Well Testing for Asset Management - What You Need to Know

Ground Water Science
Science and Planning for Earth's Most Critical Resource

Stuart Smith

OTCO Water Workshop 2017

Goals for the Presentation

- Practical asset management of wells and wellfields depends on quality in planning (including actual hydrogeology), design, and construction, and establishing trends in well performance and well condition.
- Both valuation and lifecycle cost analysis depends on evaluating well condition.
- This presentation will highlight the types of well testing needed for these tasks and their performance standards.

Refresher: Steps of Utility Asset Management (more or less)

- Asset Identification
- Asset Valuation – GASB 34 (objective assessment of depreciation … a whole ‘nother talk)
- Inspection and data collection
- Condition assessment/assess deterioration model
- Life-cycle cost analysis
- Maintenance/rehab planning and implementation
- Prioritizing, financial planning
- Water security

Inspection and data collection for the following:

- Condition assessment/assess deterioration model
- Life-cycle cost analysis
- Maintenance/rehab planning and implementation
- Prioritizing, financial planning
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First (where possible): Intelligent planning for long-term performance

- Plan to avoid human-generated and natural water quality issues
- Optimize long-term production
- Plan for long-term well system performance by understanding that physical, chemical, and biological components of aquifers conspire to clog and corrode your well systems and how to delay the damage

Optimize the asset.
For Wells:

Employ actual *Hydrogeology** as you plan and engineer your groundwater supply Project

* By professionals, not your circuit rider or whatever. As with “certified operator” there are professional standards for “hydrogeologist” and the practice of hydrogeology

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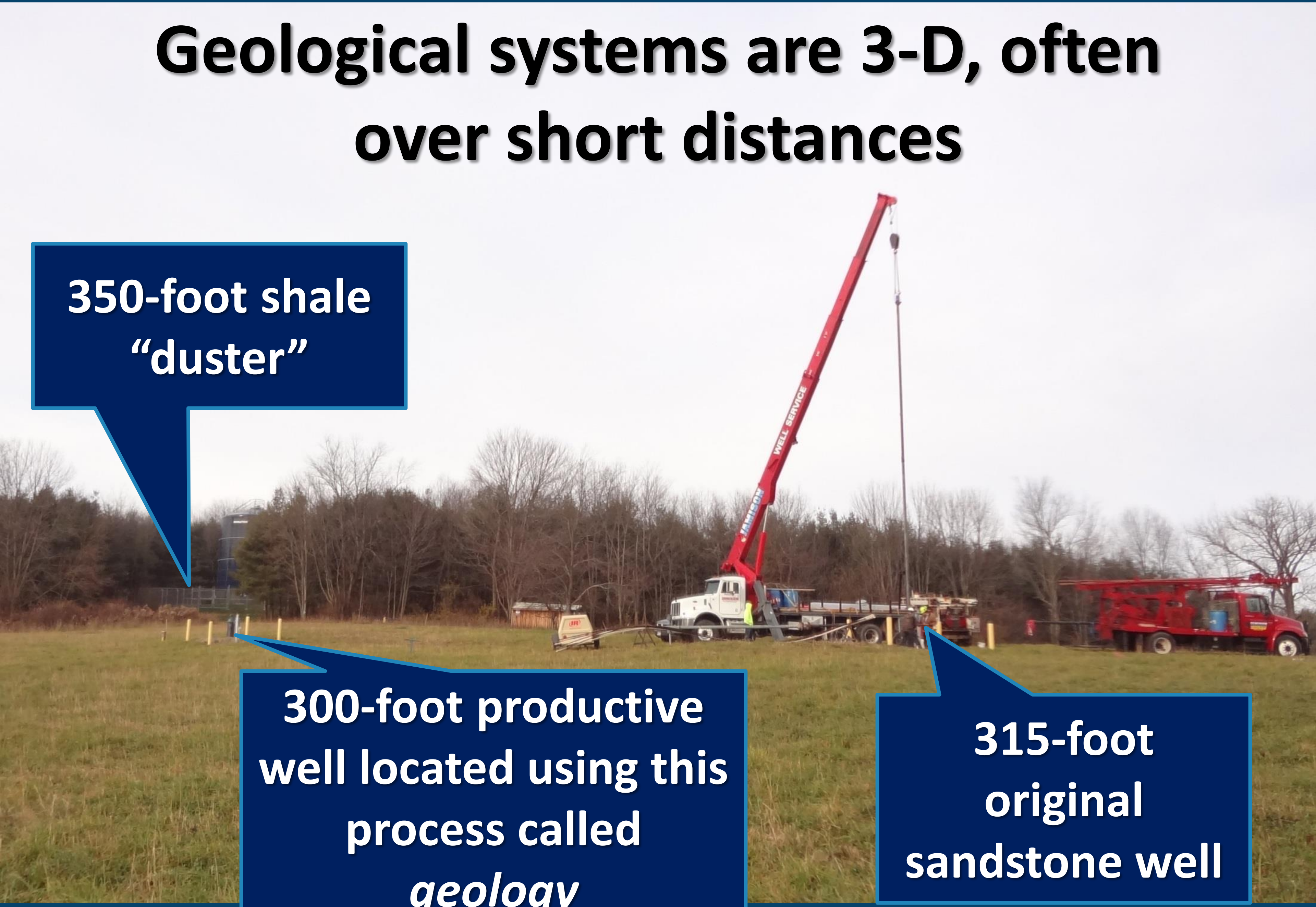
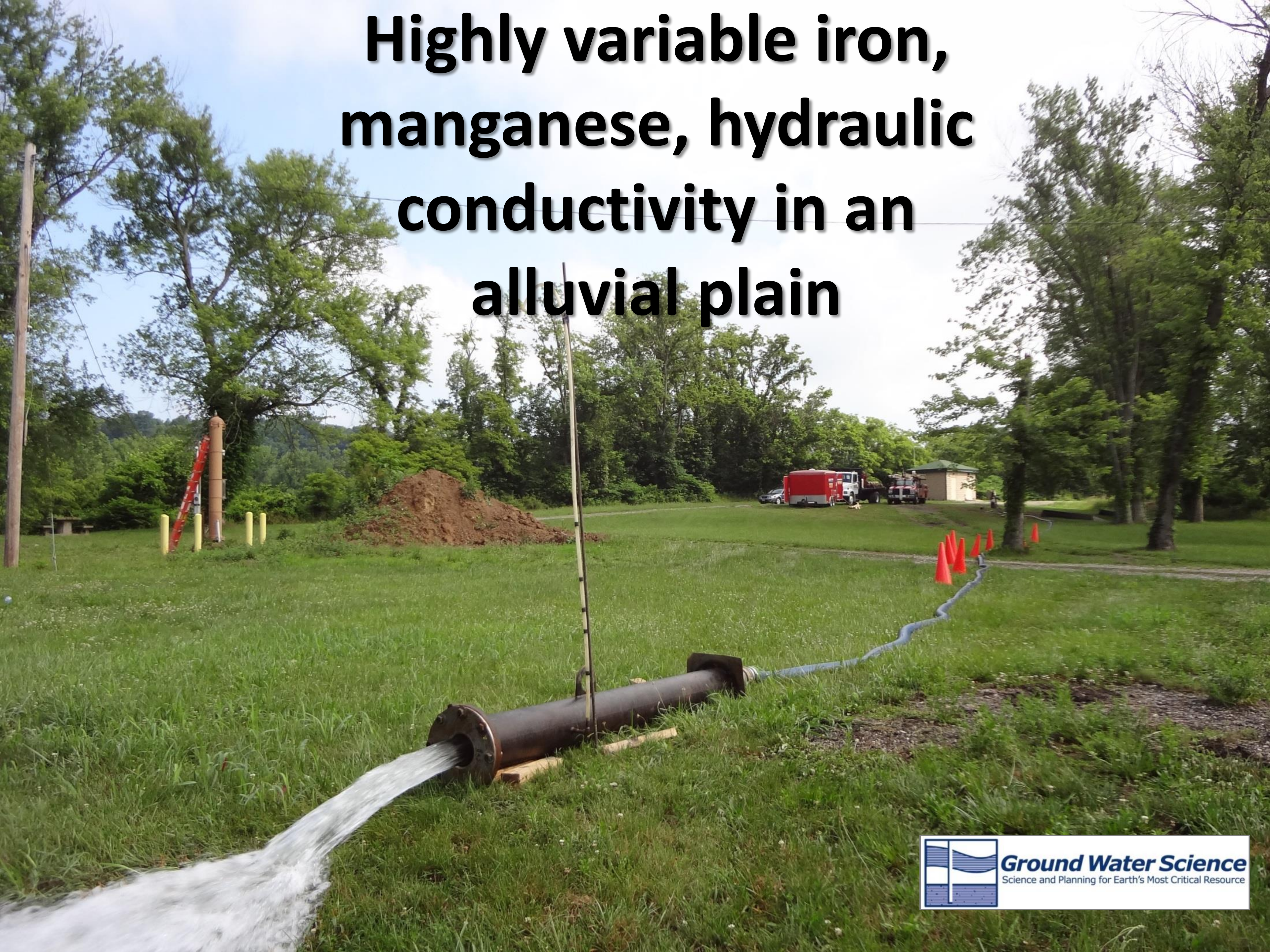
Geological systems are 3-D, often over short distances



Highly variable iron, manganese, hydraulic conductivity in an alluvial plain



Geologist-led test drilling provides extensive information about a potential wellfield location in "real time"

In this case
- Lithology
- Onsite water quality
- Onsite airlift yield calculation

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Source Water Protection and Monitoring task description

- Source water protection of a wellfield or surface water supply should be based on scientific analysis using site-specific and valid data
- Needed: active, regular water quality monitoring to detect contamination or change or to modify the risk assessment.

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What can go wrong?

