

Whole-Landscape Restoration of a Leveled California Vernal Pool Terrain

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Ongoing Vernal Pool Habitat Loss

- Unknown amount of loss from 1700s to 1990s
- Approximately 5% loss from 2005 to 2012 (47,306 acres, Witham 2013)
- Unknown amount of loss since 2012
- No Net Loss Policy: first adopted by G. H. W. Bush, re-iterated under Clinton, G. W. Bush, and Obama
- 1,679 acres of habitat created 2005-2012 (Witham 2013)

 Habitat Extant 2012

 Habitat Lost 2005-2012

Mitigation Strategy 1: Add pools to an existing vernal pool landscape



-  Created Pool
-  Natural Pool

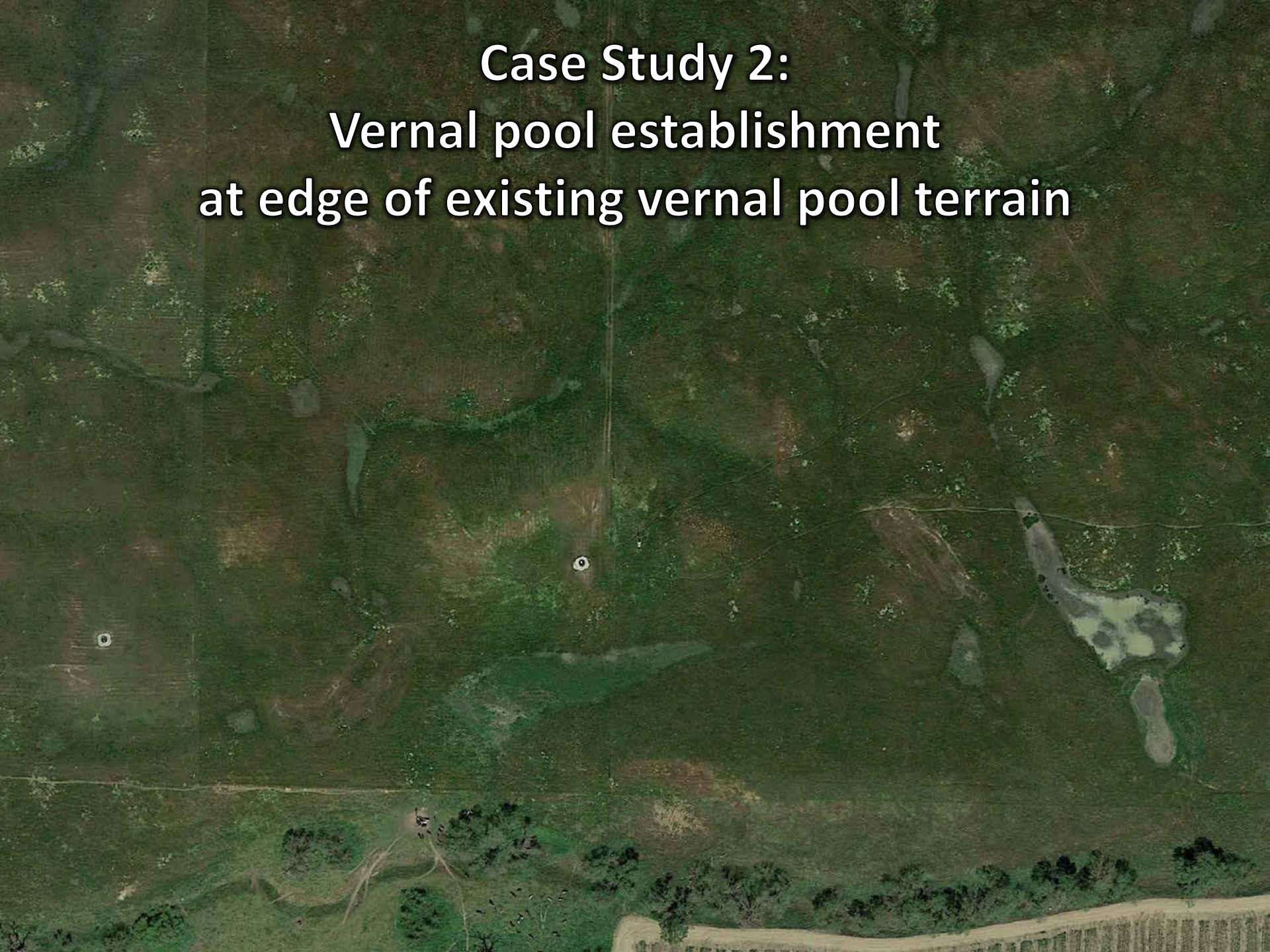
Mitigation Strategy 2: Build pools in a non-vernal pool landscape



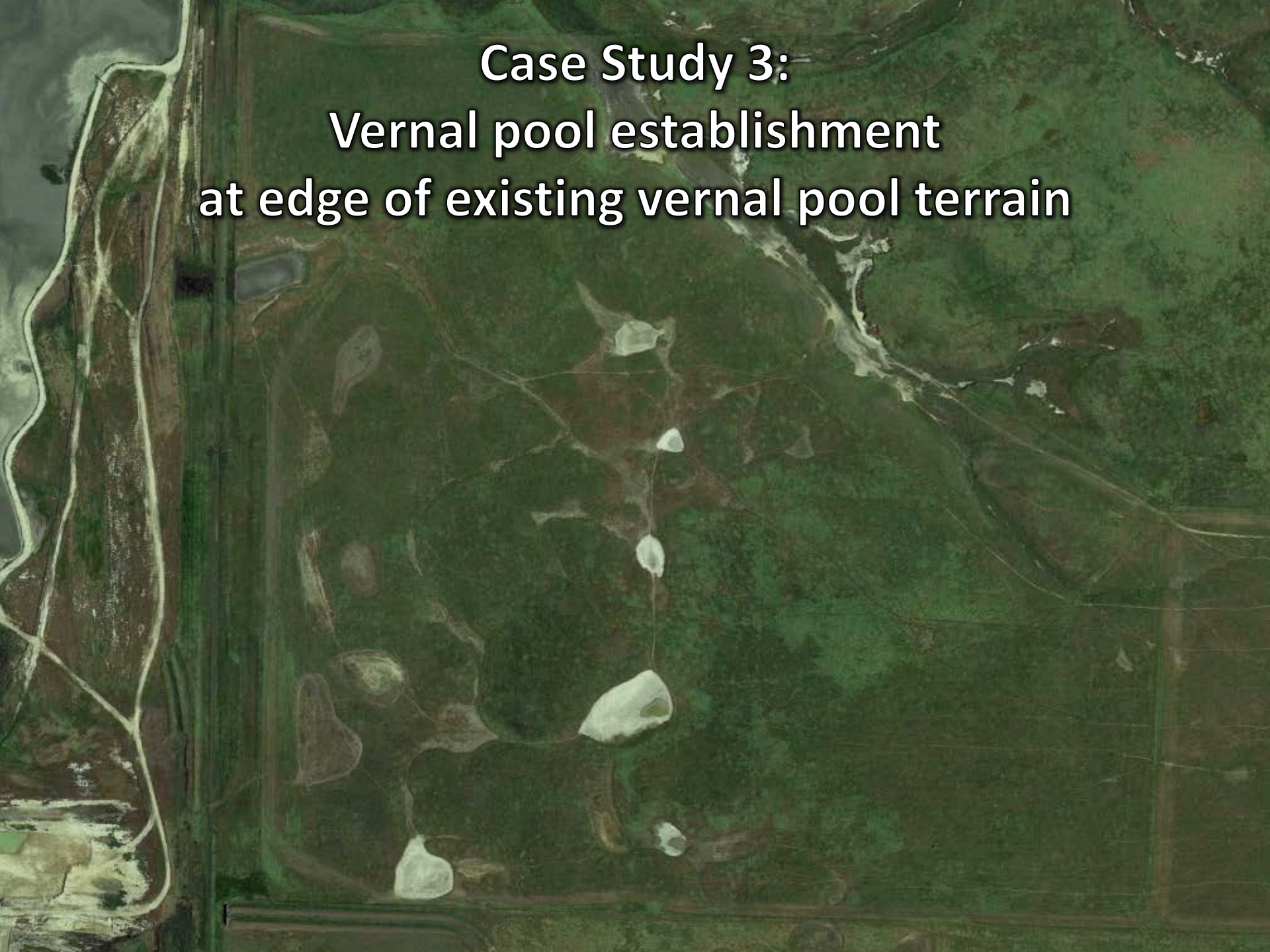
Case Study 1: Vernal pool establishment in a flat landscape



**Case Study 2:
Vernal pool establishment
at edge of existing vernal pool terrain**



**Case Study 3:
Vernal pool establishment
at edge of existing vernal pool terrain**

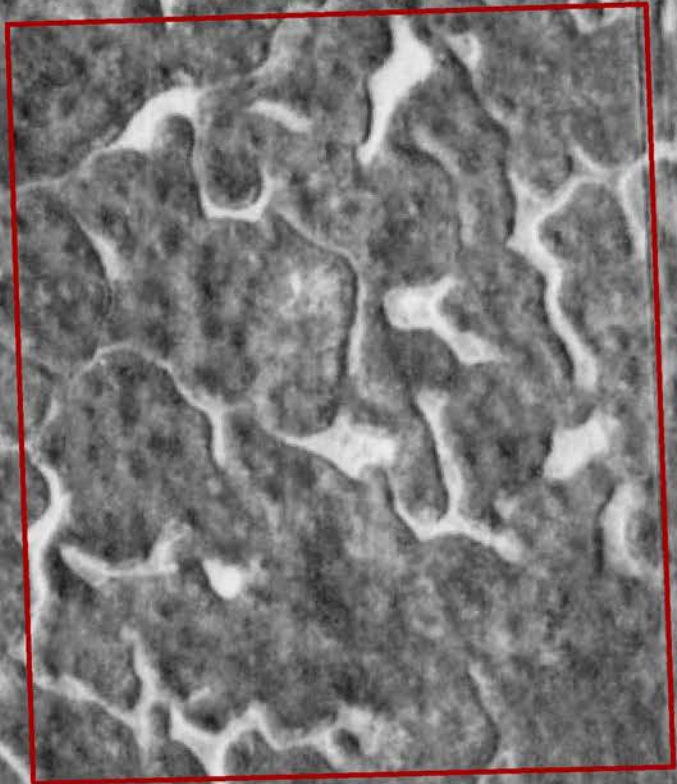


An aerial photograph showing a rural landscape. A road with a median runs diagonally from the top left towards the bottom center. To the left of the road is a residential area with houses and trees. To the right and below the road are large, flat agricultural fields, some of which appear to be degraded or have been altered. The text is overlaid on the top portion of the image.

**Mitigation Strategy 3:
Restore/Re-establish degraded vernal
pool habitat**

Case Study 4: Leveled landscape re-establishment

1946



2018



Case Study 5: Partially leveled landscape restoration

1950



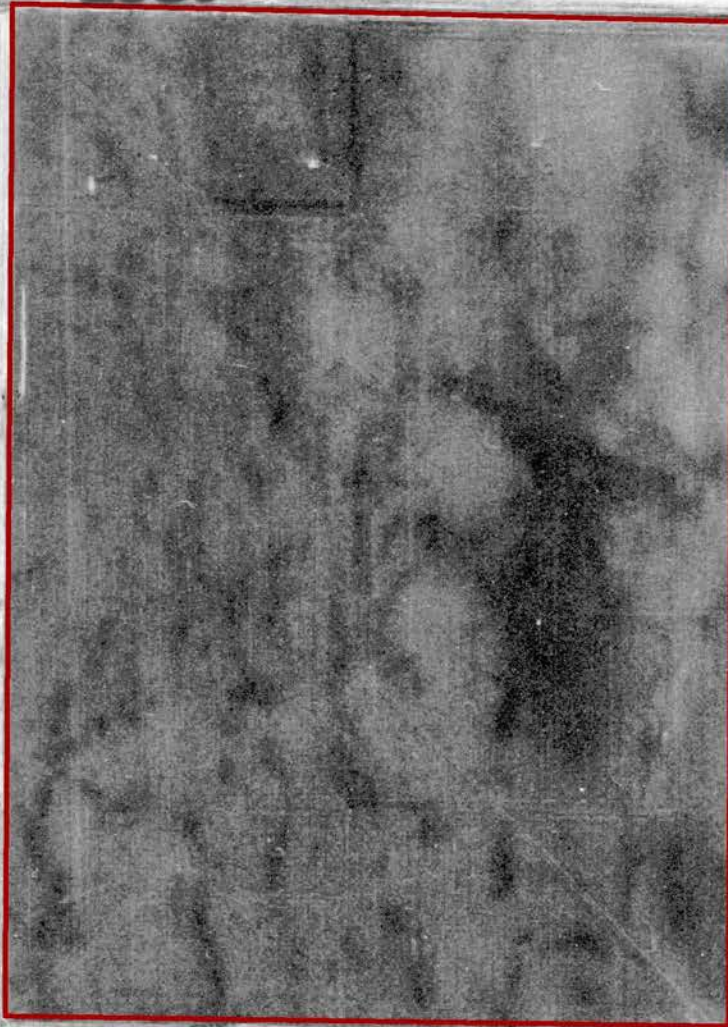
2012



Case Study 6:

Leveled landscape re-establishment

- 1937



- 2016

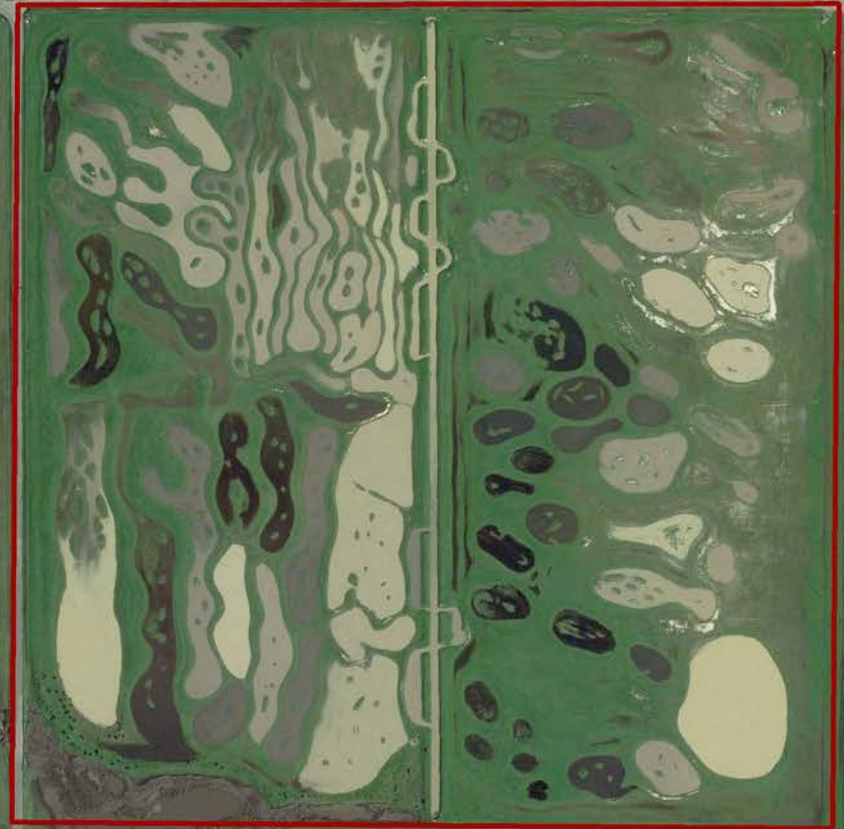
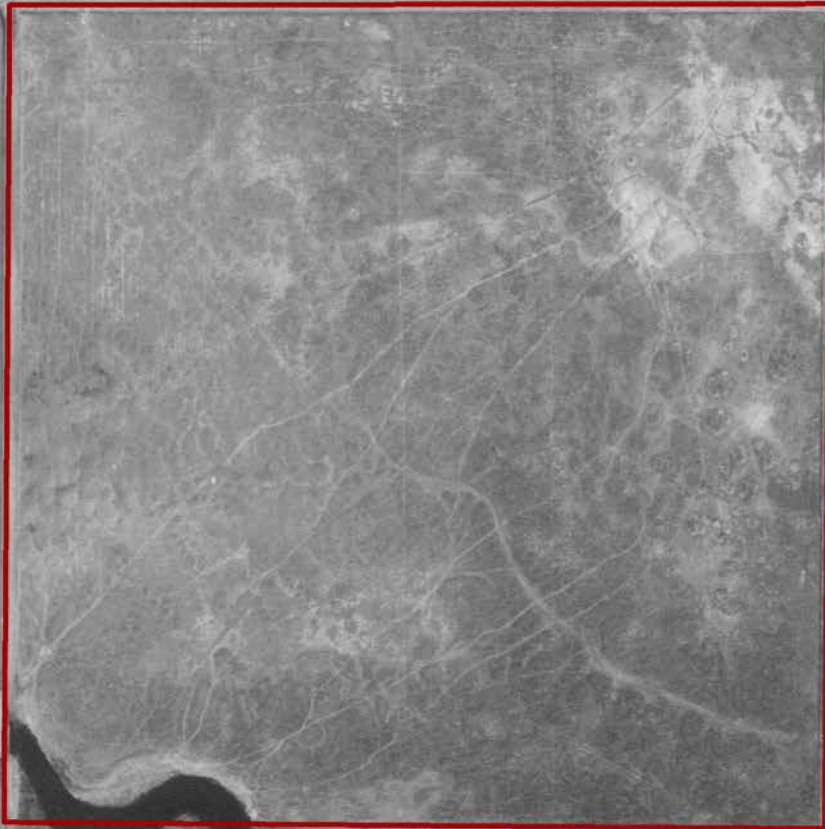


Case Study 7:

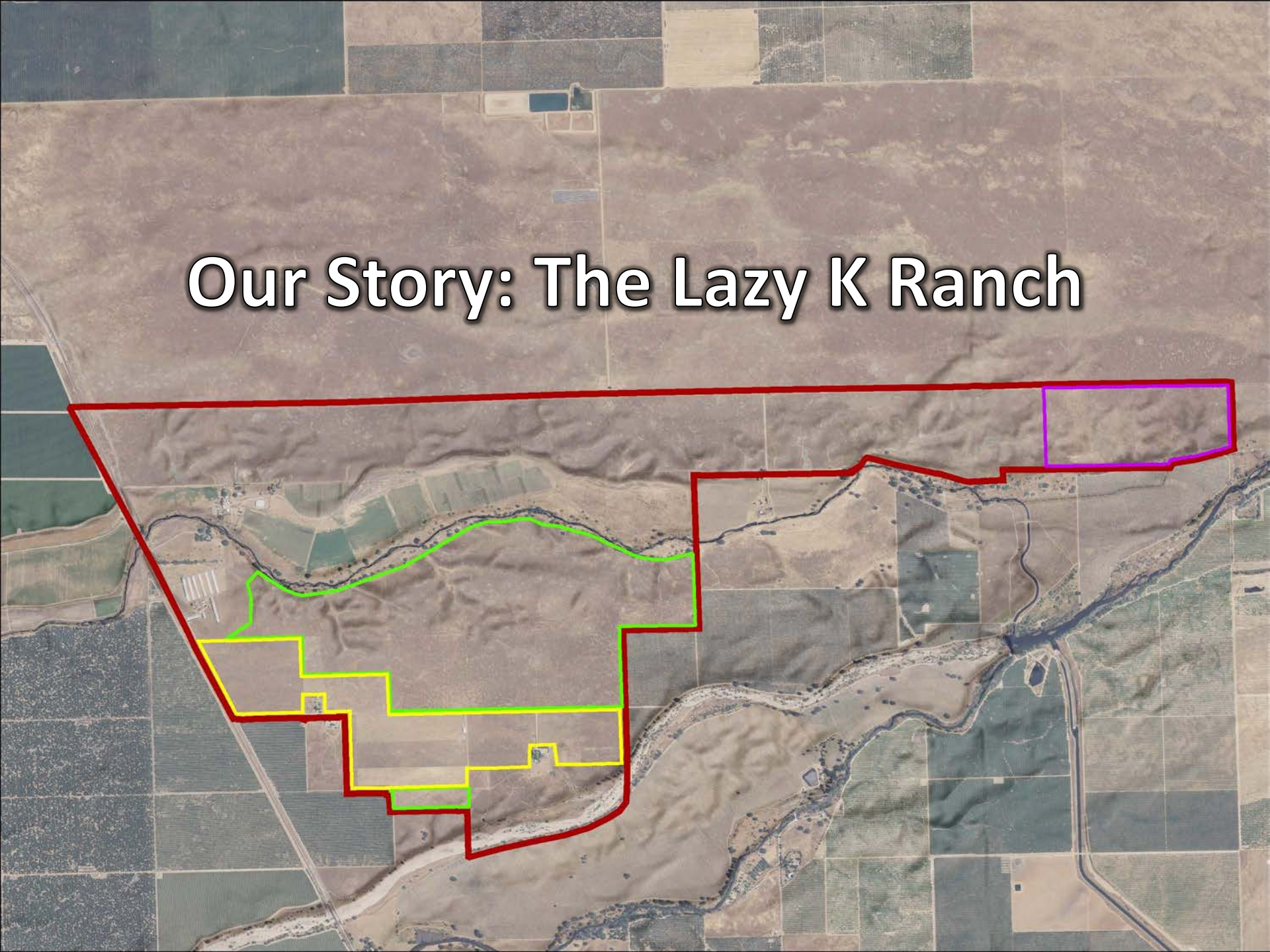
Leveled landscape re-establishment

1937

2016




Our Story: The Lazy K Ranch



A Unique Opportunity

- Big potential to live up to


 Succulent Owl's-Clover

 Vernal Pool Fairy Shrimp

 Midvalley Fairy Shrimp

 Vernal Pool Tadpole Shrimp

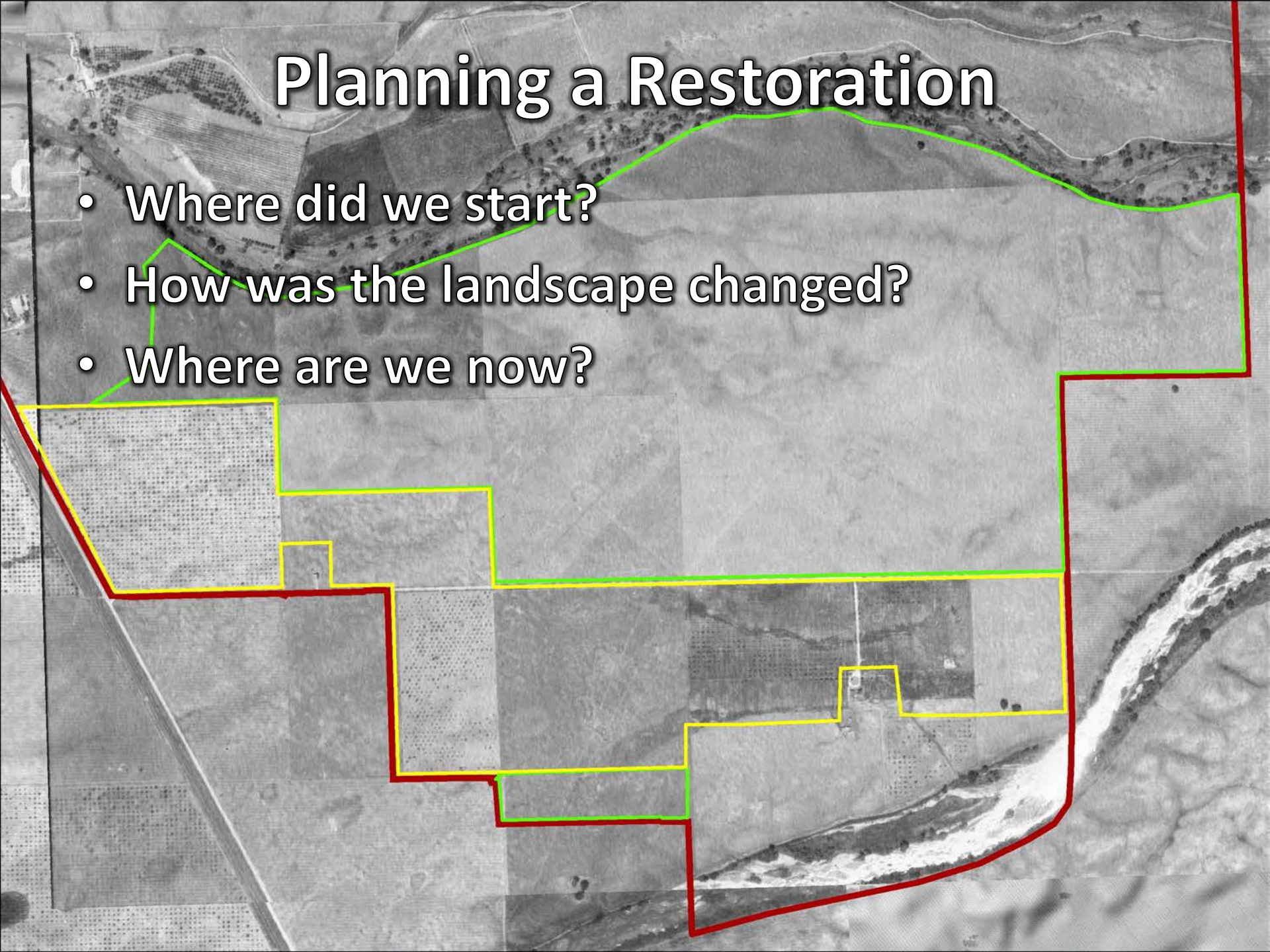
 Western Spadefoot

 California Tiger Salamander



Planning a Restoration

- Where did we start?
- How was the landscape changed?
- Where are we now?



Where did we start?

