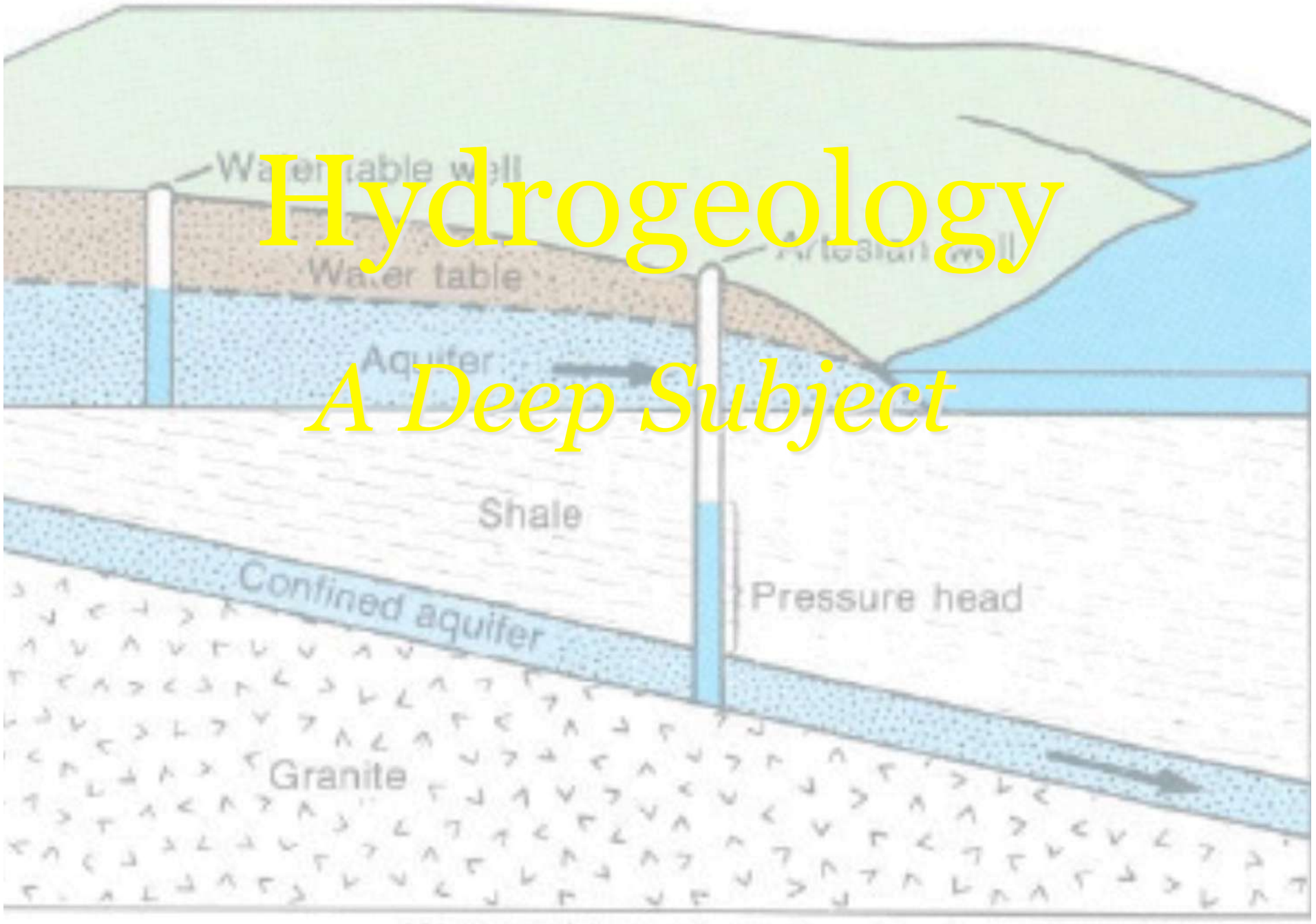
Hydrogeology

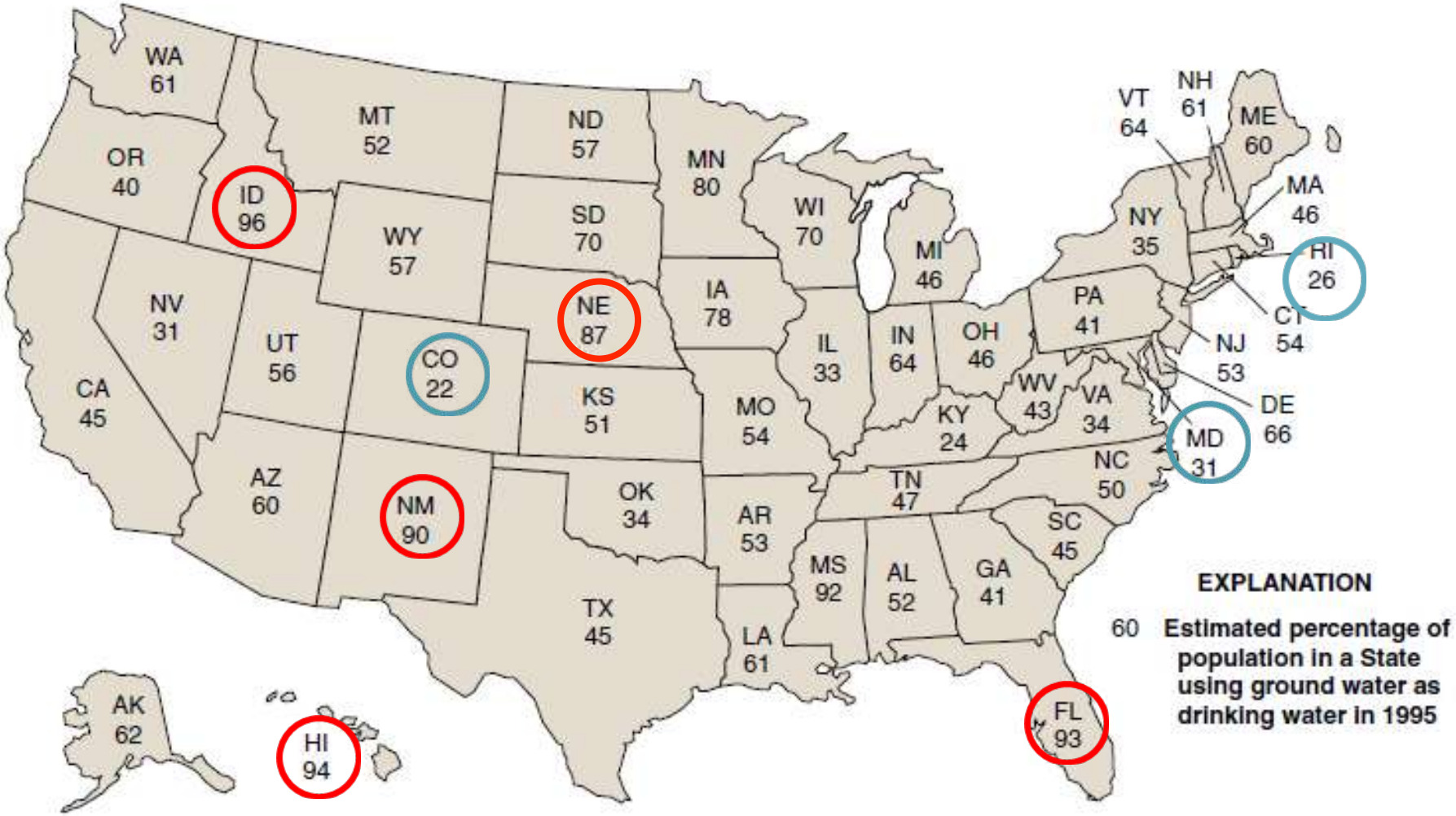
A Deep Subject



Background

This event combines several elements

- **Geology and hydrology, specifically associated with aquifers and groundwater**
- **Technology and procedures in the development and exploration of groundwater resources**
- **Environmental issues that impact groundwater, both quality and quantity; correction (or prevention?) of environmental impacts**
- **Groundwater modelling (simplified)**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WV 43
OH 46
PA 41
NY 35
VT 64
NH 61
ME 60
MA 46
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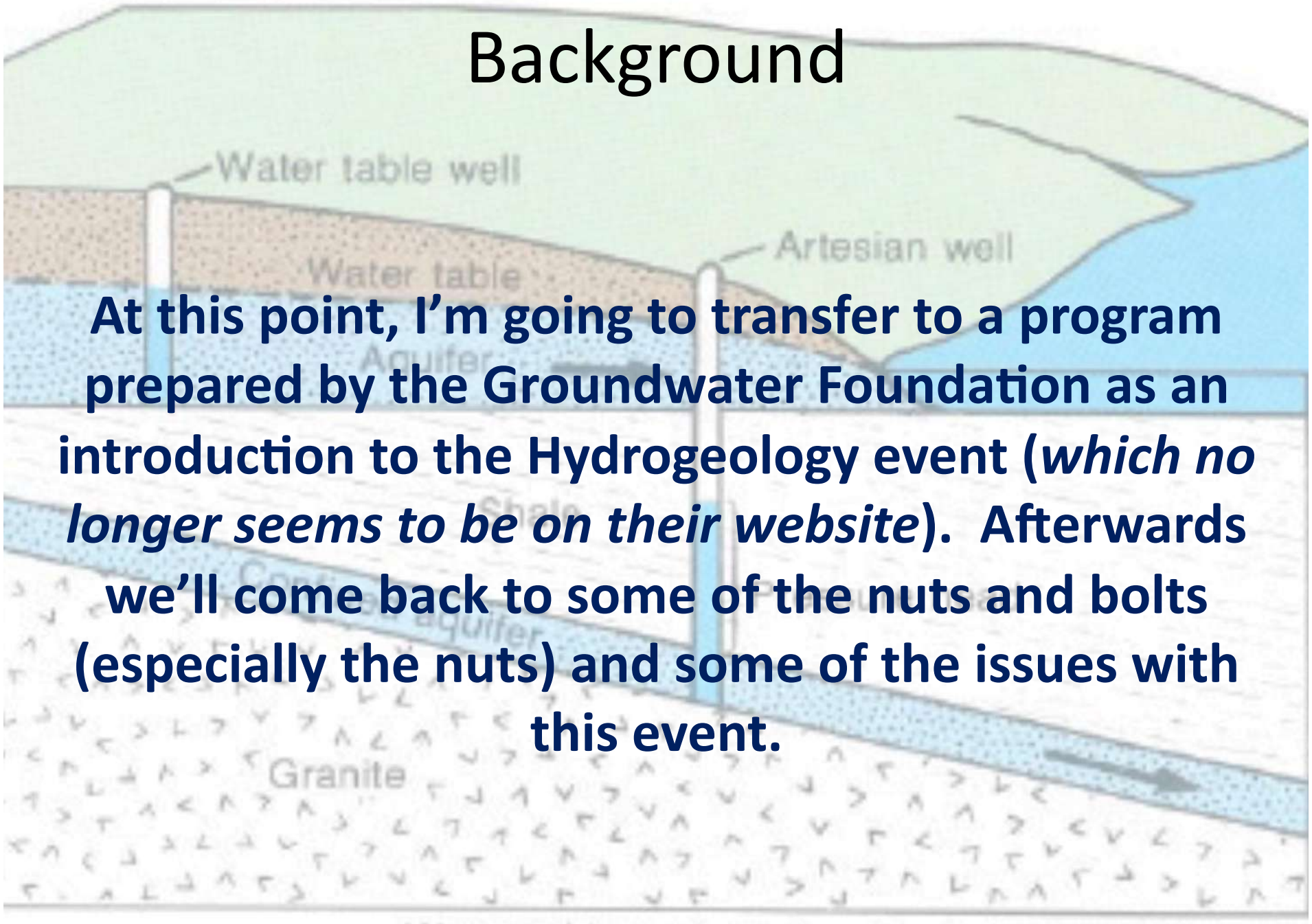
EXPLANATION
60 Estimated percentage of population in a State using ground water as drinking water in 1995

Background



