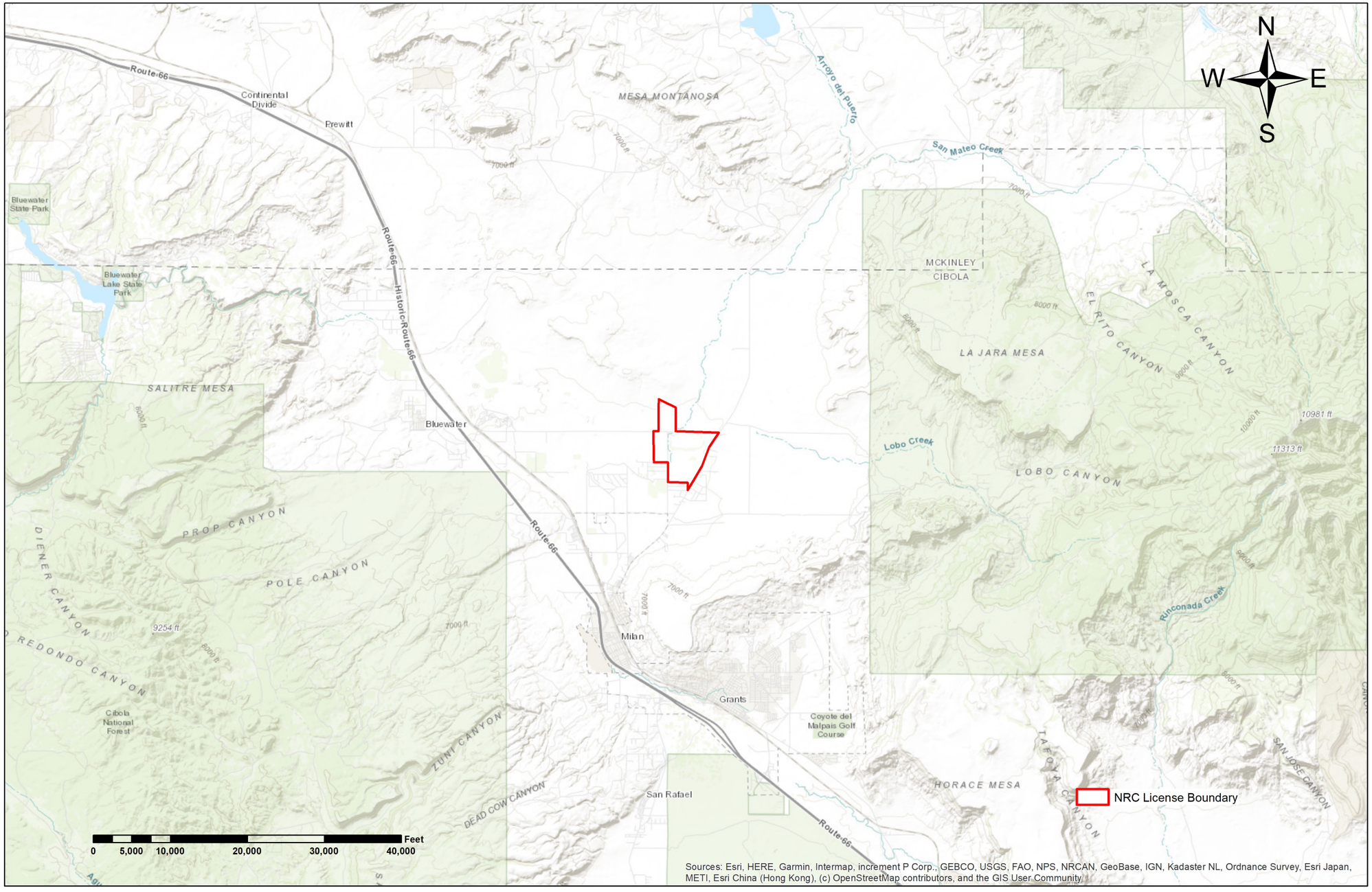

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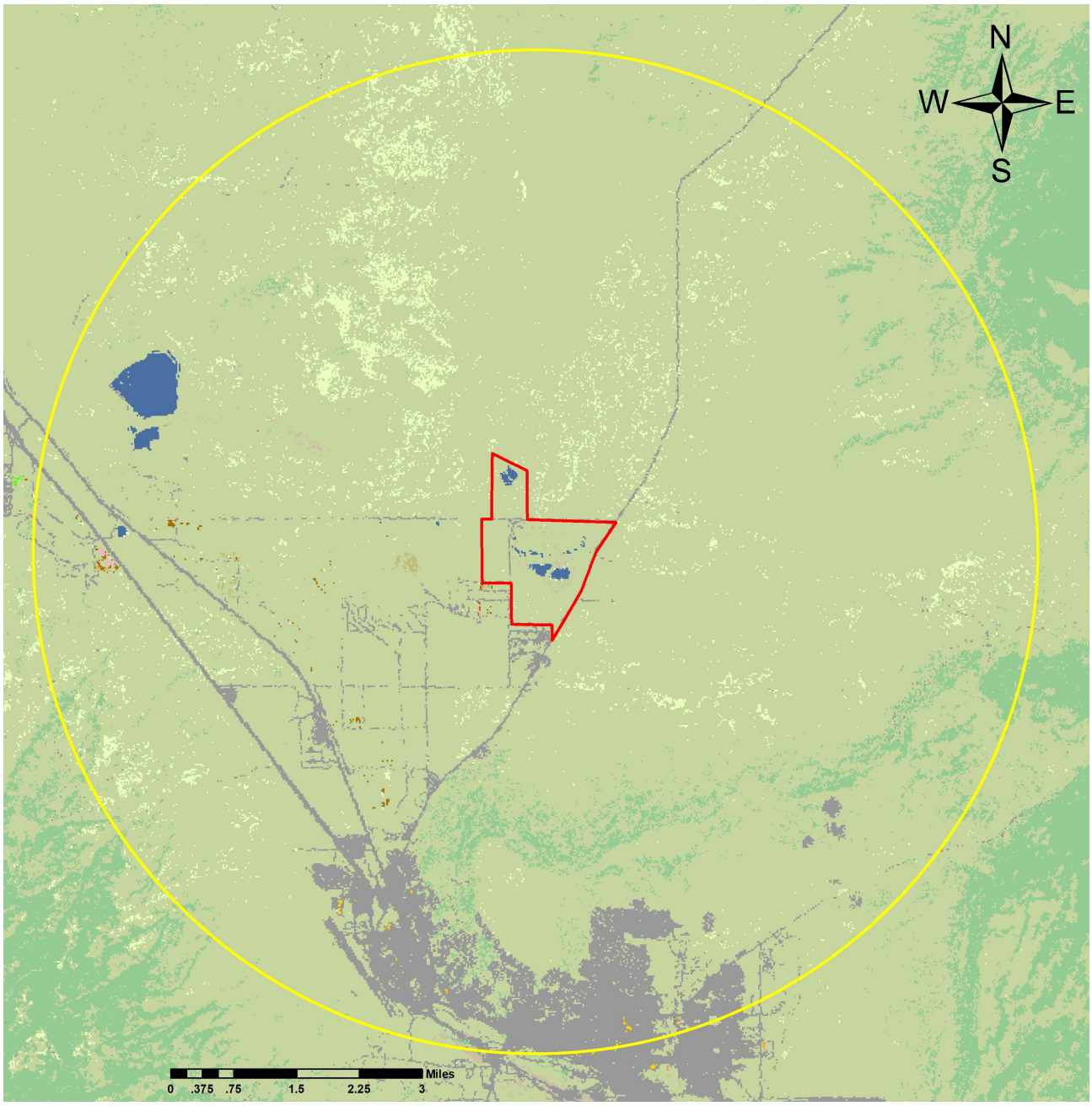
Figure 3-1
Topography



Five Mile Buffer
NRC License Boundary
Shrubland
Evergreen Forest
Open Water
Developed/Open Space
Developed/Low Density
Developed/Medium Density

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Corrective Action Program

Figure 3-2
Land Use within Five Miles of the GRP

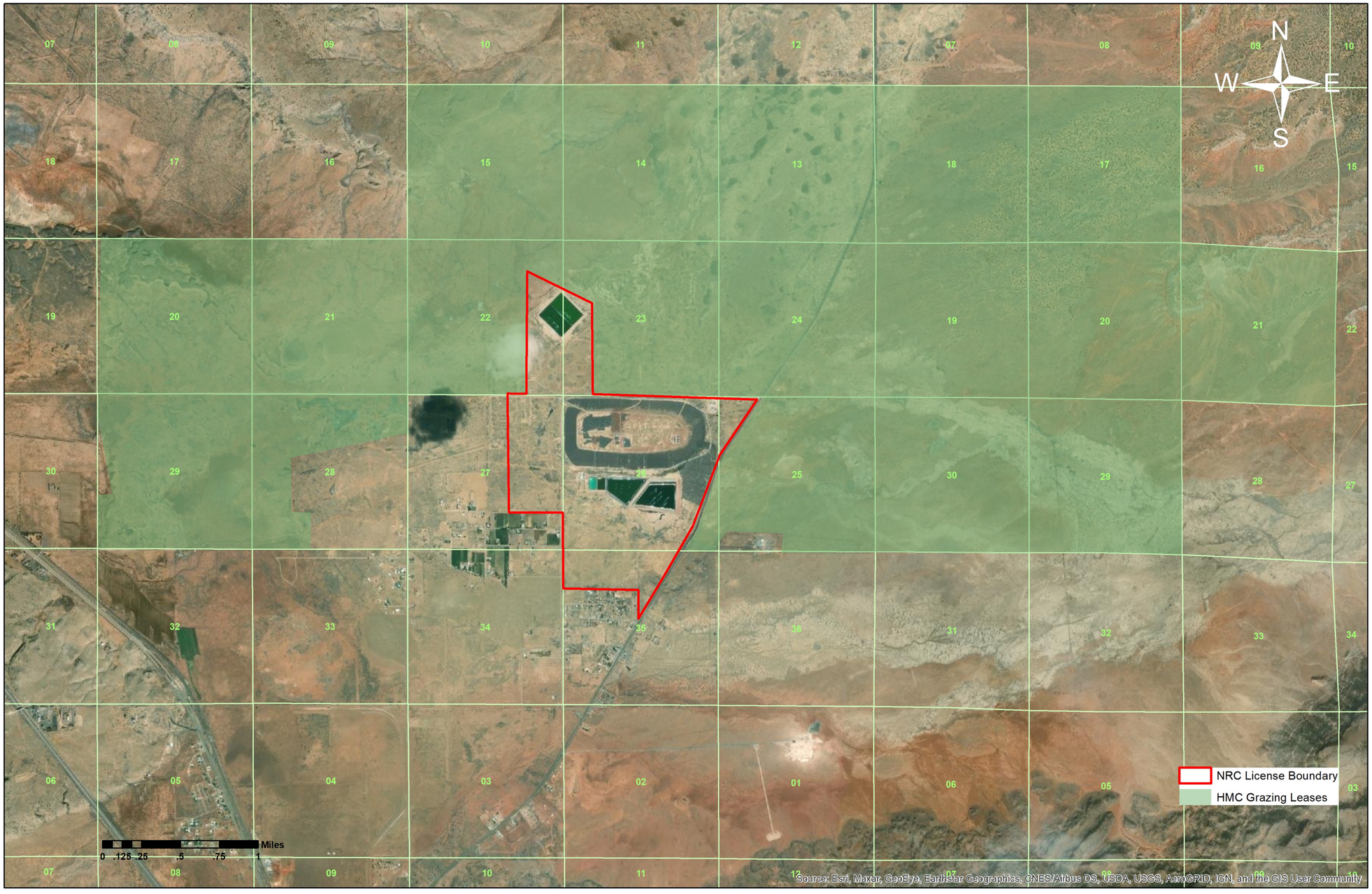

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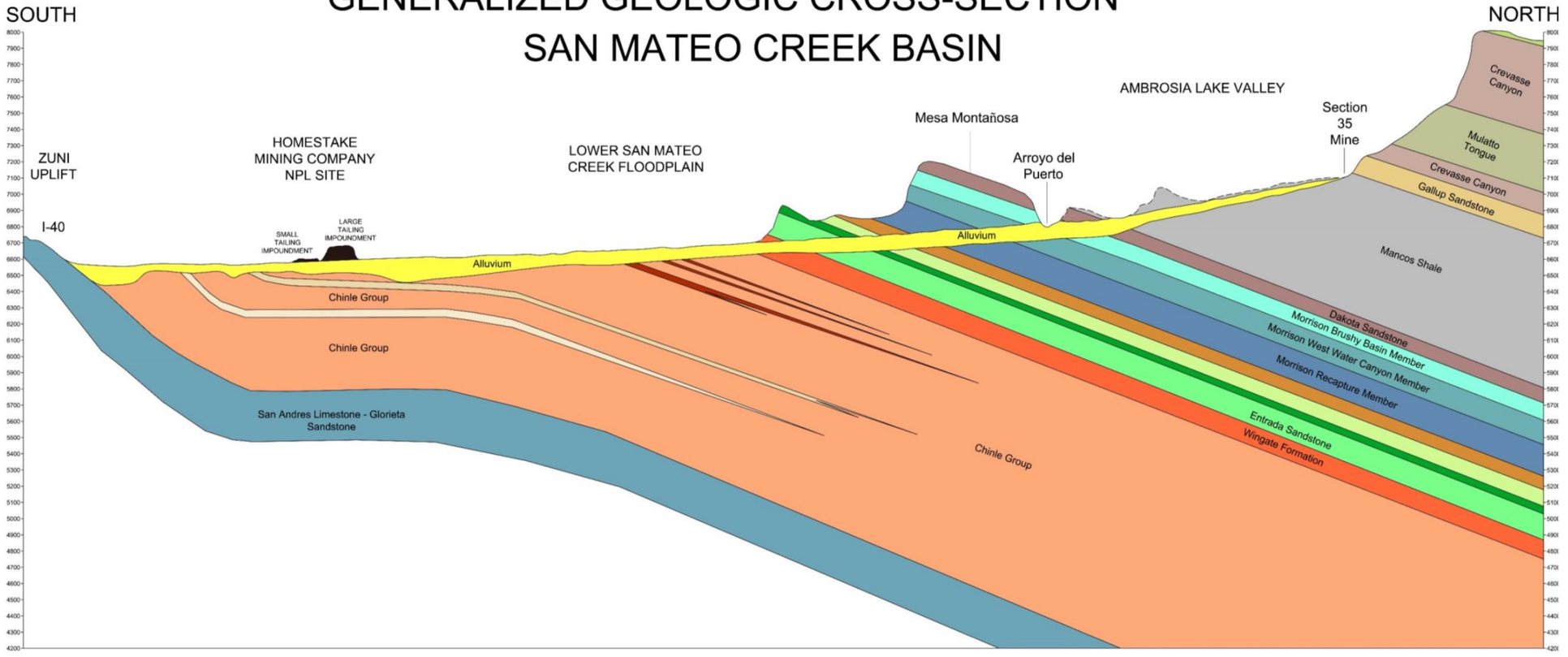
Figure 3-3
HMC Grazing Leases

Grants Reclamation Project
Corrective Action Program

Figure 3-4
Transportation Corridors

GENERALIZED GEOLOGIC CROSS-SECTION
SAN MATEO CREEK BASIN



Legend

- Alluvium/Eolian
- Point Lookout Sandstone
- Crevasse Canyon
- Mulatto Tongue
- Gallup Sandstone
- Mancos Shale
- Dakota Sandstone Formation
- Morrison Formation - Brushy Basin Member
- Morrison Formation - Westwater Canyon Member
- Morrison Formation - Recapture Member
- Bluff Sandstone
- Summerville Formation
- Todilto Limestone
- Entrada Sandstone
- Wingate Formation
- Chinle Group
- Other Chinle Sandstone
- Upper Chinle Sandstone
- Middle Chinle Sandstone
- San Andres Limestone - Glorieta Sandstone

NOTES:
1. VERTICAL EXAGGERATION = 10X
2. ELEVATIONS ARE IN FEET ABOVE MEAN SEA LEVEL.
3. SURFACE GEOLOGY IS BASED ON U.S. GEOLOGICAL SURVEY AND NEW MEXICO BUREAU OF GEOLOGY AND MINERAL RESOURCES 1967 AND 2011 GEOLOGIC MAPS OF THE DOS LOMAS QUADRANGLE, CIBOLA AND MCKINLEY COUNTIES, NEW MEXICO.
4. THIS CROSS SECTION REPRESENTS AN INTERPRETATION OF GEOLOGIC DATA AND IS SUBJECT TO CHANGE AS NEW DATA BECOME AVAILABLE.
5. THIS CROSS SECTION IS FOR ILLUSTRATION PURPOSES ONLY. IT IS DESIGNED TO AID IN THE UNDERSTANDING OF THE GENERAL GEOLOGIC FRAMEWORK OF THE STUDY AREA.
6. THE BEDROCK FORMATIONS SHOWN CROPPING OUT ABOVE THE ALLUVIUM ARE PROJECTED ONTO THE CROSS SECTION FROM THE WEST TO SHOW MESA MONTAÑOSA AND AMBROSIA LAKE VALLEY TERRAIN.

0 150 300 600
VERTICAL SCALE IN FEET
VERTICAL EXAGGERATION: 10X

0 1500 3000 6000
HORIZONTAL SCALE IN FEET

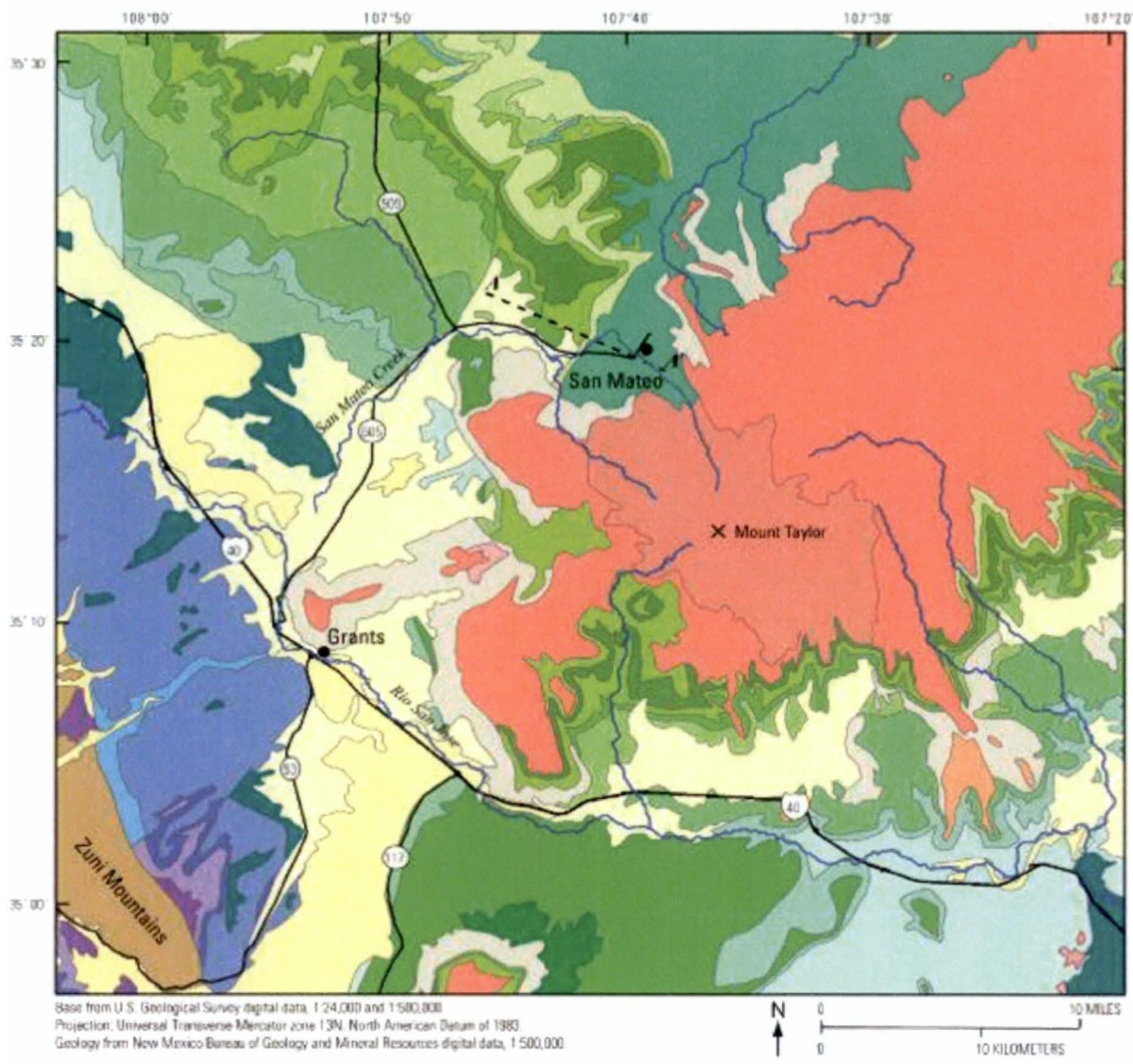
SEMS ID: NMN000606847
TDD NO: 0001/17-039

Cross Section Location shown on Figure 3-7

Source: Weston, 2018

Note: One of the Chinle water-bearing units beneath the GRP is missing in this figure.

Figure 3-5
Generalized Cross Section
Through the San Mateo Basin



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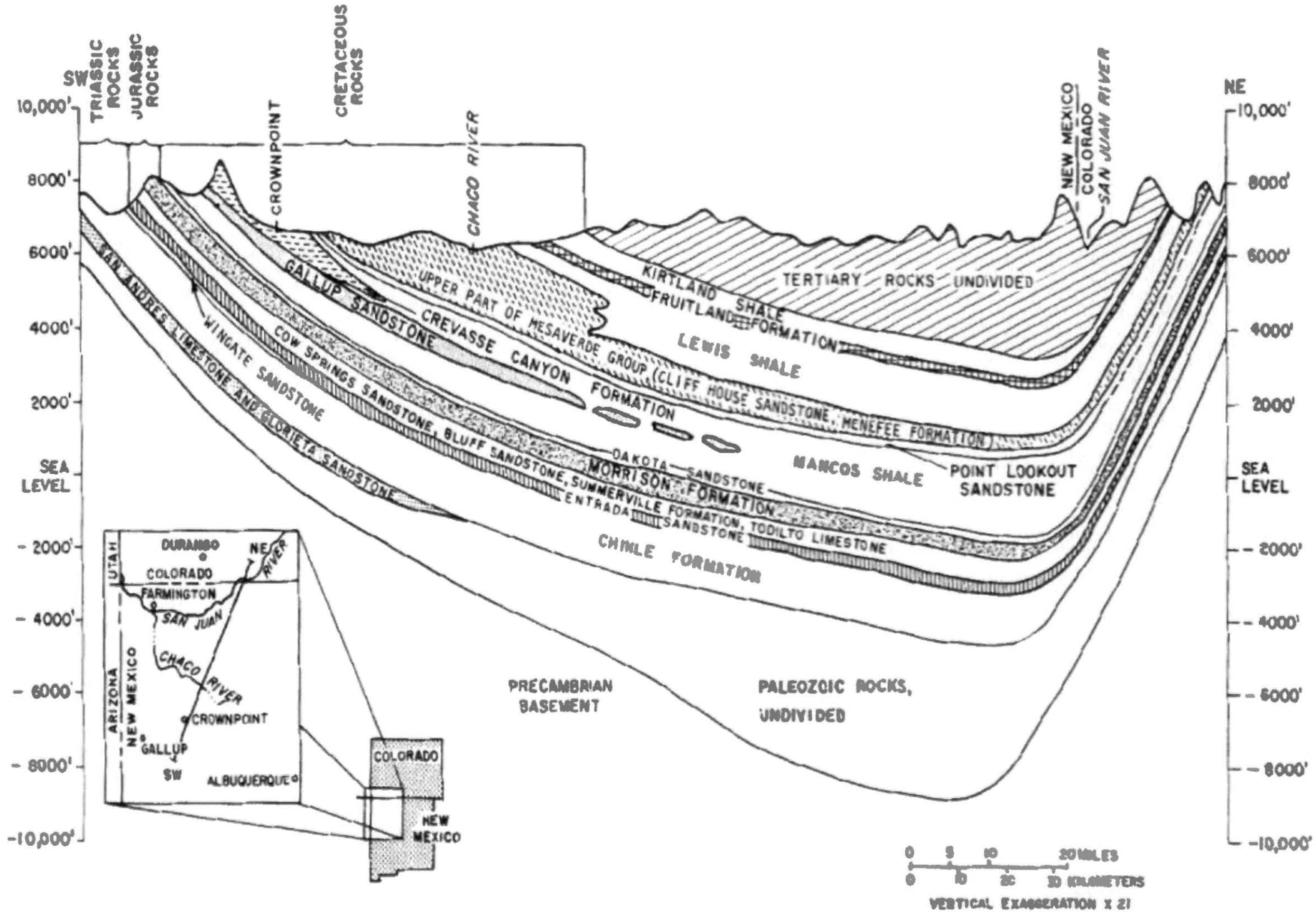
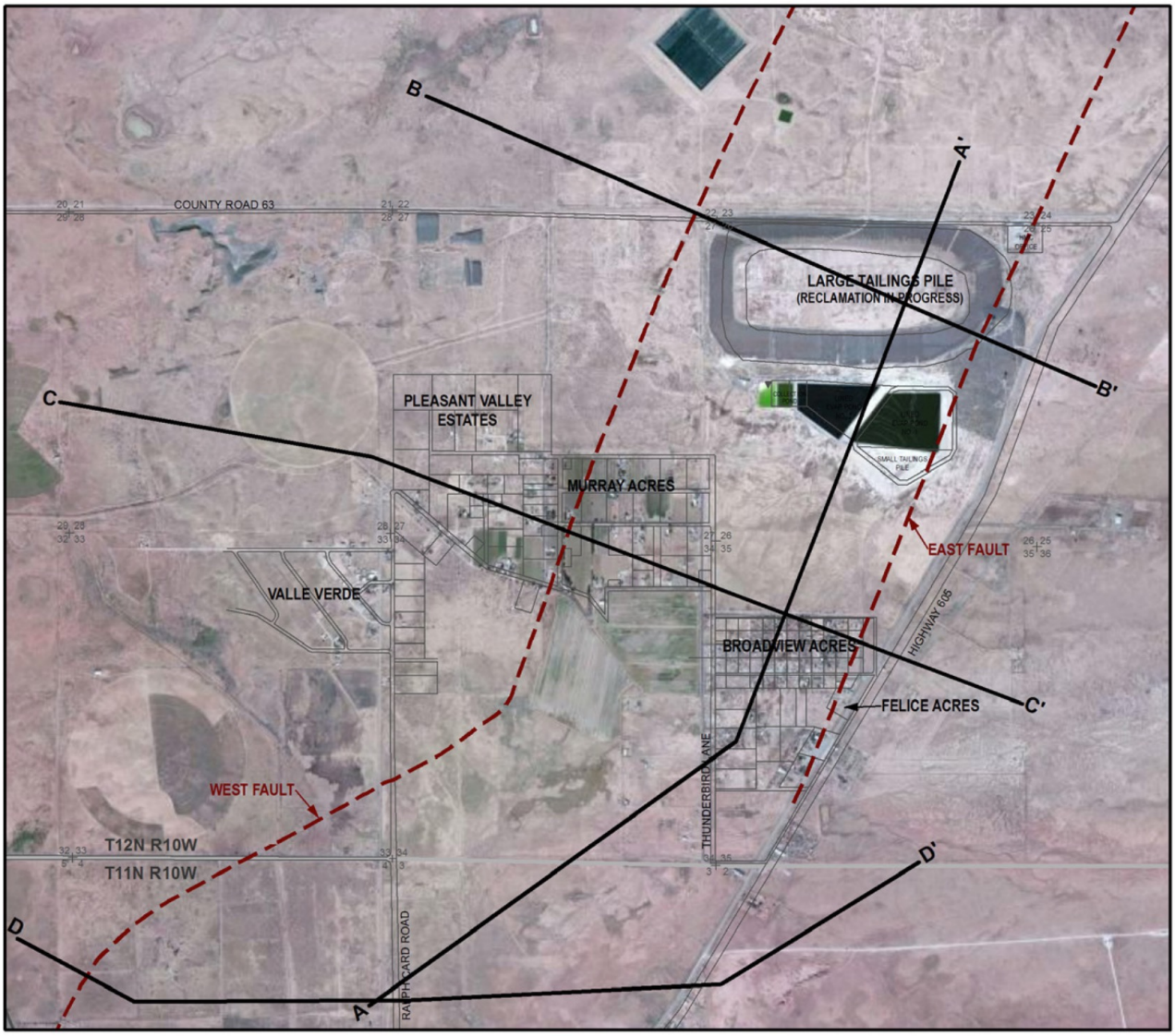
Grants Reclamation Project
Corrective Action Program

Figure 3-6
Surface Geology of the
San Mateo Creek Basin



Source: Frenzel and Lyford, 1982

Figure 3-7
Regional Geologic Cross Section
Through the San Juan Basin



LEGEND:

Hydrogeologic Cross Section Line

Fault

N

0 1,250 2,500

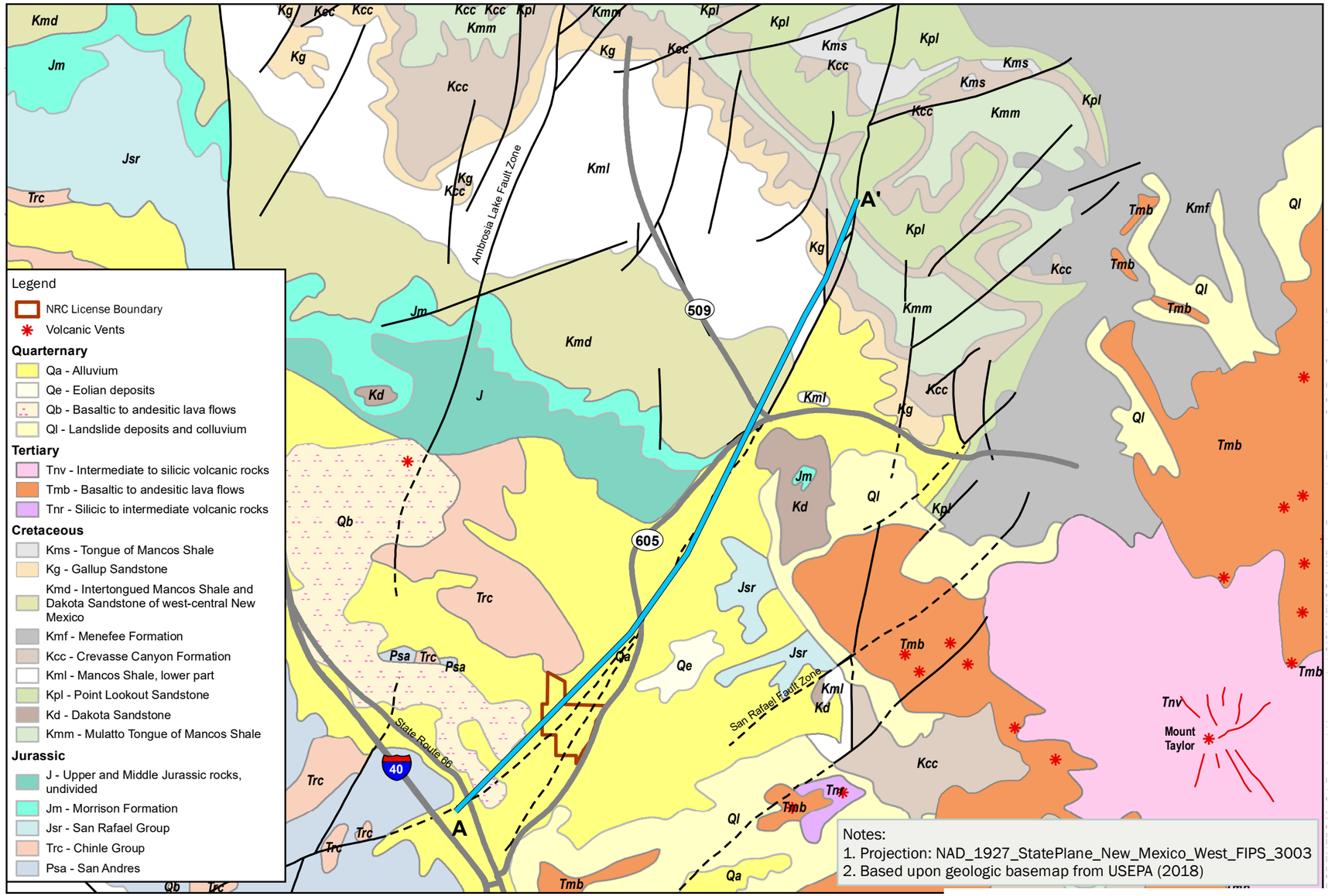
Feet

Aerial: Bing Maps - © 2010 Microsoft Corporation and its data suppliers

Source: Grants Reclamation Project Updated Corrective Action Program, HMC, 2012

Grants Reclamation Project
Corrective Action Program

Figure 3-8
Faults Mapped at GRP

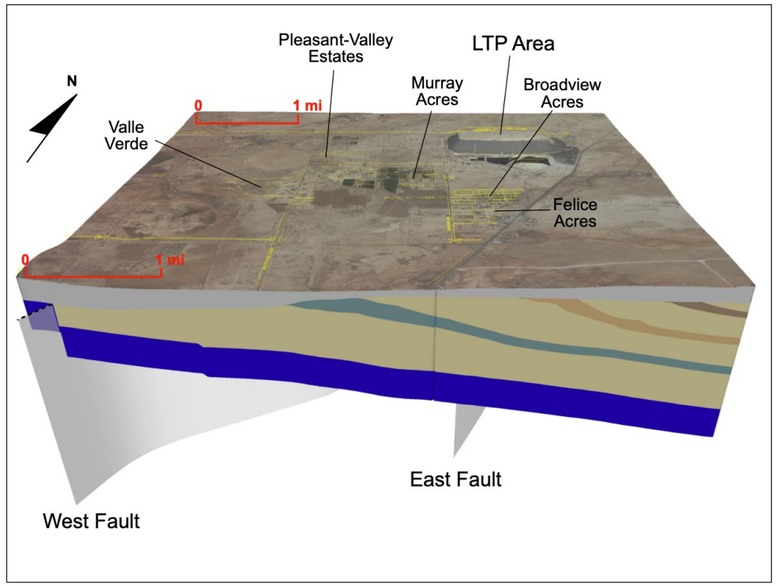


Cross Section Along Blue Line Shown in Figure 3-5

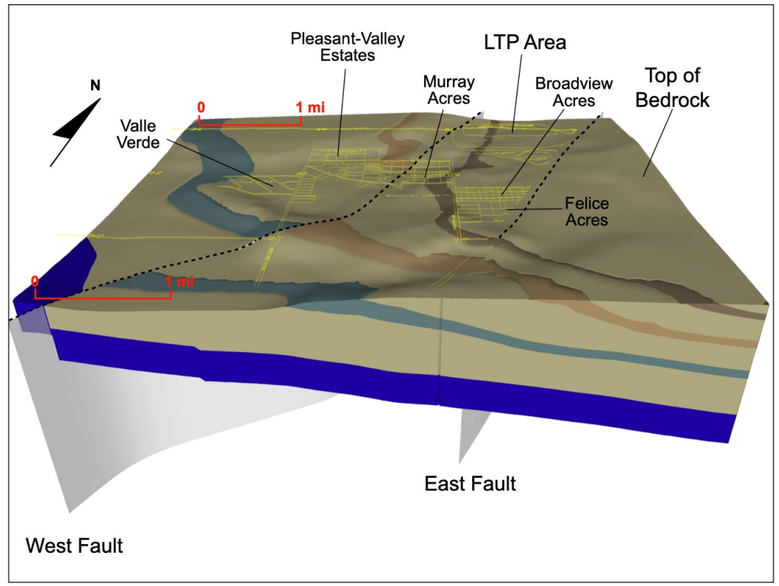
Source: Weston, 2018

Grants Reclamation Project
Corrective Action Program

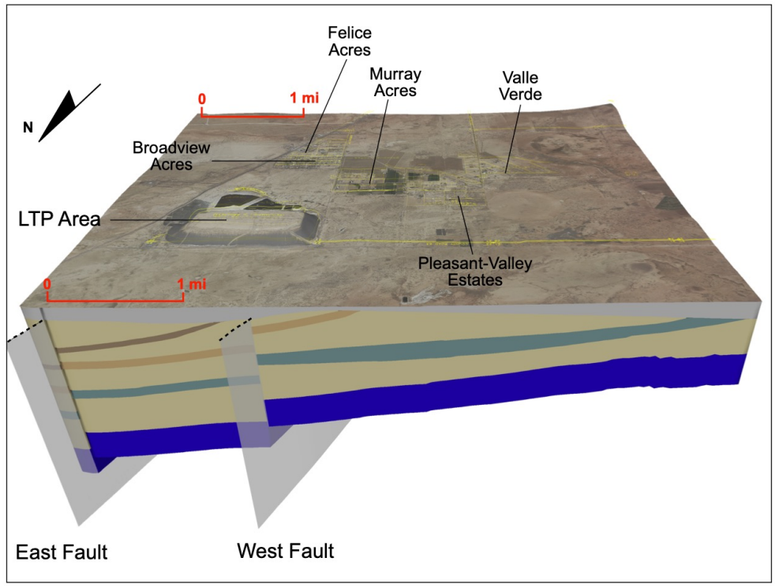
Figure 3-9
Surface Geology near the GRP



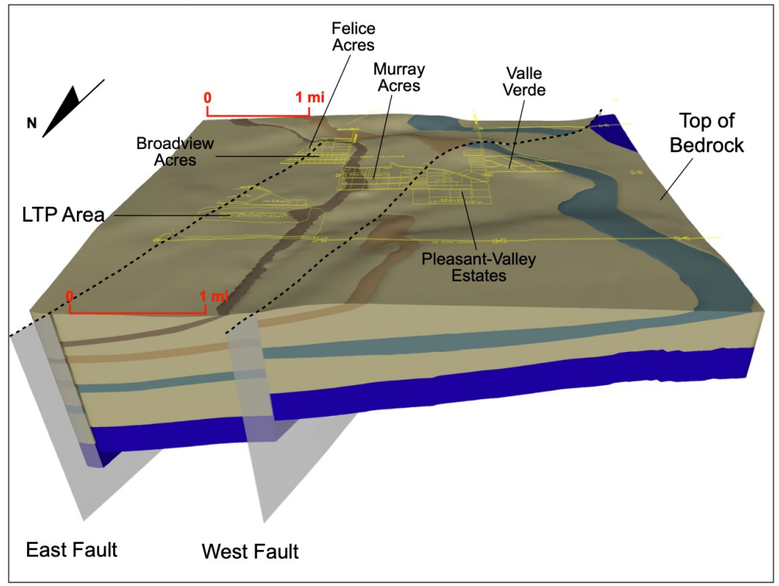
1. ALLUVIUM AND BEDROCK BLOCK MODEL – FACING NORTH



2. BEDROCK BLOCK MODEL DEPICTING CHINLE AND SAN ANDRES-GLORIETTA AQUIFER SUBCROP LOCATIONS – FACING NORTH



3. ALLUVIUM AND BEDROCK BLOCK MODEL – FACING SOUTH



4. BEDROCK BLOCK MODEL DEPICTING CHINLE AND SAN ANDRES-GLORIETTA AQUIFER SUBCROP LOCATIONS – FACING SOUTH

LEGENDS:

BEDROCK HYDROSTRATIGRAPHY

- ALLUVIUM
- CHINLE SHALE
- UPPER CHINLE AQUIFER
- CHINLE SHALE
- MIDDLE CHINLE AQUIFER
- CHINLE SHALE
- LOWER CHINLE AQUIFER
- CHINLE SHALE
- SAN ANDRES-GLORIETTA AQUIFER

NOTES:

1. 3D model output depicted at 5x vertical exaggeration.

Adopted from:
Grants Reclamation Project Updated Corrective Action Program, HMC, 2012

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Grants Reclamation Project
Corrective Action Program

Figure 3-10
3D Hydrogeology

CROSS SECTION A-A'

0 1200' 2400'

HORIZONTAL SCALE

SOUTH
A

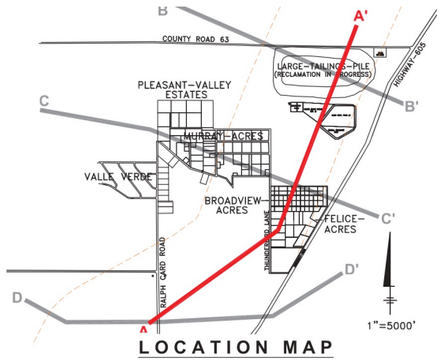
NORTH
A'

D–D'
RALPH CARD ROAD
THUNDERBIRD LANE
FELICE ACRES SUBDIVISION
C–C'
LINED EVAPORATION POND No.2
LARGE TAILINGS PILE
B–B'
COUNTY ROAD 63

6,750
6,500
6,250
6,000
5,750
5,500

ELEVATION IN FEET

GROUND
TOP OF BEDROCK
ALLUVIUM
CHINLE SHALE
UPPER CHINLE AQUIFER
CHINLE SHALE
CHINLE SHALE
MIDDLE CHINLE AQUIFER
CHINLE SHALE
LOWER CHINLE AQUIFER
CHINLE SHALE
SAN ANDRES–GLORIETTA AQUIFER



LOCATION MAP

NOTE:

1. THREE–DIMENSIONAL MODEL OUTPUT DEPICTED AT 5X VERTICAL EXAGGERATION.

LEGEND:

- LARGE TAILINGS PILE
- ALLUVIUM
- CHINLE SHALE
- UPPER CHINLE AQUIFER
- MIDDLE CHINLE AQUIFER
- LOWER CHINLE AQUIFER
- SAN ANDRES–GLORIETTA AQUIFER
- WATER TABLE

Adopted from:
Grants Reclamation Project Updated Corrective Action Program, HMC, 2012

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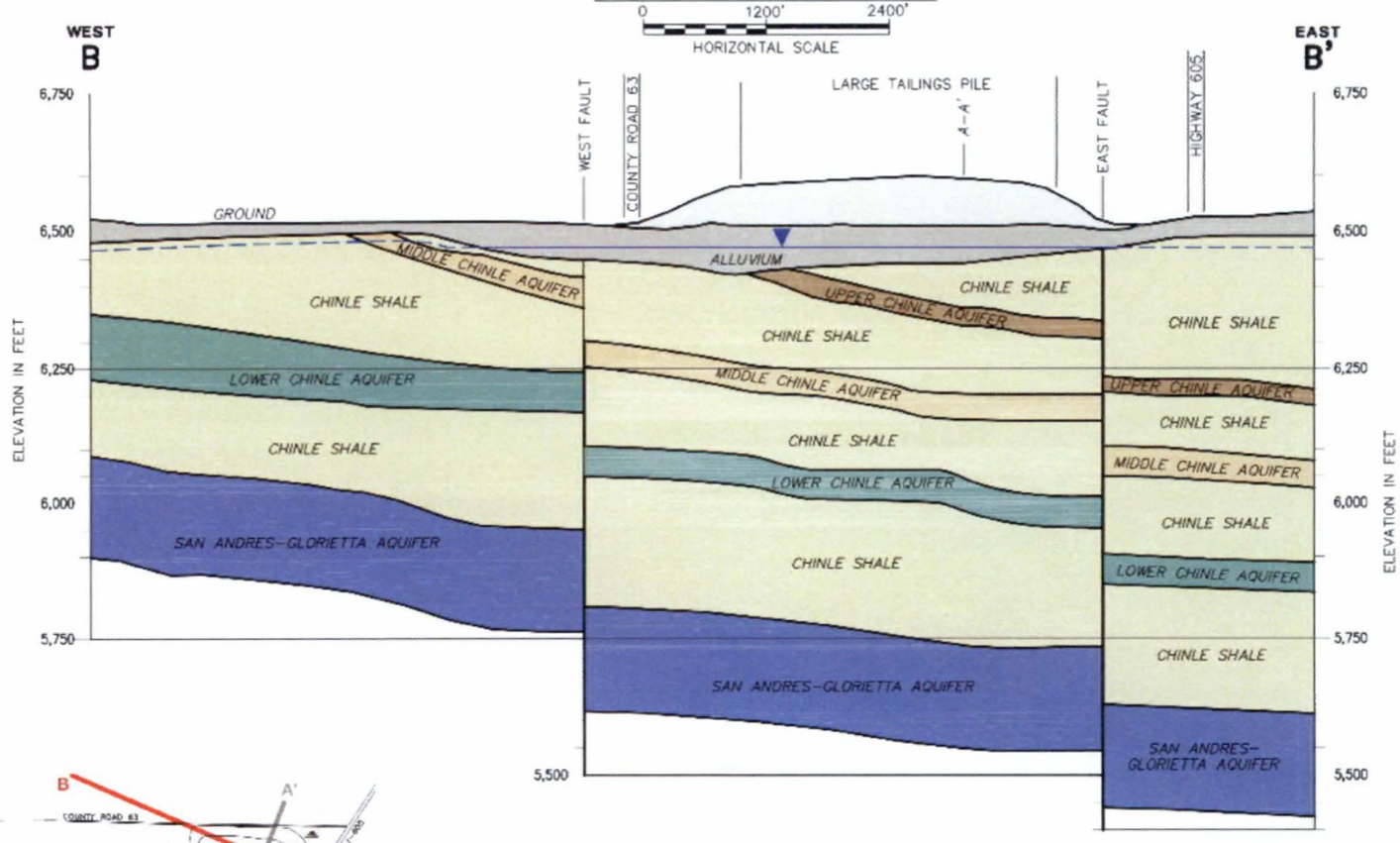
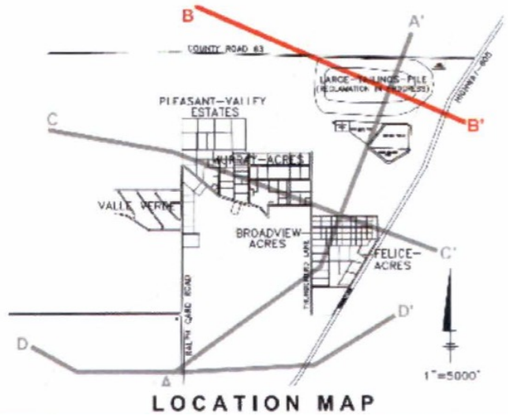
Grants Reclamation Project
Corrective Action Program

Figure 3-11
Cross Section A-A'

CROSS SECTION B-B'





LOCATION MAP

NOTE:

1. THREE-DIMENSIONAL MODEL OUTPUT DEPICTED AT 5X VERTICAL EXAGGERATION.

LEGEND:

- LARGE TAILINGS PILE
- ALLUVIUM
- CHINLE SHALE
- UPPER CHINLE AQUIFER
- MIDDLE CHINLE AQUIFER
- LOWER CHINLE AQUIFER
- SAN ANDRES-GLORIETTA AQUIFER
- WATER TABLE

Adapted from:
Grants Reclamation Project Updated Corrective Action Program, HMC, 2012

Grants Reclamation Project
Corrective Action Program

Source: HDR, 2016

Figure 3-12
Cross Section B-B'

CROSS SECTION C-C'

0 1200' 2400'

HORIZONTAL SCALE

WEST C

EAST C'

PLEASANT VALLEY ESTATES | WEST FAULT | MURRAY ACRES | THUNDERBIRD LANE | A–A' | BROADVIEW ACRES | EAST FAULT | HIGHWAY 605

6,750
6,500
6,250
6,000
5,750
5,500

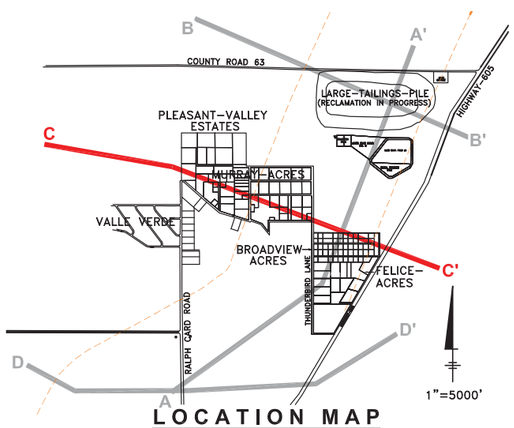
ELEVATION IN FEET

GROUND
ALLUVIUM
BASALT
ALLUVIUM
ALLUVIUM
CHINLE SHALE
LOWER CHINLE AQUIFER
CHINLE SHALE
SAN ANDRES–GLORIETTA AQUIFER
CHINLE SHALE
UPPER CHINLE AQUIFER
MIDDLE CHINLE AQUIFER
CHINLE SHALE
LOWER CHINLE AQUIFER
CHINLE SHALE
SAN ANDRES–GLORIETTA AQUIFER
CHINLE SHALE
UPPER CHINLE AQUIFER
CHINLE SHALE
MIDDLE CHINLE AQUIFER
CHINLE SHALE
LOWER CHINLE AQUIFER
CHINLE SHALE
SAN ANDRES–GLORIETTA AQUIFER

DATE MODIFIED: 08/31/15

MODIFIED BY: JDLoving

G:\ENVCAD\Irvine\ACTIVITY\0001200\007\C0000001\A0000120.007C_xSect C-C.pdf



LOCATION MAP

NOTES:

1. THREE–DIMENSIONAL MODEL OUTPUT DEPICTED AT 5X VERITICAL EXAGGERATION.
2. GEOLOGIC CONTACTS DASHED WHERE INFERRED.

LEGEND:

- ALLUVIUM
- BASALT
- CHINLE SHALE
- UPPER CHINLE AQUIFER
- MIDDLE CHINLE AQUIFER
- LOWER CHINLE AQUIFER
- SAN ANDRES–GLORIETTA AQUIFER
- WATER TABLE

Modified: September 4, 2015
Adopted from:
Grants Reclamation Project Updated Corrective Action Program, HMC, 2012

