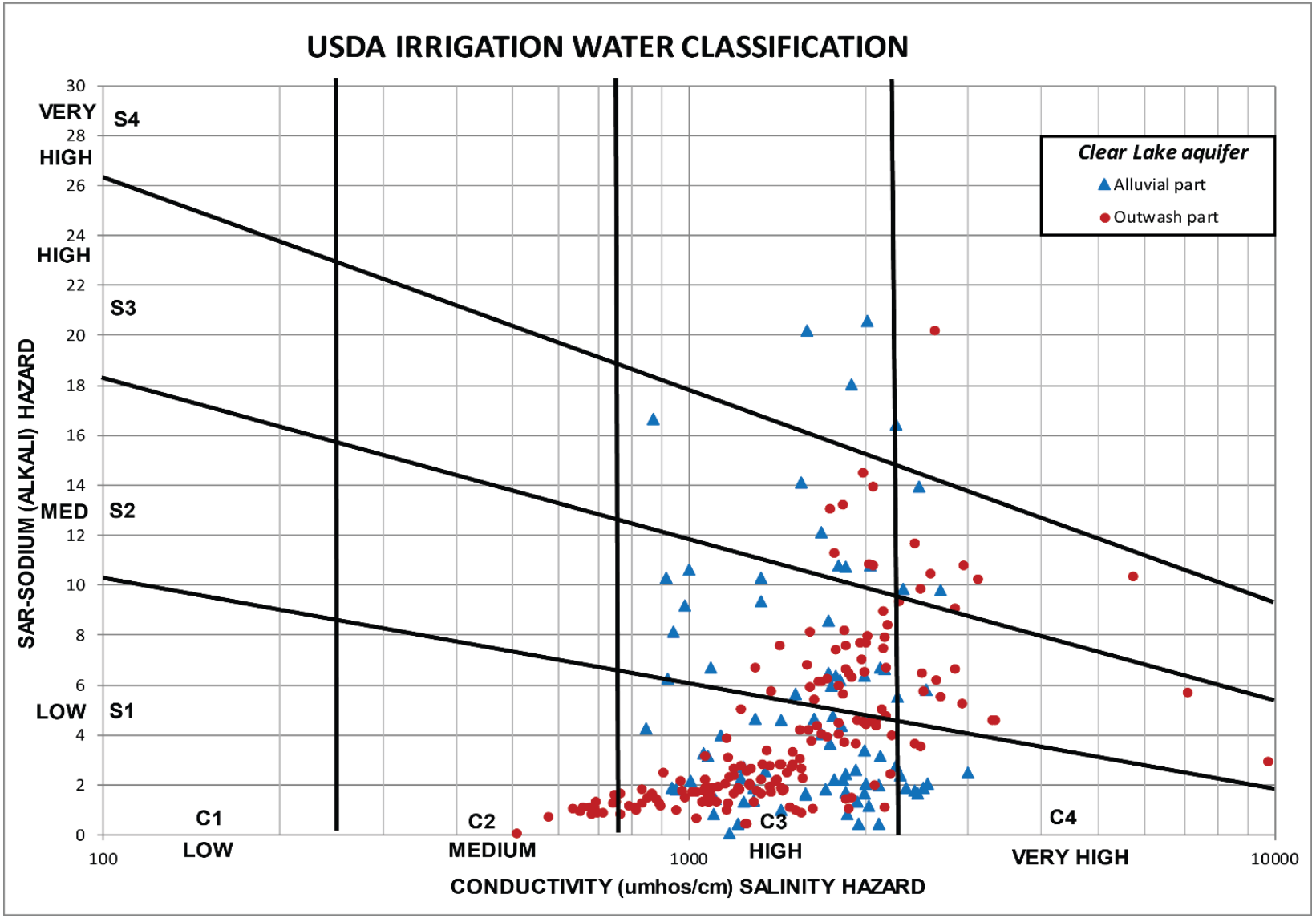

N
S
Approximate Aquifer Boundary
2100
2000
1900
1800
1700
1600
Elevation (ft AMSL)
152600
44449
44453
44455
3769
44460
44461
148901
44462
121781
Fort Union Bedrock
Lake Clay
Outwash Sand and Gravel
Alluvial Sand and Gravel
Glacial Till
Outwash Sand
1.0 Mile
15 X Vertical Exaggeration
(GWIC ID numbers above cross section wells)



Gwic ID	Aquifer	SAR	SC
169218	Clear Lake	1.9	1292
169217	Clear Lake	2.1	1553
221634	Clear Lake	10.3	2325
221637	Clear Lake	62.0	2120
3612	Fort Union	65.3	2889



Clear Lake Aquifer Water Quality



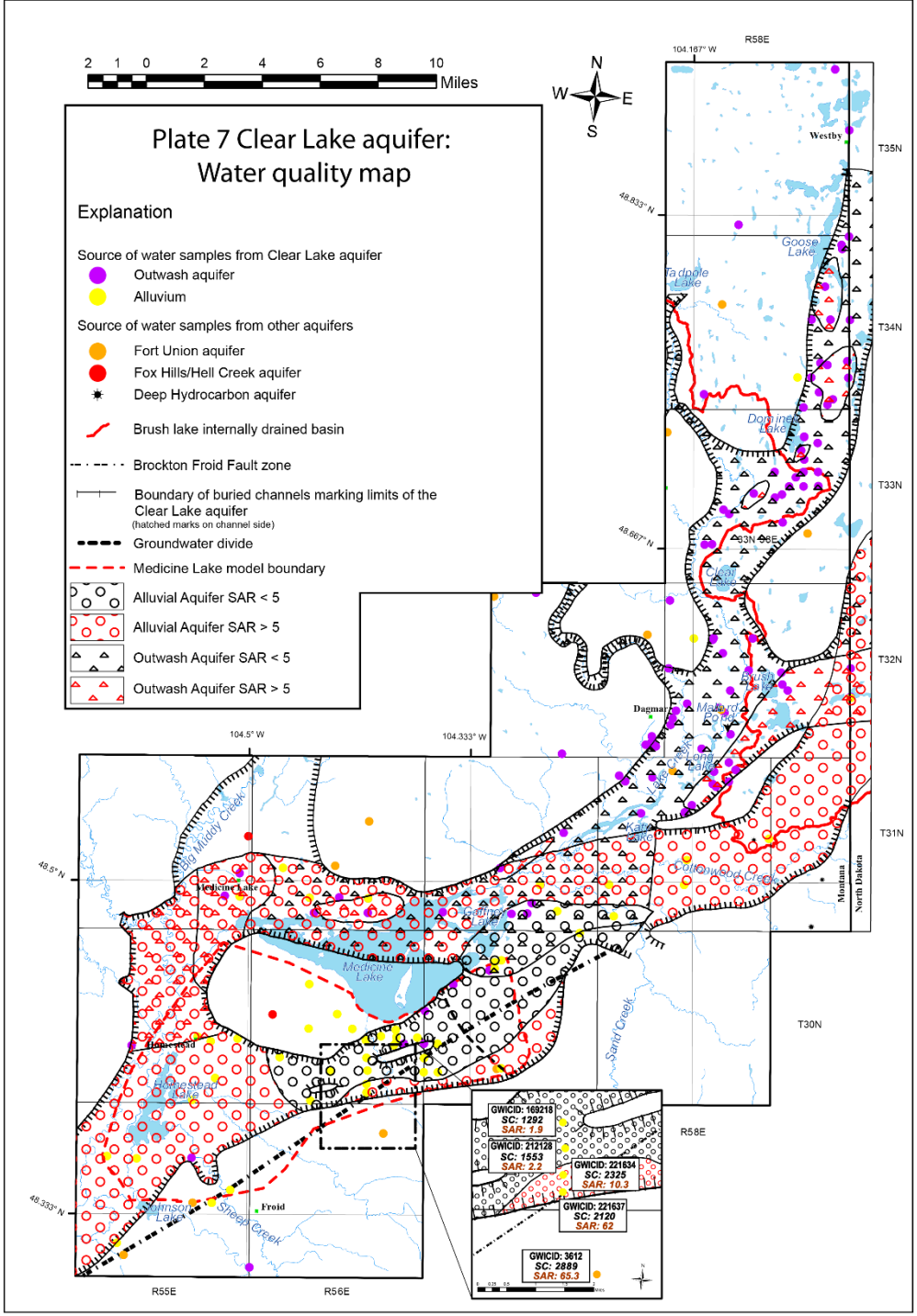
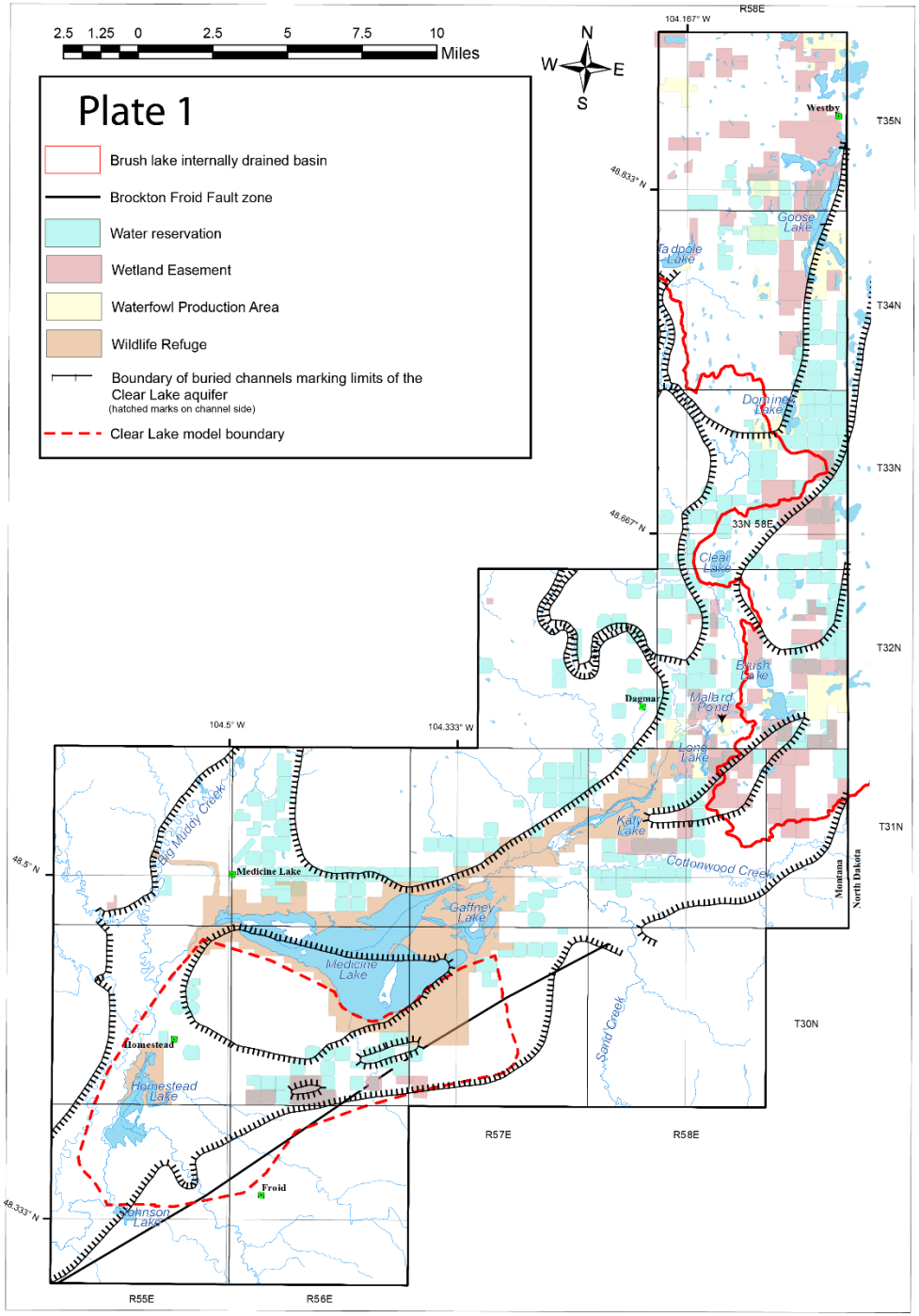


Plate 7 Clear Lake aquifer:
Water quality map
Explanation
Source of water samples from Clear Lake aquifer
Outwash aquifer
Alluvium
Source of water samples from other aquifers
Fort Union aquifer
Fox Hills/Hell Creek aquifer
Deep Hydrocarbon aquifer
Brush lake internally drained basin
Brockton Froid Fault zone
Boundary of buried channels marking limits of the Clear Lake aquifer
(hatched marks on channel side)
Groundwater divide
Medicine Lake model boundary
Alluvial Aquifer SAR < 5
Alluvial Aquifer SAR > 5
Outwash Aquifer SAR < 5
Outwash Aquifer SAR > 5
2 1 0 2 4 6 8 10 Miles
N
W
E
S
104.167° W
104.5° W
104.333° W
48.833° N
48.667° N
48.5° N
48.333° N
R58E
R55E
R56E
T35N
T34N
T33N
T32N
T31N
T30N
Westby
Dagmar
Froid
Medicine Lake
Goose Lake
Tadpole Lake
Dominek Lake
Clear Lake
Brush Lake
Big Muddy Creek
Cottonwood Creek
Sand Creek
Sheep Creek
Johnson Lake
Homestead Lake
Montana
North Dakota
GWICID: 169218
SC: 1292
SAR: 1.9
GWICID: 212128
SC: 1553
SAR: 2.2
GWICID: 221634
SC: 2325
SAR: 10.3
GWICID: 221637
SC: 2120
SAR: 62
GWICID: 3612
SC: 2889
SAR: 65.3