Elevation in Feet

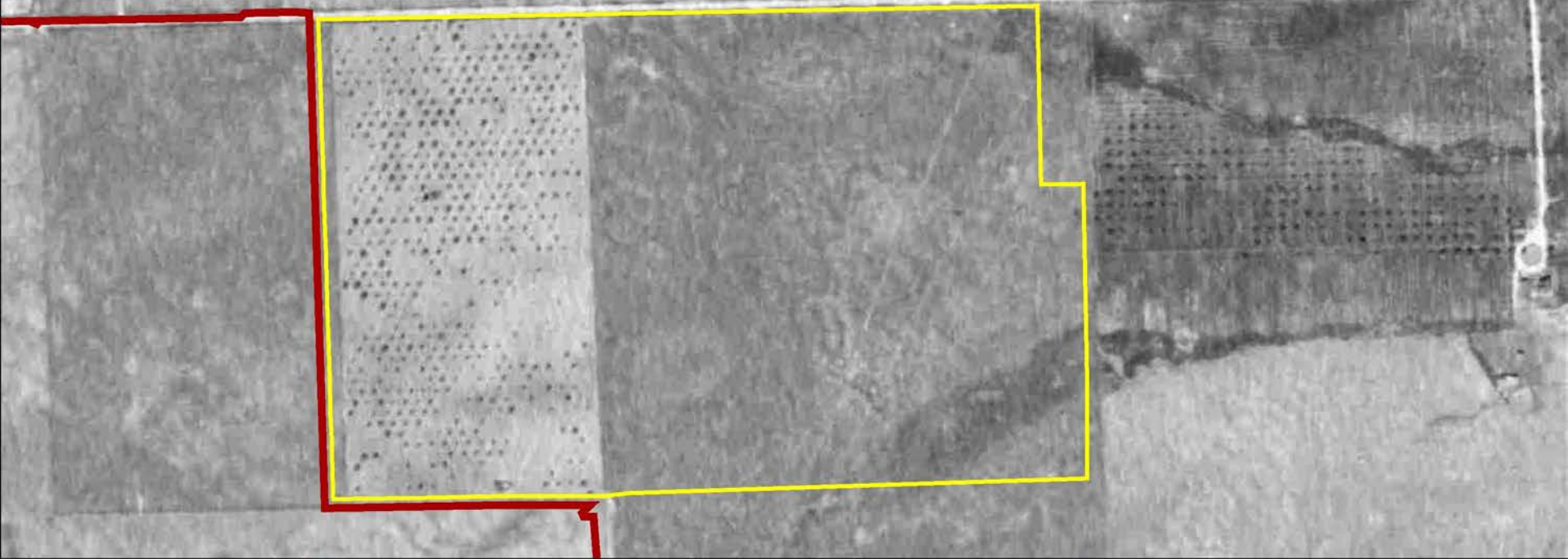


Where did we start?