Grants Reclamation Project
Corrective Action Program

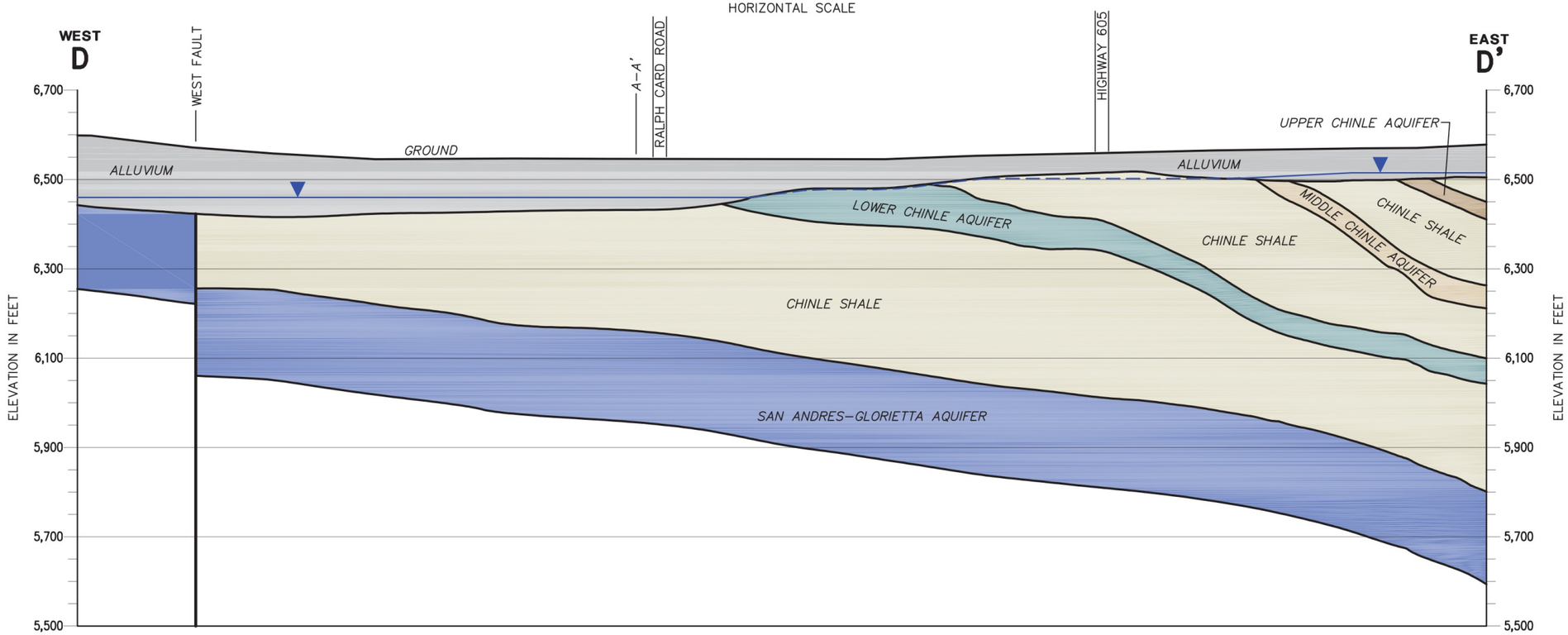
Source: HDR, 2016

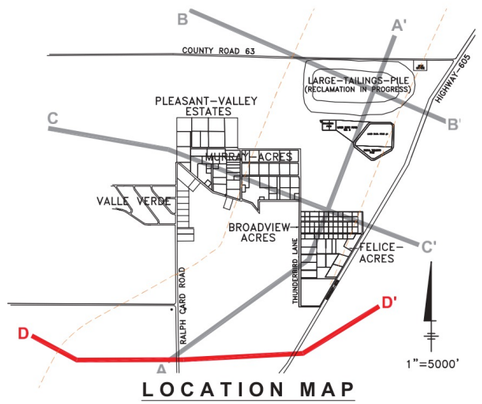
Figure 3-13
Cross Section C-C'

CROSS SECTION D-D'

0 1200' 2400'

HORIZONTAL SCALE





LOCATION MAP

NOTE:

1. THREE-DIMENSIONAL MODEL OUTPUT DEPICTED AT 5X VERTICAL EXAGGERATION.

LEGEND:

- LARGE TAILINGS PILE
- ALLUVIUM
- CHINLE SHALE
- UPPER CHINLE AQUIFER
- MIDDLE CHINLE AQUIFER
- LOWER CHINLE AQUIFER
- SAN ANDRES-GLORIETTA AQUIFER
- WATER TABLE

Adopted from:
Grants Reclamation Project Updated Corrective Action Program, HMC, 2012

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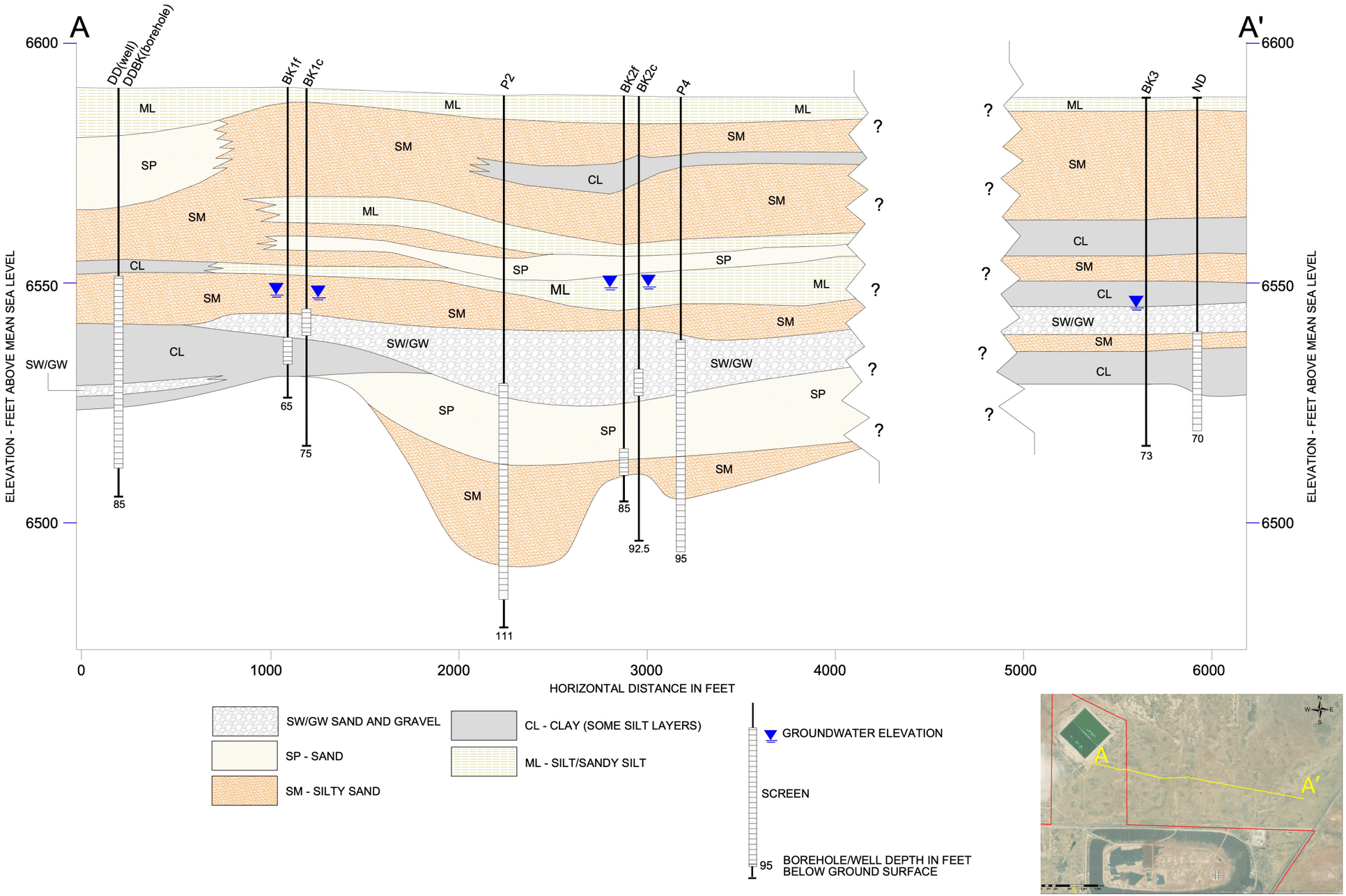
Grants Reclamation Project
Corrective Action Program

Figure 3-14
Cross Section D-D'



Grants Reclamation Project
Corrective Action Program

Source: Arcadis, 2019

Figure 3-15
Cross Section North of
Large Tailings Pile

NORTH
A

SOUTH
A'

IW-1D IW-1S IW-2D IW-2S IW-3D IW-3S IW-4D IW-4S IW-5D IW-5S IW-6D IW-6S IW-7D IW-7S IW-8D IW-8S IW-9D IW-9S IW-10D IW-10S IW-11D IW-11S IW-12D IW-12S IW-13D IW-13S IW-14D IW-14S IW-15D IW-15S IW-16D IW-16S IW-17D IW-17S

DEPTH (FEET BGS.)

0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120

0.0970 04/15/15
0.583 04/15/15
0.198 04/14/15
1.77 04/15/15
0.210 04/13/15
144 04/13/15
1.07 04/13/15
0.279 04/12/15
2.01 04/12/15
1.59 04/12/15
1.67 04/10/15
0.904 04/11/15
1.62 04/10/15
0.680 04/11/15
0.444 04/11/15

LEGEND:

- FINES (SILTS AND CLAYS) WITH NO TO SOME (10-50%) SAND GRAVEL
- SAND WITH SOME (21-50%) FINES
- FINE TO MEDIUM SAND WITH NO TO LITTLE (0-20%) FINES
- MEDIUM TO COARSE SAND WITH NO LITTLE (0-20%) FINES
- SAND WITH LITTLE TO SOME (10-50%) GRAVEL
- GRAVEL
- BEDROCK

1.07 04/13/15 — WELL SCREEN; CONCENTRATION OF URANIUM (mg/L) AND DATE SAMPLED

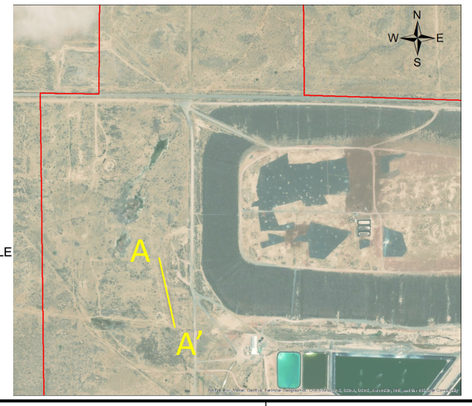
DEPTH TO WATER TABLE (FEET BGS.)

NOTES:

BGS = BELOW GROUND SURFACE
mg/L = MILLIGRAMS PER LITER

0 60' 120'
GRAPHIC SCALE
HORIZONTAL SCALE

0 20' 40'
GRAPHIC SCALE
VERTICAL SCALE



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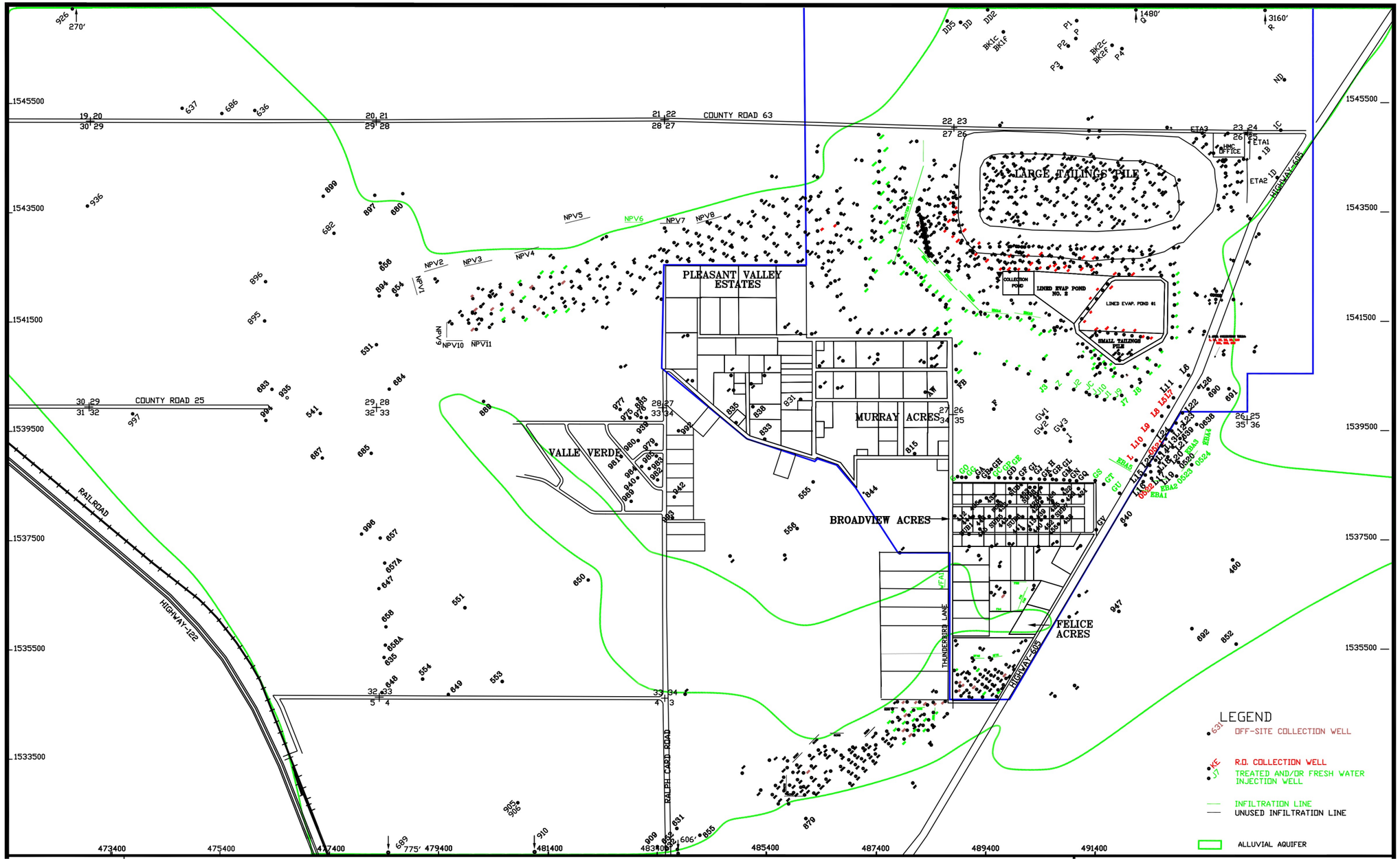
Corrective Action Program

Source: Arcadis, 2016

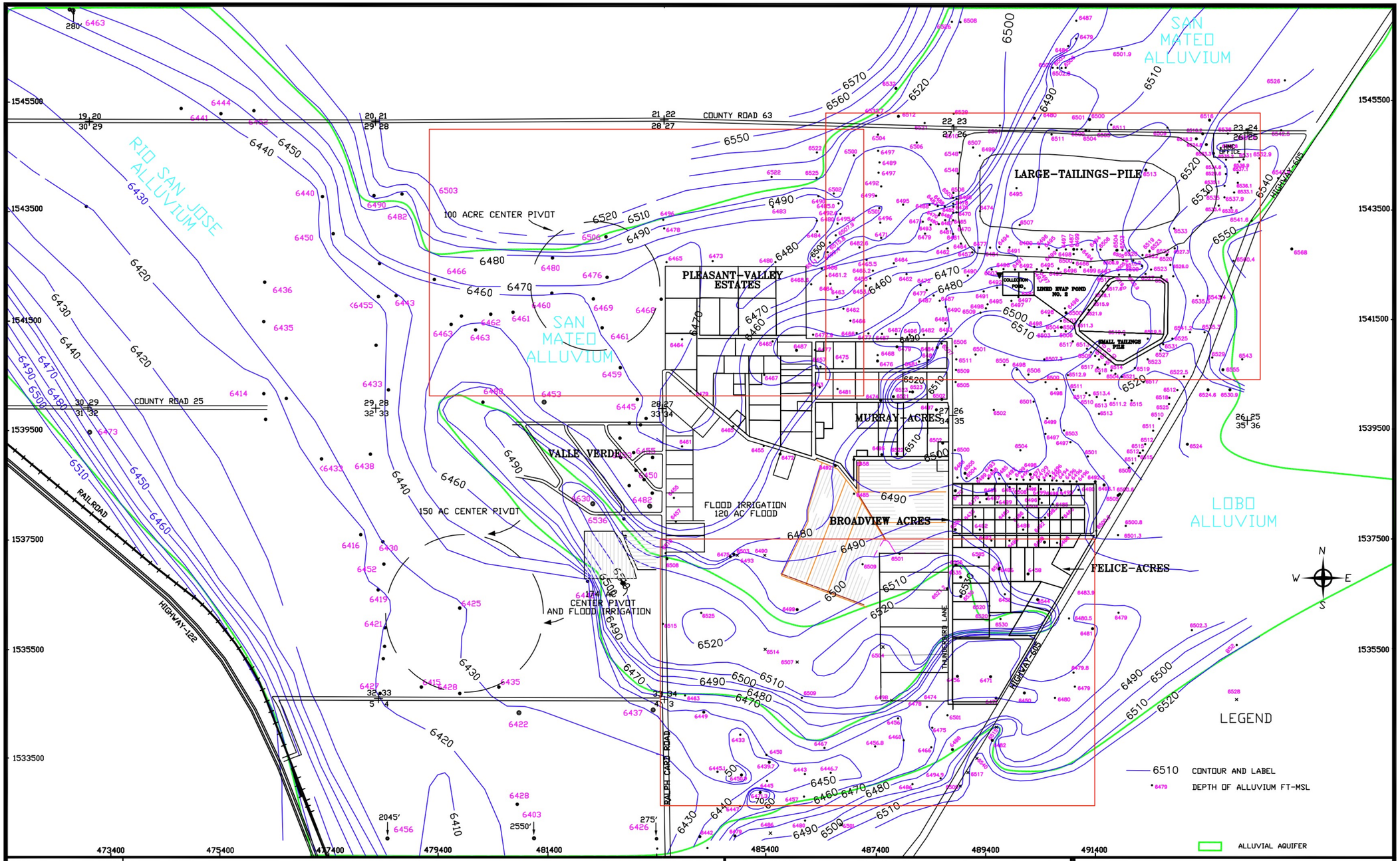
Figure 3-16
Cross Section West of
Large Tailings Pile



Grants Reclamation Project
Corrective Action Program

Elevation-feet above mean sea level

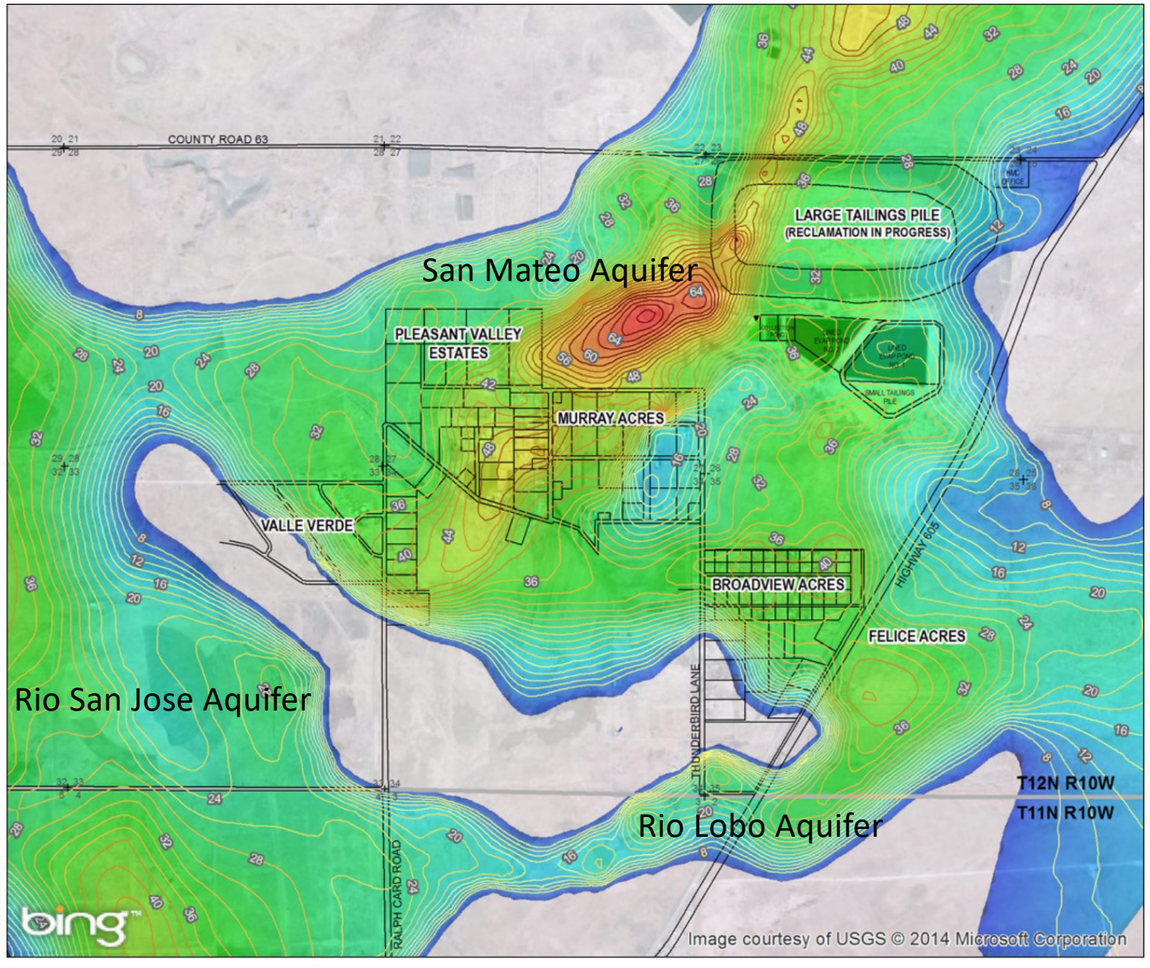
Figure 3-17
Alluvial Well Locations



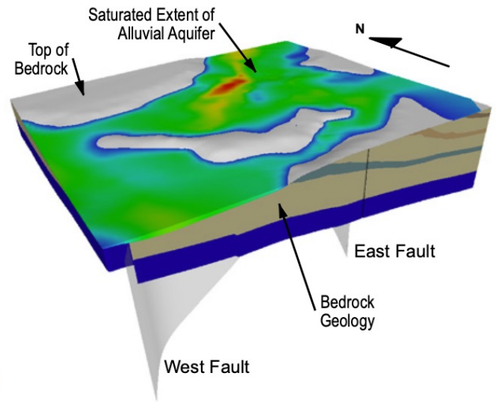
Grants Reclamation Project
Corrective Action Program

Elevation-feet above mean sea level

Figure 3-18
Elevation of Base of the Alluvium



3D BEDROCK GEOLOGY AND SATURATED EXTENT OF ALLUVIAL AQUIFER - FACING NORTHEAST



LEGENDS:

Saturated Alluvial Thickness (feet)

69
60
52
43
34
26
17
9
0

Bedrock Hydrostratigraphy

- Chinle Shale
- Upper Chinle Aquifer
- Chinle Shale
- Middle Chinle Aquifer
- Chinle Shale
- Lower Chinle Aquifer
- Chinle Shale
- San Andres-Glorietta Aquifer

Source: Grants Reclamation Project Updated Corrective Action Program, HMC, 2012

N

0 1,350 2,700 Feet

Aerial: Bing Maps - © 2010 Microsoft Corporation and its data suppliers

Thickness Contours in Feet

- 8 - 16
- 17 - 26
- 27 - 36
- 37 - 46
- 47 - 56
- 57 - 68

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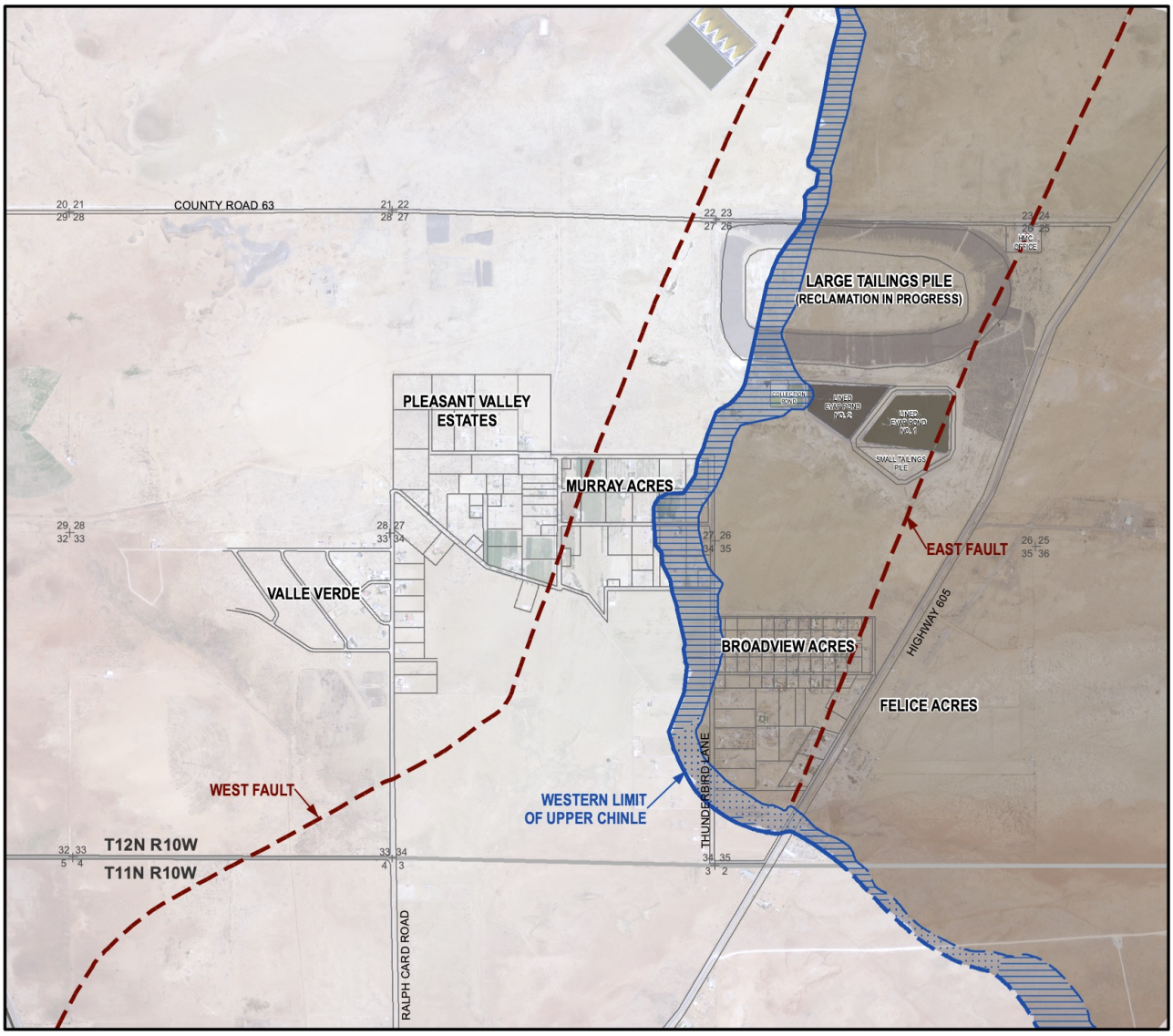
Grants Reclamation Project
Corrective Action Program

Figure 3-19
Saturated Extent of Alluvial Aquifer



LEGEND:

Fault

Subcrop of Upper Chinle Alluvium Overlies Sandstone
(Subcrop boundary dashed where inferred)

Saturated Alluvium

Unsaturated Alluvium

6400 Extent of Upper Chinle Aquifer with Elevation Contour (ft-amsl)

N

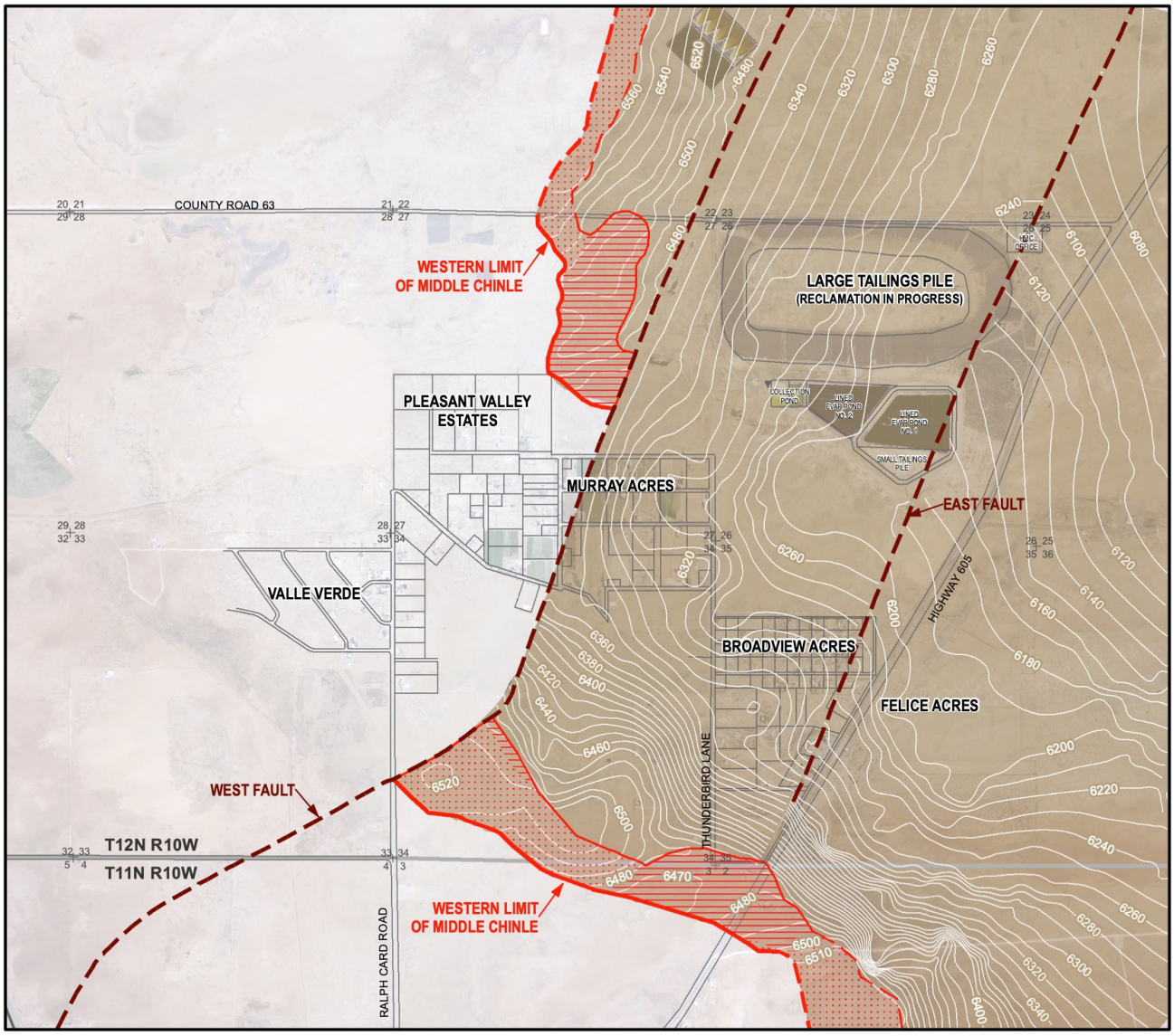
0 1,250 2,500 Feet

Aerial Source: NAIP 2011

Adopted from: Grants Reclamation Project Updated Corrective Action Program, HMC, 2012

Grants Reclamation Project
Corrective Action Program

Figure 3-20
Extent of the Upper Chinle



LEGEND:

Fault

Subcrop of Middle Chinle Alluvium Overlies Sandstone
(Subcrop boundary dashed where inferred)

Saturated Alluvium

Unsaturated Alluvium

Extent of Middle Chinle Aquifer with Elevation Contour (ft-amsl)

N

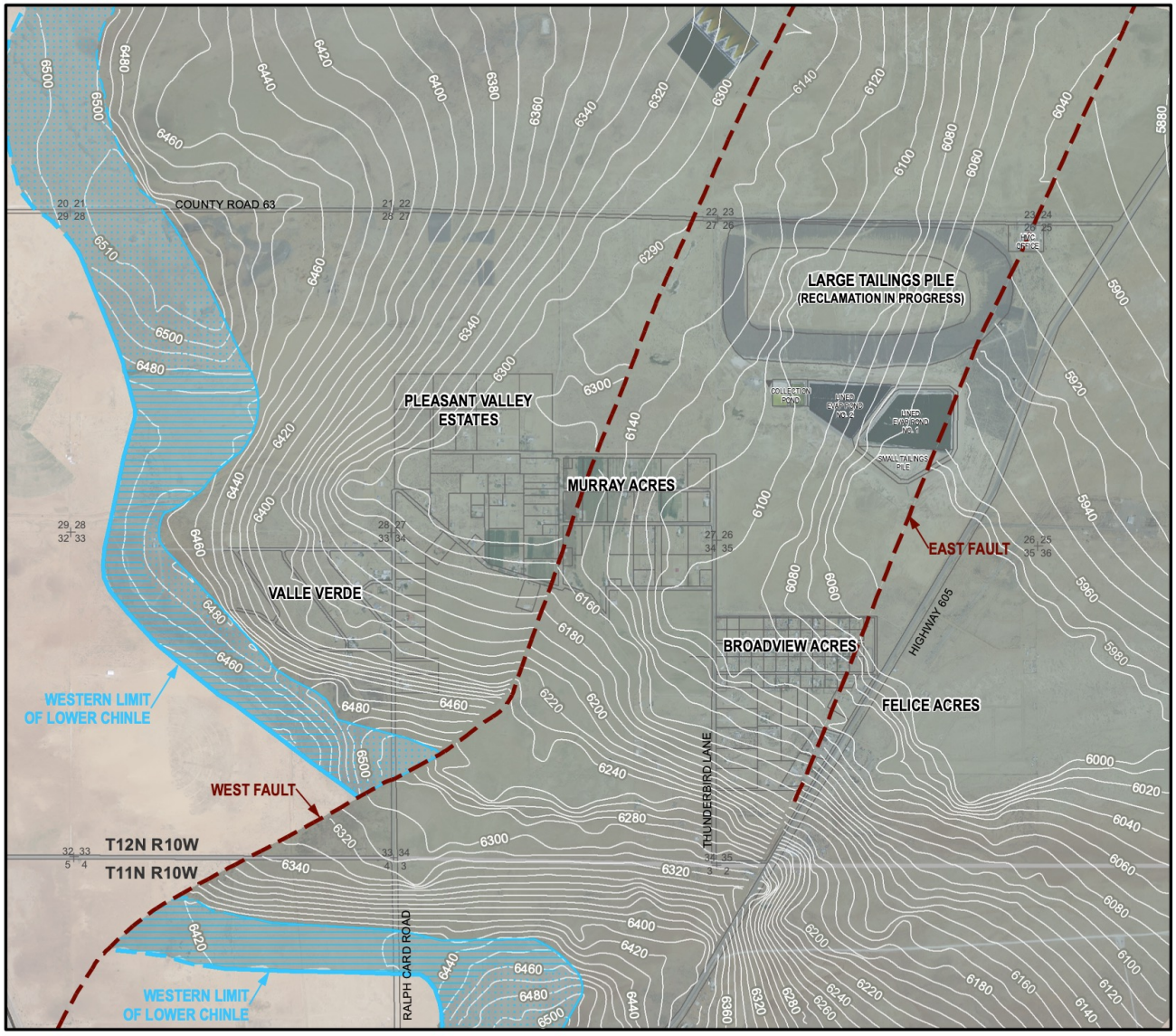
0 1,250 2,500 Feet

Aerial Source: NAIP 2011

Adopted from: Grants Reclamation Project Updated Corrective Action Program, HMC, 2012

Grants Reclamation Project
Corrective Action Program

Figure 3-21
Extent of the Middle Chinle



LEGEND:

Fault

Subcrop of Lower Chinle
Alluvium Overlies Secondary Porosity
(Subcrop boundary dashed where inferred)

Saturated Alluvium

Unsaturated Alluvium

6400 Extent of Lower Chinle Aquifer with Elevation Contour (ft-amsl)

N

0 1,250 2,500 Feet

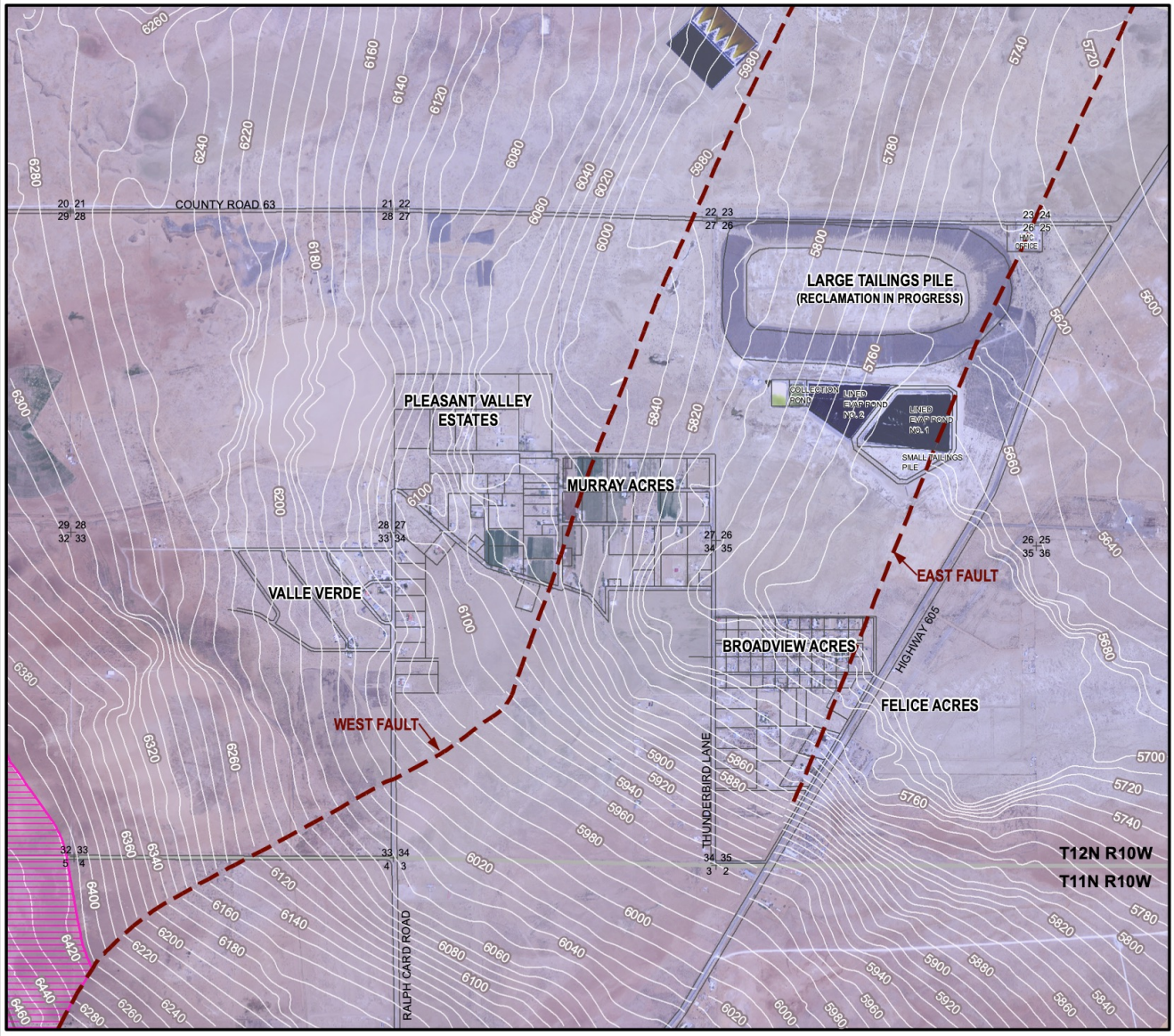
Aerial Source: NAIP 2011

Adopted from: Grants Reclamation Project Updated Corrective Action Program, HMC, 2012

HOMESTAKE

Grants Reclamation Project
Corrective Action Program

Figure 3-22
Extent of the Lower Chinle



LEGEND:

Fault

Subcrop of San Andres-Glorietta Alluvium Overlies Limestone

Saturated Alluvium

Extent of San Andres-Glorietta Aquifer with Elevation Contour (ft-amsl)

N

0 1,250 2,500 Feet

Aerial Source: NAIP 2011

Adopted from: Grants Reclamation Project Updated Corrective Action Program, HMC, 2012

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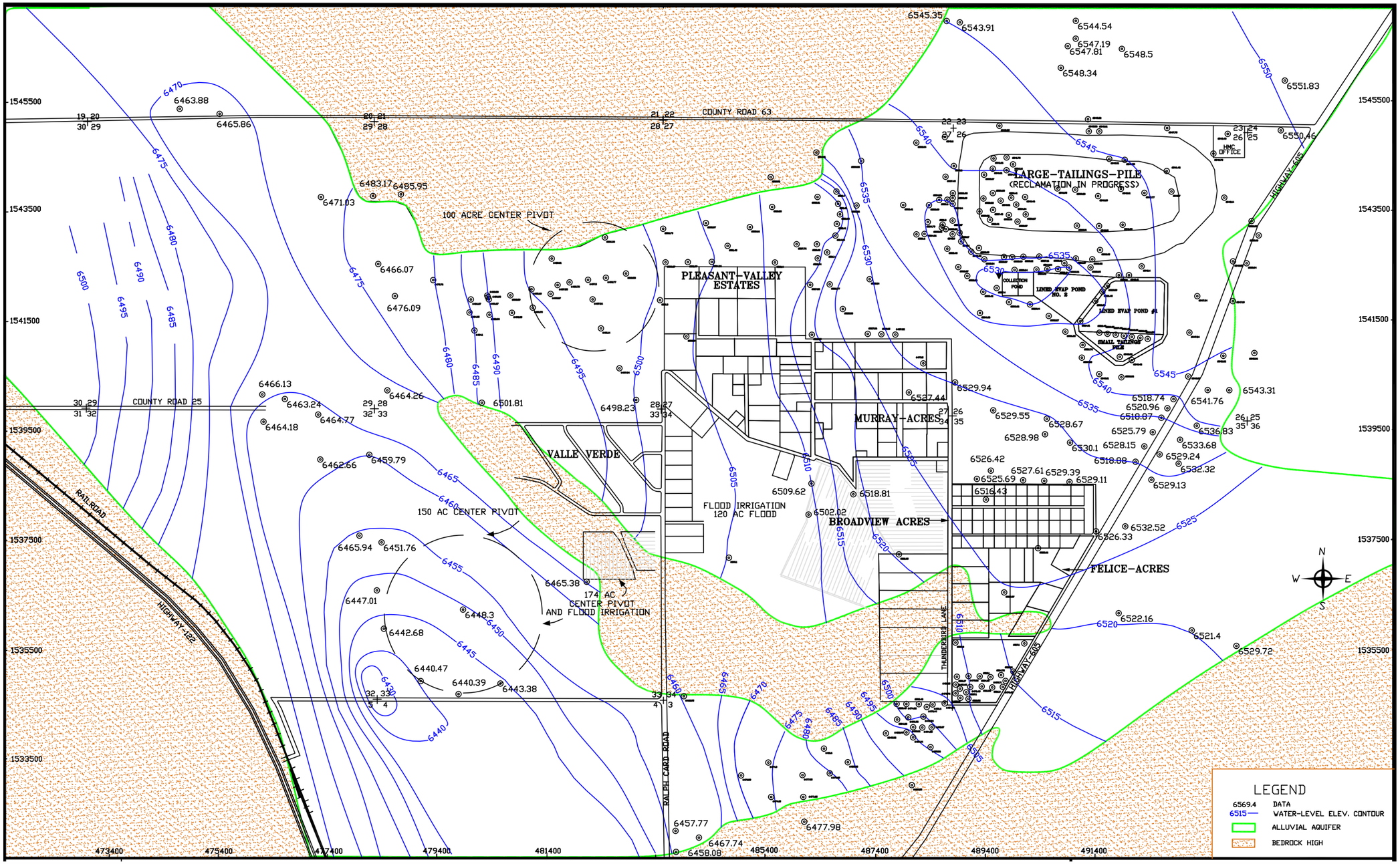
Corrective Action Program

Figure 3-23
Extent of San Andres Limestone and Glorieta Sandstone



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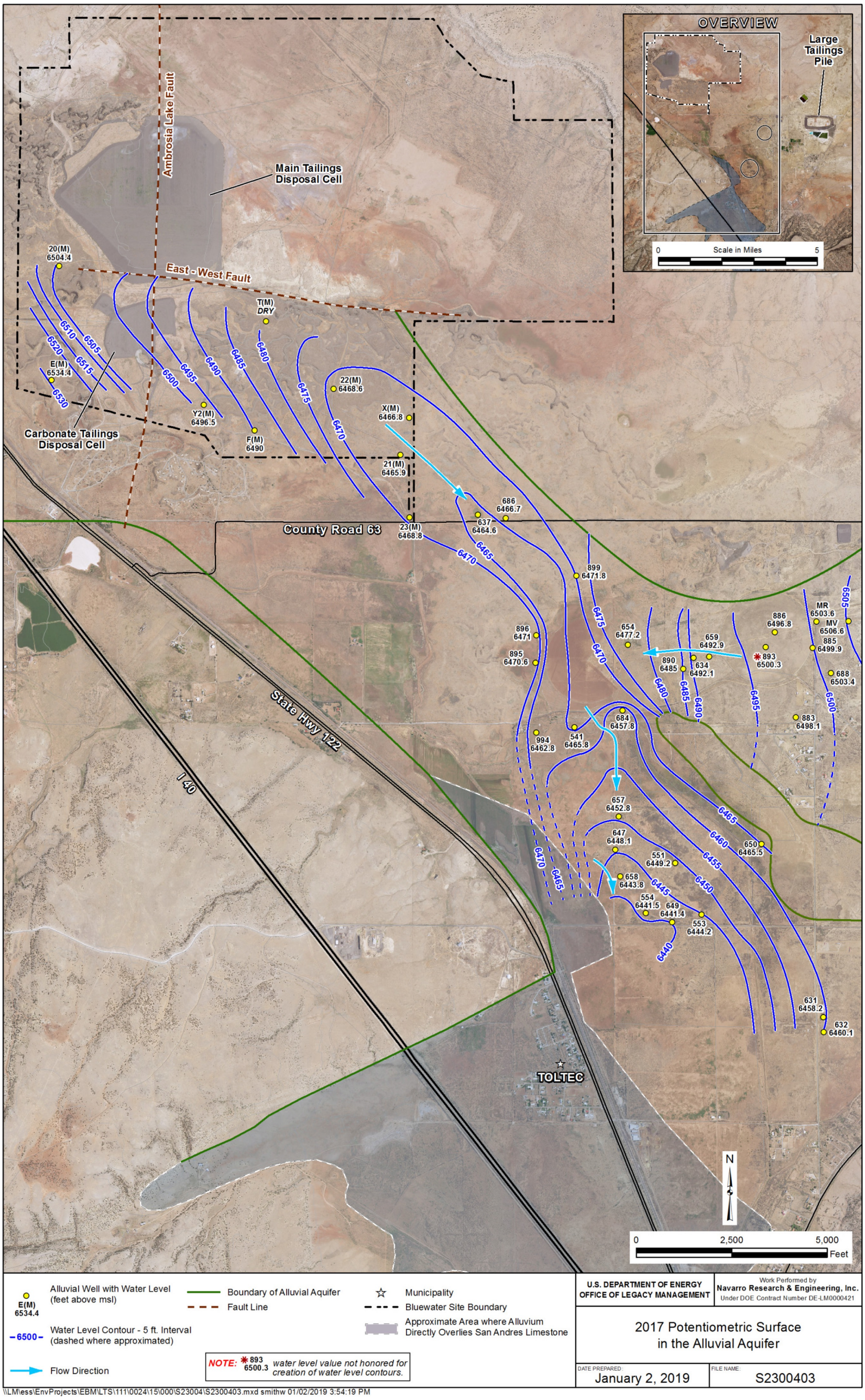
Elevation-feet above mean sea level

Figure 3-24
Groundwater Potentiometric Surface
Alluvial Aquifer



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Grants Reclamation Project

Source: DOE 2019

Figure 3-25
San Jose Groundwater Elevation Contours

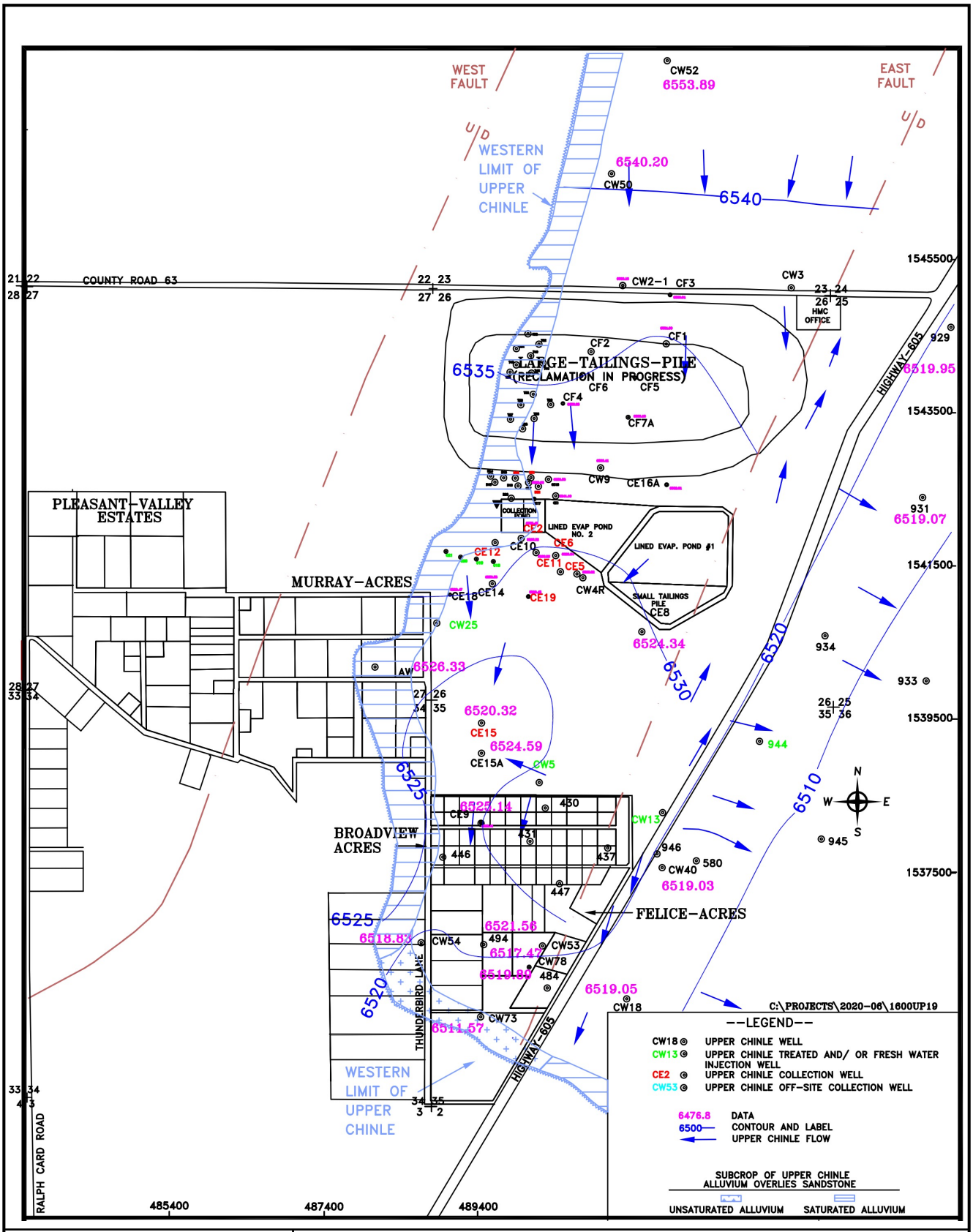

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Figure 3-26
Groundwater Potentiometric Surface
Upper Chinle

