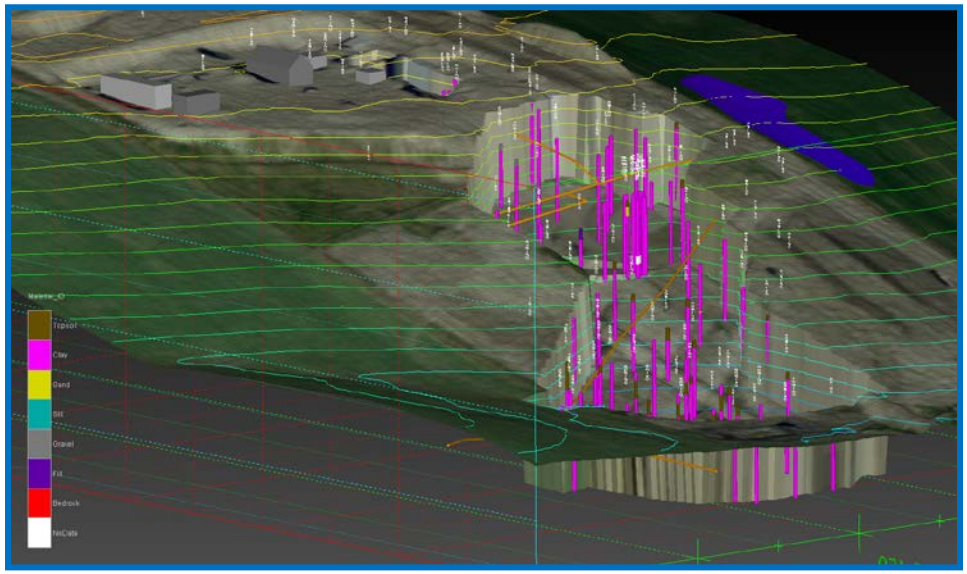
The Importance of Considering Combined Surface Water and Groundwater Drainage Issues When Planning Site Remediation



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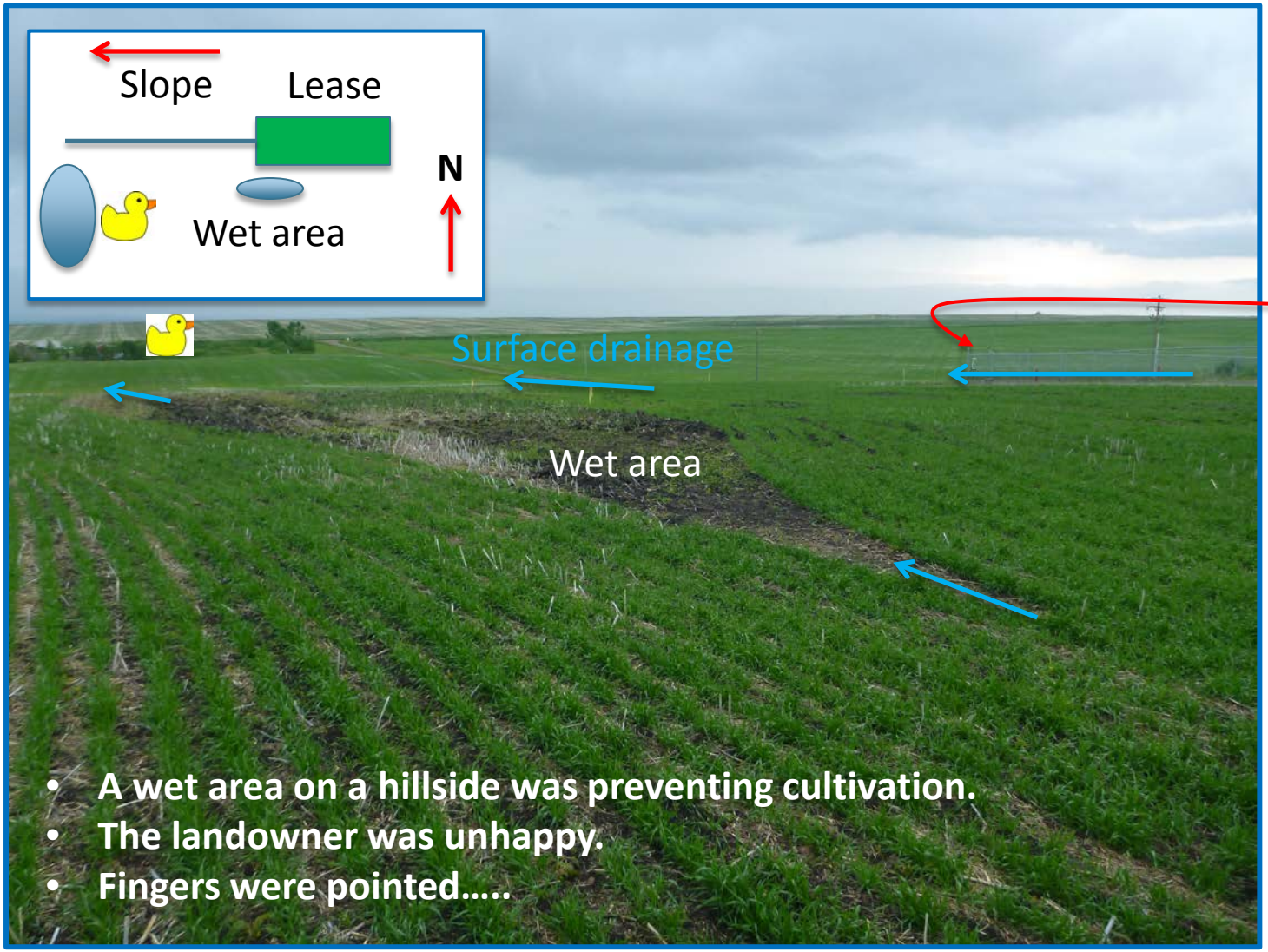
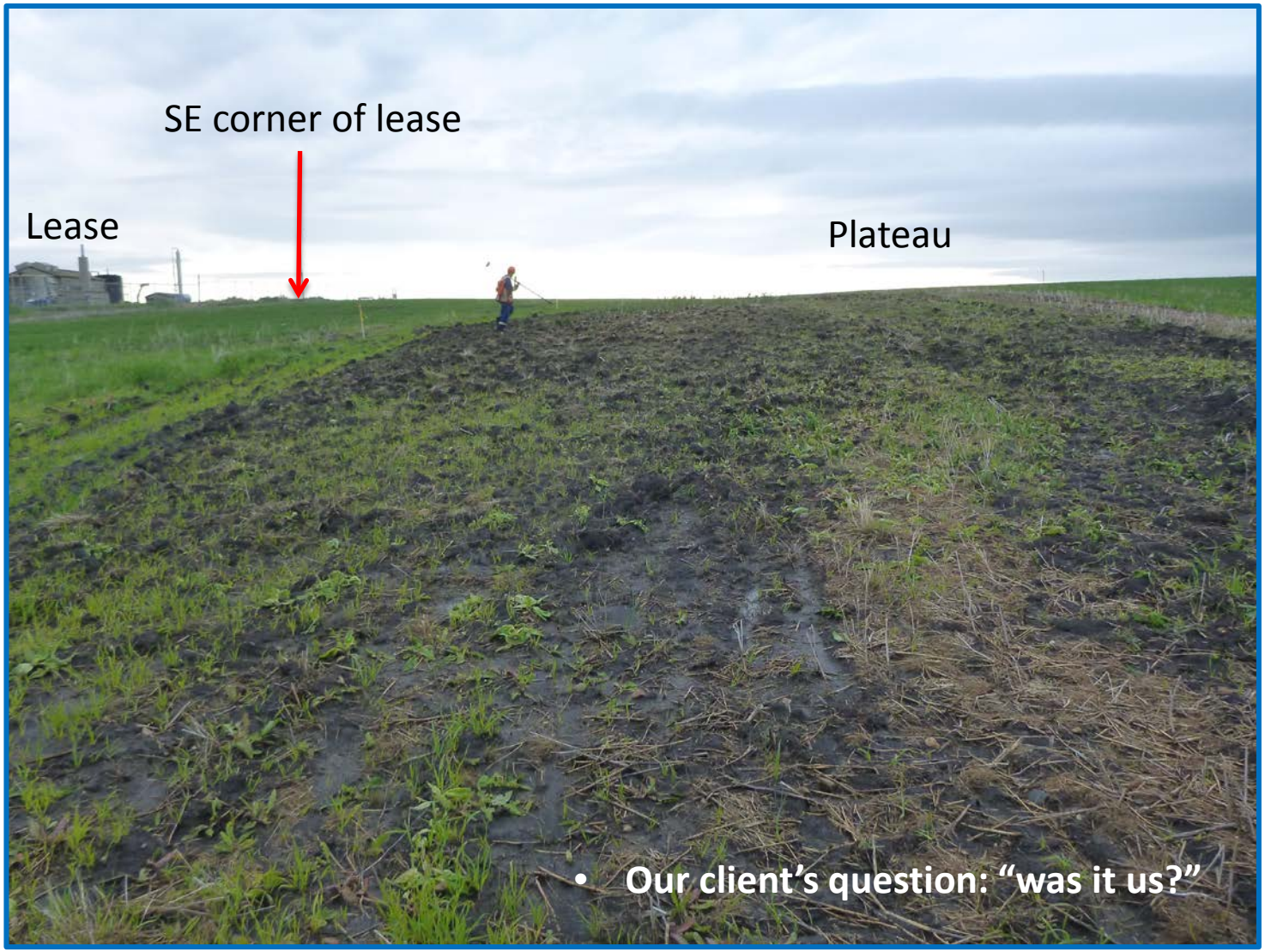
Identifying the problem