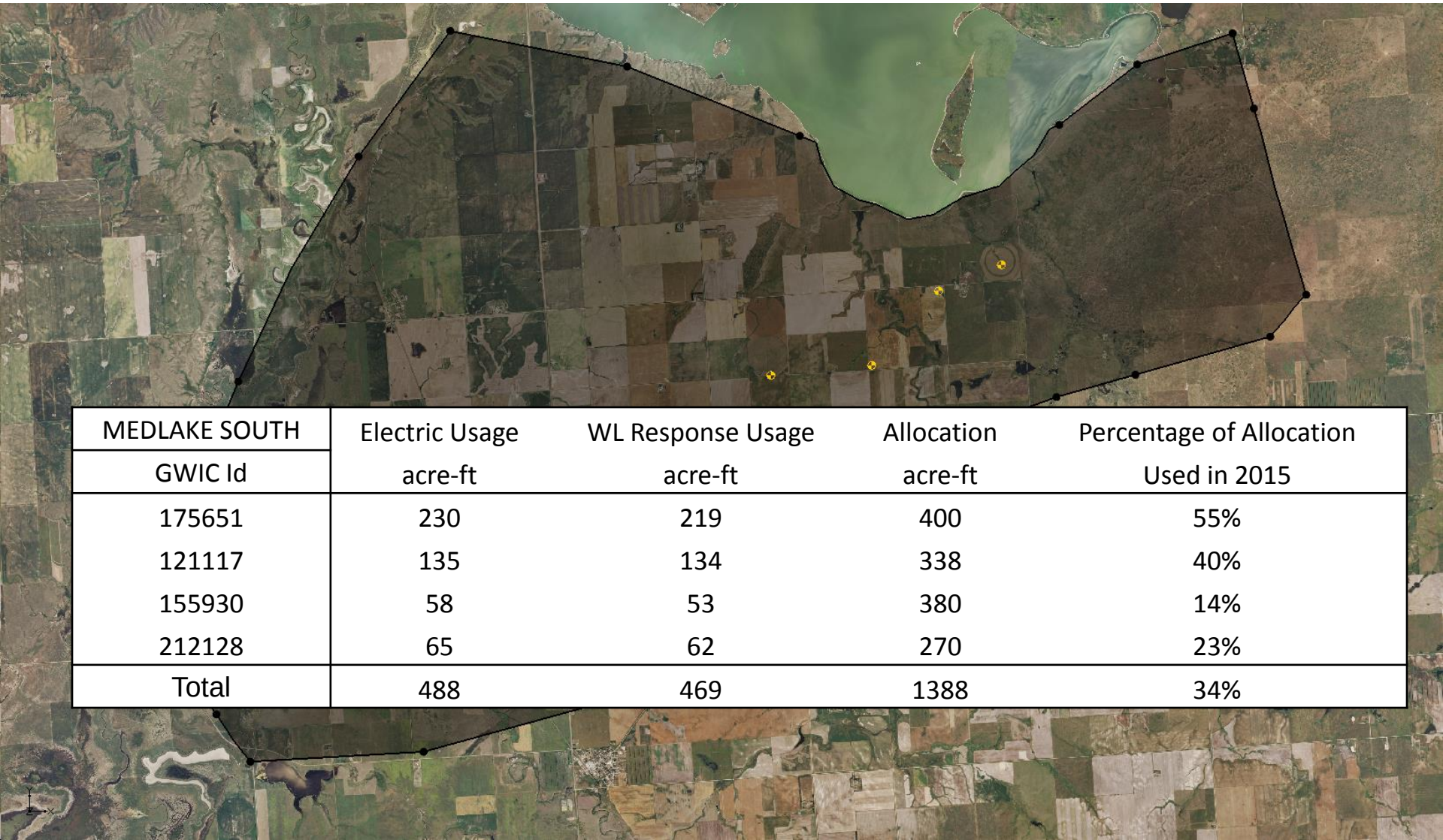

Medicine Lake South
Groundwater Model


2.5 1.25 0 2.5 5 7.5 10
Miles
N
W
E
S
Plate 1
Brush lake internally drained basin
Brockton Froid Fault zone
Water reservation
Wetland Easement
Waterfowl Production Area
Wildlife Refuge
Boundary of buried channels marking limits of the Clear Lake aquifer
(hatched marks on channel side)
Clear Lake model boundary
104.167° W
R58E
Westby
T35N
48.833° N
Goose Lake
Tadpole Lake
T34N
Dominek Lake
T33N
48.667° N
33N 58E
Clear Lake
T32N
Brush Lake
Dagmar
Mallard Pond
104.5° W
104.333° W
Long Lake
Kain Lake
T31N
48.5° N
Big Muddy Creek
Medicine Lake
Cottonwood Creek
Montana
North Dakota
Gaffney Lake
Medicine Lake
T30N
Sand Creek
Homestead
Homestead Lake
R57E
R58E
Froid
48.333° N
Johnson Lake
R55E
R56E

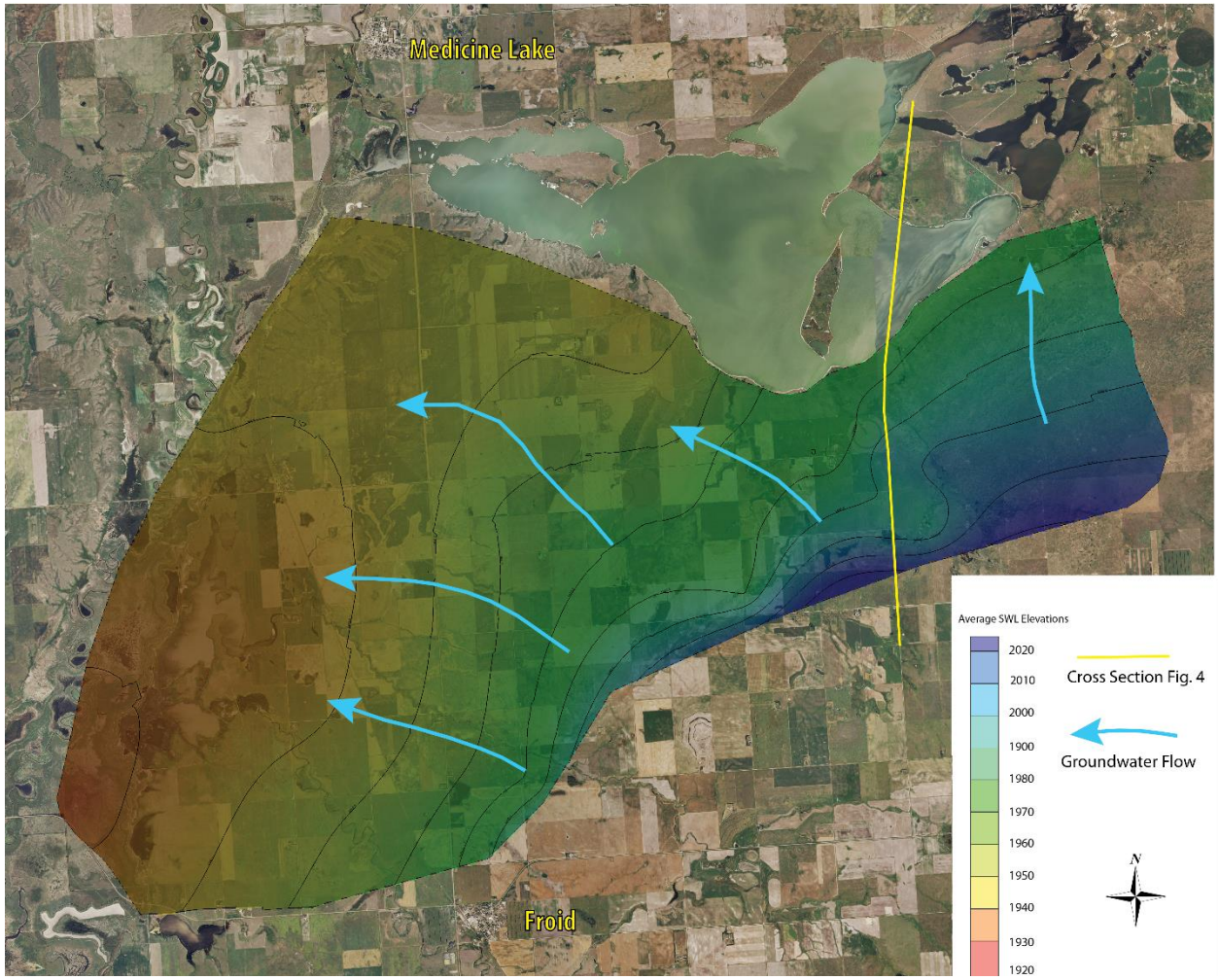
Model Boundary

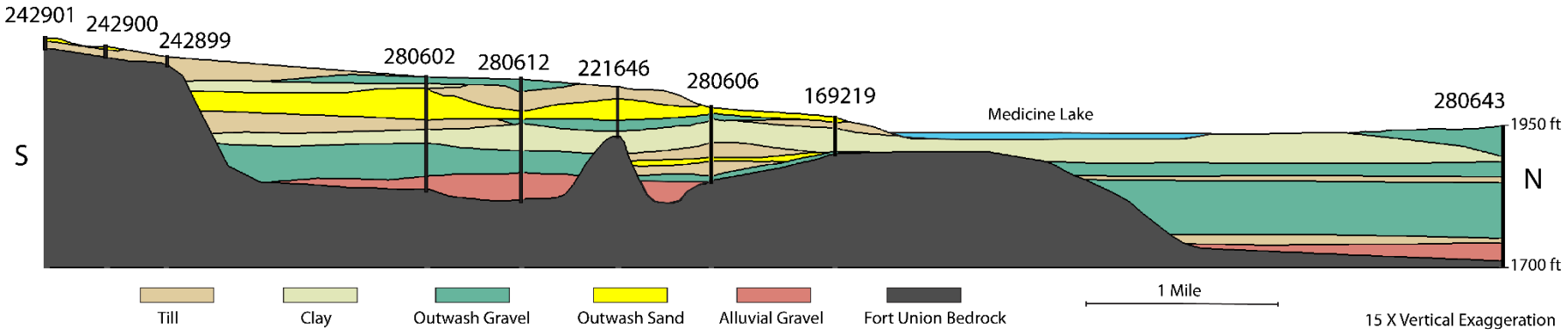
Sand Dunes Recharge Area

Existing Irrigation Wells

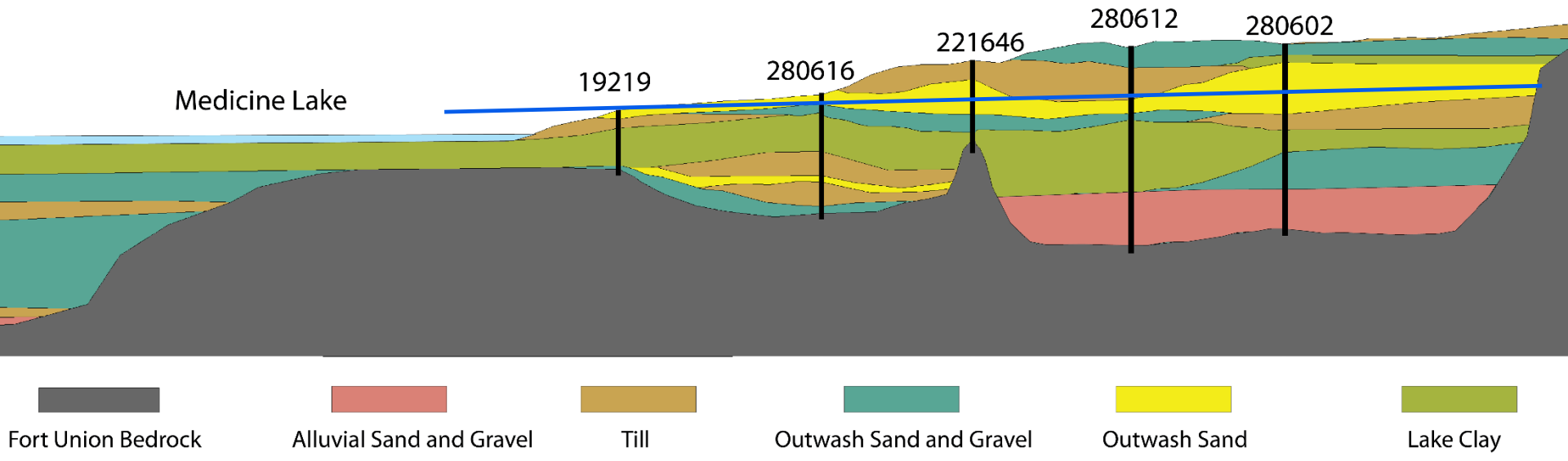


MEDLAKE SOUTH	Electric Usage	WL Response Usage	Allocation	Percentage of Allocation
GWIC Id	acre-ft	acre-ft	acre-ft	Used in 2015
175651	230	219	400	55%
121117	135	134	338	40%
155930	58	53	380	14%
212128	65	62	270	23%
Total	488	469	1388	34%

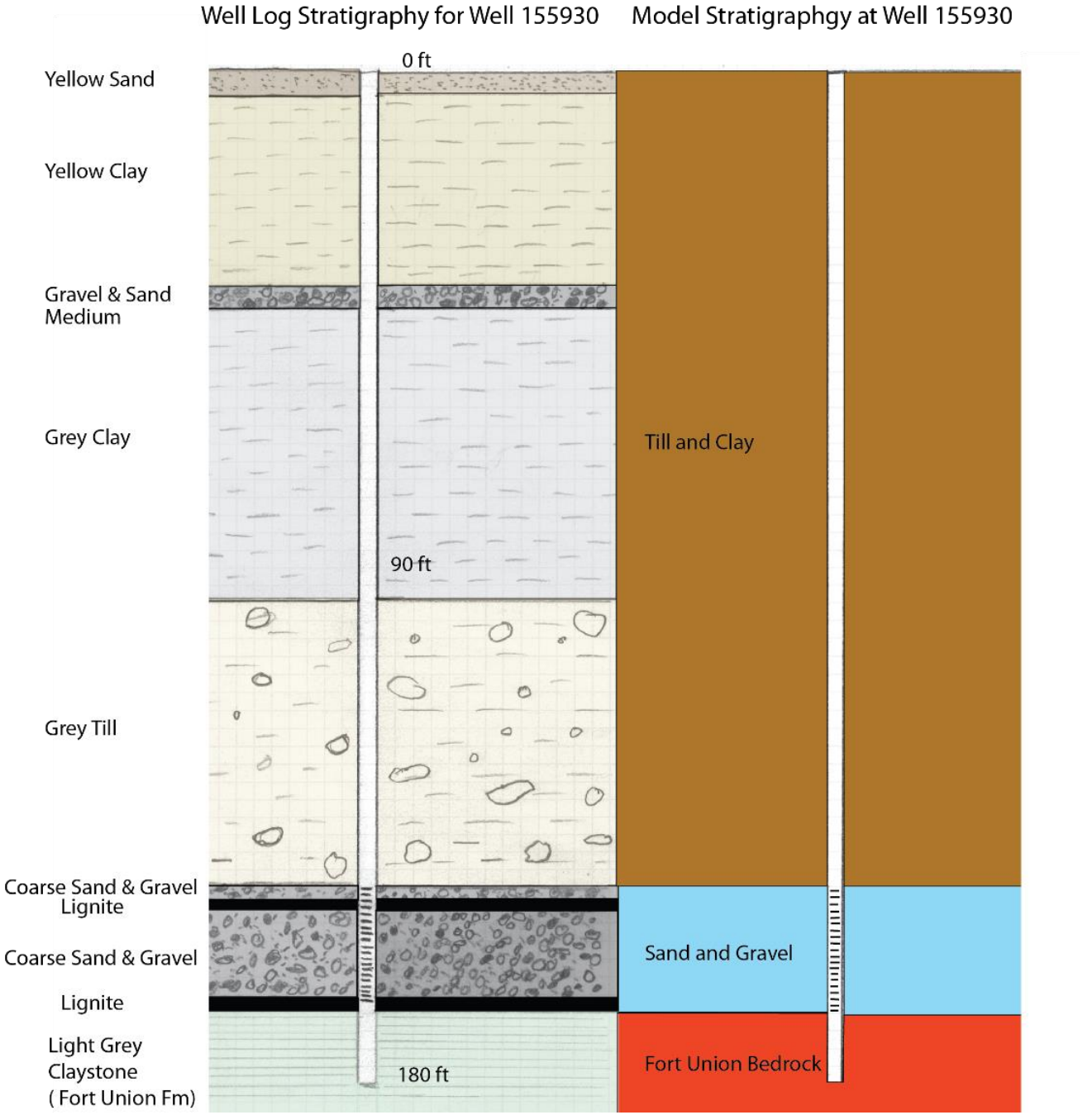

Medicine Lake
Froid
Average SWL Elevations
2020
2010
2000
1900
1980
1970
1960
1950
1940
1930
1920
Cross Section Fig. 4
Groundwater Flow
N


242901
242900
242899
280602
280612
221646
280606
169219
Medicine Lake
280643
S
N
1950 ft
1700 ft
Till
Clay
Outwash Gravel
Outwash Sand
Alluvial Gravel
Fort Union Bedrock
1 Mile
15 X Vertical Exaggeration