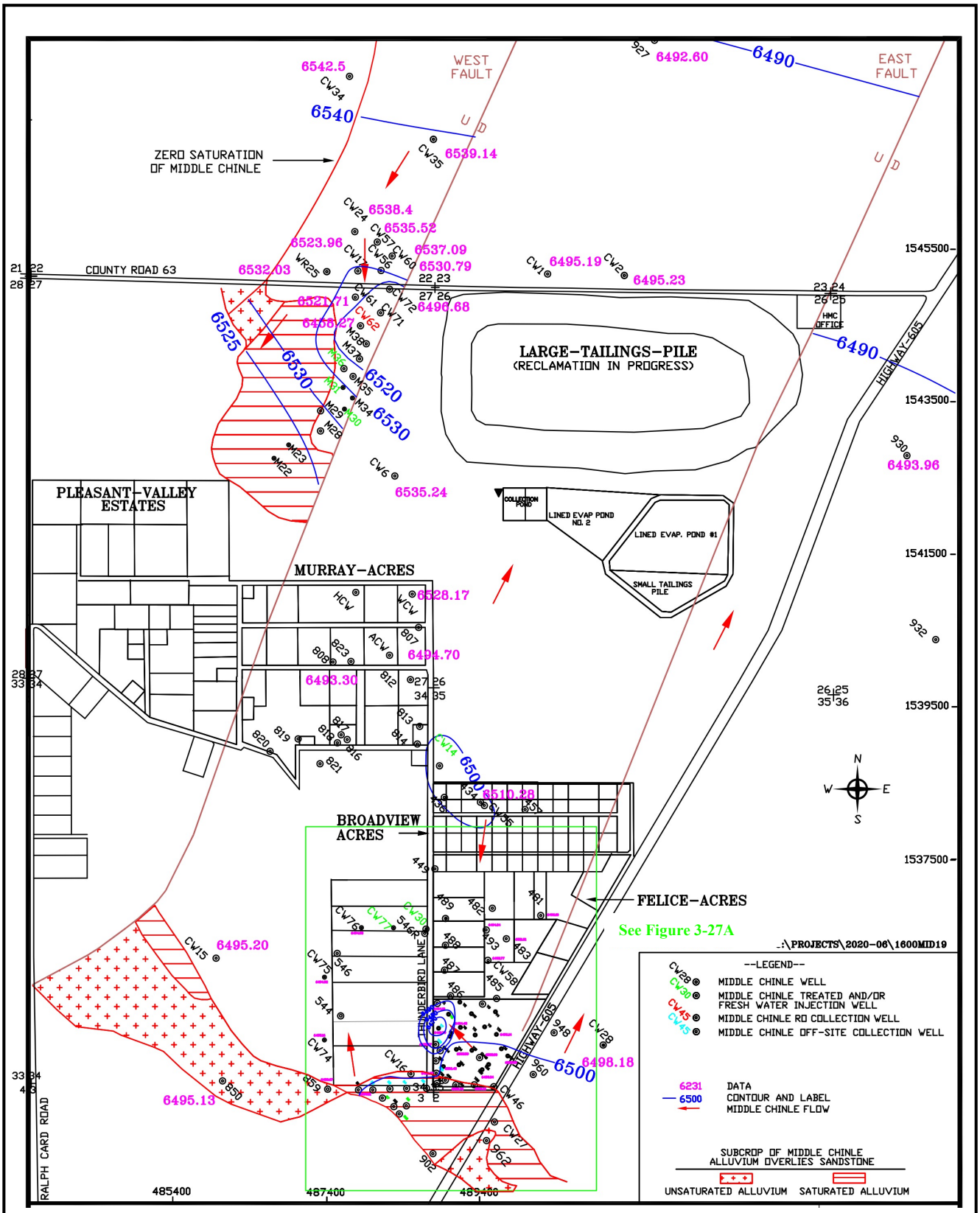

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Figure 3-27
Groundwater Potentiometric Surface
Middle Chinle

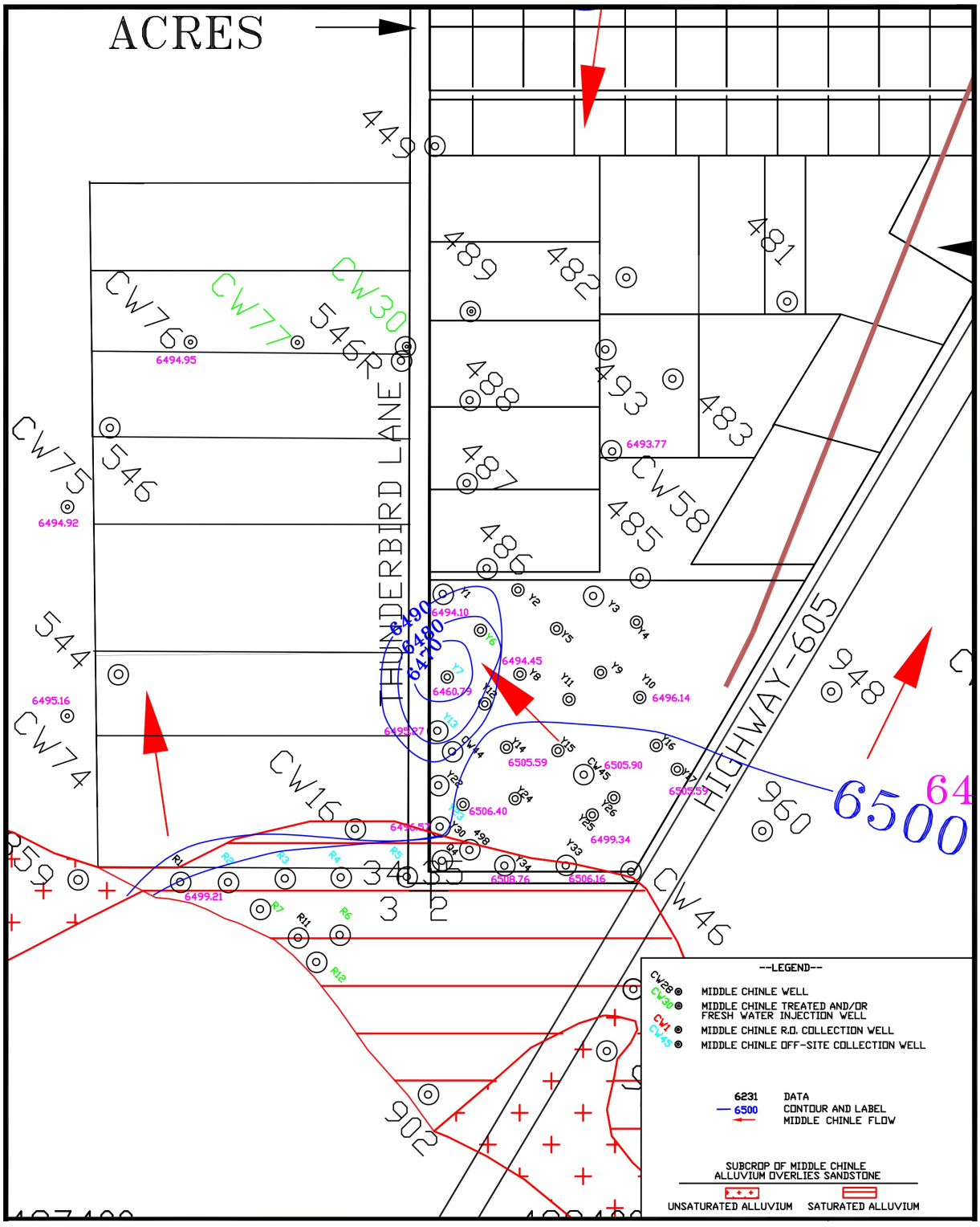

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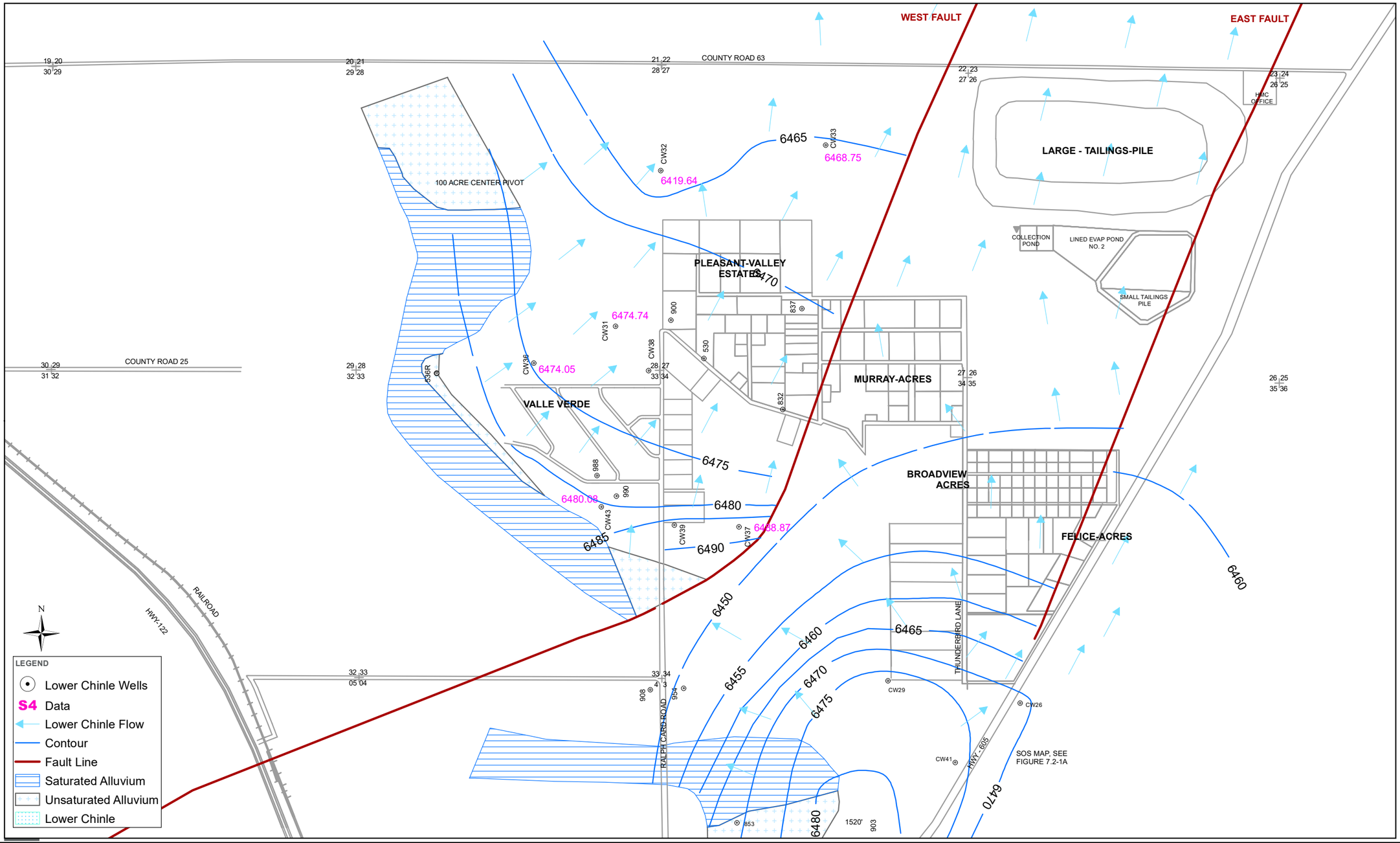
Figure 3-27A
Groundwater Potentiometric Surface
Middle Chinle - Inset



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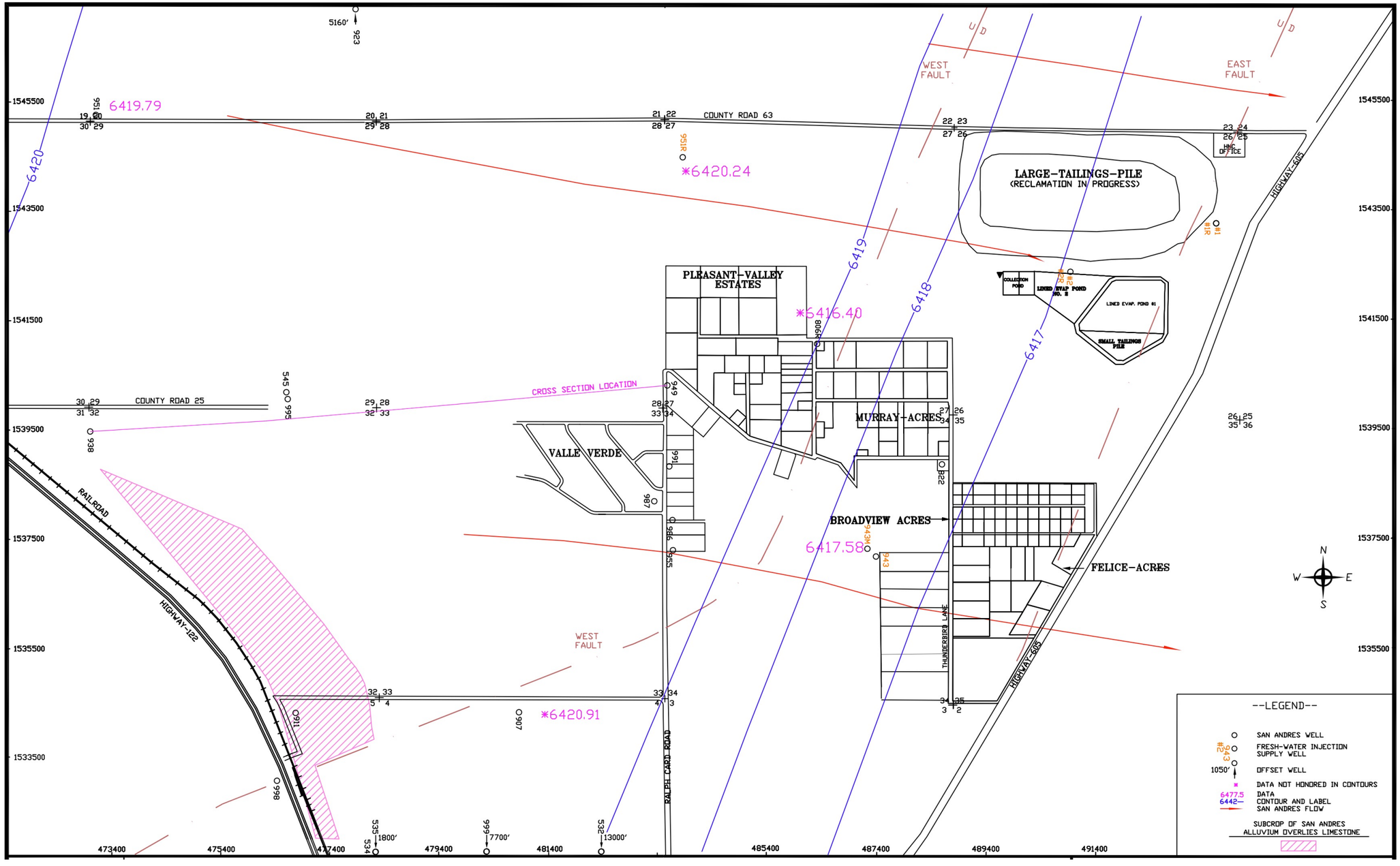
Corrective Action Program

Elevation-feet above mean sea level

Figure 3-28
Groundwater Potentiometric Surface
Lower Chinle



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Elevation-feet above mean sea level

Figure 3-29
Groundwater Potentiometric Surface
San Andres-Glorieta Aquifer

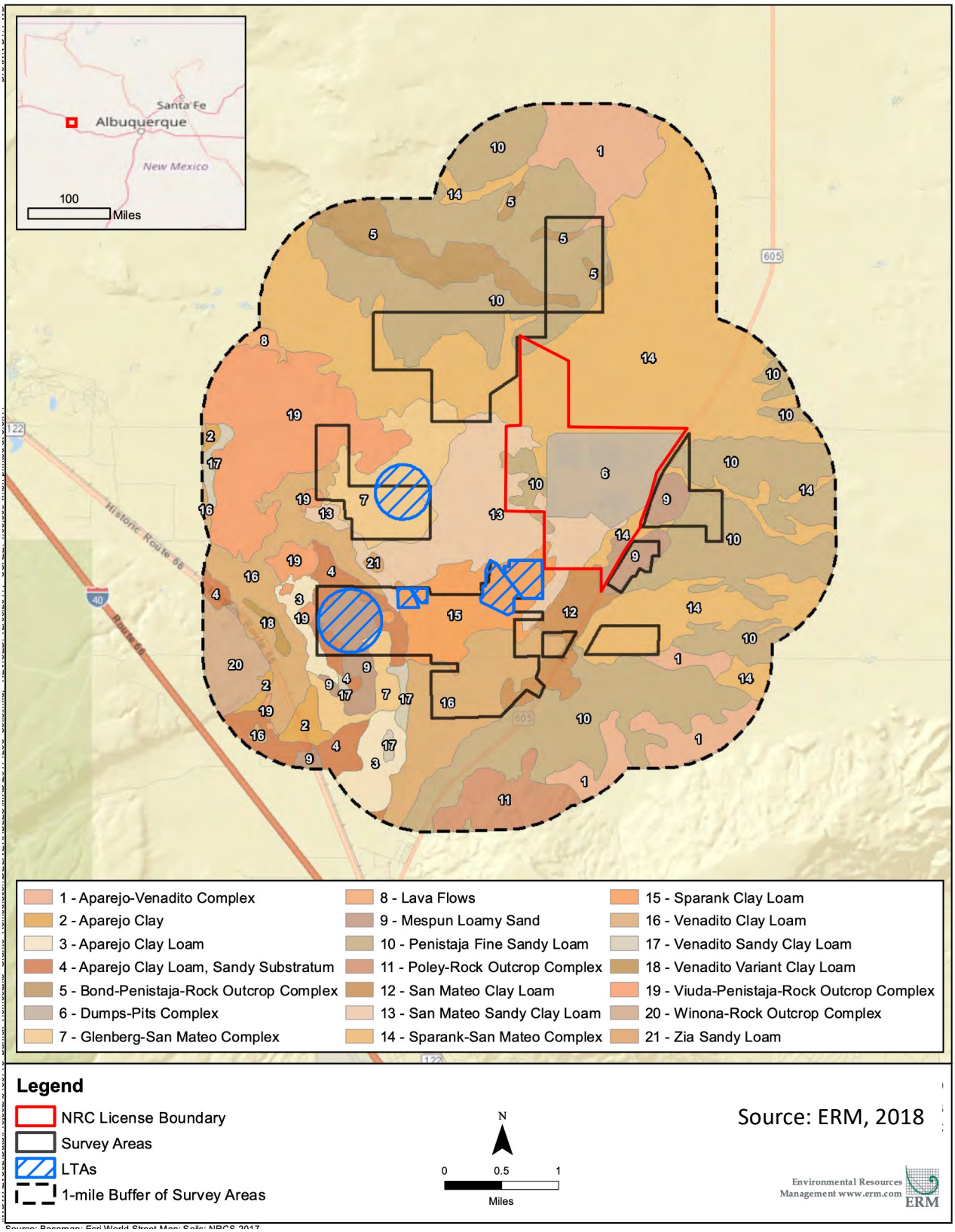

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Figure 3-30
NRCS Soil Map

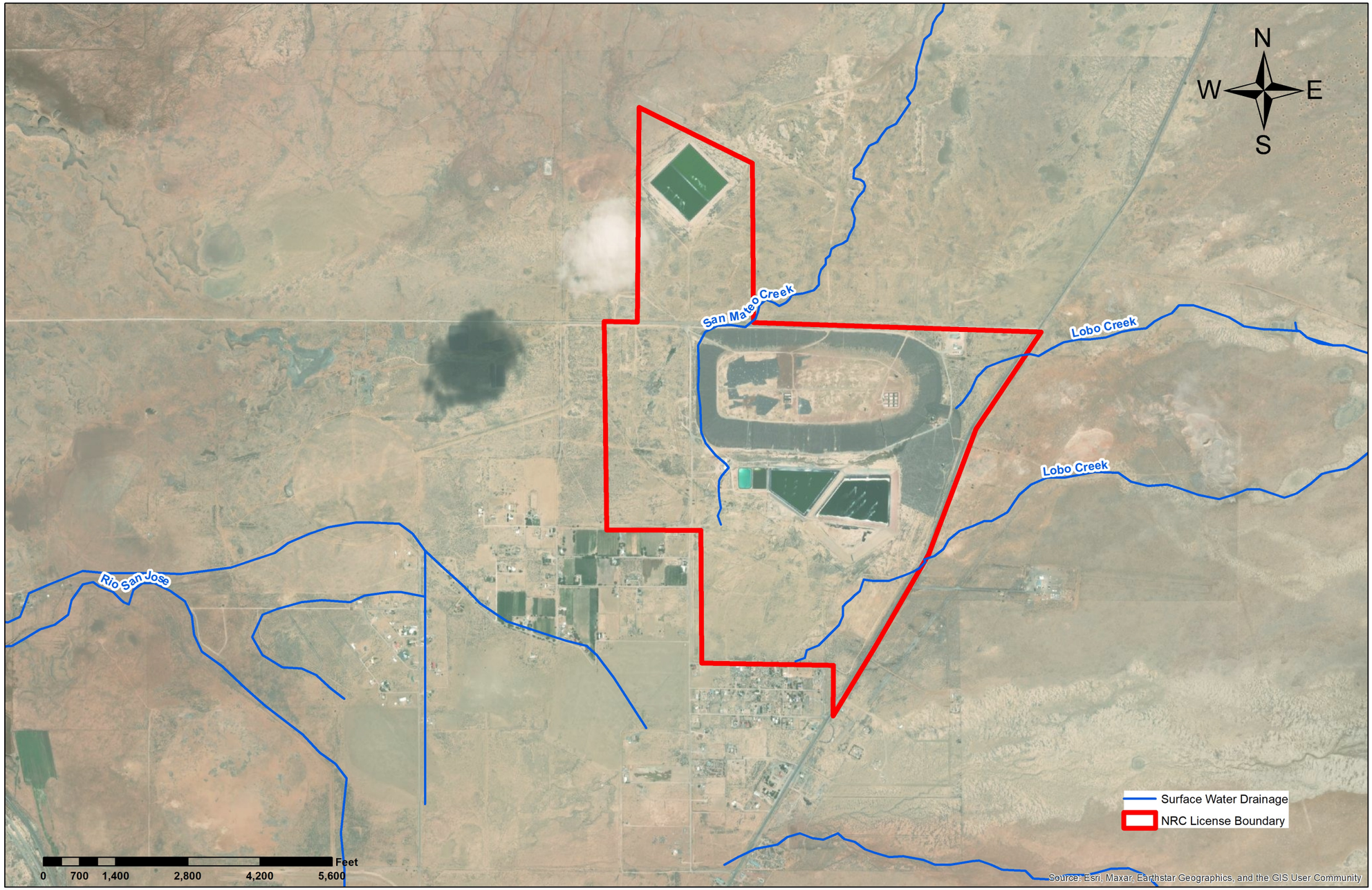

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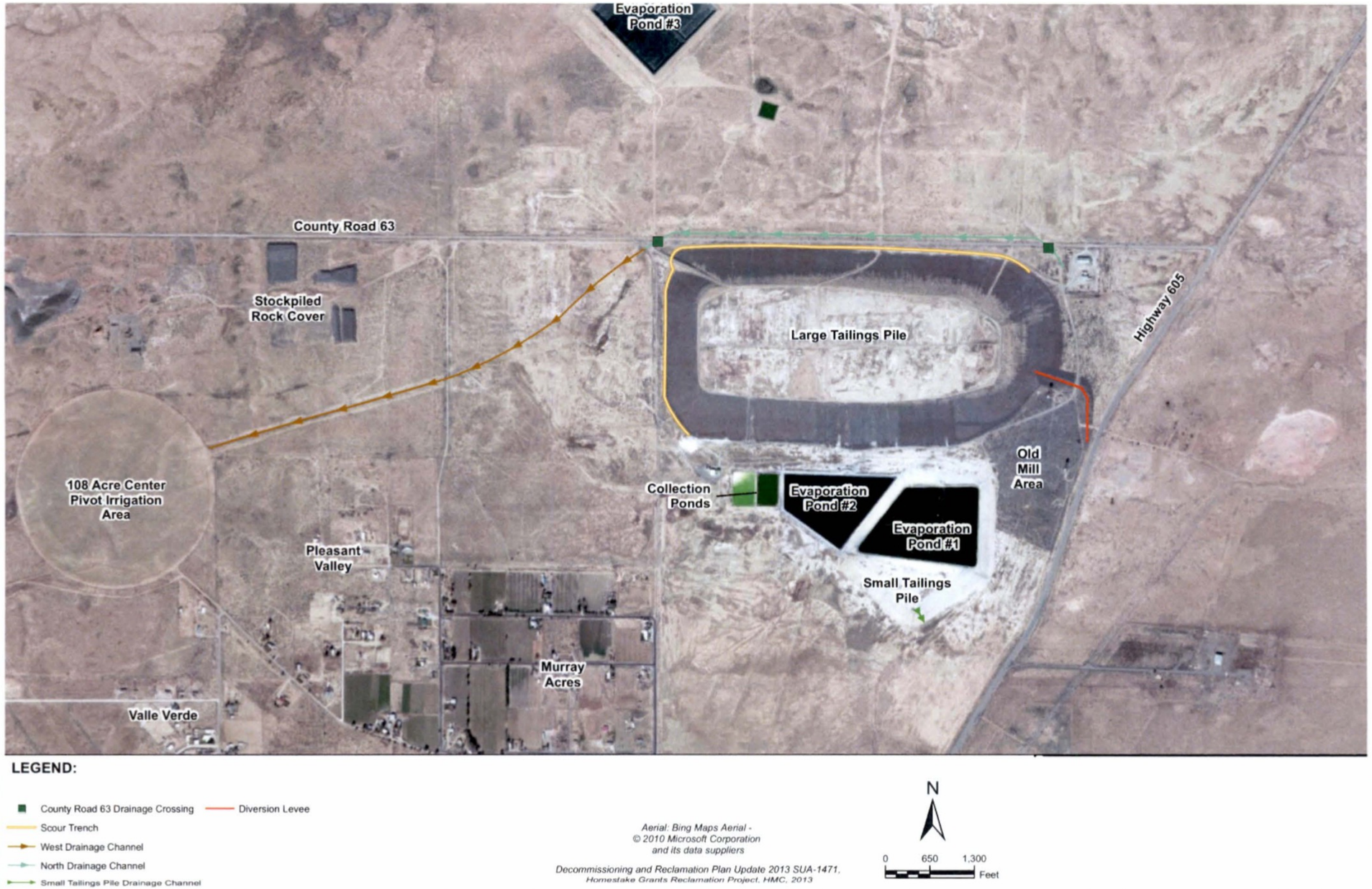
Figure 3-31
Surface Water Drainages



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Corrective Action Program

Source: HDR, 2016

Figure 3-32
GRP Constructed Drainage Features

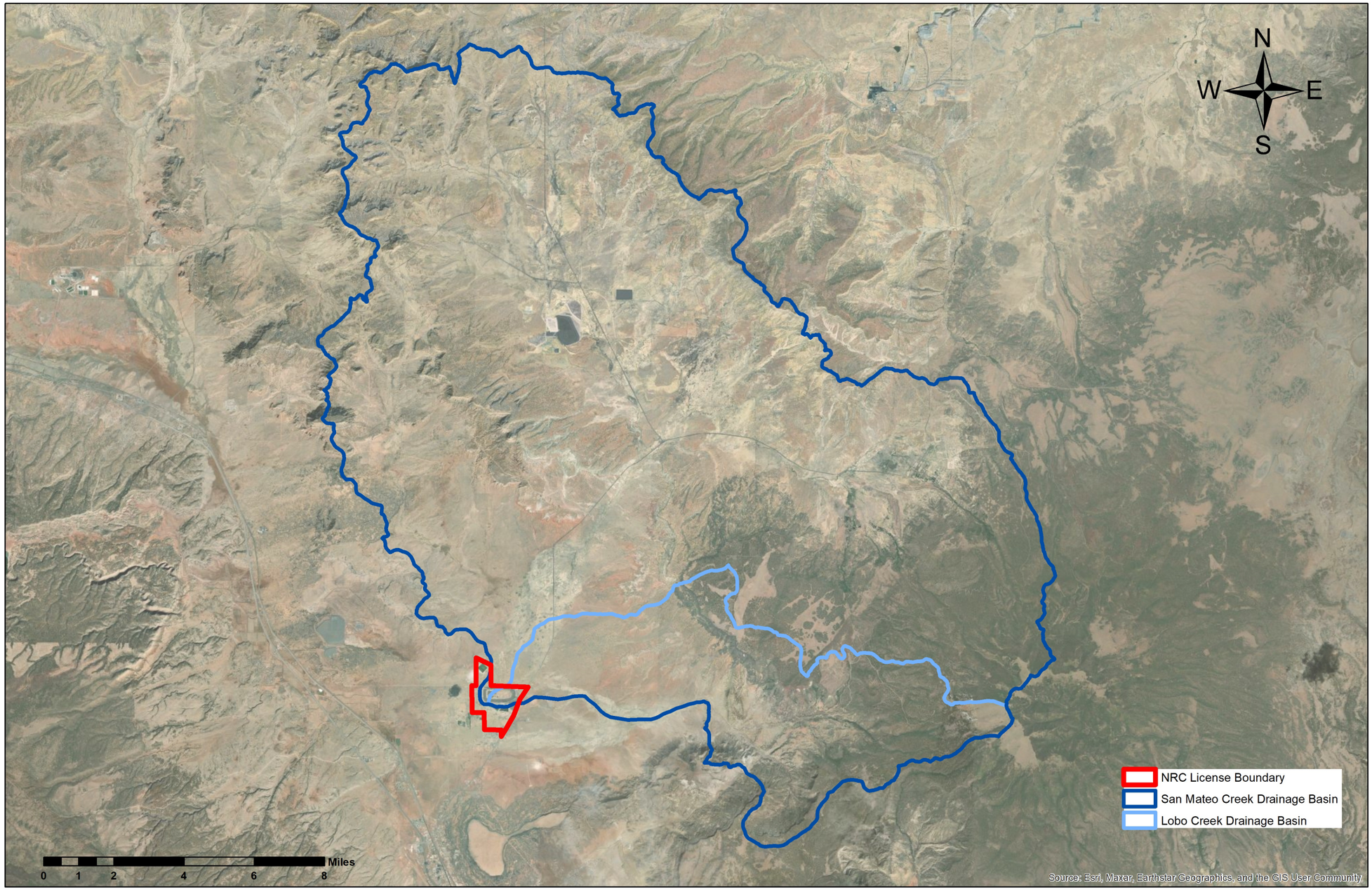

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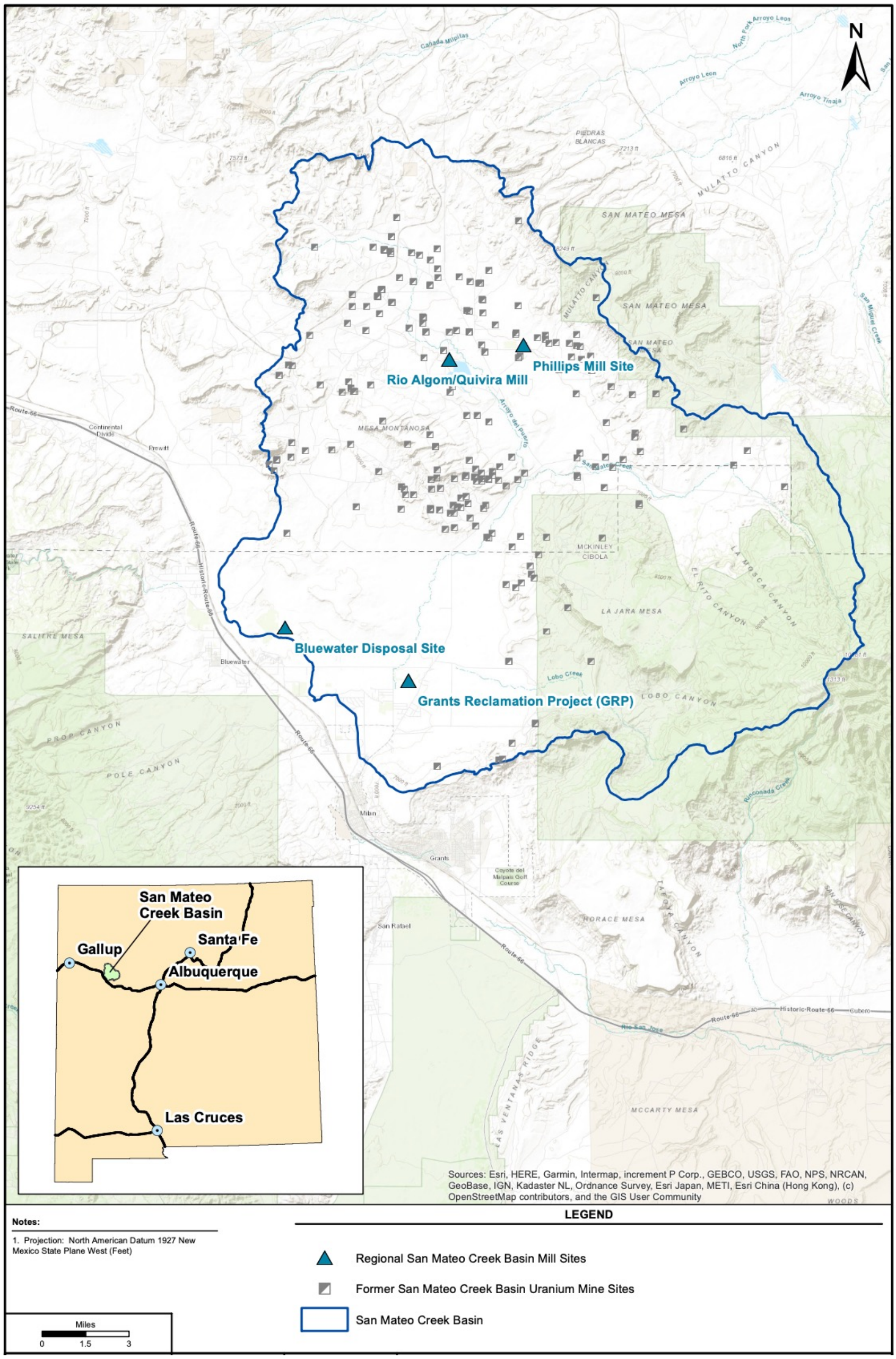
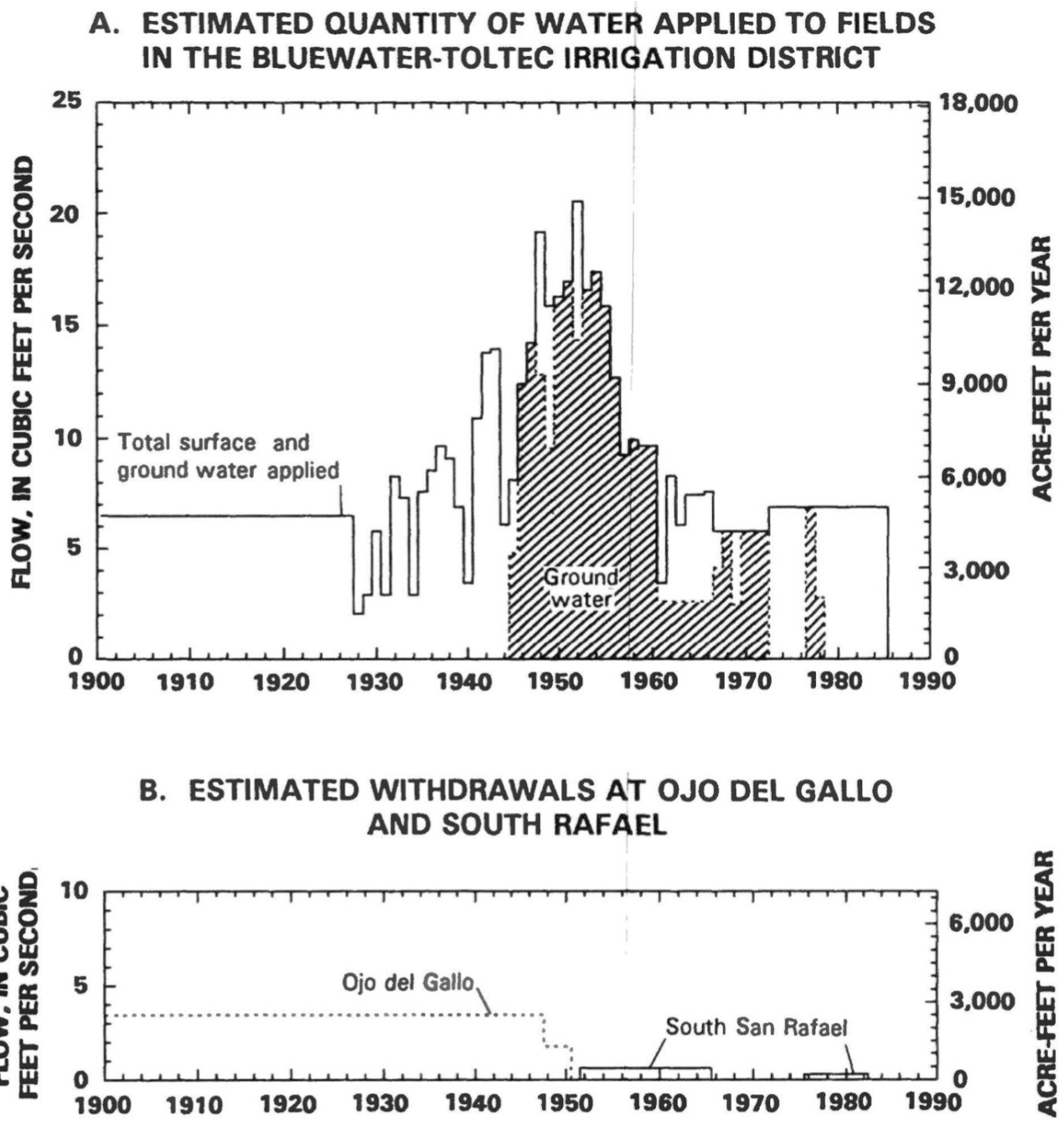
Figure 3-33
Regional Surface Water Drainage Basins



Grants Reclamation Project	Source: Weston, 2016	**Figure 3-34** Grants Mineral Belt



Source: Frenzel, 1992

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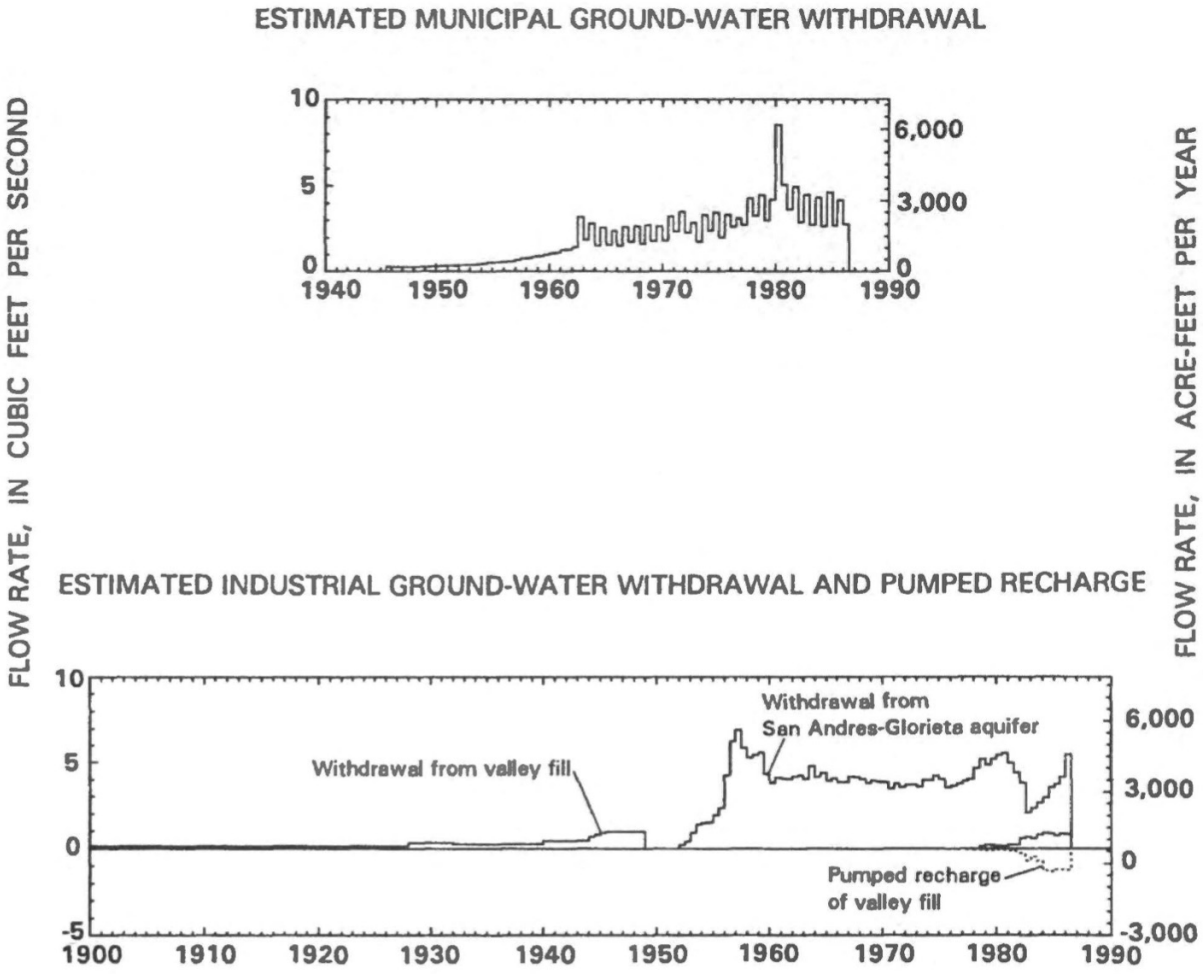
Figure 3-35
Estimated Irrigation Pumping in the San Andres Limestone and Glorieta Sandstone Aquifer



Source: Frenzel, 1992

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Corrective Action Program

Figure 3-36
Estimated Municipal and Industrial Pumping in the San Andres Limestone and Glorieta Sandstone Aquifer

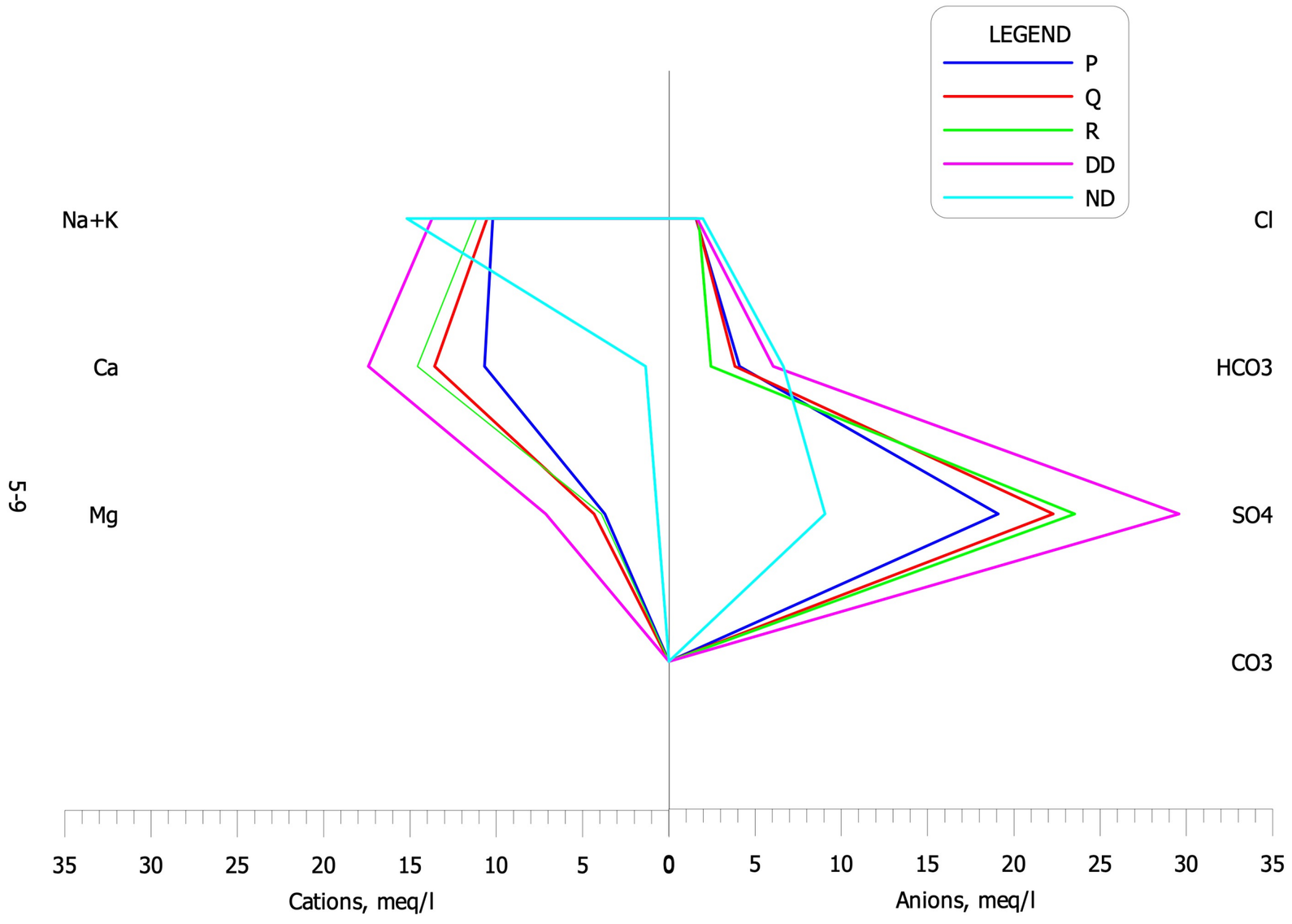

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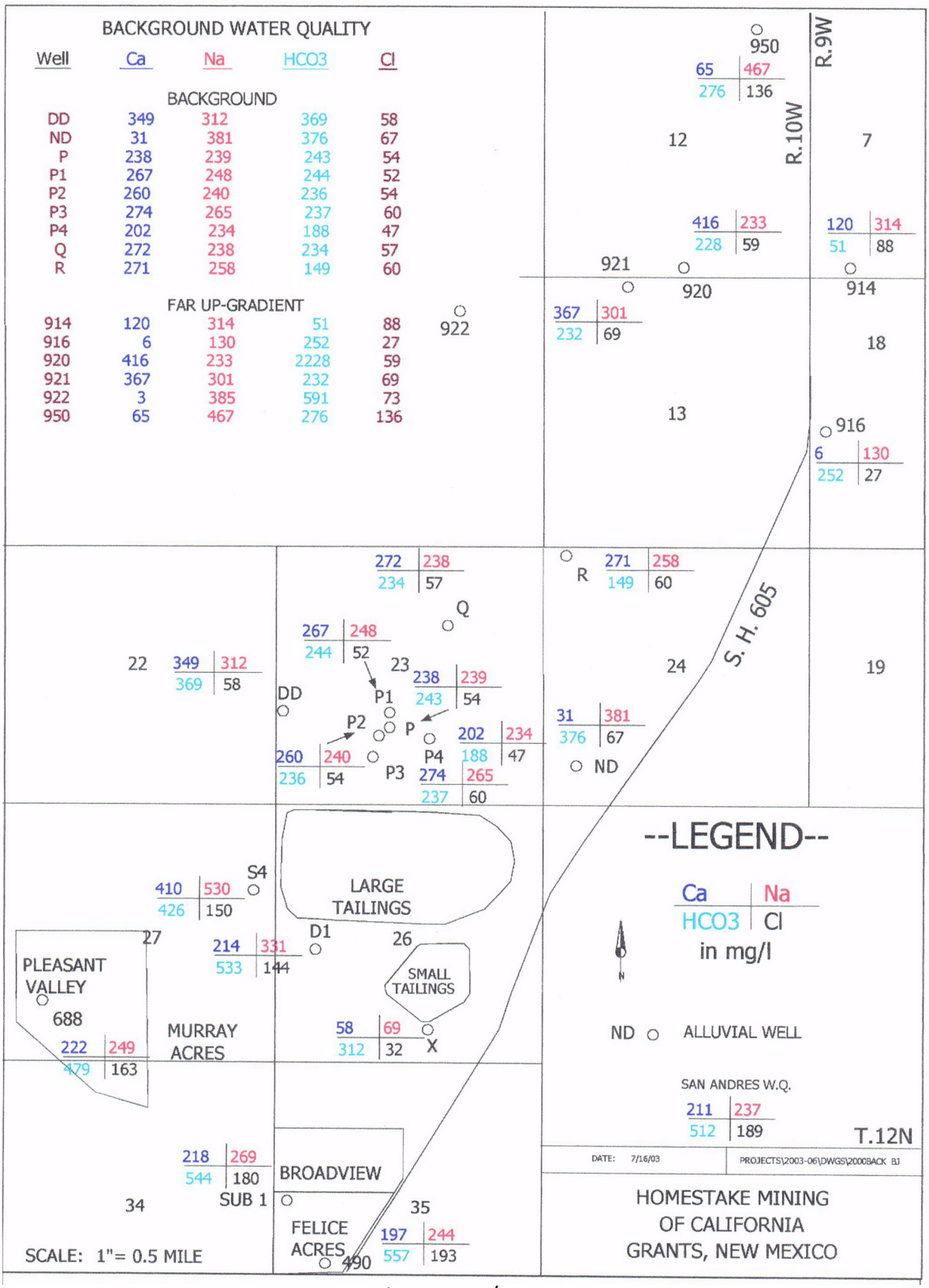
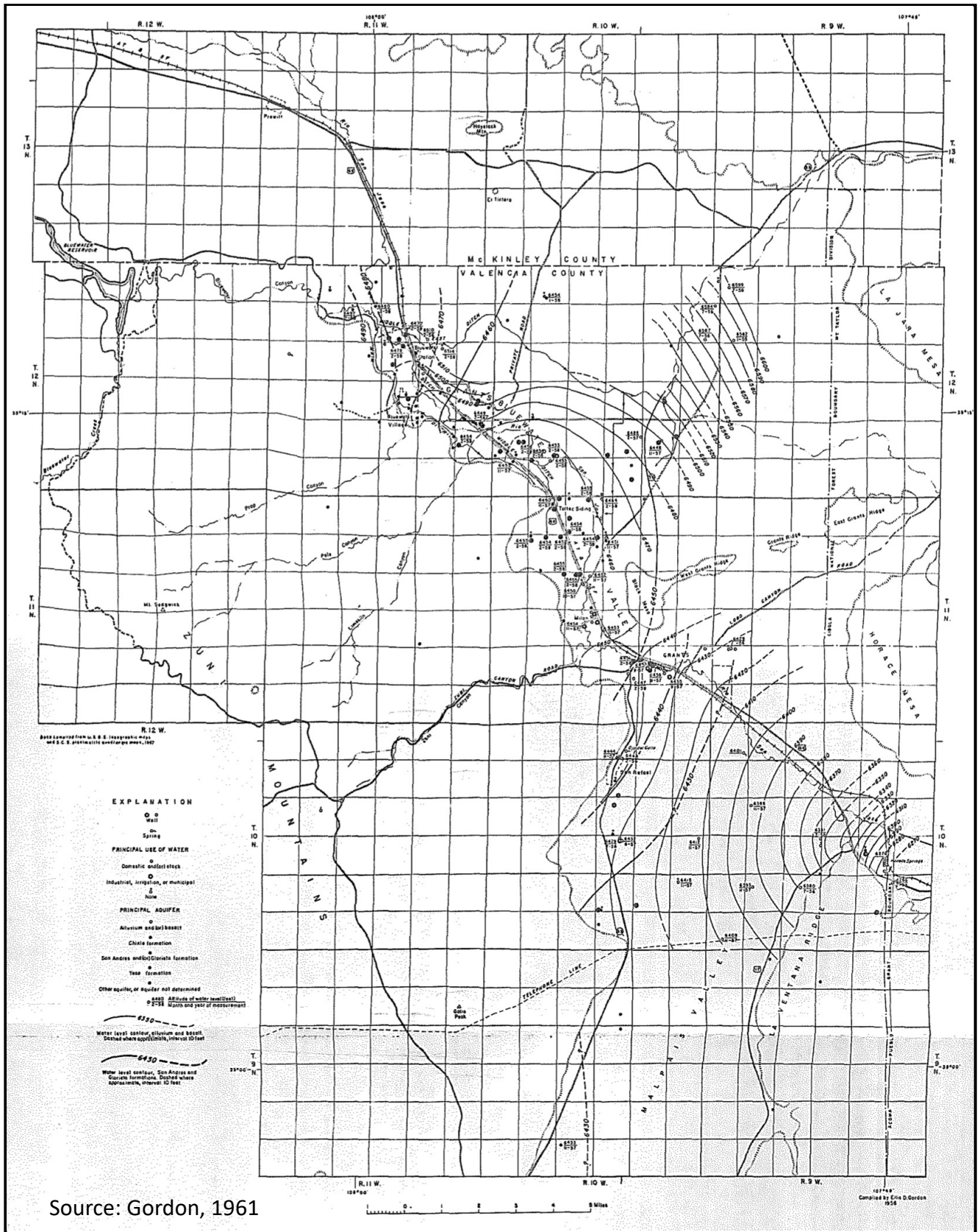
Figure 3-37
Stiff Diagram Comparison of Near Upgradient Alluvial Groundwater Quality