SW corner of lease

- A wet area on a hillside was preventing cultivation.
- The landowner was unhappy.
- Fingers were pointed…..

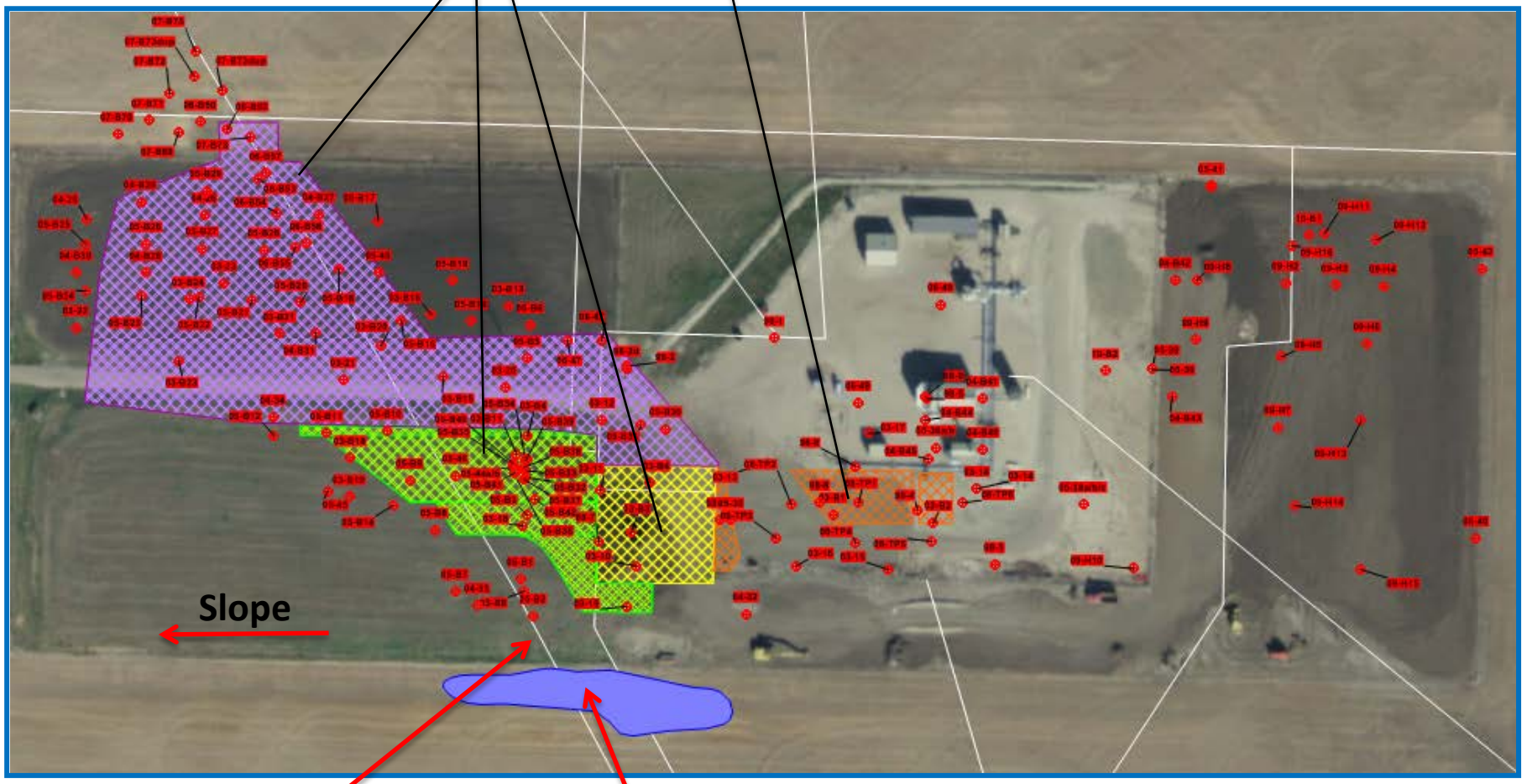
Looking uphill (east)



- Our client's question: "was it us?"

Site History

Remediated areas: dig, clean, replace to 4-6 mbgs – over four years (2005-2008).



Water-bearing pipeline

Wet area (off-lease)

White lines: pipelines

Initial Hypotheses for Cause of Wet Area (from kick-off discussion)

1. It's natural! 
2. Water pipeline-related:
   - Pipe broke during remediation or site activity 
   - Pipe broke before site purchase 
   - Pipe is just leaky 
3. Caused by site remediation - but the wet area was not disturbed, so how? 
4. Something and/or someone else entirely? 

(Nobody was in agreement)

Plenty of Data and Information Sources

- 15 years of third-party monitoring reports
- Remediation activity reports
- Borehole/test pit/probe logs (>150)
- Hydraulic conductivity results from 26 wells
- Remediation reports, photographs
- LiDAR and aerial imagery
- Abacus Datagraphics plans
- Regional mapping, topo data etc.

Initial Difficulties

The existing data and reports were inconclusive, and supported multiple interpretations.

- **Exactly** where are the pipelines?
- No intrusive site access allowed.
- Primary data were inconsistent:
  - K values
  - GW levels
  - Geology
- Stereotypical response: "*let's drill some more wells!*".