Understanding new potential challenges
For example, the interesting new neighbors

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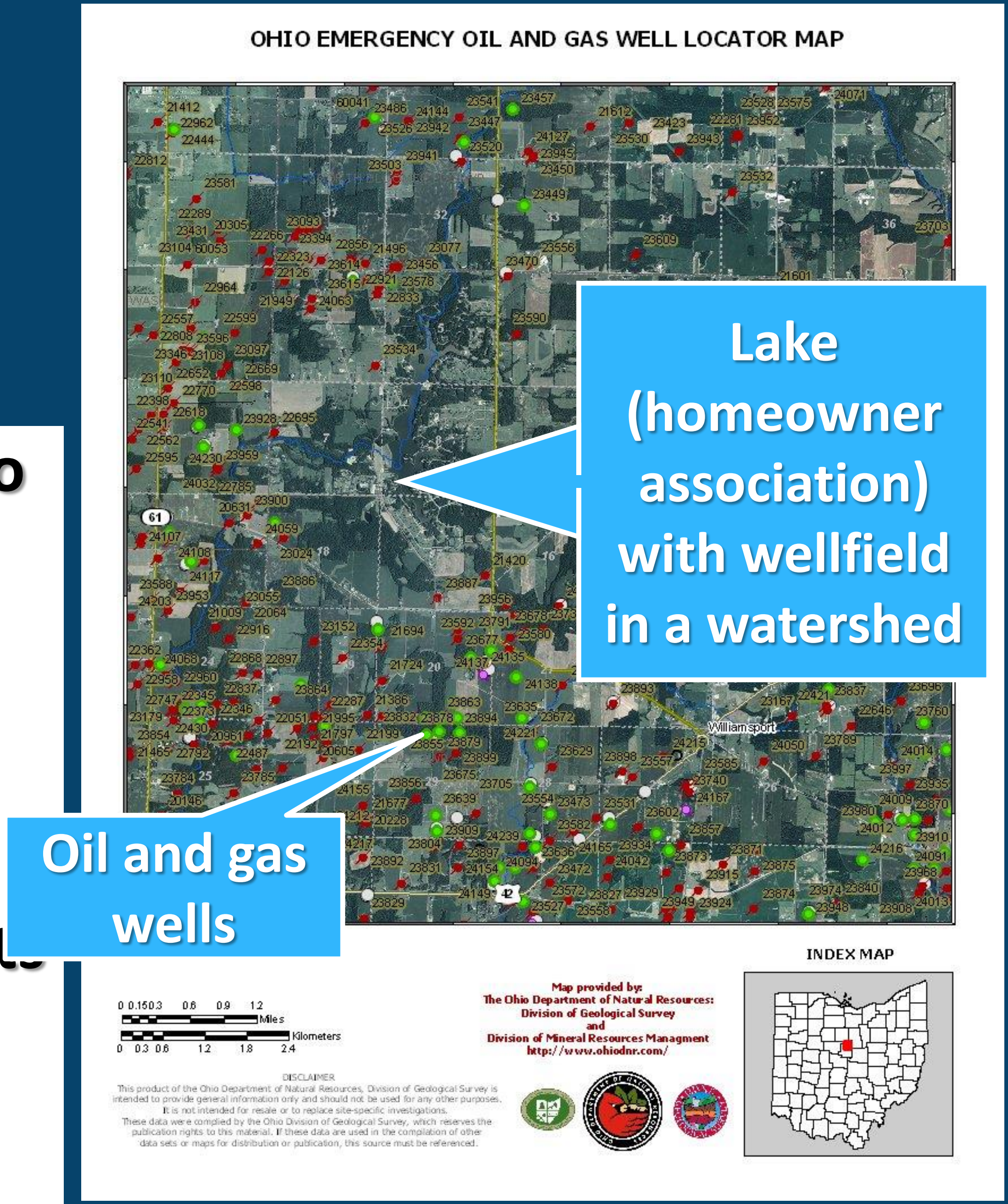
And their associated infrastructure

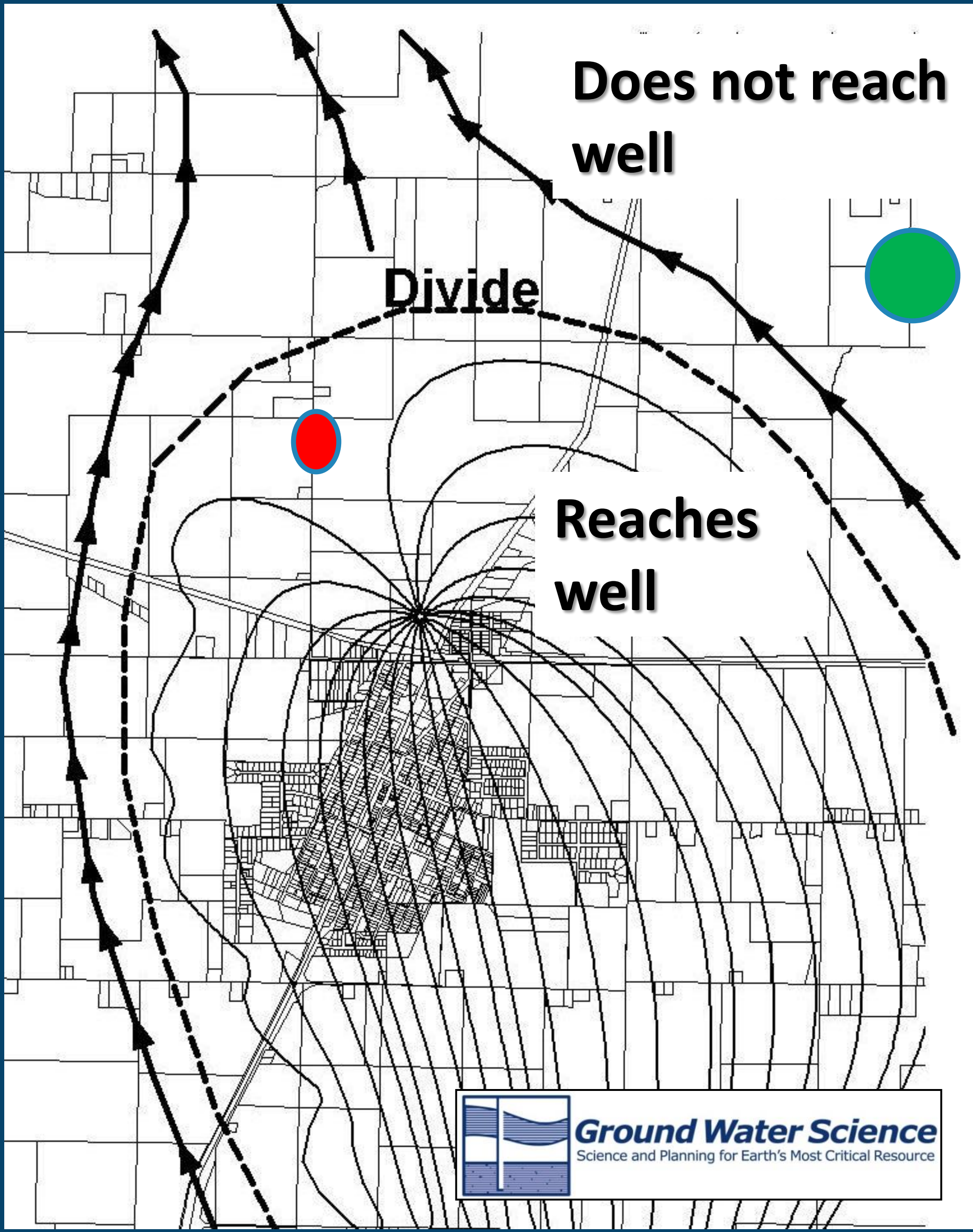
Assessing vulnerability (risk)

- Contamination has to be within the watershed – surface or ground water
- There has to be an active source
- Hydrologic constraints
- What are the mitigating factors?



Physics and hydrology Modeling flow paths of an Ohio wellfield:

Part of the ground water flow is towards the well. The flow in the rest of the aquifer remains to the northwest. A divide is created between the two flow paths.



Well Construction Design

Despite detailed well construction and siting rules in Ohio that remove much uncertainty and improve well quality, there is a necessary place for individual well design, including

- the sizing and selection well screens and filter packs, materials and well diameter
- In rock well situations, drilling as much borehole as possible during initial construction is more cost-effective
- Both *hydrogeology driven*
- Pumps selected and sized to match the well
- Design for monitoring and maintenance

Wellfield asset management

- The “wild” – engineered interface
- Limited access
- Limited feedback

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AM = Intelligent planning for long-term performance (ground water division)

- **Plan for long-term well system performance by understanding that physical, chemical, and biological components of aquifers conspire to clog and corrode your well systems and how to delay the damage.**
- **More than hiring the well contractor to clean the wells you think need to be cleaned as you have spare budget.**
- **Be *intentional and scientific* about it.**

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A challenging environment impacts AM and inadequate AM (including lack of active environmental monitoring and control) opens the way to regulatory and environmental "events"
NO TRESPASSING
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Facility Memory

- Wellfields: Need long-interval (days to weeks) data point collection intervals
- Storage and retrieval: need scale of decades
- Be able to <u>store your own data</u> (vendors come and go)…
- Think long-term: Store as something retrievable long-term
- Hard-copy (paper records) <u>a really good choice</u>. OK, maybe “the cloud”