Units are mg/L

Grants Reclamation Project
Corrective Action Program

Figure 3-38
Major Ionic Constituent Concentration Comparisons
of Background Alluvial Wells



Source: Gordon, 1961

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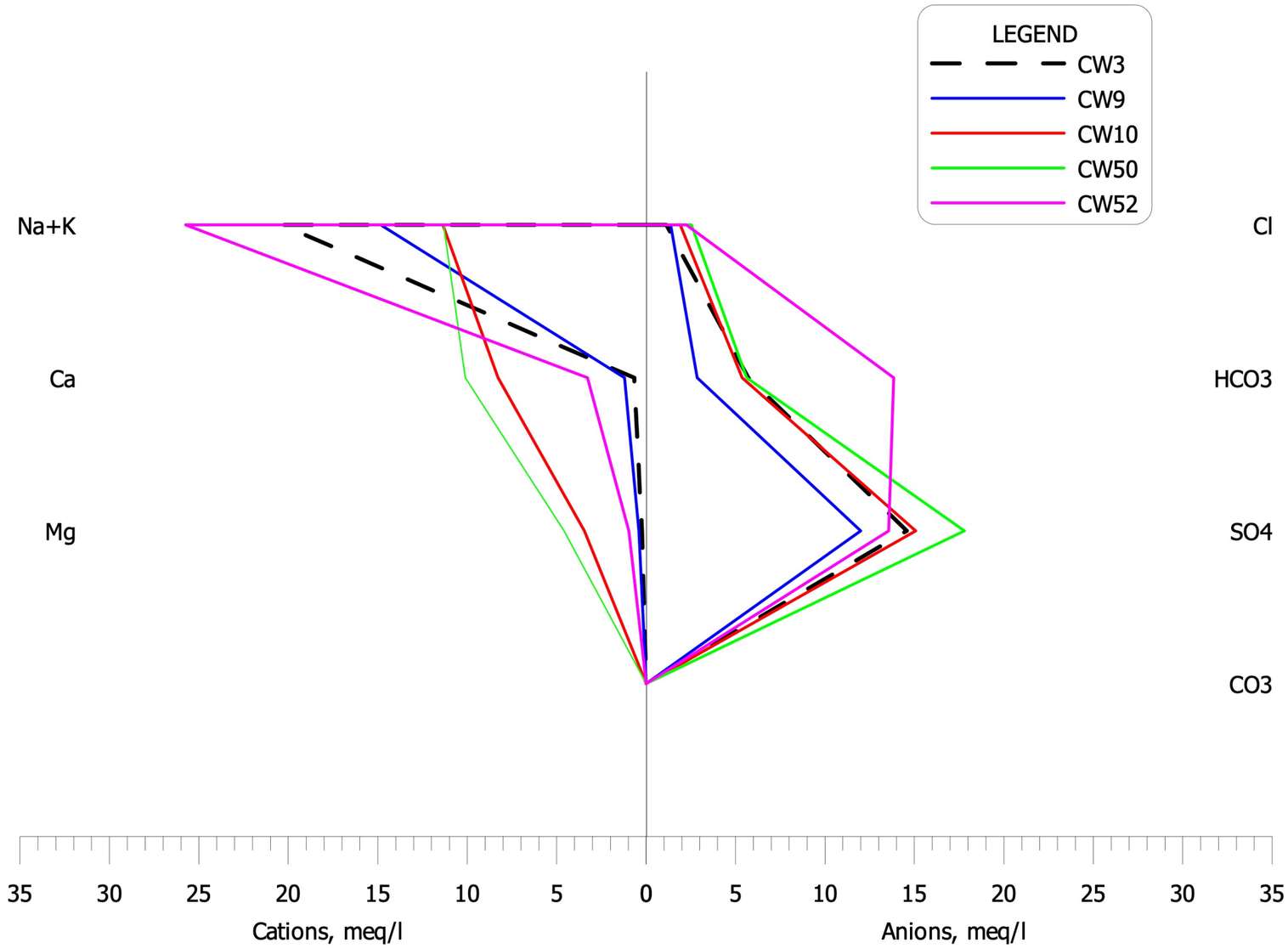
Figure 3-39
Chinle Background Wells



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Corrective Action Program

Figure 3-40
Stiff Diagram Comparison of Upper Chinle Groundwater Quality in the North Wells

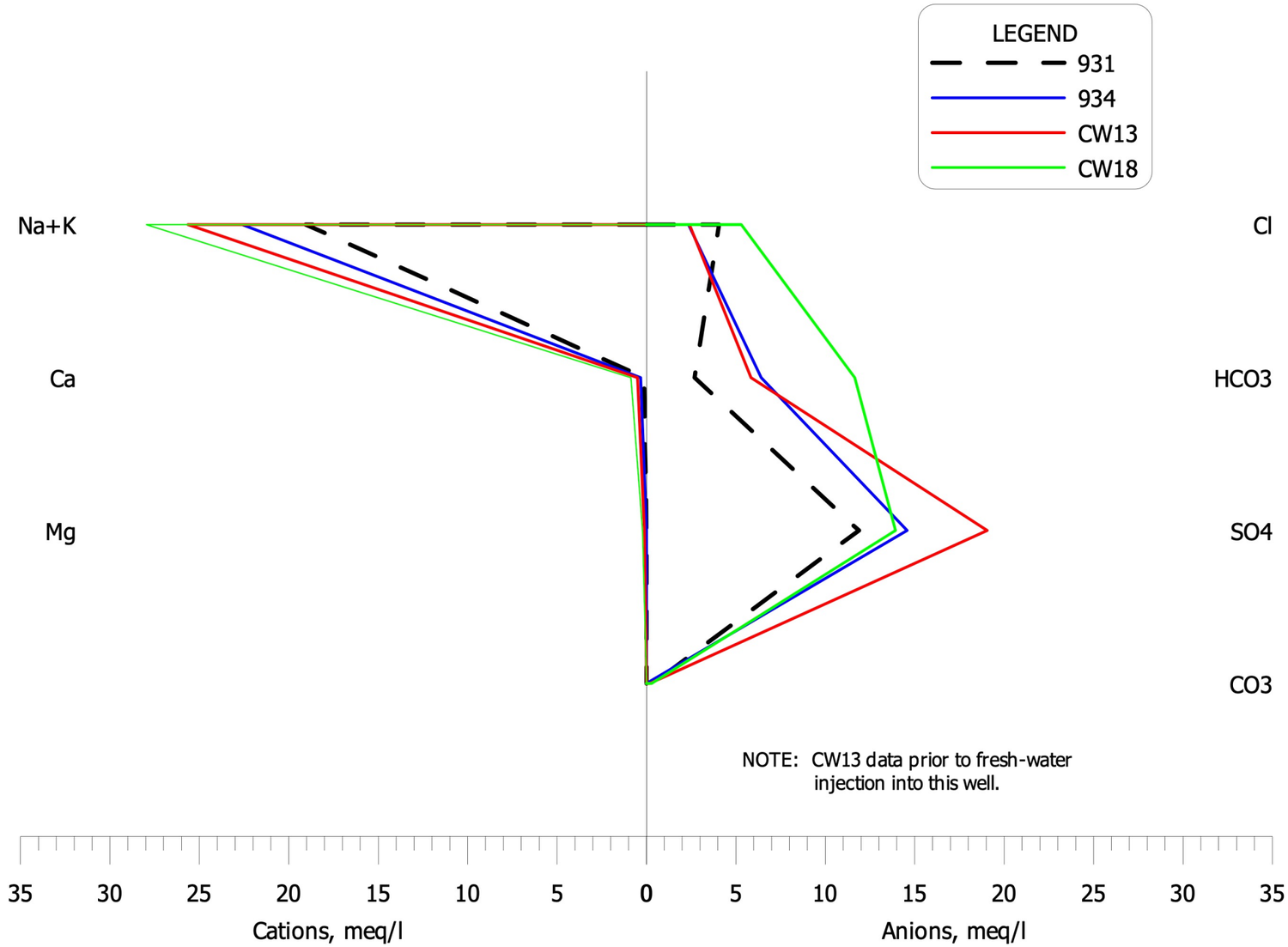

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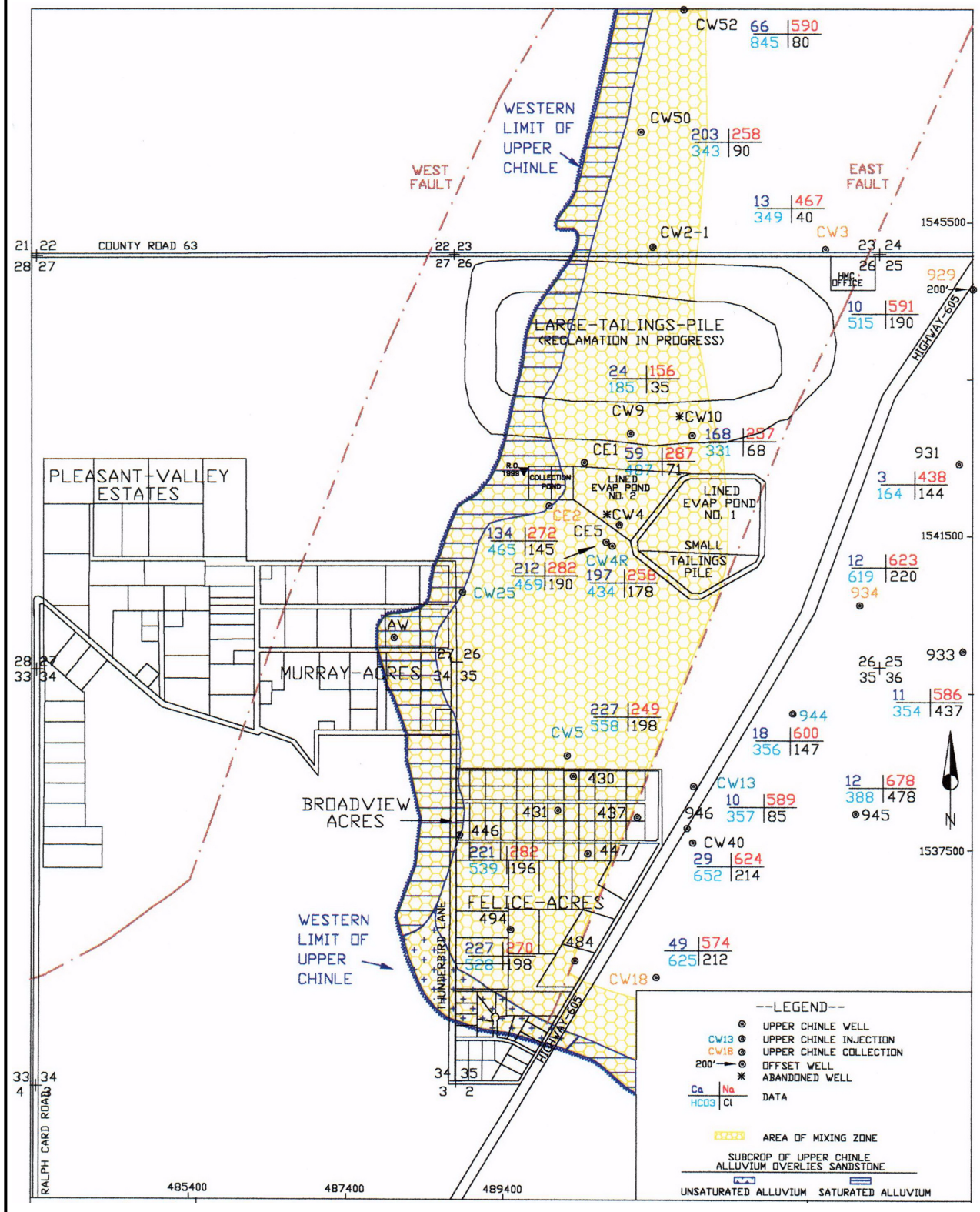
Figure 3-41
Stiff Diagram Comparison of Upper Chinle Groundwater Quality in the East Wells



Units are mg/L

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Corrective Action Program

Figure 3-42
Major Ionic Constituent Concentration Comparisons of the Upper Chinle Groundwater

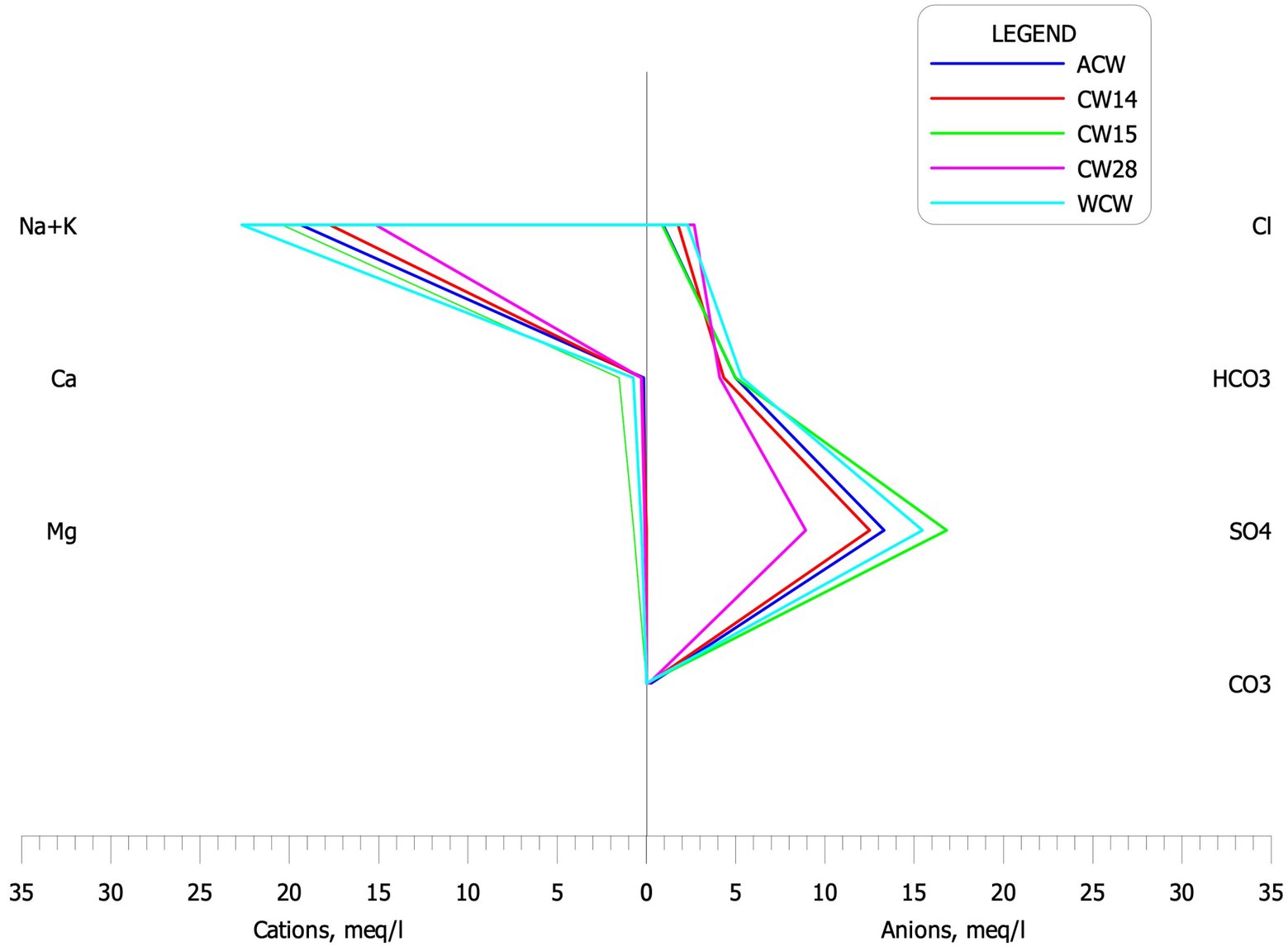

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Figure 3-43
Stiff Diagram Comparison of Middle Chinle Groundwater Quality in the South Wells

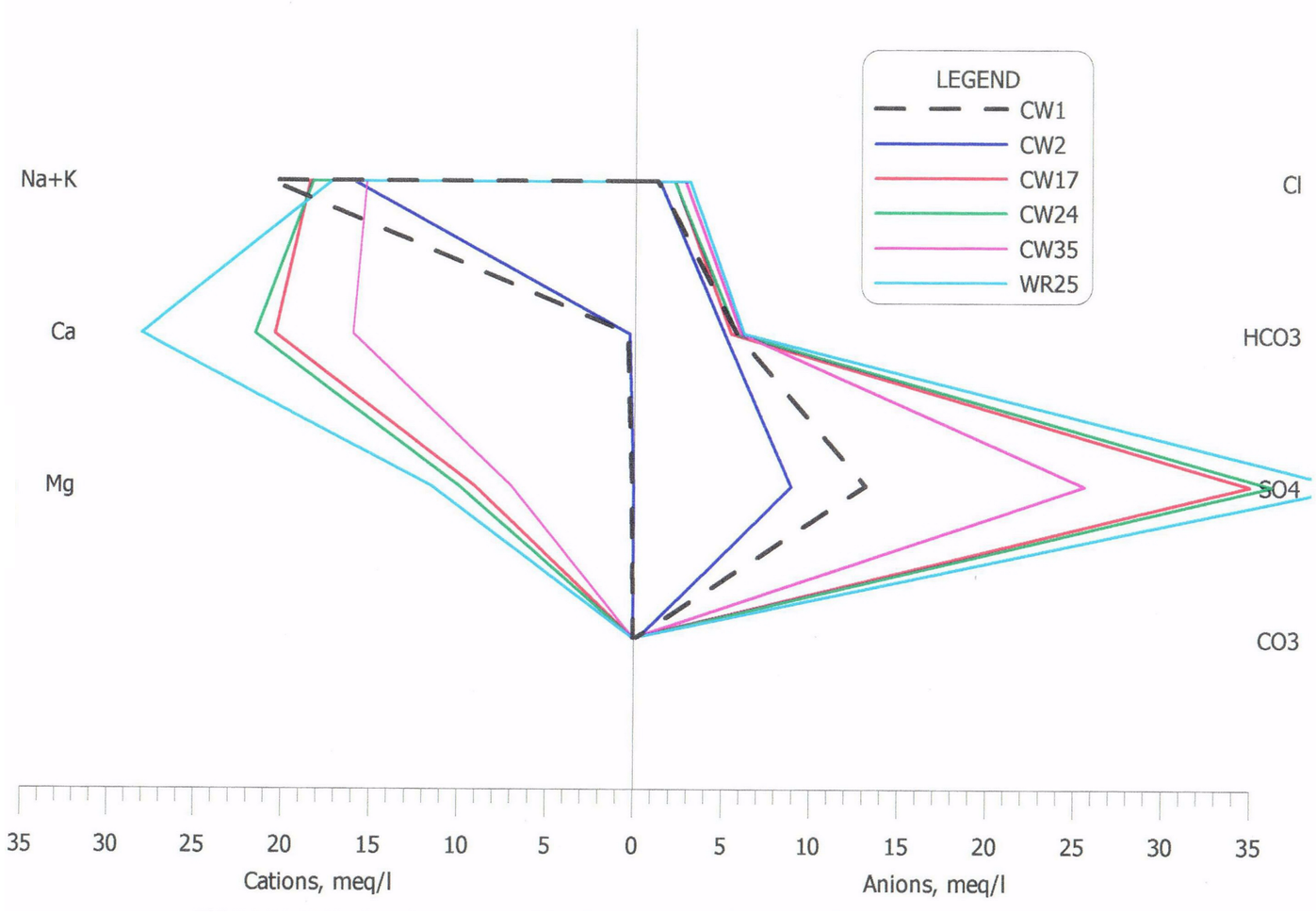

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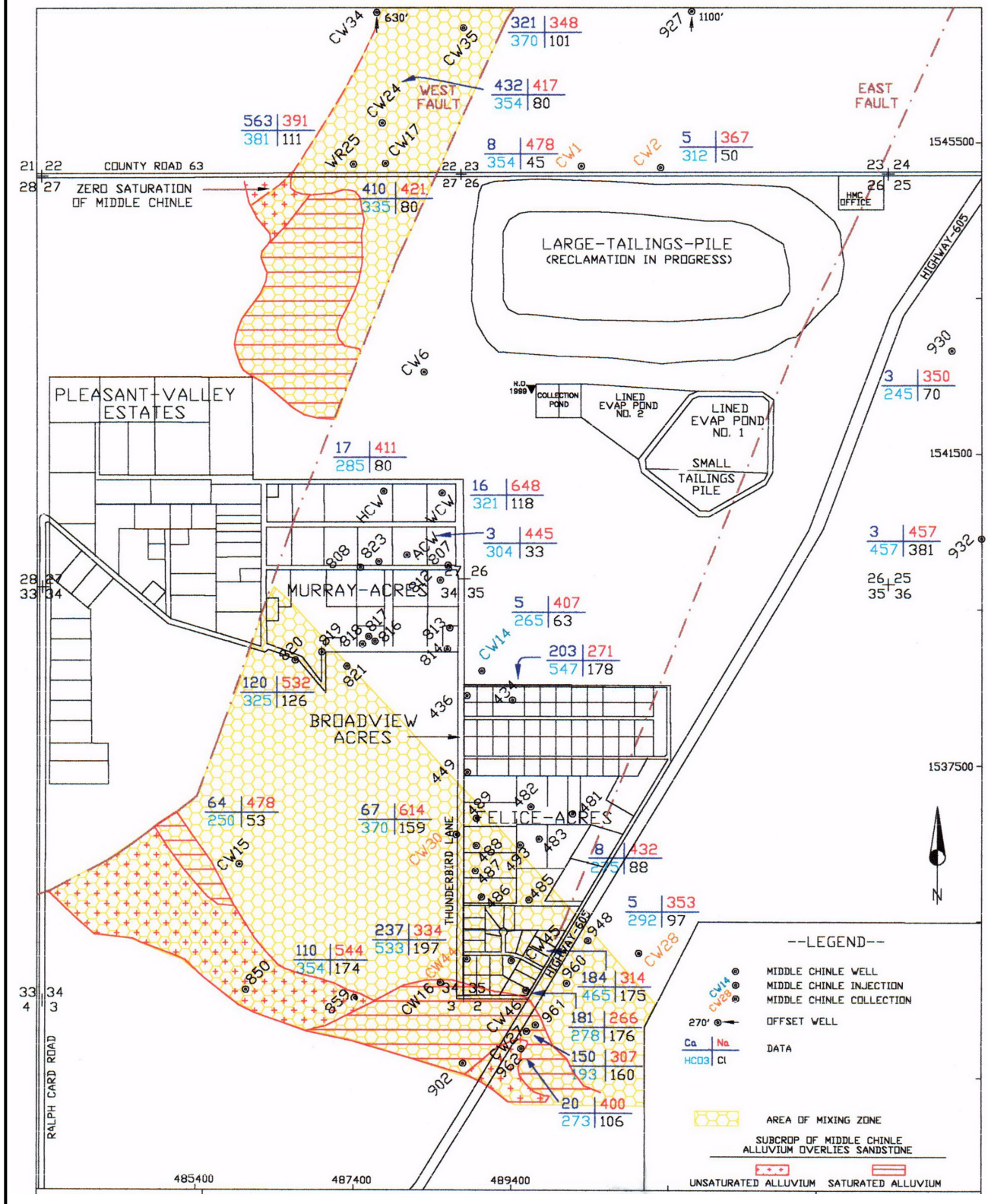
Figure 3-44
Stiff Diagram Comparison of Middle Chinle Groundwater Quality in the North Wells



Units are mg/L

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Figure 3-45
Major Ionic Constituent Concentration Comparisons of the Middle Chinle Groundwater

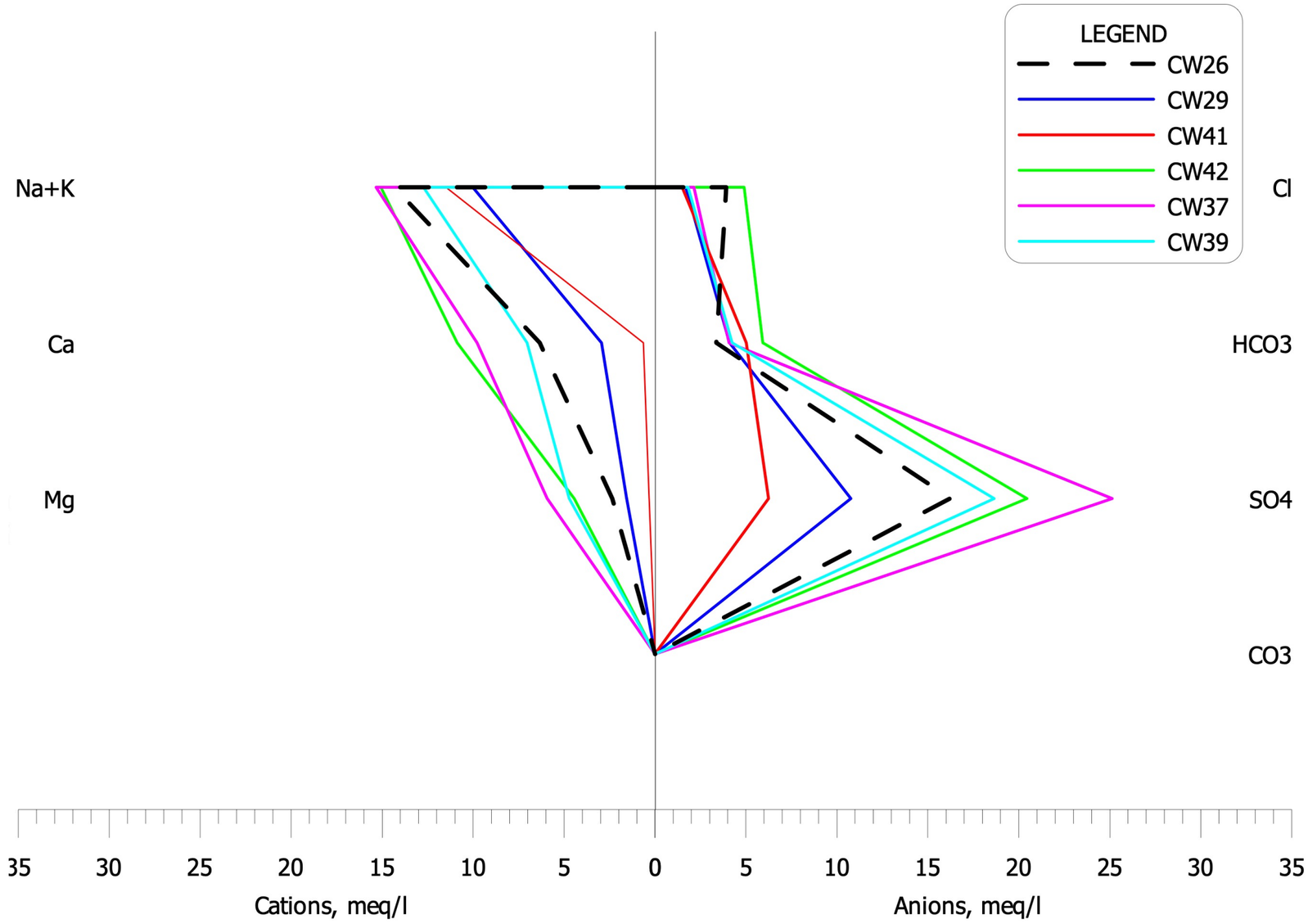

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Figure 3-46
Stiff Diagram Comparison of Lower Chinle Groundwater Quality in the South Wells

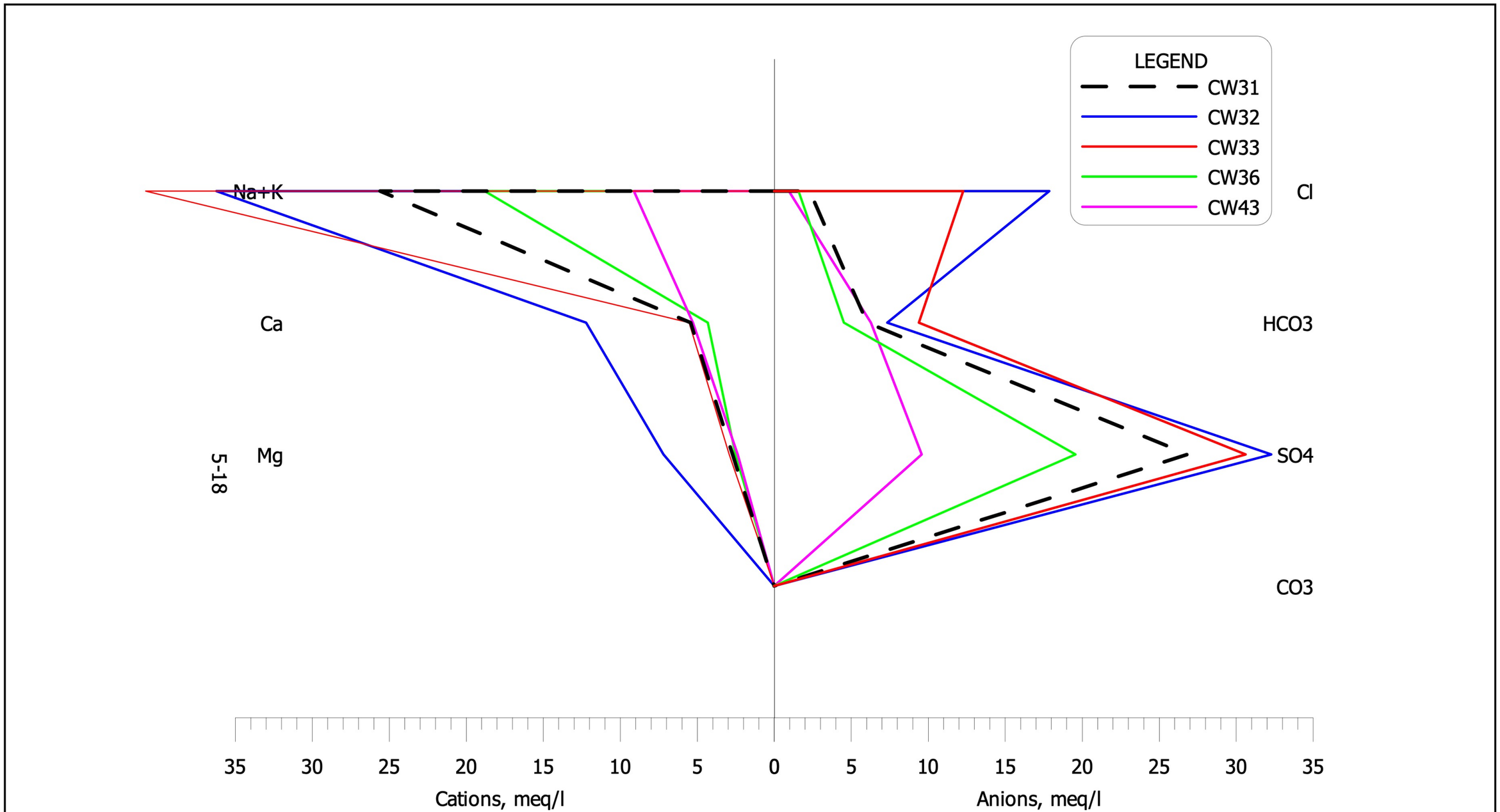

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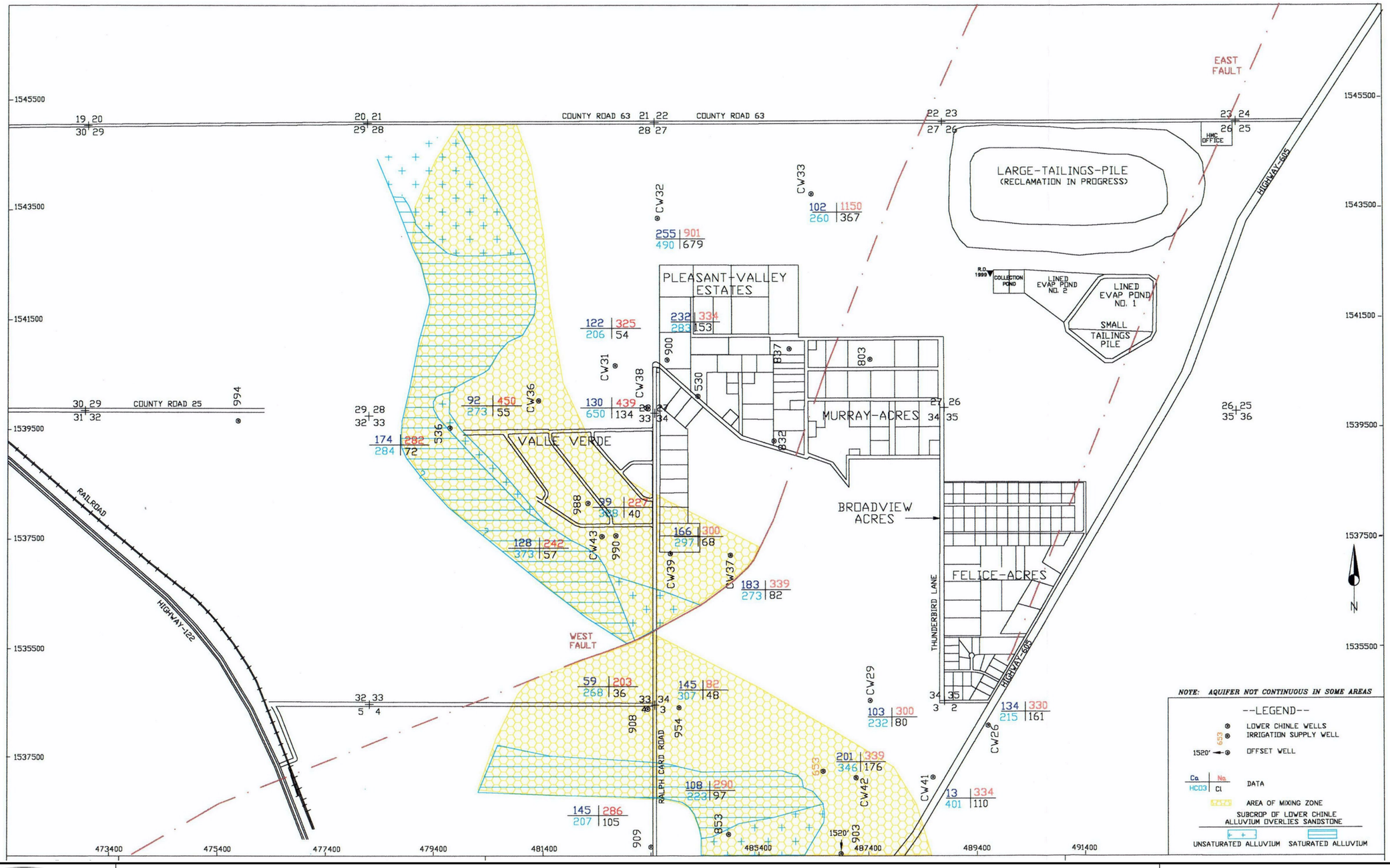
Figure 3-47
Stiff Diagram Comparison of Lower Chinle Groundwater Quality in the North Wells



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Corrective Action Program

Units are mg/L

Figure 3-48
Major Ionic Constituent Concentration Comparisons of the Lower Chinle Groundwater

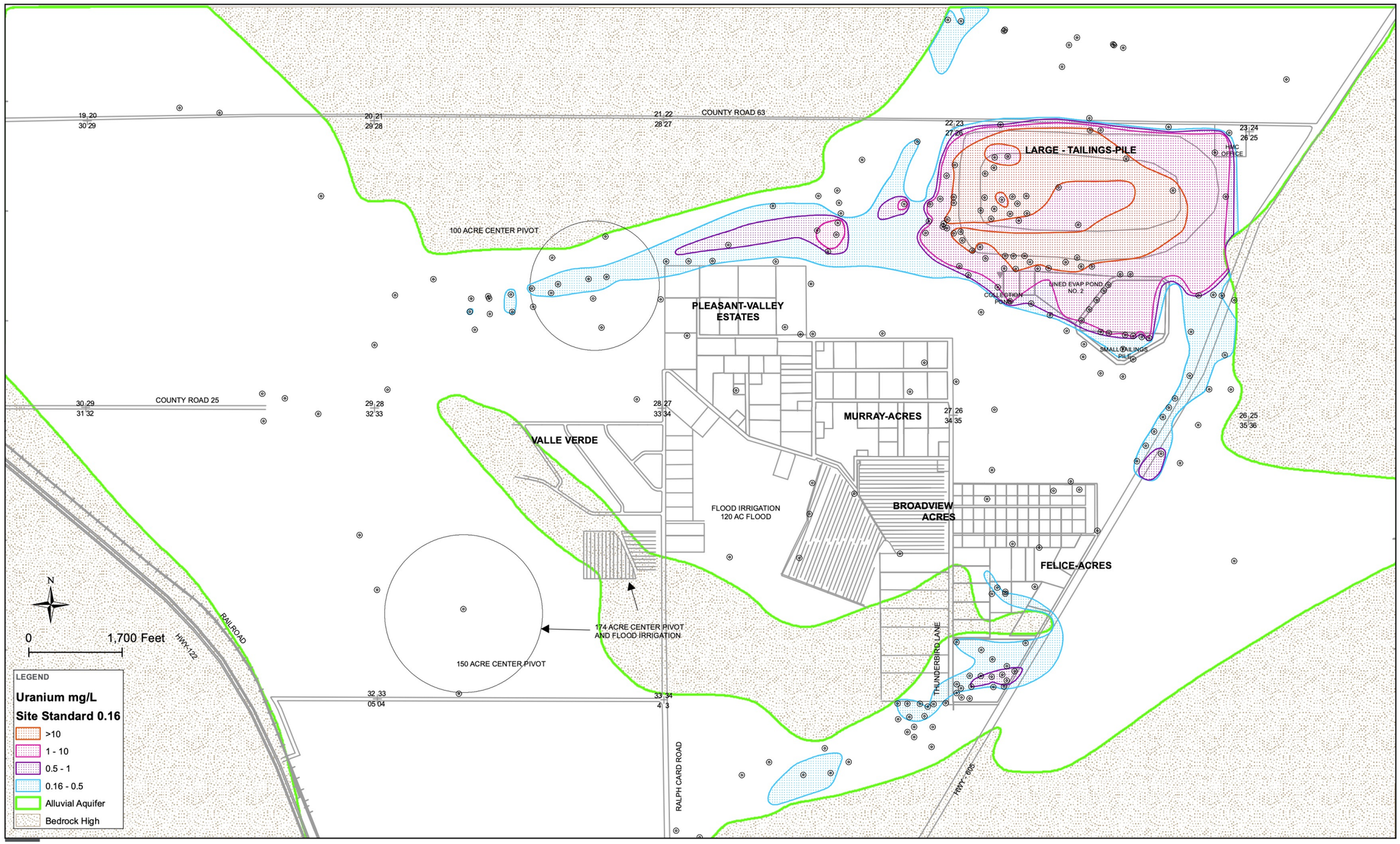

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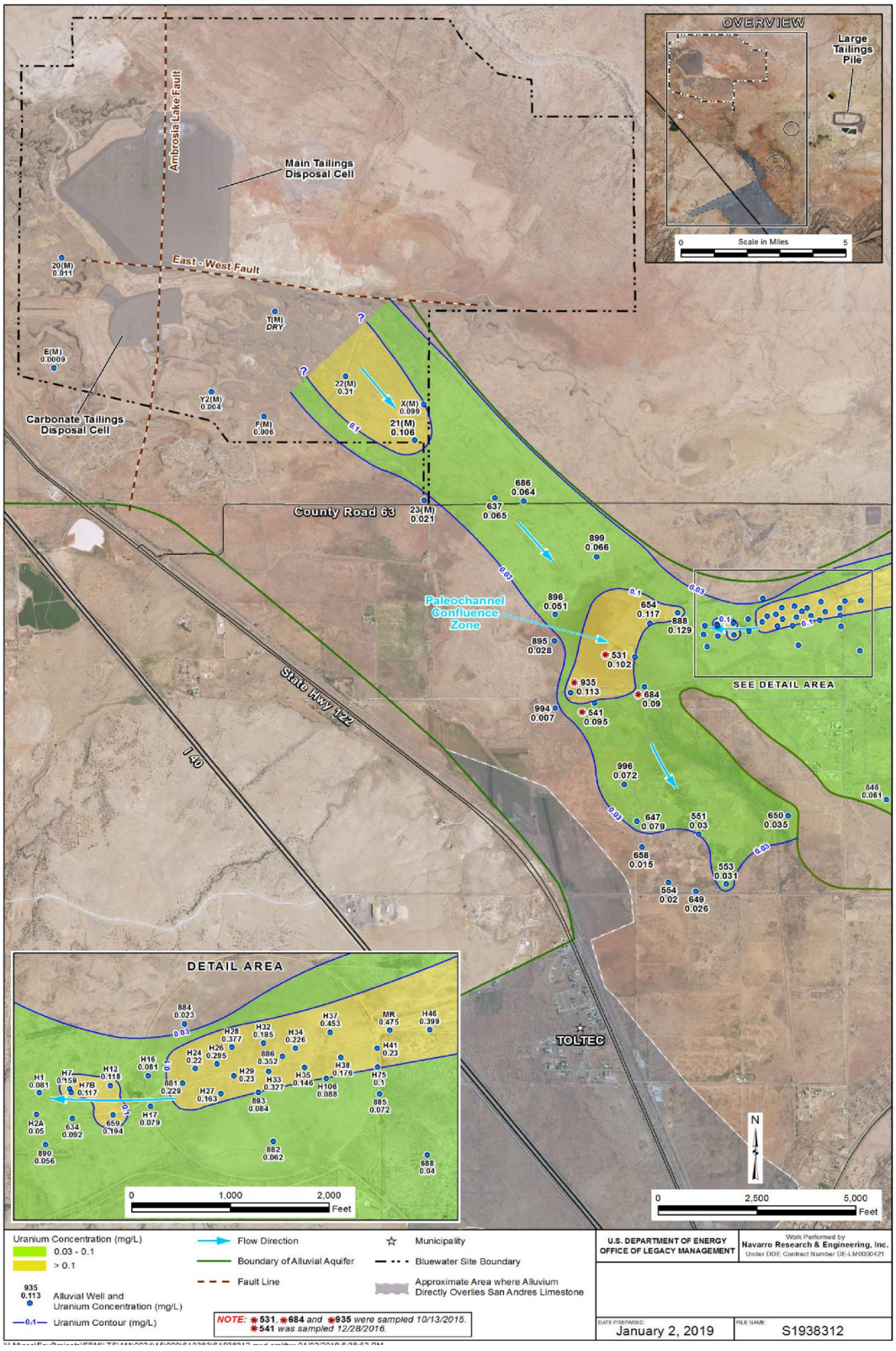
Figure 3-49
Alluvial Groundwater
Uranium Concentrations



Source: DOE, 2019

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Corrective Action Program

Figure 3-50
Rio San Jose Groundwater
Uranium Concentrations

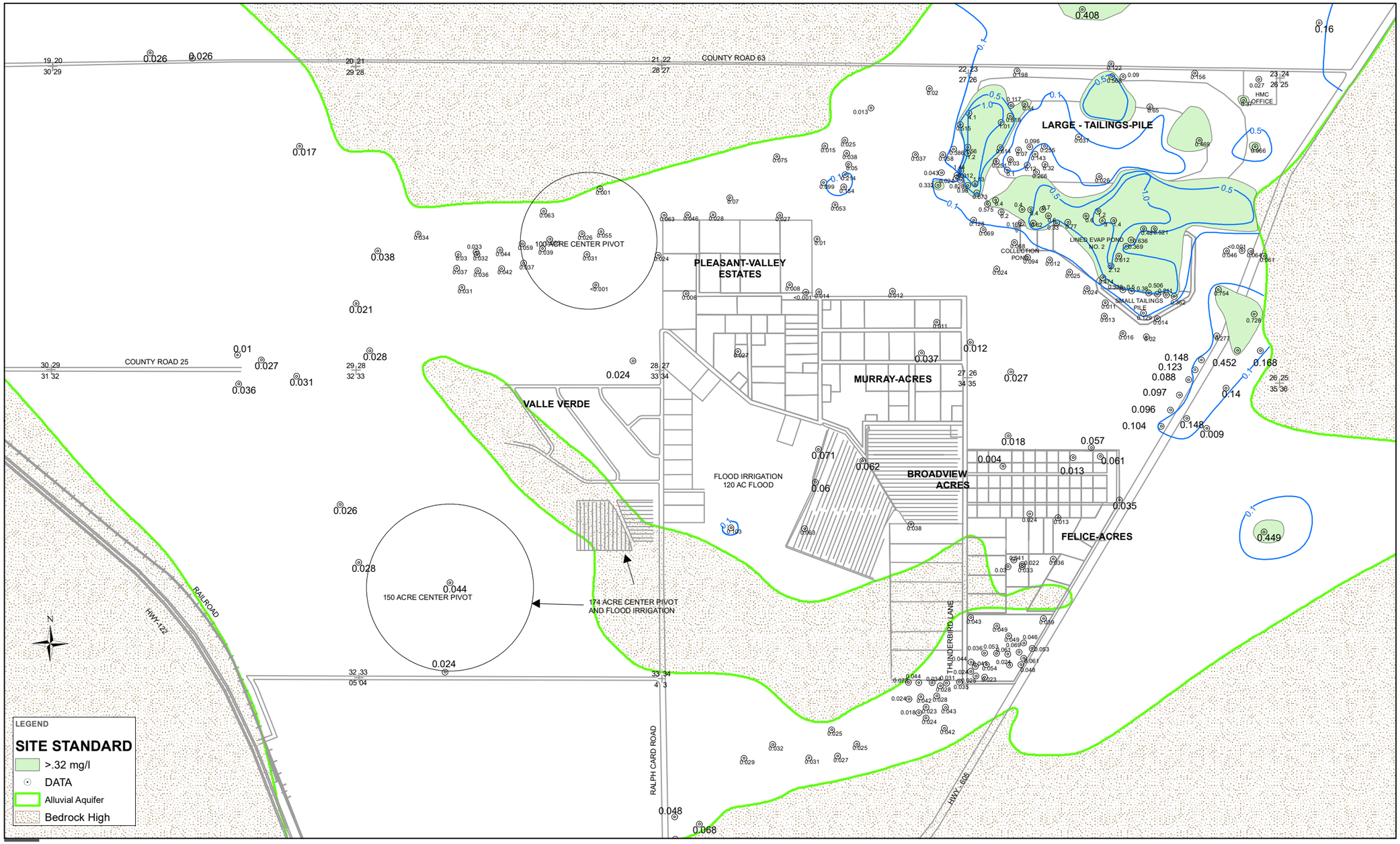

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Figure 3-51
Alluvial Groundwater
Selenium Concentrations