→ **"No."**

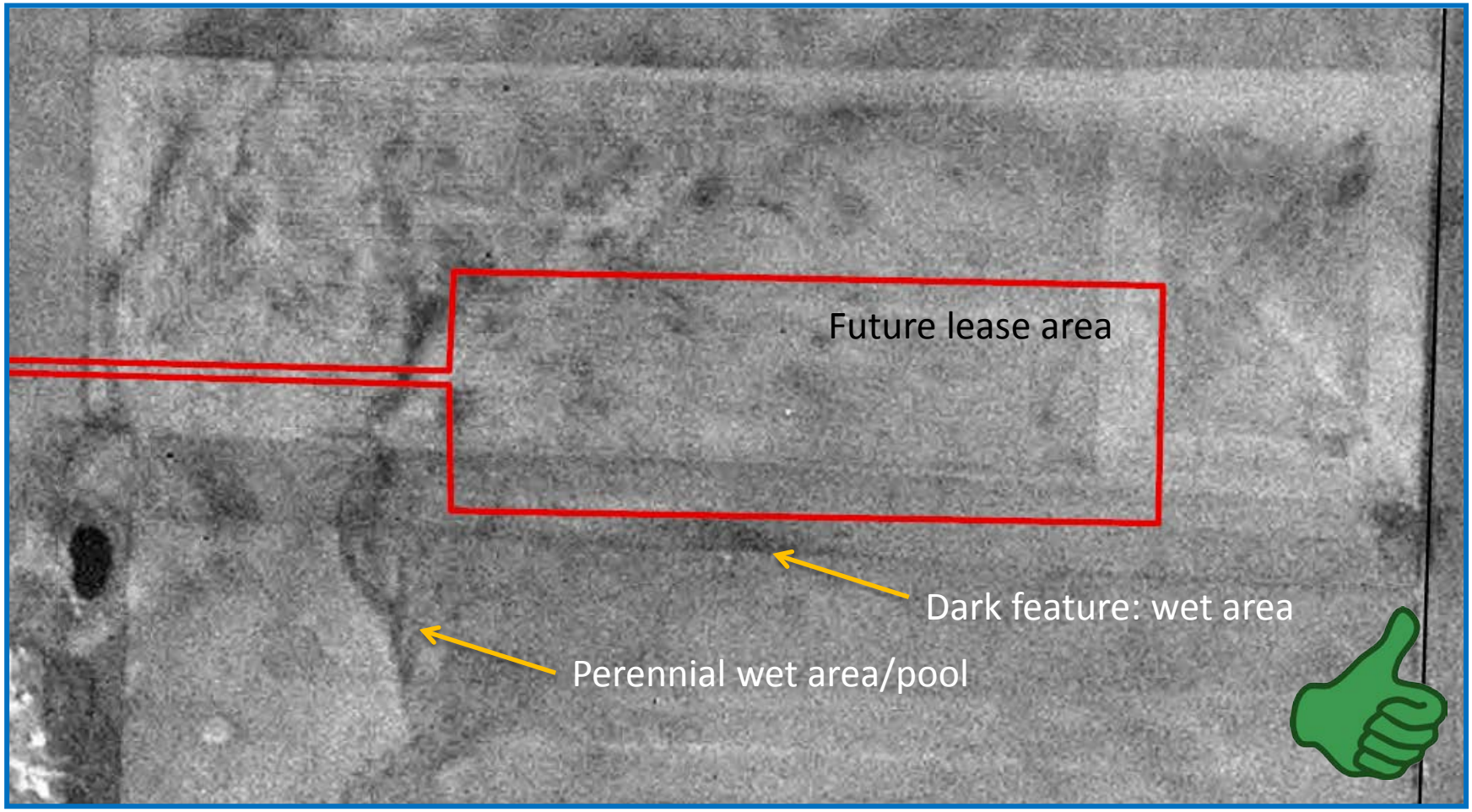
Alternative: Painstaking Review Process

Strip it back to the bare bones. *Test everything.*

- Identify reliable data sources (imagery, LiDAR)
- Obtain original field notes. Check them.
- Follow the data trail through every report table.
- Identify gaps and inconsistencies.
- Cross-plot data to find anomalies.
- Construct a 3D spatial site model.

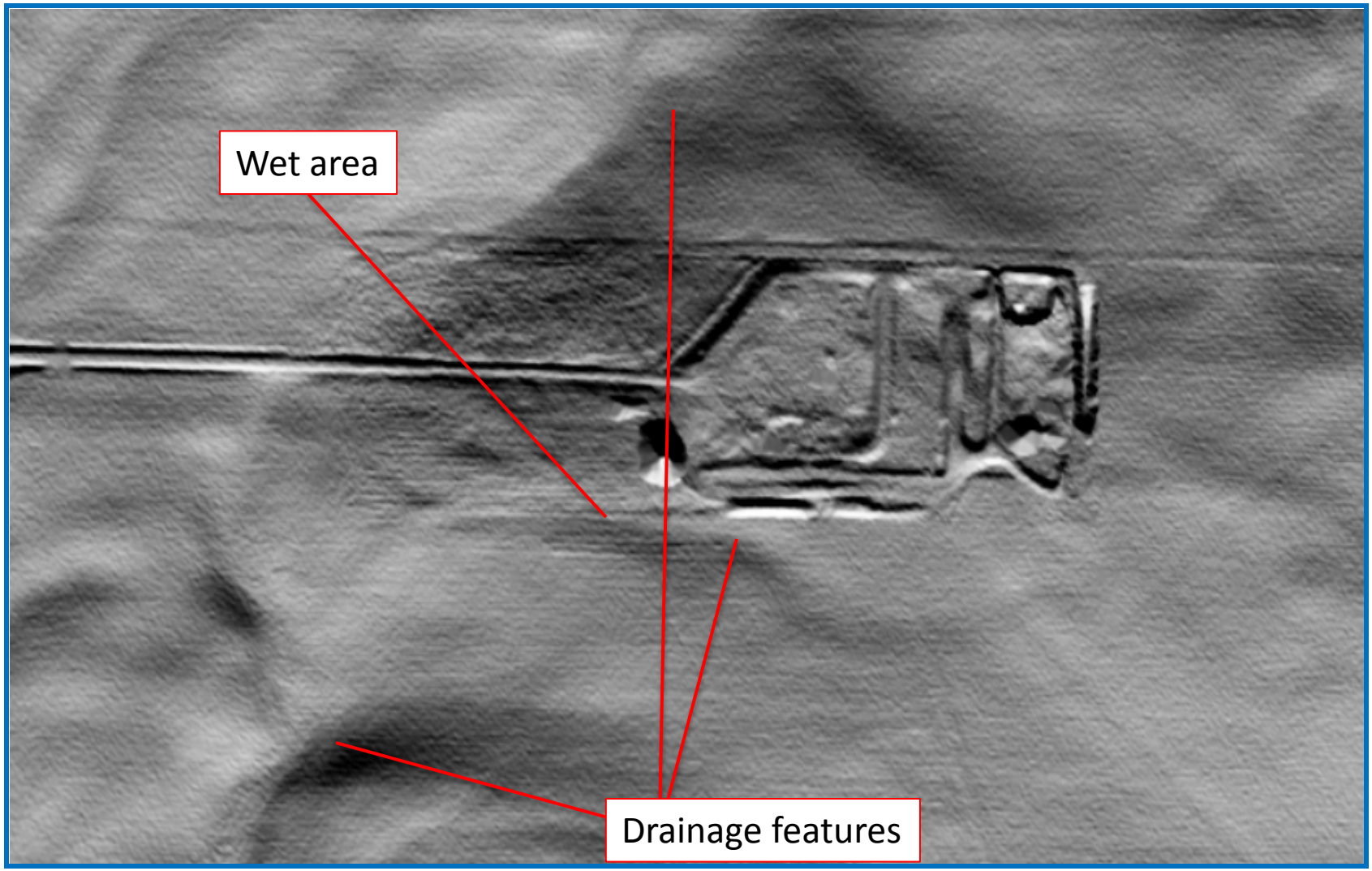
Then evaluate the initial hypotheses.

1950 Aerial Image



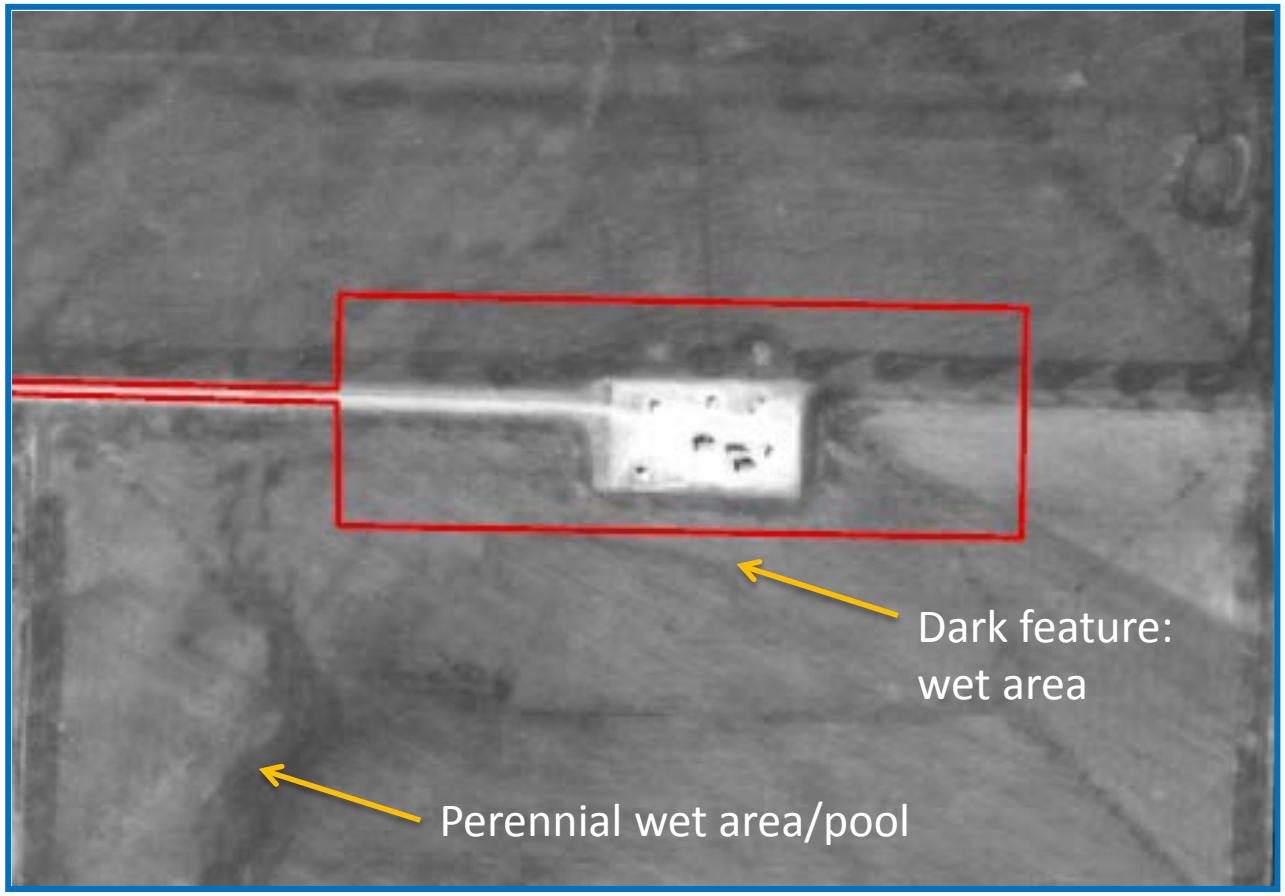
"*It's natural*". Job Done! (Is there a prize for the shortest RemTech talk ever?)