At this point, I'm going to transfer to a program prepared by the Groundwater Foundation as an introduction to the Hydrogeology event (*which no longer seems to be on their website*). Afterwards we'll come back to some of the nuts and bolts (especially the nuts) and some of the issues with this event.

Hydrogeology
Division C Event

Nebraska Department of Environmental Quality

SCIENCE OLYMPIAD
Exploring the World of Science

J.A. Woollam Foundation

Science Olympiad
Summer Institute

The Nebraska Environmental Trust
preserving NATURAL NEBRASKA™ for future generations

KACEE
KANSAS ASSOCIATION FOR CONSERVATION & ENVIRONMENTAL EDUCATION

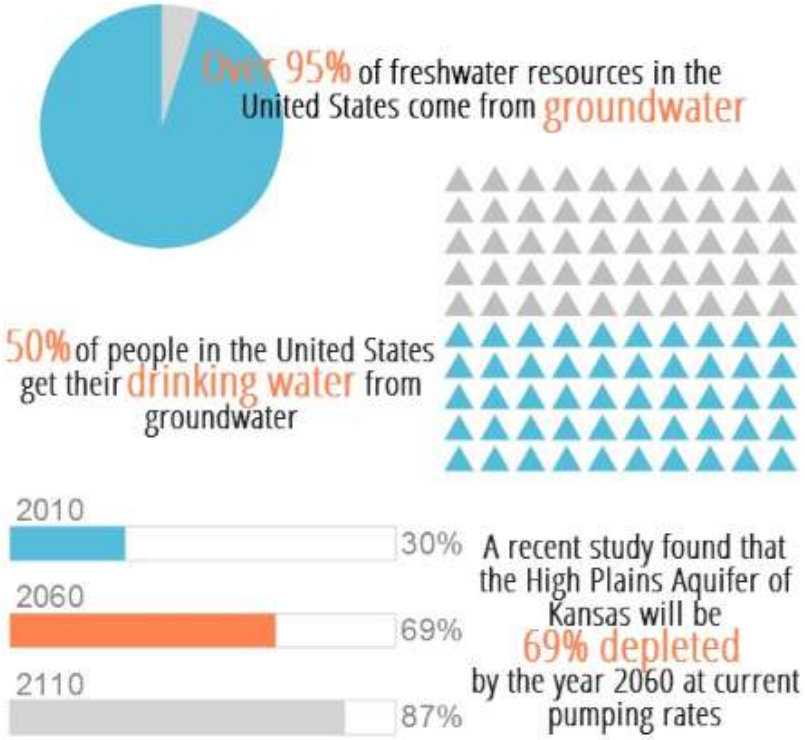
OLSSON ASSOCIATES

Hydrogeology – What is it?

- **Hydrogeology – The study of groundwater**
- **A new SO Division C event incorporating groundwater computer modeling**

Why is Hydrogeology important?

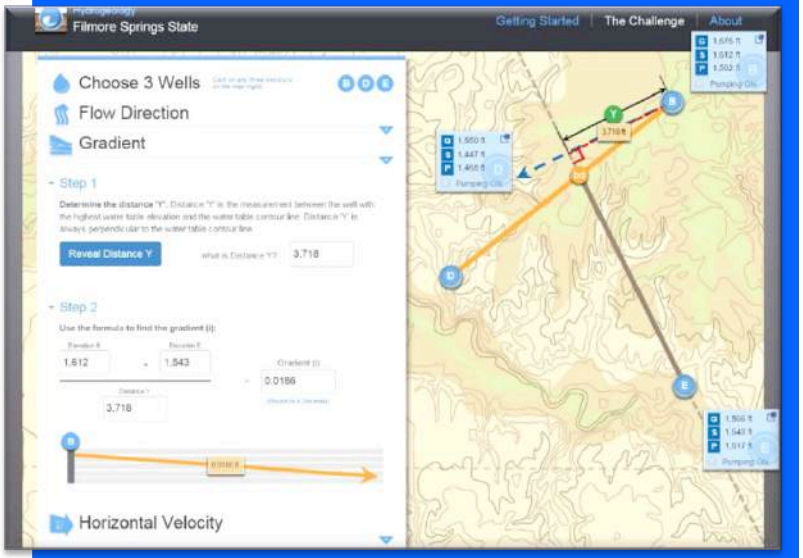
Groundwater Facts:



- **Allows students to visualize a resource (groundwater) that is difficult to see in every day life.**
- **Computer modeling has wide applications in many fields, not just groundwater**

About Hydrogeology

- Three part event
  - Part 1: Written Test
  - Part 2: Running the model
  - Part 3: Applying model output to real life (??) situations



Running the Event: Required Items

A computer or tablet with access to the internet

Writing utensils

<u>Optional Items</u>

Calculator

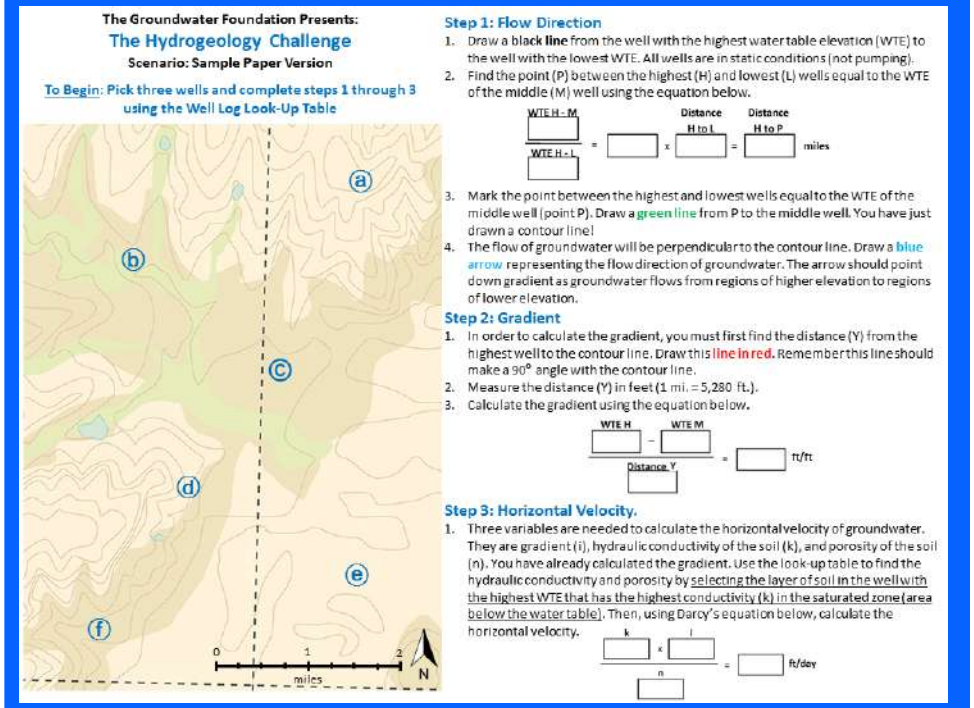
Protractor

8.5” x 11” Note Sheet

http://groundwater.beehere.net

No Computer? No Problem!

- There is a paper version of the Hydrogeology Challenge (groundwater computer model)
- Requires: Rulers, Colored Pencils
- Contact ~~Anthony Lowndes~~ Jessica Wheeler at The Groundwater Foundation if you wish to use the paper version



The Groundwater Foundation Presents:

The Hydrogeology Challenge

Scenario: Sample Paper Version

To Begin: Pick three wells and complete steps 1 through 3 using the Well Log Look-Up Table

ⓐ ⓑ ⓒ ⓓ ⓔ ⓕ

0 1 2 miles N

Step 1: Flow Direction

1. Draw a black line from the well with the highest water table elevation (WTE) to the well with the lowest WTE. All wells are in static conditions (not pumping).
2. Find the point (P) between the highest (H) and lowest (L) wells equal to the WTE of the middle (M) well using the equation below.

$$\frac{\text{WTE H - M}}{\text{WTE H - L}} = \square \times \text{Distance H to L} = \text{Distance H to P}$$ miles

3. Mark the point between the highest and lowest wells equal to the WTE of the middle well (point P). Draw a green line from P to the middle well. You have just drawn a contour line!
4. The flow of groundwater will be perpendicular to the contour line. Draw a blue arrow representing the flow direction of groundwater. The arrow should point down gradient as groundwater flows from regions of higher elevation to regions of lower elevation.

Step 2: Gradient

1. In order to calculate the gradient, you must first find the distance (Y) from the highest well to the contour line. Draw this line in red. Remember this line should make a 90° angle with the contour line.
2. Measure the distance (Y) in feet (1 mi. = 5,280 ft.).
3. Calculate the gradient using the equation below.

$$\frac{\text{WTE H} - \text{WTE M}}{\text{Distance Y}} = \square \text{ ft/ft}$$

Step 3: Horizontal Velocity.

1. Three variables are needed to calculate the horizontal velocity of groundwater. They are gradient (i), hydraulic conductivity of the soil (k), and porosity of the soil (n). You have already calculated the gradient. Use the look-up table to find the hydraulic conductivity and porosity by selecting the layer of soil in the well with the highest WTE that has the highest conductivity (k) in the saturated zone (area below the water table). Then, using Darcy's equation below, calculate the horizontal velocity.

$$\frac{k \times i}{n} = \square \text{ ft/day}$$

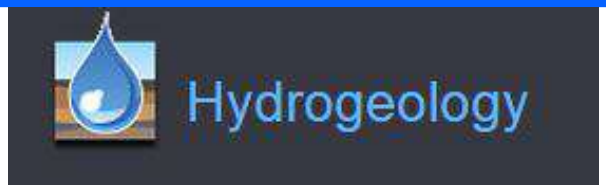
The Competition

- Students work in teams of up to 2
- They have 50 minutes to complete all three parts of the event
- They can complete the three parts in any order (*Nope!*)
- Event set-up is simple:
  - Generally a computer lab is preferred
  - Place two chairs per one computer
  - Pull up model URL on computer (or tablet)
  - You're ready to go!

Part 1

- Written Test
- 25% of total score *(Now 30%)*
- May include concepts such as:
  - The fundamentals of groundwater and hydrogeology
  - Surface-groundwater interactions
  - The relation of groundwater flow to geologic structure
  - The management of contaminated groundwater
- Questions can be multiple choice, true/false, fill in the blank, or short answer

