RECAP OF WGWA ANNUAL CONFERENCE 2016

By Lee Trotta, WGWA Newsletter Editor

The theme of this year's conference was "Mapping in Three Dimensions – 3D Visualization Applications for the Geosciences" and the Milwaukee-area's best and brightest were in attendance. Held at the Milwaukee Marriott West, the conference was sponsored by Natural Resource Technology, Foth, Wisconsin Water Well Association, Inc., Midwest Geosciences Group, and Fehr Graham. Mike Raimonde welcomed attendees on behalf of the WGWA.

Our first speaker, Dave Nemetz of Shannon & Wilson, described his use of GIS to evaluate complicated data at a Superfund site in southern Illinois. Over 9000 samples of ground water, surface water, sediments, air, etc., had been collected. Metals of concern included arsenic, cadmium, cobalt, and

nickel. However, no obvious source related to historical activity at the site was apparent and there was no connection to industrial sources. Linear relation of plots with naturally-occurring iron indicated a natural occurrence. A high water table in low-permeability till may oxygenate at the surface and cause precipitation of manganese oxides. The manganese oxides will scavenge cobalt. Iron oxides will scavenge arsenic. Calcium highs indicated areas of groundwater discharge (which corresponded to metal precipitation areas). These findings were backed up by specific conductivity data. The groundwater input did not have detectable arsenic, so the oxygenation process occurred over a long period of time. In the end, the client was not penalized by DNR because groundwater/surface-water interaction was the culprit.

The second presentation was given by two ERM employees, John Roberts and David De Courcy-Bower, and was titled “3-D Visualization and LNAPL Conceptual Site Model Development – A Case Study”. Conceptual site model (CSM) development for remediation sites with multiple sources of light non-aqueous phase liquid (LNAPL) impacts goes hand-in-hand with defining an effective remedial strategy. Accurate depiction of LNAPL investigation data to define the extents of comingled LNAPL types with differing physical properties can be challenging. Have you sampled low-saturation LNAPL or high-

saturation LNAPL? Sand over clay (or vice versa) can exaggerate the thickness of LNAPL measured in a well. Even knowing the thickness won't predict the rate of LNAPL recovery, etc.

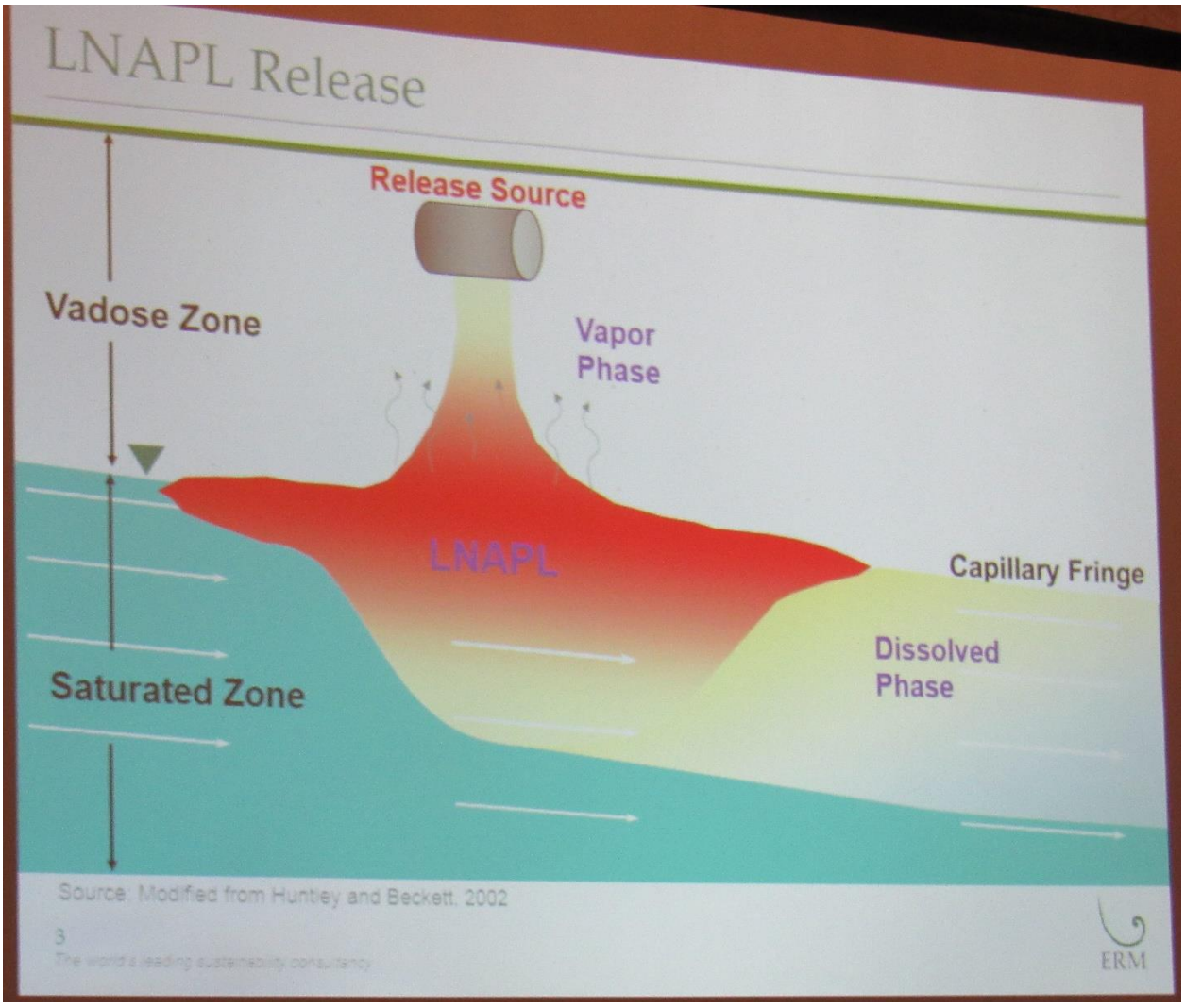
This case study illustrates how three dimensional (3-D) visualization of sub-surface laser induced fluorescence (LIF) data in conjunction with site specific geologic and sample data may be used to improve the LNAPL CSM and refine remedial strategy/options.