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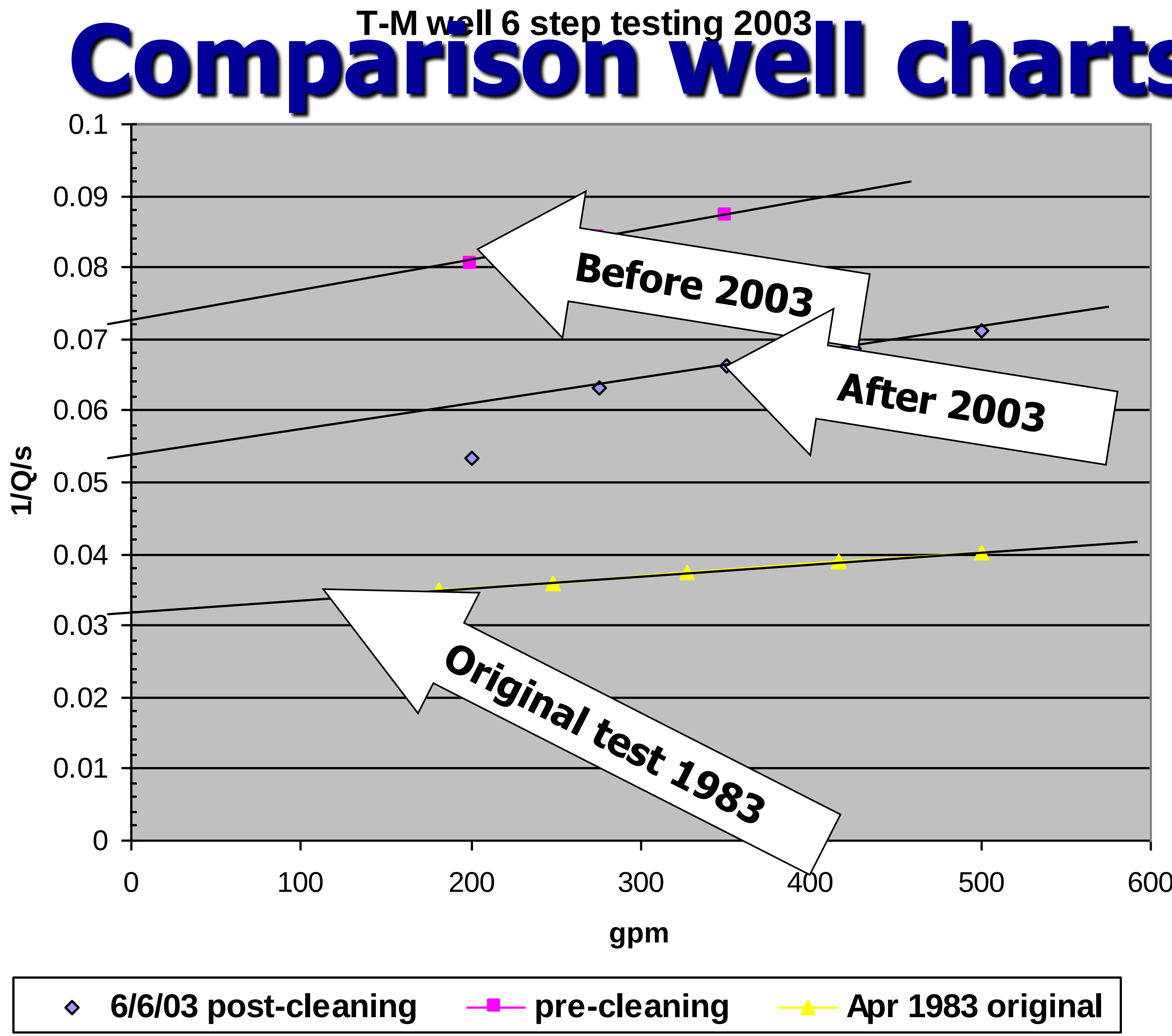
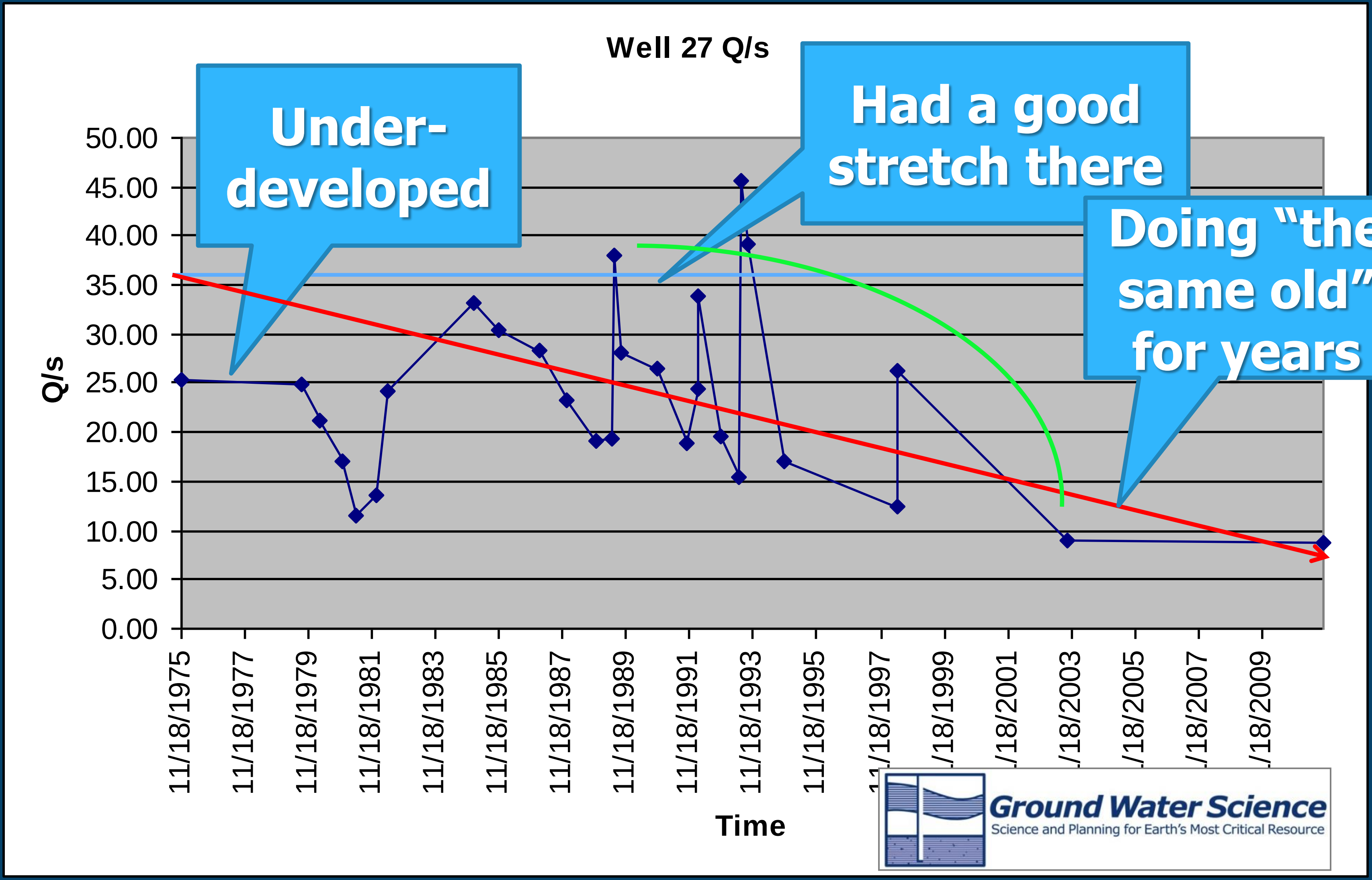
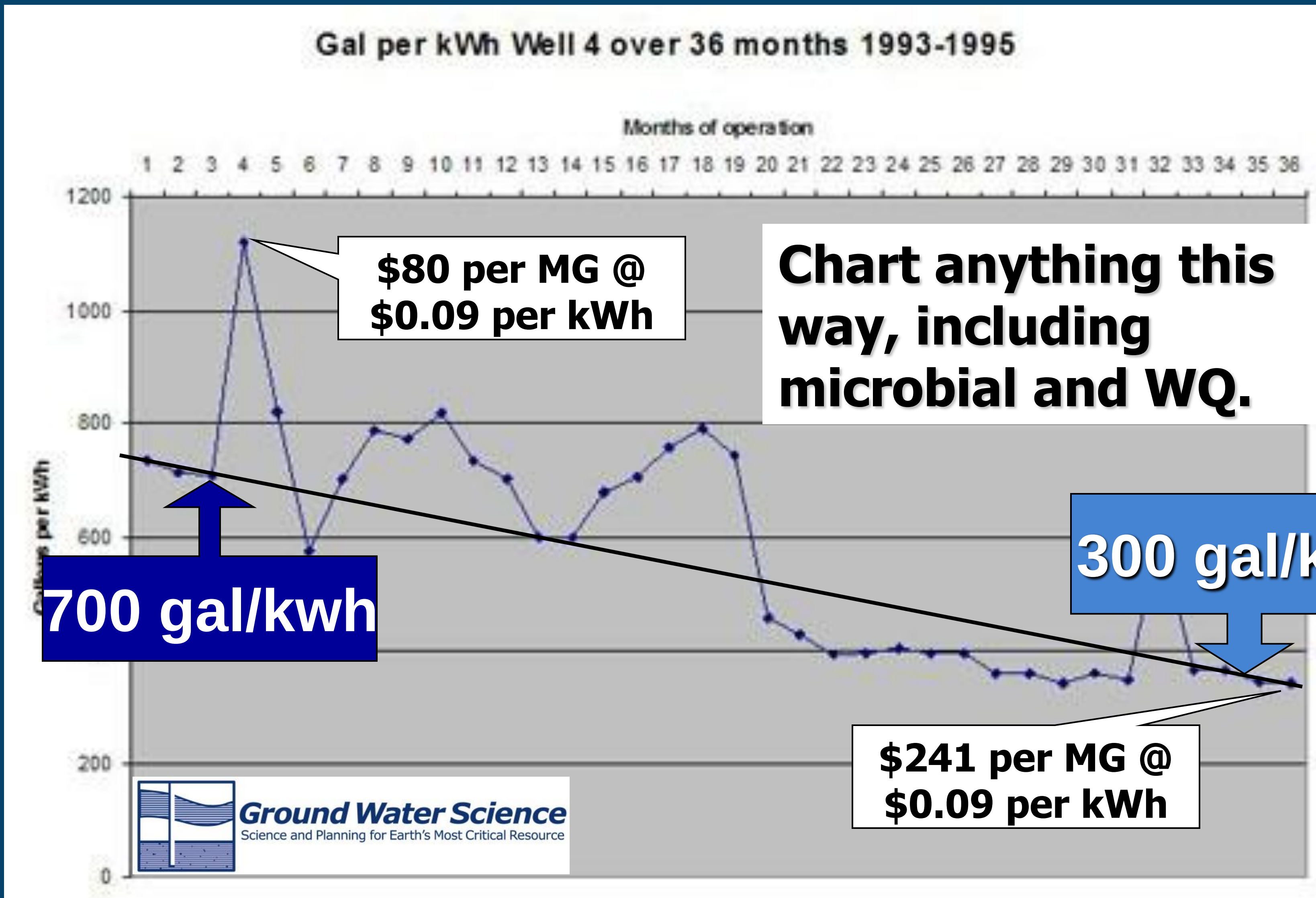
Comparison well charts