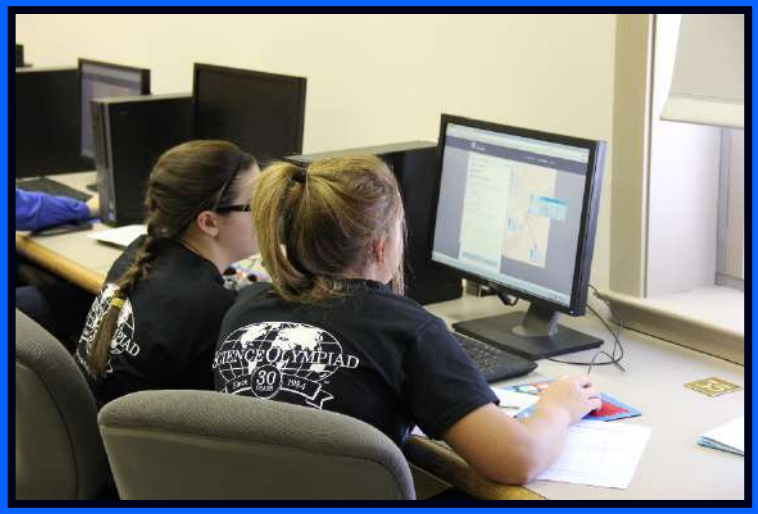
Part 2



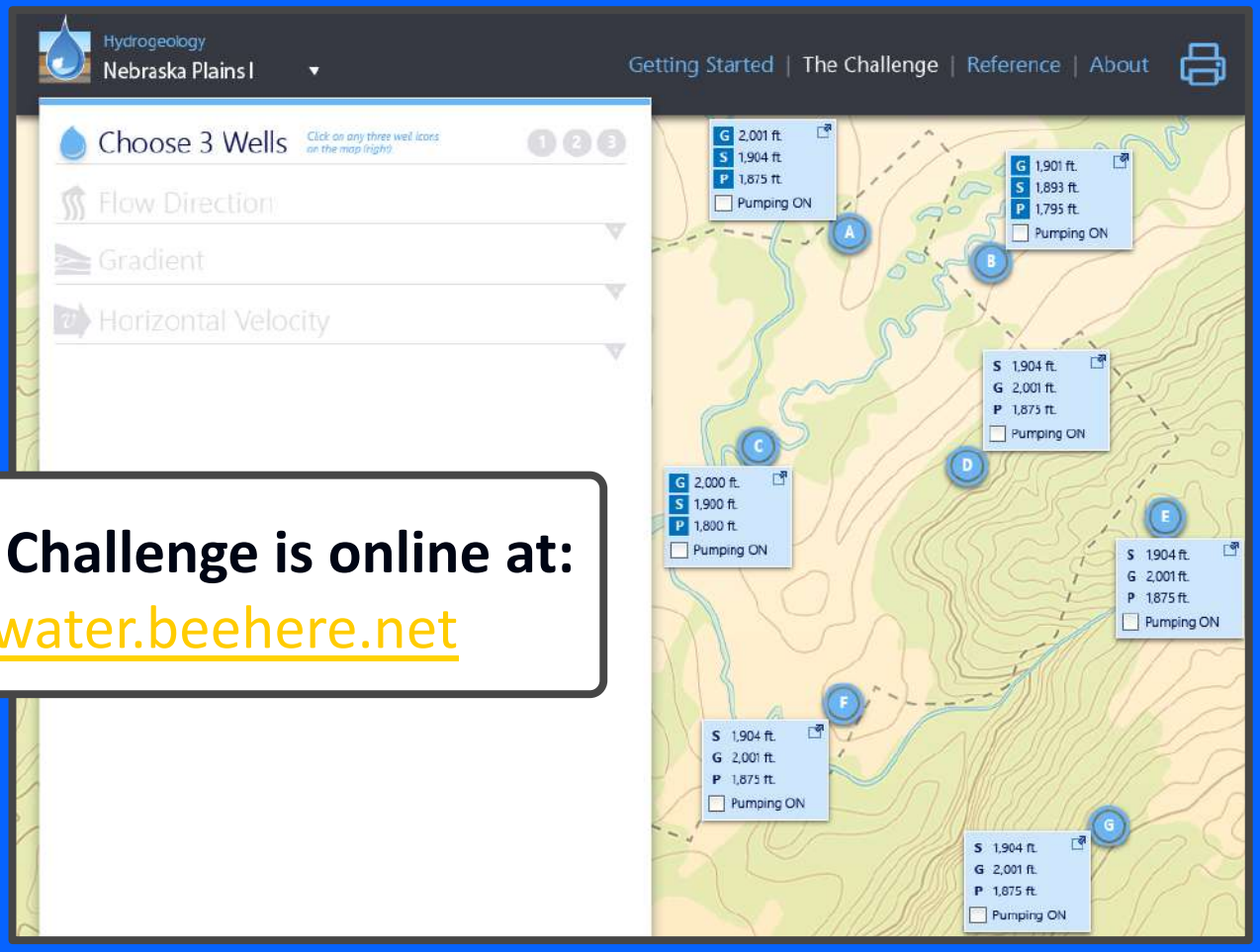
- **Students run the Hydrogeology Challenge for a scenario in which the Event Supervisor select <u>three wells in static conditions</u>**
- **25% of total score** ***(Now 10%)***
- **Easy Grading – the computer grades it for you!!!** ***Not if you opt for the paper version.***

The Hydrogeology Challenge

- Learning Tool
- Basic Groundwater Modeling Concepts
  - Flow Direction
  - Gradient
  - Horizontal Velocity
- Simple Calculations
- Simple Assumptions
- Fun and easy! *(Way too easy?)*



The Hydrogeology Challenge



The Hydrogeology Challenge is online at:
http://groundwater.beehere.net

Part 3

- The Event Supervisor provides a set of circumstances for which the students:
  - Evaluate the risk of contamination to wells
  - Explain any and all assumptions made in their analysis
  - Complete a Remediation Techniques Table
- 50% of total score *(Now 60%)*
- Most complex portion of event, but resources will be available to allow even non-experts to write this portion of the event.

Part 3 – Set of Circumstances

- The Set of Circumstances must include:
  - Non-static conditions (at least one well must be pumping water)
  - A pollutant (from the Contaminant Table)
  - A pollution source to be located at one well.
- The Set of Circumstances may include:
  - Well types
  - Well uses
  - Any other information the Event Supervisor deems relevant to the scenario

Part 3 – Modeling

- **The students will manipulate the Hydrogeology Challenge scenario to determine:**
  - **Which wells are at risk**
  - **Approximate time frame until the contaminant may reach at risk wells**

Part 3 – Remediation Table

- **Students fill out a Remediation Techniques Table:**

Example of Remediation Technique Table for use in Hydrogeology: Water for the World Event

Remediation Technique	Definition	In-situ or ex-situ	Type (Biological, Phyical, or Chemical)	Cost (low, medium, high)	Applicable to [Given Pollutant] (yes/no)
Air Stripping					
Phytoremediation					
Activated Carbon Treatment					
Bioremediation					

Part 3 – Additional Questions

- **Students will use their results from the Hydrogeology Challenge and Remediation Techniques Table to answer questions about the scenario.**
- **Questions can be multiple choice, true/false, fill in the blank, or short answer.**

Contaminant Table

Contaminant Table for Hydrogeology: Water for the World

Category	Sub-category	Pollutant	About	DNAPL or LNAPL?*	Sources
Volatile Organic Compounds (VOCs)**	Halogenated	Carbon Tetrachloride	A grain fumigant used to make refrigerants and propellants for aerosol cans as well as a solvent and dry cleaning agent.	DNAPL	Disposal in landfills; accidental releases from production uses; grain storage facility
		Chloroform	A chemical that used to be used as an extraction solvent and is now mainly used to make propellant and refrigerant.	DNAPL	Pulp and paper mills; municipal and industrial waste water; large processing facilities; Septic Systems
		Perchloroethylene (PCE)	A solvent often used for dry cleaning and metal degreasing.	DNAPL	Dry Cleaners; Textile operations; Metal degreasing activities
		Trichloroethylene (TCE)	An industrial solvent commonly used for metal degreasing, refrigerant manufacturing, and cleaning kerosene-fueled rocket engines.	DNAPL	Industrial degreasing operations; automotive industry; metal machining industry; chemical waste sites; leaking storage tanks and pipelines; Landfills
		Fluorotrichloromethane (Freon 11)	Prior to 1996 this compound was widely used as a refrigerant. Freon-11 was banned in 1996 for its ozone depletion potential.	DNAPL	Illegal drug labs; Landfills; industrial solvent spills
	Nonhalogenated	Acetone	A common solvent used for cleaning, nail polish remover, and paint thinner.		Production wastewater; Landfills
		Methanol	A naturally occurring substance often used as a gasoline additive, paint stripper, propellant for aerosol cans, and cleaners.		Release from tank truck or rail cars; Underground methanol storage tank
		Benzene, Toluene, Ethylbenzene, and Xylene (BTEX)	A group of naturally-occurring chemicals that are typically found in petroleum products. They have a strong odor and are highly flammable.	LNAPL	Leaks from underground storage tanks; Fuel spills; Landfills; Pipeline leaks
		Methyl Tert-Butyl Ether (MTBE)	A manufactured chemical compound used as a fuel additive and solvent. It has an offensive taste and odor.		Leaks from underground or aboveground storage tanks; Fuel spills; Pipeline leaks; Landfills
Semivolatile Organic Compounds (SVOCs)	Halogenated	Pentachlorophenol (PCP)	A white solid that is used as a wood preservative and was used as an herbicide in the past. Herbicide use of PCP was banned in 1987.	DNAPL	Leaching from treated wood products; spills at industrial facilities; hazardous waste sites; atmospheric deposition in precipitation
		Polychlorinated Biphenyls (PCBs)	PCBs were banned in 1977, but before then they were used as coolants and lubricants. They can still be found in some products	DNAPL	Landfills; Discharge of waste chemicals

Remediation Techniques

SUGGESTED REMEDIATION TECHNIQUES

Regional (Red)	State (Blue and Red)	National (Green, Blue, and Red)
Air stripping Bioremediation Activated Carbon Treatment (Assuming Pumping) Phytoremediation Monitored Natural Attenuation Reverse Osmosis Vertical Egineered Barriers (VEB) Incineration	All of the categories from Regional plus the following: Permeable Reactive Barrier (PRB) Chemical Reduction Oxidation Air Sparging Bioslurping or Dual Phase Extraction Precipitation/Coagulation/Flocculation	All of the categories and pollutants from Regional and State plus any other techiques found in the Remediation Technologies Screening Matrix

*The cost of a remediation technique can vary greatly and depends upon many factors. This table is meant to be an estimated cost based on data from the Remediation Technologies Screening Matrix and Reference Guide (1994) as well as professional opinion.