2009 LiDAR



Therefore, our wet area is in a long-standing depression, albeit sloping.

2000 Aerial Image



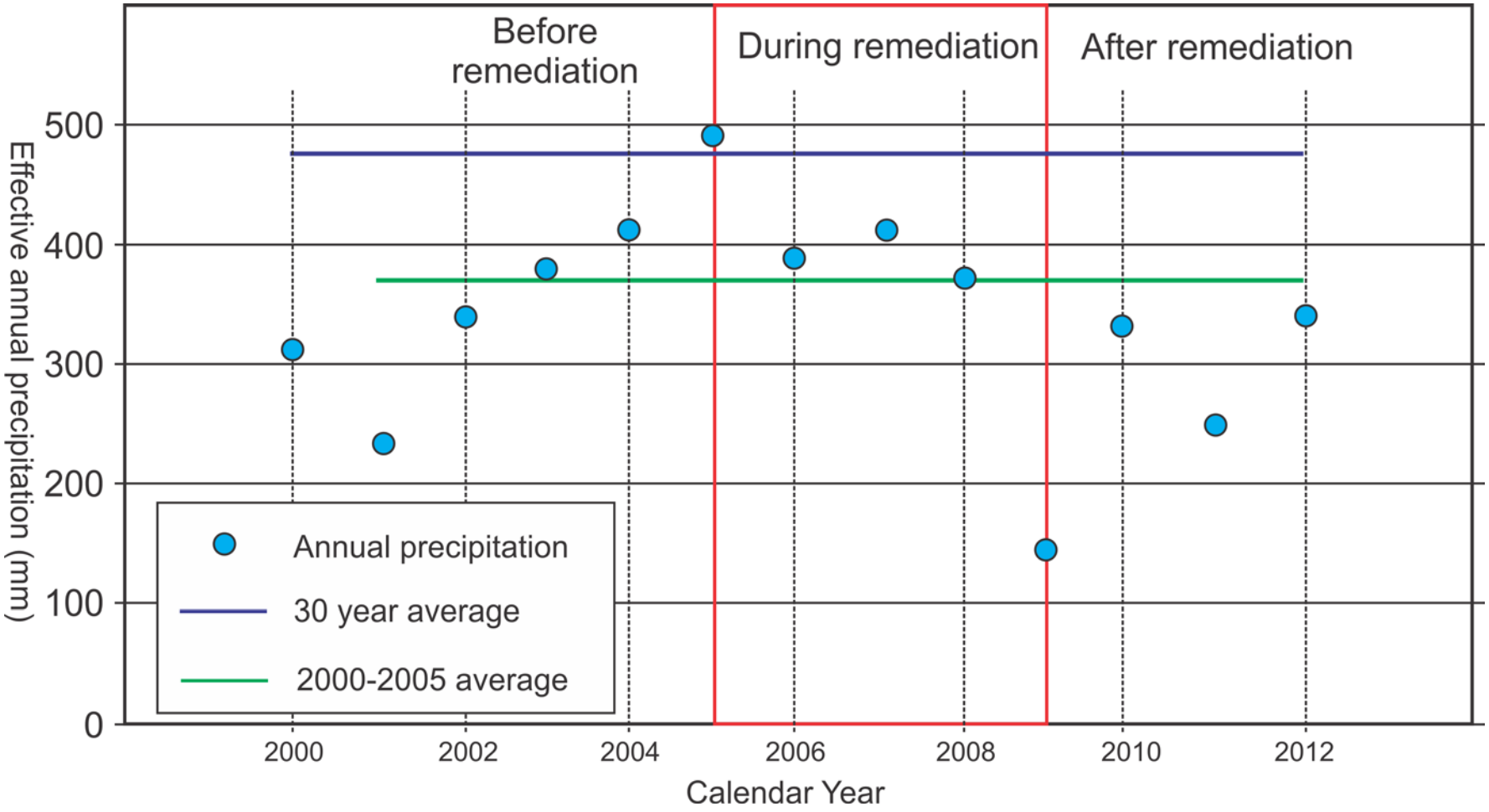
Yes, the site is naturally prone to the development of wet areas, but…..

…the question asked by our client wasn't, "*can we blame somebody else?*".

It was: "***Was it us?***"

Env. Canada Rainfall Data

- Wet area is predisposed to gather water. Where from?