Histories: A 34-year specific capacity history of a well



Trend Analysis: gal per kWh

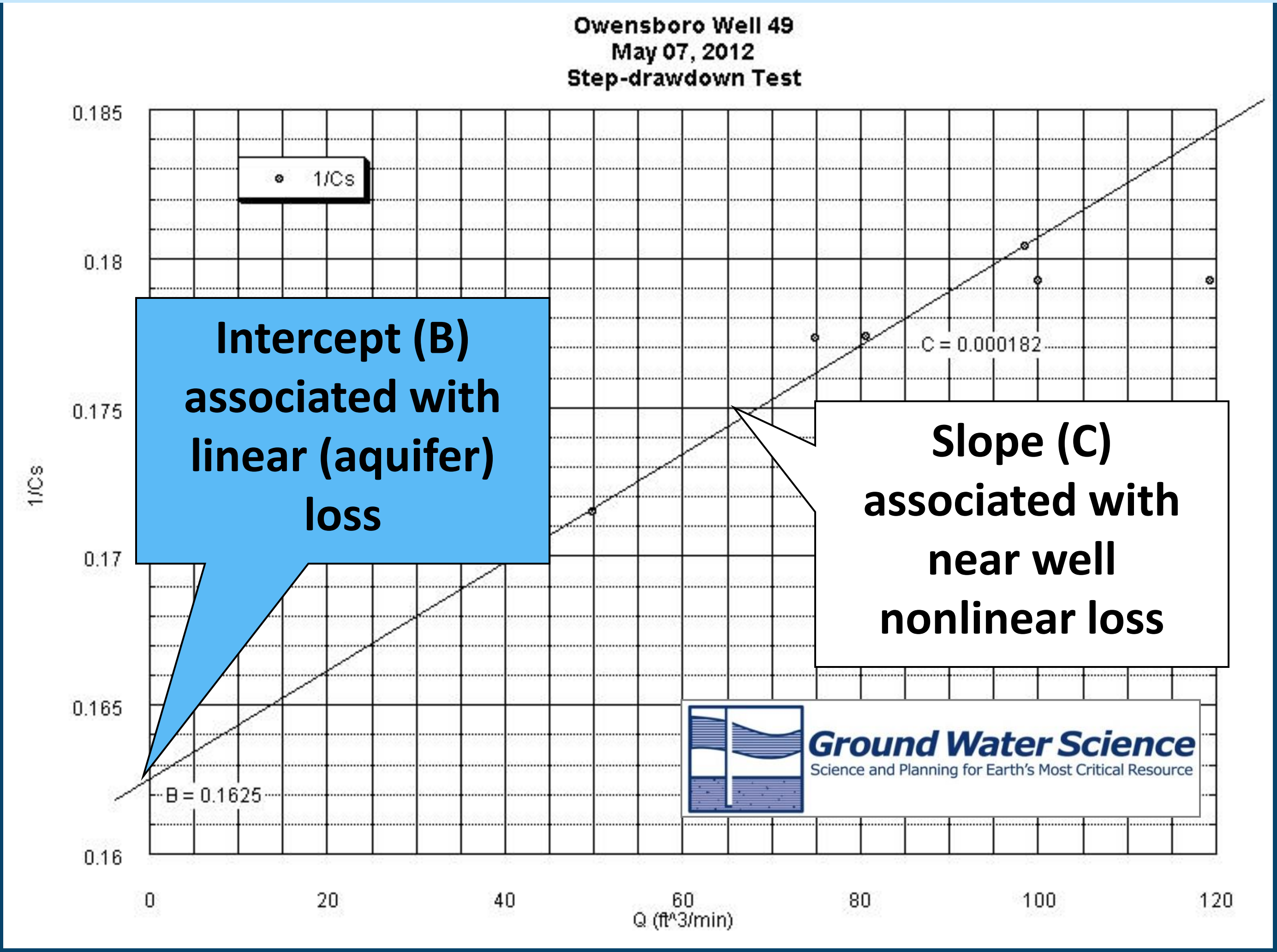


Detect anomalies (“anomaly” – not normal, unusual)

Well performance testing

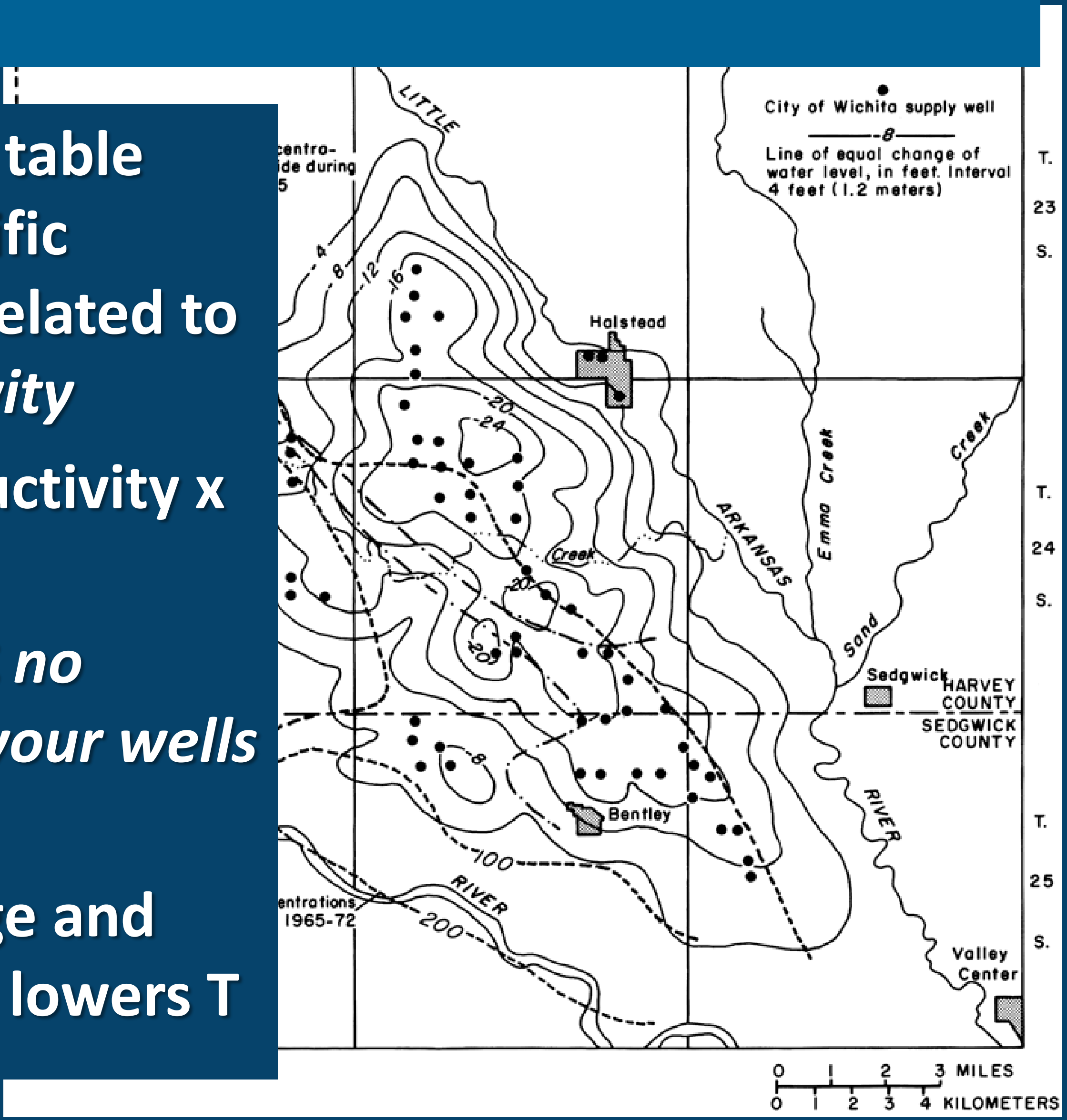
- Test plan
- Accurate water level measurement
- Timed for analysis
- Accurate flow measurement
- Geologist taking data

Specific capacity not the whole story: Step-drawdown test analysis to determine well loss components



Beyond well tests: Understanding the aquifer

- Especially in water table aquifers, well specific capacity is tightly related to aquifer *transmissivity*
- T = hydraulic conductivity x thickness
- Lower T = lower SC *no matter how clean your wells are*
- Both lower recharge and excessive pumping lowers T



Before and after cleaning and periodically

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Before and after well cleaning
and periodically
Set up to make this as easy as possible
and you are more likely to do it.
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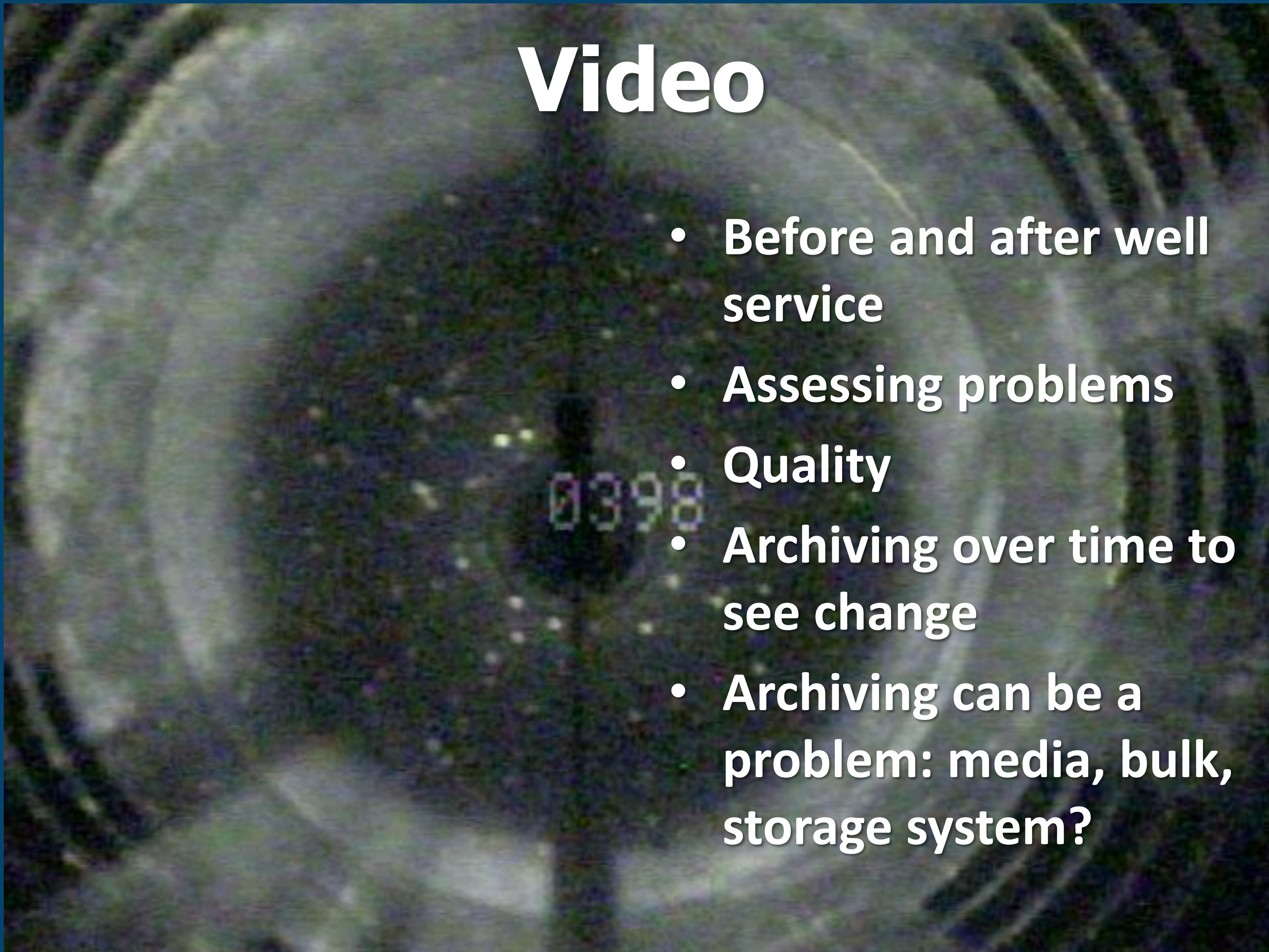
Meanwhile, collect routine well data