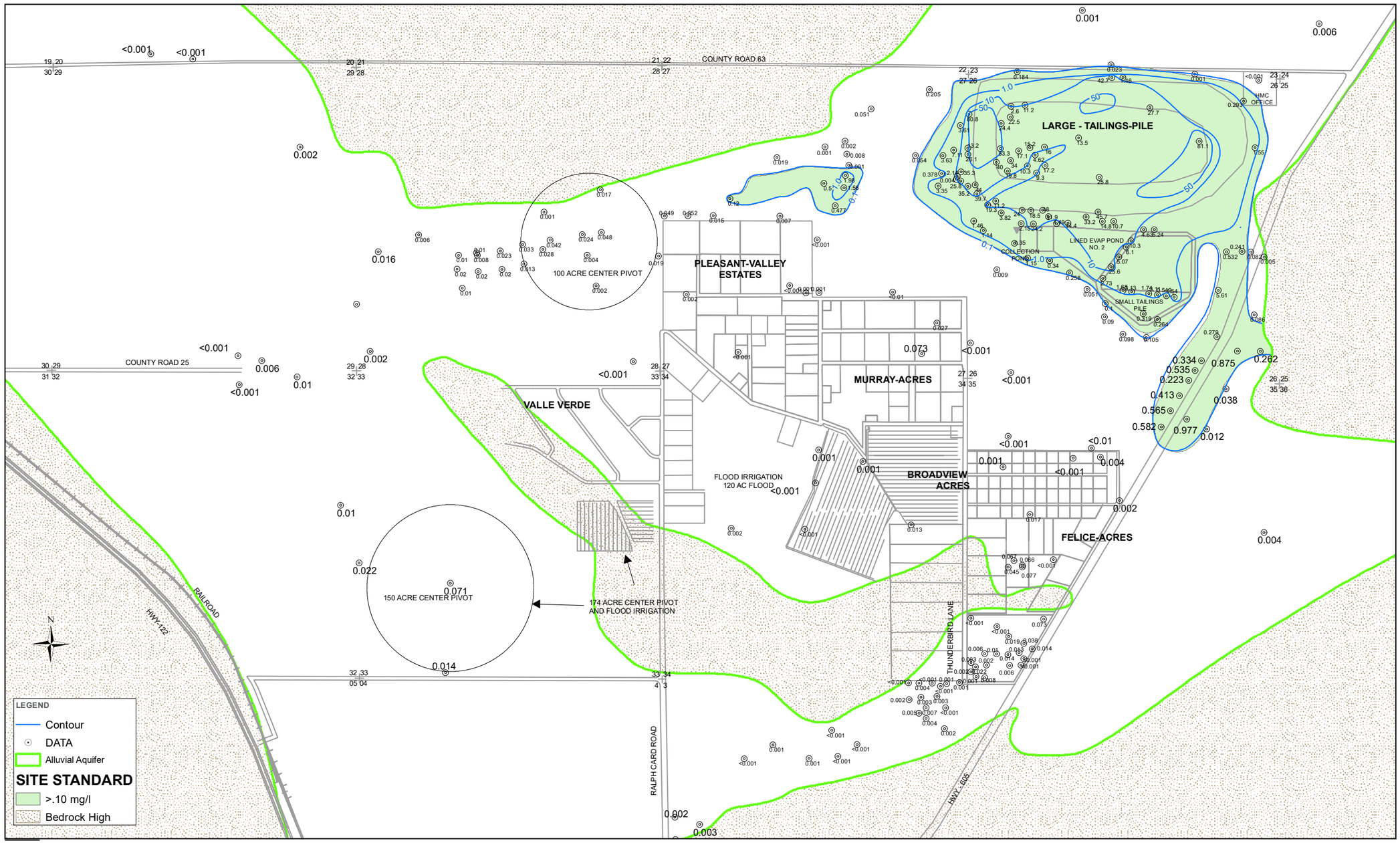

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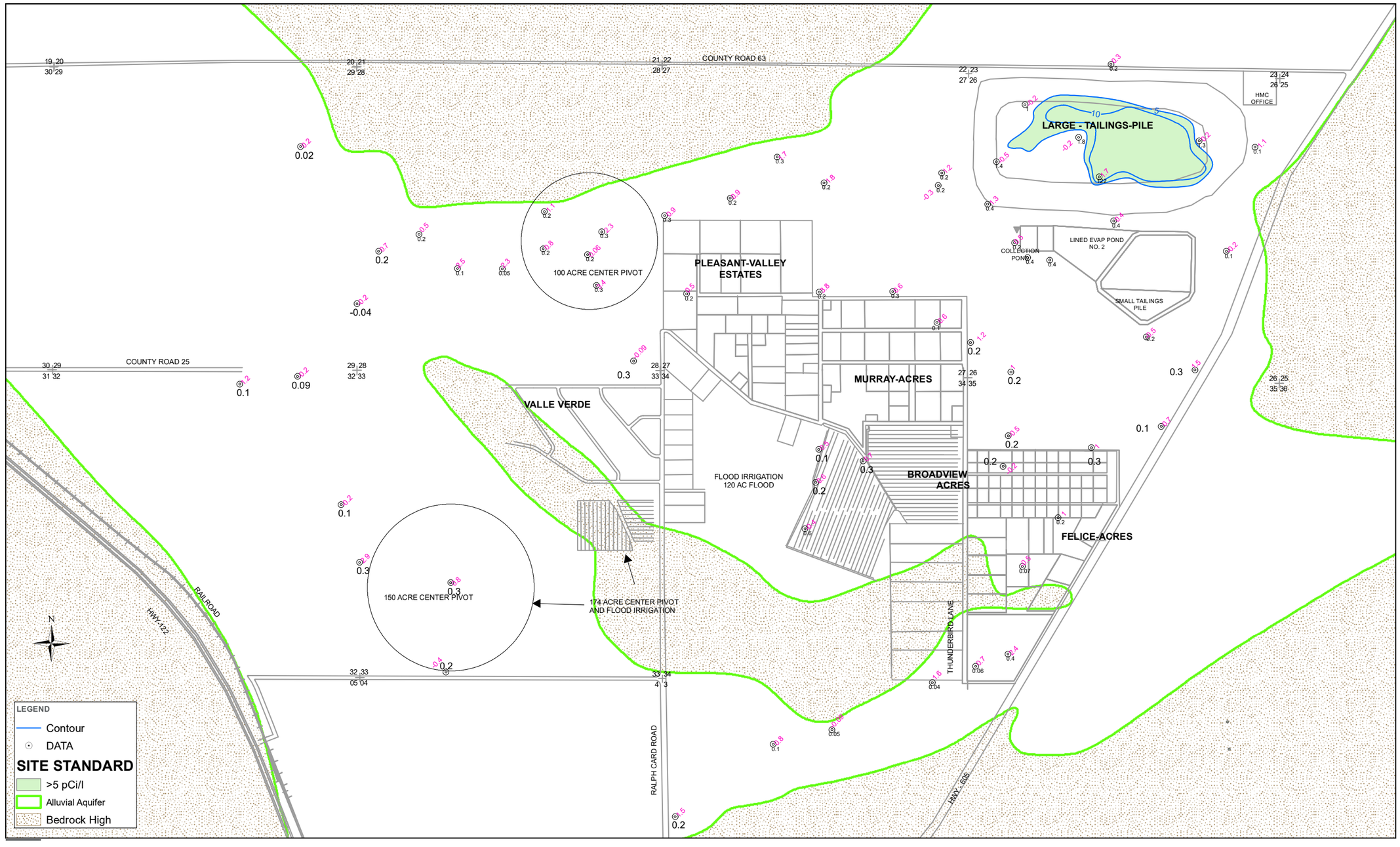
Figure 3-52
Alluvial Groundwater
Molybdenum Concentrations



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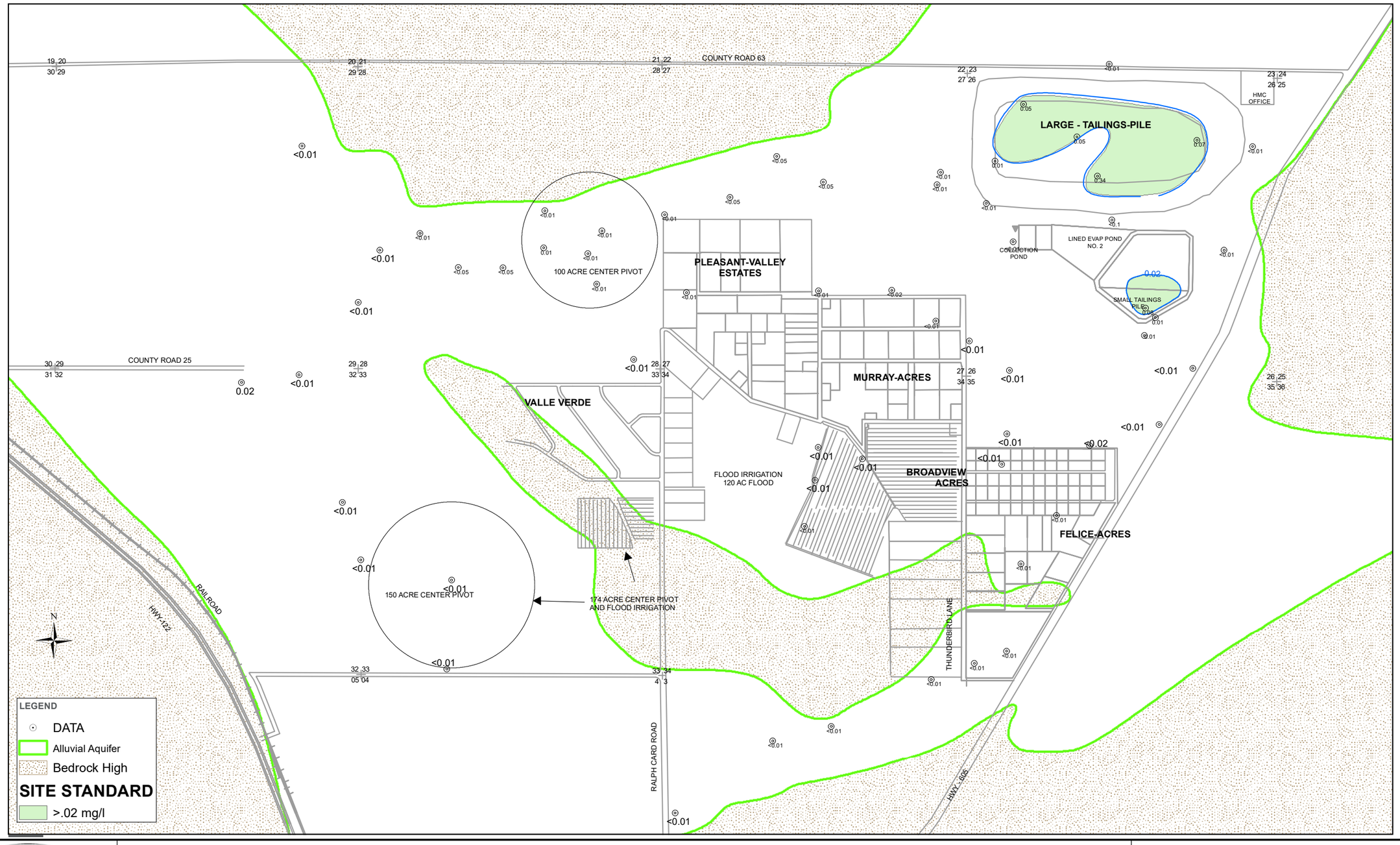
Corrective Action Program

Figure 3-53
Alluvial Groundwater
Radium-226+228 Concentrations



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Corrective Action Program

Figure 3-54
Alluvial Groundwater
Vanadium Concentrations

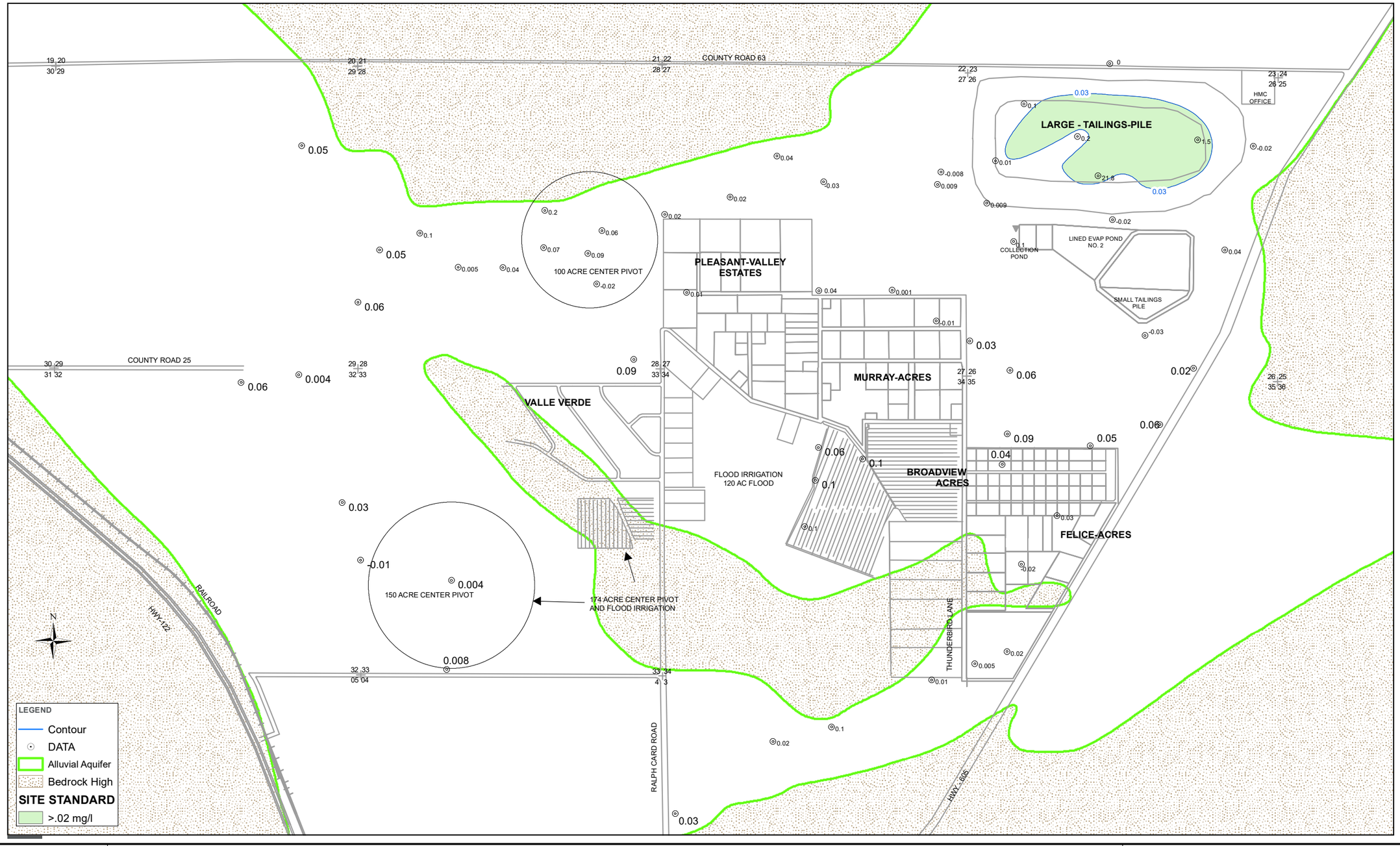

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Figure 3-55
Alluvial Groundwater
Thorium-230 Concentrations

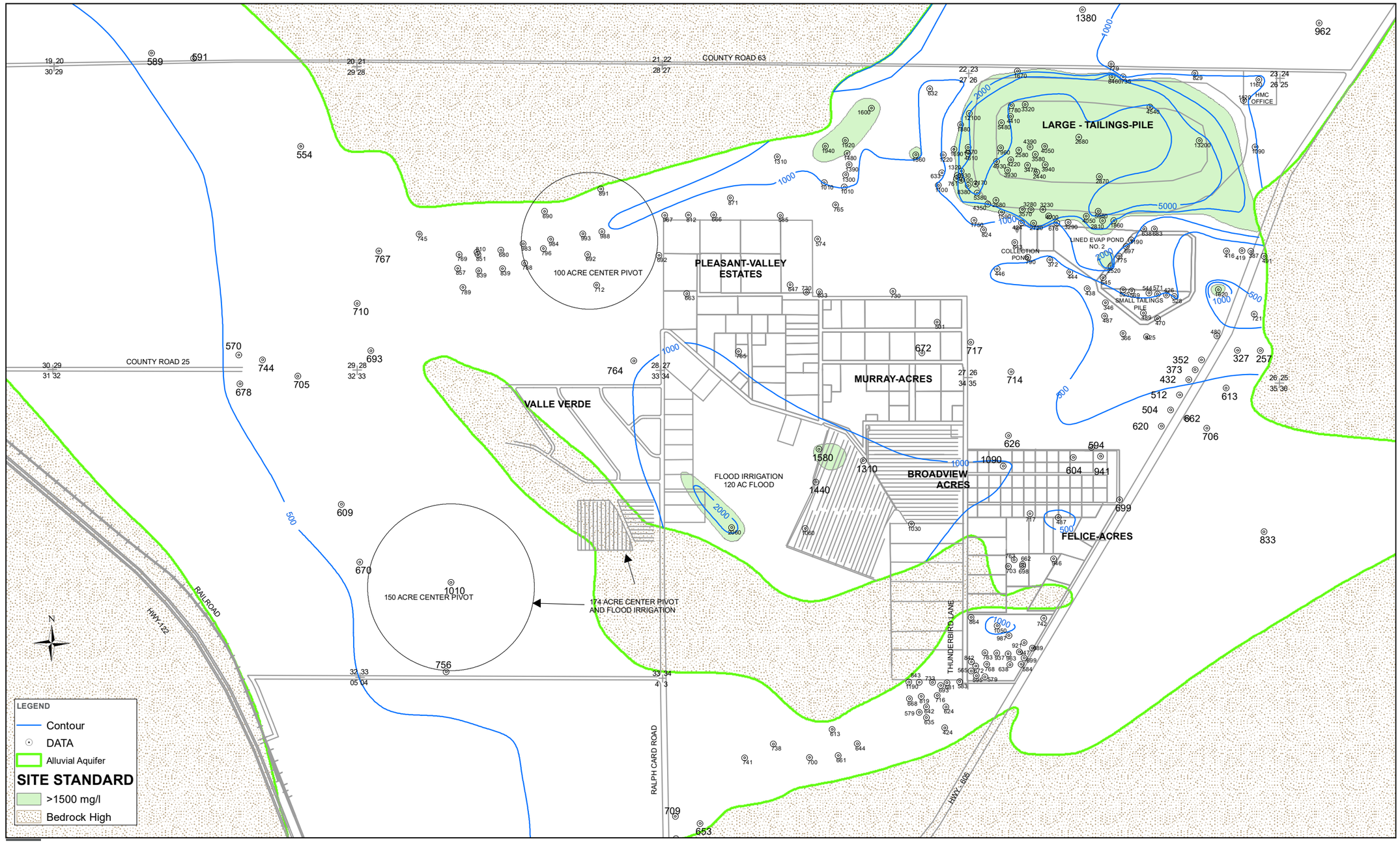

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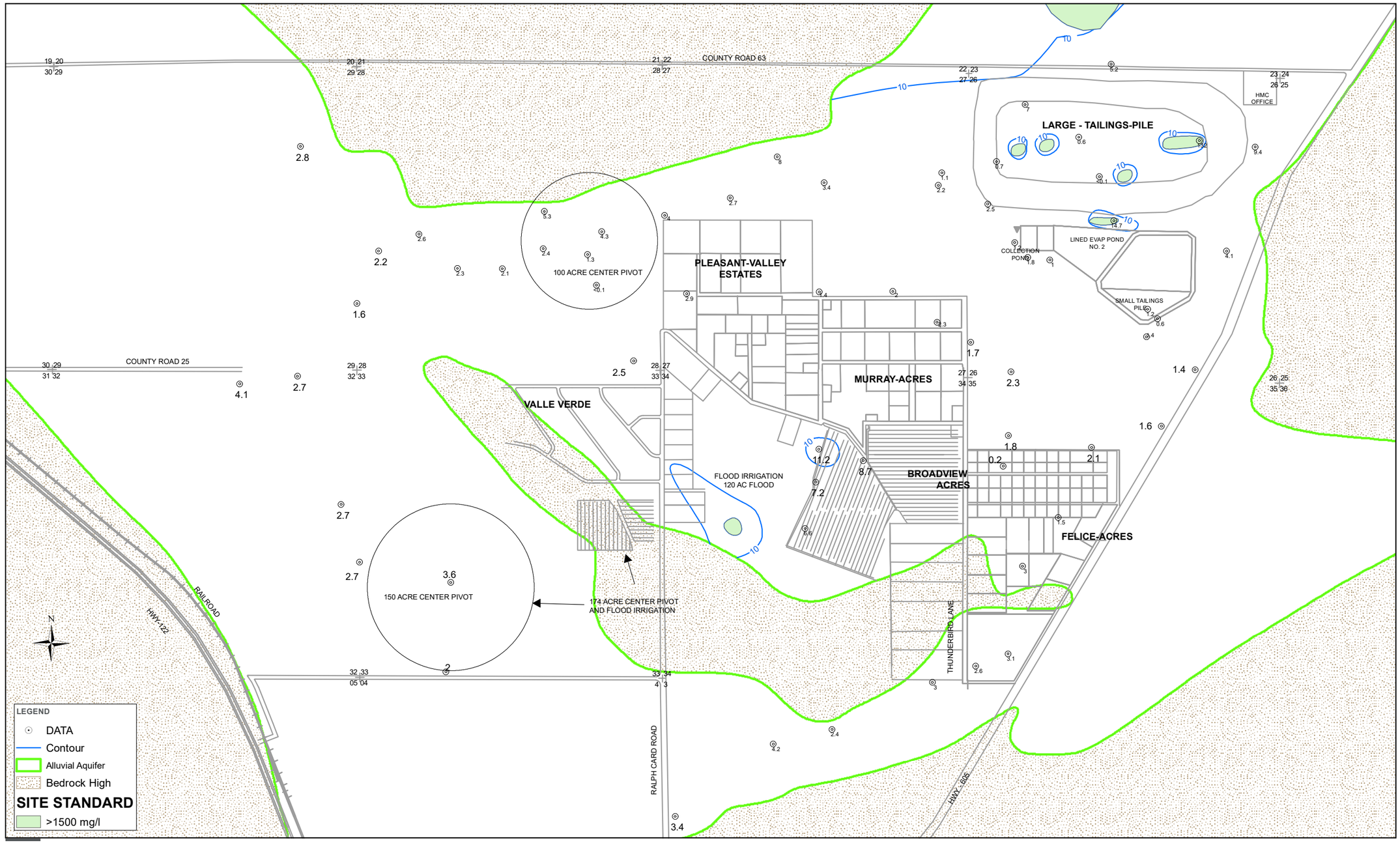
Figure 3-56
Alluvial Groundwater
Sulfate Concentrations



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Corrective Action Program

Figure 3-57
Alluvial Groundwater
Nitrate Concentrations

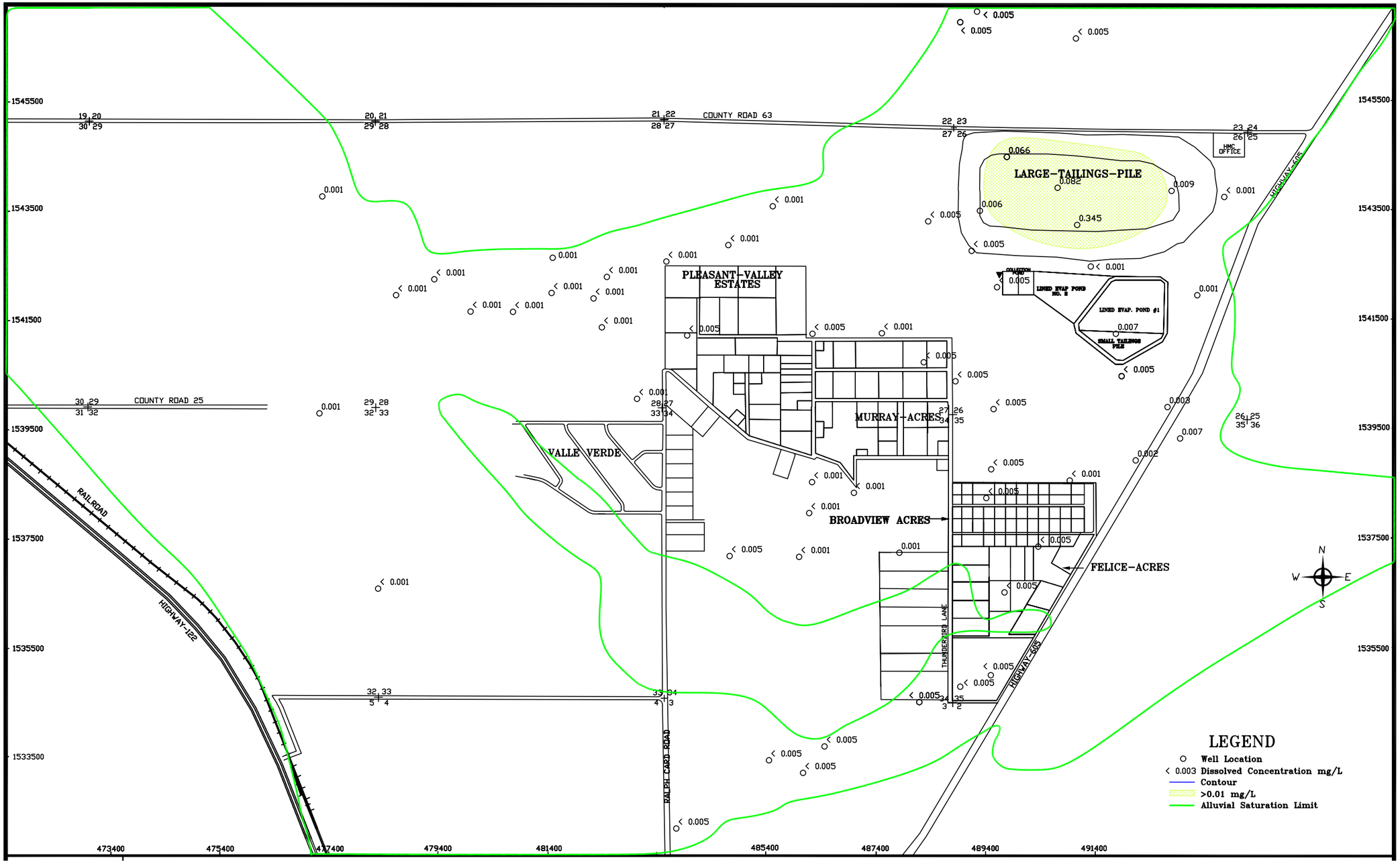

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Figure 3-58
Current Extent of Arsenic in Alluvial Groundwater

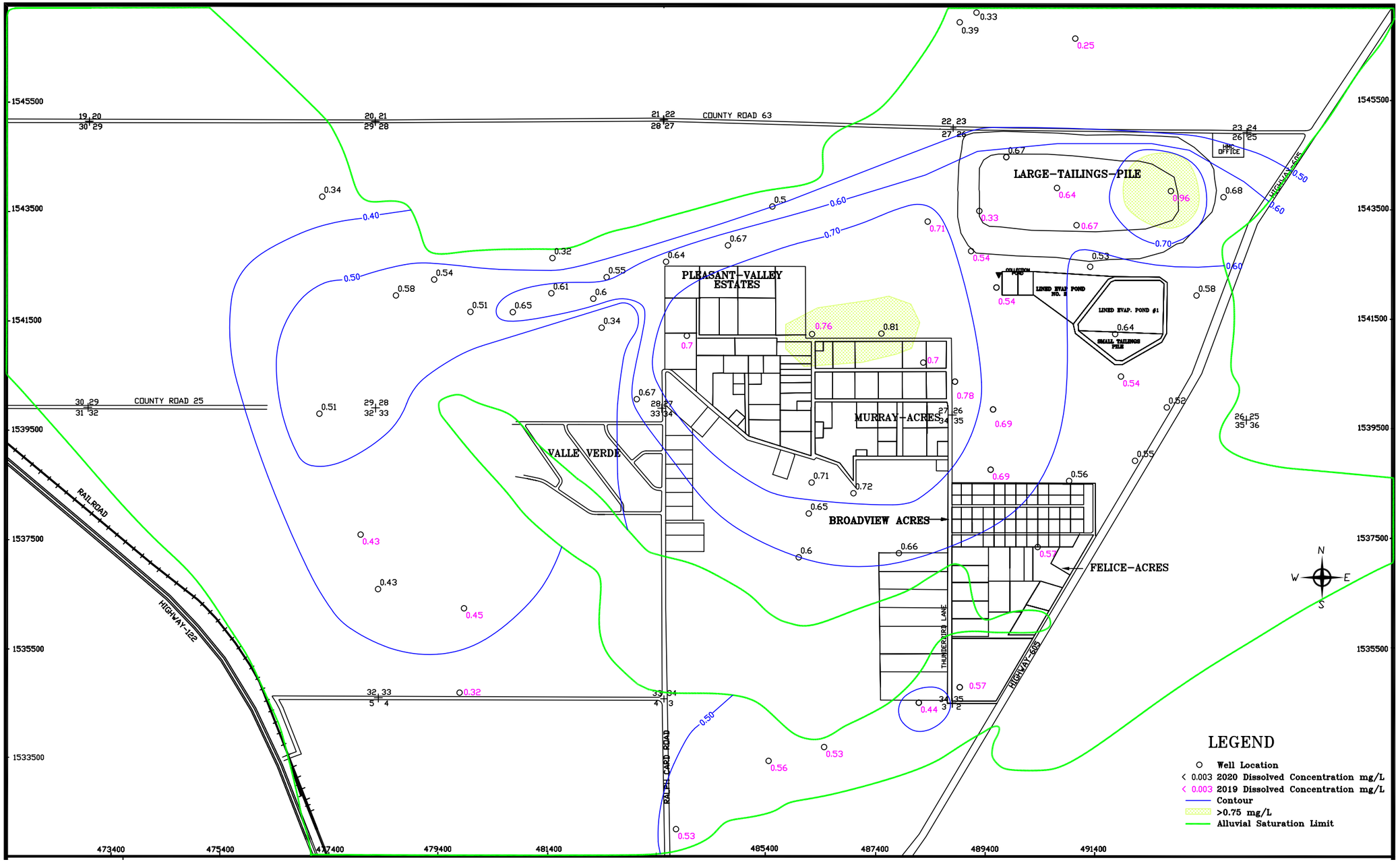

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Figure 3-59
Current Extent of Boron in Alluvial Groundwater

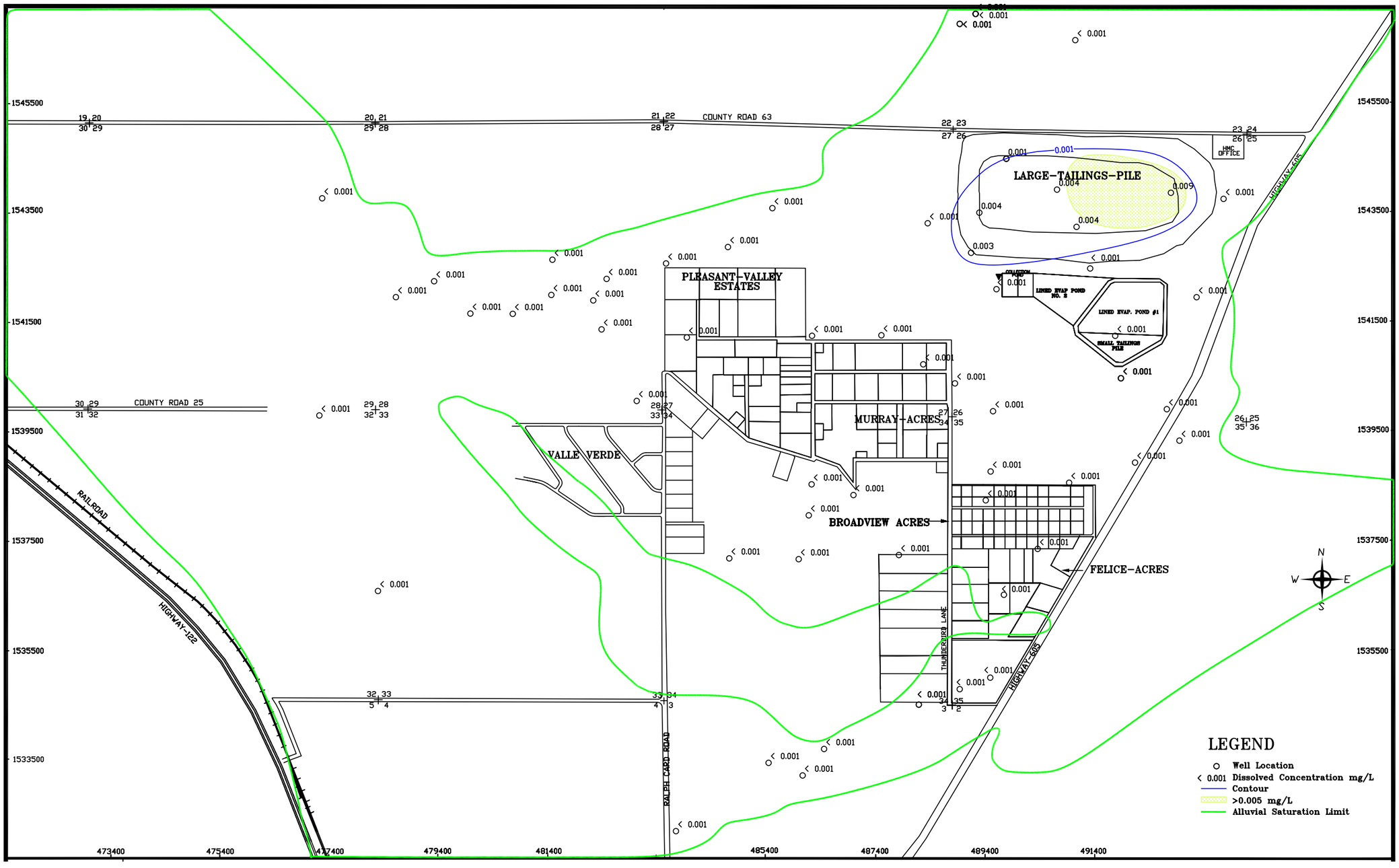

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Figure 3-60
Current Extent of Cadmium in Alluvial Groundwater

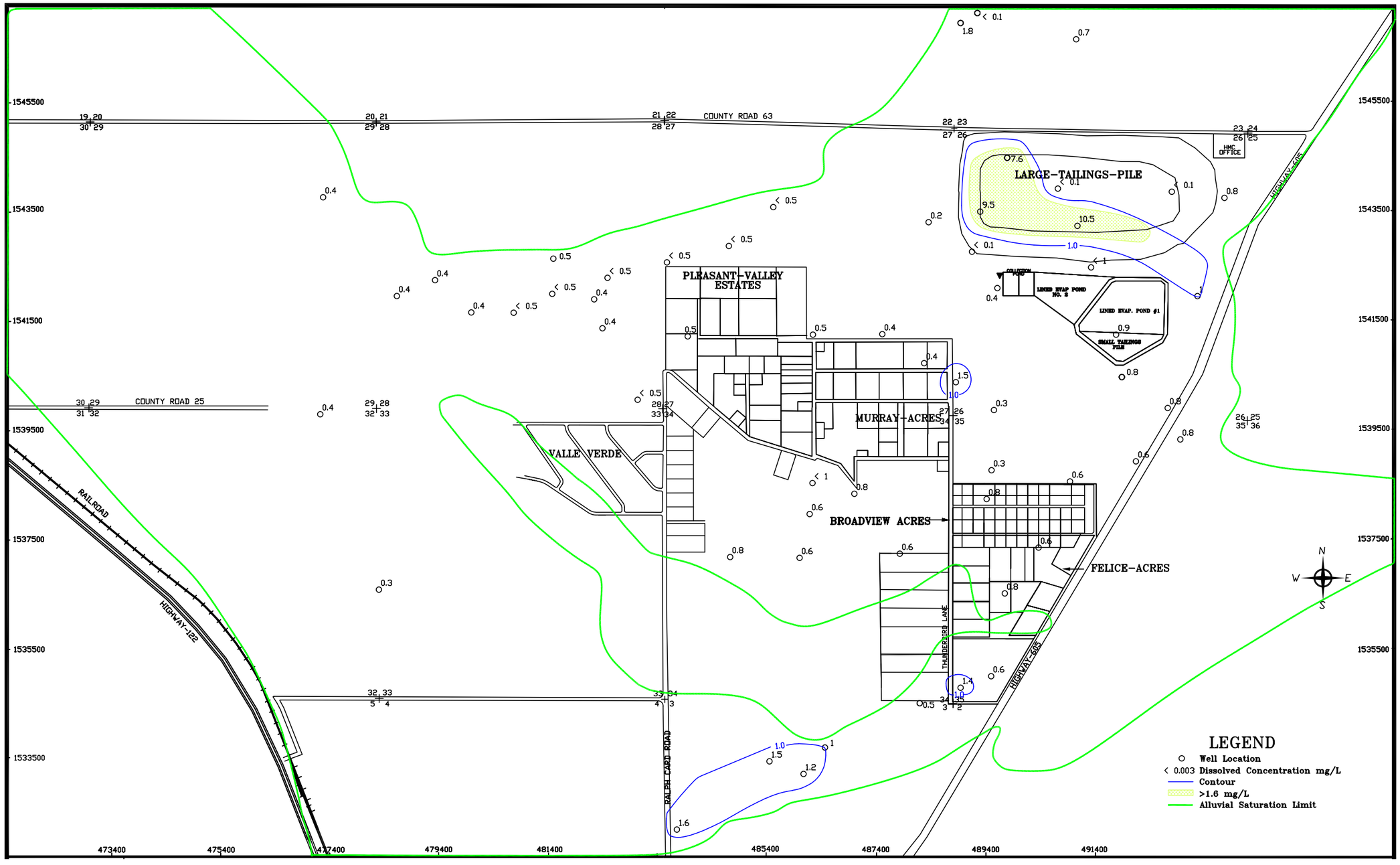

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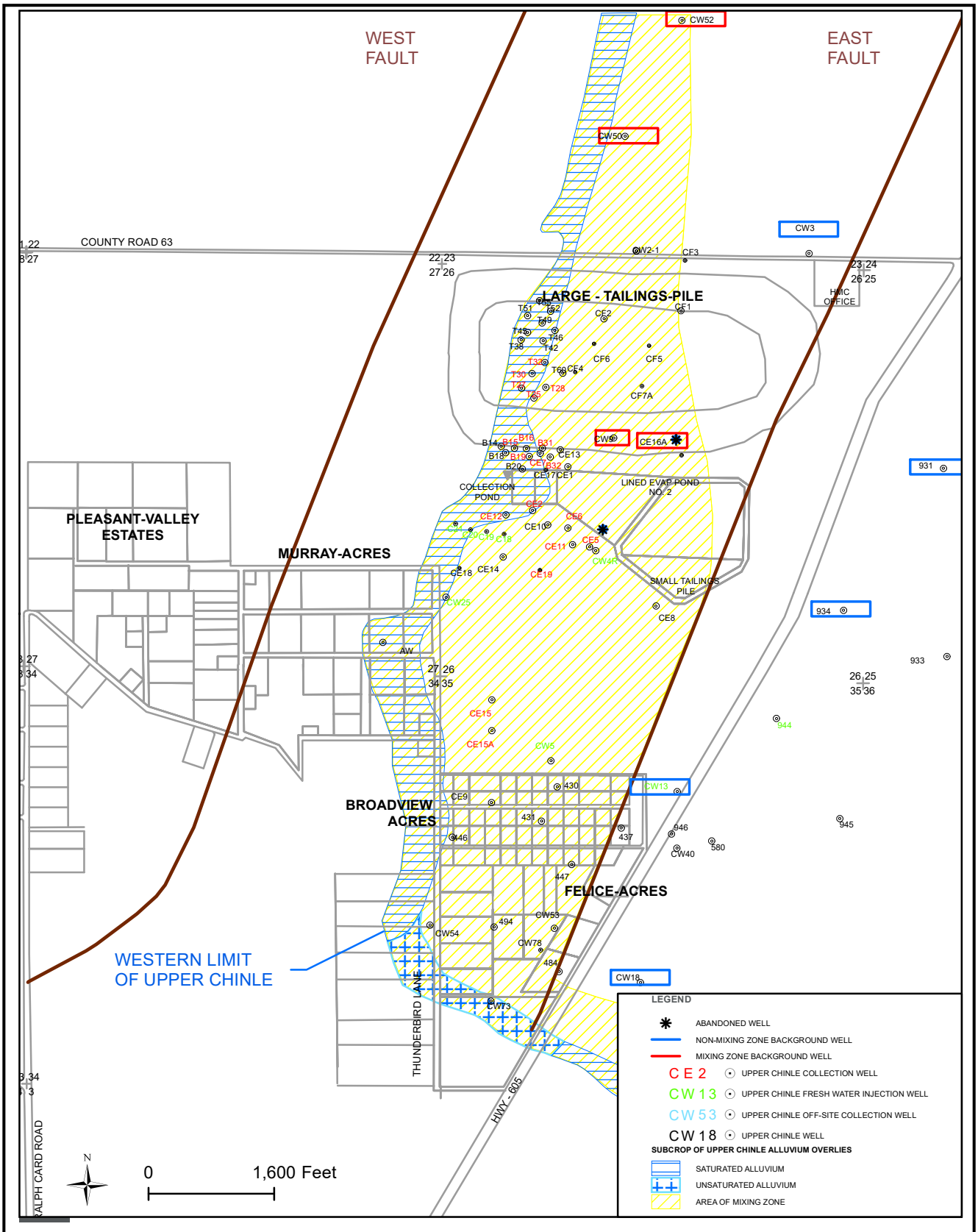
Figure 3-61
Current Extent of Fluoride in Alluvial Groundwater



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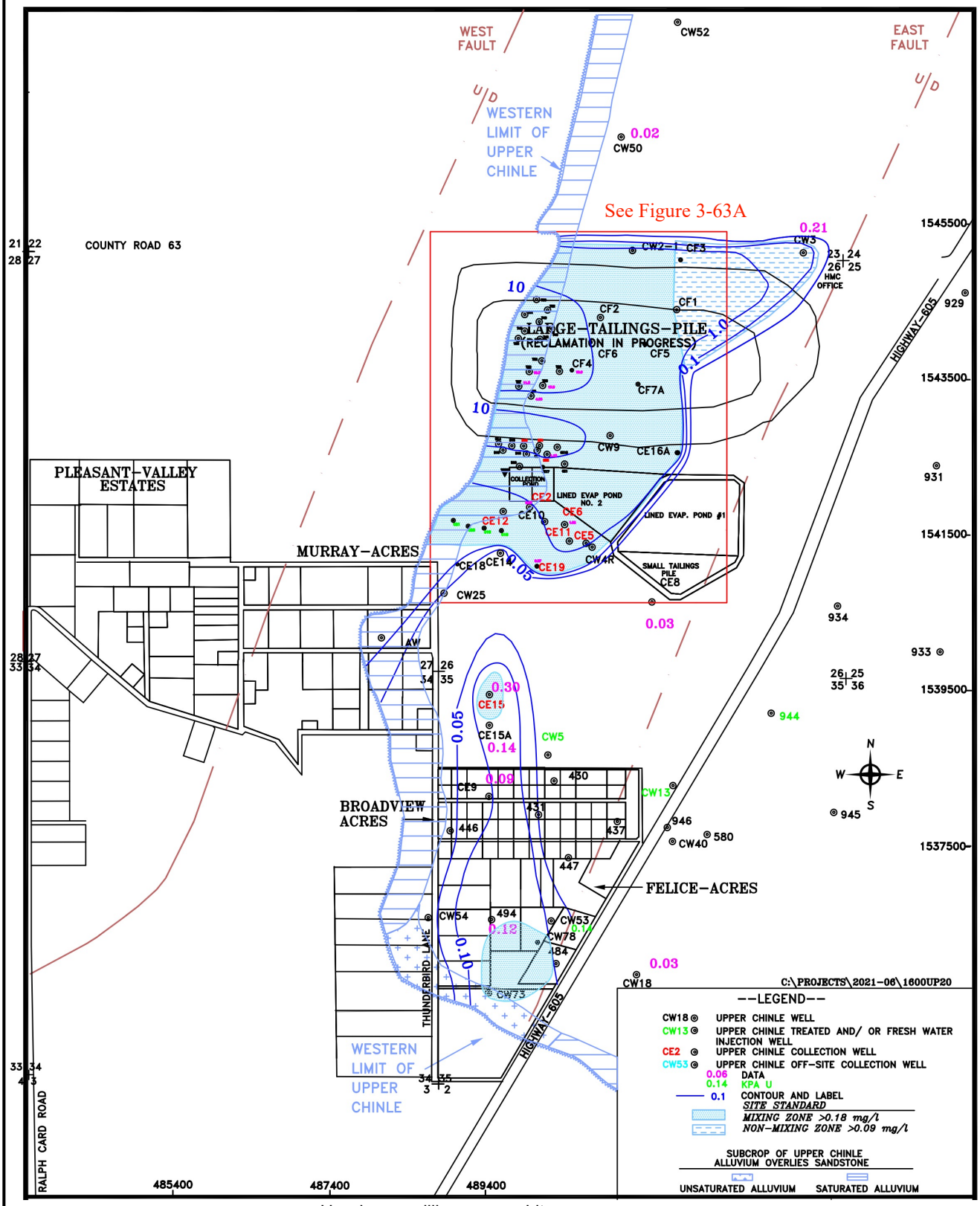
Corrective Action Program

Figure 3-62
Upper Chinle Mixing Zone



Uranium – milligrams per Liter

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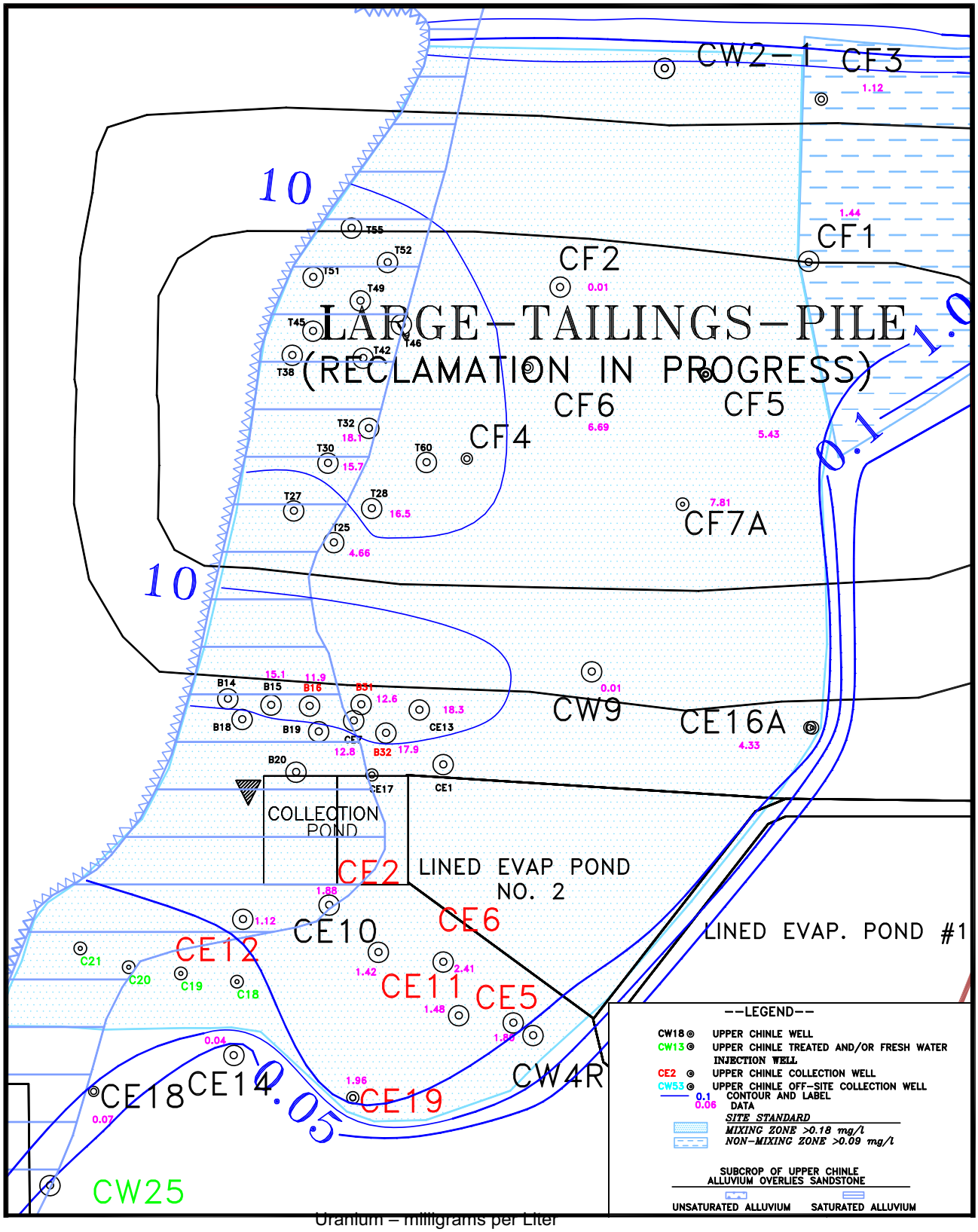
Figure 3-63
Upper Chinle Groundwater
Uranium Concentrations



Uranium – milligrams per Liter

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Figure 3-63A
Upper Chinle Groundwater
Uranium Concentrations - Inset