Aquifer Isolation from Medicine Lake

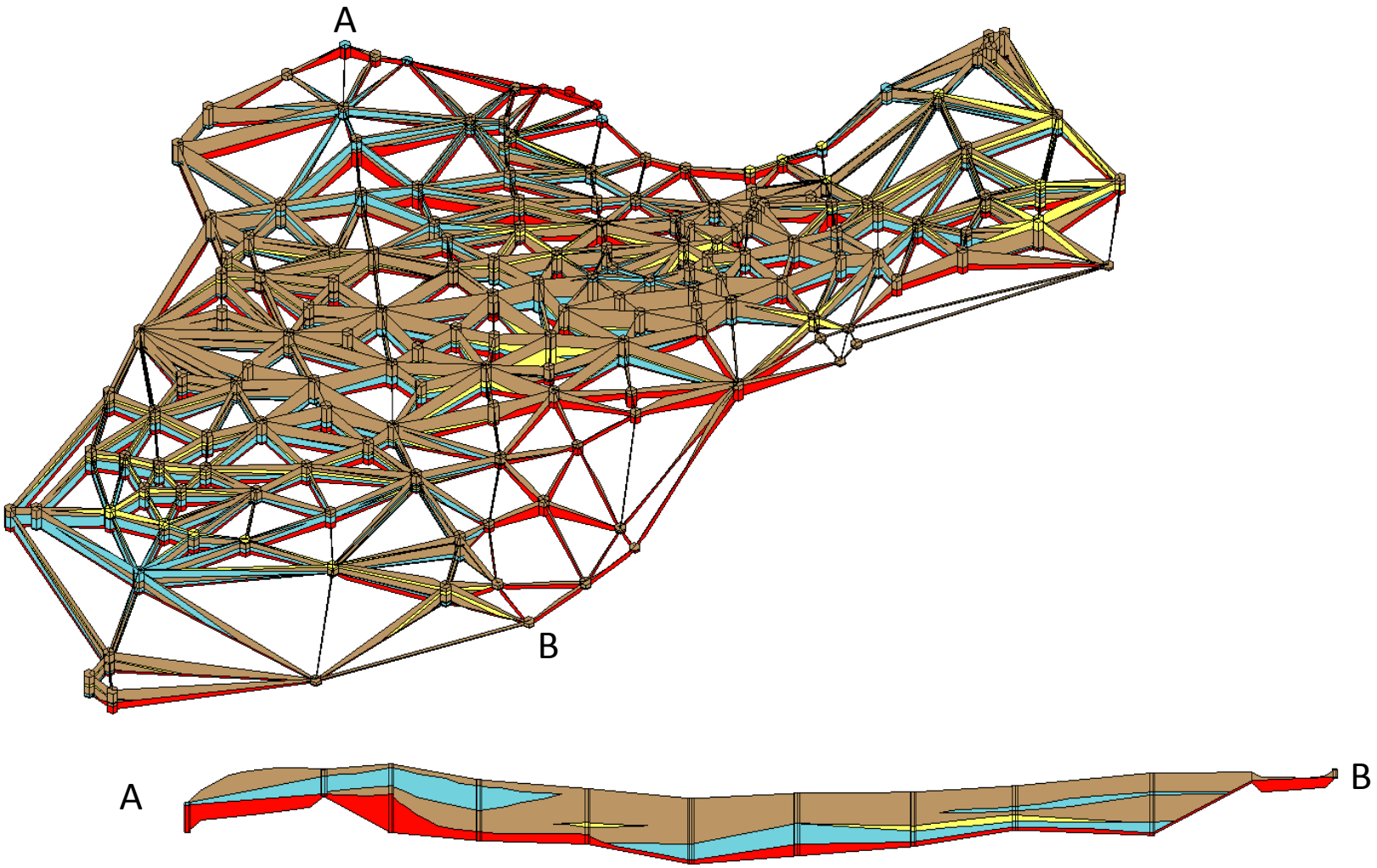


Stratigraphy Modeling

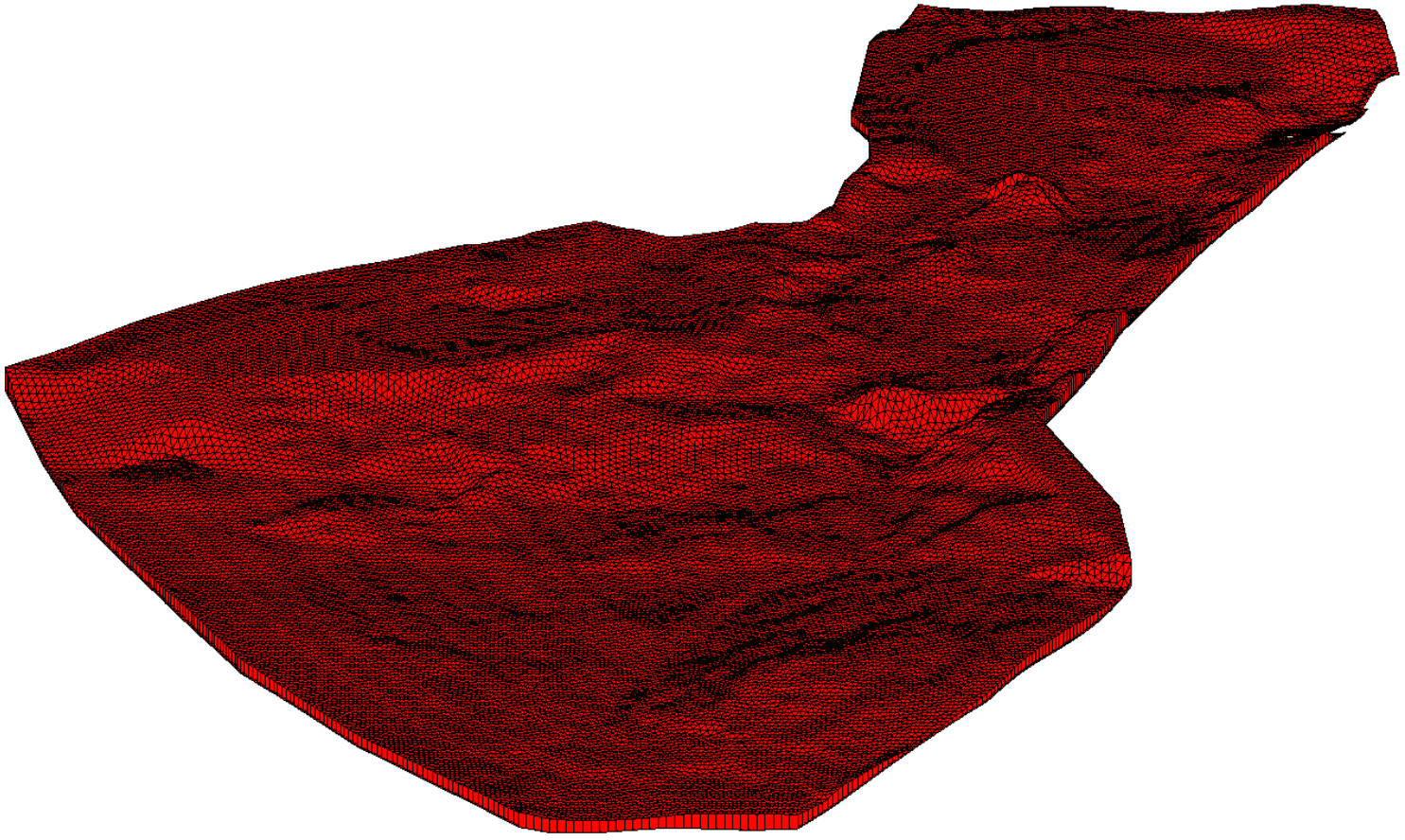


Boreholes and Cross Sections

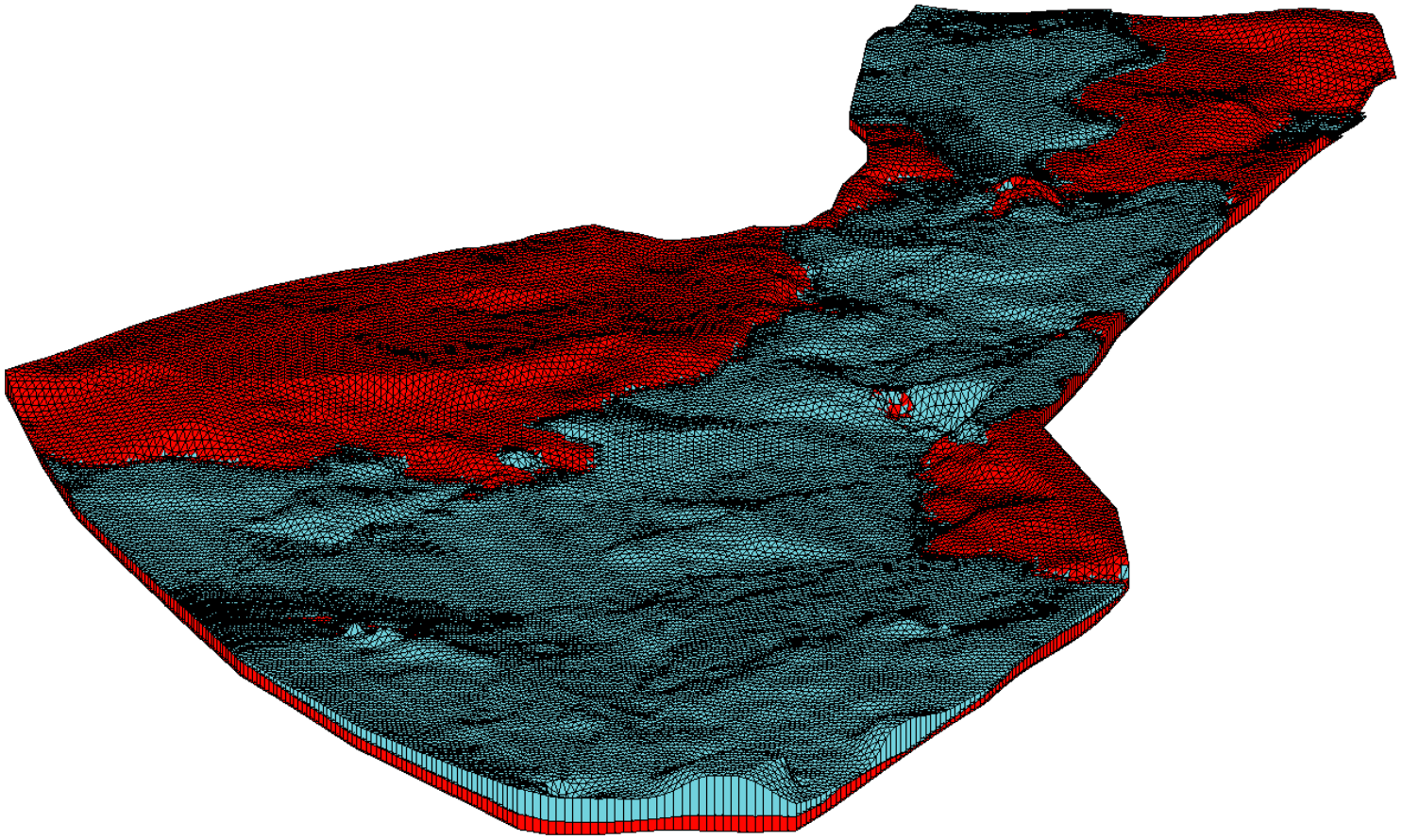
Cross Sections



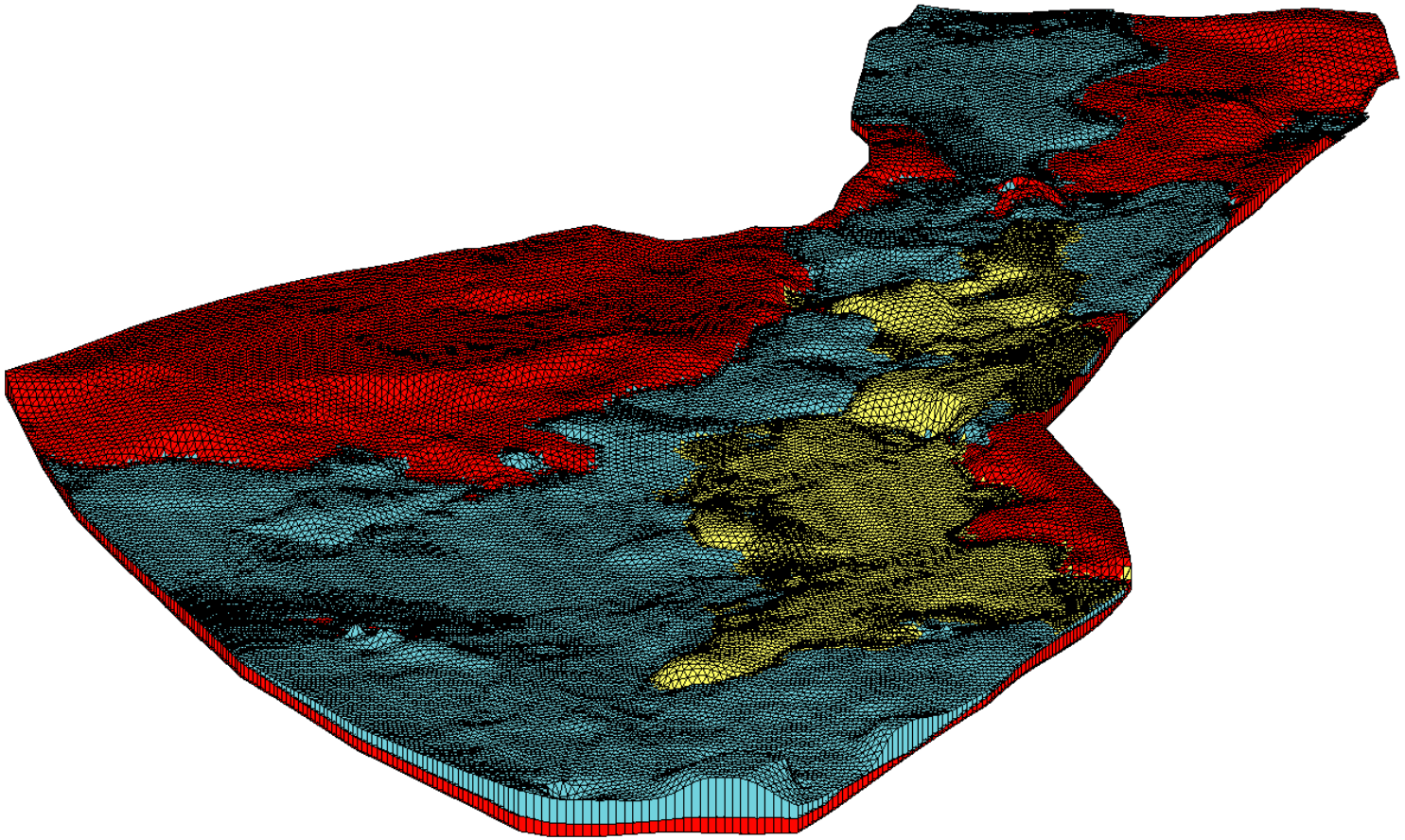
Fort Union Bedrock



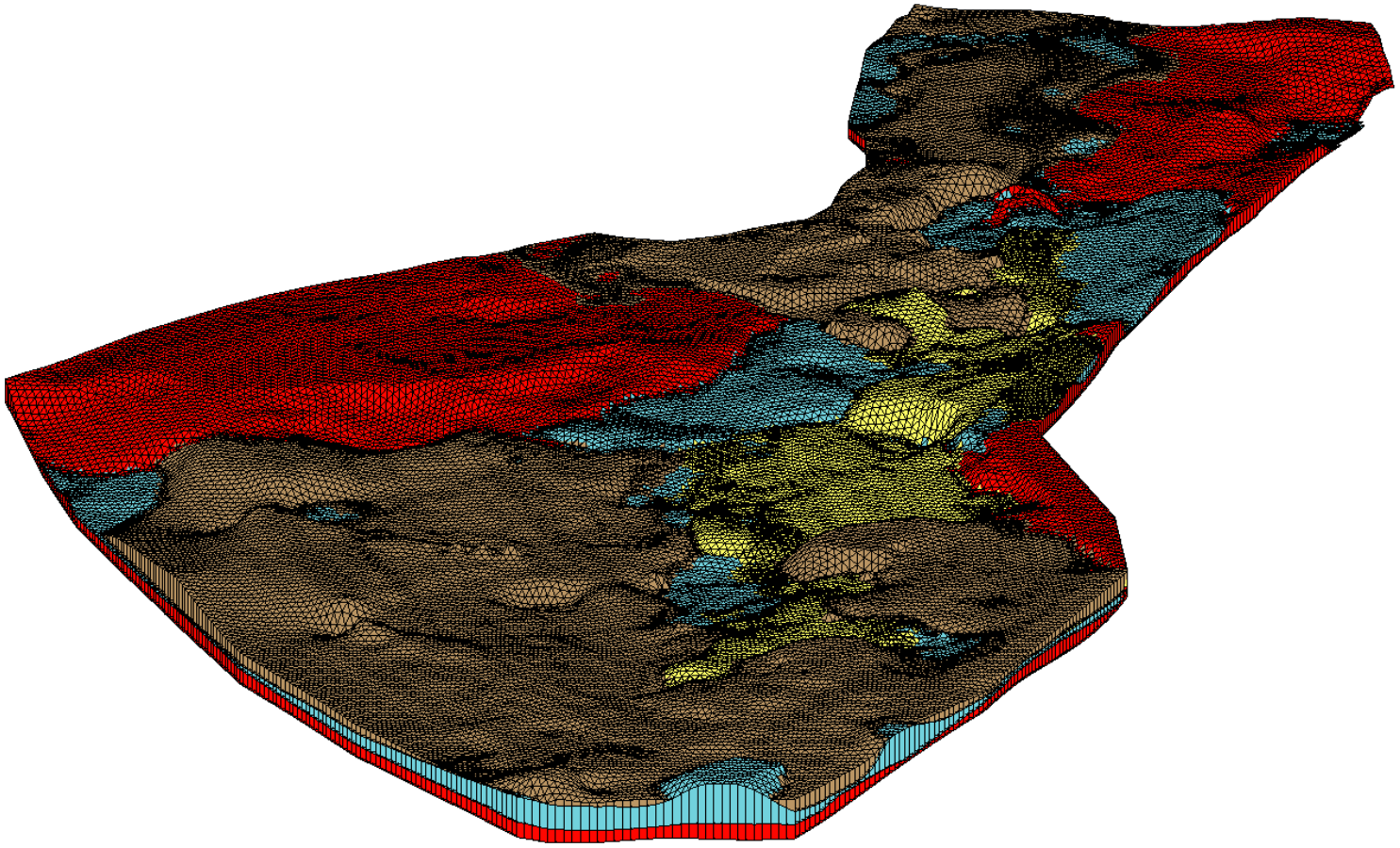