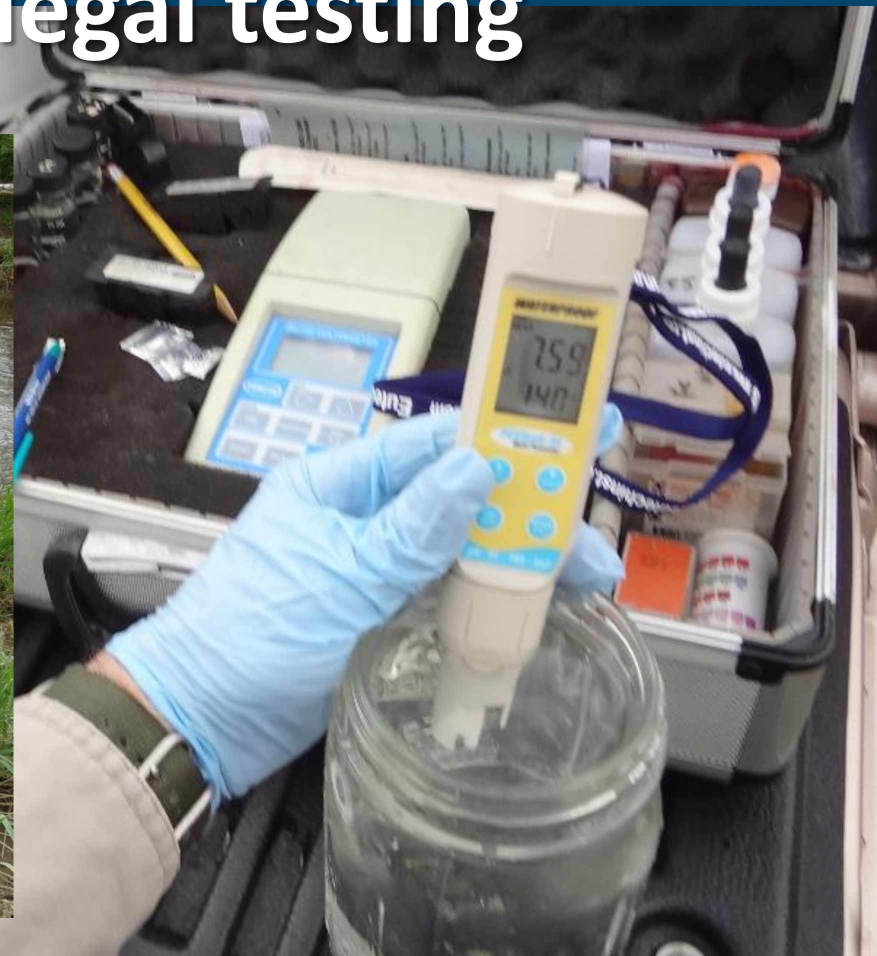
- Static (nonpumping) water levels
- Pumping water levels
- Flow rate (corresponding to PWL)
- Some reasonable interval depending on change
- Manual (by hand) or using sensors
- Check and maintain sensors, since they clog, coat over and corrode too

Video

- Before and after well service
- Assessing problems
- Quality
- Archiving over time to see change
- Archiving can be a problem: media, bulk, storage system?



Water quality monitoring: Beside and beyond your "EPA" legal testing



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Water quality testing during performance step tests

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What to Test For?
What do you want to know?

- Is the water sanitary and safe? SDWA parameters
- Taste and odor, corrosion and clogging: major ions, iron, sulfur, certain natural bacteria tests. SDWA+ and the "maintenance" tool kit
- Constituents that show that "alien" water has arrived, constituents specific to a matter of concern
- Nutrient sources
- Patterns of contamination such as bacteria or water quality change.

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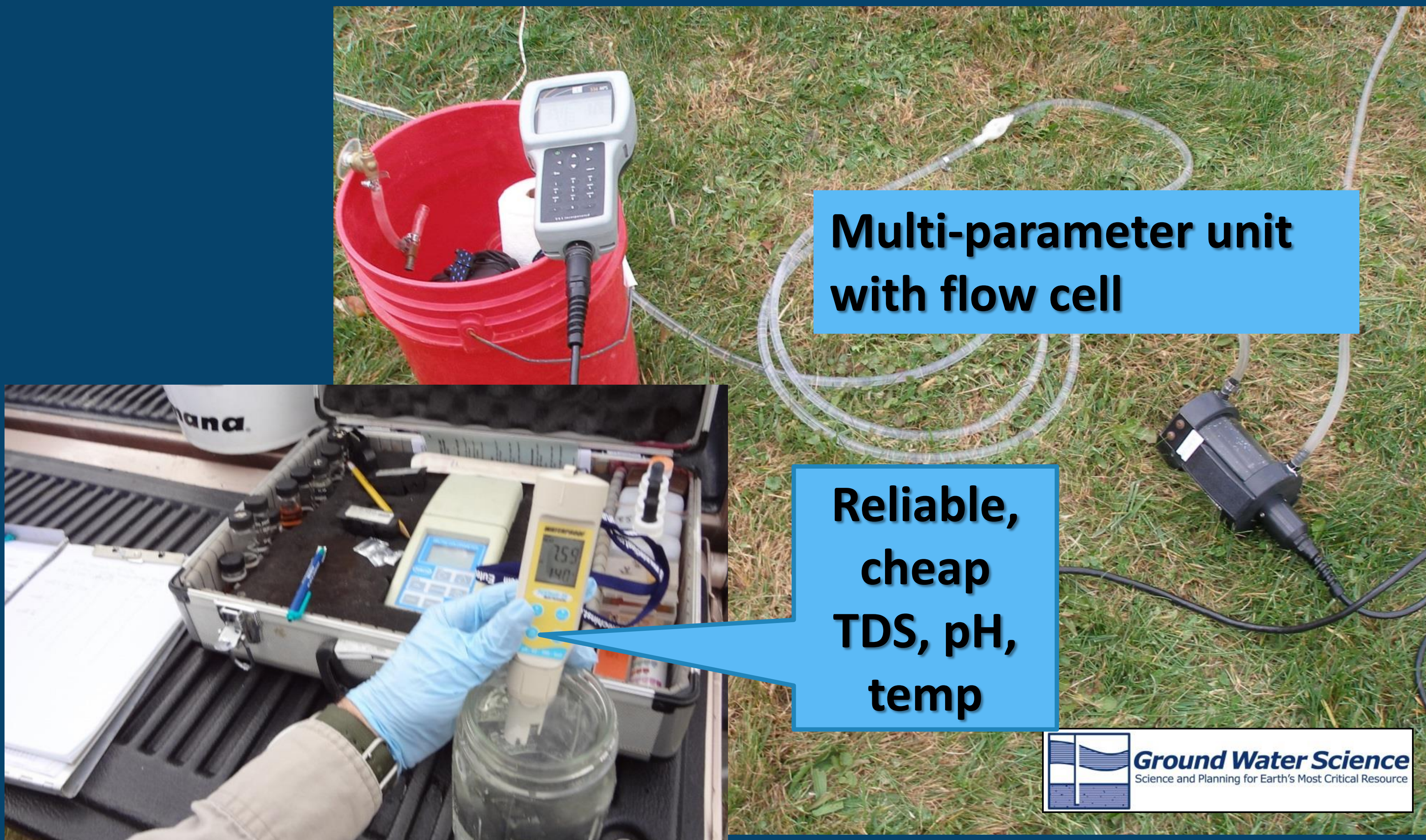
Water quality monitoring: Field instruments