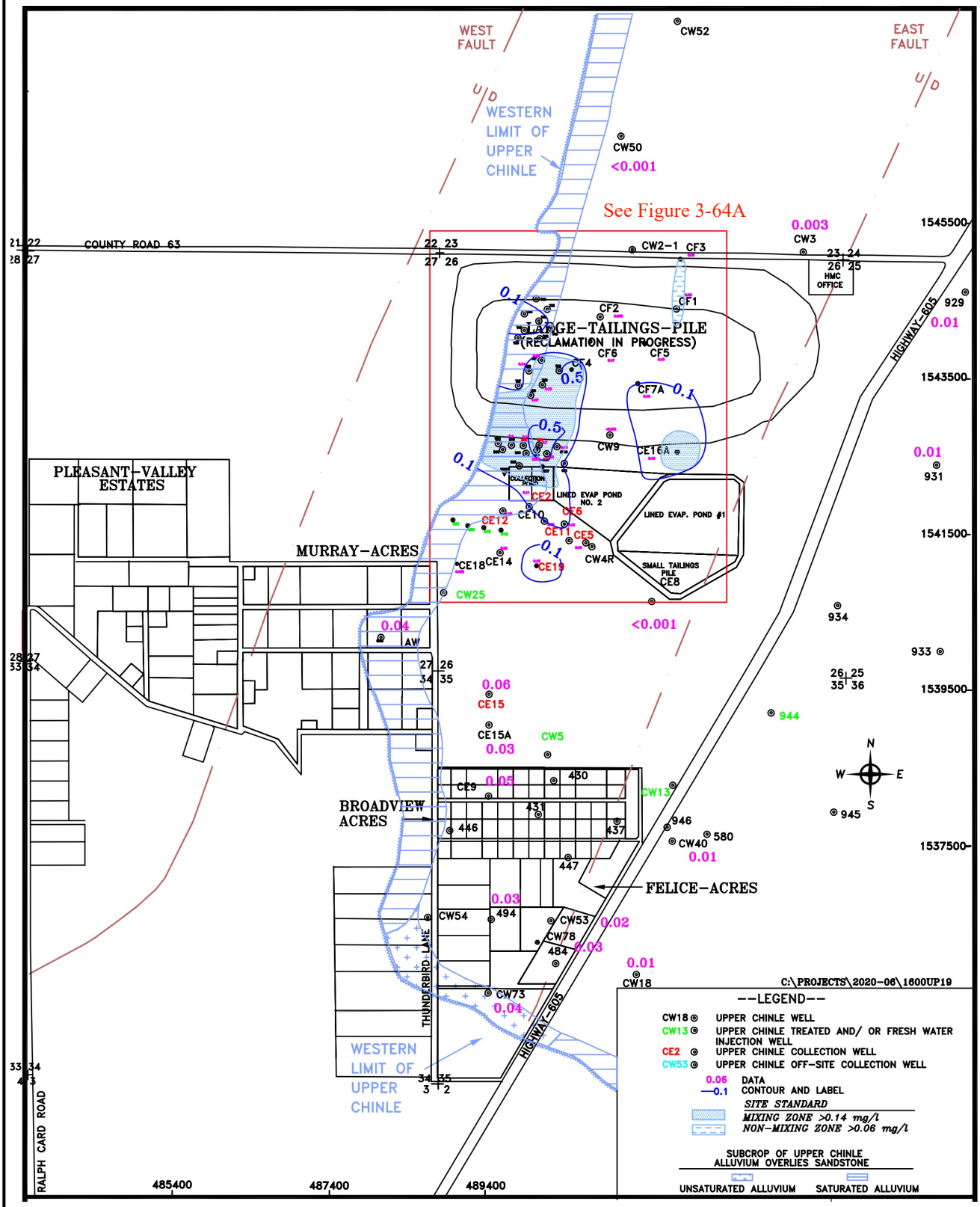

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Figure 3-64
Upper Chinle Groundwater
Selenium Concentrations

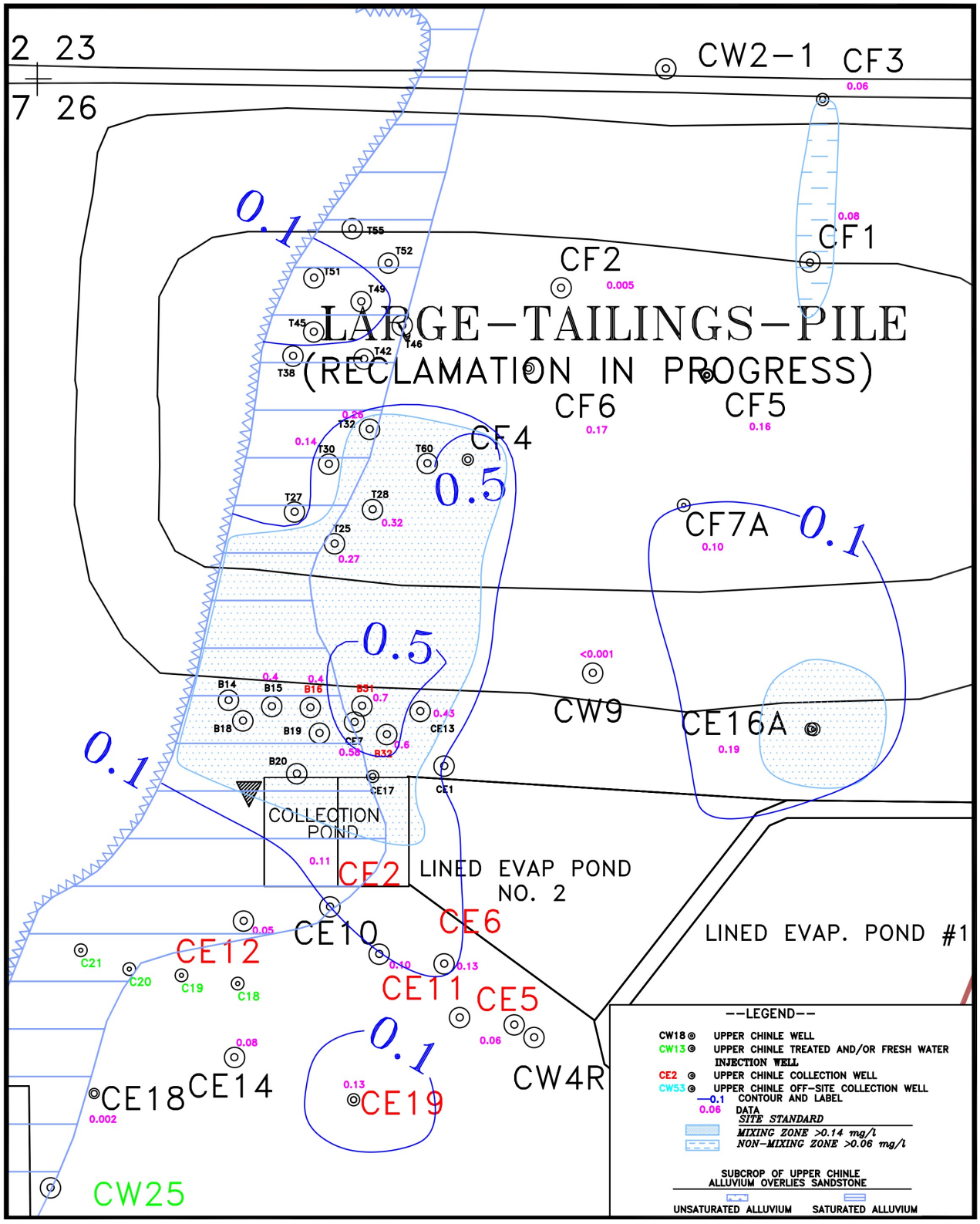

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Figure 3-64A
Upper Chinle Groundwater
Selenium Concentrations - Inset

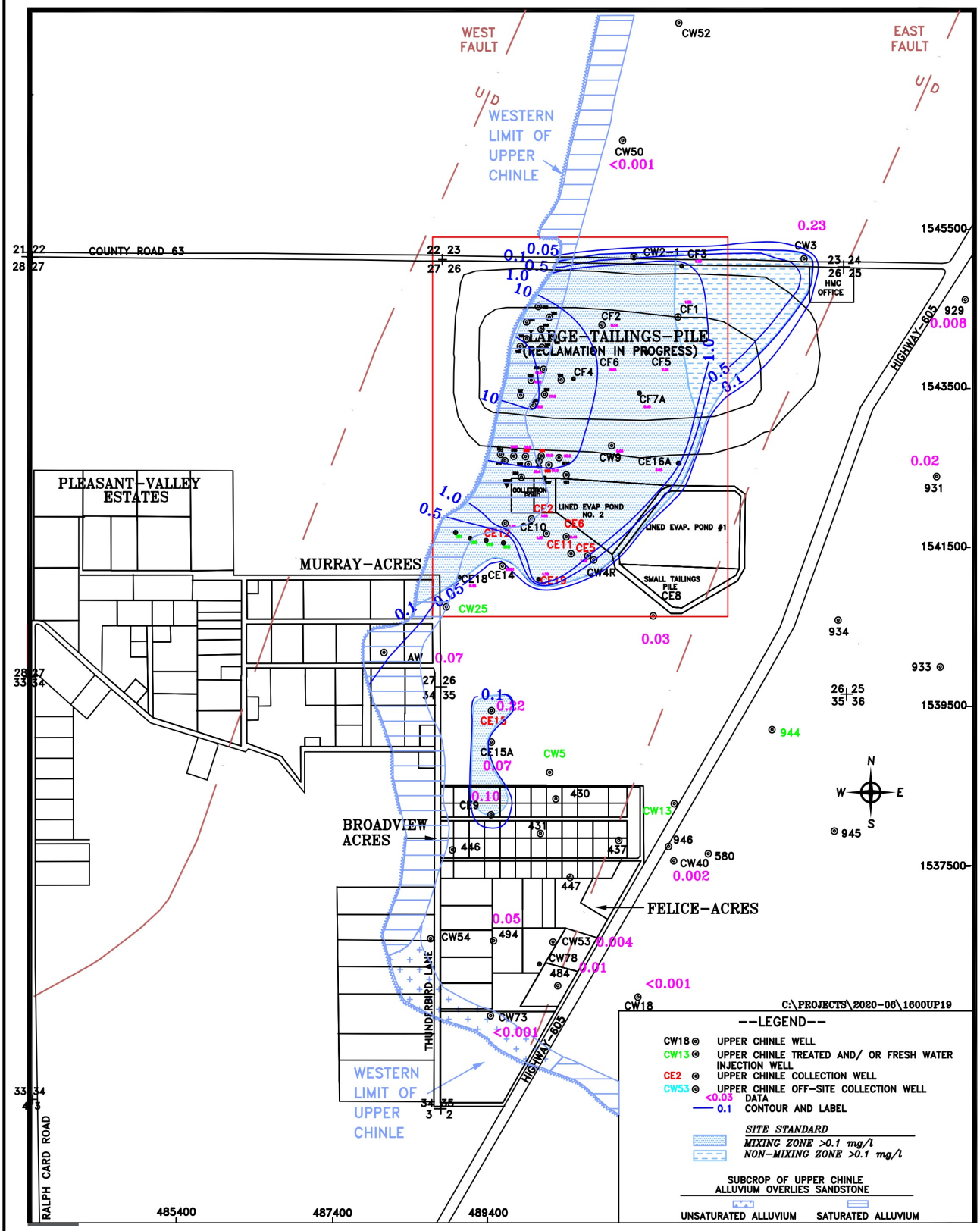

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Figure 3-65
Upper Chinle Groundwater
Molybdenum Concentrations

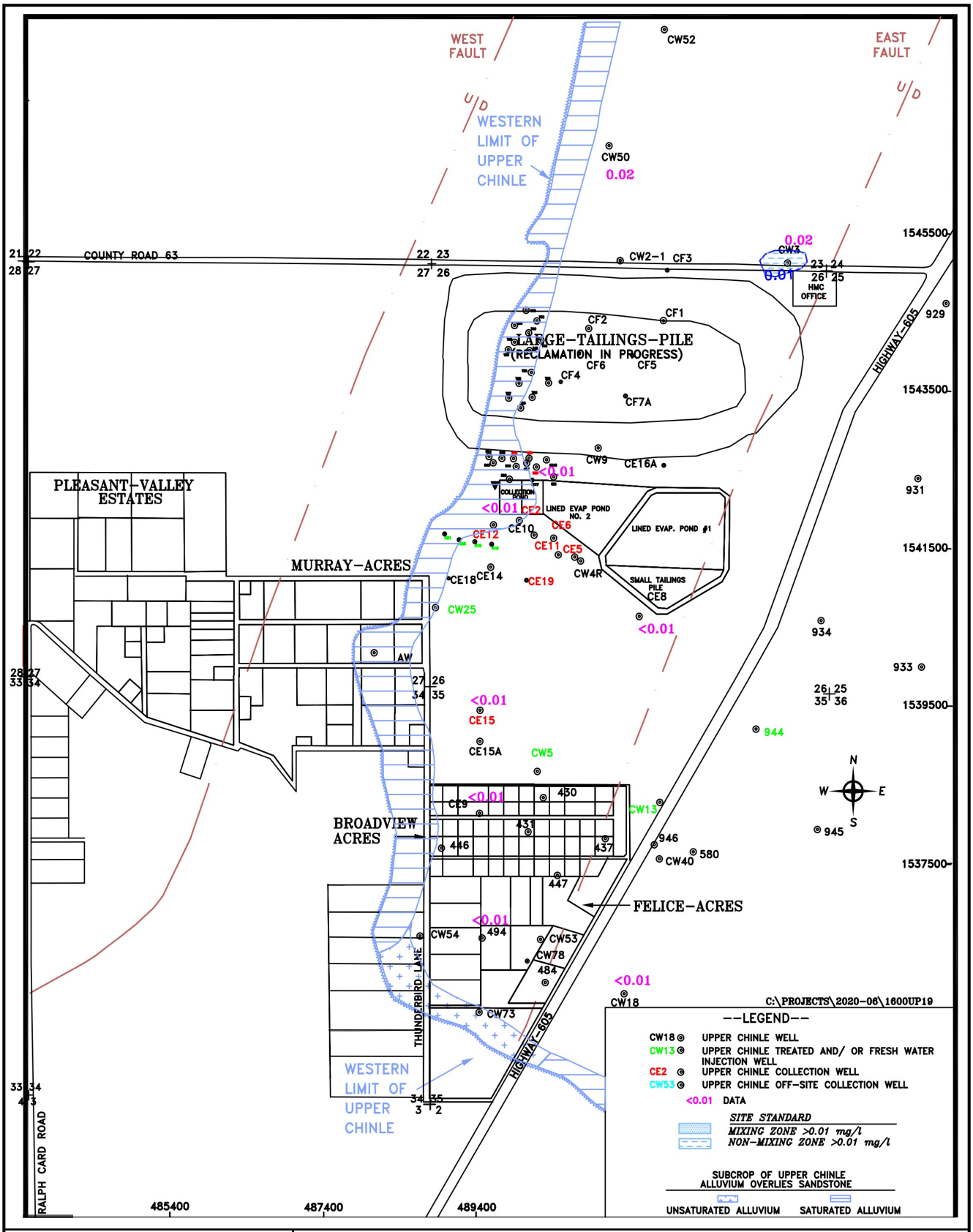

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Figure 3-66
Upper Chinle Groundwater
Vanadium Concentrations

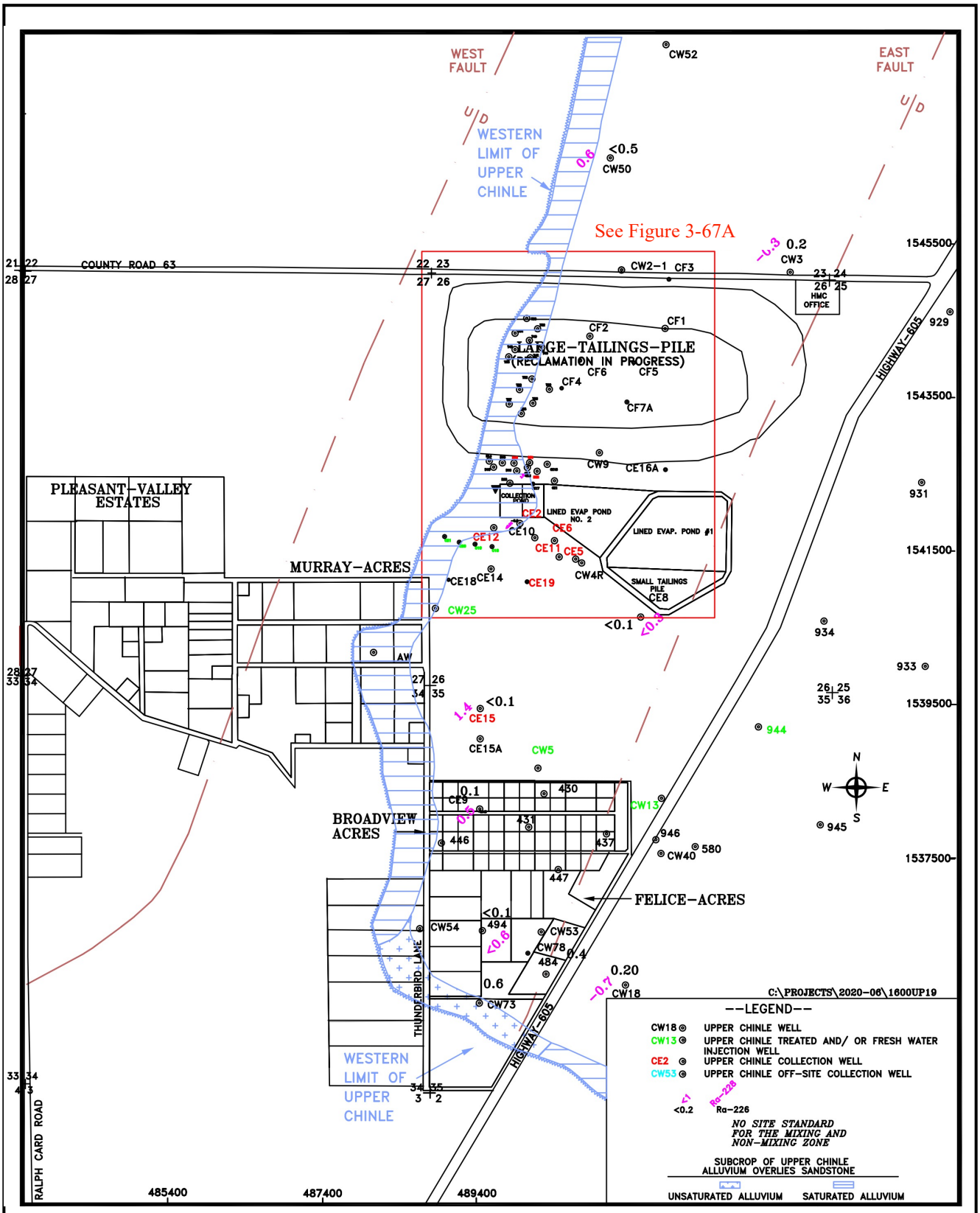

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Figure 3-67
Upper Chinle Groundwater
Radium 226+228 Concentrations

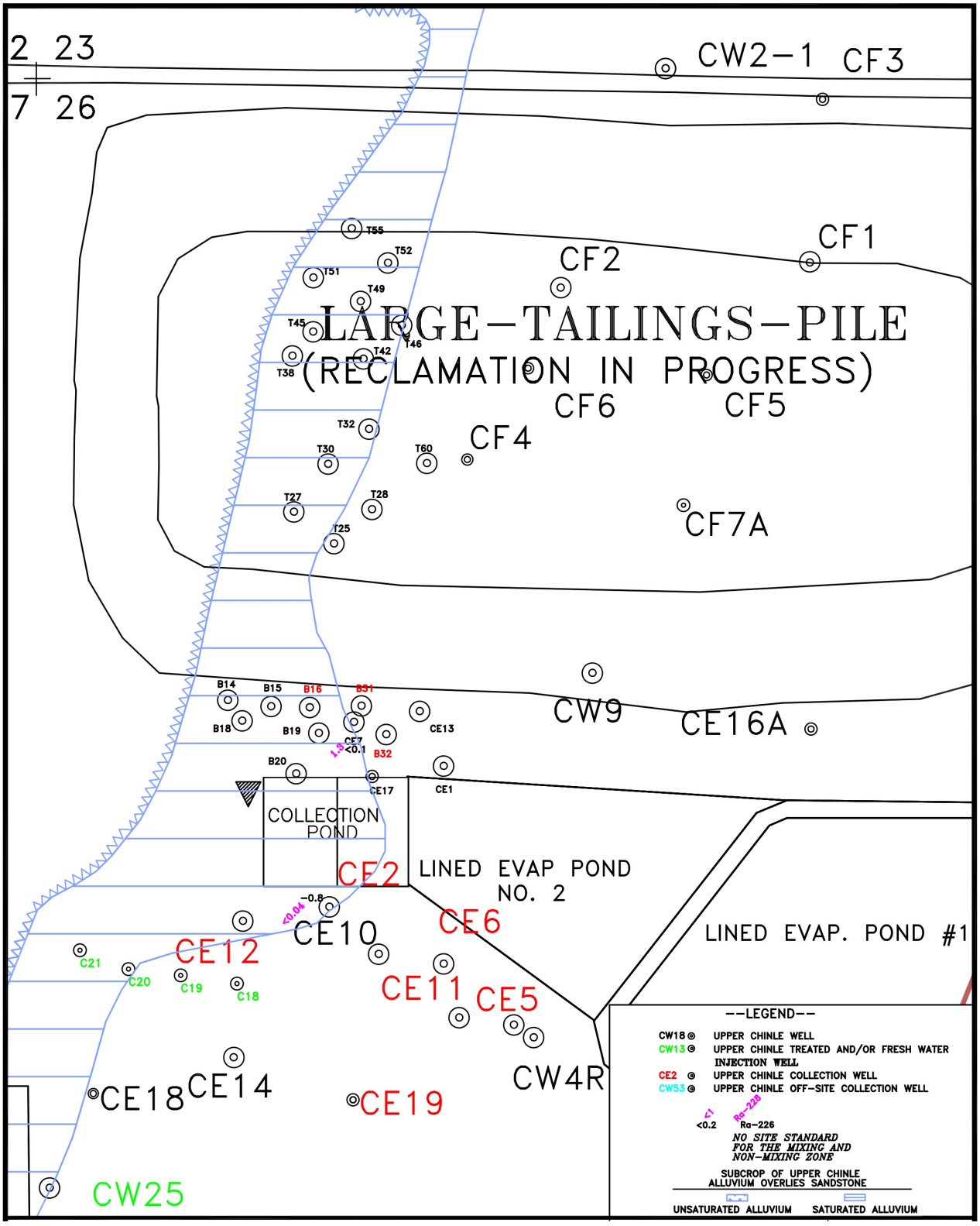

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Figure 3-67A
Upper Chinle Groundwater
Radium 226+228 Concentrations - Inset

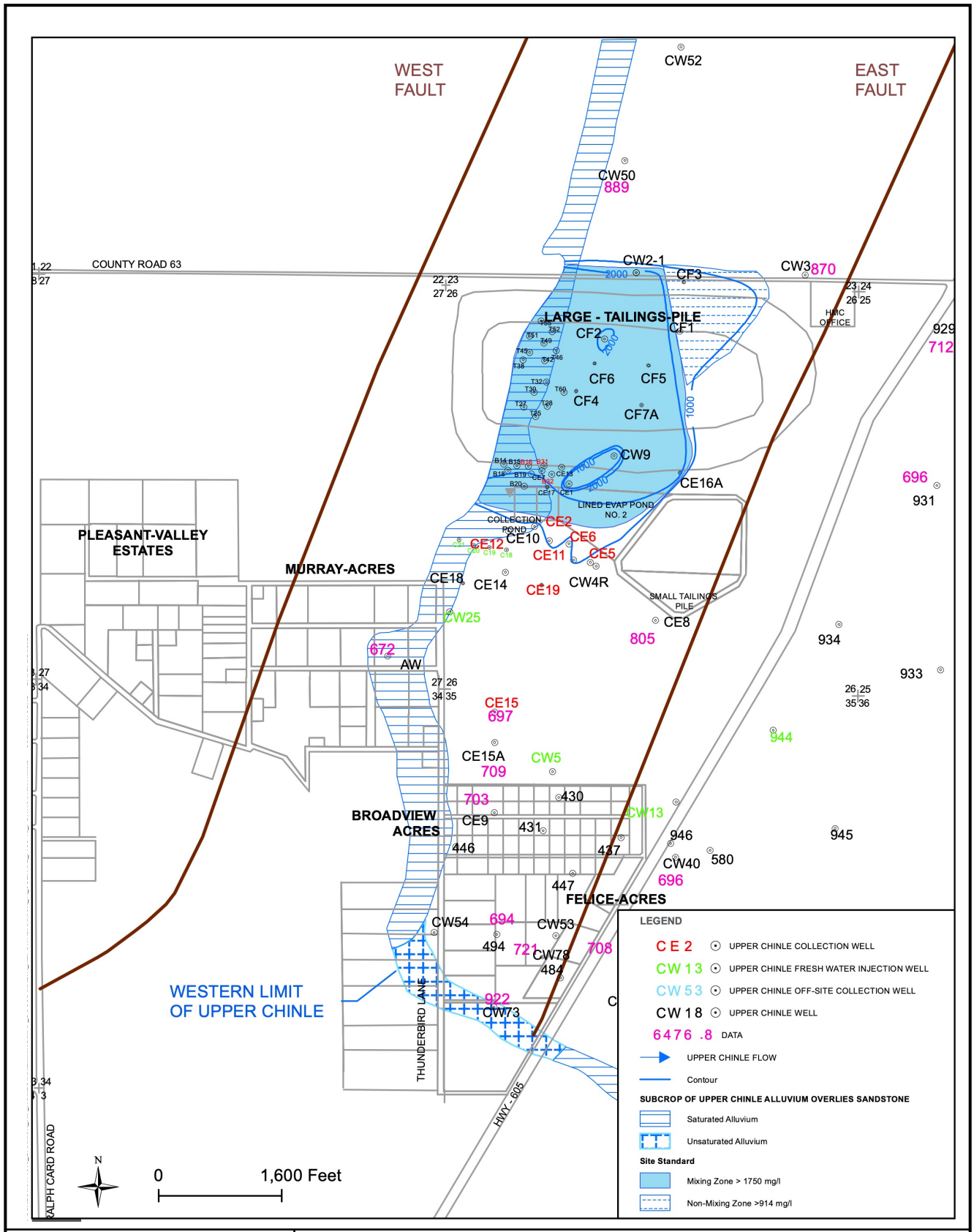

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Figure 3-68
Upper Chinle Groundwater
Sulfate Concentrations

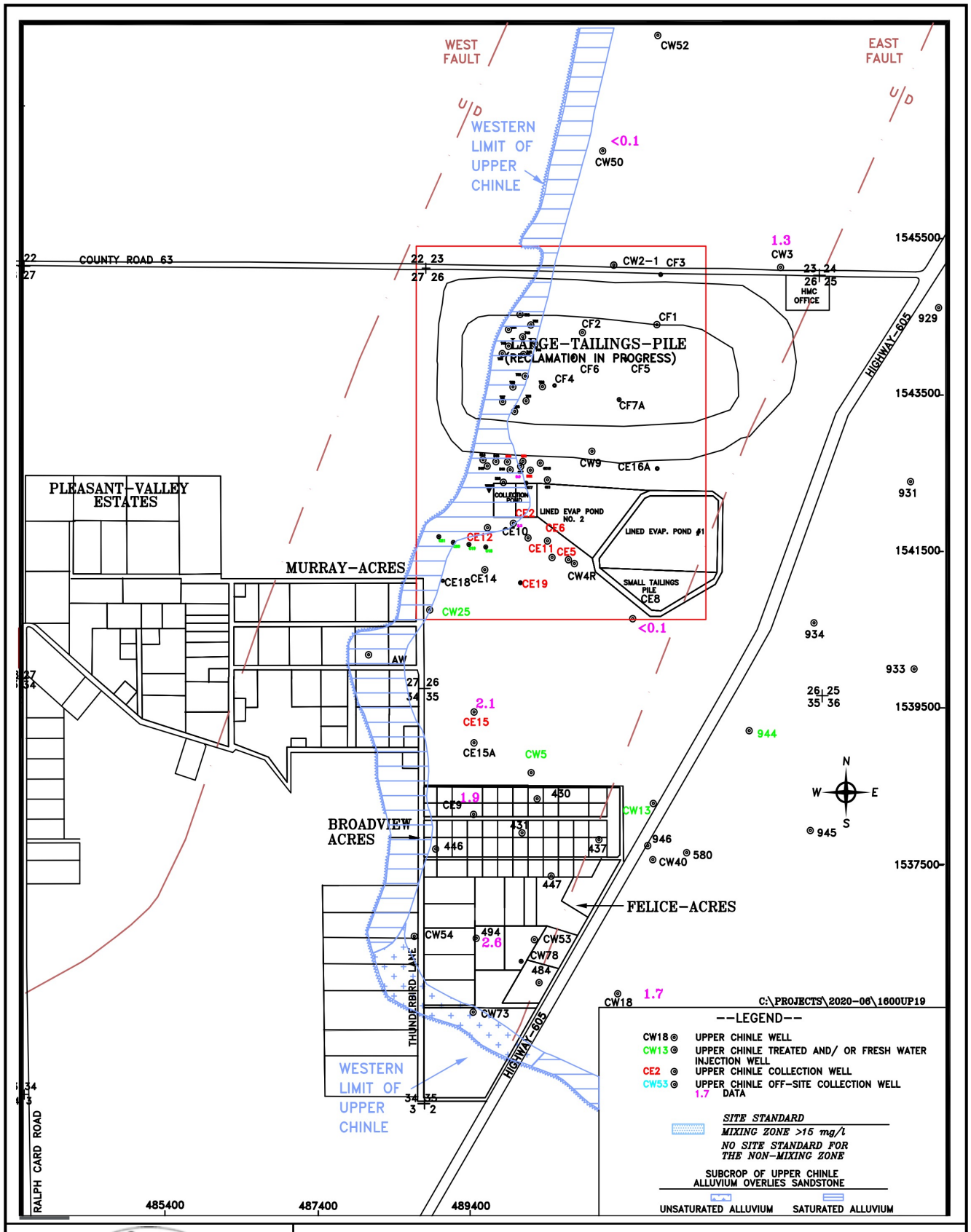

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Figure 3-69
Upper Chinle Groundwater
Nitrate Concentrations

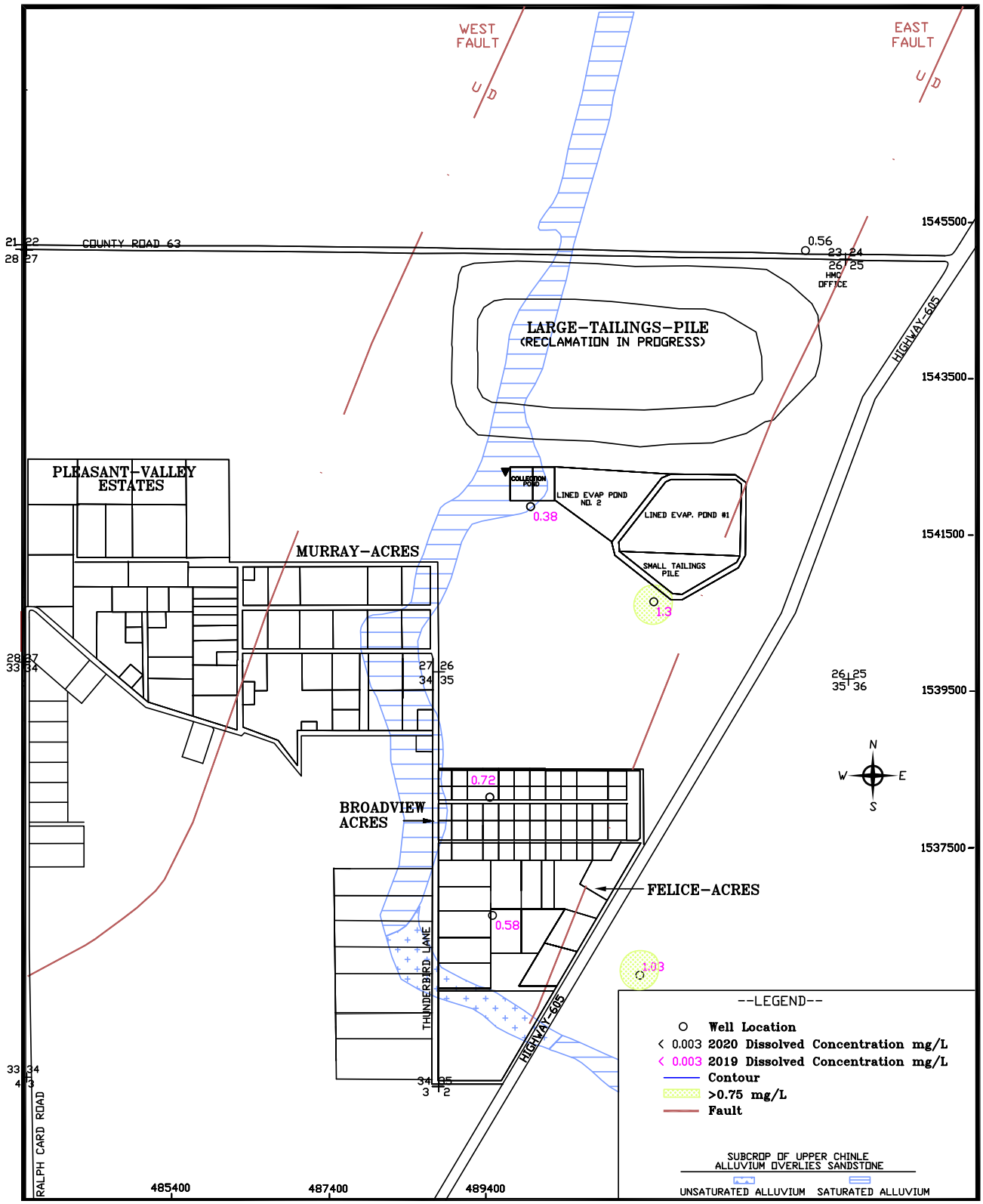

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Figure 3-70
Current Extent of Boron in the Upper Chinle Groundwater

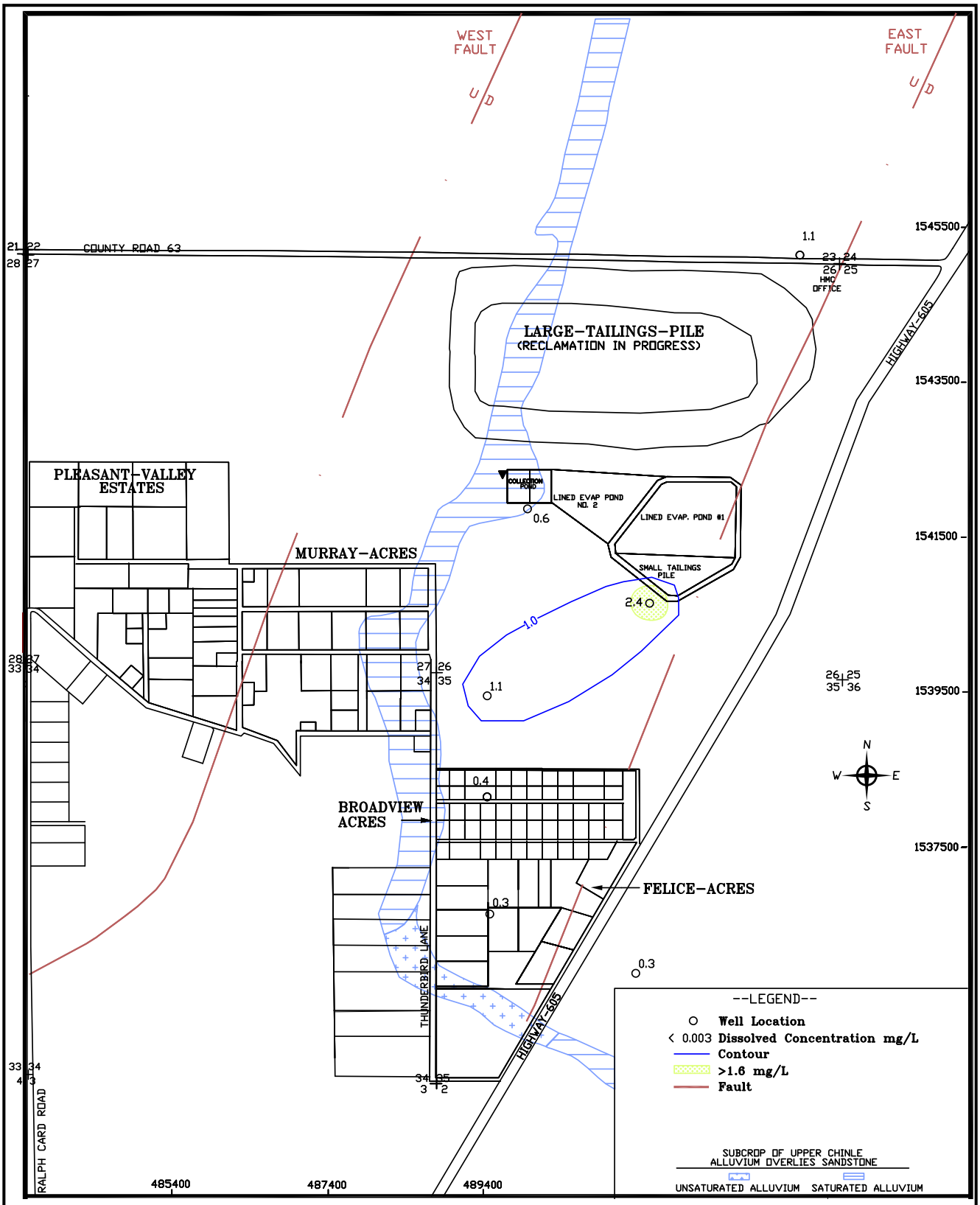

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Figure 3-71
Current Extent of Fluoride in the Upper Chinle Groundwater

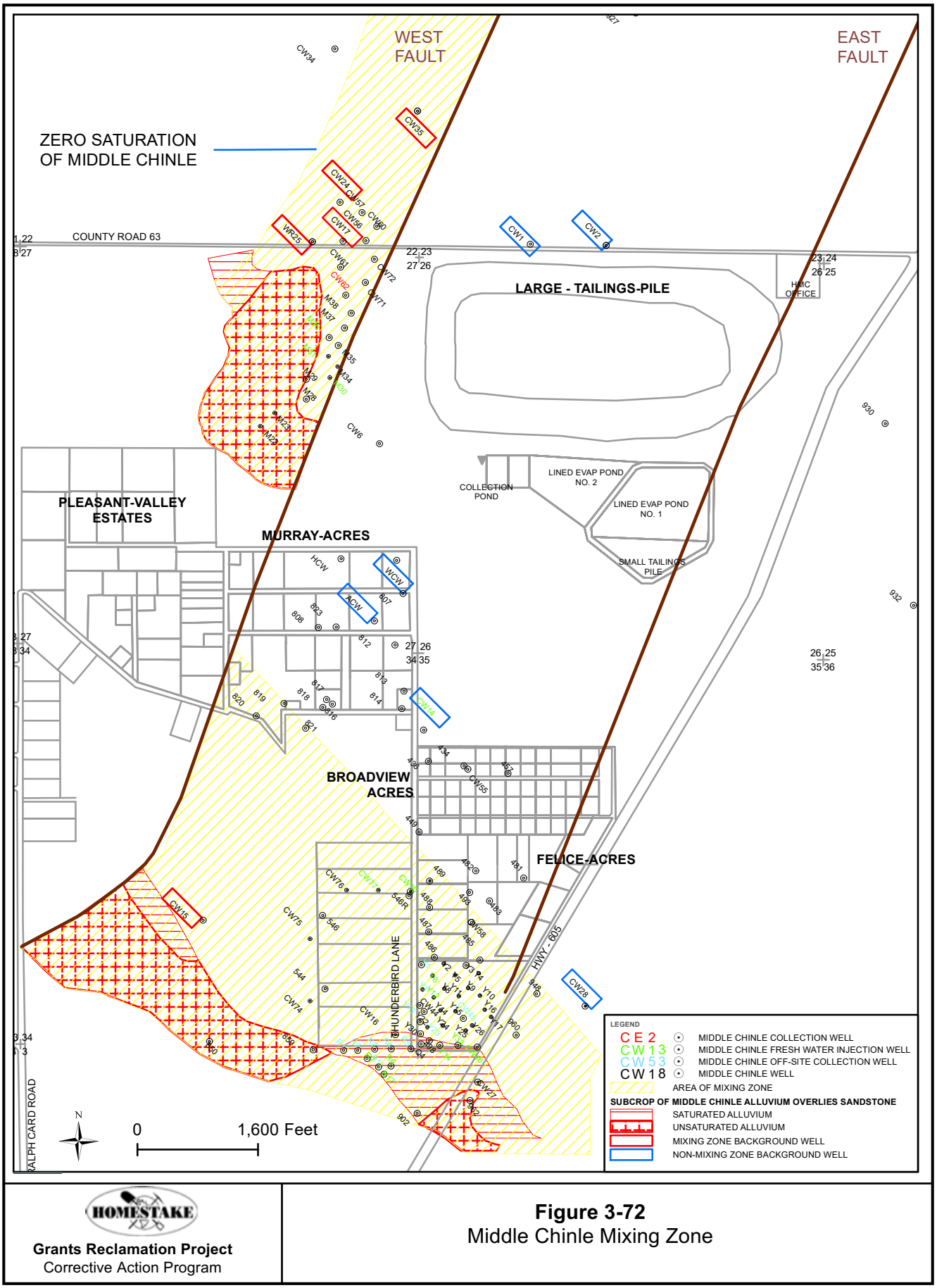

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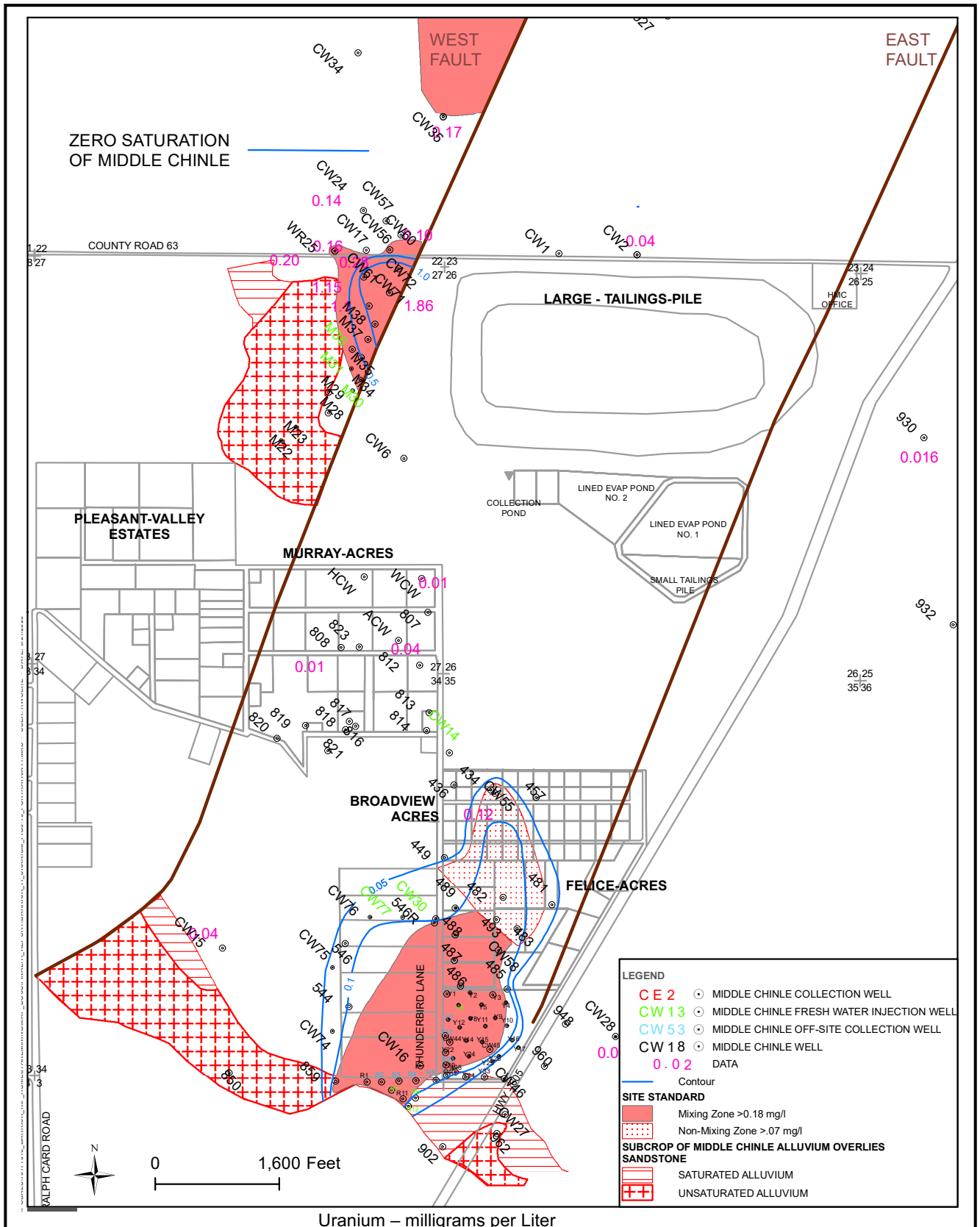
Figure 3-72
Middle Chinle Mixing Zone



Uranium – milligrams per Liter

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Figure 3-73
Middle Chinle Groundwater
Uranium Concentrations

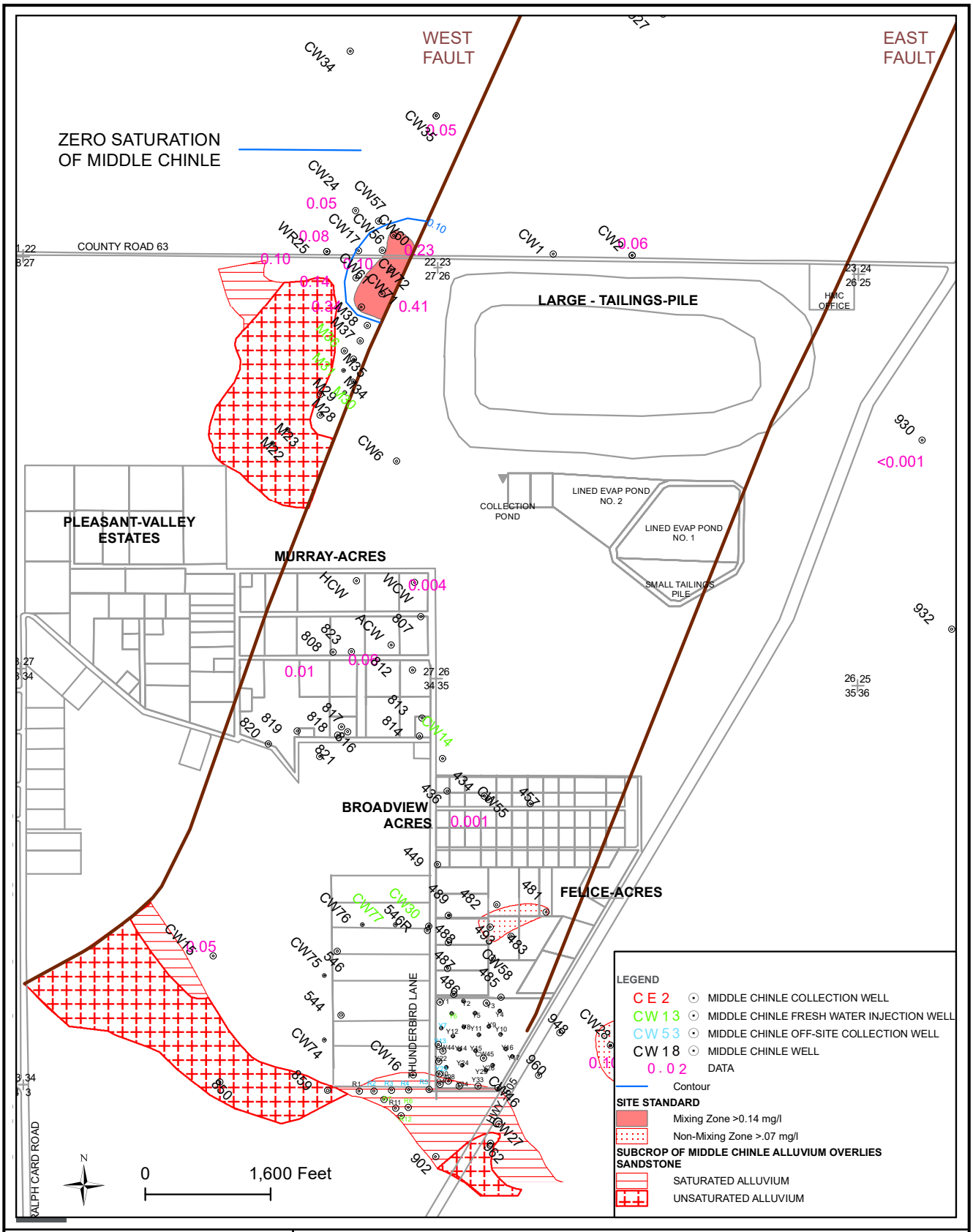

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Figure 3-74
Middle Chinle Groundwater
Selenium Concentrations