- Unlikely to be caused by rainfall alone

Pipeline Hypotheses

- It's natural!
- Pipeline-related:
  - Pipe broke during remediation or site activity 
  - Pipe broke before site purchase 
  - Pipe is just leaky 
- Caused by site remediation - but the wet area was not disturbed, so how?
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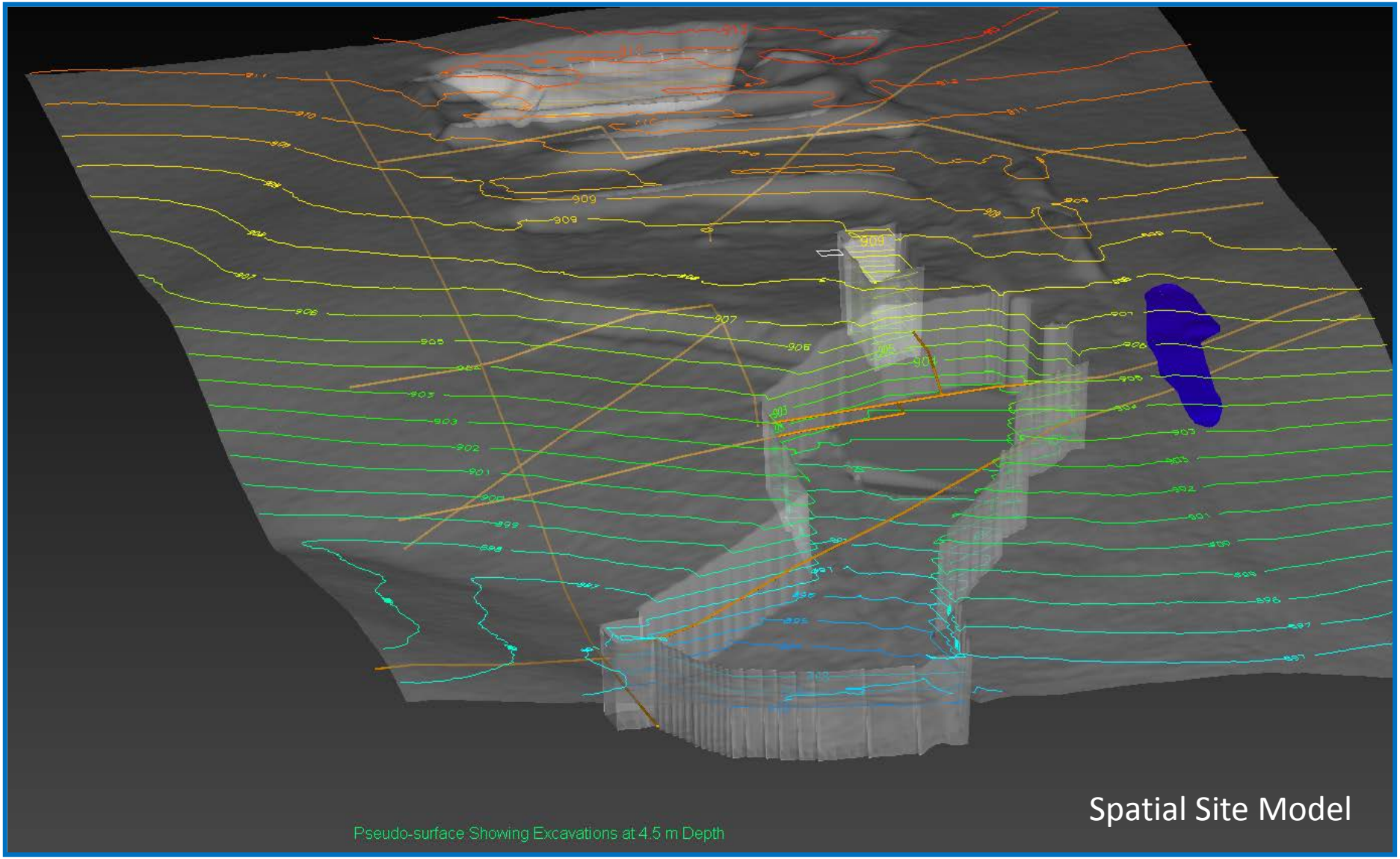
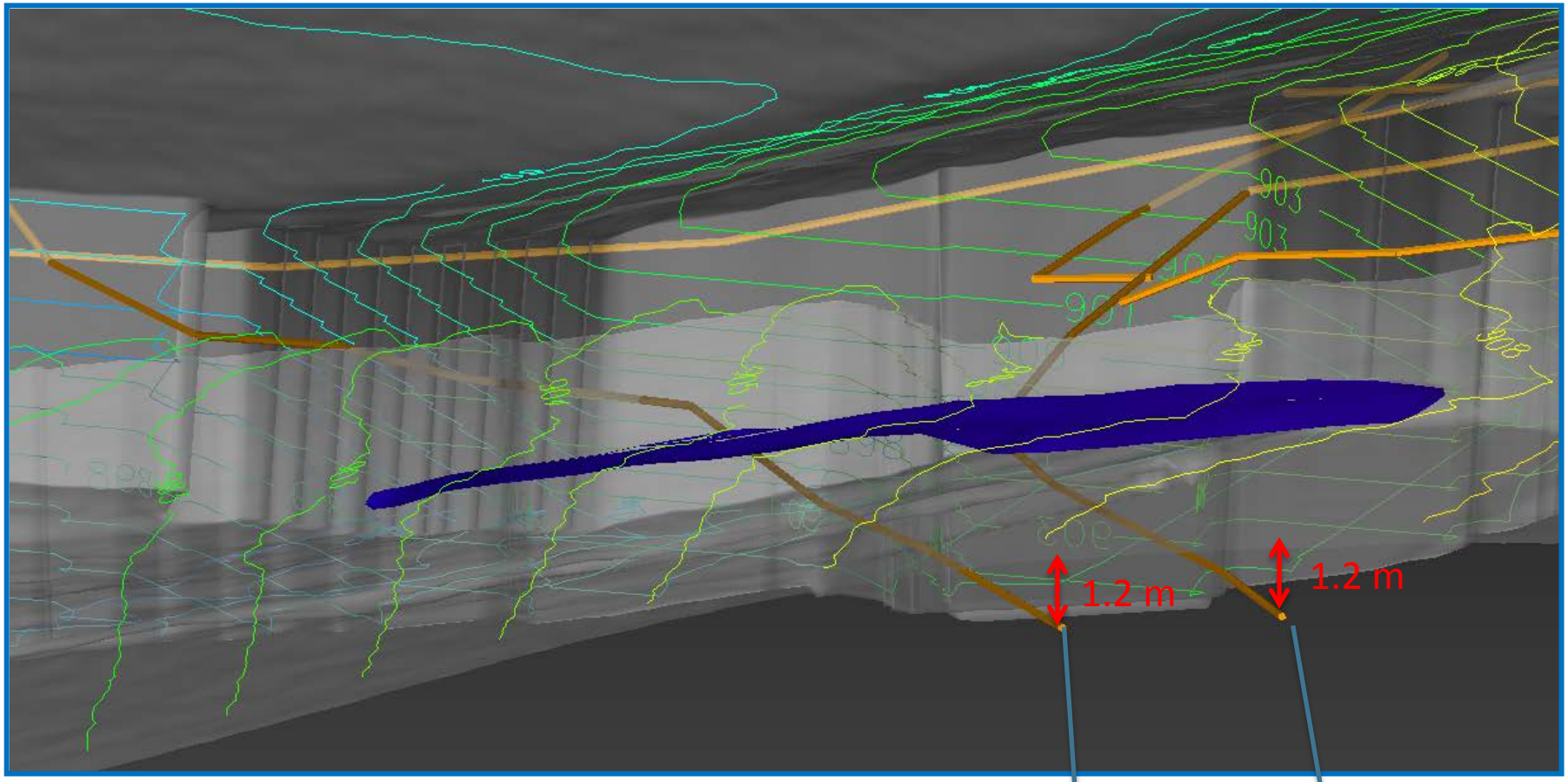
Surprise! It's a 3D visualization…



LiDAR side-view



Water doesn't (generally) flow uphill – the pipeline is not the cause.

Initial Hypotheses

- It's natural!
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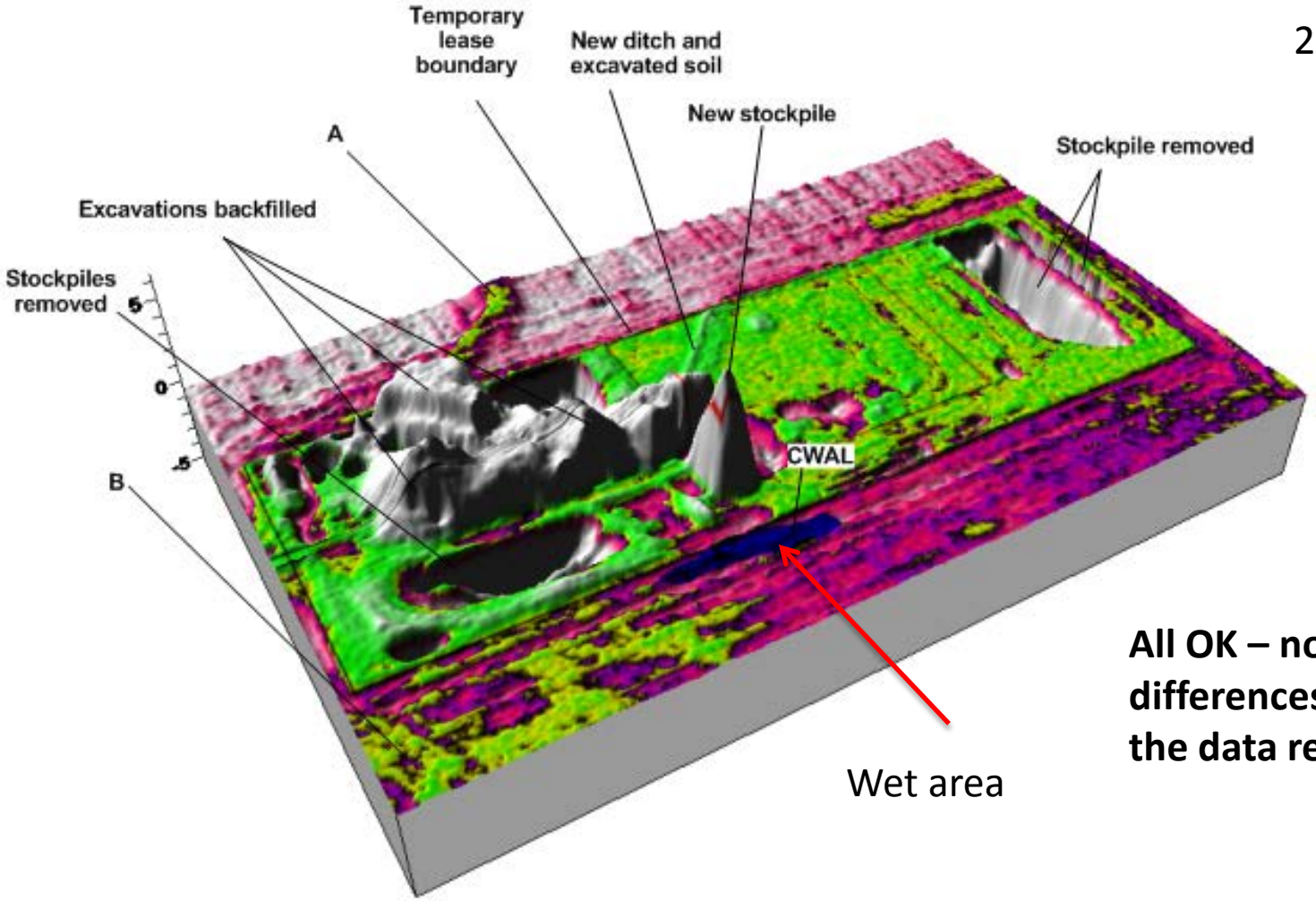
Groundwater Check

Before interpreting historical groundwater data, check:

- Borehole geology;
- Well locations;
- Ground and well top elevations;
- Screen materials;
- K values;
- Depths to water; and
- Calculations of GW elevation.