Multi-parameter unit with flow cell

Reliable, cheap TDS, pH, temp

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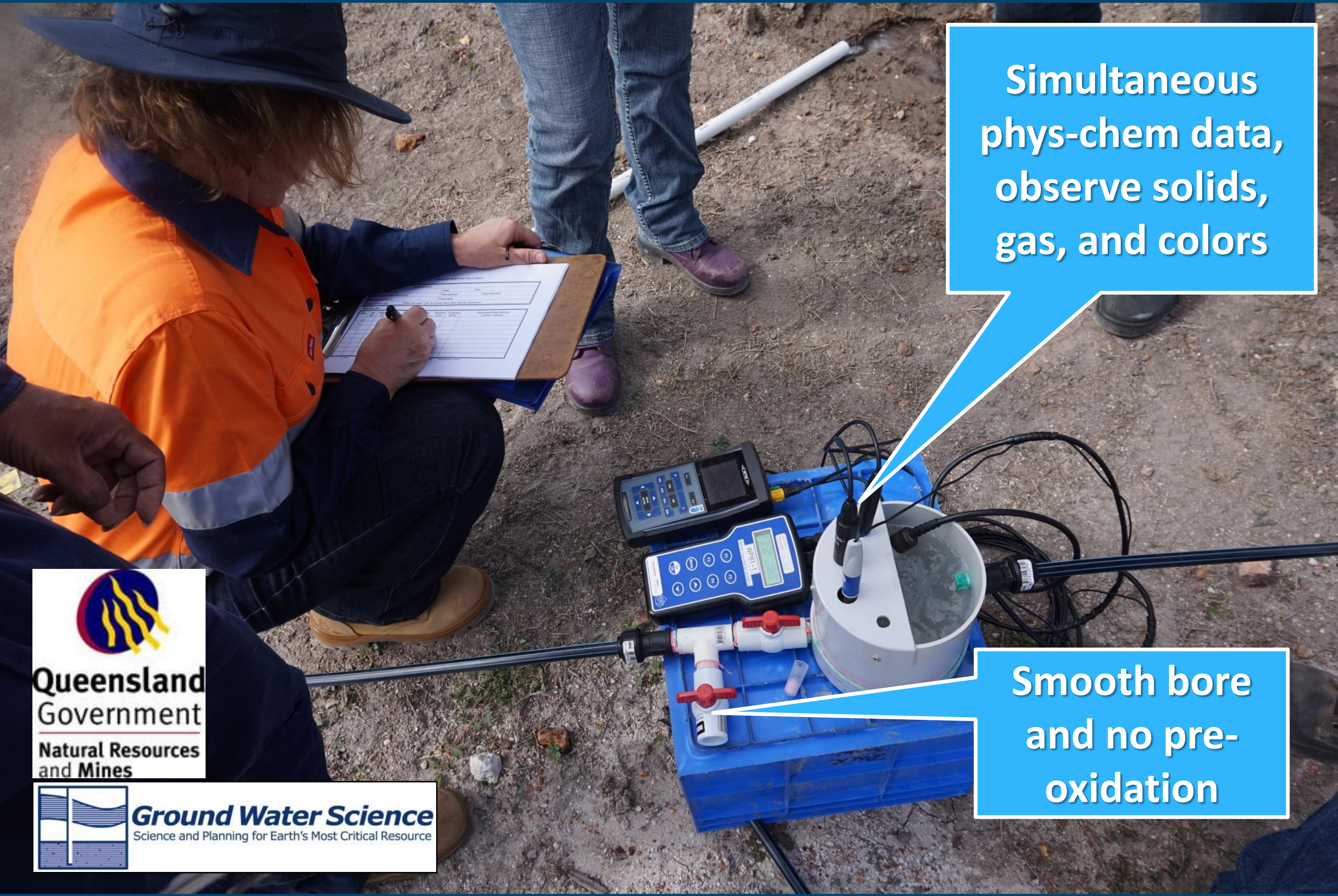
Simultaneous phys-chem data, observe solids, gas, and colors
Smooth bore and no pre-oxidation
Queensland Government
Natural Resources and Mines
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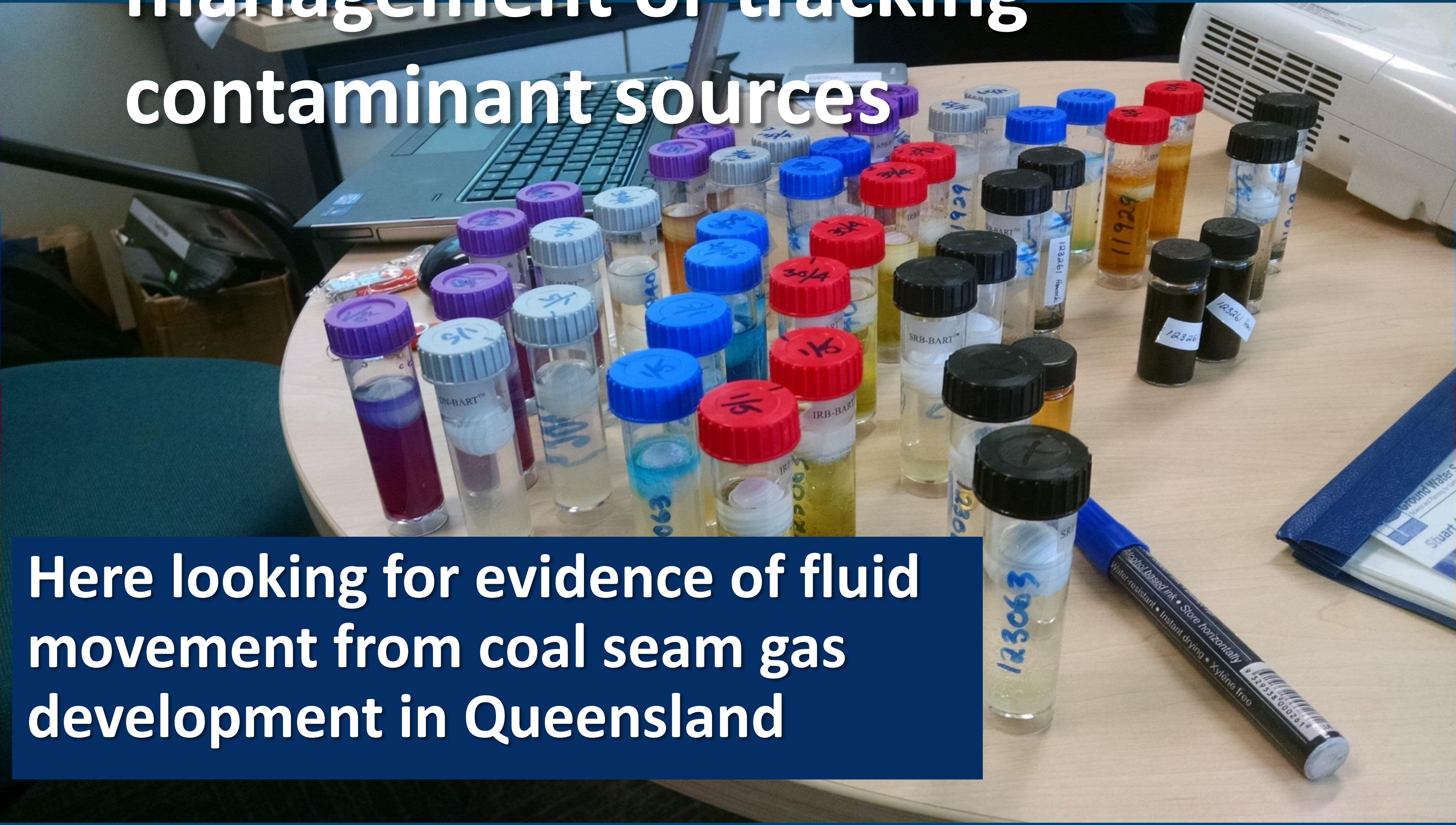
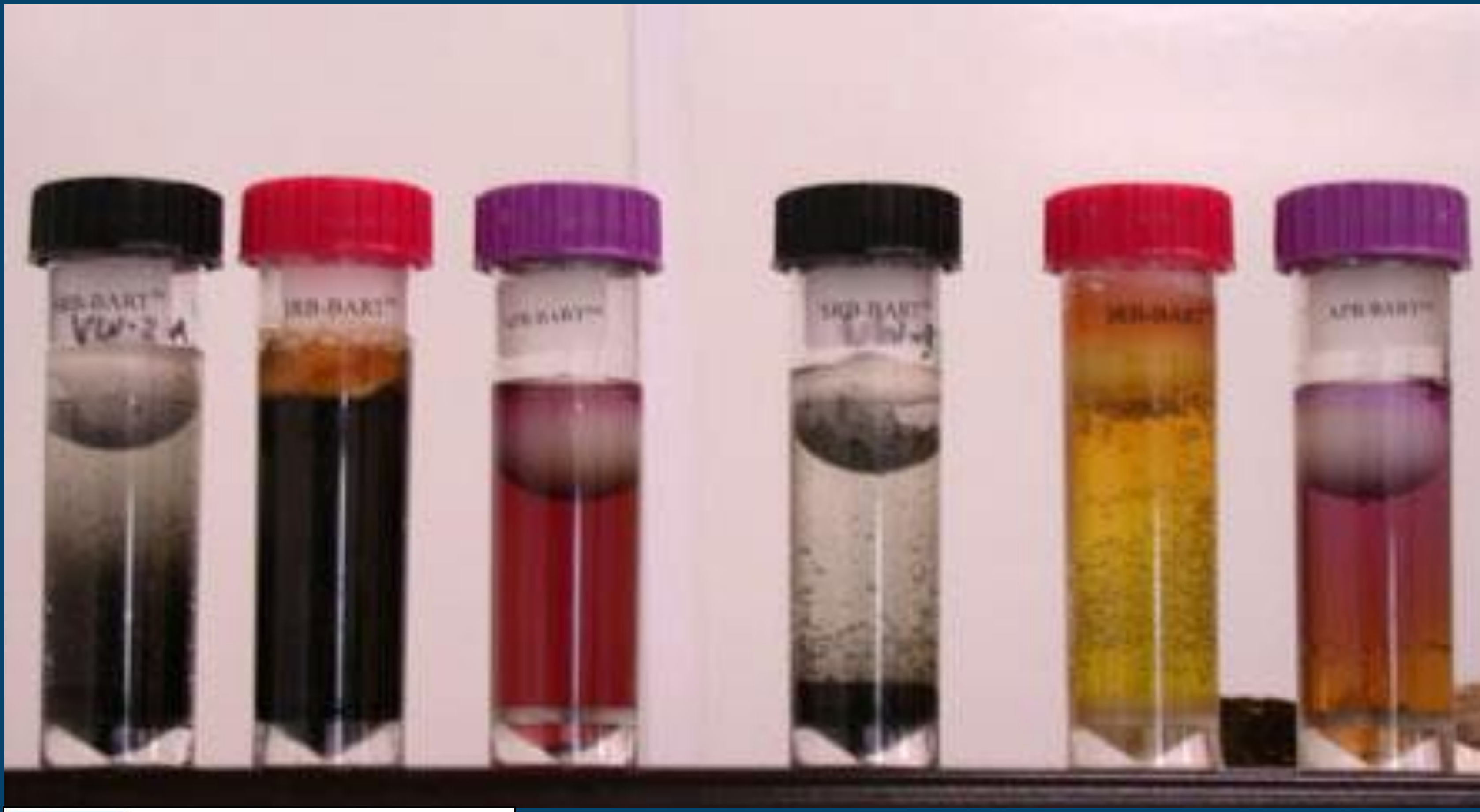
Biological testing for asset management or tracking contaminant sources