Historical releases at a 37-acre machine-gun plant resulted in a large combined area of multiple LNAPL types and several smaller areas across the site. The plant had petroleum storage and trenches for moving it. When the plant building was destroyed, oil seeped to the surface during periods of high water table elevations (due to sewer stoppage). The observed LNAPL types ranged from dark, thick oil to less viscous water soluble cutting oils.

A total of 112 LIF direct-push borings were advanced to delineate the horizontal and vertical extent of LNAPL, provide a semi-quantitative estimate of LNAPL saturation distribution, and provide an understanding of the distribution of different LNAPL types. LIF works similarly to electrical conductivity. Different oil products will fluoresce differently. Products may mix but can be sorted out with fluorescence wave lengths. 3D visualization software (by MVS) was used to enable depiction of the LIF data and prepare cross-sections through the impacted areas. The results of additional focused soil sampling and laboratory analysis were combined with the LIF visualizations to further develop and refine several LNAPL CSMs for different areas of the site. Multiple sources and entry points were depicted, but with low mobility and little lateral movement. The CSM also indicated that continued operation of LNAPL skimming/pumping systems would be unlikely to appreciably reduce the overall LNAPL mass, so remedial actions were focused on mobile LNAPL containment to prevent it from day-lighting at the surface.

David De Courcy-Bower

John Roberts



Next Dr. John Luczaj of UW-Green Bay spoke on "Modern Aquifer Chemistry as a Function of Water-Rock Interaction: A Case Example from Eastern Wisconsin". Paleozoic rocks in eastern Wisconsin preserve a complex diagenetic history that strongly influences modern aquifer chemistry. Major ion composition in the aquifer is controlled by the host rock. Trace minerals can impart a strong chemical signature. These minerals may have been placed by groundwater/surface-water interaction or hydrothermal events. The most significant event was a progression of hydrothermal dolomitization and associated Mississippi Valley type (MVT) mineralization followed by later calcite cementation. Ancient water-rock interaction involved heated brines (~80-100 degrees C) moving out of the Michigan basin during the Paleozoic Era, and perhaps later.

Whole-rock chemistry, geologic mapping, and chemical and isotopic analysis have revealed a clearer picture of the processes responsible for today's aquifer chemistry. In addition to dolomitization, a complex array of trace sulfides, sulfates, carbonates, and fluorite mineralization is heterogeneously distributed throughout the rocks, including newly discovered nickel and cobalt-bearing minerals. The top of the St Peter Sandstone has sphalerite, etc., deposited. These nodules disintegrate over time into

sulfuric acid. Metals plumes may occur downgradient of St. Peter quarries. When fractures and seepage fronts are examined, you find many dangerous minerals: As, Cr, Cd, Ni, Al, Co, Pb. The Celestine mineral gives us strontium problems at 10-50 mg/liter farther east along flowpaths. Water level fluctuations may cause sulfide oxidation and associated reactions liberate these minerals. Radium above EPA limits is prevalent in parts of the aquifer, with concentrations increasing eastward, but the source remains elusive. Elevated Li, B, Na, and Cl are related to dilution of Michigan basin brines, rather than water-rock interaction.