LiDAR check: time-lapse

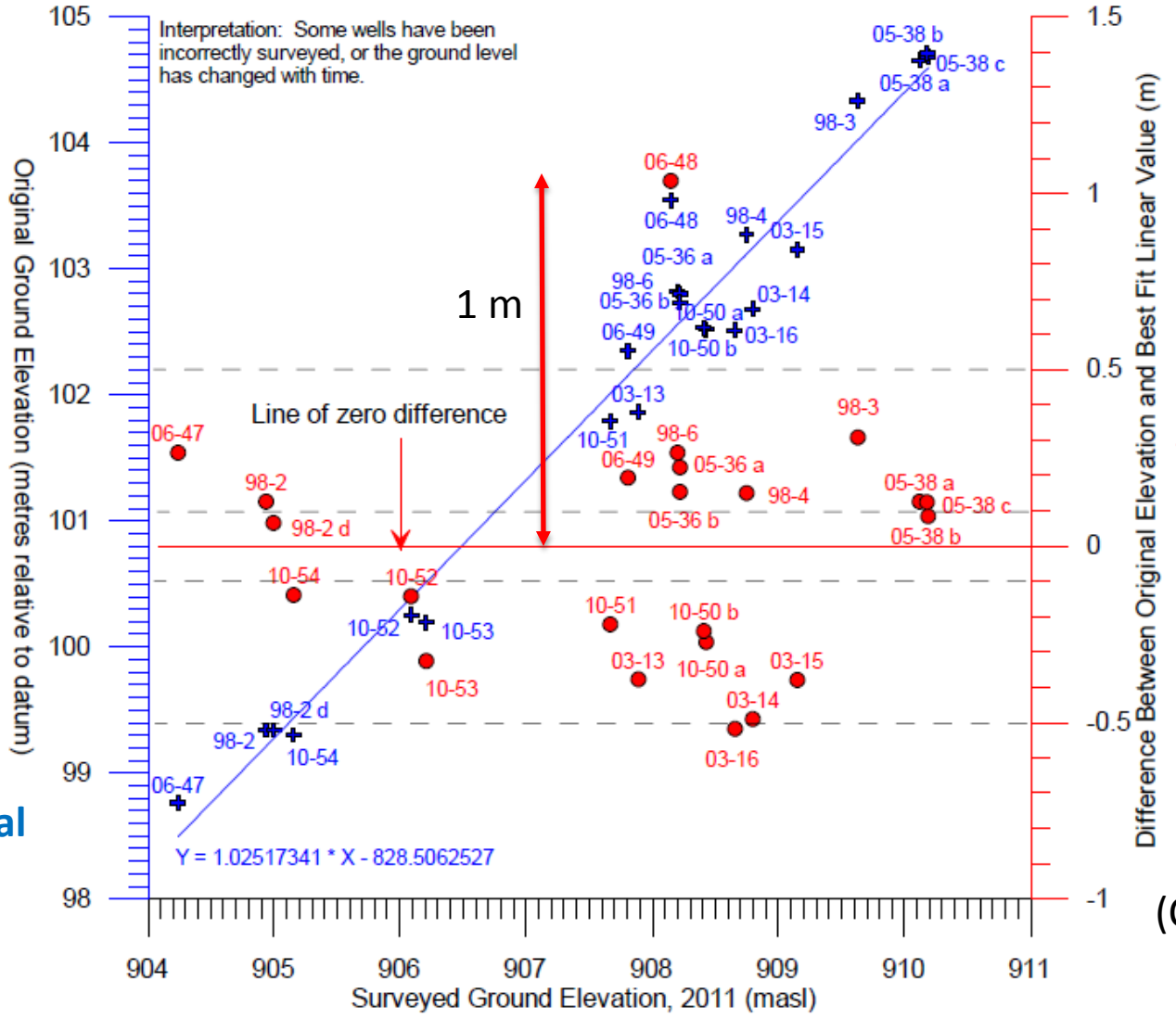
2009 vs 2007



All OK – no unexplained differences that exceed the data resolution

Shaky ground...

Tip: read blue, then red



Blue: original survey vs. subsequent survey

Red: how far from the best-fit line are the original survey elevs?

(Cross-plots are awesome!)

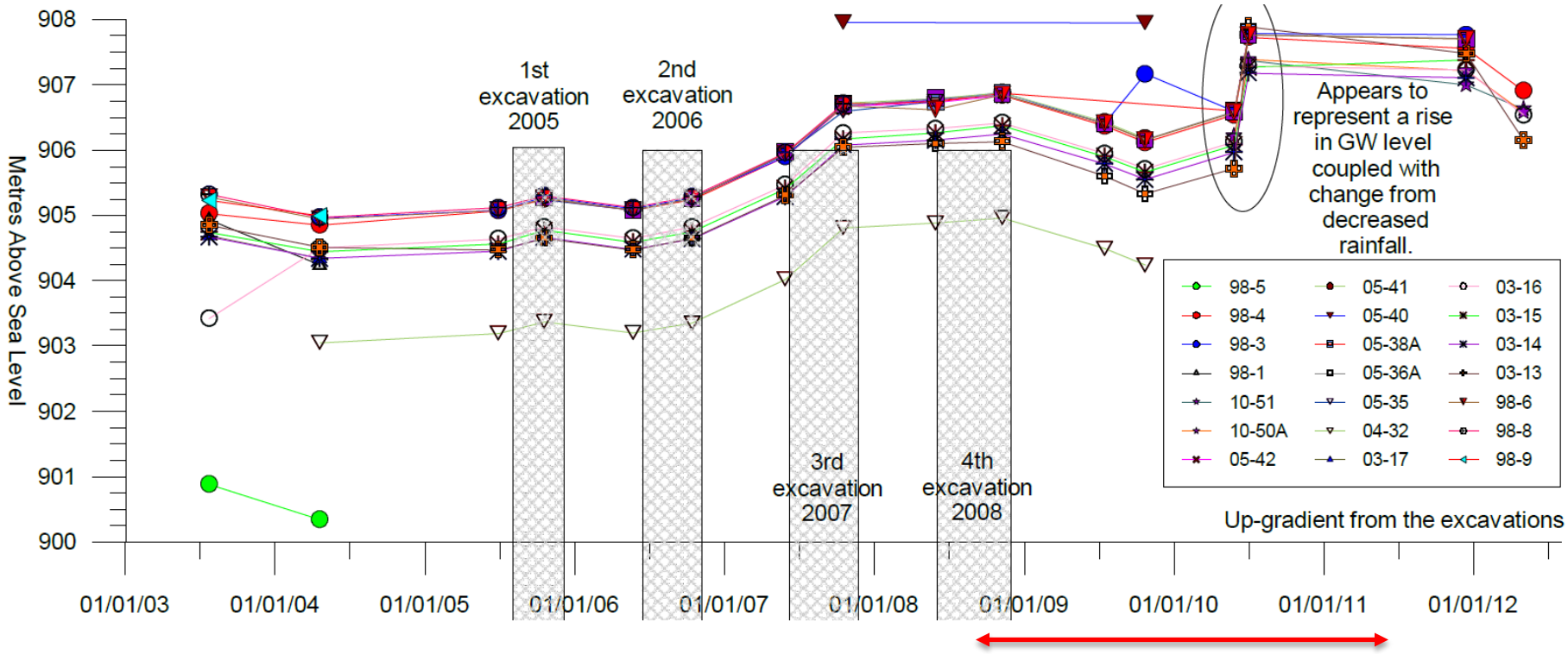
Groundwater Levels Review / Honesty Check

Confession time…..