Here looking for evidence of fluid movement from coal seam gas development in Queensland

Anaerobic corrosion profile with APB-BART, SRB-BART, IRB-BART



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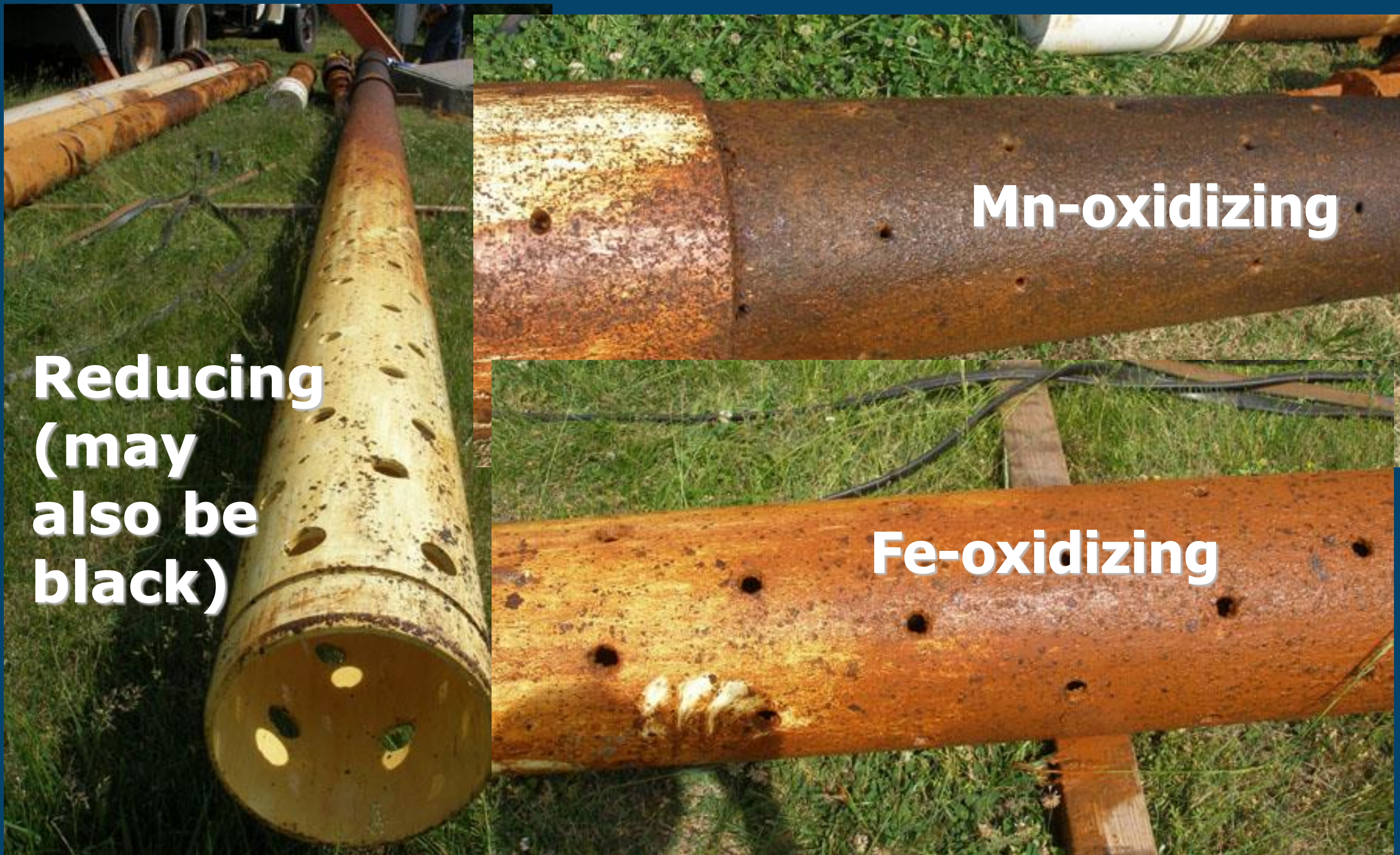
All bio testing combined with physical-chemical

Observation: Redox gradations




With data we can predict mechanisms that will degrade well performance, and the timing reasonably well – and you really should plan accordingly
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Likewise, we can predict water quality

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most of what you need to do microbial ecology fits in a few boxes in the vehicle or even a kayak

Biochemical Methods

- For example, DNA quantitative polymerase chain reaction (qPCR) to
  - Enumerate specific microbial groups
  - provide a profile of the microbial community and identify microorganisms present
  - Repeated tests allow a comparision over distance or time

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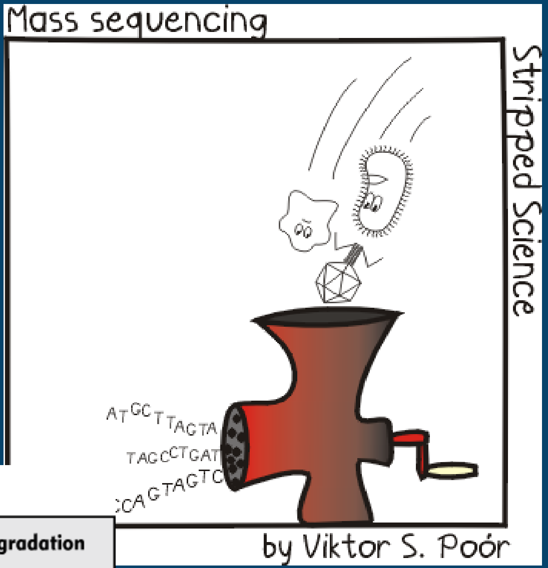
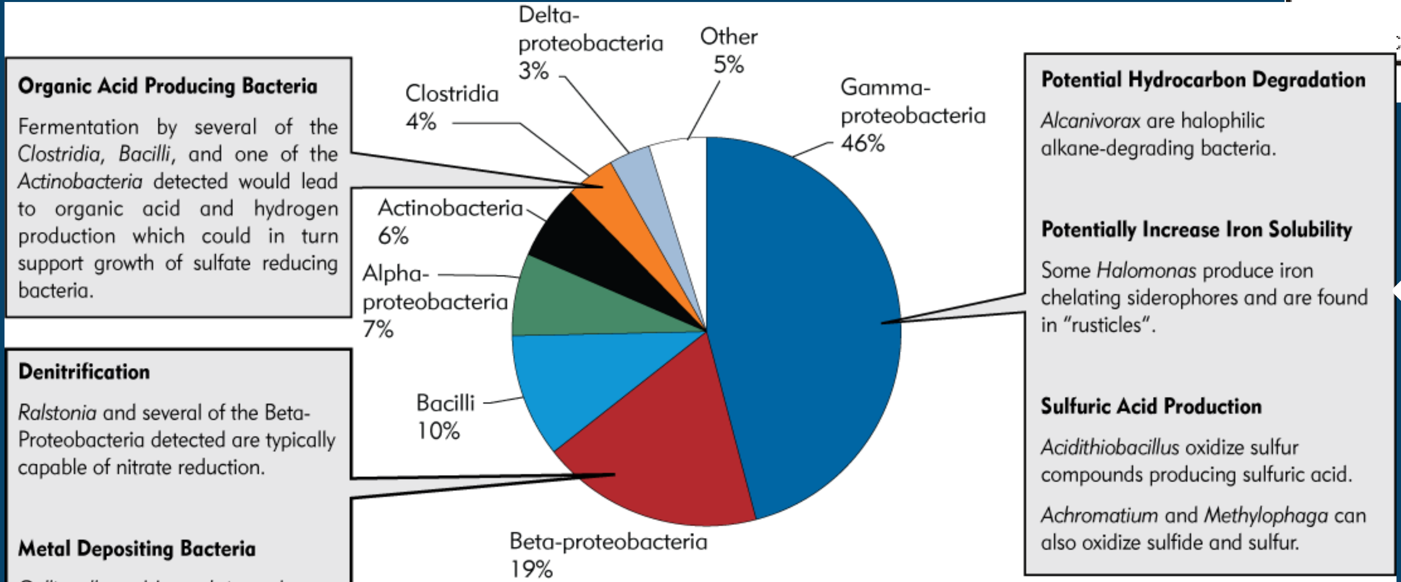
Next-Generation Sequencing

- Much information for the budget
- Things you miss otherwise
- Environmental and asset management purposes





The pie chart above depicts a microbial community profile from a field sample. Identification of specific bacteria and their potential roles in microbial processes including corrosion are highlighted in the call out boxes.

Microbial Insights, Inc.