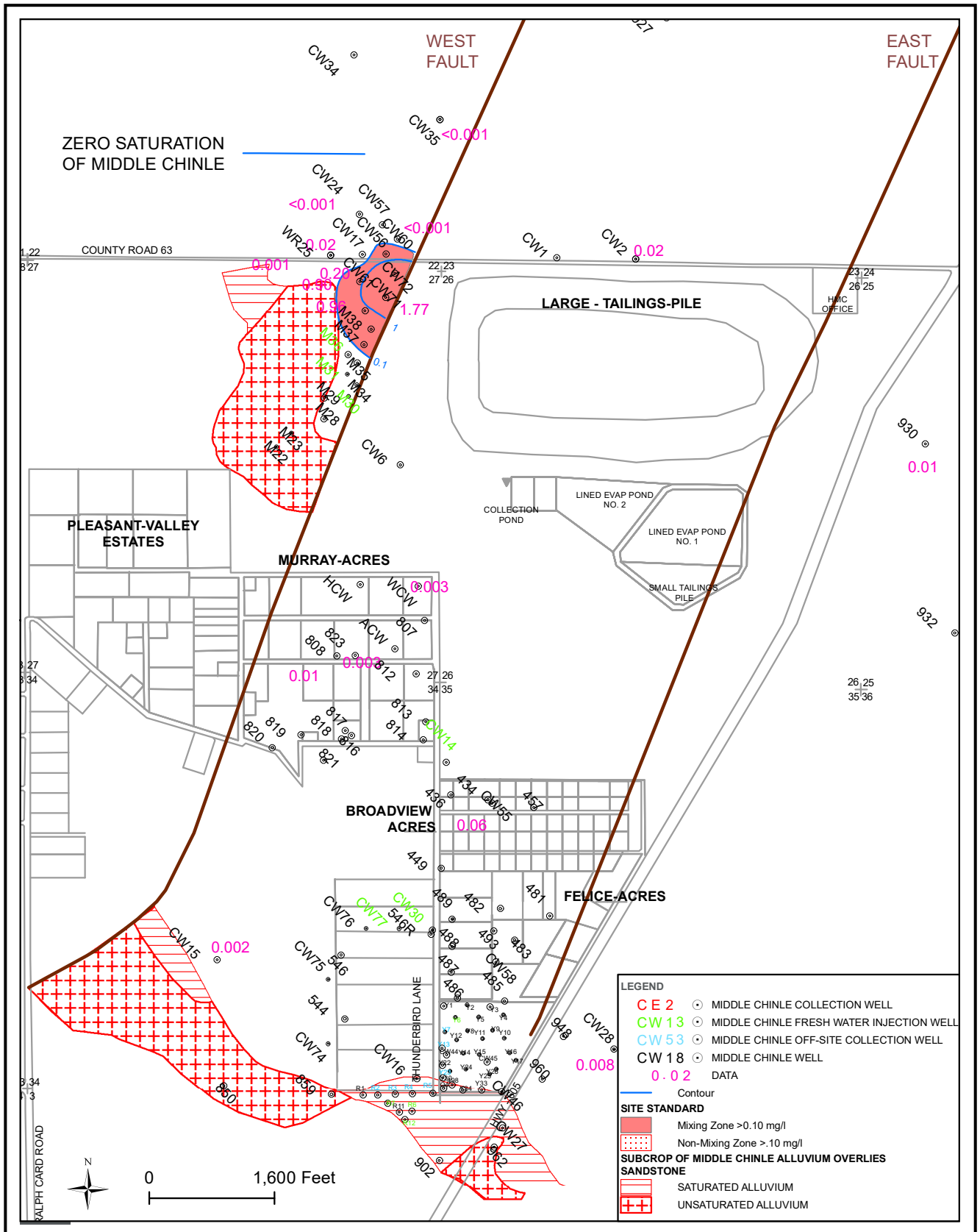

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Figure 3-75
Middle Chinle Groundwater
Molybdenum Concentrations

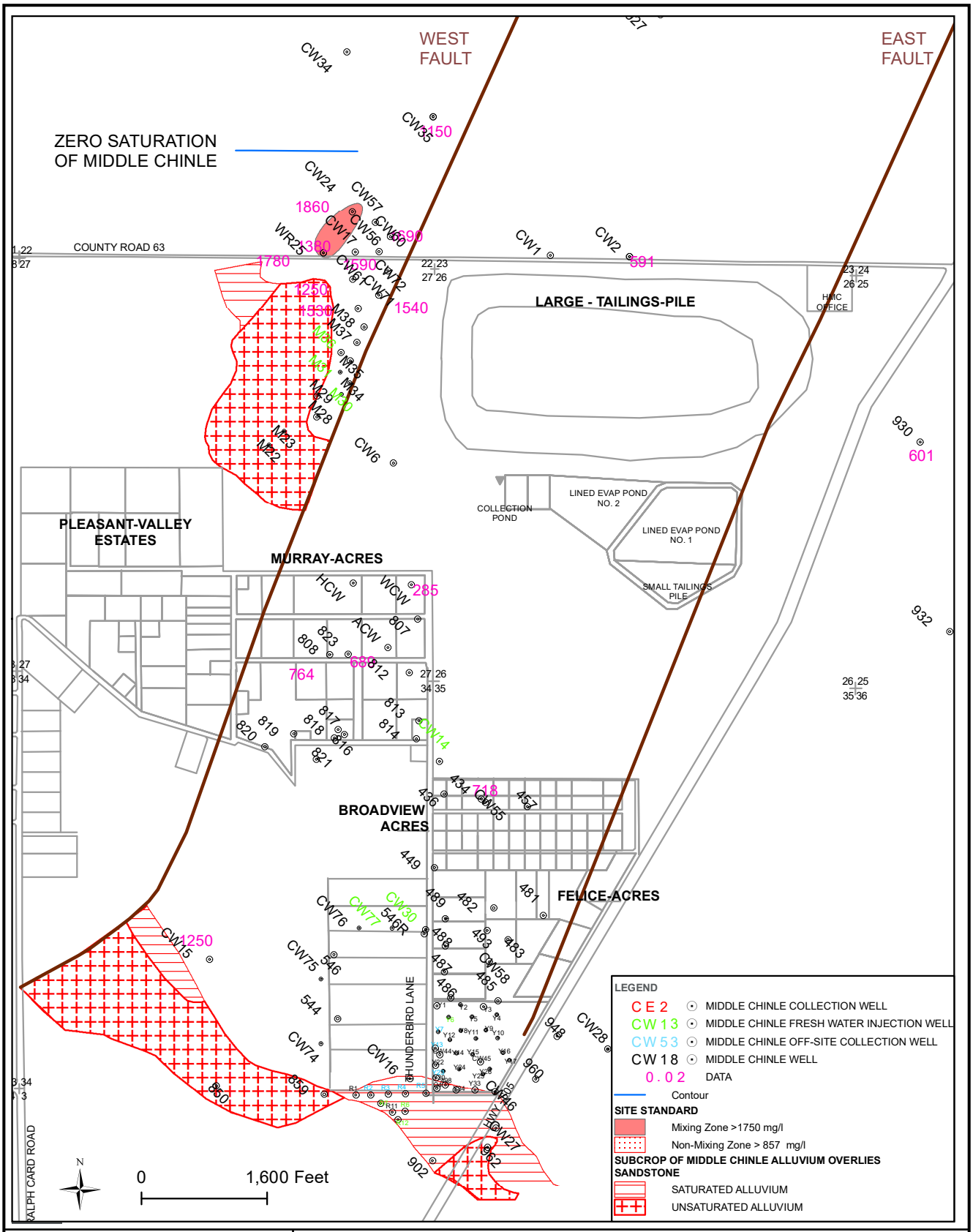

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Figure 3-76
Middle Chinle Groundwater
Sulfate Concentrations

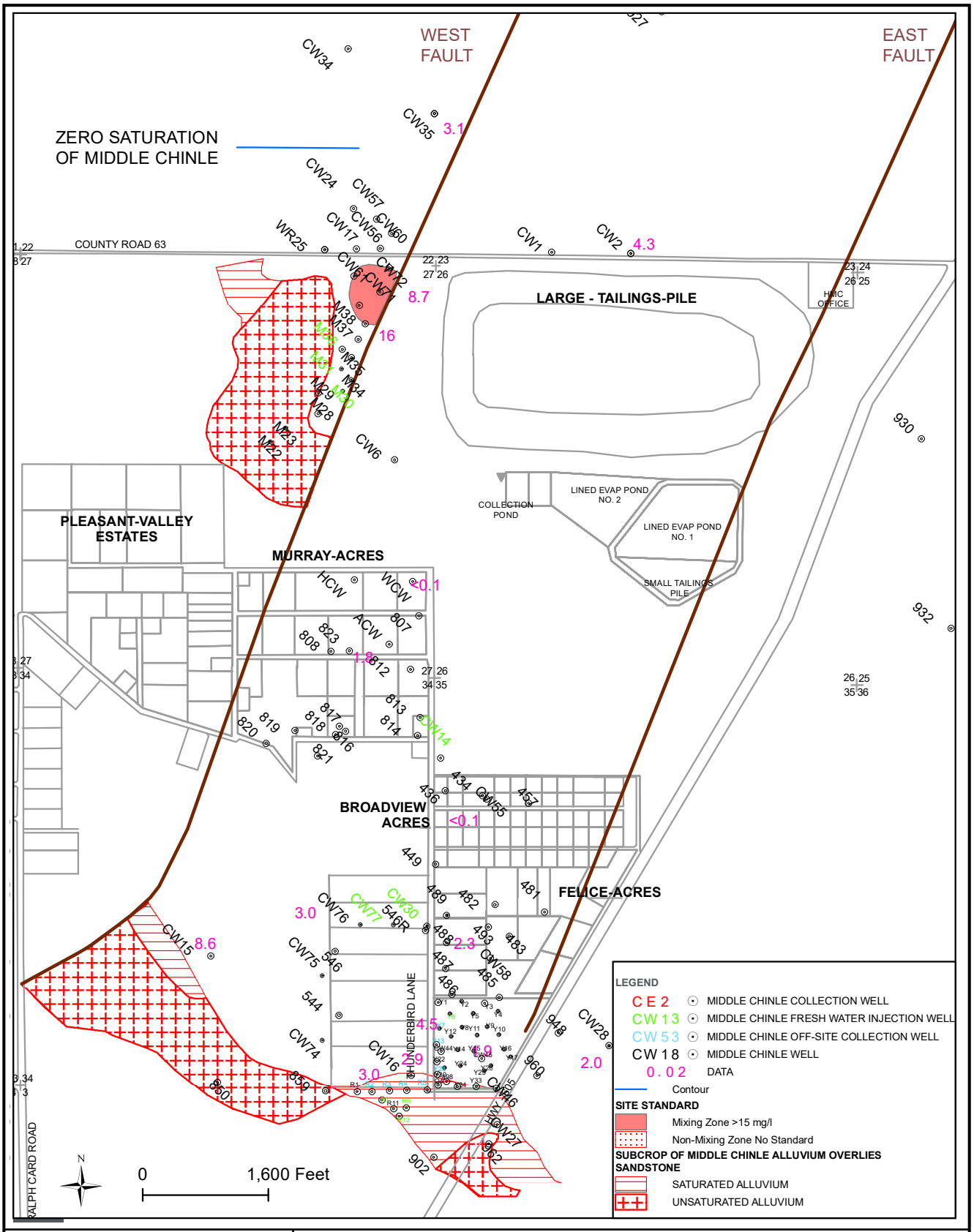

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Figure 3-77
Middle Chinle Groundwater
Nitrate Concentrations

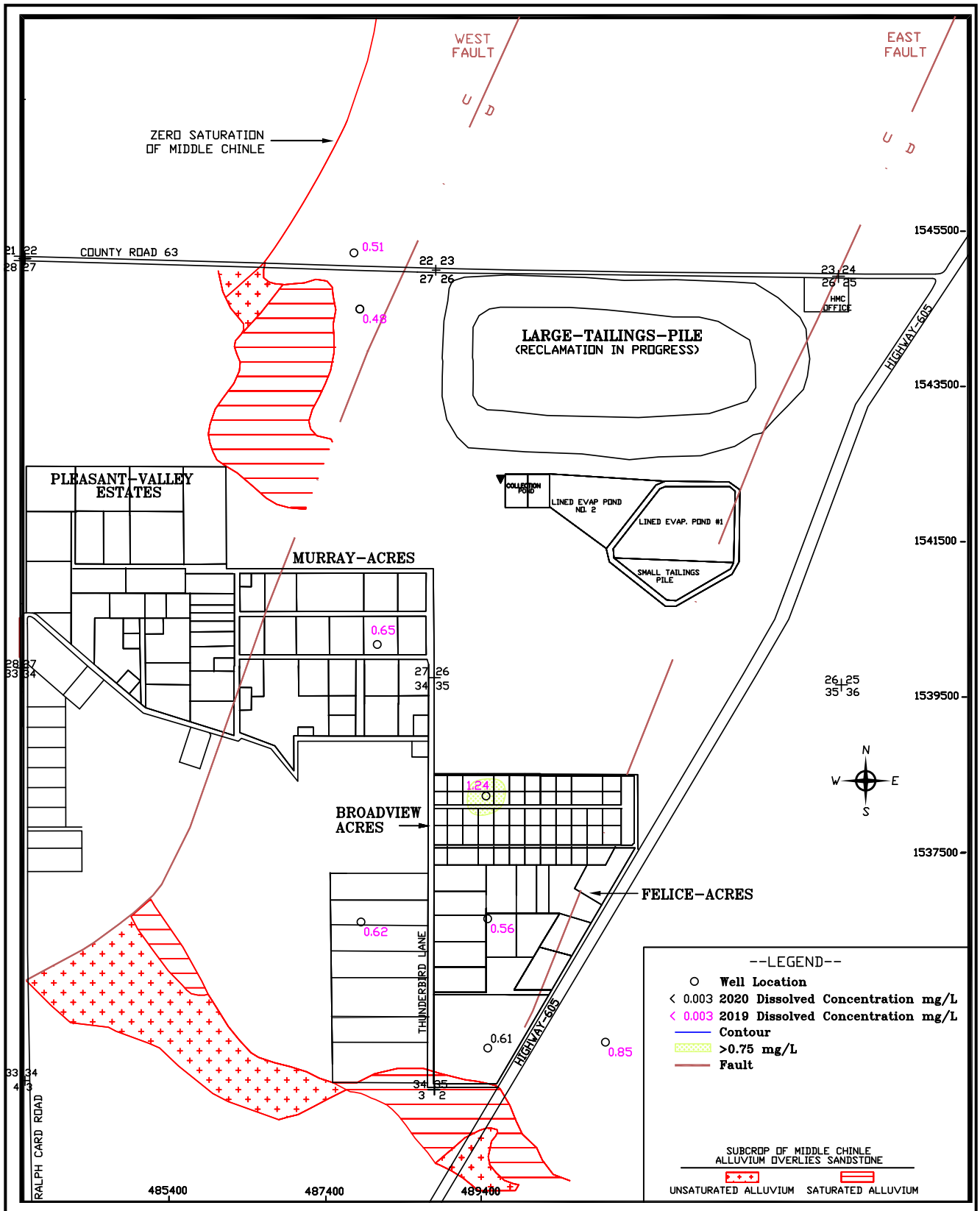

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Figure 3-78
Current Extent of Boron in
Middle Chinle Groundwater

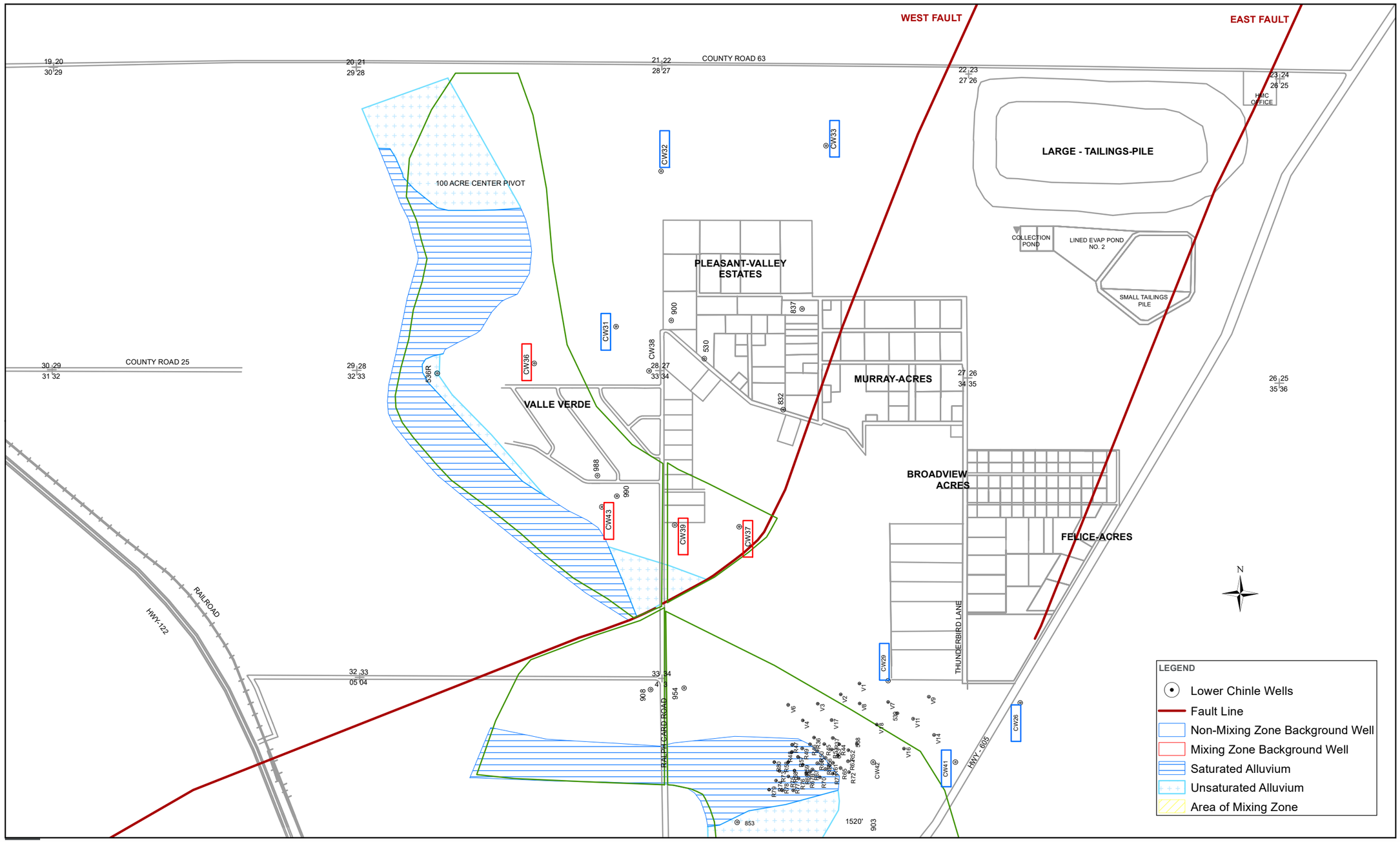

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Figure 3-79
Lower Chinle Mixing Zone

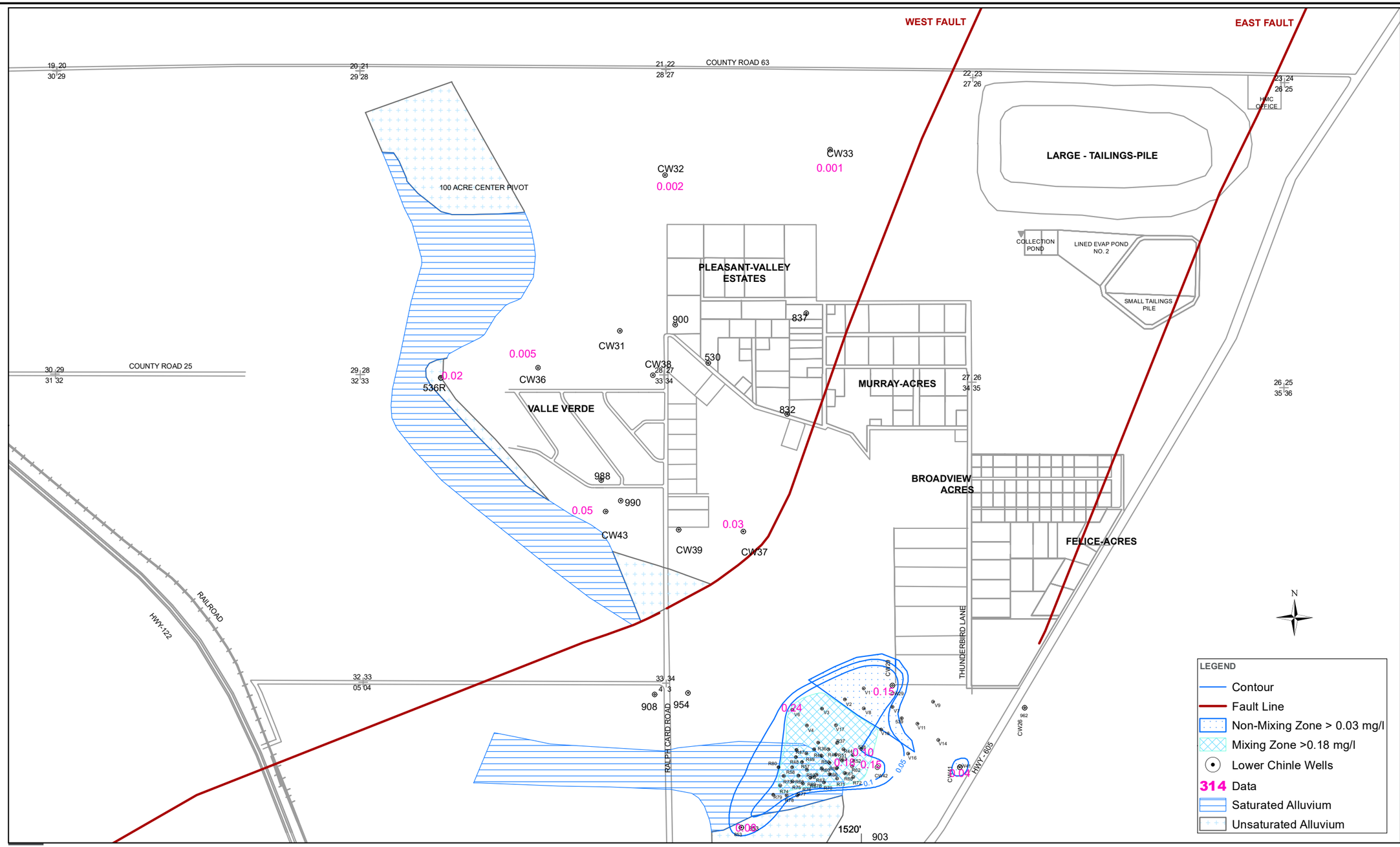

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Figure 3-80
Lower Chinle Groundwater
Uranium Concentrations

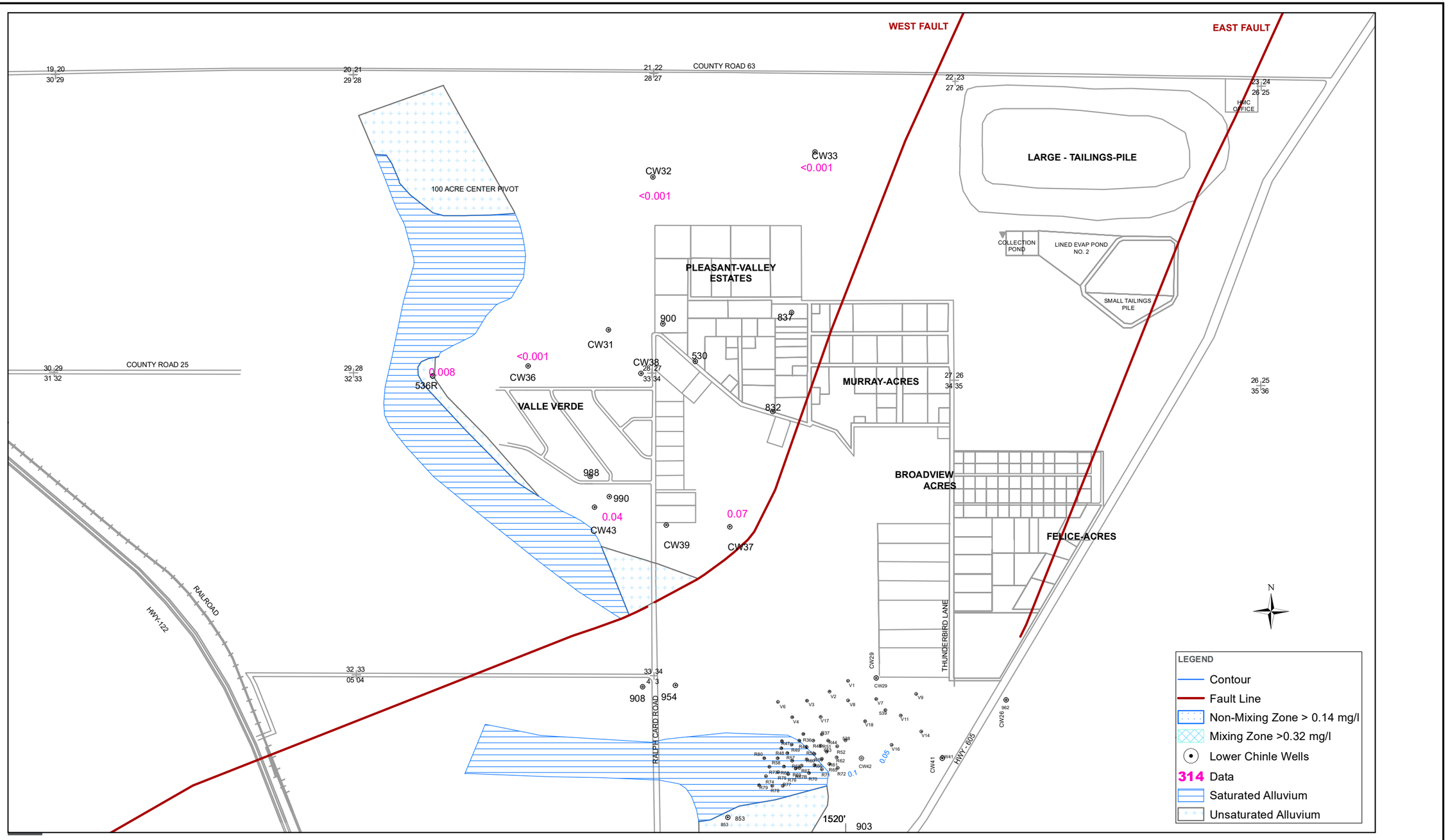

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Figure 3-81
Lower Chinle Groundwater
Selenium Concentrations

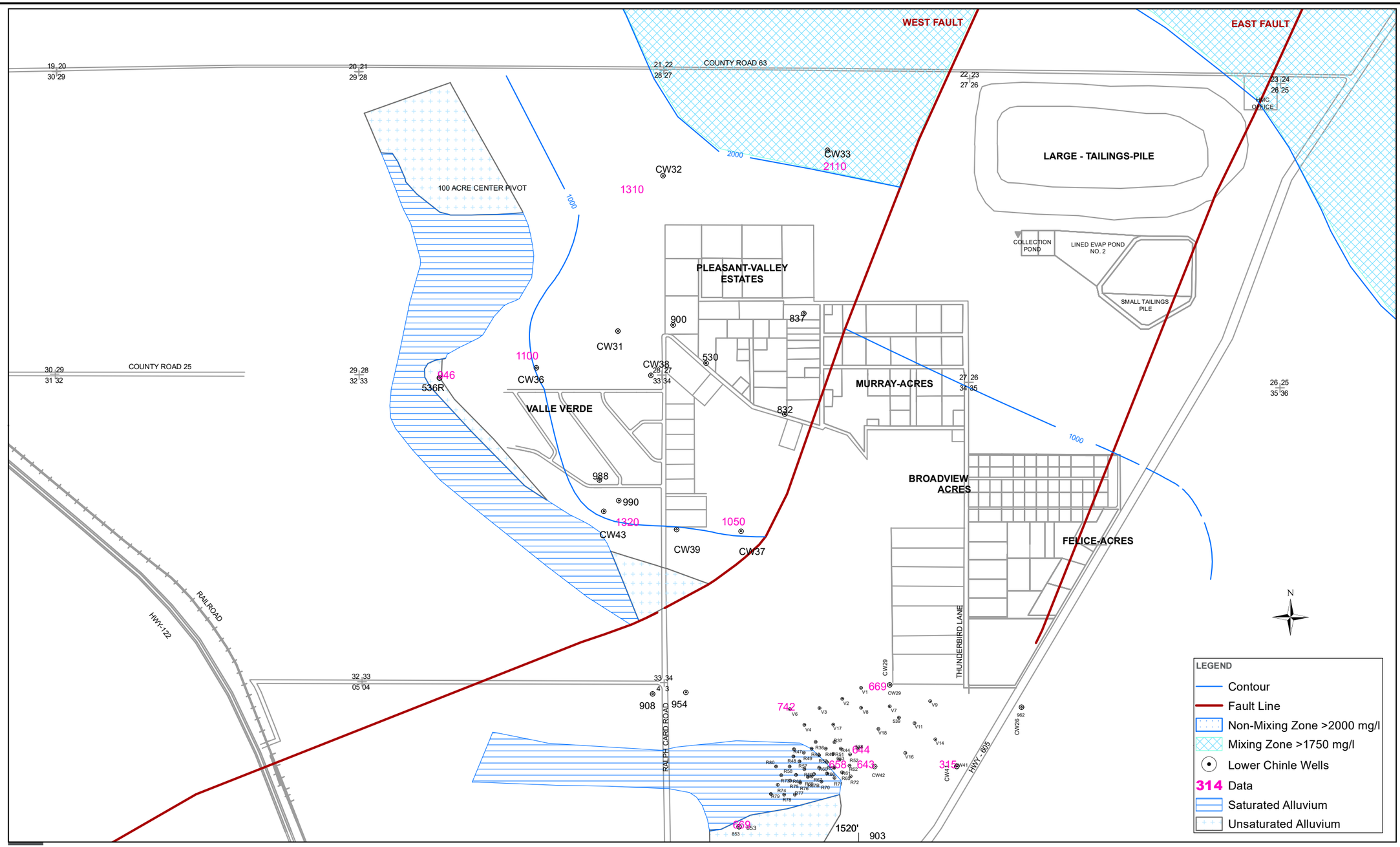

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Figure 3-82
Lower Chinle Groundwater
Sulfate Concentrations

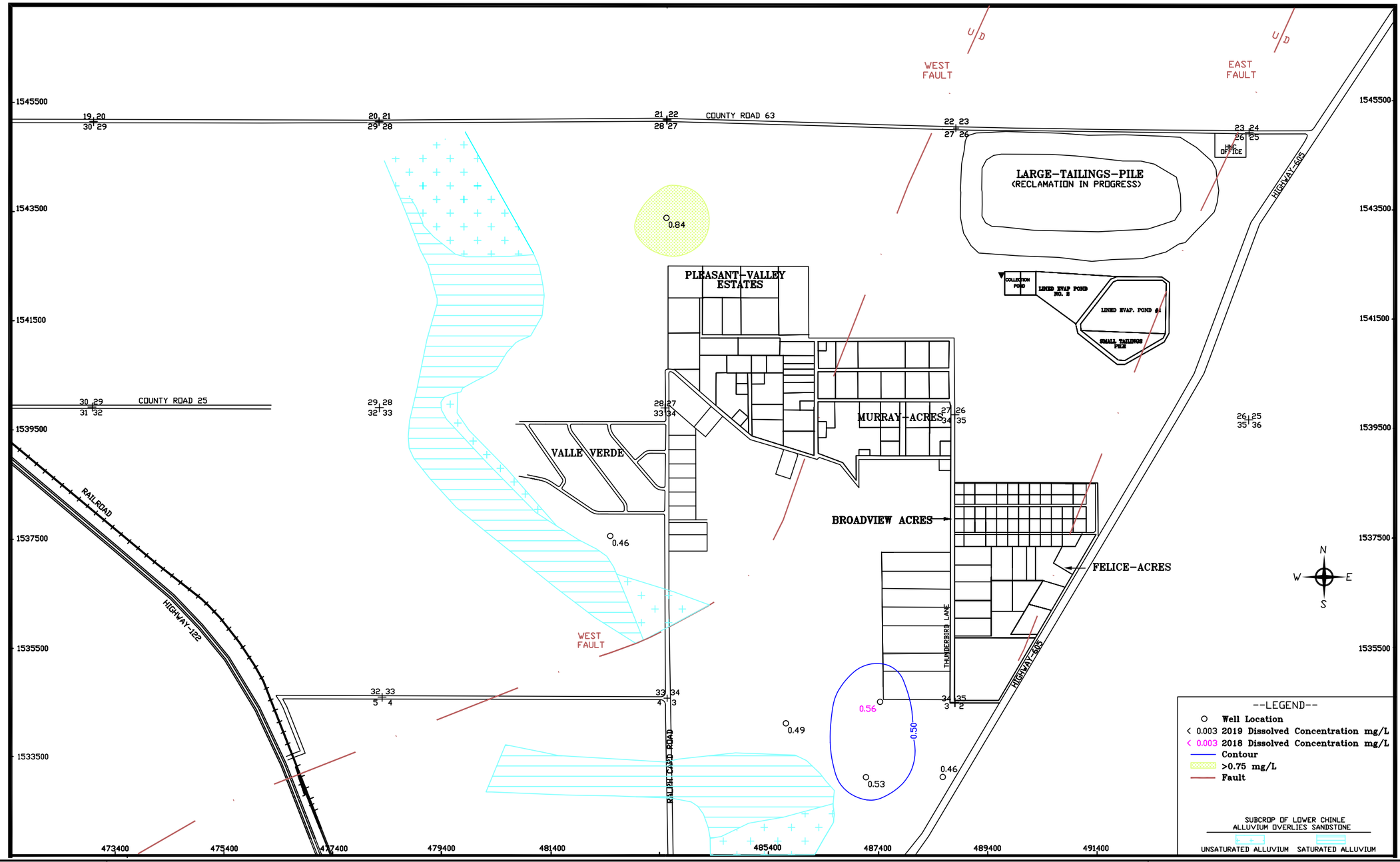

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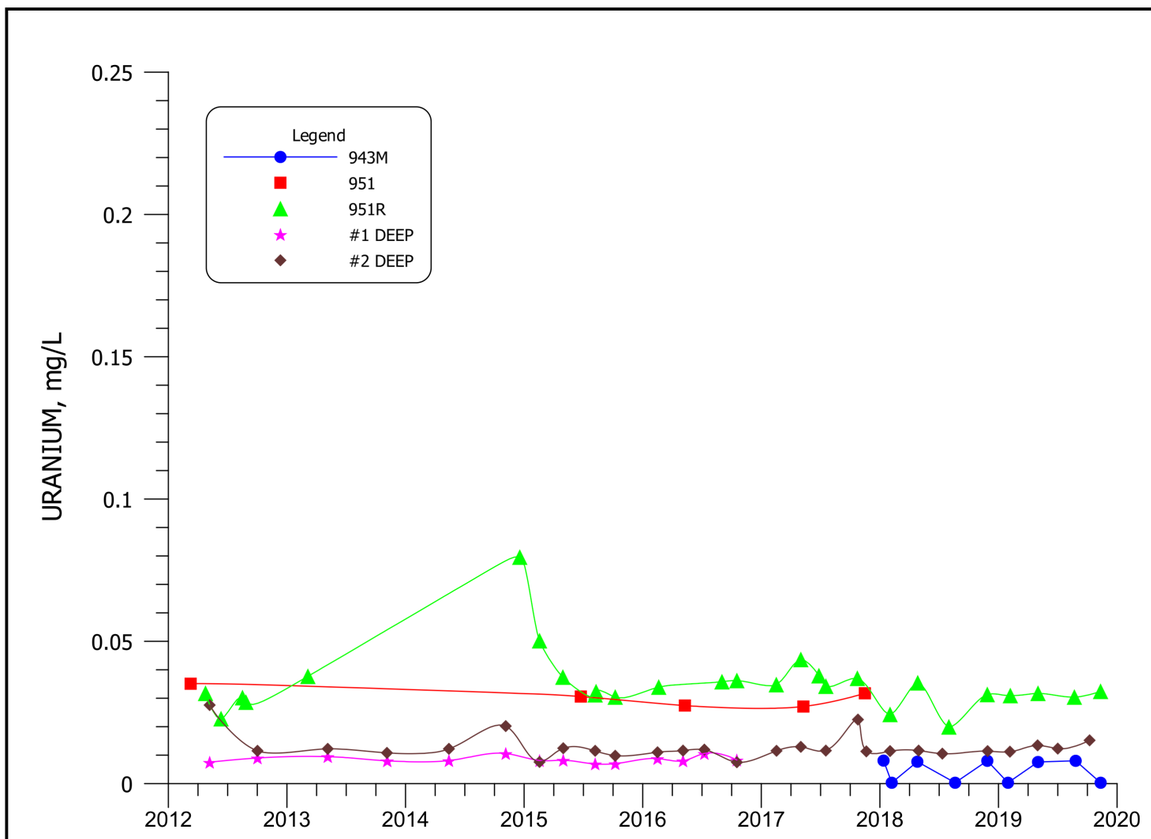
Figure 3-83
Current Extent of Boron in Lower Chinle Groundwater



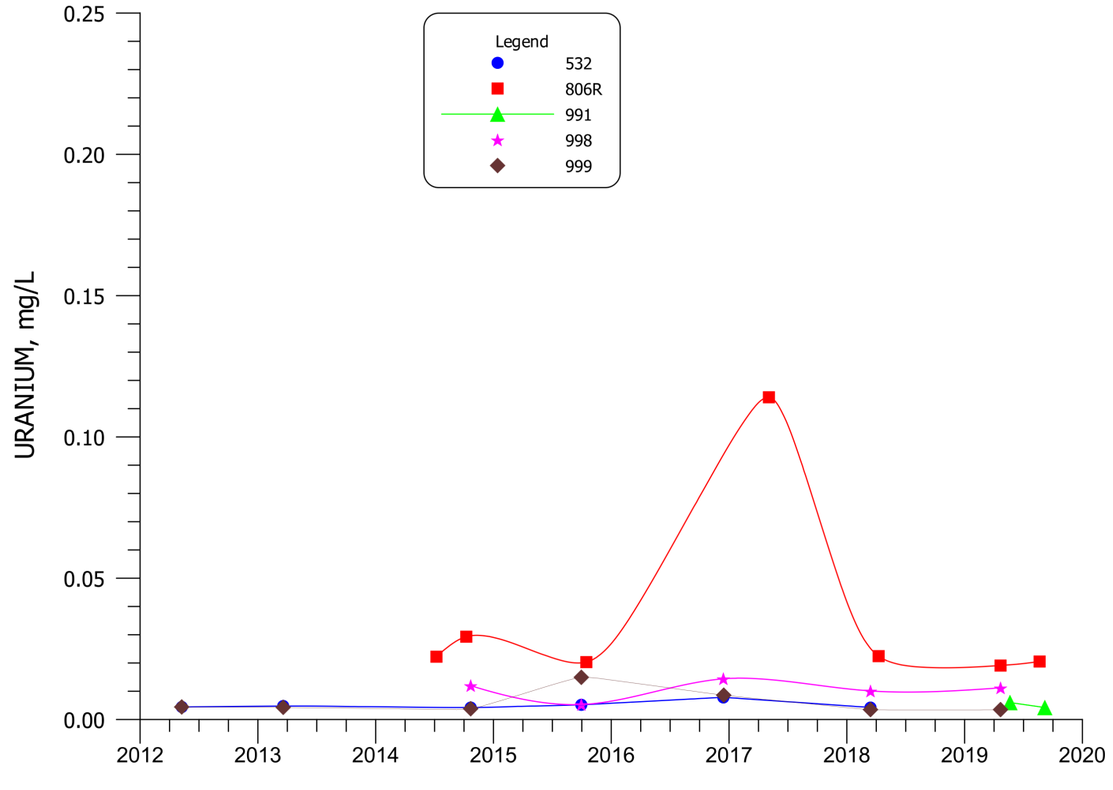


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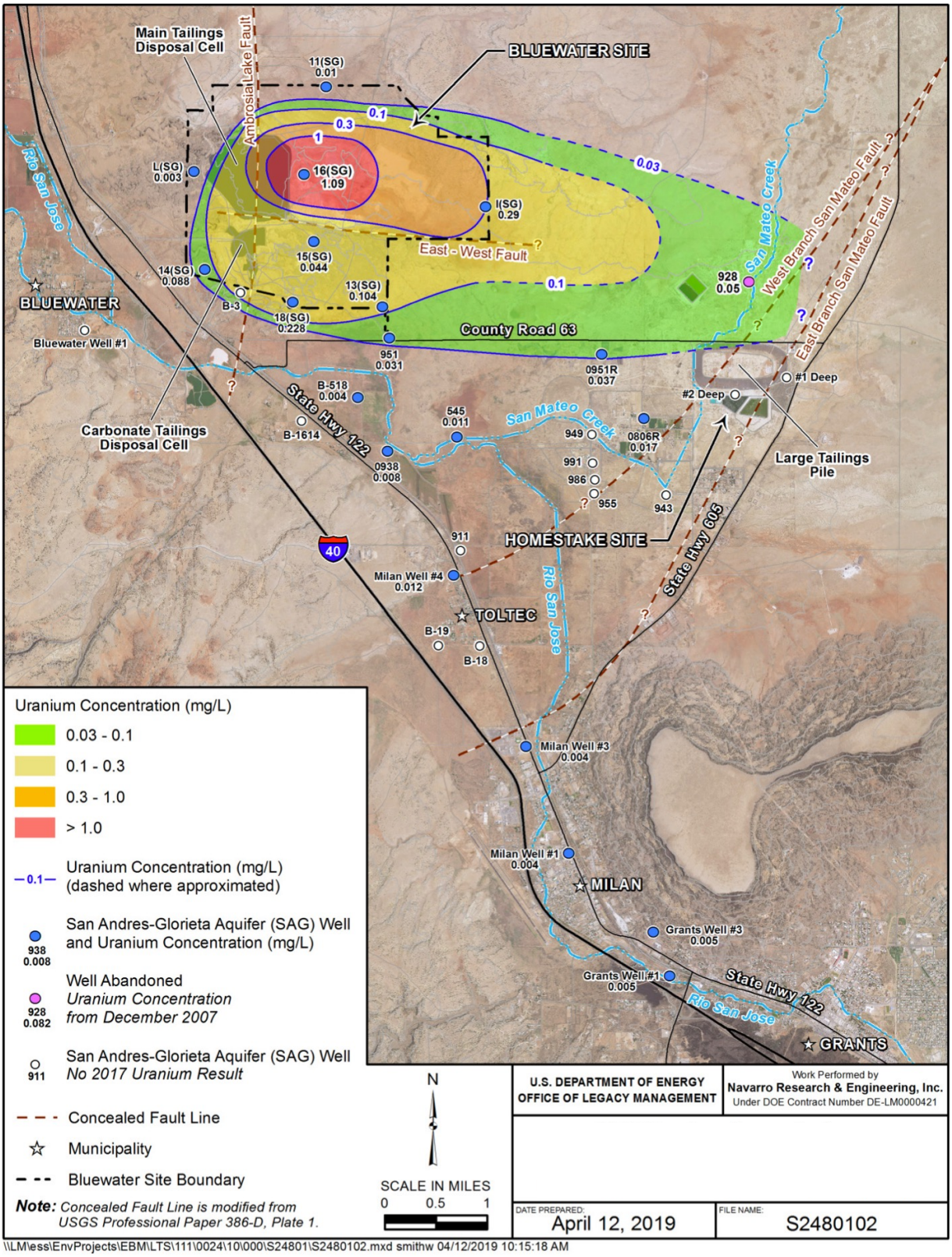
Figure 3-84
Uranium Concentration versus Time
In San Andres-Glorieta Groundwater



Source: DOE, 2020

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Figure 3-85
Recent Uranium Concentrations in
San Andres-Glorieta Groundwater

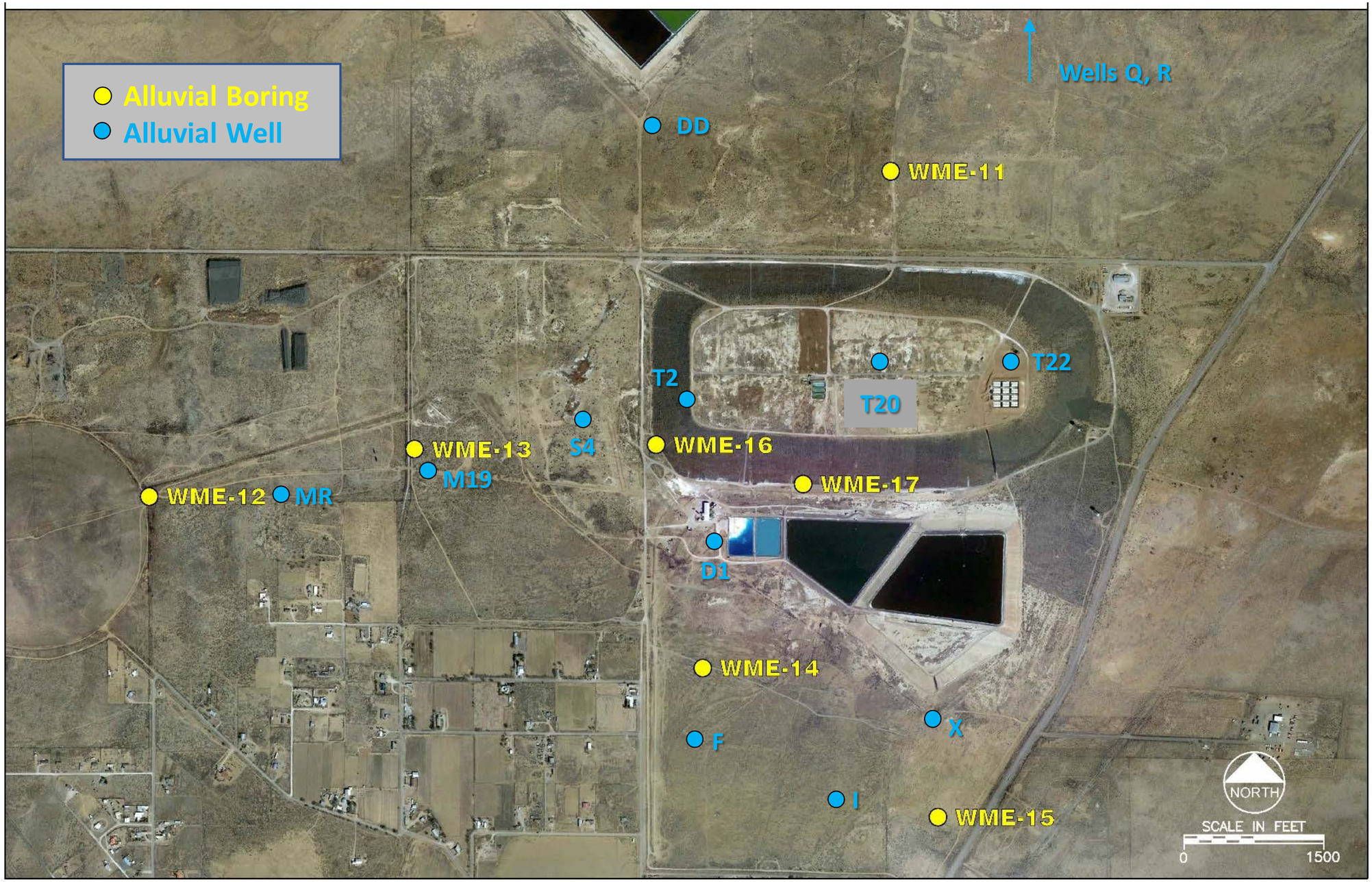

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Figure 3-86
Location of Alluvial Borings and Wells for Solids Collection and Water Quality Evaluation