History of Change

- Landowner interviews
- Historical aerial imagery

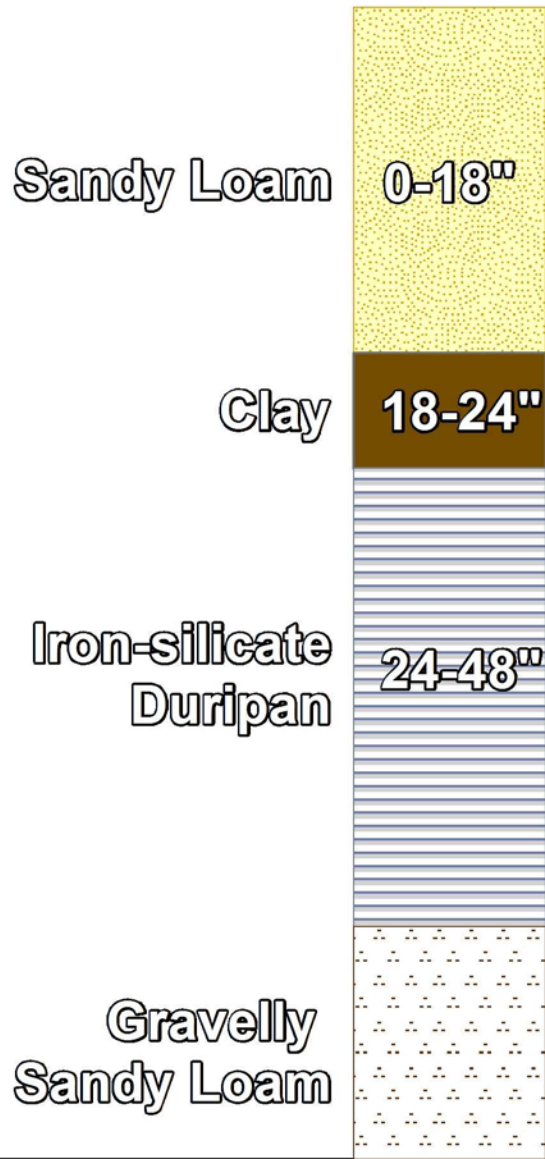


The terrain before restoration

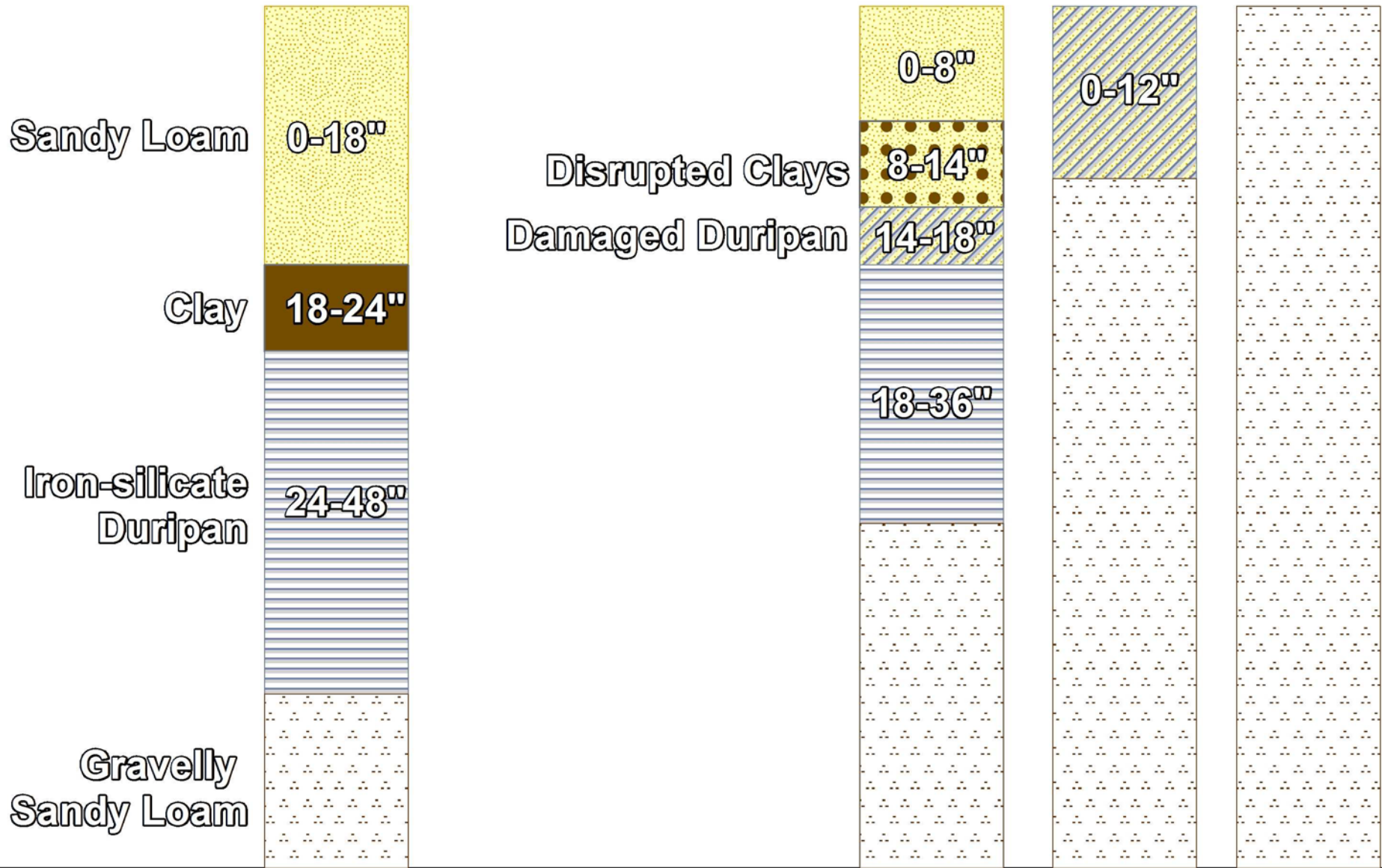
- Over 400 soil pits



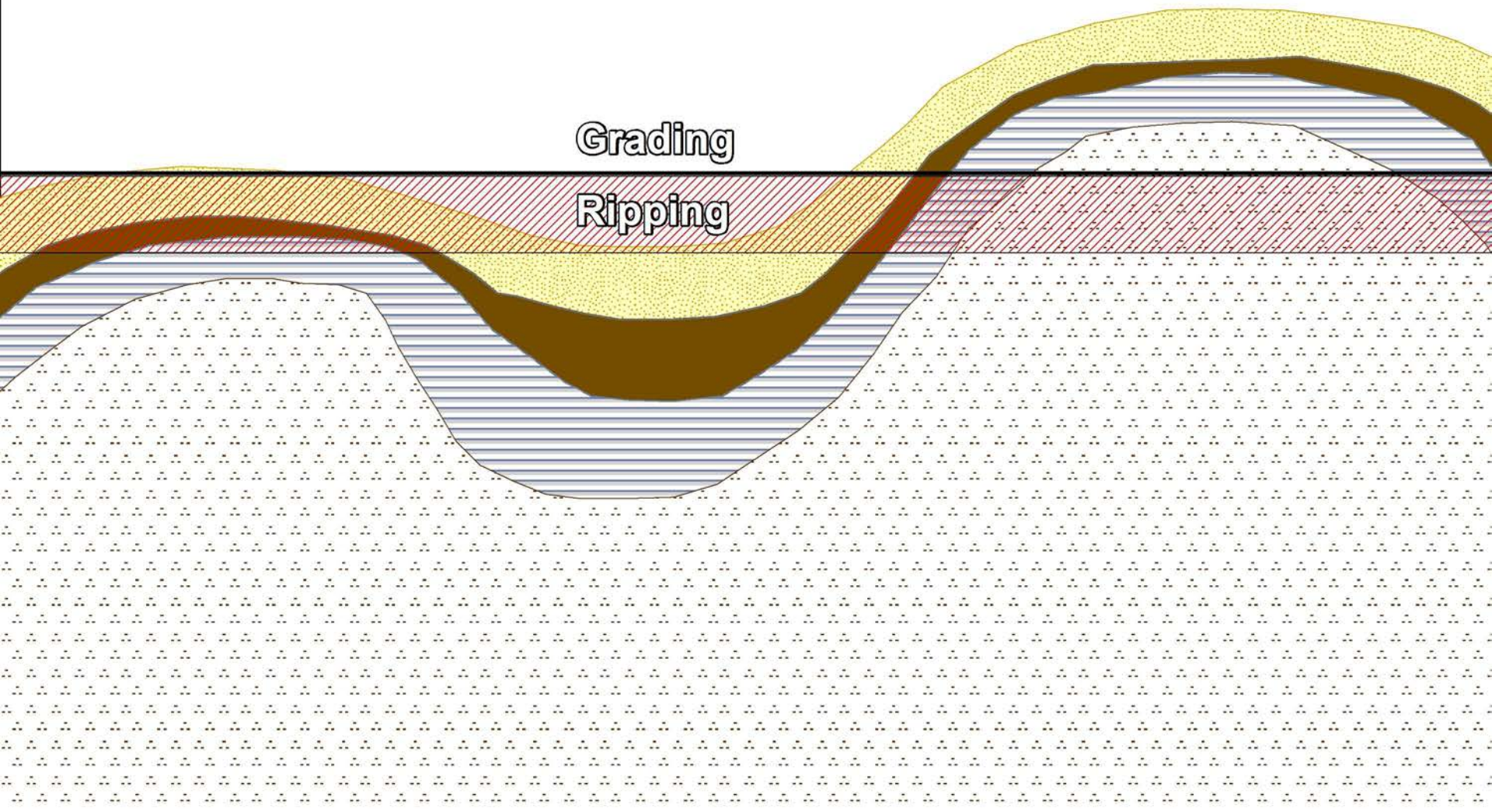
The terrain before restoration



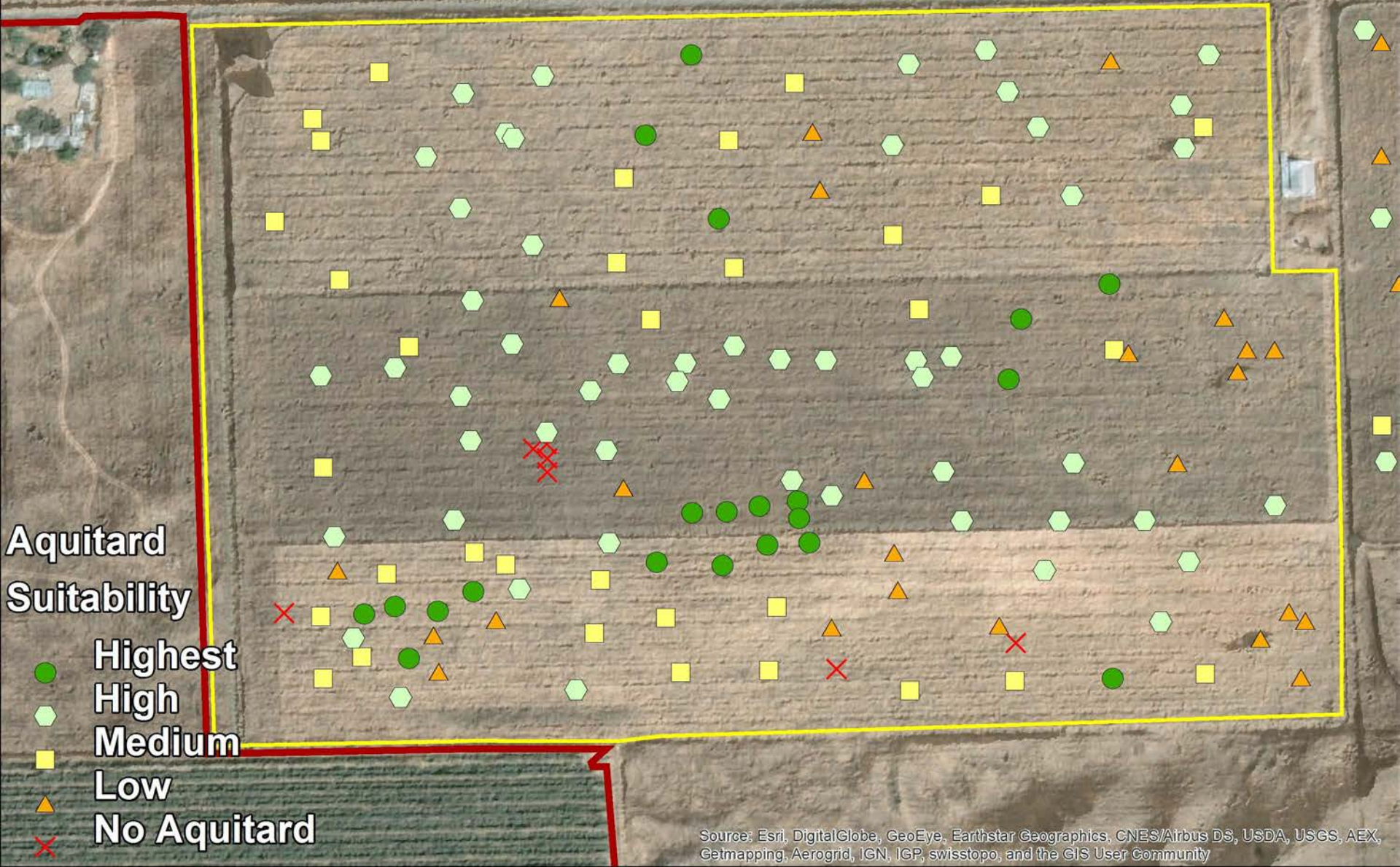
The terrain before restoration



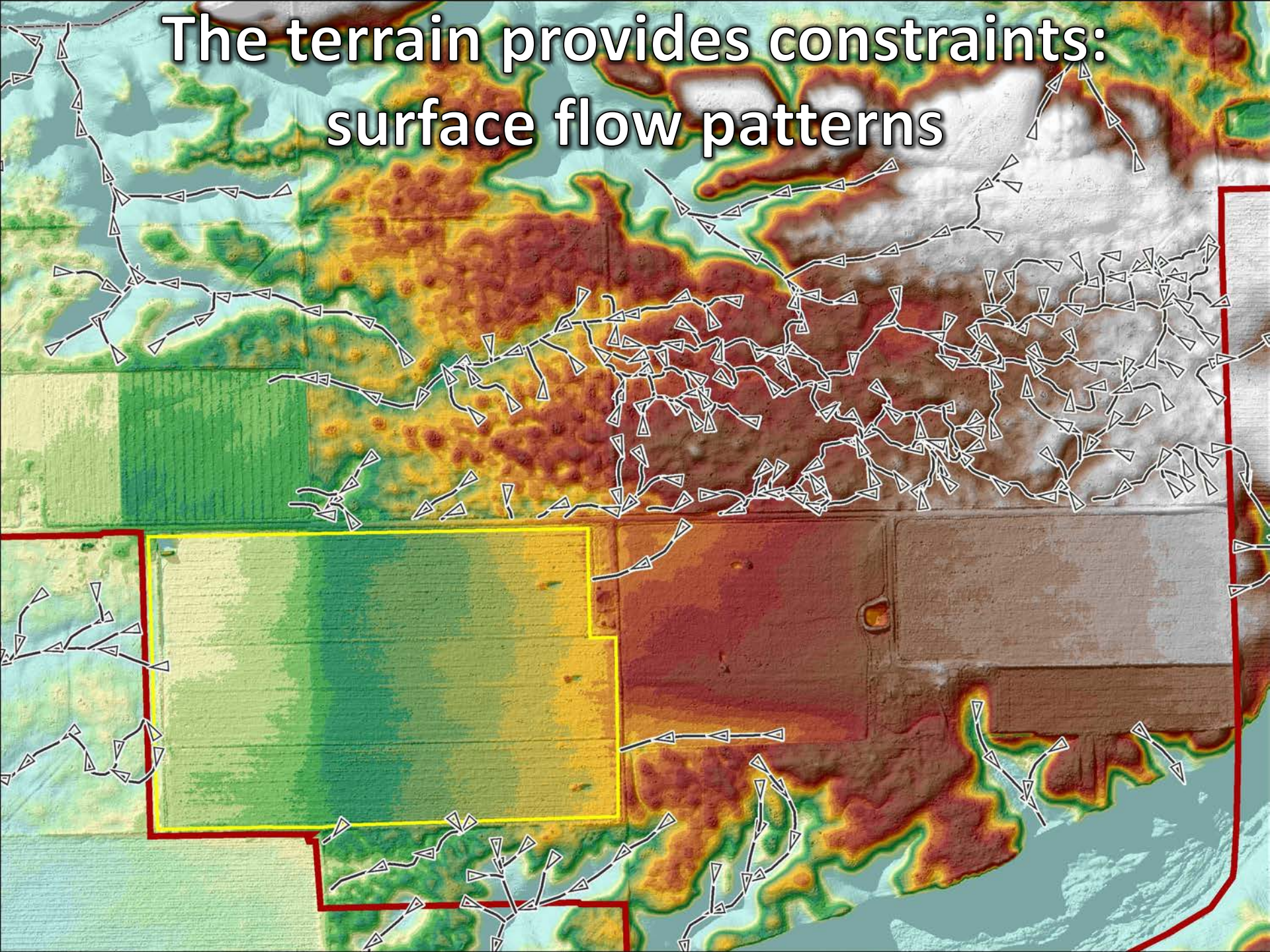
The terrain before restoration



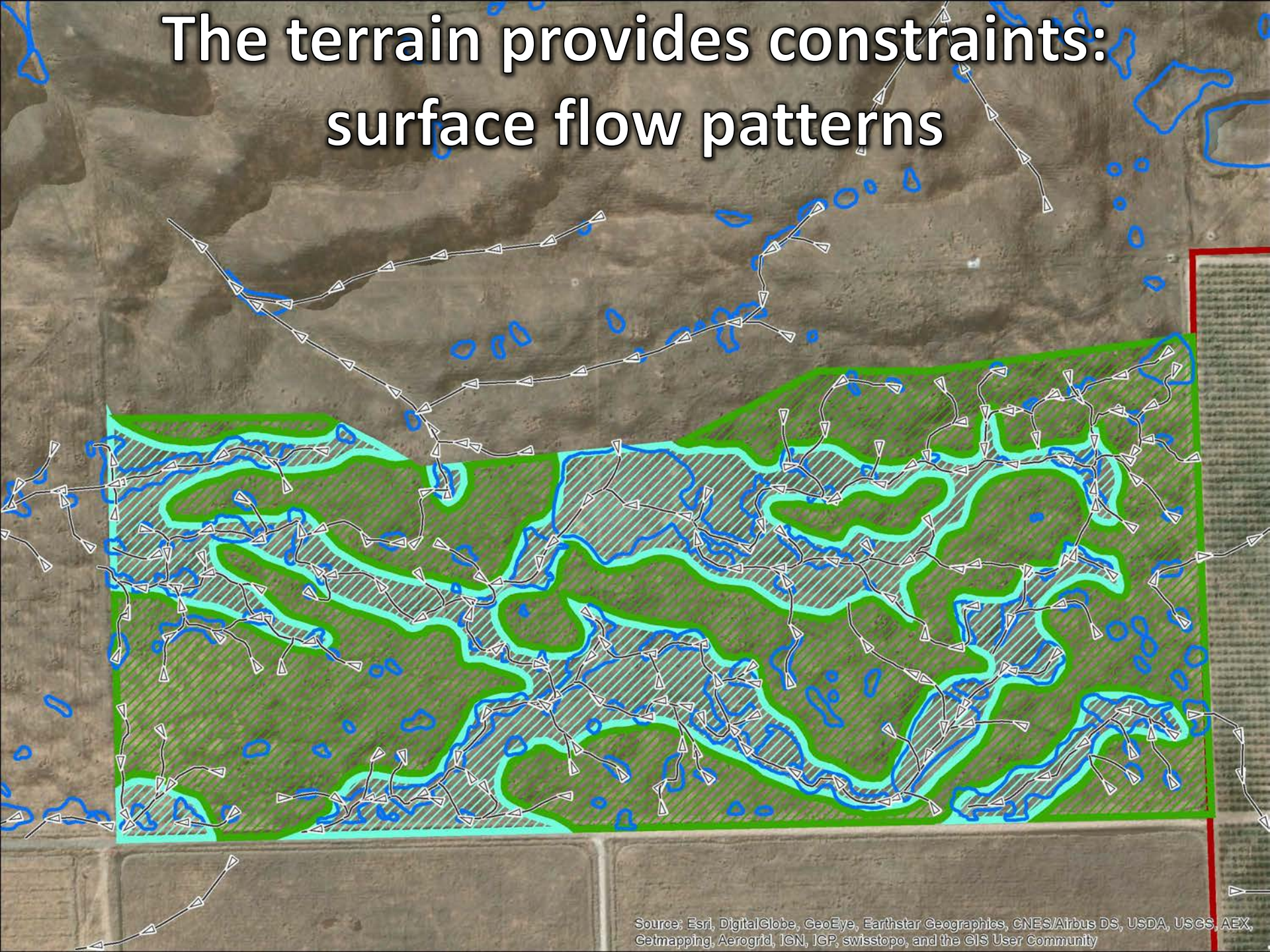
The terrain before restoration



The terrain provides constraints:
surface flow patterns