Further Resources For Remediation Techniques

- http://www.epa.gov/superfund/remedytech/remed.htm
- https://clu-in.org/products/citguide/
- https://frtr.gov/matrix2/section3/table3_2.pdf

Scoring

- Highest Score Wins
- Part 1= ~~25%,~~ Part 2 = ~~25%,~~ Part 3 = ~~50%~~
- Tiebreakers:
  - 1st tiebreaker: highest score on Part 3
  - 2nd tiebreaker: highest score on pre-selected questions from Part 1

Additional Hydrogeology Resources

- **All additional resources (Contaminant/remediation tables, lesson plans, Hydrogeology Challenge website, etc.) are currently located at www.groundwater.org/so.html**
- **Many new resources have been added:**
  - **2014 Workshop Video**
  - **Hydrogeology Challenge Walkthrough Video**

  I recommend viewing both of these videos – at least once
  - **Updated Event Guides for Students and Event Supervisors – *designed to make running Hydrogeology easy!***

How to Get Started

Contact ~~Anthony Lowndes~~ (left last spring) Jessica Wheeler at

The Groundwater Foundation

jwheeler@groundwater.org

402-434-2740 ext. 111

www.groundwater.org/so.html

Some of the problems that we identified last year

- Probably the biggest obstacle is that this is an unfamiliar topic to most folks and there are limited resources to draw on at most high schools.
- That makes it difficult for the uninitiated to put a test together. Or to find an "initiated" person to help.
- The Groundwater Foundation is looking at putting together a few "package" exams to help fill this gap. Probably for use at Regional competitions. (Maybe State??)

Problems (continued)

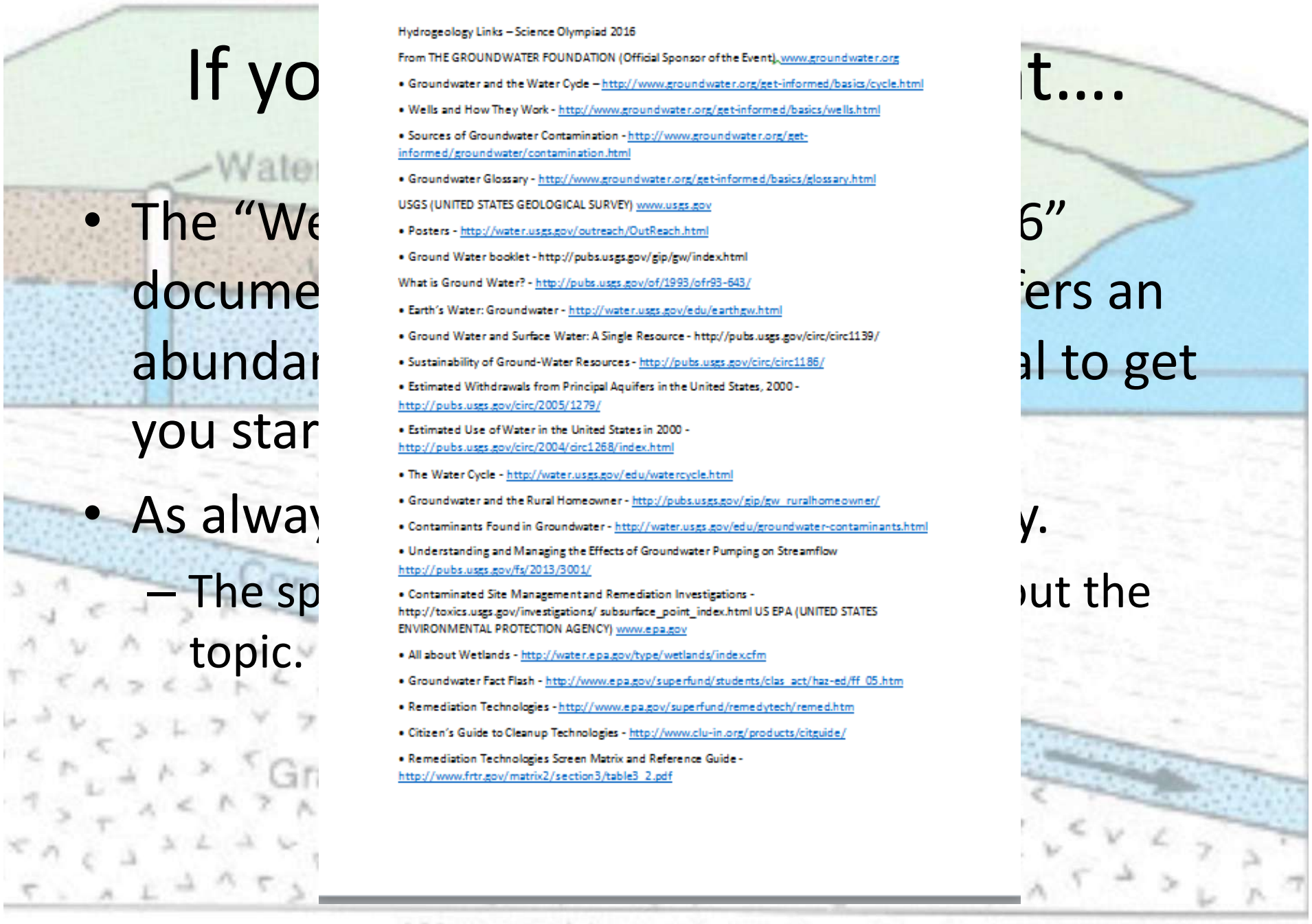
- Part 2, the Hydrogeology Challenge is not a "challenge"; more like the Hydrogeology Exercise
  - It's too easy (excessive "hand holding") – not likely to change
  - Scenarios (physical settings) were all very similar - got better, getting more better (we hope)
  - The modeling simplifications warp reality
  - Way too much relative weight (one of the biggest changes)
- Too few questions (in parts 1 and 3)

Problems (continued)

- Limited creativity/depth in the questions; redundant, simple, no math
- Virtually all the tests follow the "cookbook" (the Event Guide) – no surprise, minimal challenge – Every test looked the same
- The Remediation Techniques Table – as a creative analysis element – hasn't got much on the ball.
  - *Just check your notes, fill in the blanks*

Next steps (maybe??)

- Read the event description (Duh!)
- Read the "Event Guide" (downloadable from the Groundwater Foundation website)
  - This provides a much more thorough description of what was anticipated for this event and helps make more sense out of the event description
  - The "Guide" (unfortunately) is the same as last year with only a few minor changes



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- As alway…y.
  - The sp…out the topic.