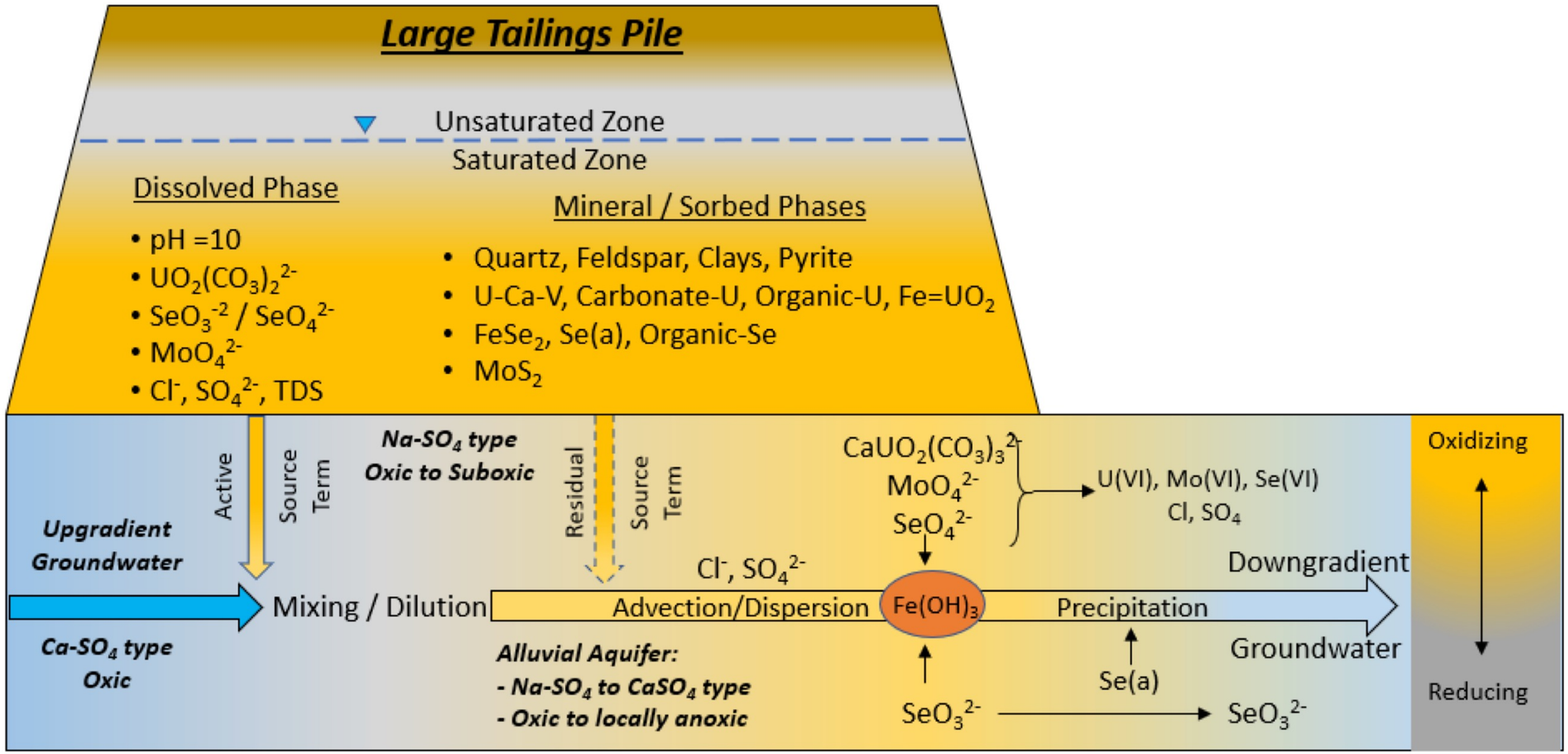
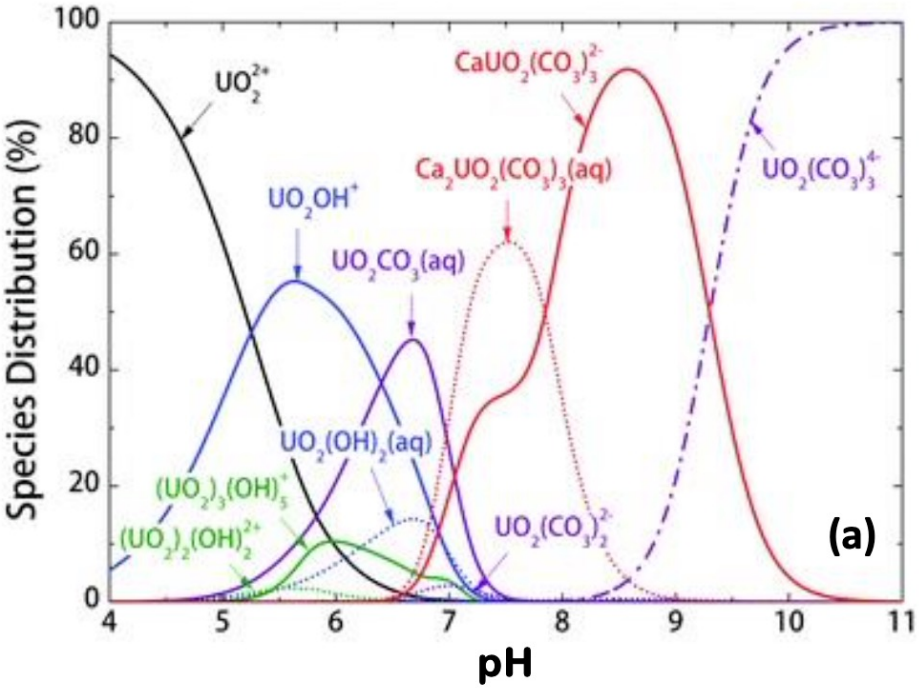
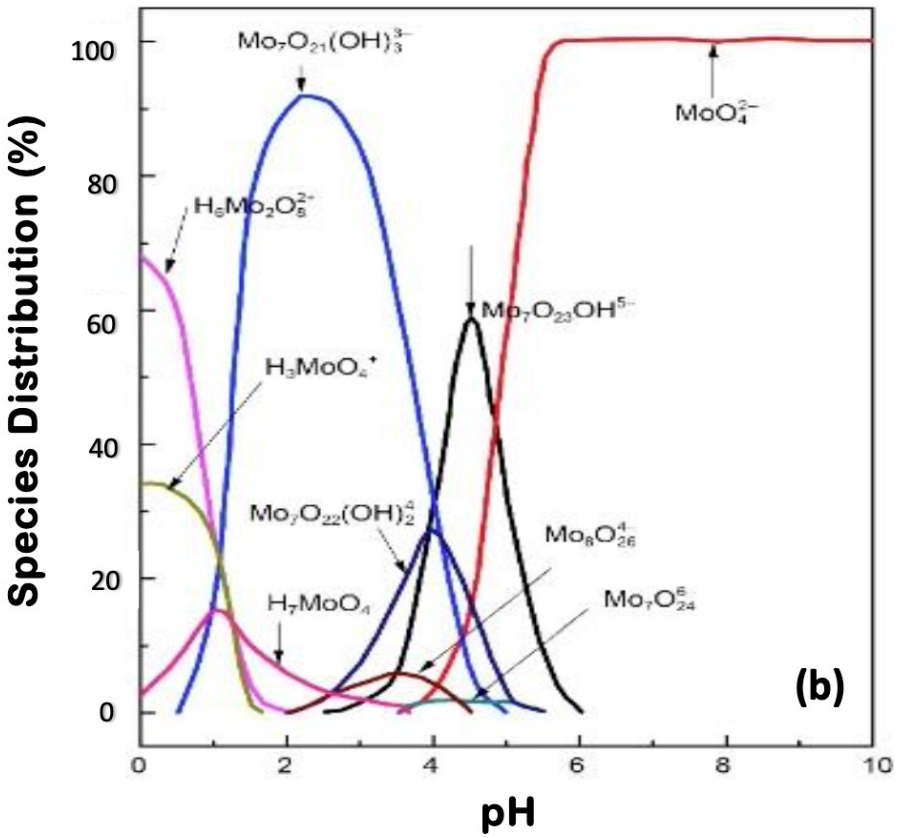


Figure 3-87
Conceptual Geochemical Model
for Constituent Sources and Transport





Source: Lee et al. (2011); Lee and Yun (2013)

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Figure 3-88
Uranium and Molybdenum Speciation as a Function of pH

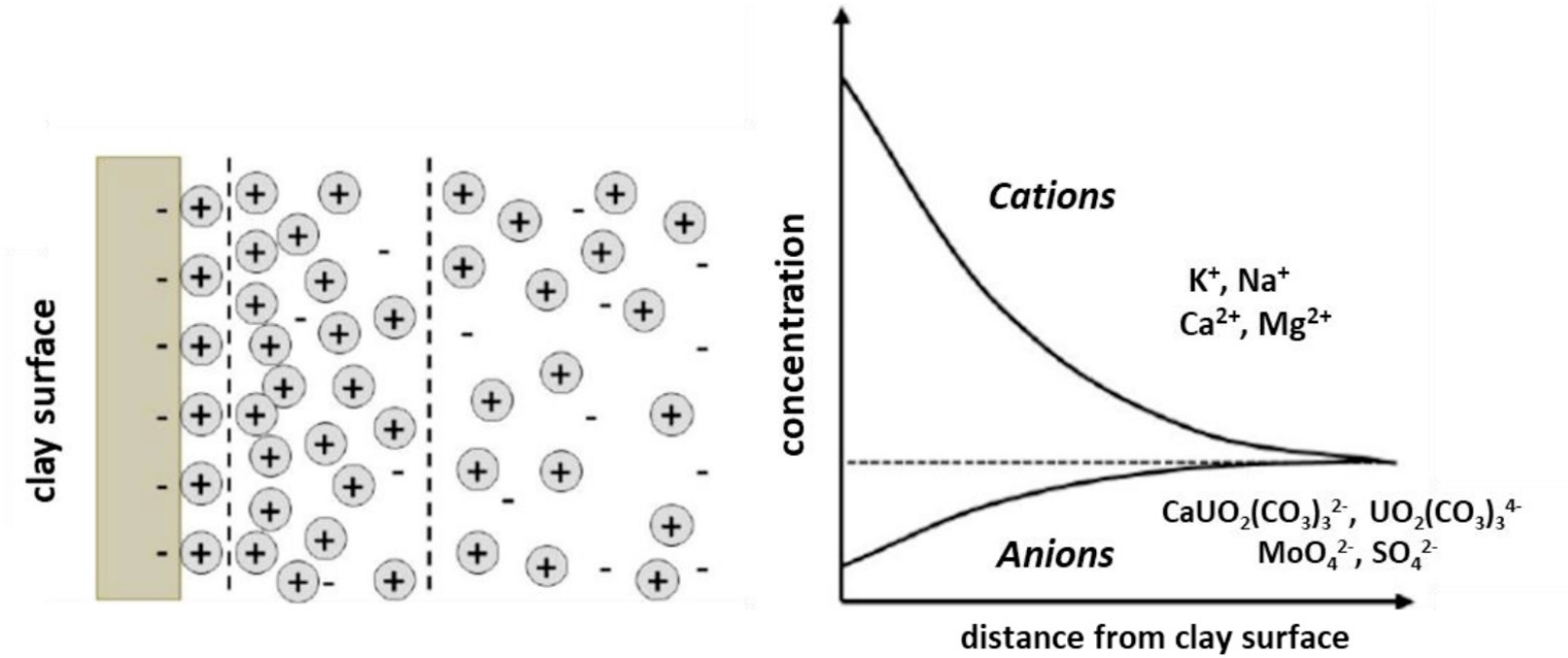

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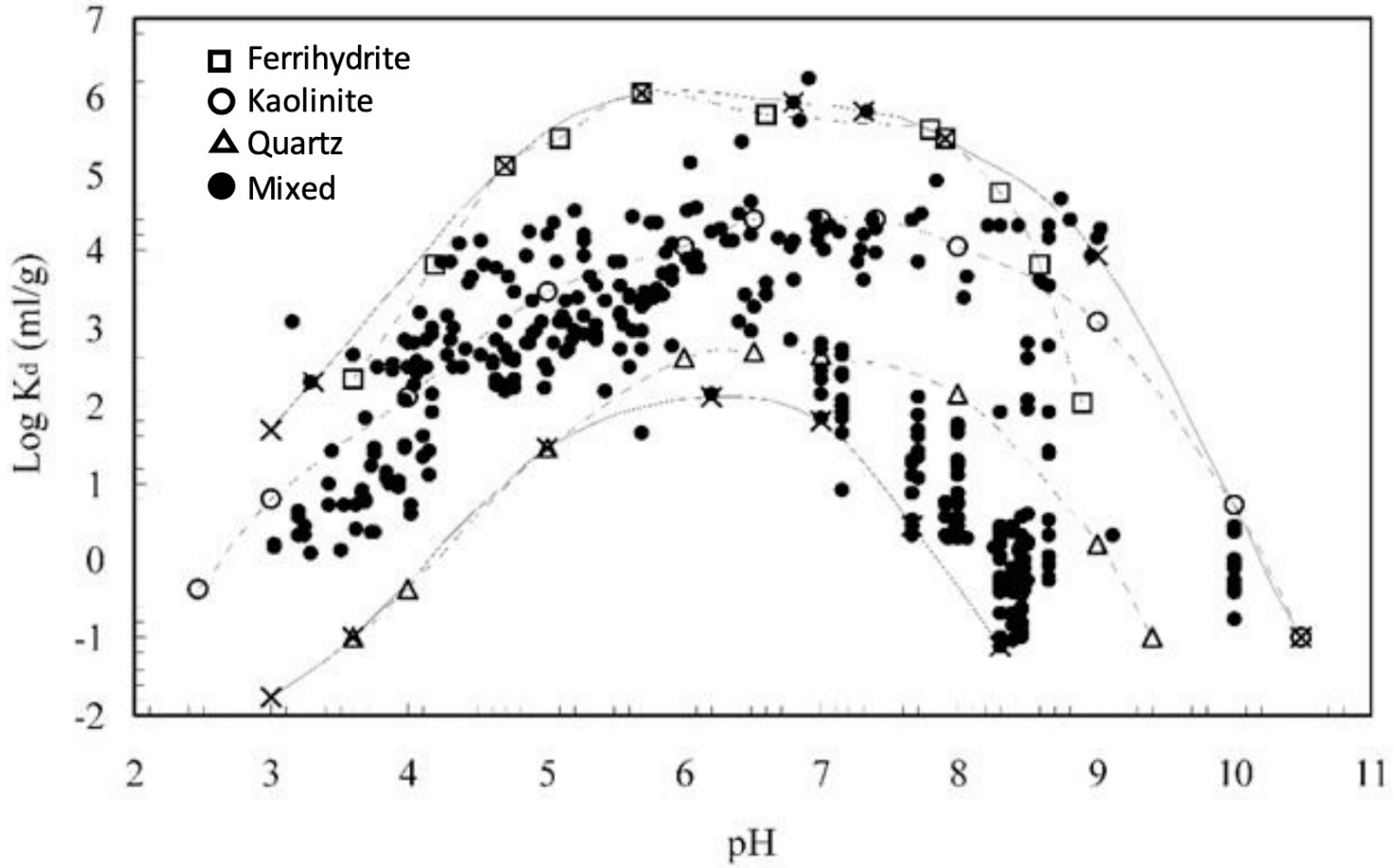
Figure 3-89
Distribution of Ions Adjacent to a Clay Surface



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Source: EPA, 1999a

Figure 3-90
Range of Uranium K_d Values for Various Minerals

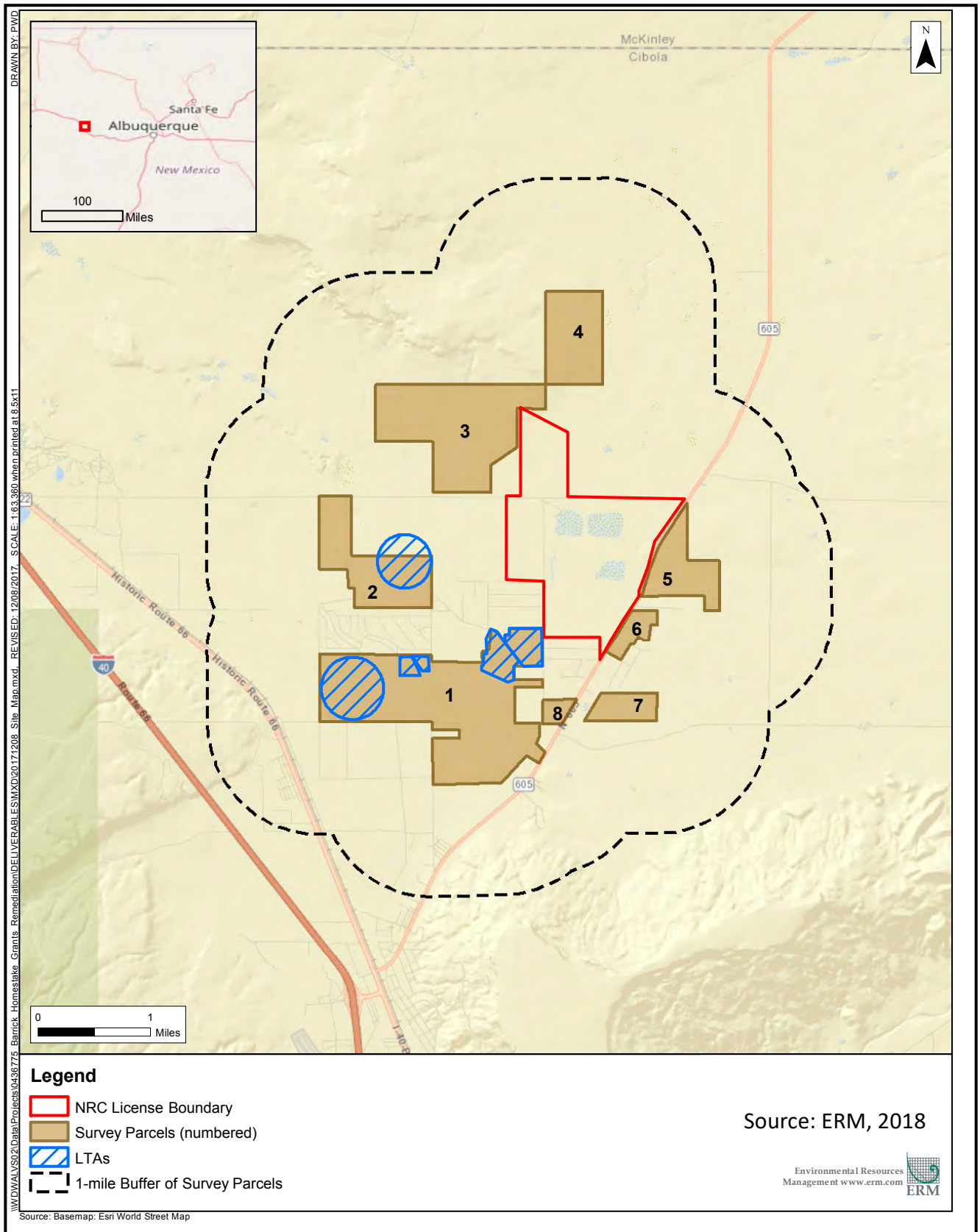

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Figure 3-91
Study Area for Environmental Survey

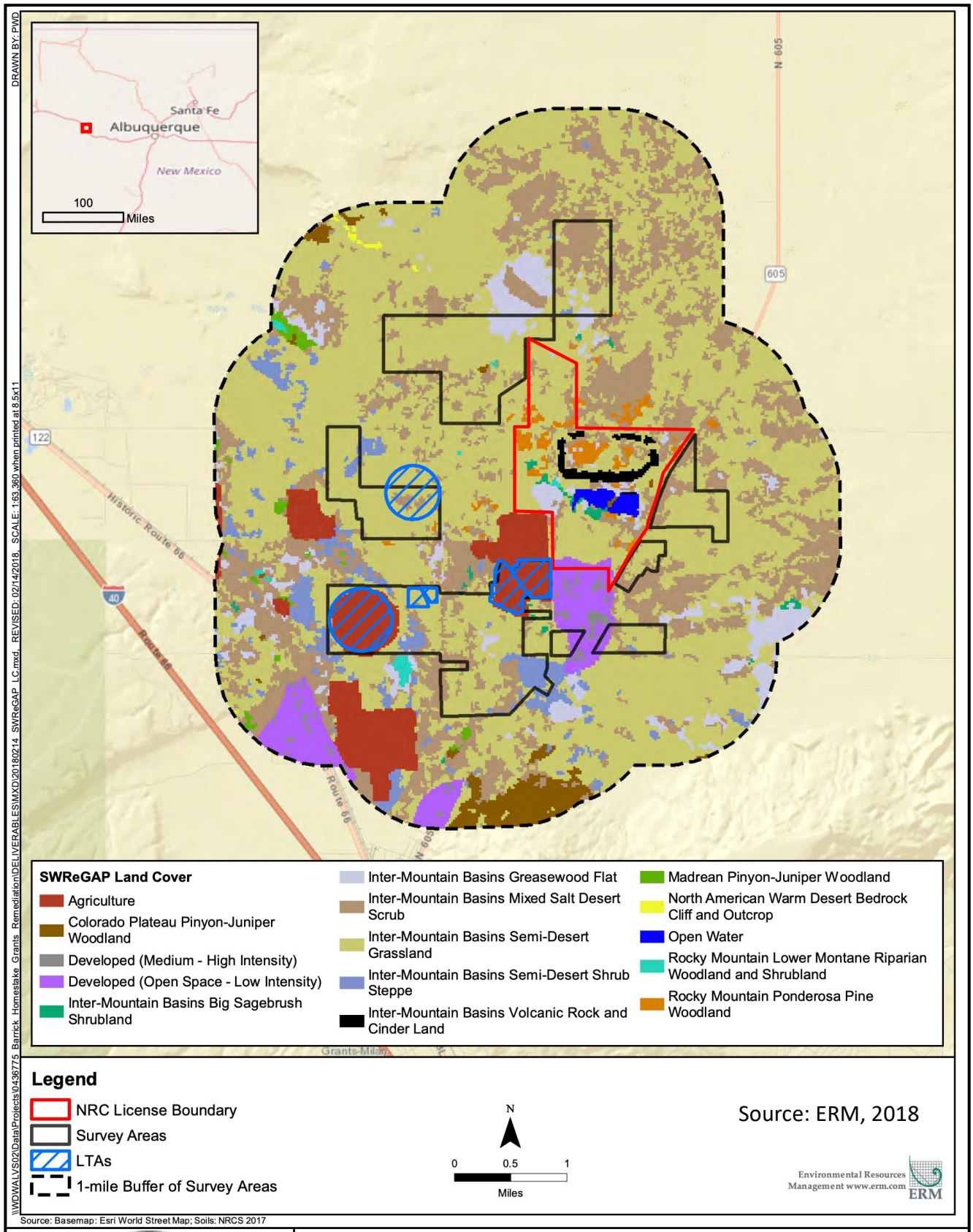

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Figure 3-92
Vegetation Communities

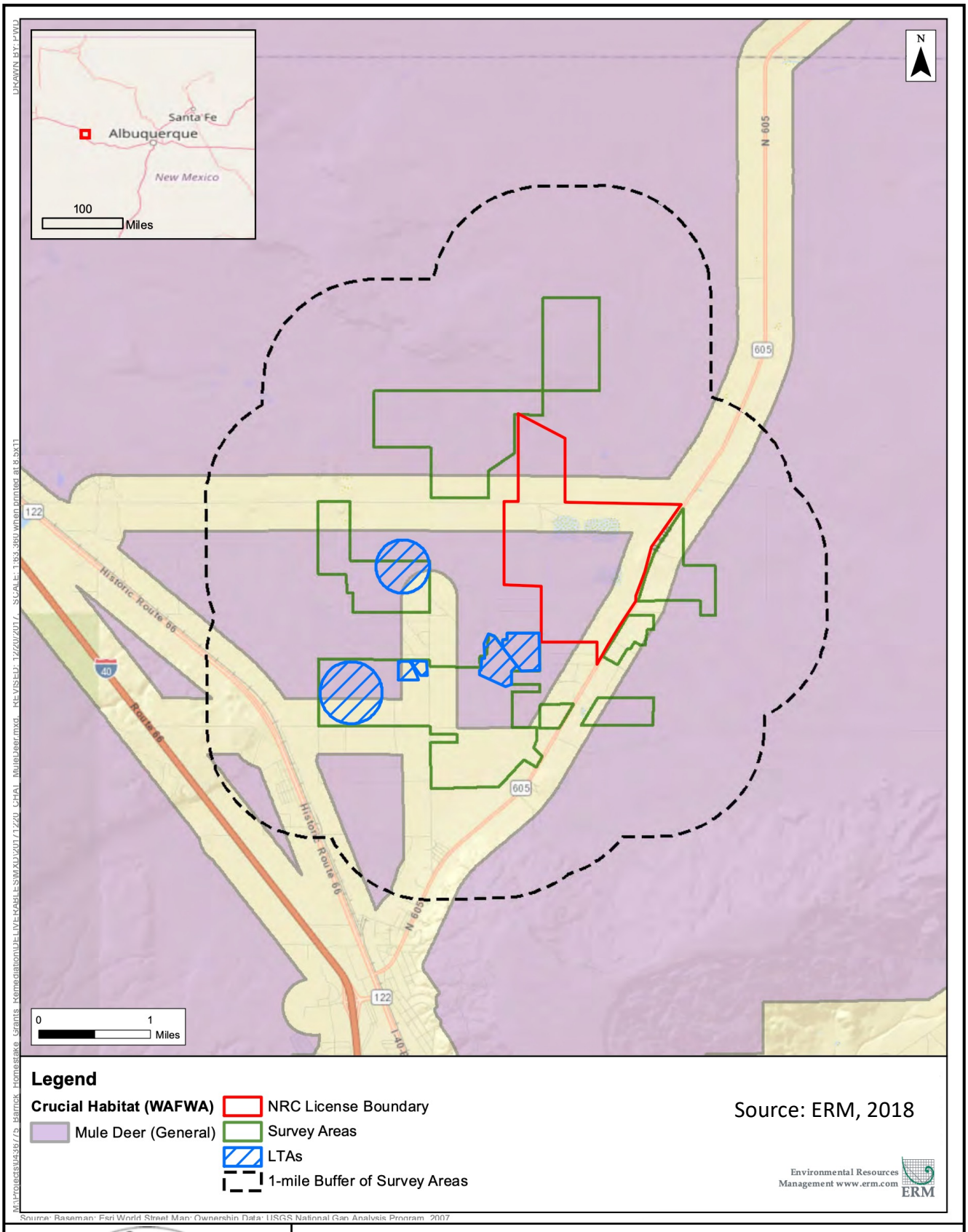

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Figure 3-93
Crucial Mule Deer Habitat

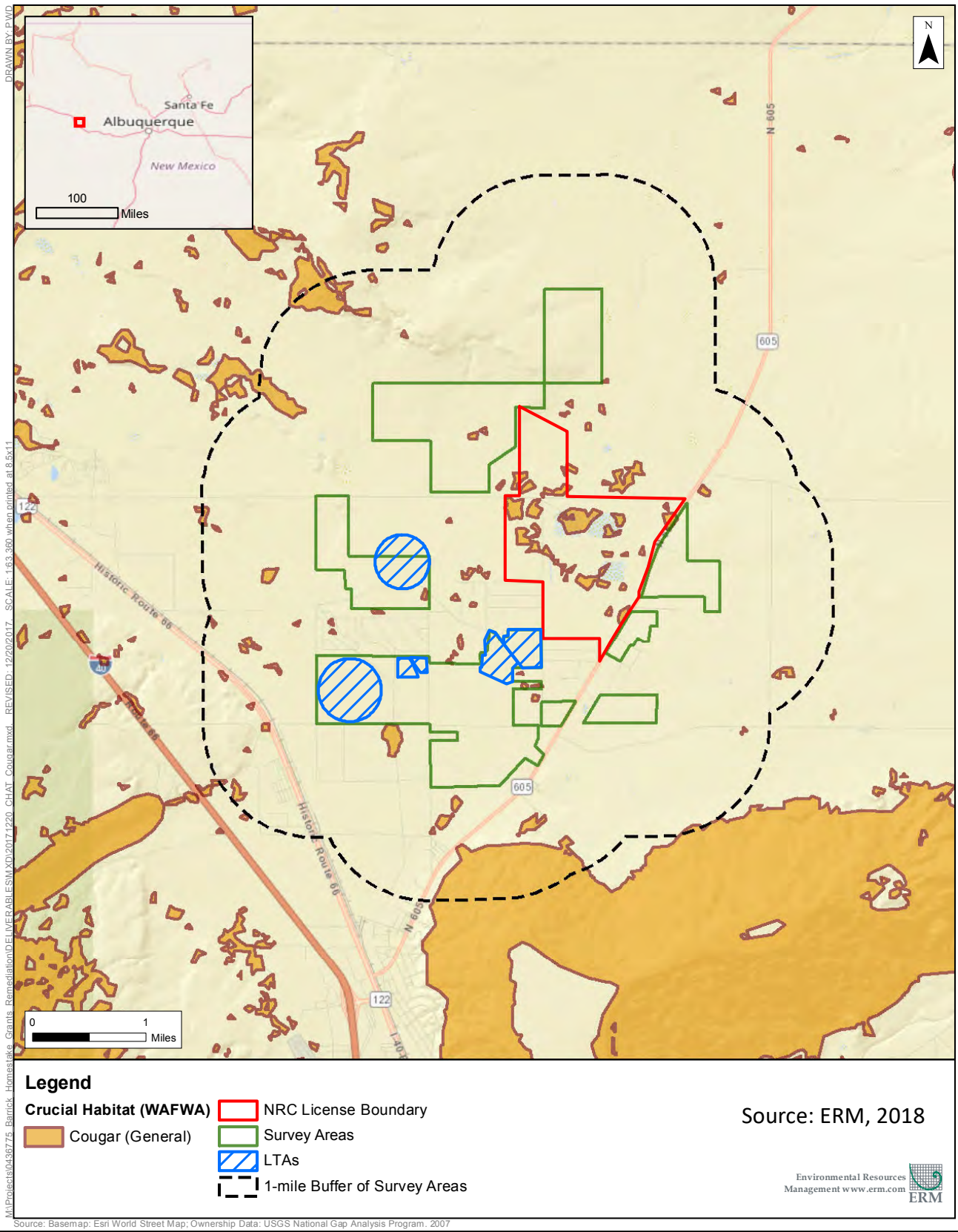

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Figure 3-94
Crucial Cougar Habitat

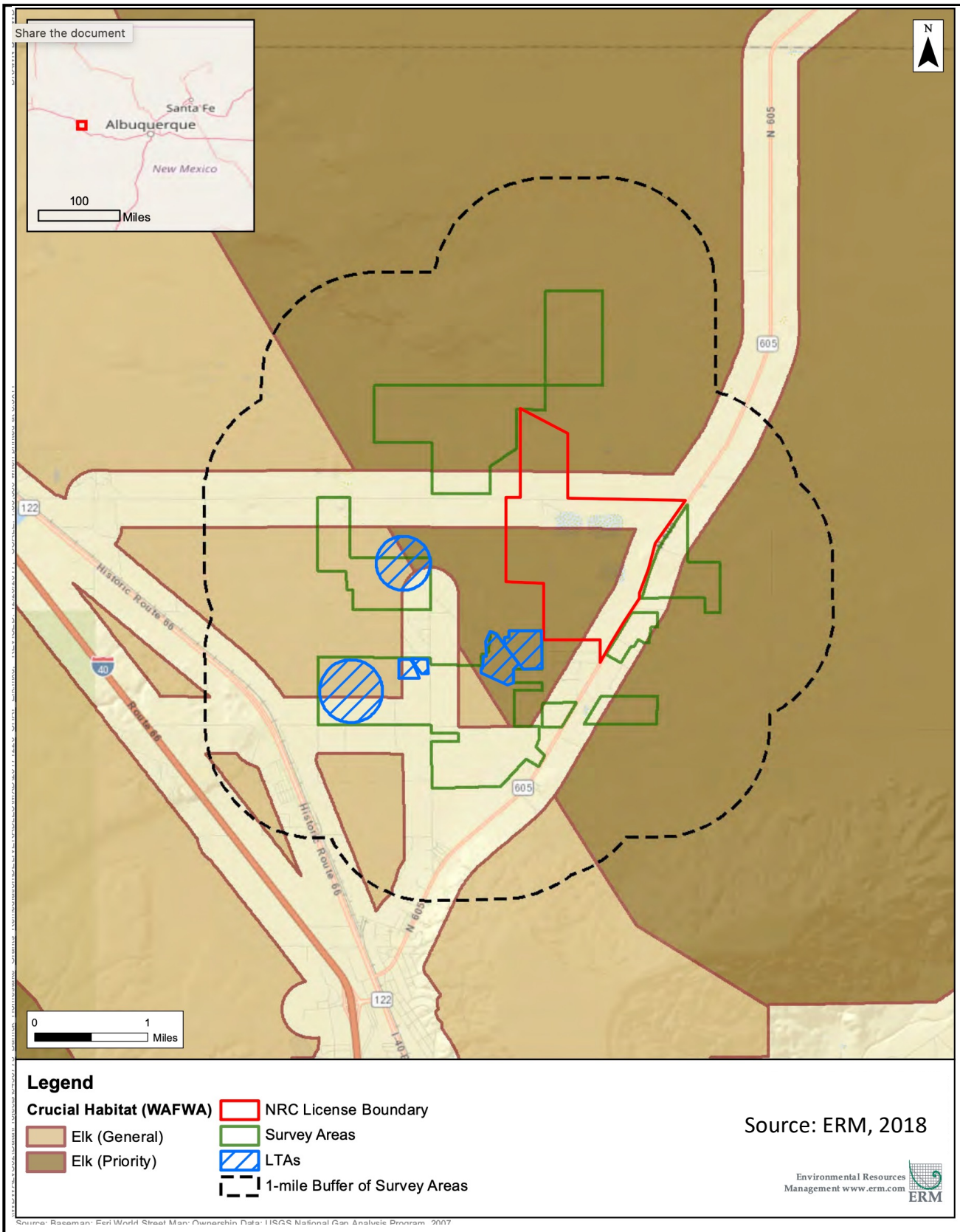

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Figure 3-95
Crucial Elk Habitat

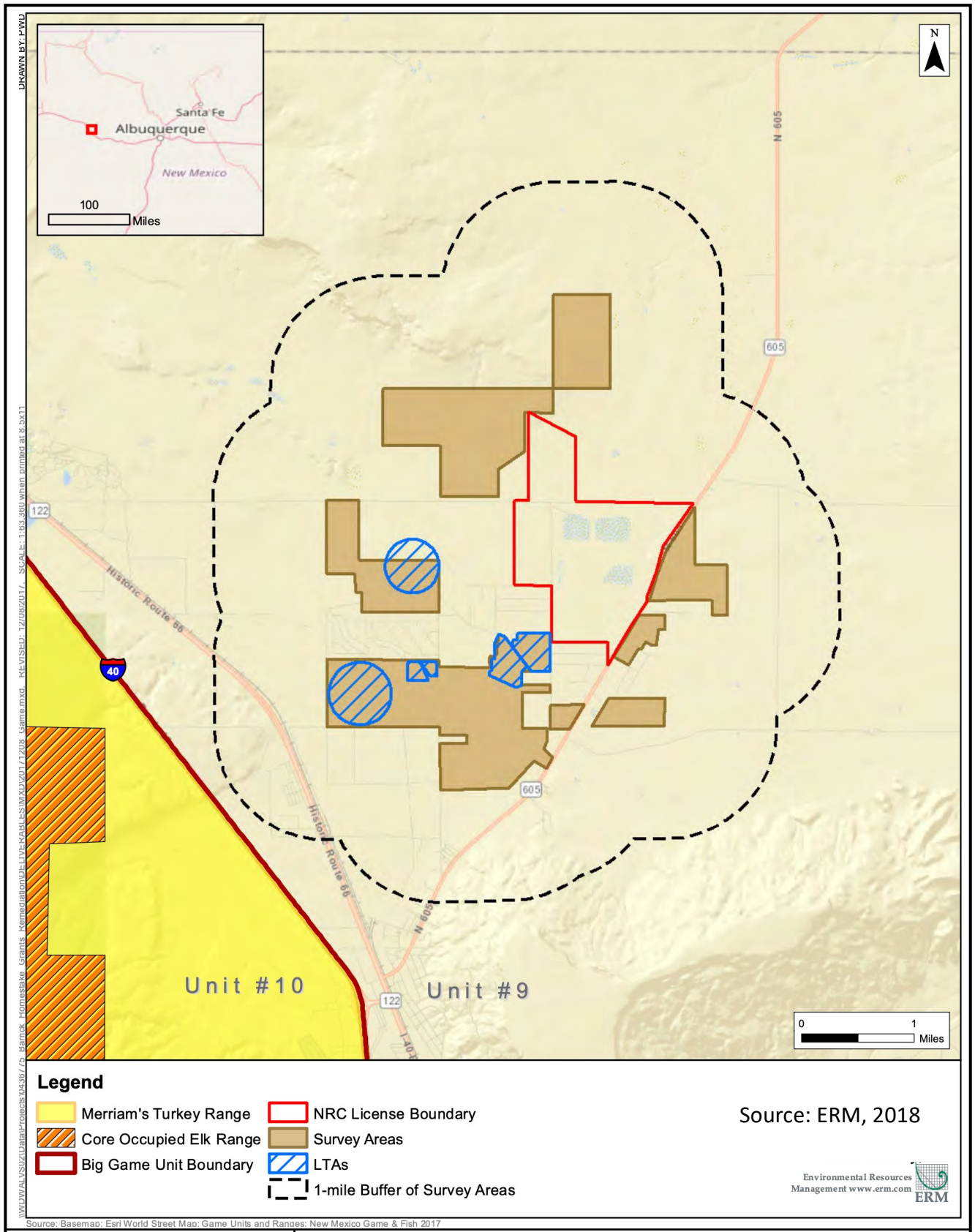

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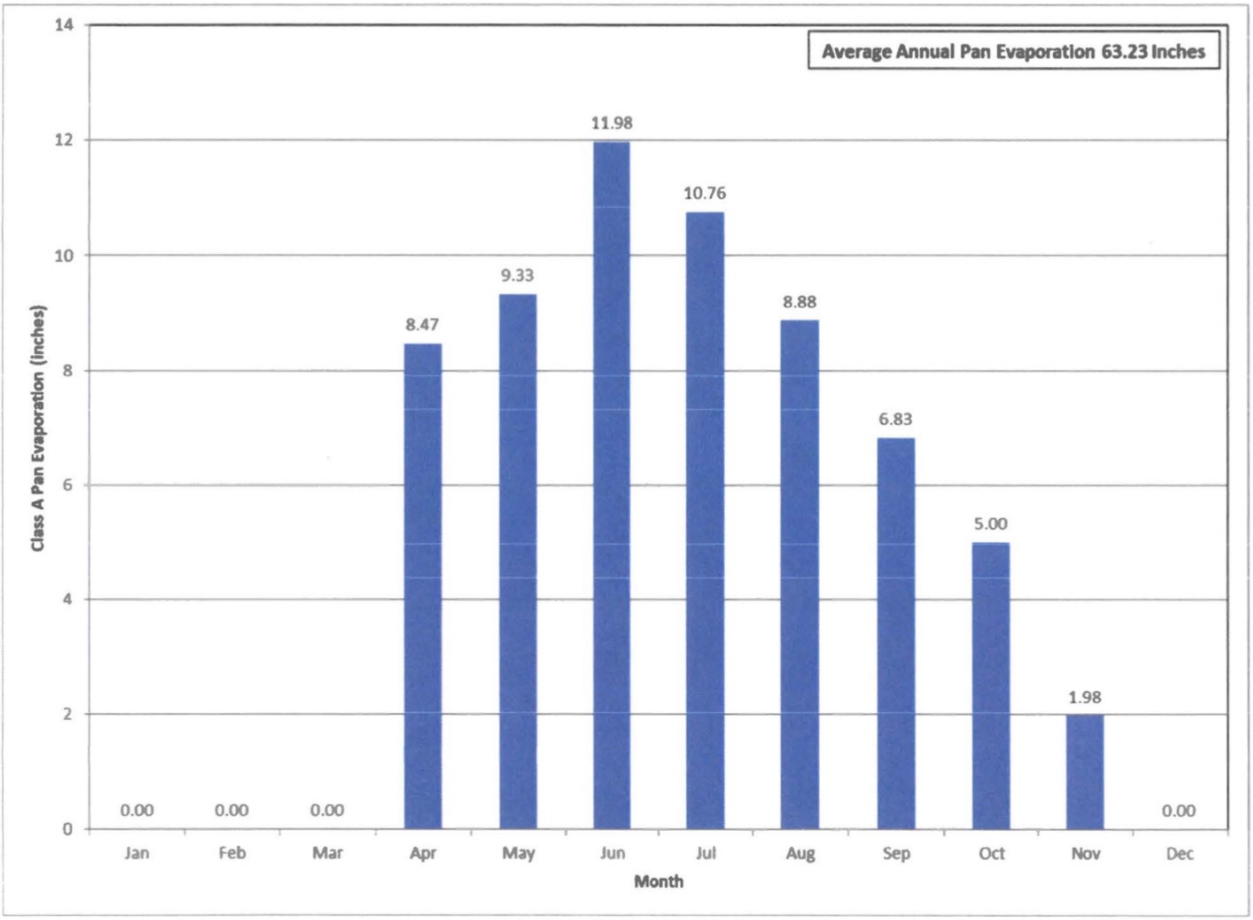
Figure 3-96
Meriam's Turkey Range and Game Units



Source: WRCC, 2019

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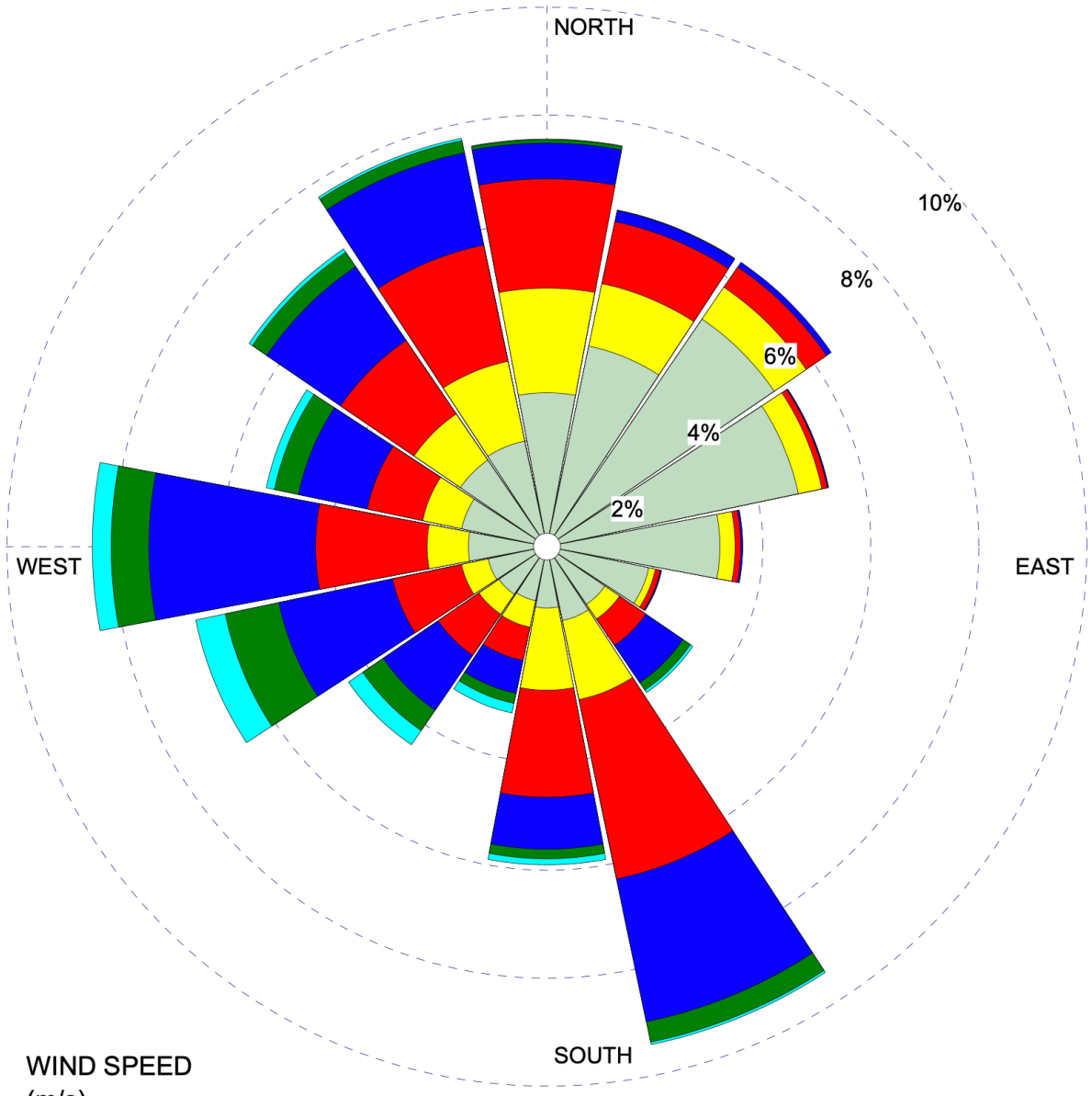
Figure 3-97
Class A Pan Evaporation at Laguna, New Mexico 1914-2005



WIND SPEED
(m/s)

- >= 11.1
- 8.8 - 11.1
- 5.7 - 8.8
- 3.6 - 5.7
- 2.1 - 3.6
- 0.5 - 2.1

Calms: 7.17%

DATA PERIOD:	AVG. WIND SPEED:
Start Date: 1/1/2009 - 06:00 End Date: 12/31/2012 - 17:00	3.51 m/s
CALM WINDS:	TOTAL COUNT:
7.17%	16,796 hrs.

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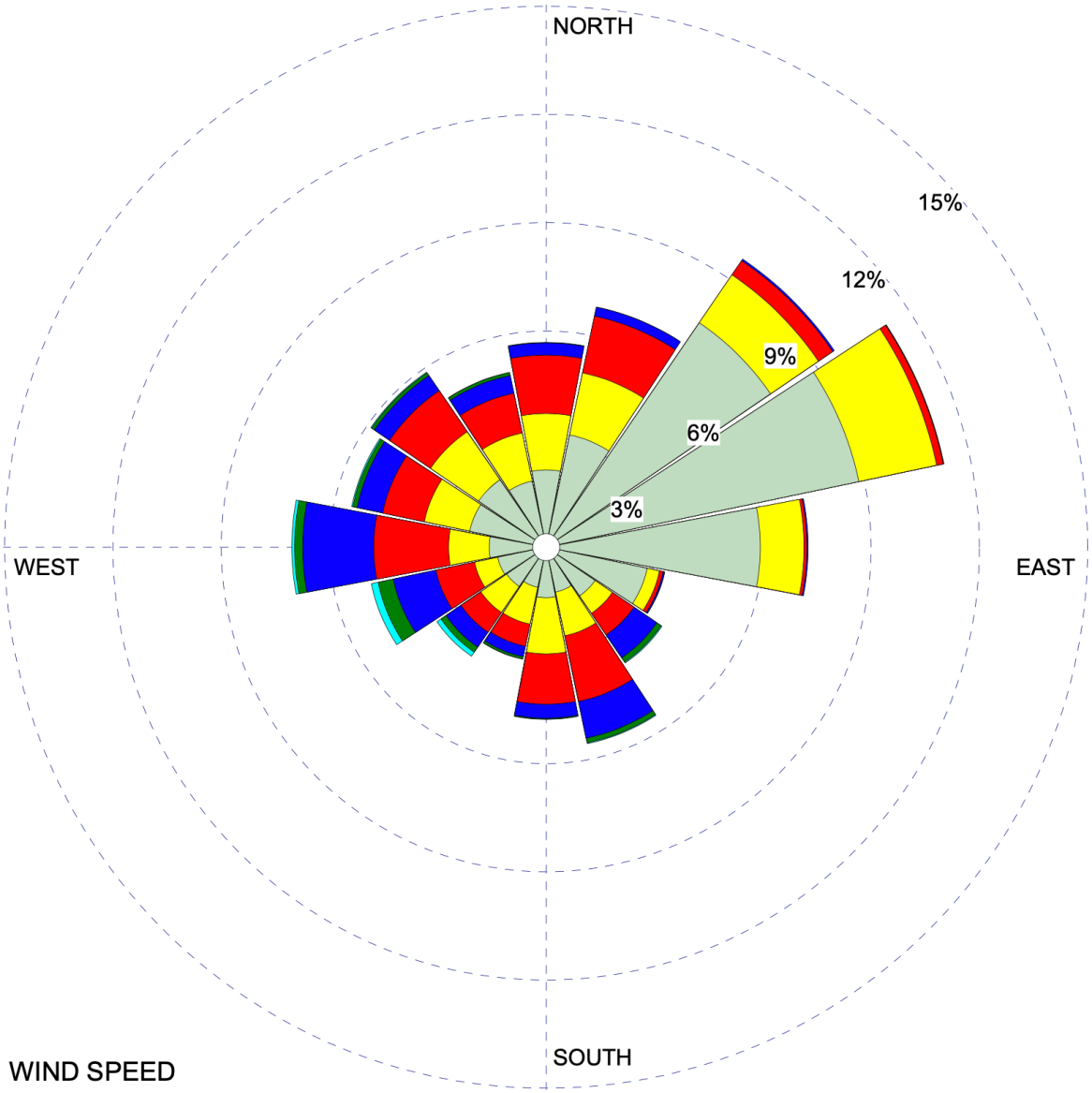
Figure 3-98
Daytime Wind Rose



WIND SPEED
(m/s)

- >= 11.1
- 8.8 - 11.1
- 5.7 - 8.8
- 3.6 - 5.7
- 2.1 - 3.6
- 0.5 - 2.1

Calms: 6.34%

DATA PERIOD: Start Date: 1/1/2009 - 00:00 End Date: 12/31/2012 - 23:00	AVG. WIND SPEED: 2.62 m/s
CALM WINDS: 6.34%	TOTAL COUNT: 19,605 hrs.

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Figure 3-99
Nighttime Wind Rose

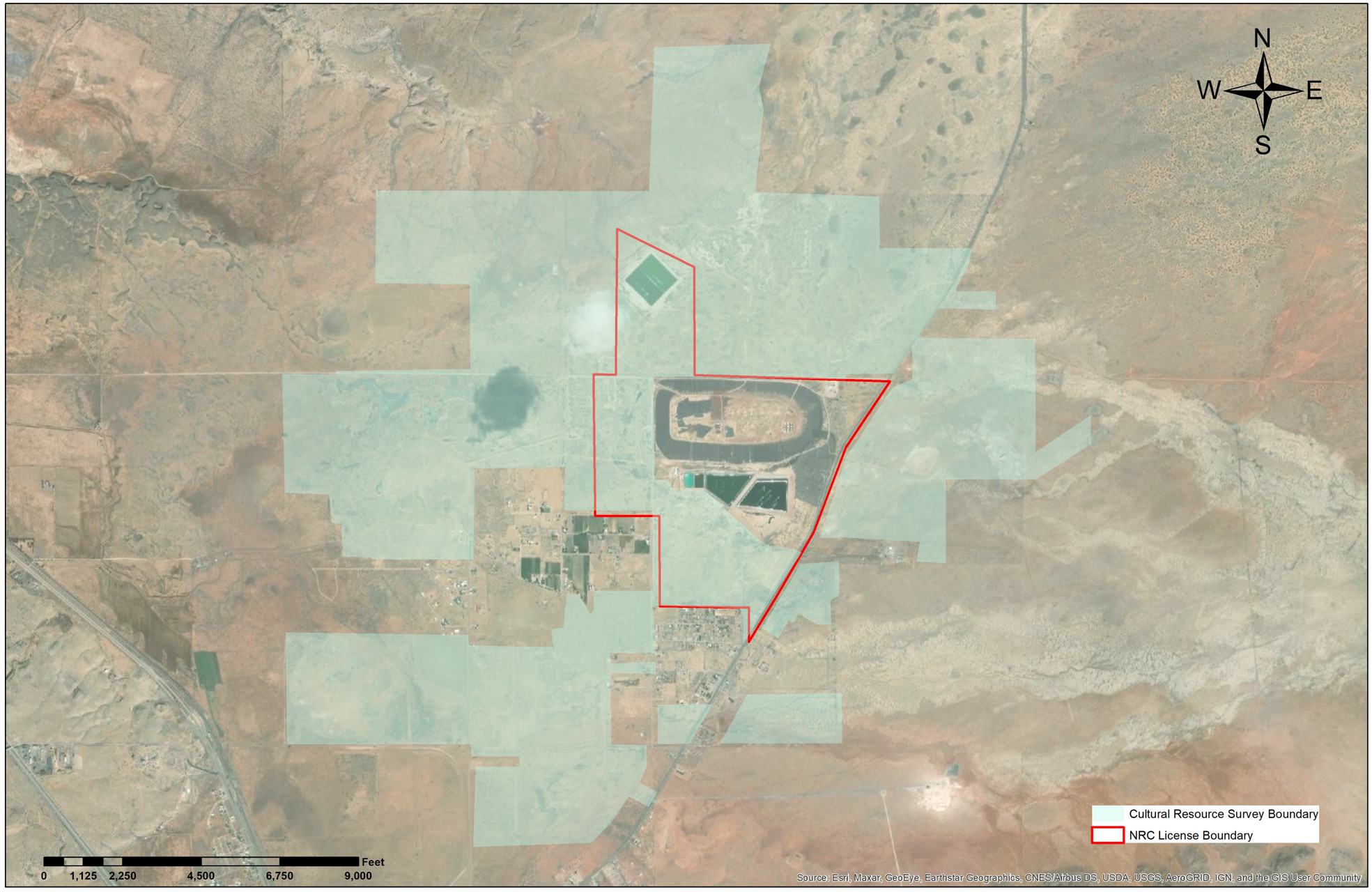

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Figure 3-100
Cultural Survey Areas