The terrain provides constraints: surface flow patterns



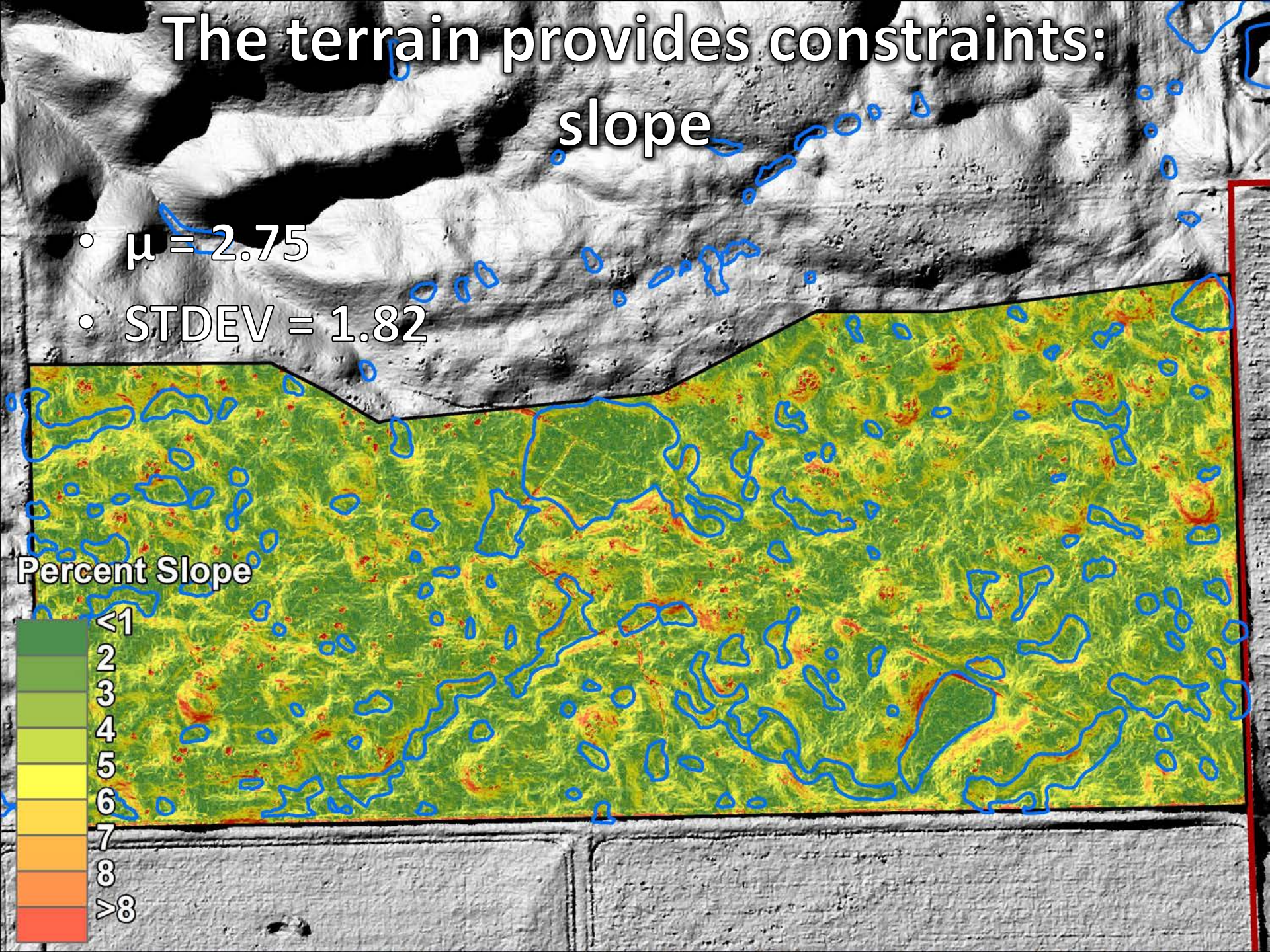
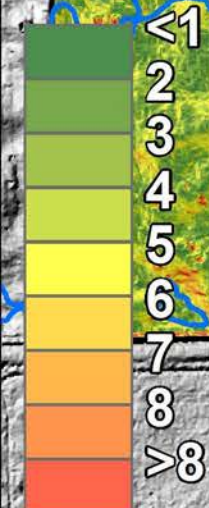
The terrain provides constraints: elevation of aquitard



The terrain provides constraints: slope

- $\mu = 2.75$
- STDEV = 1.82

Percent Slope



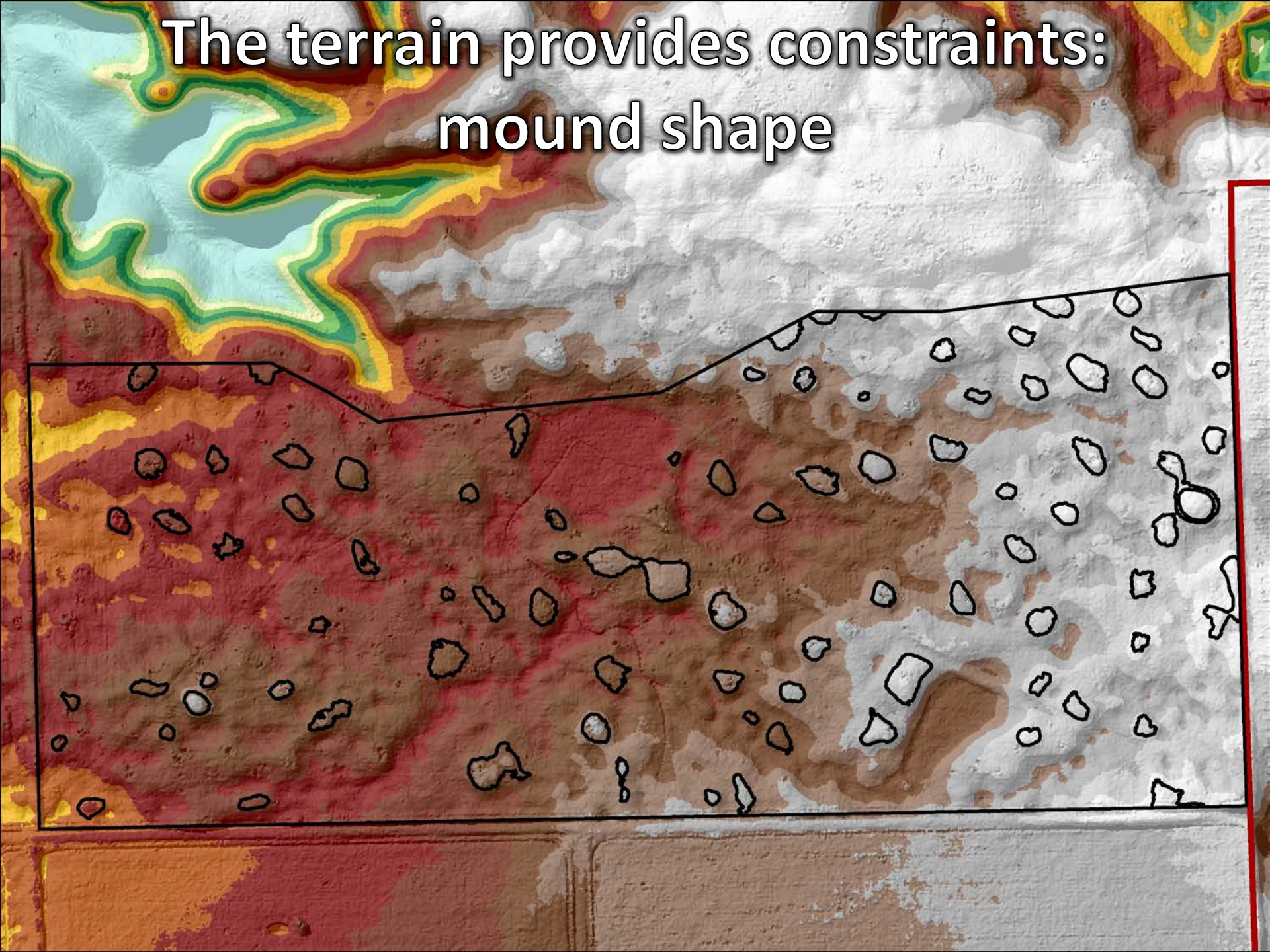
The terrain provides constraints:

slope

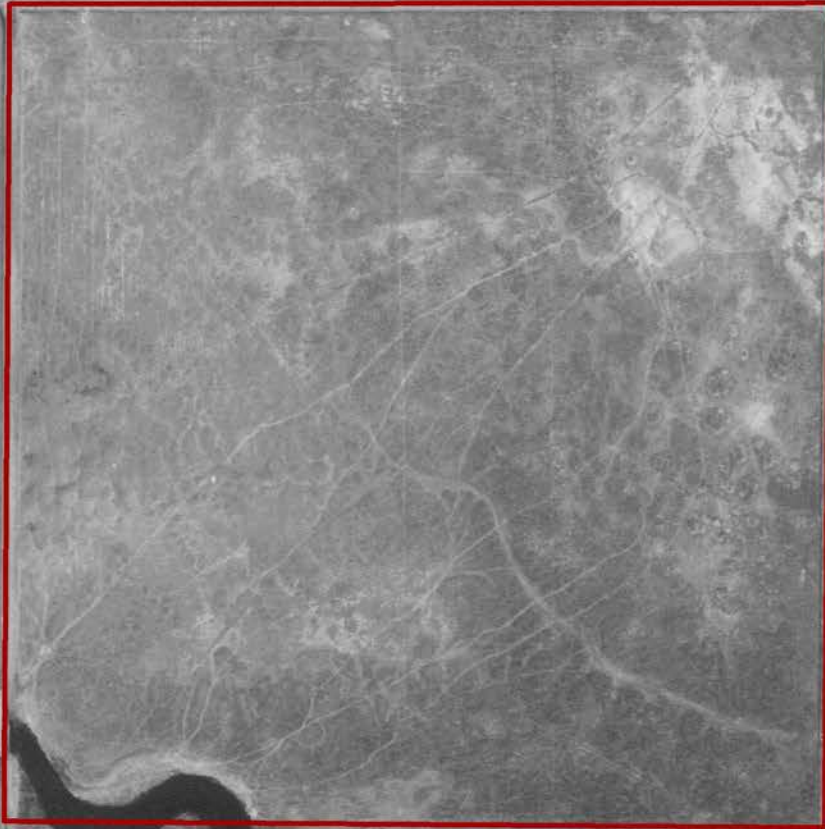


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

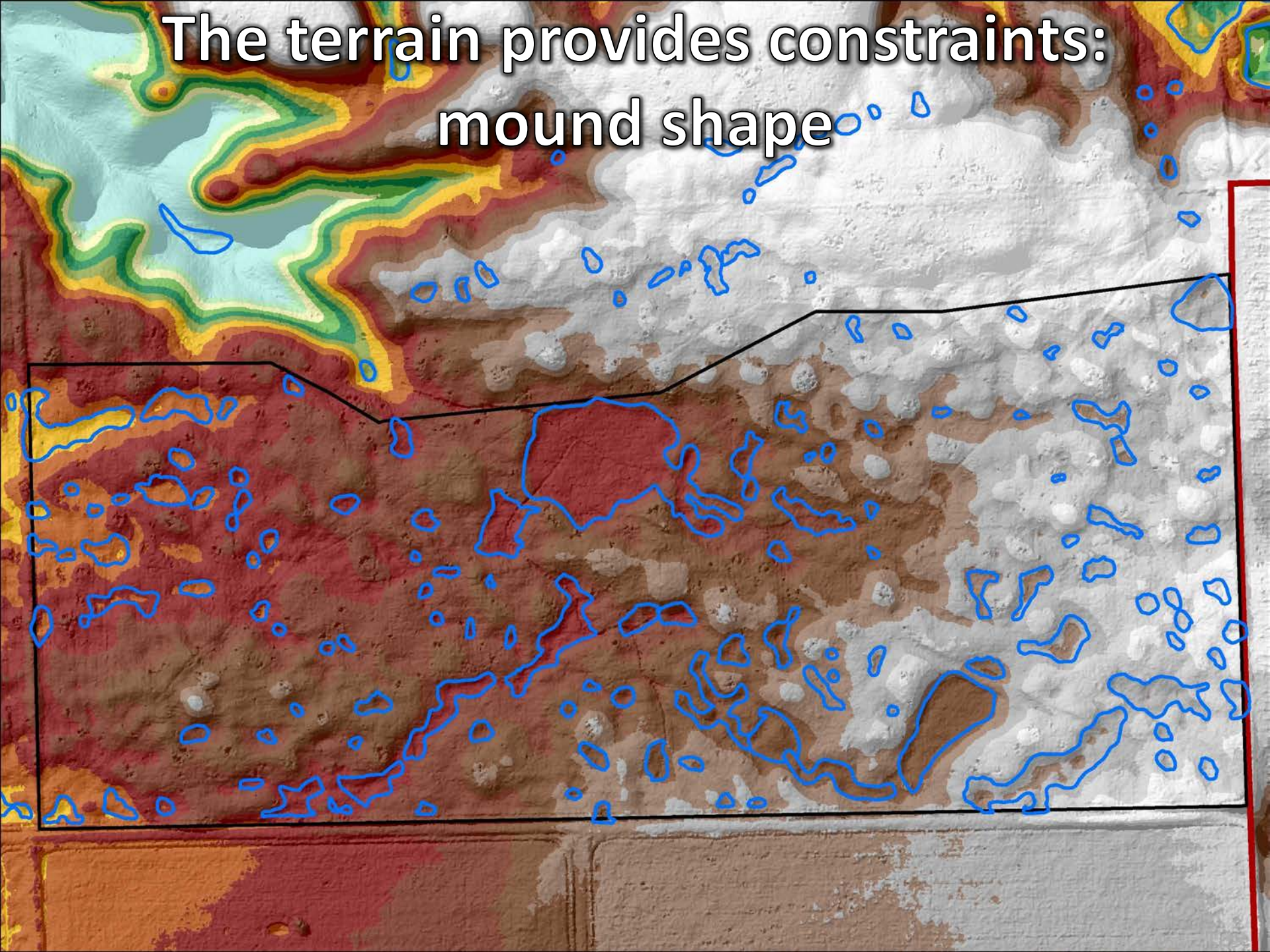
The terrain provides constraints:
mound shape