Lower Alluvial and Glacial Gravel



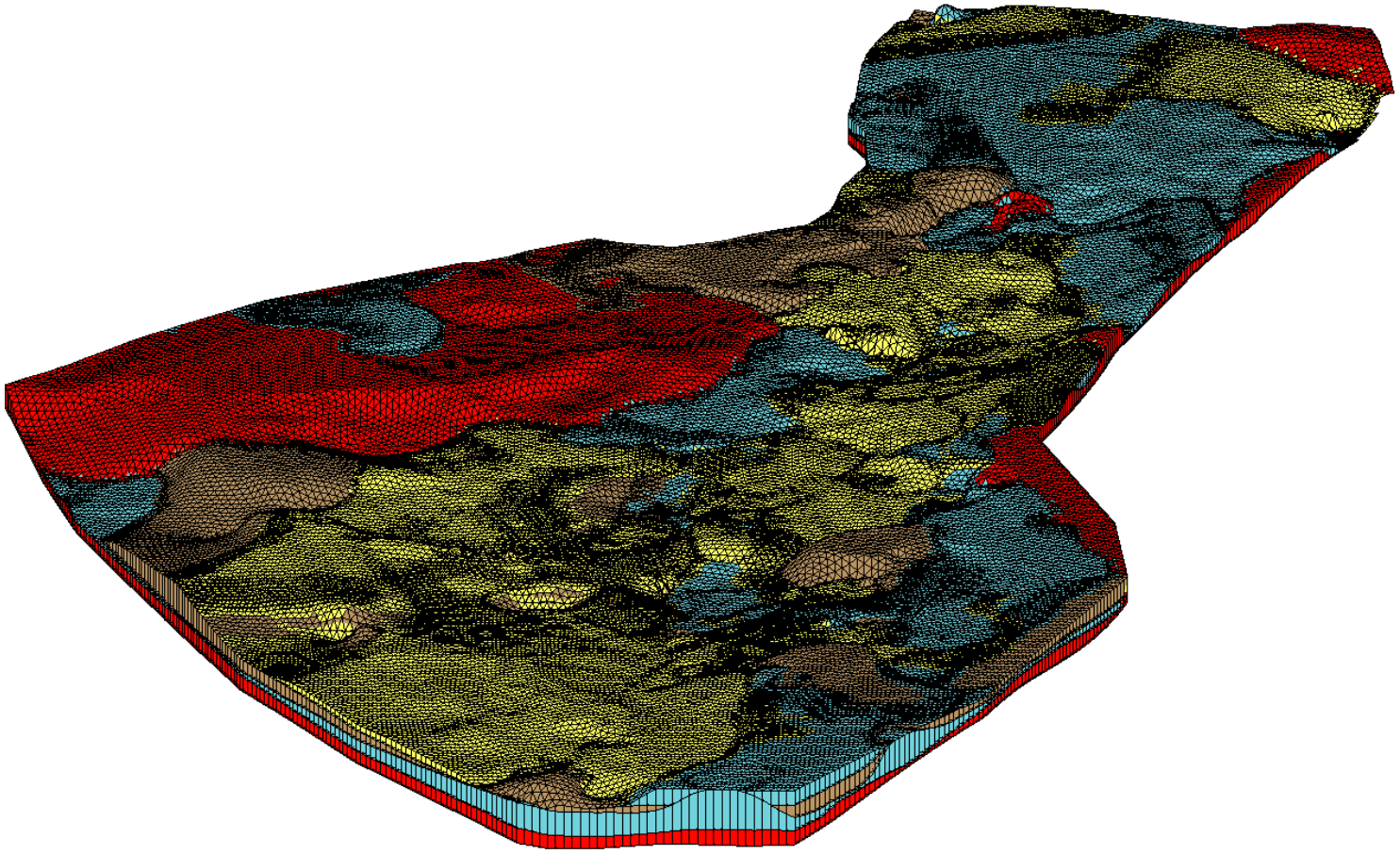
Sand



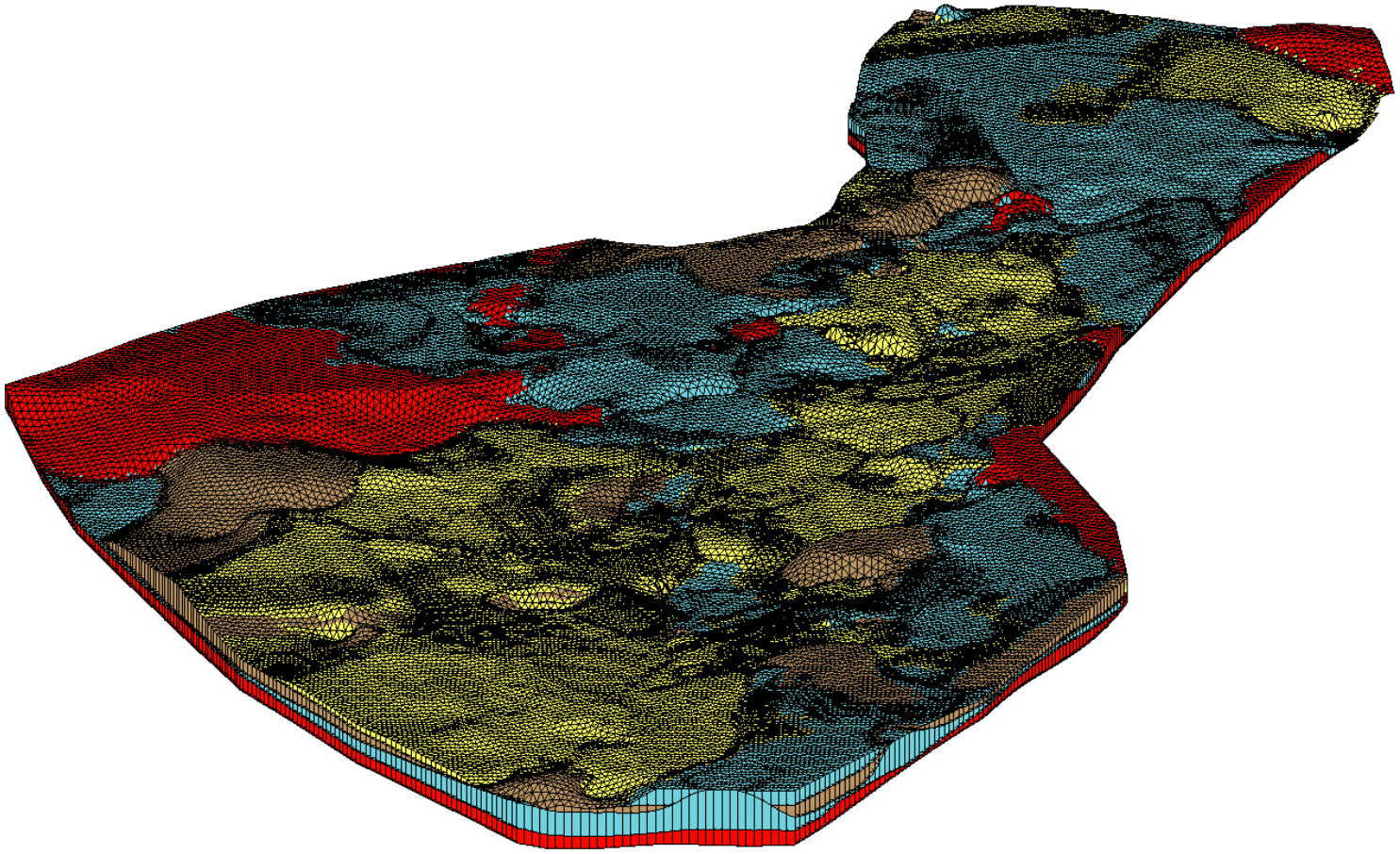
Glacial Till and Lake Clay



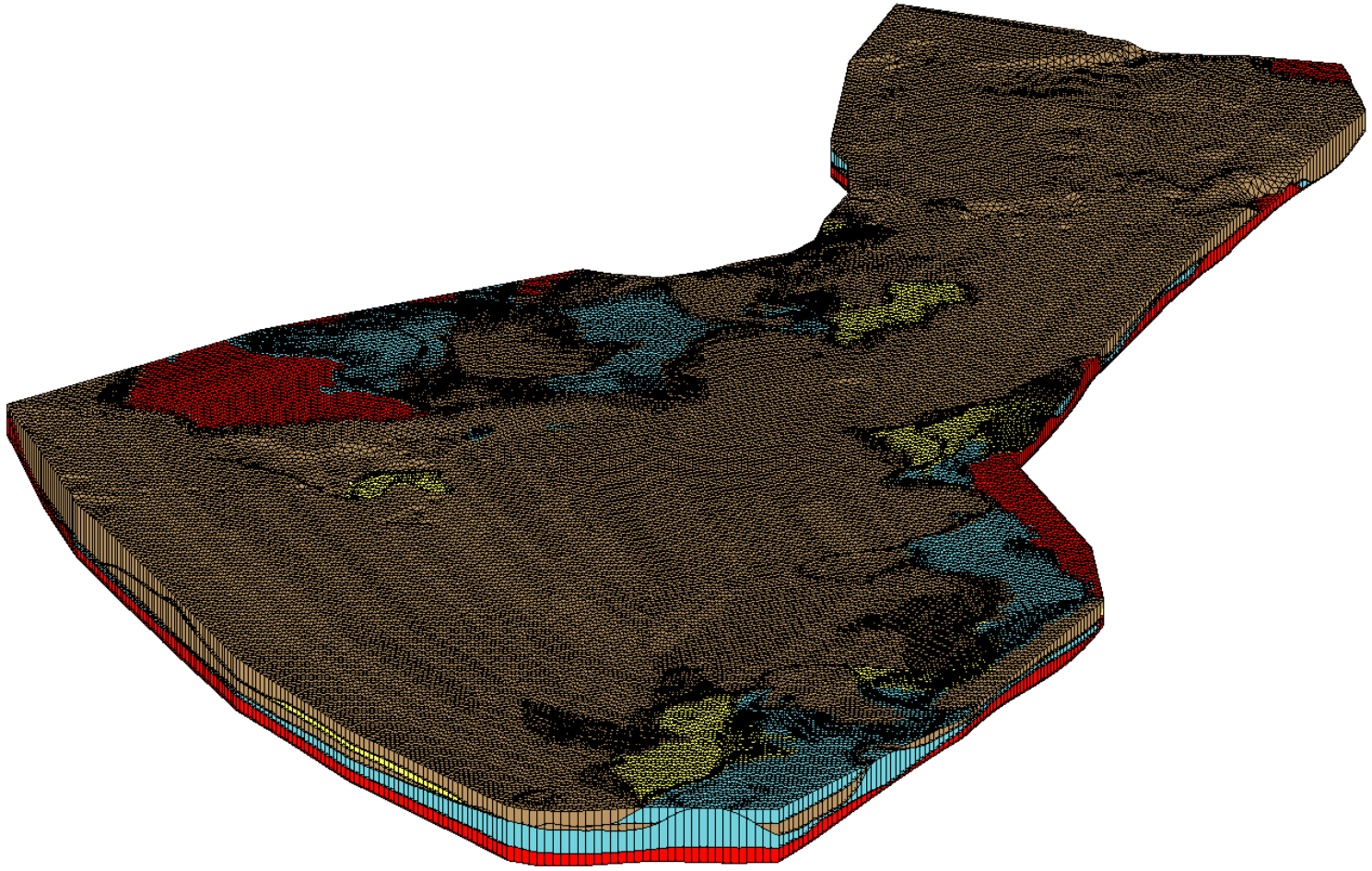
Glacial Outwash Sand and Gravel



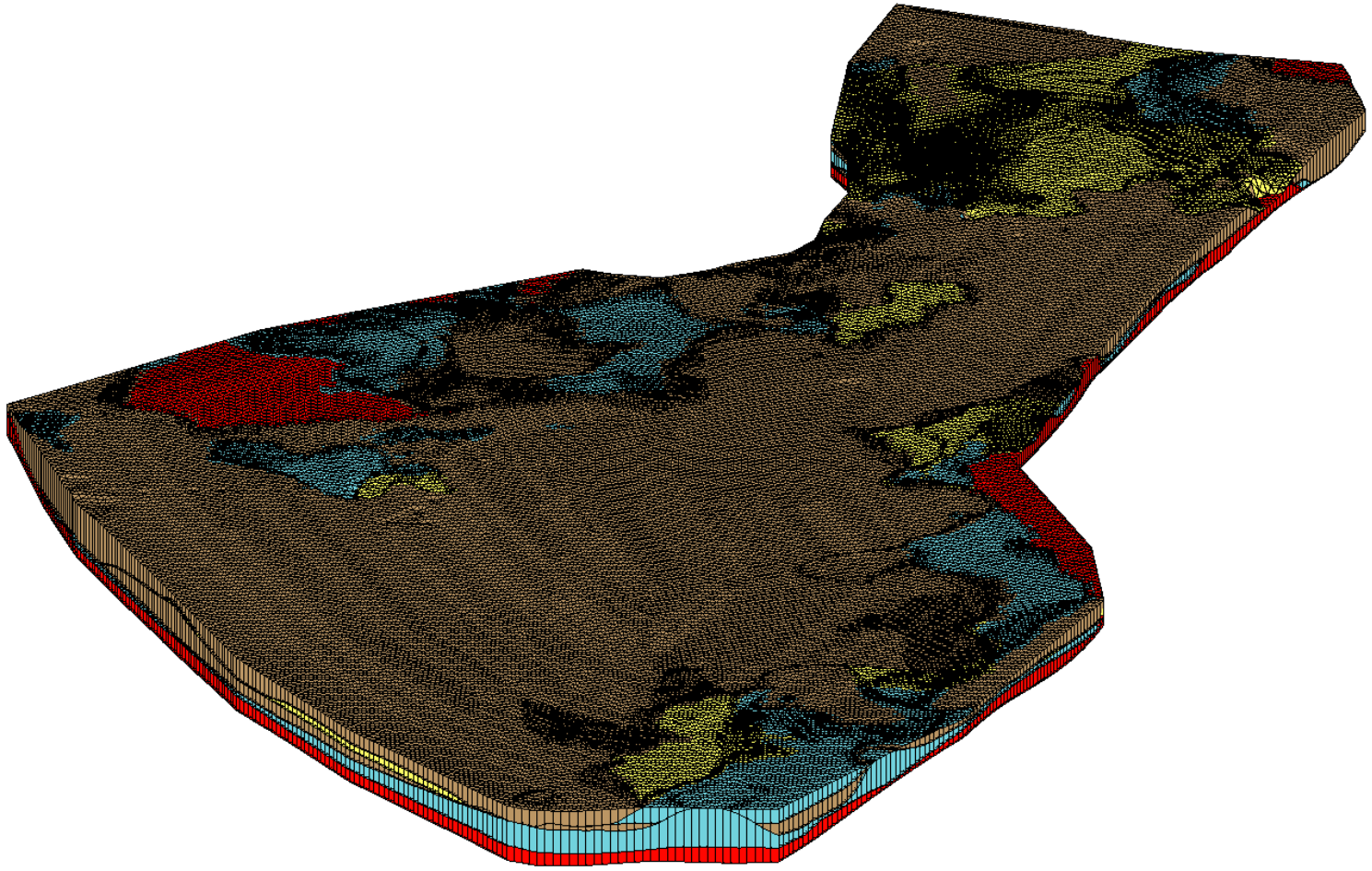
Upper Terrace Gravels?