- 17 historical monitoring events. Obtained and reviewed field notes/report tables for 14.
- ~50% contained at least one transcription or calculation error.
- Worst event contained 9 errors in 16 measurements.
- Several wells' data had been swapped.
- One year's data doubly corrected for stick-up.
- Worst error was a 4m GW level shift.

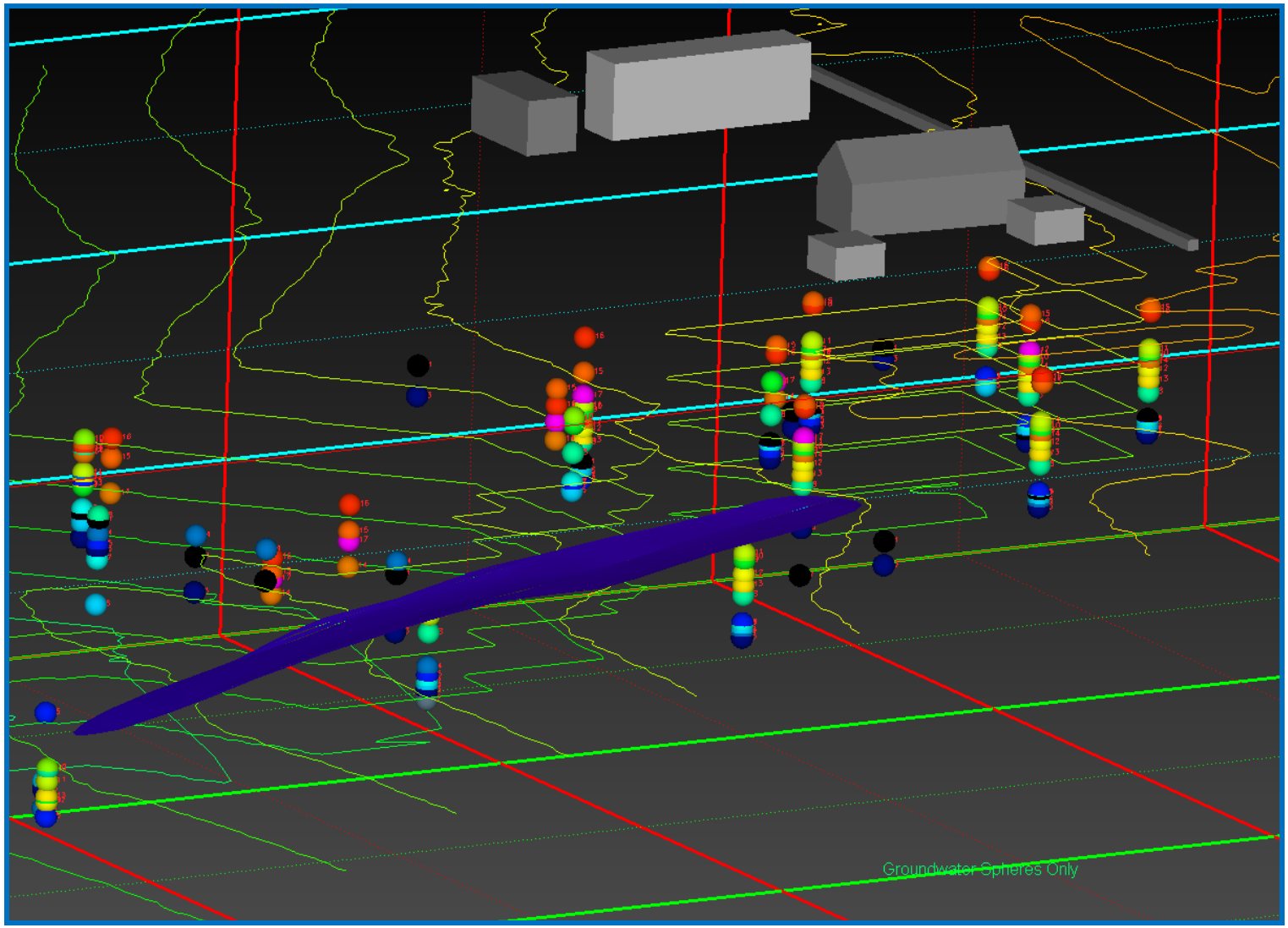
Groundwater Levels Up-Slope From Remediated Zone