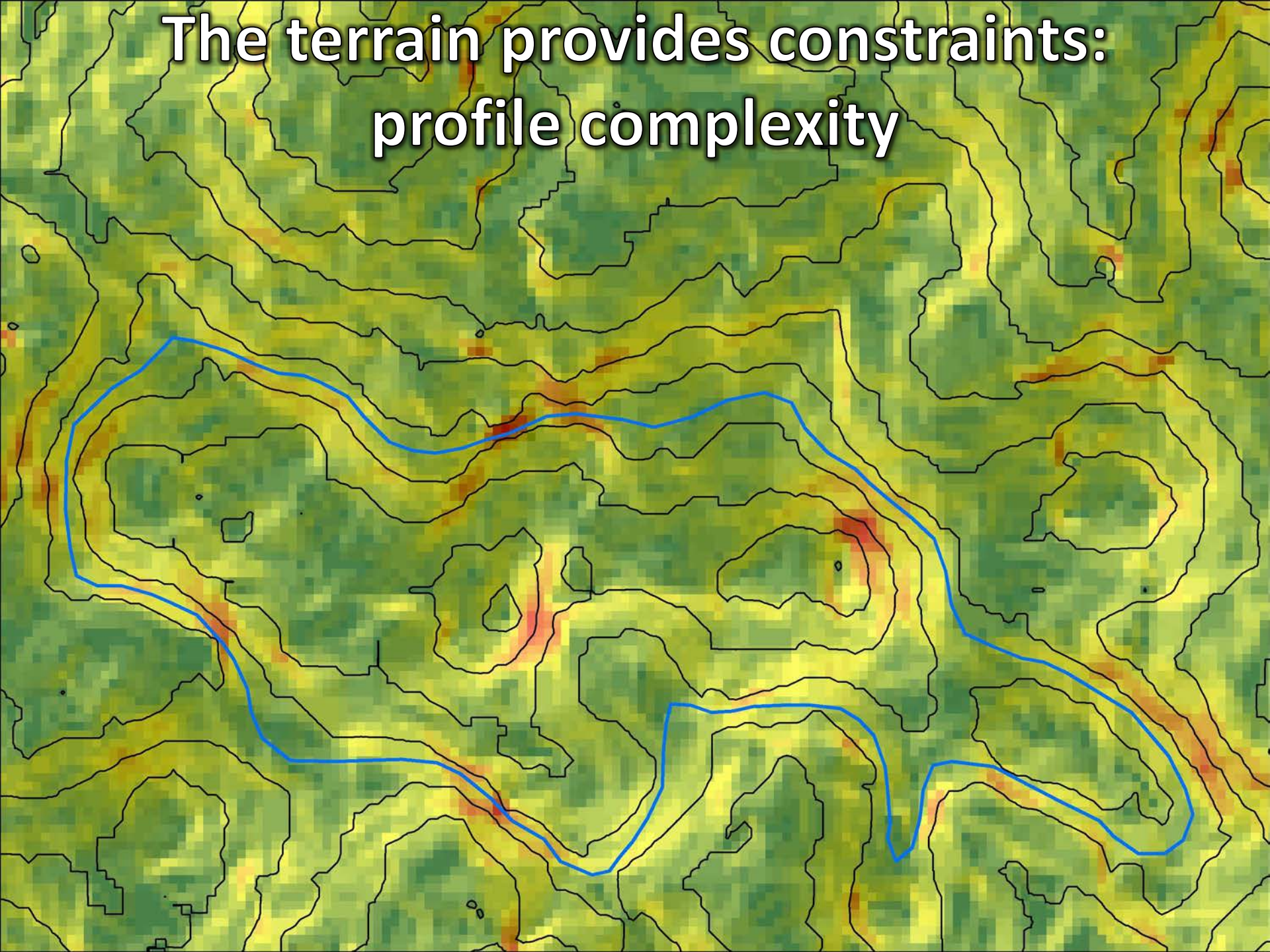
The terrain provides constraints:
mound shape



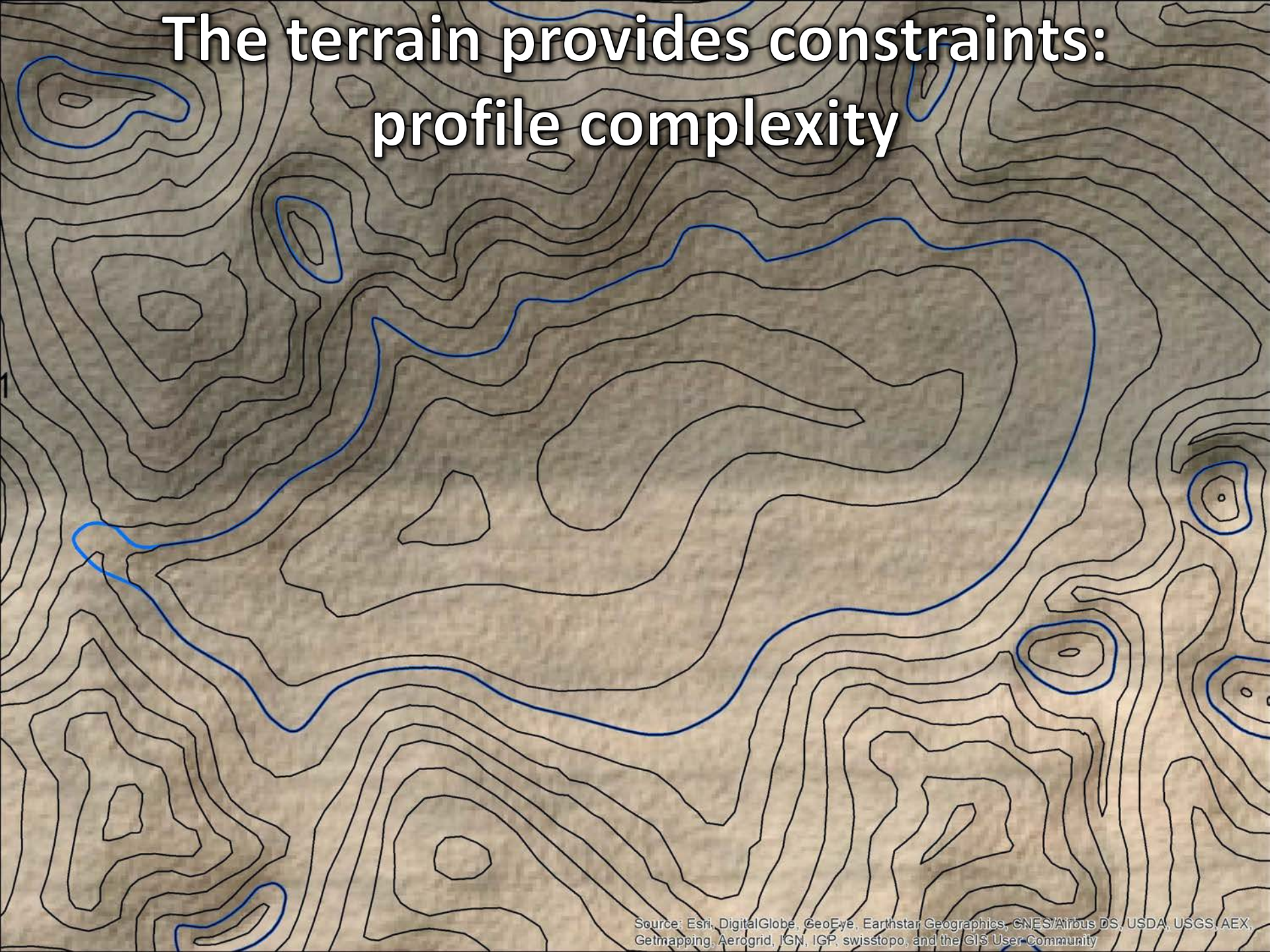
The terrain provides constraints:
mound shape



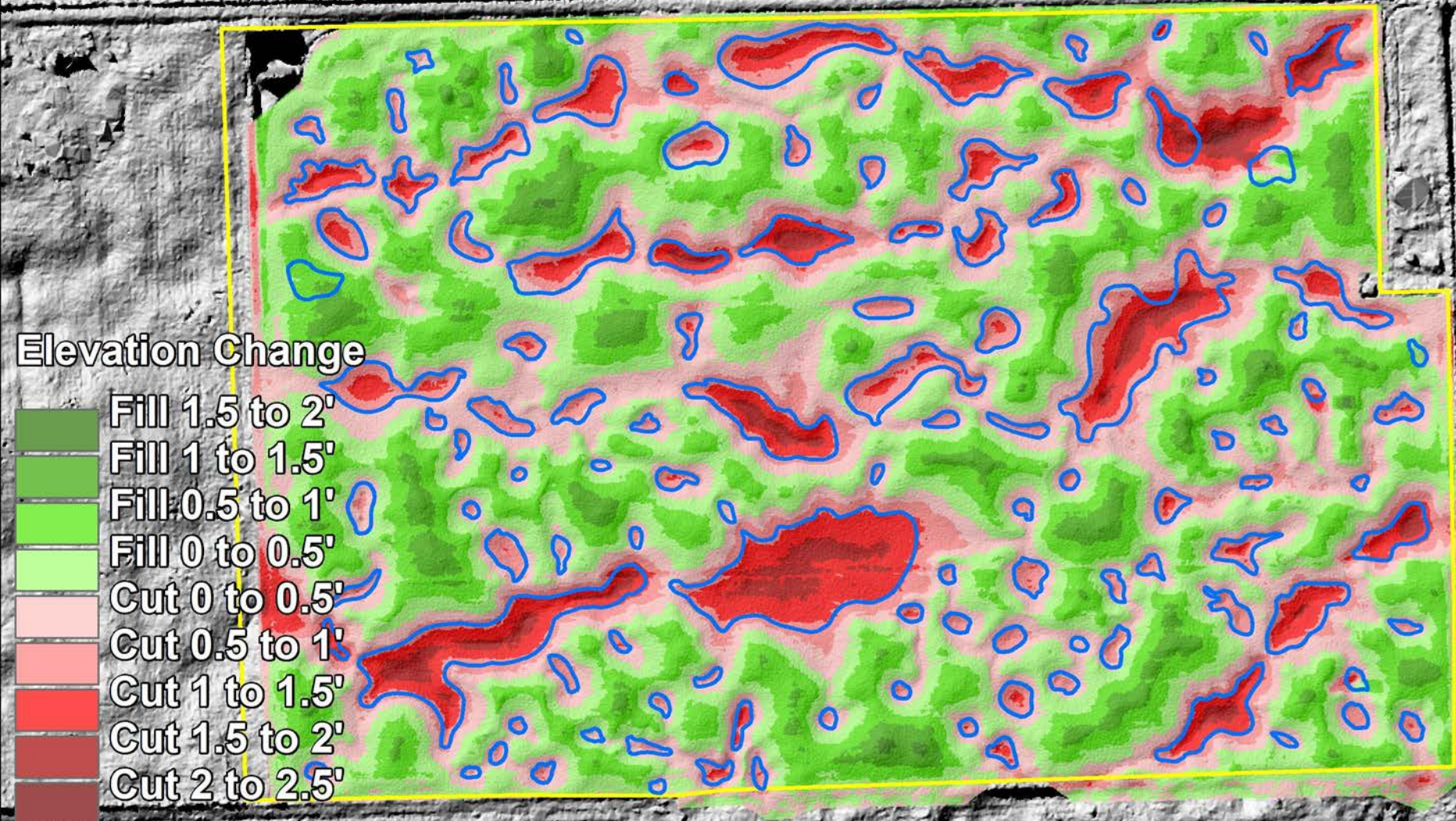
The terrain provides constraints:
profile complexity



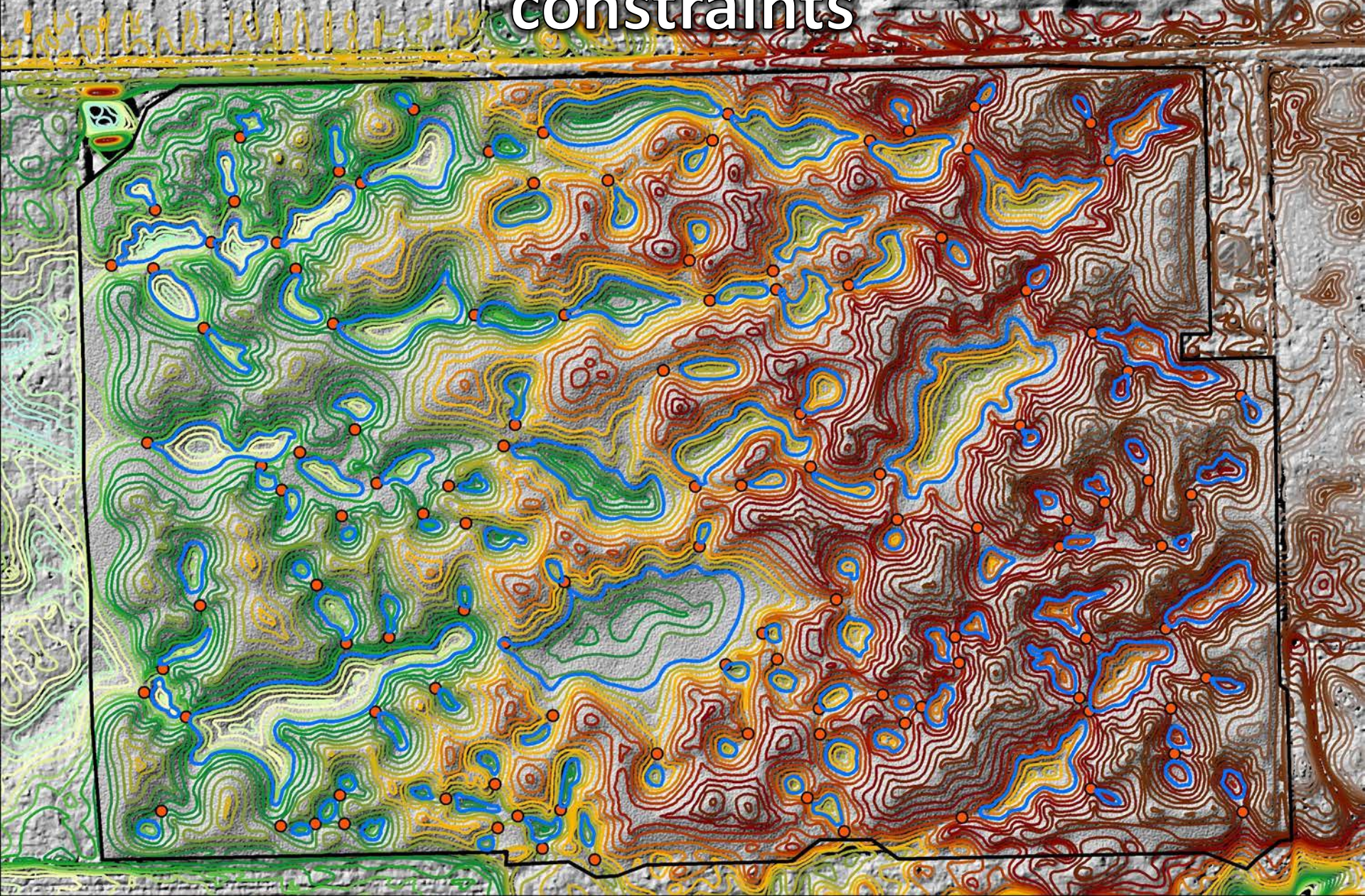
The terrain provides constraints: profile complexity