Hydrogeology Links – Science Olympiad 2016

From THE GROUNDWATER FOUNDATION (Official Sponsor of the Event), www.groundwater.org

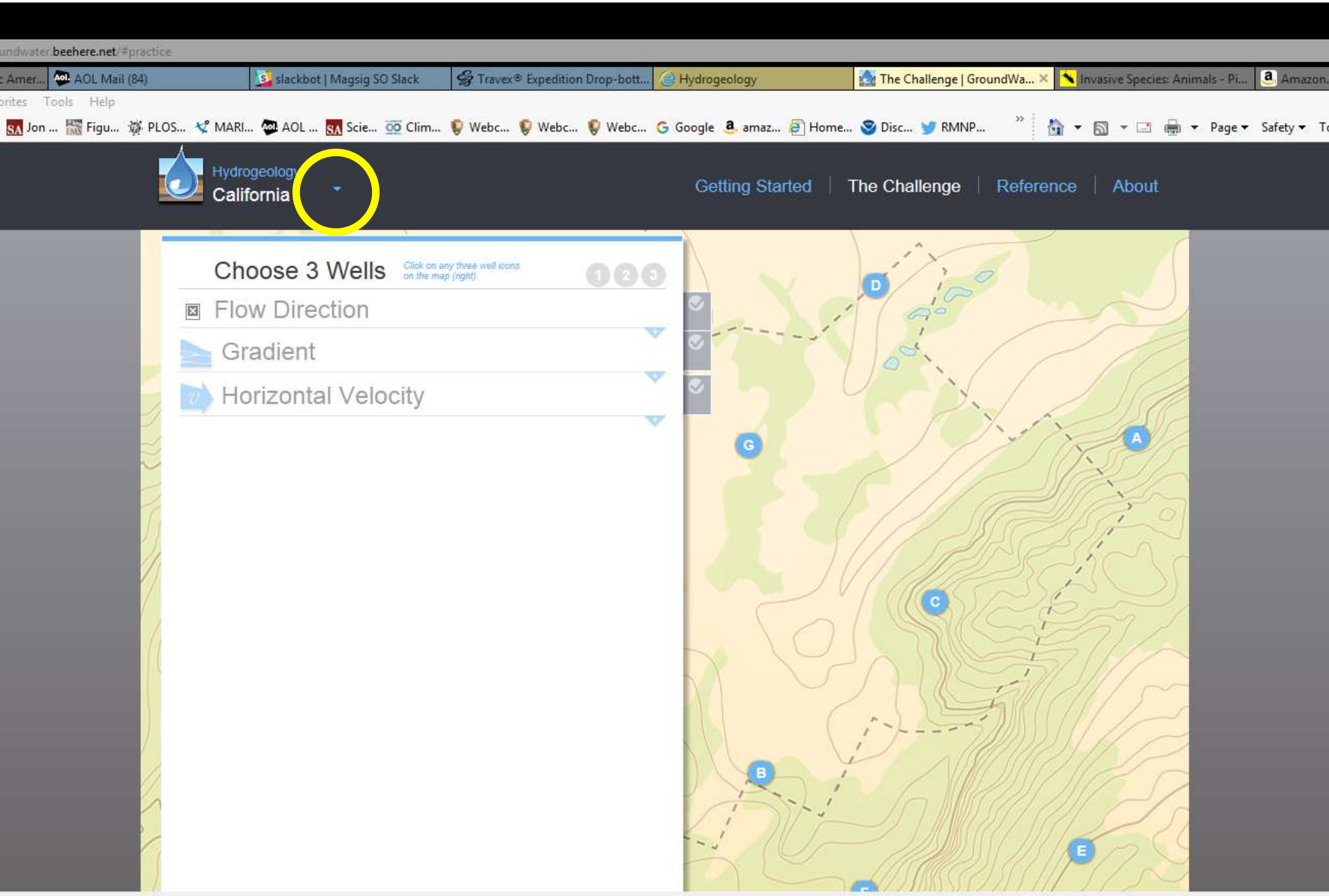
- Groundwater and the Water Cycle – http://www.groundwater.org/get-informed/basics/cycle.html
- Wells and How They Work - http://www.groundwater.org/get-informed/basics/wells.html
- Sources of Groundwater Contamination - http://www.groundwater.org/get-informed/groundwater/contamination.html
- Groundwater Glossary - http://www.groundwater.org/get-informed/basics/glossary.html

USGS (UNITED STATES GEOLOGICAL SURVEY) www.usgs.gov

- Posters - http://water.usgs.gov/outreach/OutReach.html
- Ground Water booklet - http://pubs.usgs.gov/gip/gw/index.html