Major strangeness in a Jordanian wellfield

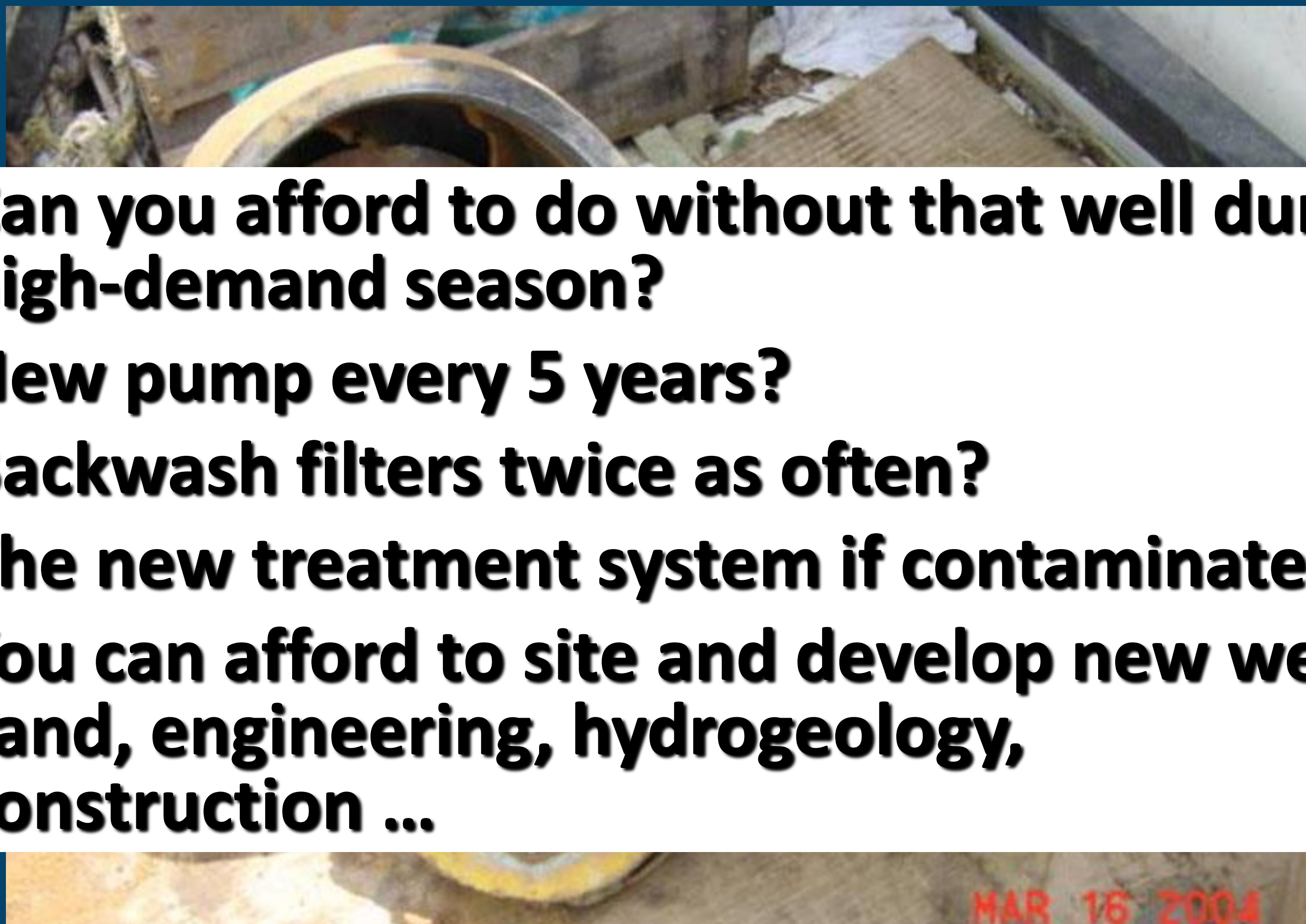
- Wells exhibiting massive biofouling a few months after construction
- Nitrate very high by our standards, and sometime nitrite higher than nitrate
- Wells are up to 560 m deep, high capacity

Better ways to evaluate the real vulnerability of radial collectors

Continuous monitoring

- **Not dependent on human sampling**
- **Potentially all year around**
- **Catches “events” between sampling events**
- **Limited range of parameters, but enough to trigger alarms and followup**

Count the cost: Can you afford to skip the PM or risk assessment?

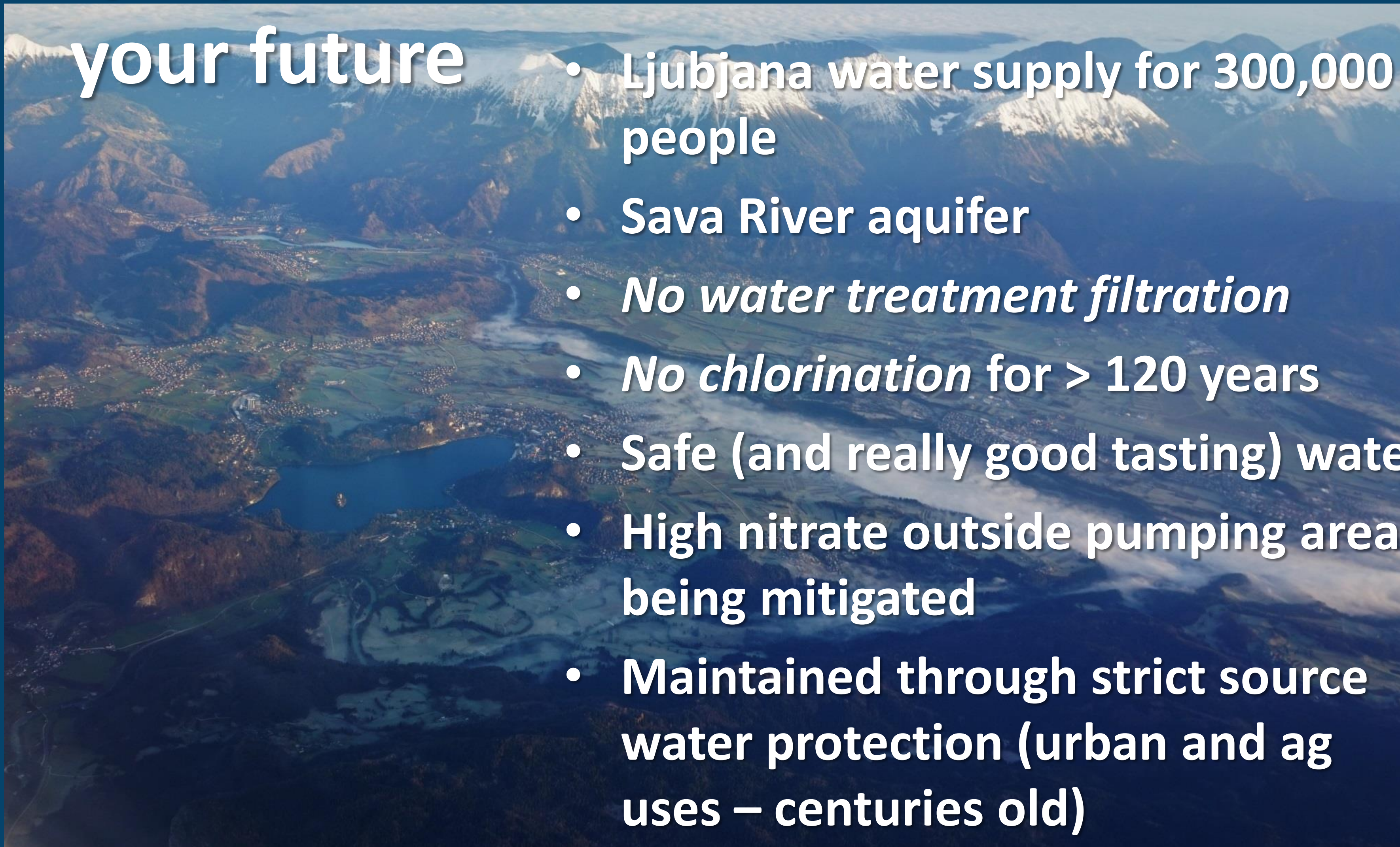


- Can you afford to do without that well during high-demand season?
- New pump every 5 years?
- Backwash filters twice as often?
- The new treatment system if contaminated?
- You can afford to site and develop new wells? Land, engineering, hydrogeology, construction …

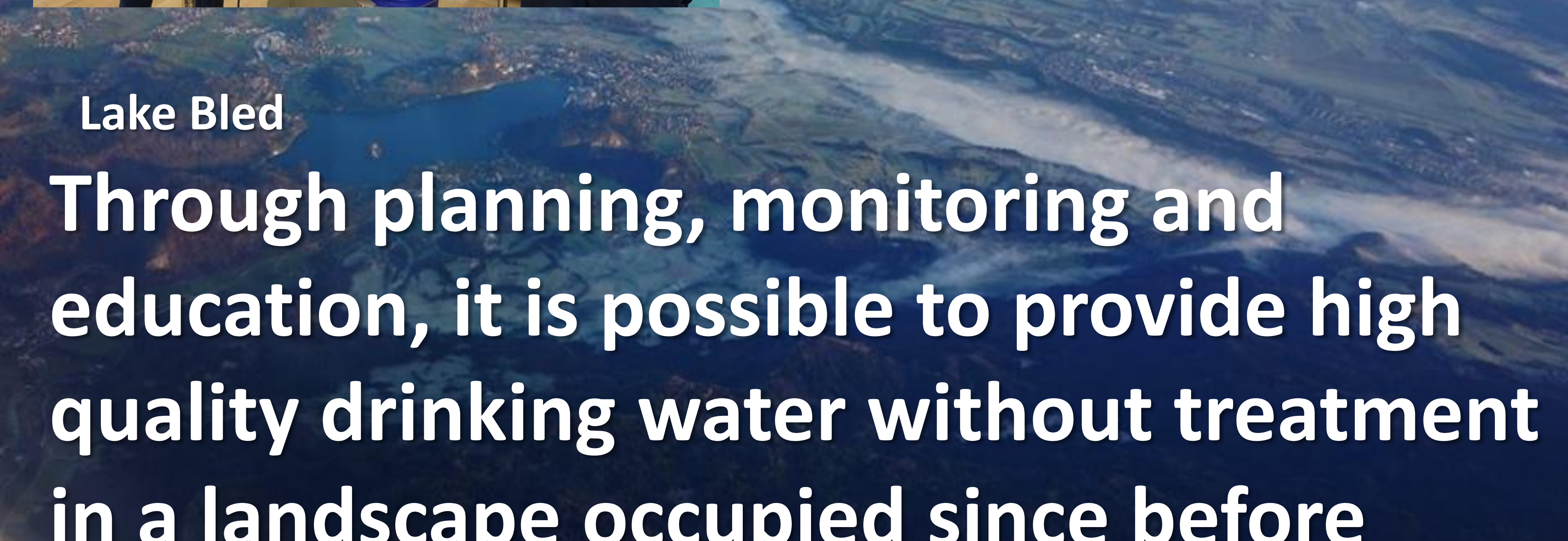
More data equals:

- Better choices in well siting and aquifer management
- Better maintenance trend lines – when to do treatments optimally for example
- Understanding water quality risks and how to deflect or avoid them
- Better communication with Ohio EPA

Ljubjana, Slovenia: this could be your future



- Ljubjana water supply for 300,000 people
- Sava River aquifer
- *No water treatment filtration*
- *No chlorination* for > 120 years
- Safe (and really good tasting) water
- High nitrate outside pumping areas being mitigated
- Maintained through strict source water protection (urban and ag uses – centuries old)



Through planning, monitoring and education, it is possible to provide high quality drinking water without treatment in a landscape occupied since before Roman times

Any questions? You can do this.

We do this talk all day in more depth when we have time and an audience

Testing risk assessment methods for wells in coal bed methane country, Australia

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stuart@groundwaterscience.com

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Why we work to improve water supplies

Water hauling is time-consuming and requires up to 1/3 of the calories a woman consumes in a day

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