The terrain provides constraints: total soil volume



The design emerges from the constraints



Get someone else to do the hard part



Get someone else to do the hard part



Get someone else to do the hard part



And make sure they do it right



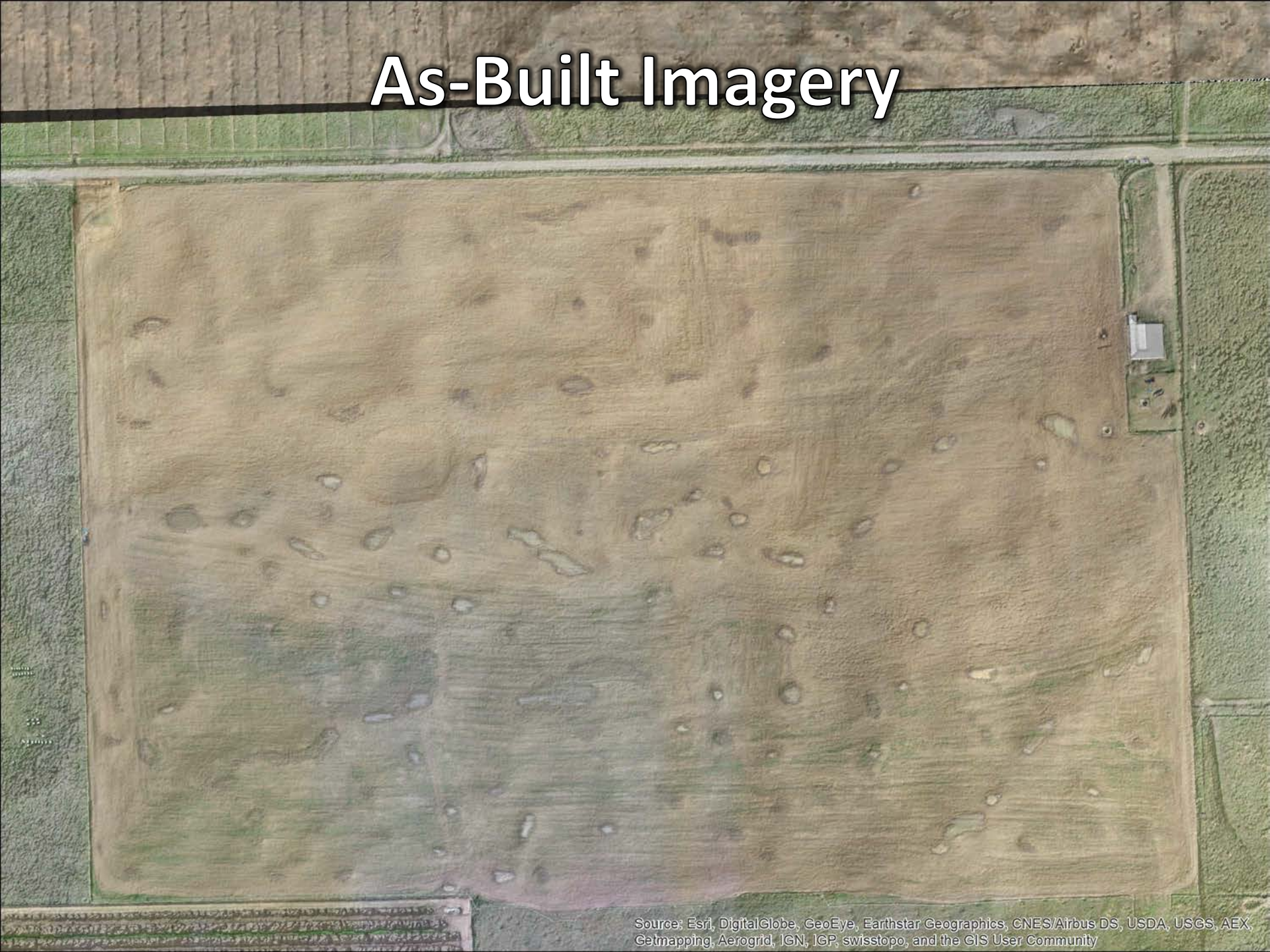
And make sure they do it right



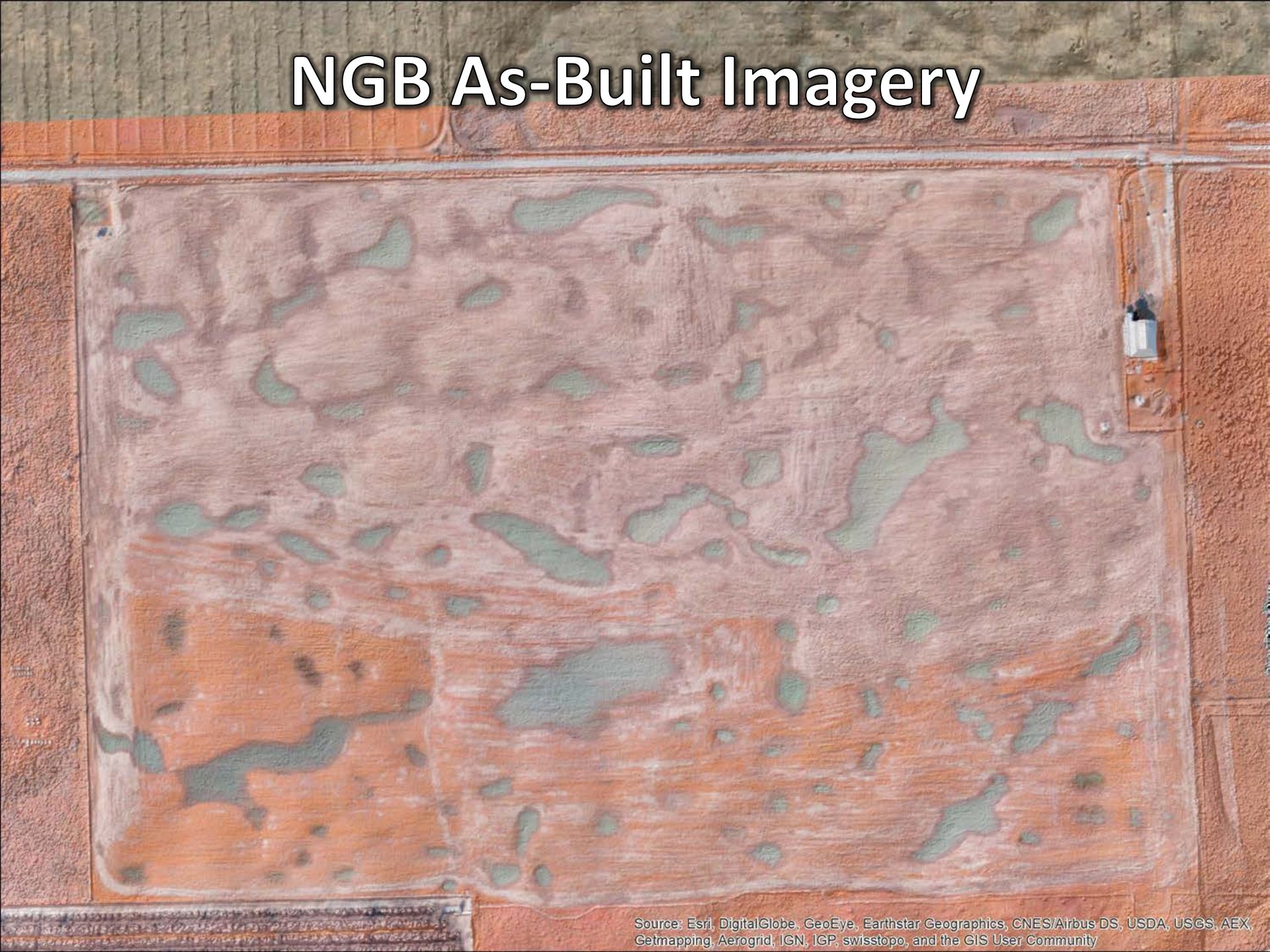
And make sure they do it right



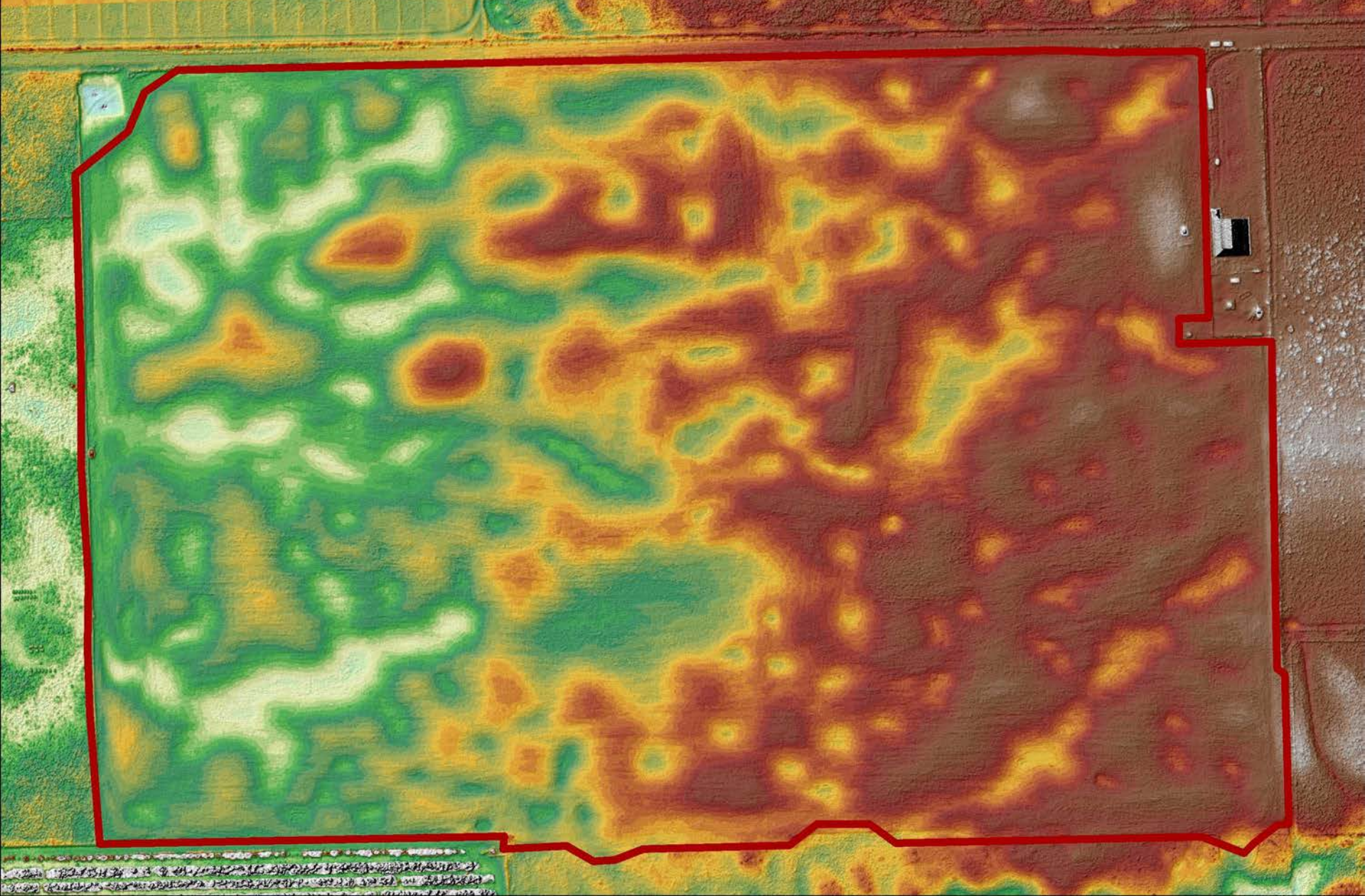
As-Built Imagery



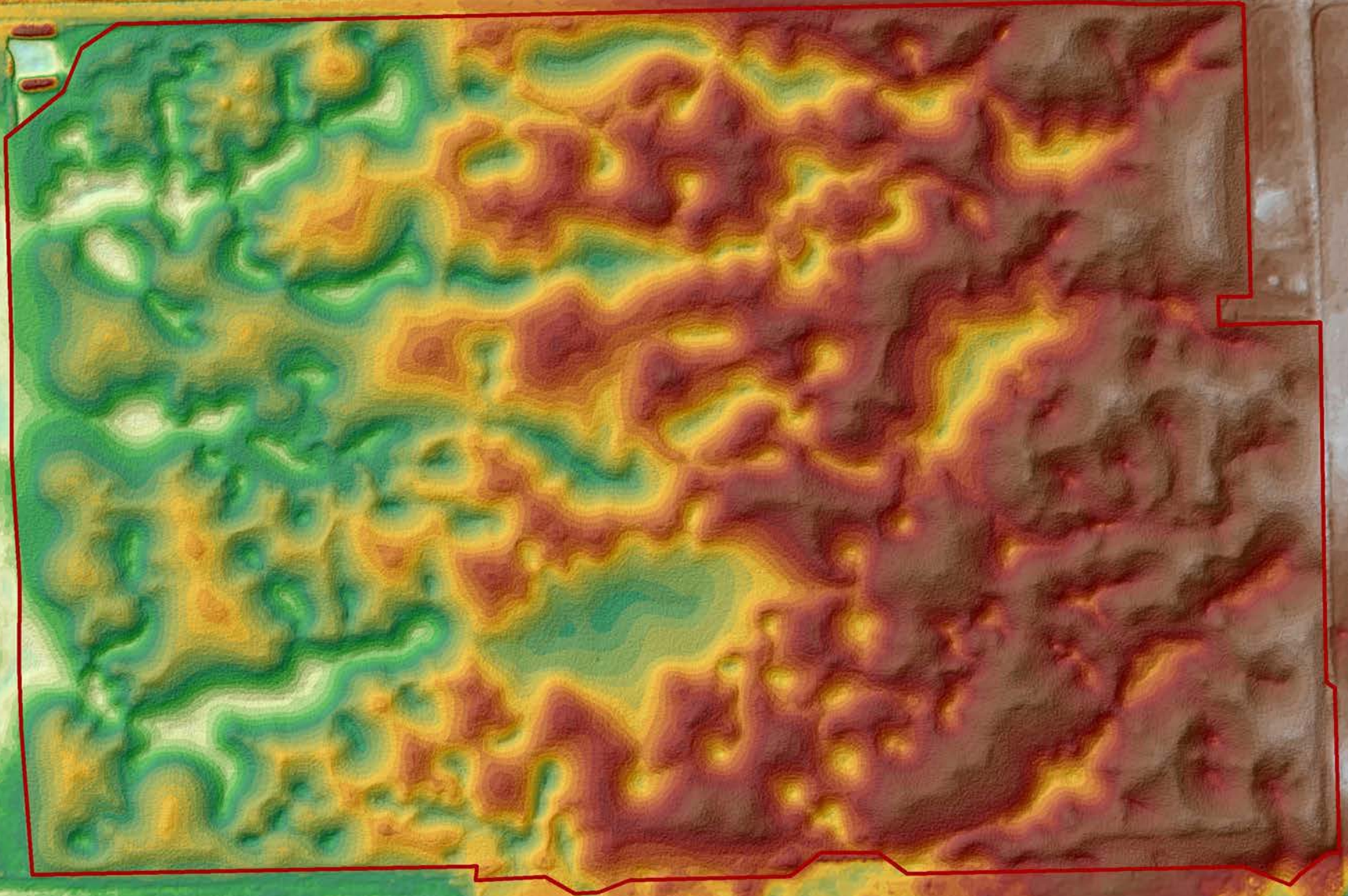
NGB As-Built Imagery

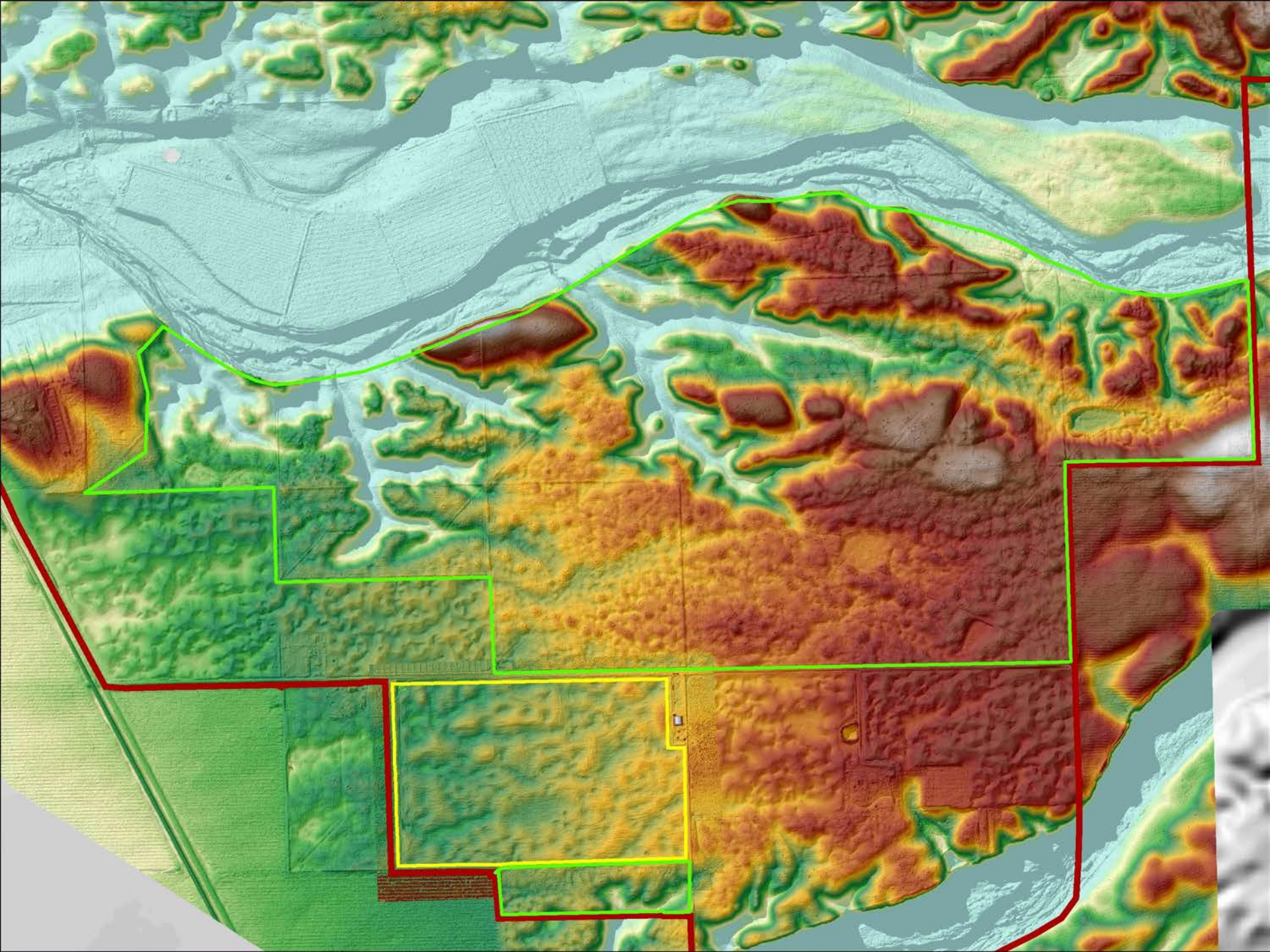


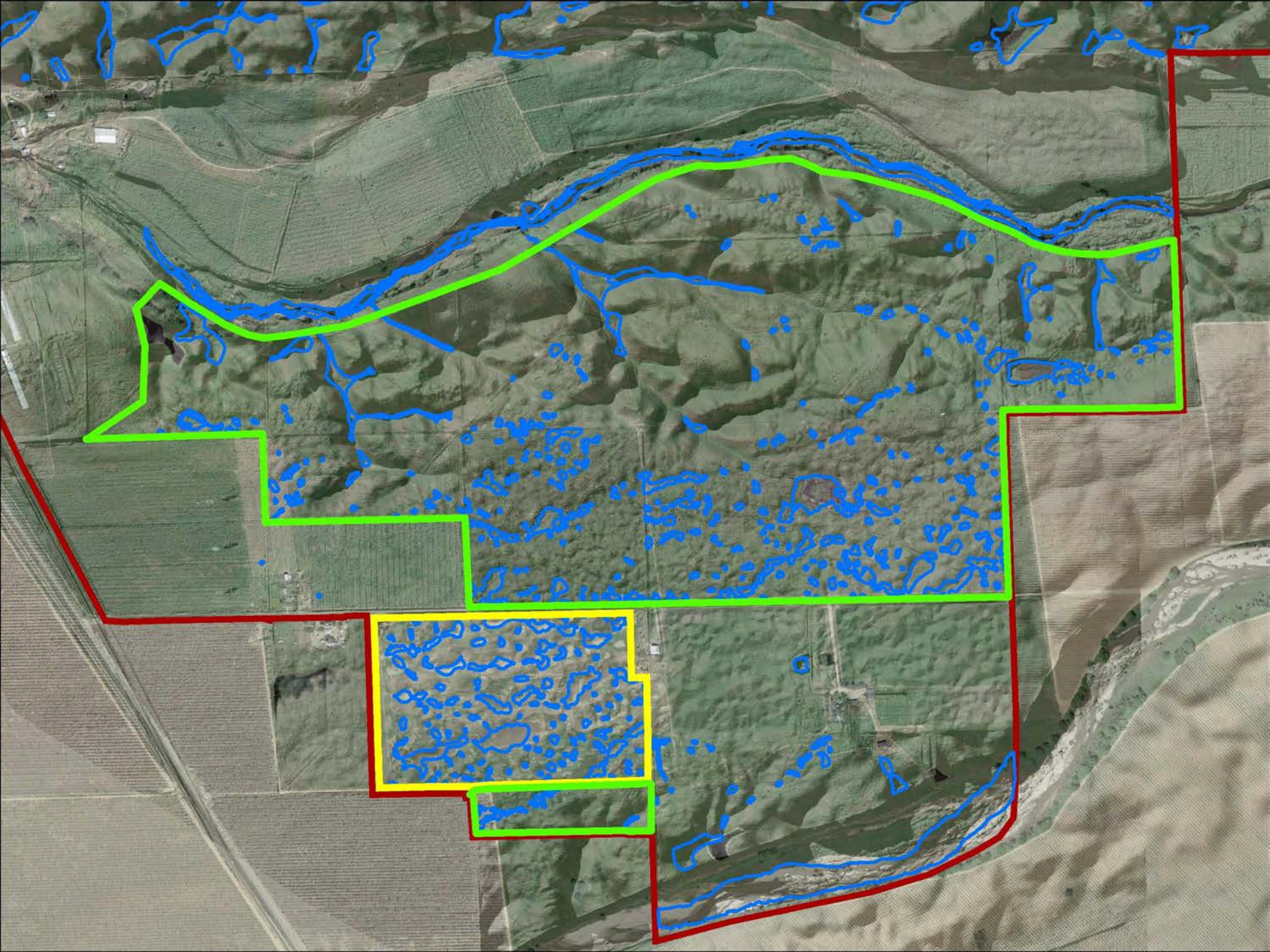
As-Built Elevation



Design Elevation













Final Thoughts

- **Lazy K Preservation and Restoration**

- Total Restoration Cost \$3.5m

- 8.5 vernal pool acres (over \$400k/ wet acre)
- 60 vernal pool grassland acres (or over \$50k/ matrix acre)

- Preservation Cost \$4m

- 26.5 vernal pool acres (\$151k/ wet acre)
- 382 vernal pool grassland acres (or \$10.5k/ matrix acre)

- **Other Preservation-Only Mitigation Project**

- Total Budget \$2.7m

- 42 vernal pool acres (\$64k/ wet acre)
- 540 vernal pool grassland acres (or \$5k/ matrix acre)

Acknowledgements

Knapp Family
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Dr. David Kelly
And the whole VNLC team

Contact us with questions!
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