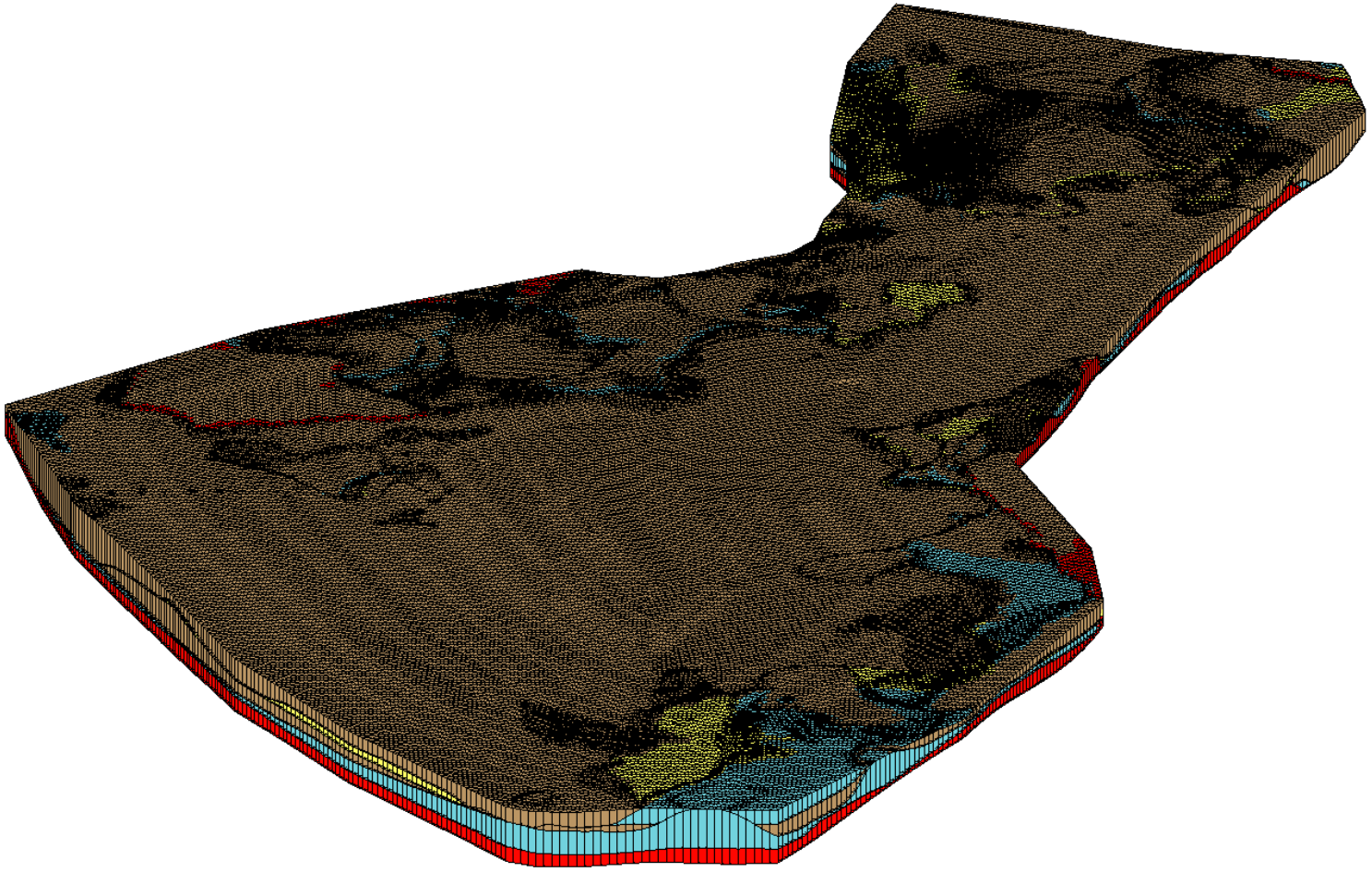
Glacial Till and Lake Clay



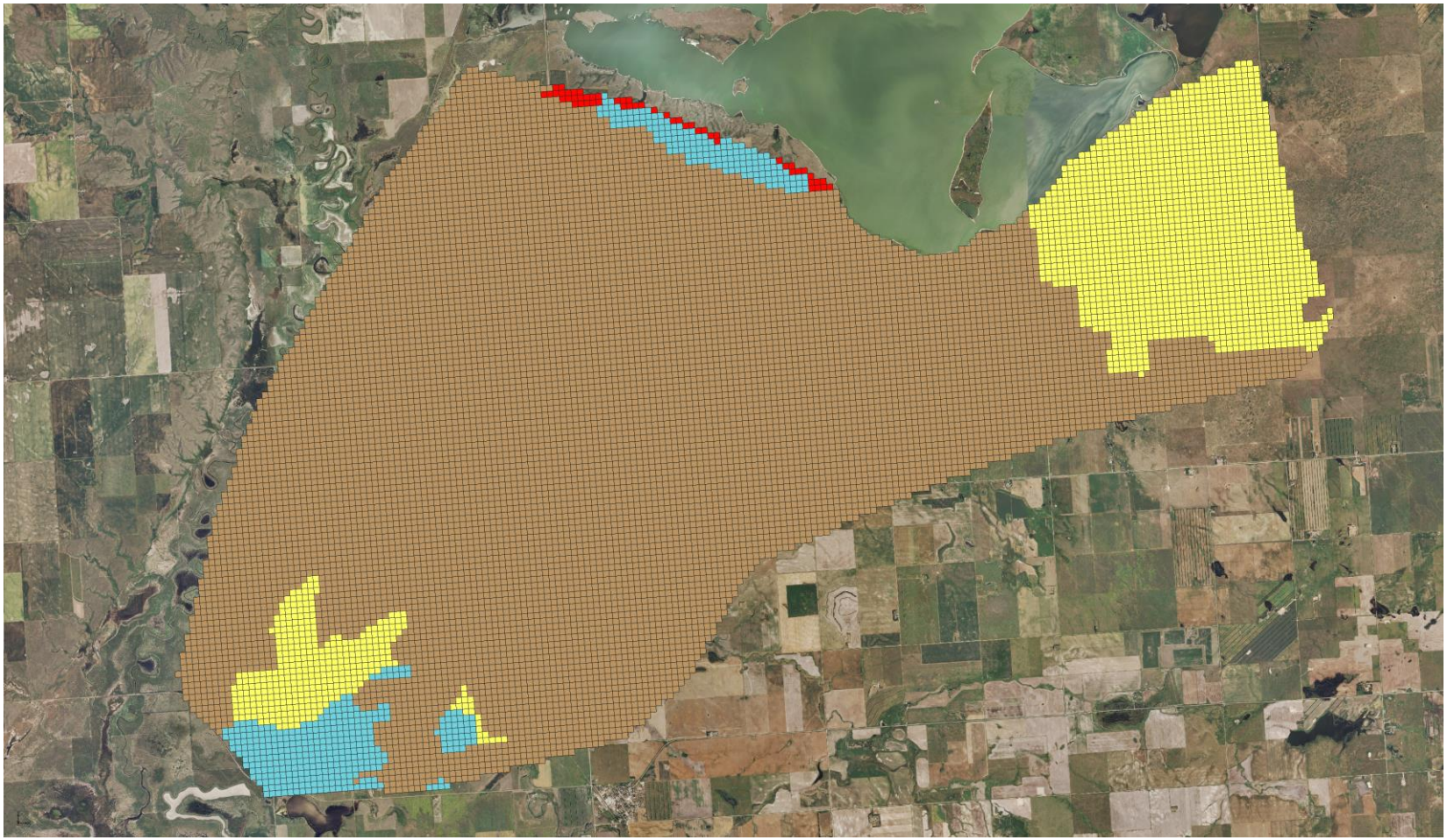
Sand Dunes and Till



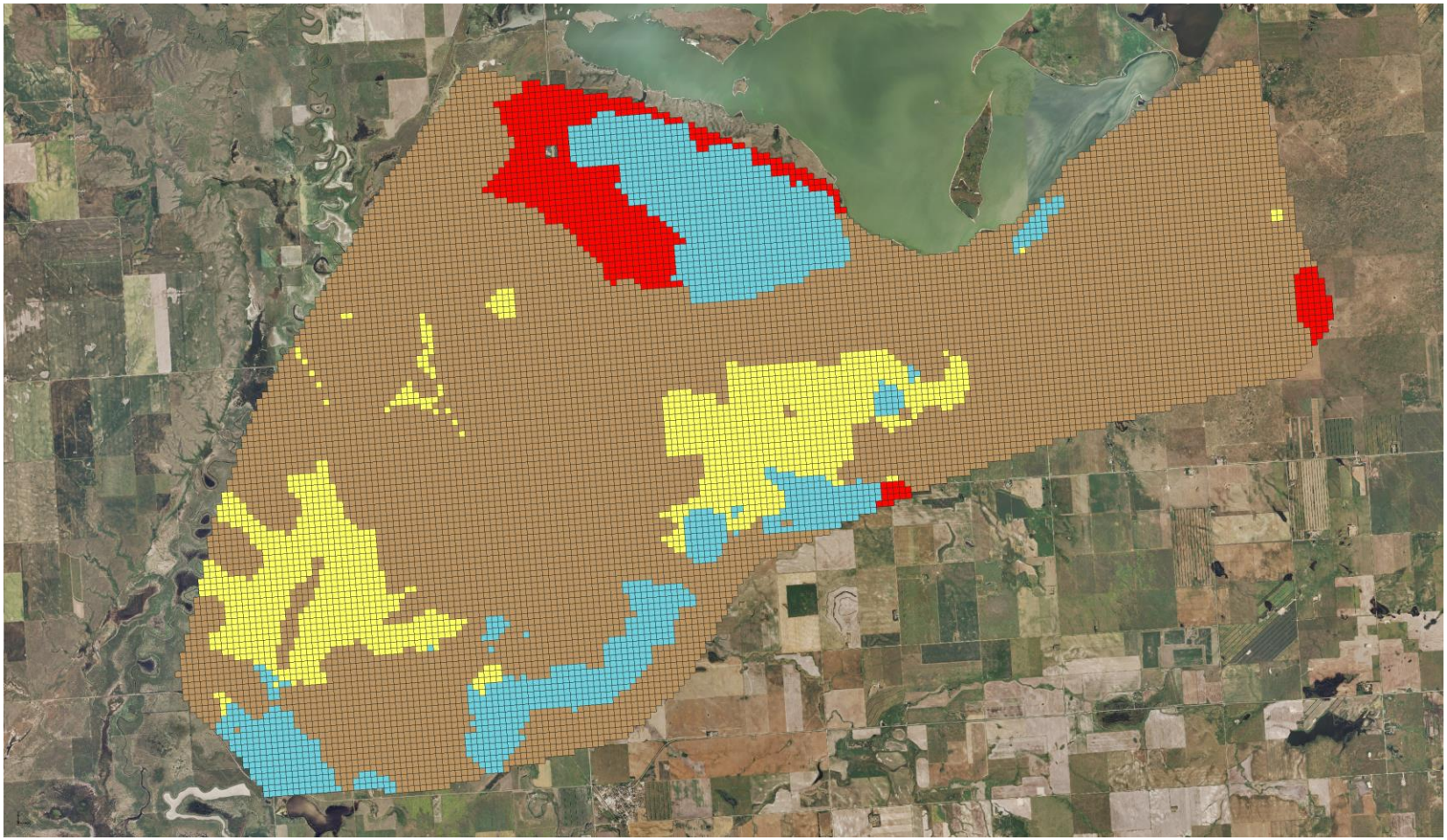
Upper Till and Clay



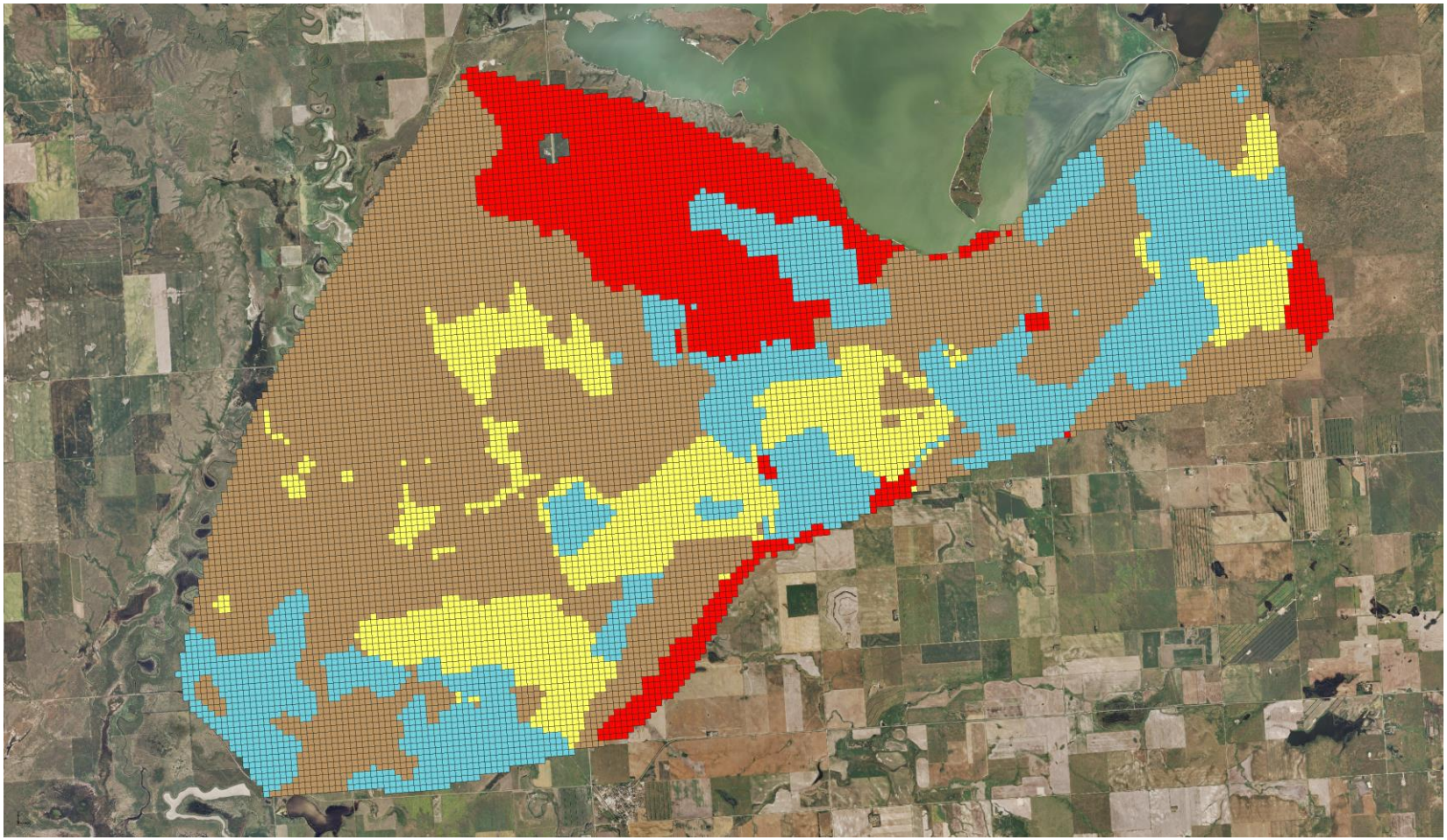