Precipitation increases

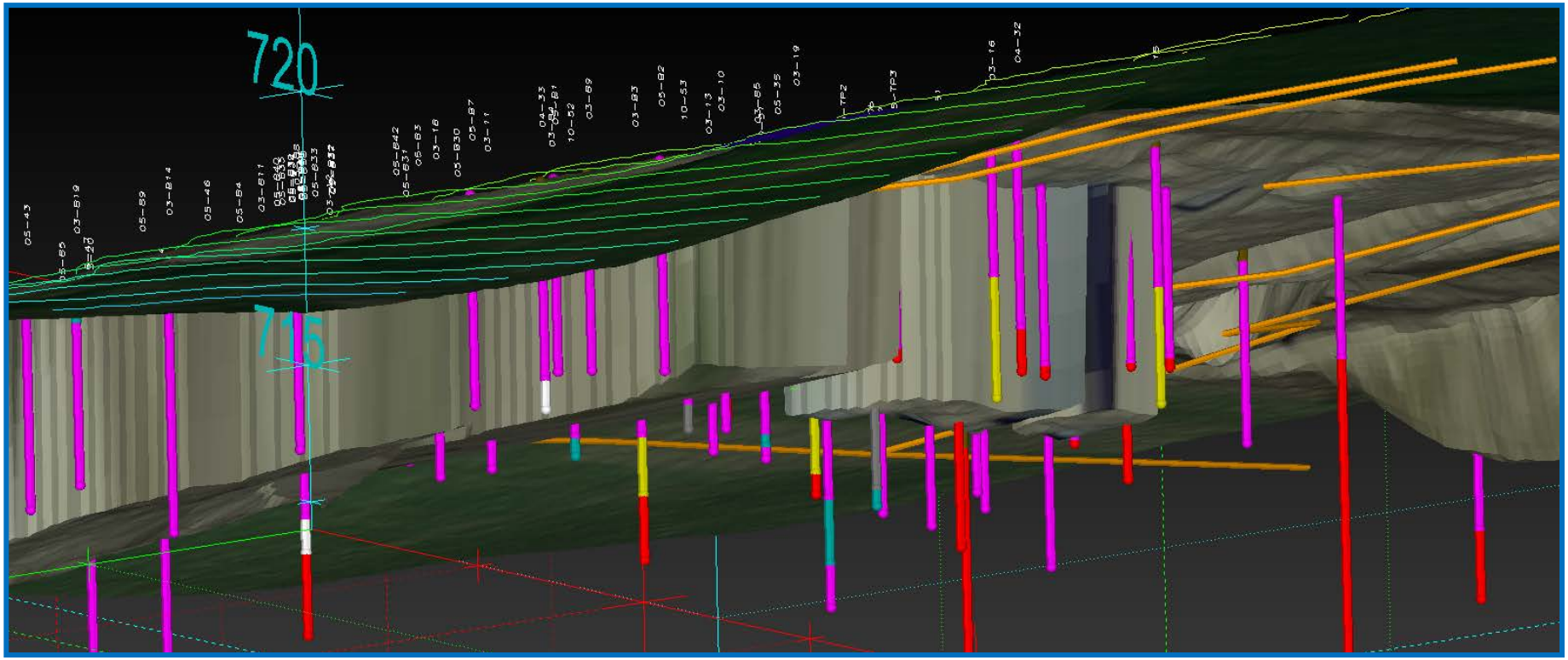


Wet area appears; worsens

Groundwater levels: darker = older



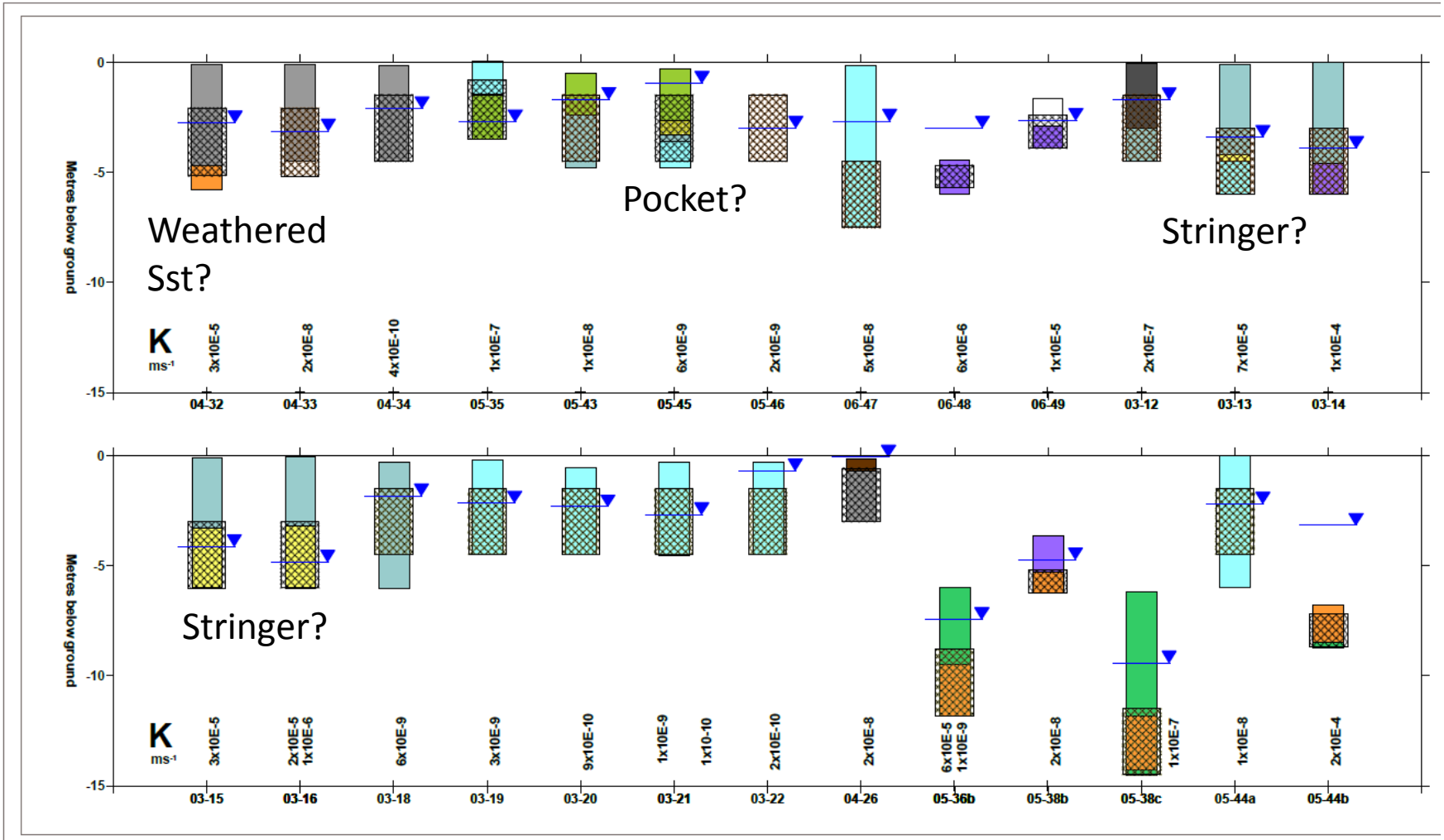
Boreholes: Sand



Till (clay)

Sand

Bedrock (sandstone, shale)



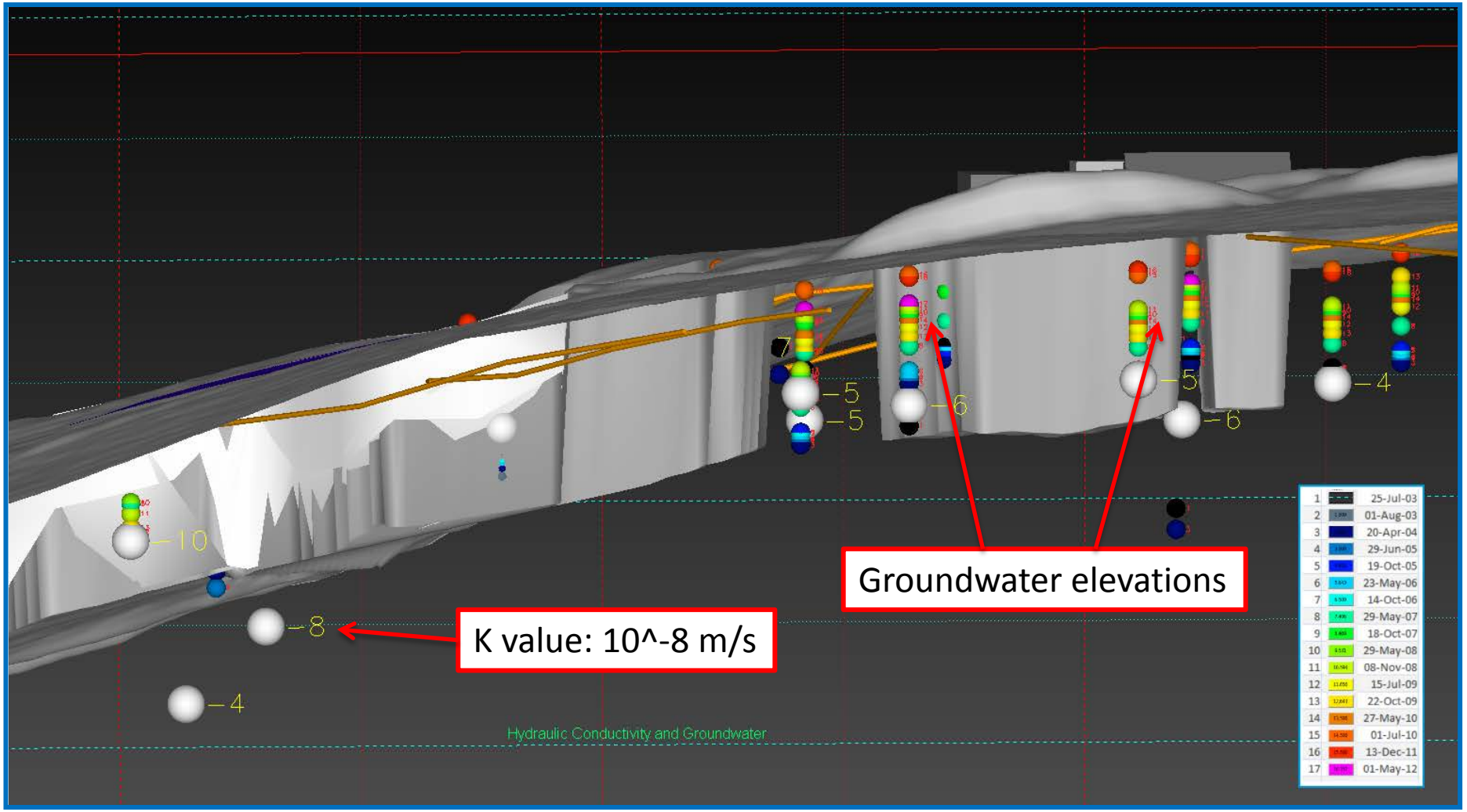
LEGEND

Subsoil, Clay Fill, Till, Clay Till, Clay, Clay Loam, Sandy Clay Loam, Silty Clay Loam, Sand, Sandstone, Siltstone, Shale, No Data, Static water level

Note: only the materials that cross the screen have been represented.

K Values vs. Screened Materials

Put measurements in their actual locations



Checkpoint

- Natural conditions favoured wet area formation, but did not explain cause.
- Pipelines were not responsible.
- After QA/QC, groundwater data told a clear story.
- Better visualization explained K test results.

- Only one hypothesis remained valid.

And the winner is....

- Thin sand layers dominated shallow GW flow.
- Remediation destroyed the soil structure.
- Homogeneous clean soils were compressed tightly.
- Groundwater “piled up” by ~3.5 m behind the obstruction, like this:

Problem identified!

What happened next?

- Additional temporary wells confirmed GW levels extended to wet area.
- Confirmed that groundwater/surface water interaction was the problem.
- Now our client was empowered to improve the situation.
- Substitute drainage is being installed on the existing leased land.
- We received a compliment ☺.

Take-home thought

Check everything!

Thanks for listening!

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