What is Ground Water? - http://pubs.usgs.gov/of/1993/ofr93-643/

- Earth's Water: Groundwater - http://water.usgs.gov/edu/earthgw.html
- Ground Water and Surface Water: A Single Resource - http://pubs.usgs.gov/circ/circ1139/
- Sustainability of Ground-Water Resources - http://pubs.usgs.gov/circ/circ1186/
- Estimated Withdrawals from Principal Aquifers in the United States, 2000 - http://pubs.usgs.gov/circ/2005/1279/
- Estimated Use of Water in the United States in 2000 - http://pubs.usgs.gov/circ/2004/circ1268/index.html
- The Water Cycle - http://water.usgs.gov/edu/watercycle.html
- Groundwater and the Rural Homeowner - http://pubs.usgs.gov/gip/gw_ruralhomeowner/
- Contaminants Found in Groundwater - http://water.usgs.gov/edu/groundwater-contaminants.html
- Understanding and Managing the Effects of Groundwater Pumping on Streamflow http://pubs.usgs.gov/fs/2013/3001/
- Contaminated Site Management and Remediation Investigations - http://toxics.usgs.gov/investigations/ subsurface_point_index.html US EPA (UNITED STATES ENVIRONMENTAL PROTECTION AGENCY) www.epa.gov
- All about Wetlands - http://water.epa.gov/type/wetlands/index.cfm
- Groundwater Fact Flash - http://www.epa.gov/superfund/students/clas_act/haz-ed/ff_05.htm
- Remediation Technologies - http://www.epa.gov/superfund/remedytech/remed.htm
- Citizen's Guide to Cleanup Technologies - http://www.clu-in.org/products/citguide/
- Remediation Technologies Screen Matrix and Reference Guide - http://www.frtr.gov/matrix2/section3/table3_2.pdf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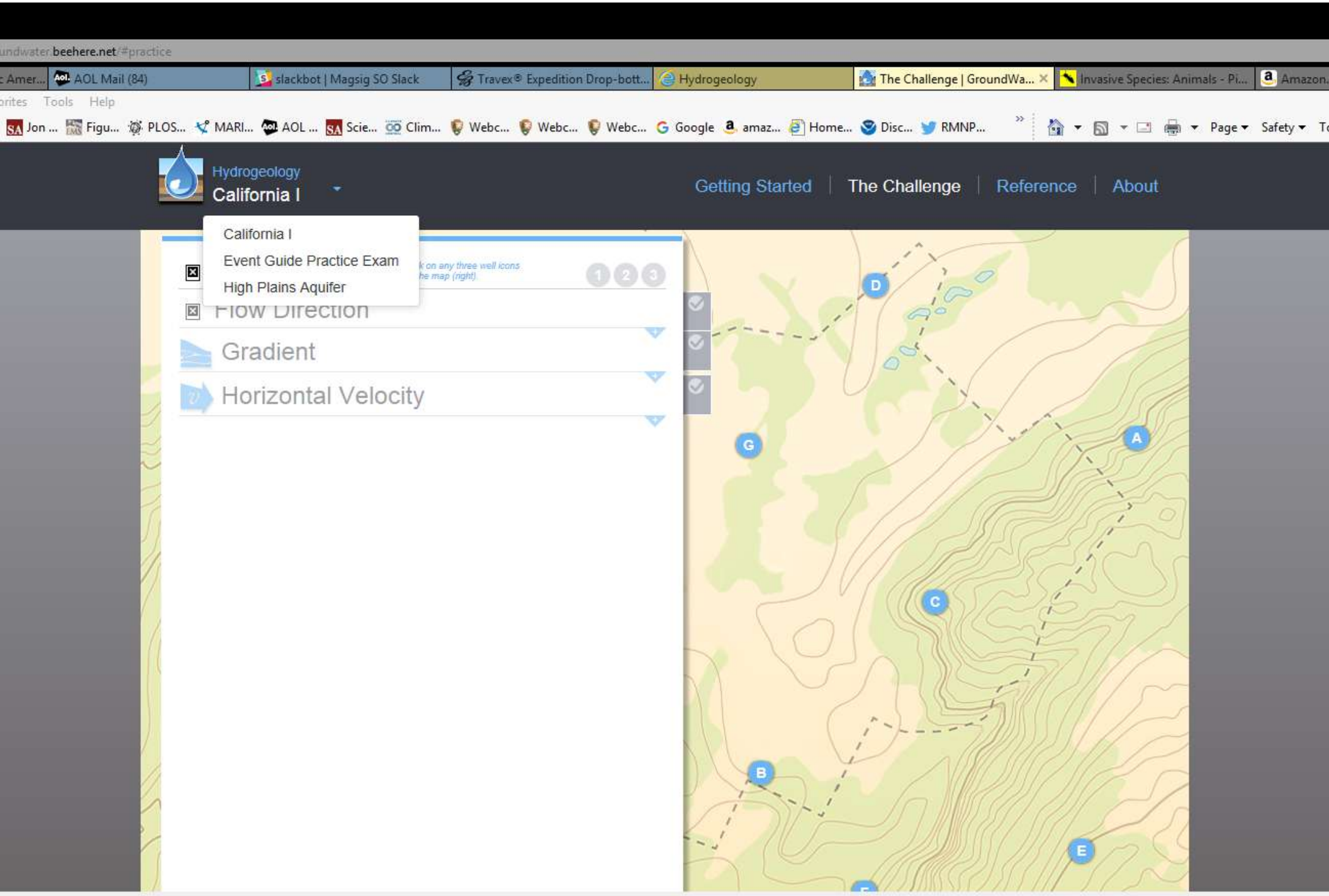
California
Getting Started
The Challenge
Reference
About
Choose 3 Wells
Click on any three well icons on the map (right).
1 2 3
Flow Direction
Gradient
Horizontal Velocity
D
A
G
C
B
E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Event Guide Practice Exam
High Plains Aquifer
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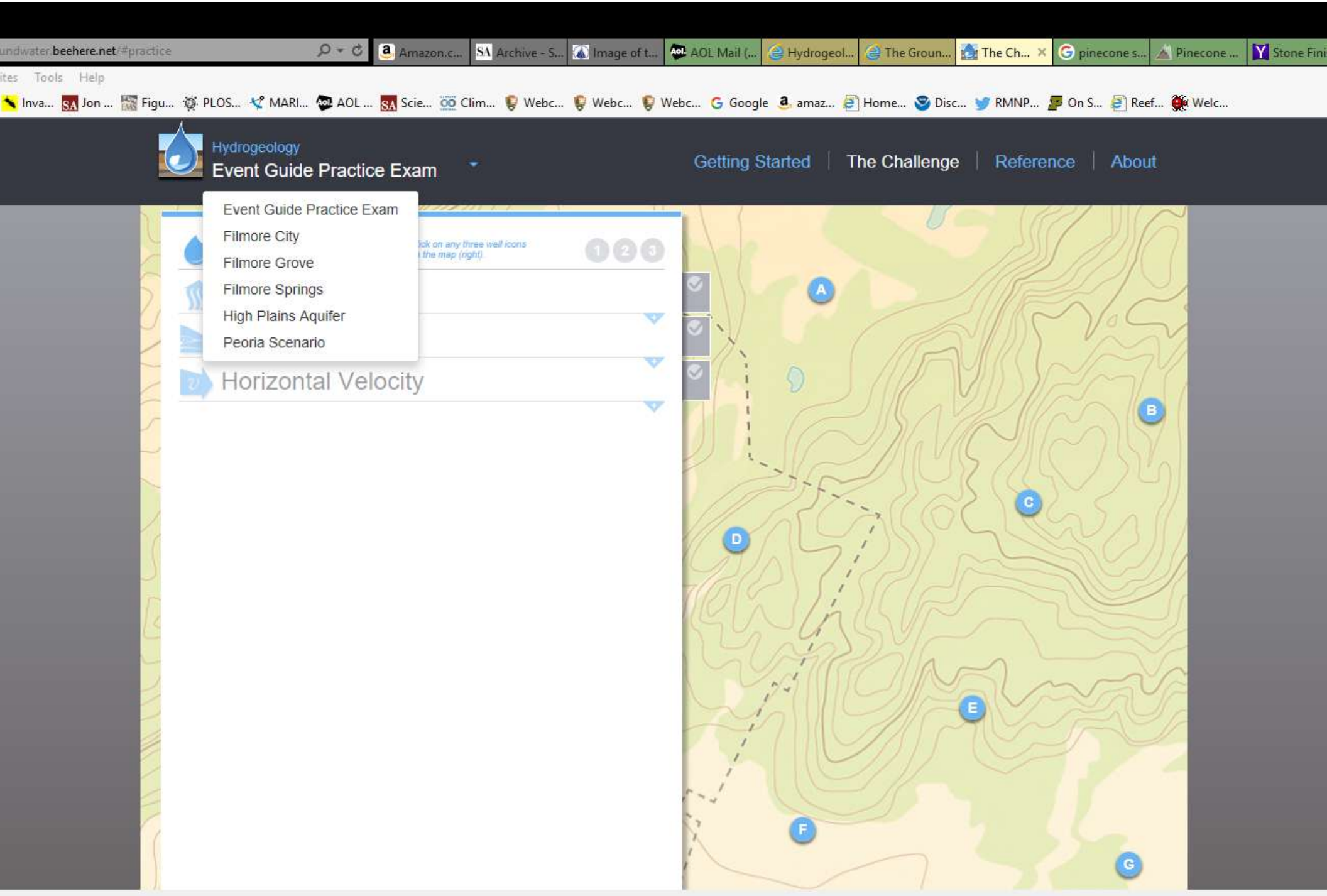
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Hydrogeology
Event Guide Practice Exam
Getting Started
The Challenge
Reference
About
Event Guide Practice Exam
Filmore City
Filmore Grove
Filmore Springs
High Plains Aquifer
Peoria Scenario
Horizontal Velocity
A
B
C
D
E
F
G

If you're running an event….

- You should contact The Groundwater Foundation (Jessica Wheeler) at least two weeks in advance of any competition to obtain the website for your particular scenario. Or to obtain a "paper" version.
  - Provide your name, the name of the competition, and the date of the competition.
- You will need to determine if adequate computer resources will be available to run the event on-line (paper or plastic -- or silicon?).

If you're running an event….

- Give yourself plenty of time to prepare a test, particularly to add specific circumstances to Part 2 in order to develop Part 3.
  - The assistance/input of someone familiar with GW and GW issues could be very useful.
- Try to look beyond the basics and create a rigorous and challenging test.
  - More on this in a couple of minutes

Towards that end….

- Do not treat the "Guide" like an instruction book. Or cookbook. Or worse, like a rule book. It is only a guide.
- The Guide is fixated on a test of 40 points. That's silly. Especially if you have 40 or 50 or 60 teams competing. I suggest the test be designed around a minimum of 100 points.
  - You can do that and still use the 30/10/60 weighting.

Scoring Sheet

Hydrogeology – Division C

XXXXXXX Invitational

January 30, 2016

Team No. _____ Team/School Name: _____

Part 1

Score from Part 1 _____ ÷ 44 total points (0.57) x 25 (percent of score) = _____

Part 2

Score from Part 2 _____ ÷ 26 total points (0.96) x 25 (percent of score) = _____

Part 3

Score from Part 3 _____ ÷ 45 total points (1.11) x 50 (percent of score) = _____

- Part 1
  - There should be at least 30 or 40 questions, possibly more.
  - Try some complex and/or multi part questions
  - Math questions are legitimate
  - Be creative. Ask challenging questions. Ask about types of wells, which type is most appropriate for a particular situation, etc. Wellhead protection. Different geologic settings. Pluses and minuses of different geology. All sorts of options.
  - Try to avoid the same old questions, check previous tests.
    - "What are the two types of aquifers?"

Part 2 – We're sort of stuck with this one.

However….