Layer 1



Layer 2



Layer 3



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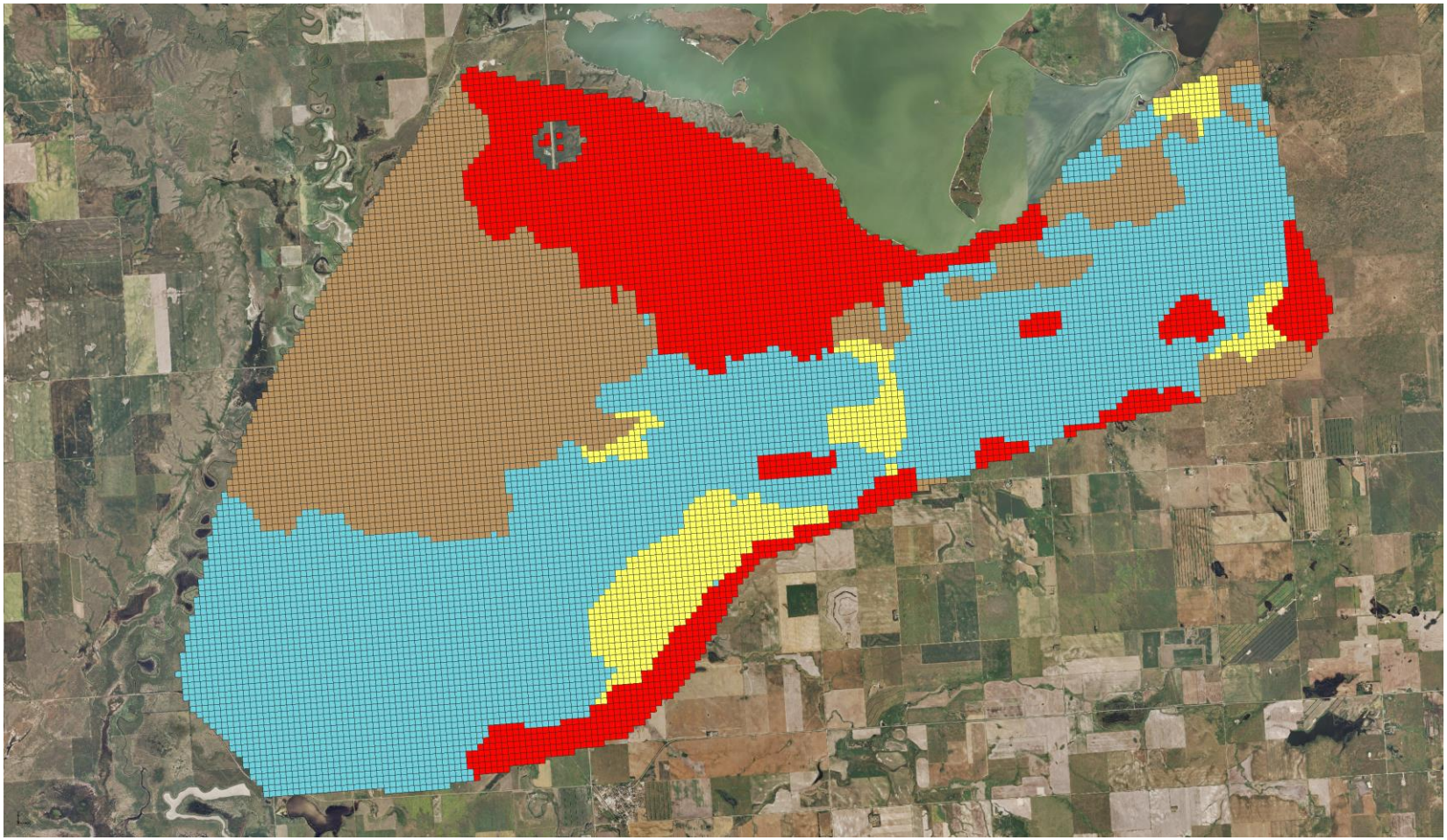
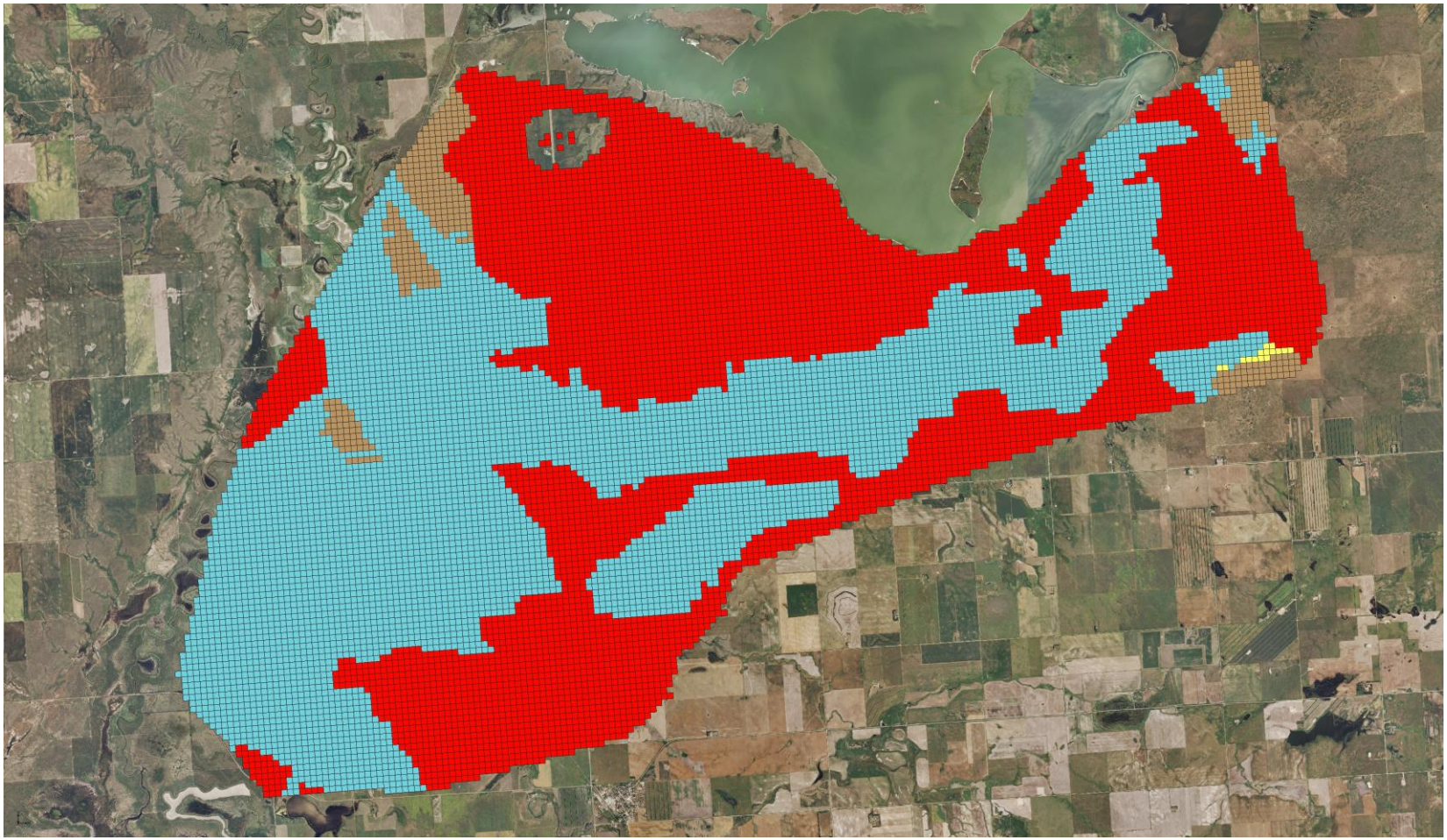
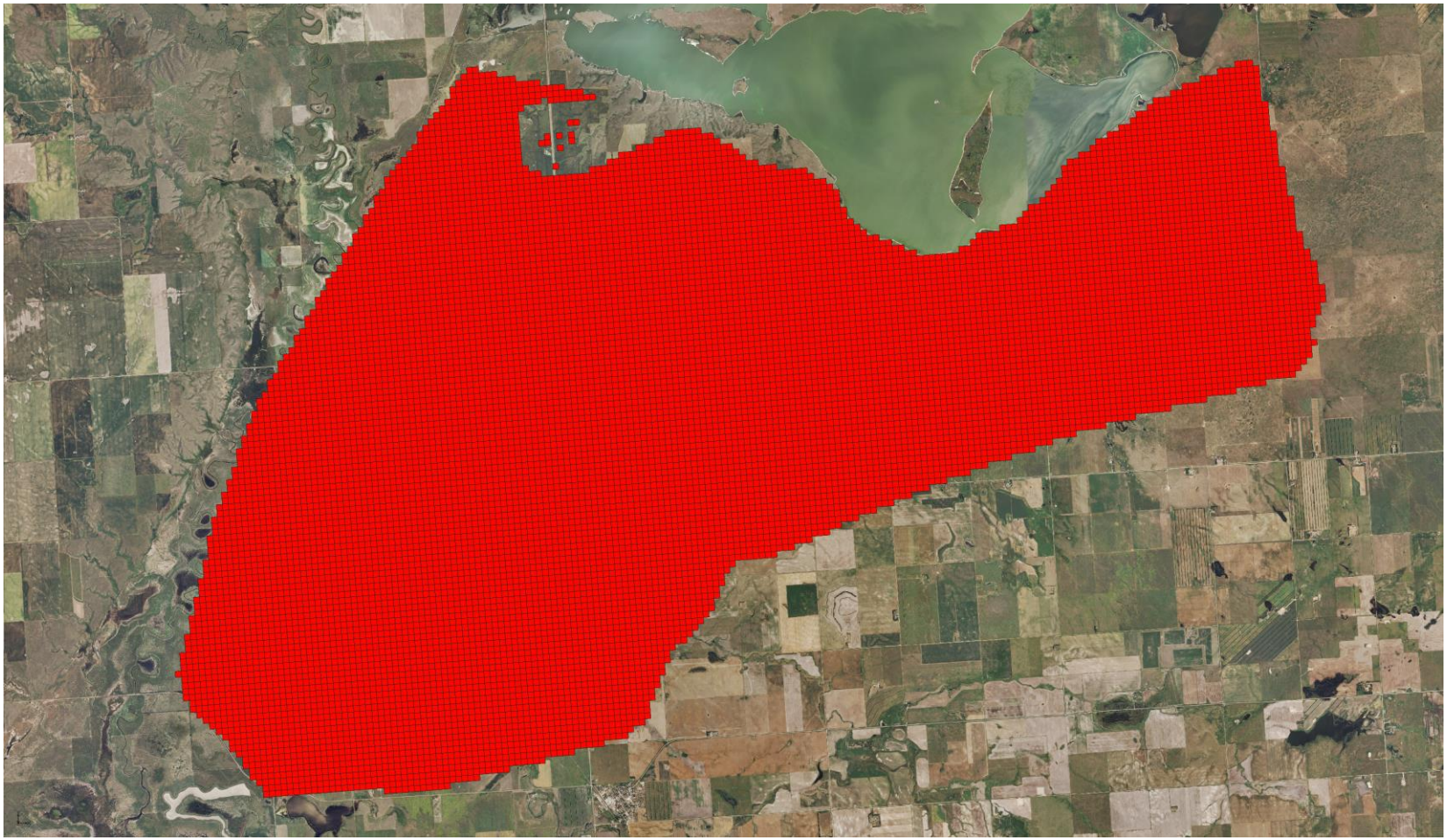


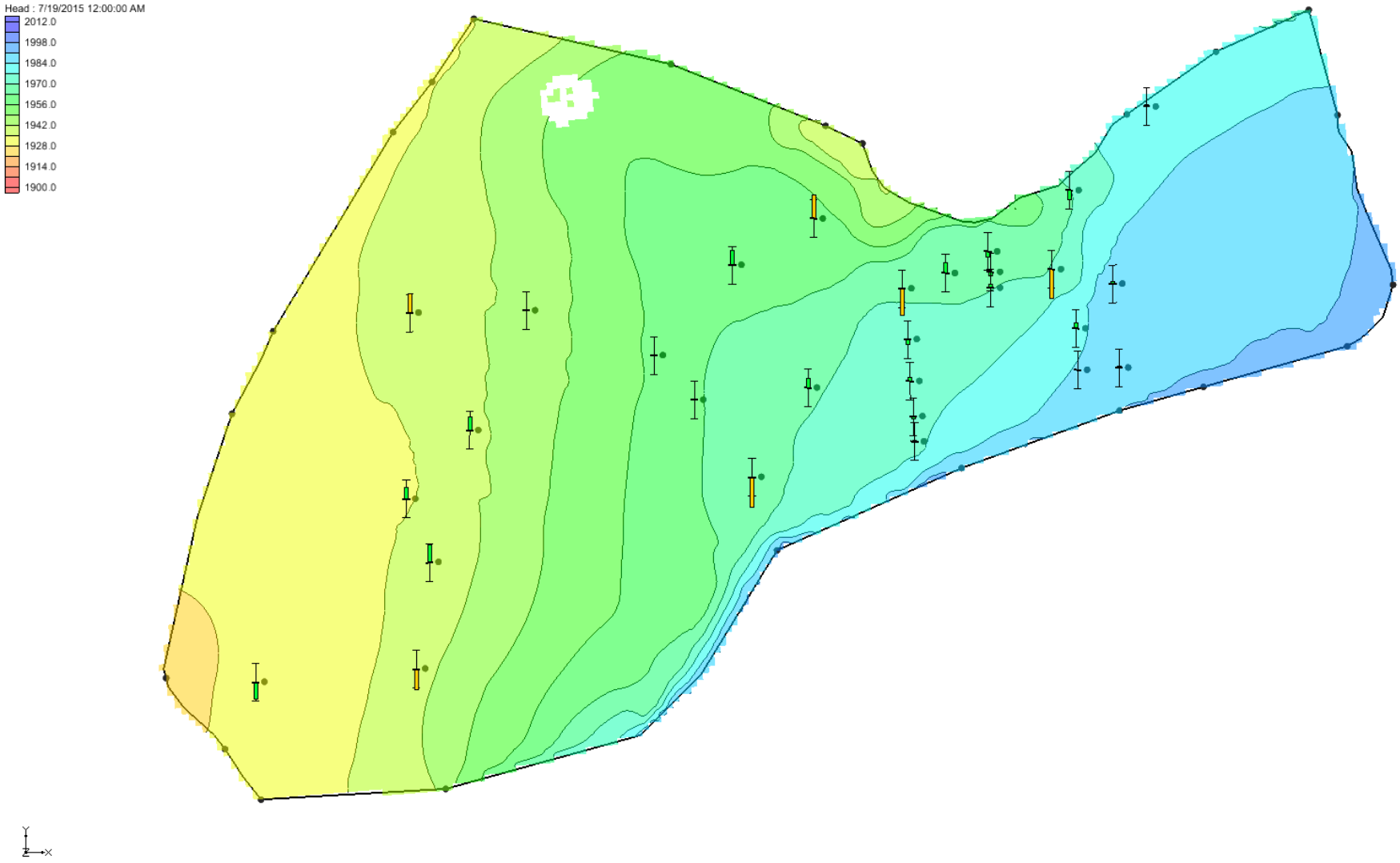
Layer 5



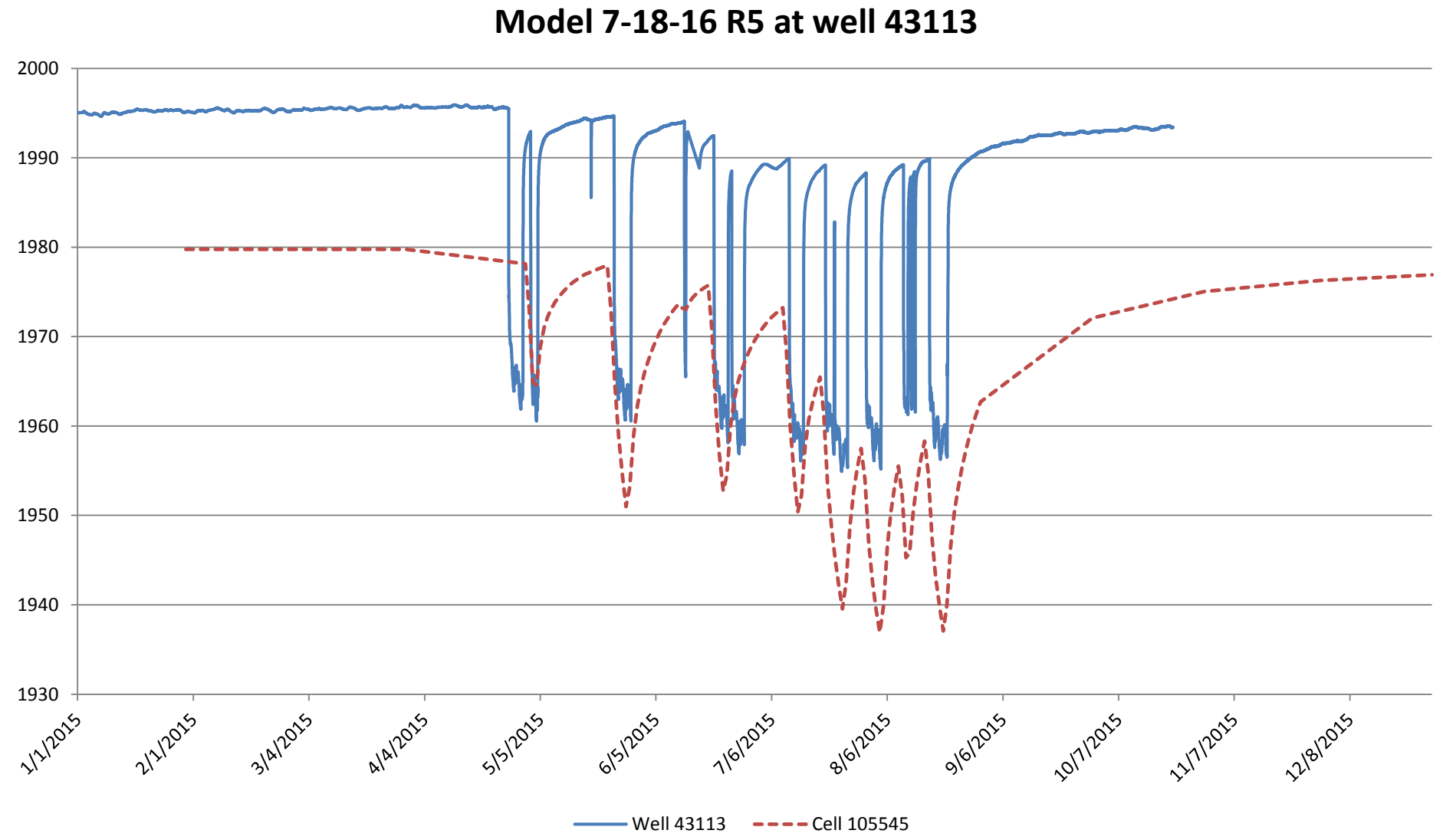
Layer 6



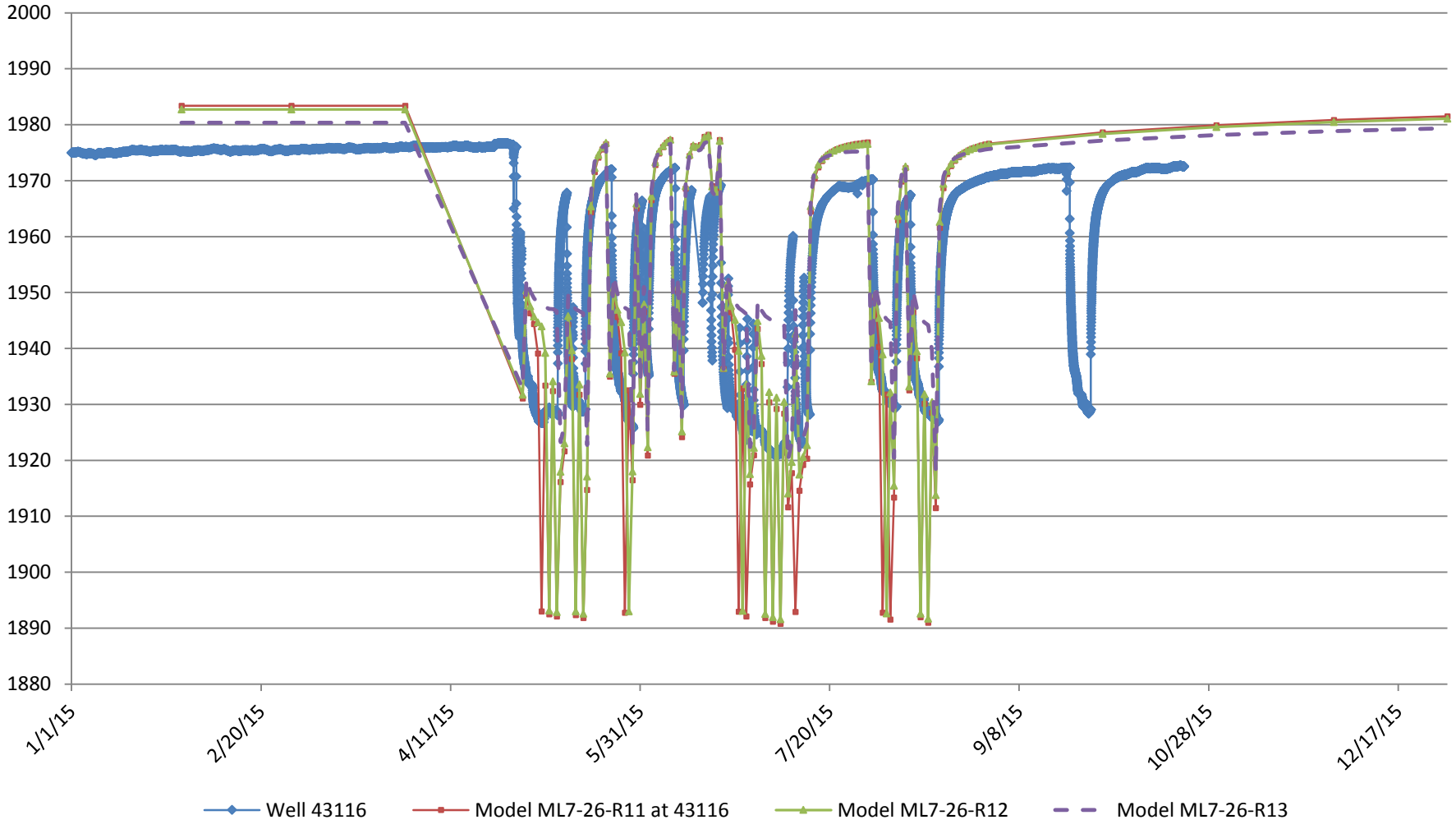
Observation Wells



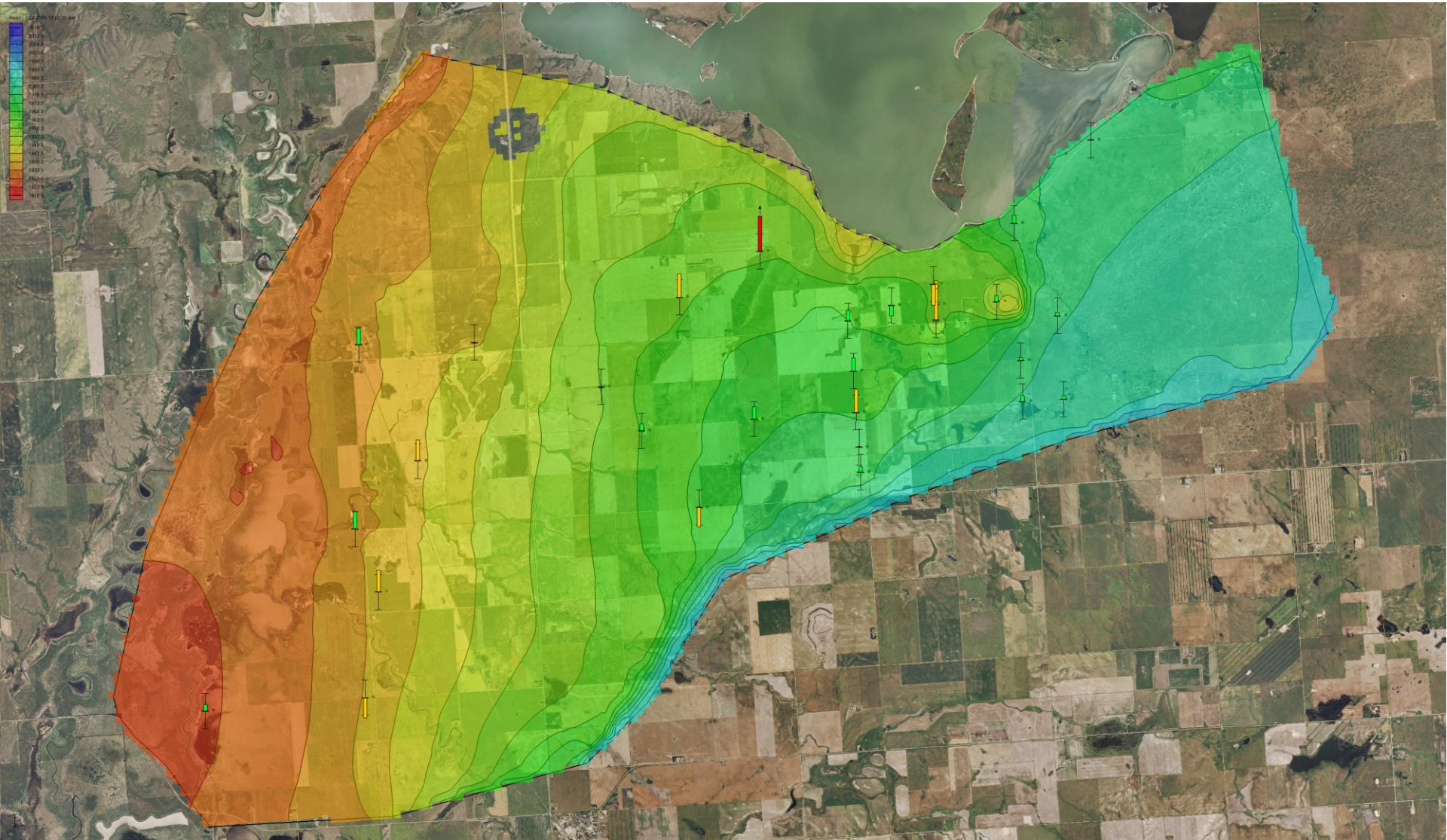
Curve matching calibration



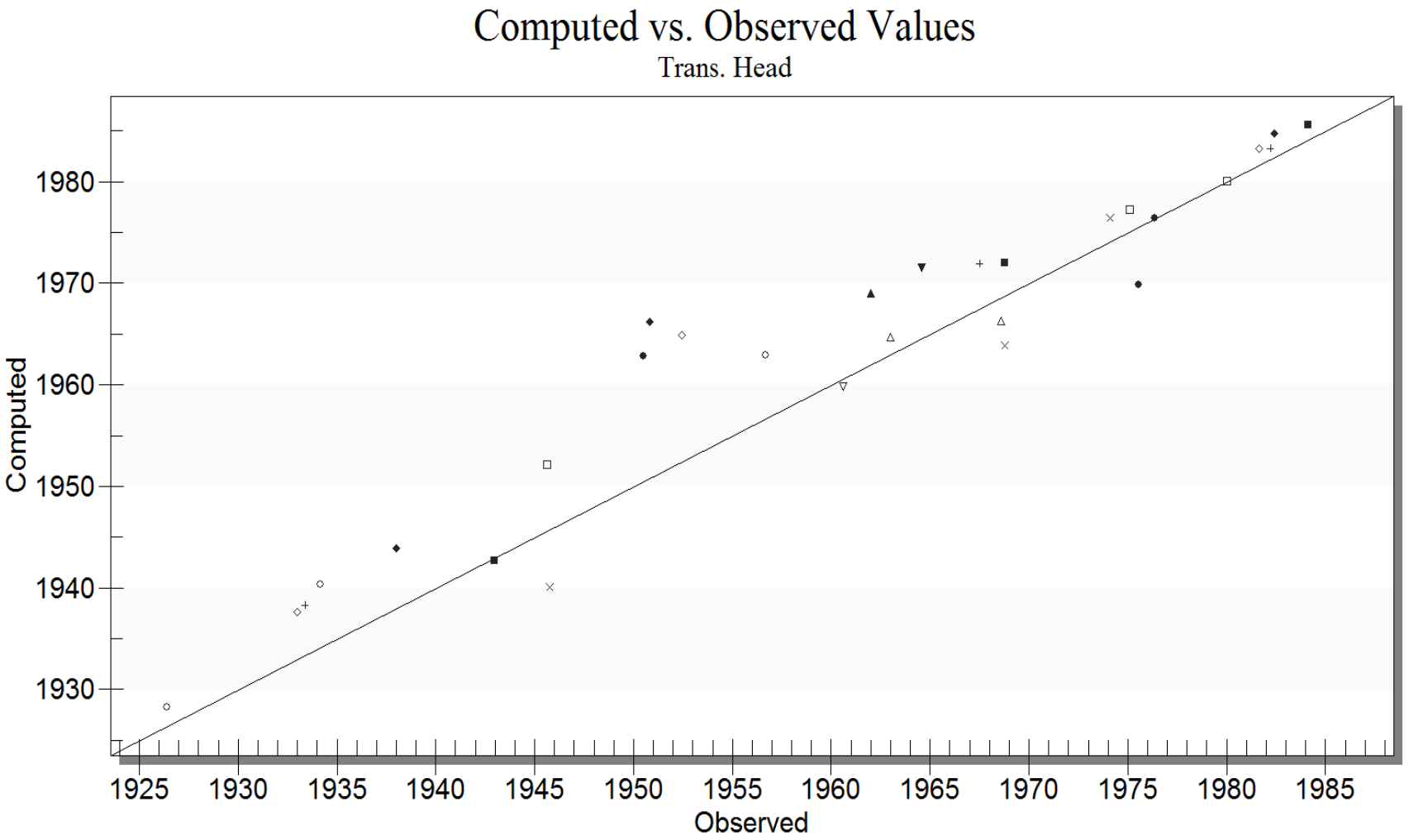
Curve matching calibration



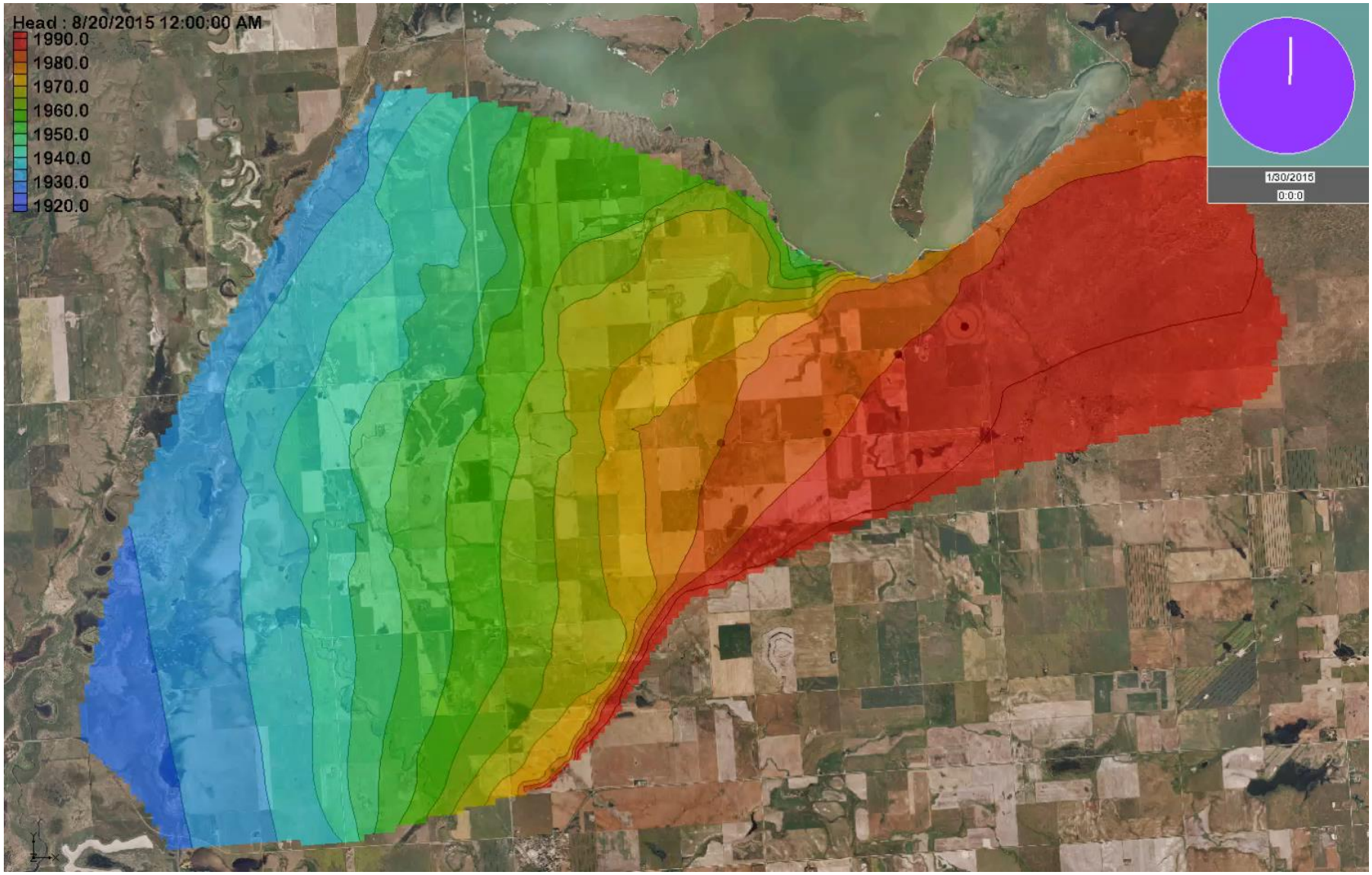
Calibration for July 25, 2015 Water Levels



Calibration for July 25, 2015



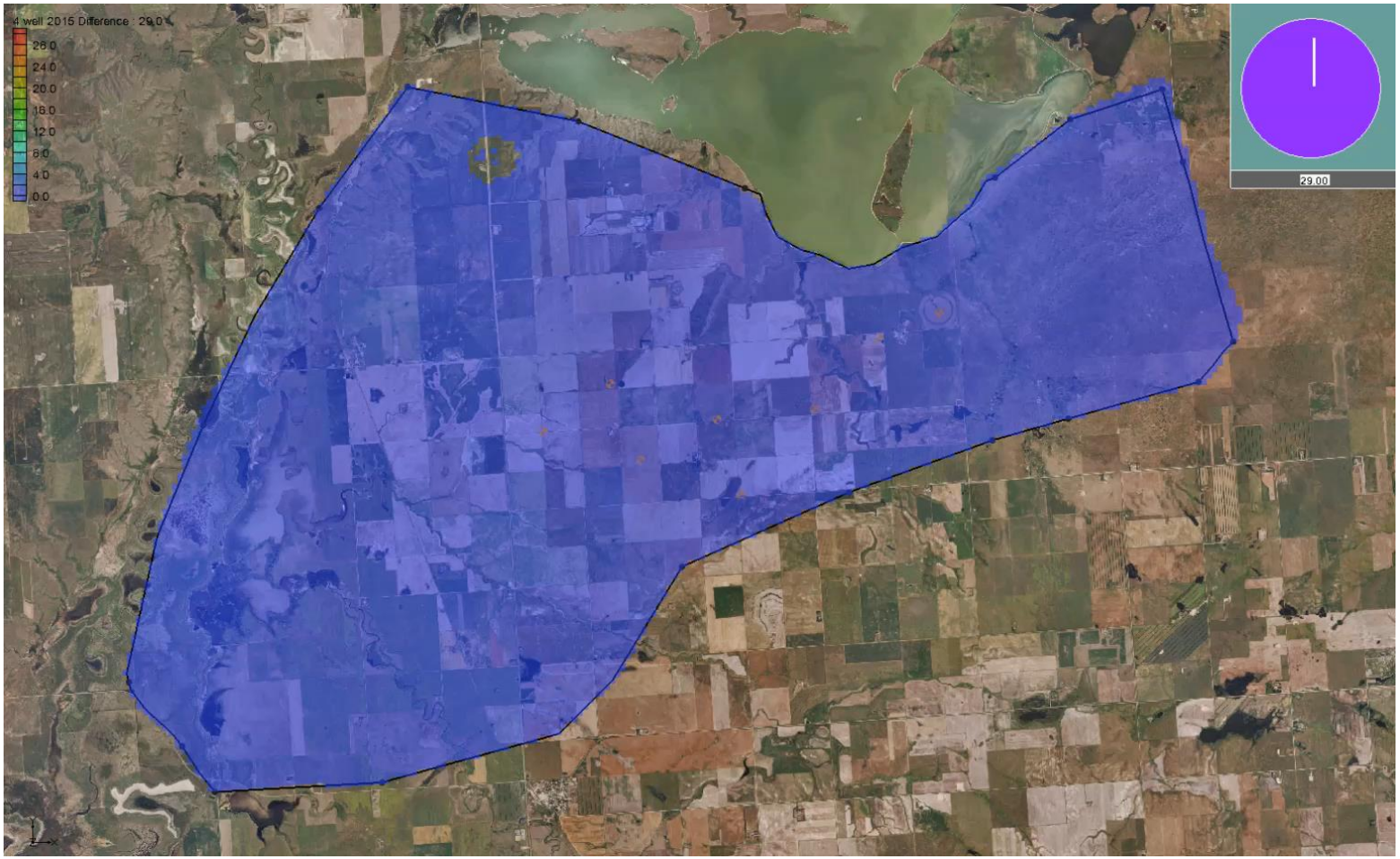
Animation for 2015 Water Levels



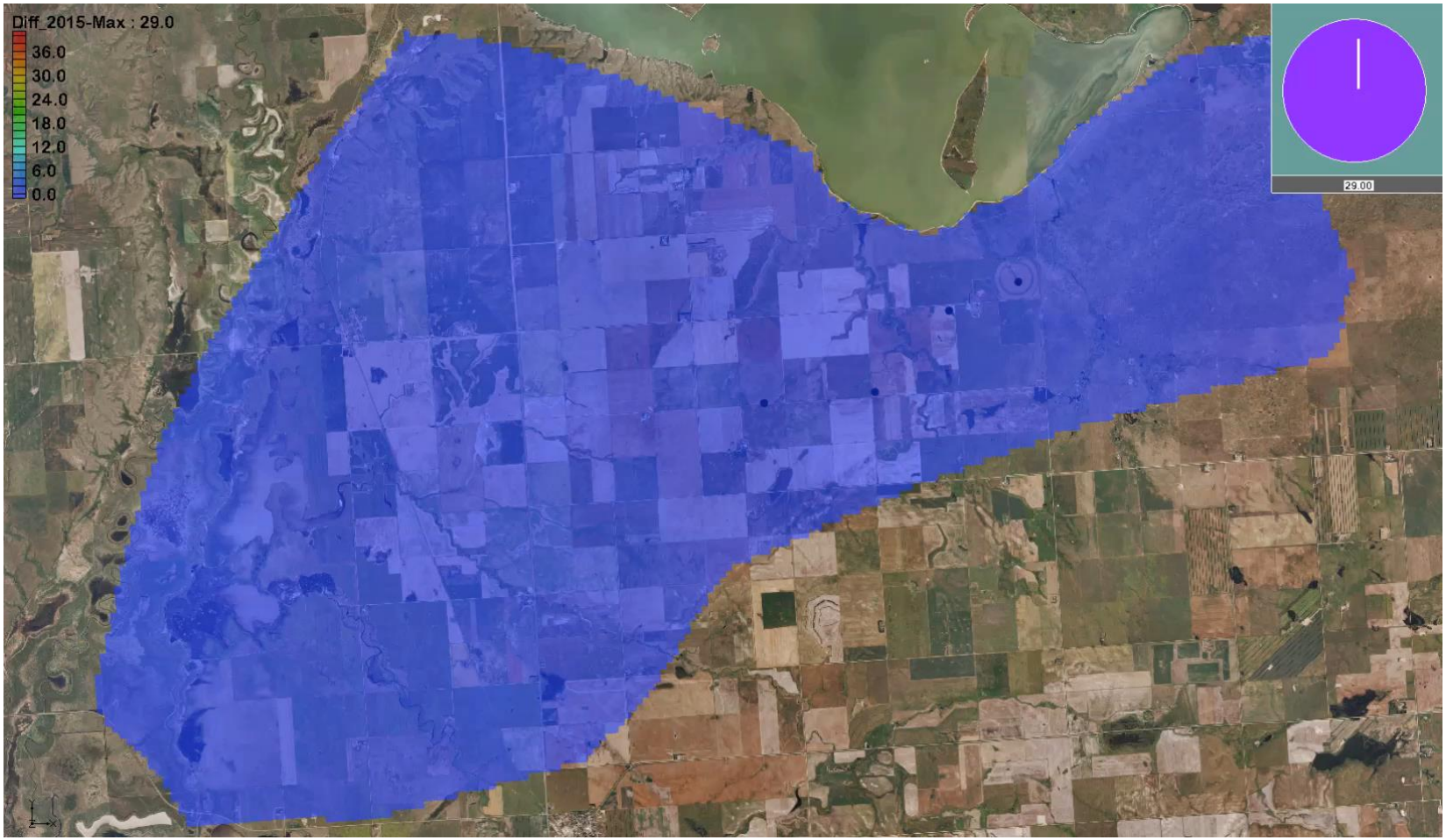
Predictive Scenarios