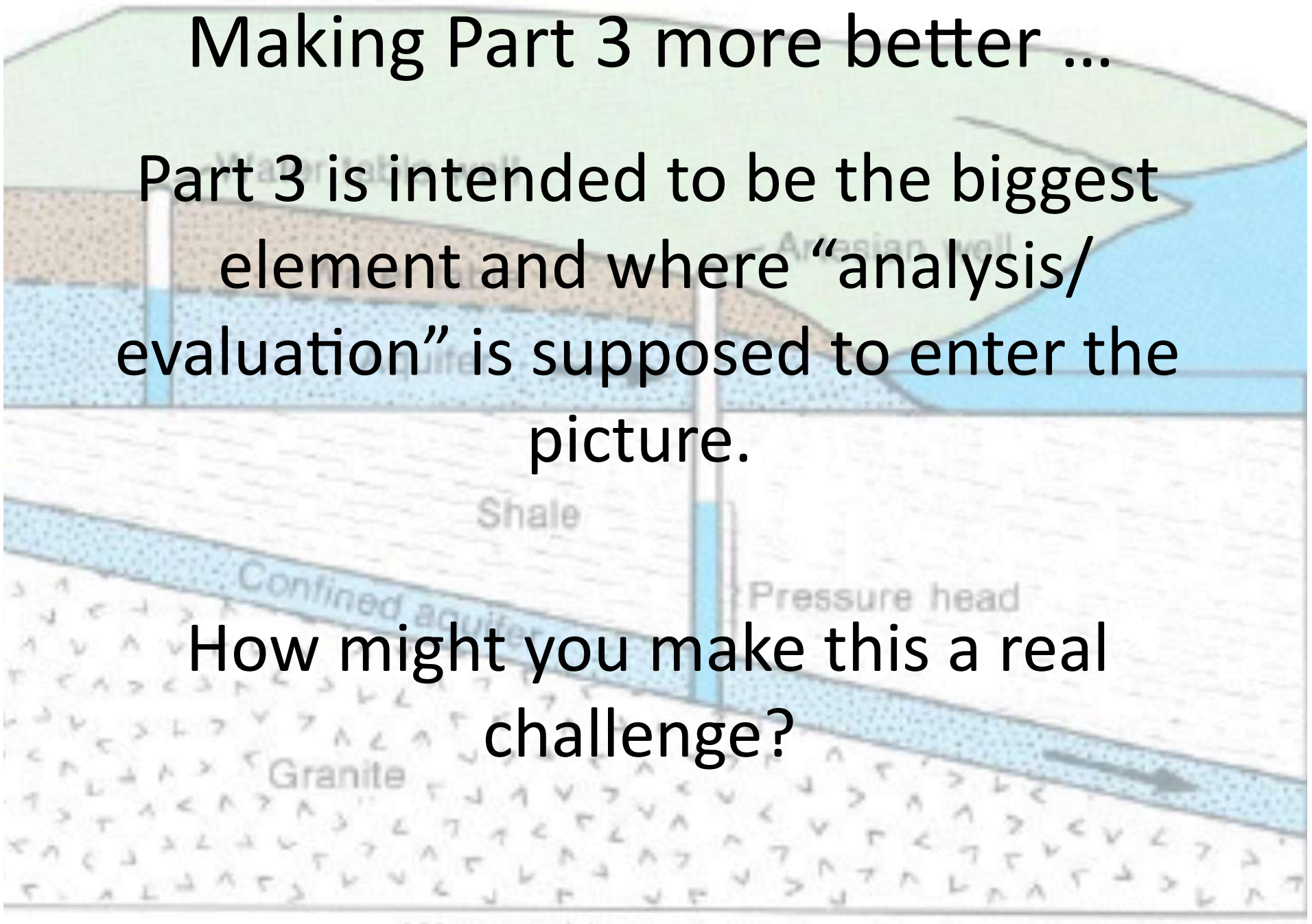
If you're feeling particularly peckish, you could offer it as the written version and remove some or all of the stupid instructions.

Yes, it makes extra work for the person running the event (writing and grading), but it's a thought, isn't it?

Making Part 3 more better …

Part 3 is intended to be the biggest element and where “analysis/ evaluation” is supposed to enter the picture.

How might you make this a real challenge?



Making Part 3 more better …

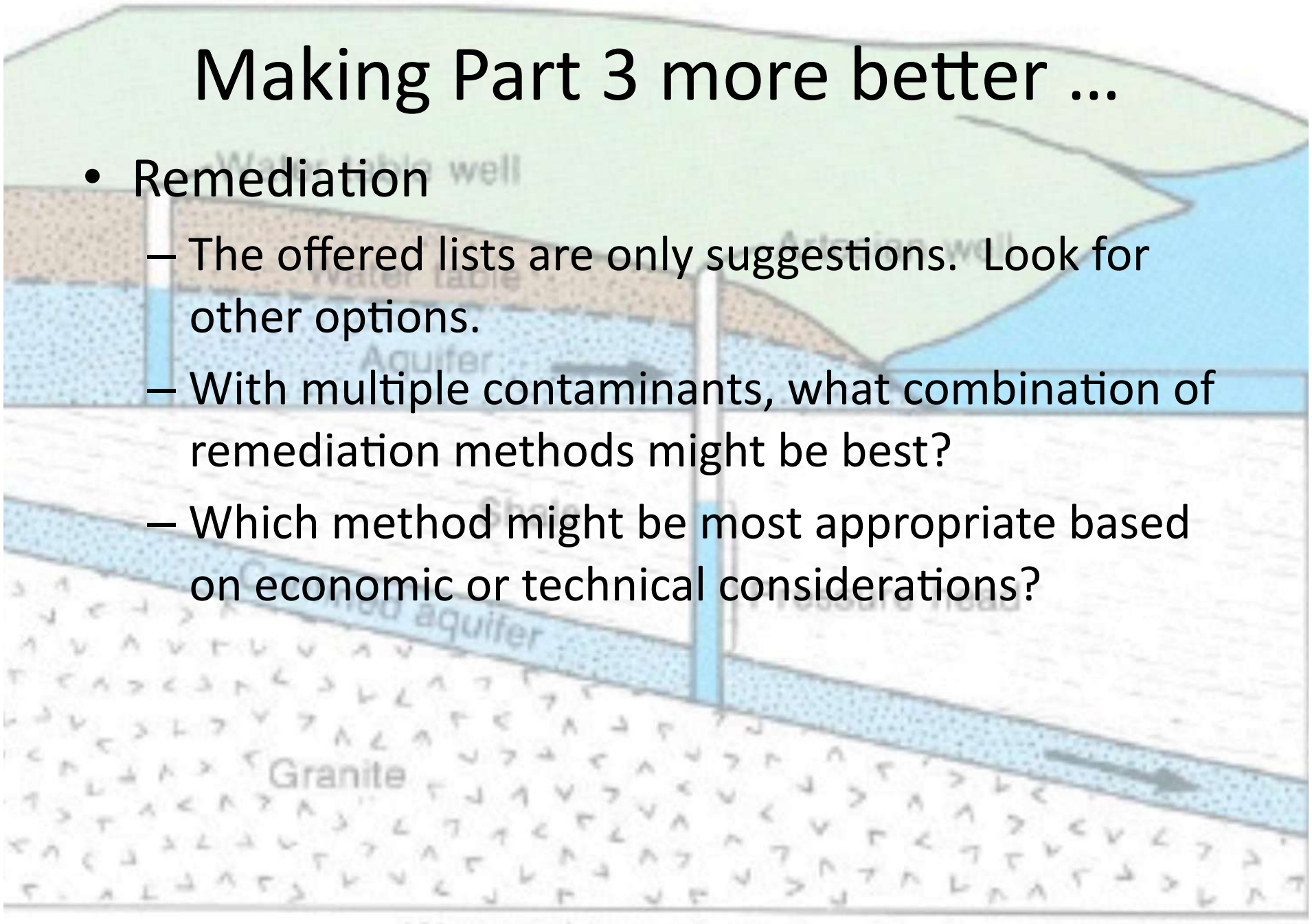
- The contaminants
  - The offered list is not exhaustive; you may use other sources/contaminants
  - Introduce more than 1 contaminant
  - Introduce a contaminant that presents very little potential for GW impacts (and one that has high potential)
  - Where might the contaminants come from, why might they be there?
  - Which contaminant should be the most immediate concern and why?
  - Which contaminant will be the biggest concern over the long term? Why?

Making Part 3 more better …

- Manipulating "the scenario"
  - All the wells in the scenario are fair game, not just the three selected for Part 2.
  - One well is supposed to be pumping; how about two?
  - Pump different wells separately. Which would present the greatest risk?
  - Move the contaminant to different wells; how does that change things?
  - Could you pump one well to protect another well?
  - Introduce new strata (a clay lens, a limestone formation, etc.); how would that change the situation?
  - Eliminate the most permeable layer; how does that change things?

Making Part 3 more better …

- Remediation
  - The offered lists are only suggestions. Look for other options.
  - With multiple contaminants, what combination of remediation methods might be best?
  - Which method might be most appropriate based on economic or technical considerations?



Making Part 3 more better …

- Analysis
  - Compare the results of the "simplified model" to "reality"; how would that change the situation?
  - Explore the proactive ; would a Wellhead Protection Plan have helped? How?
  - How could technical/economic recommendations conflict with political preferences?