- No irrigation water use.
- 4 existing wells pumping to full allocation level.
- 4 additional irrigation wells at 2015 level use.
- All 8 wells pumping at full allocation level.

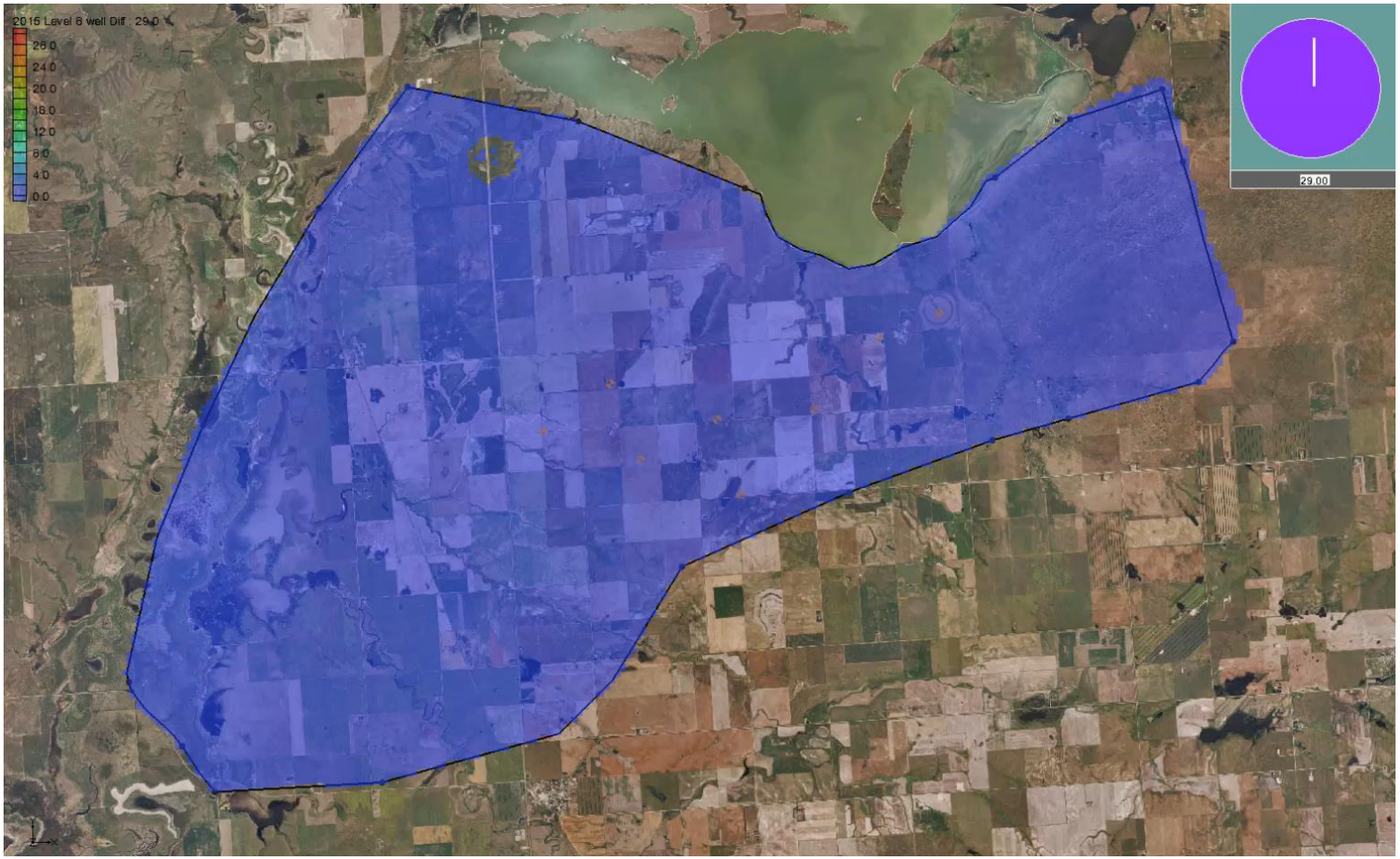
Animation of the difference between 4 well 2015 level irrigation pumping and “no use”



Animation of the difference between 4 well maximum allocation pumping and “no use”



Animation of the difference between 8 wells at 2015 level use and “no use”



Animation of the difference between 8 wells pumping at maximum allocation and “no use”