Next, Dan Tilly of Foth explained “Steps for Successful Environmental 3D Visualizations and Animations”. Presenting a complex problem using a simple 3D visualization or animation is a powerful way to educate stakeholders and decision makers. There are many products and options available for creating 3D presentations using geology hydrology and environmental data. Know your target audience and adjust accordingly. Resolution and orientation are important to the target product. Understanding project goals, data, and organization are key ingredients to a fruitful product. Following the task and knowing limitations will help mitigate project creep and costly mistakes. For instance, a full background takes processing time. Animation requires storyboards or scripts with an ideal length goal. Is there narrative, music or effects? Is there advanced 3D (water, smoke)? Know your data. Wrangle it. Organize your work

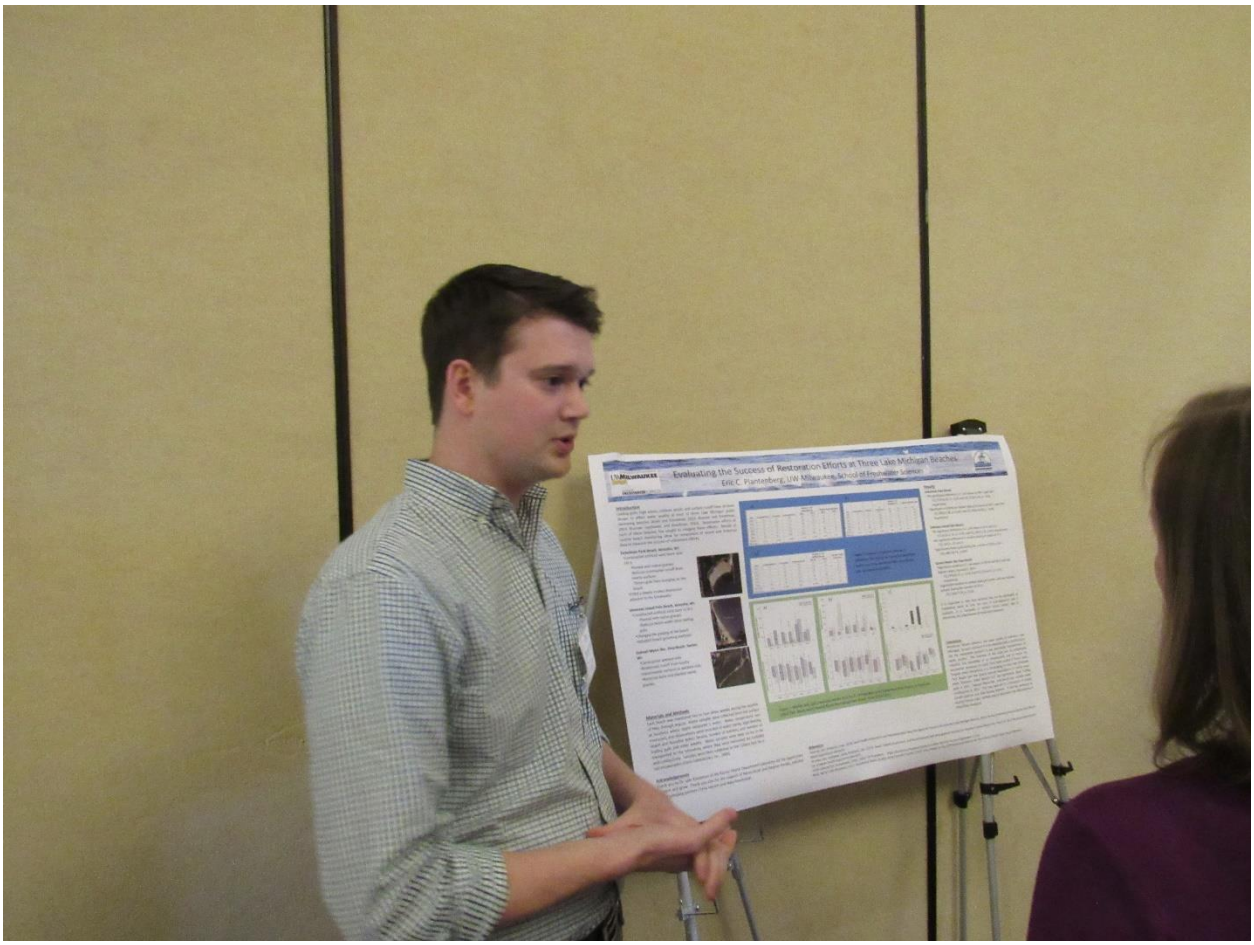
process to a schedule. Document your work and revisions. Don't assume textures or colors without communication with an expert.

Examples of 3D visualizations and animations created for a variety of applications were shown: geologic pit, dry tailings stack concept, open mine pit, sediment core, fence diagram, PAH in soil, gold mine. One of the least-expensive software tools used was "Target for ARCGIS". An animation studio must be hired after doing the GIS work if animation is your goal.

Next Mary Ellen Vollbrecht, Groundwater Section Chief for DNR, spoke on "Implementing Wisconsin's Groundwater Quality Law". Wisconsin's groundwater quality protection law was enacted in 1983. Lawmakers intended to minimize the concentration of polluting substances in groundwater by consistent use of uniform numerical contaminant standards. The law and implementing rules establish clear-cut processes for setting and achieving the numerical standards. Questions guide the process. Is the strontium problem local? Should the standard be set wider? We try to avoid a risk greater than 1:1 million regarding cancer. Many rules say "the groundwater standard will be met". There are a range of options for DNR when they are notified of an exceedance. DNR continues to fund groundwater research. The WGS and the USGS help improve delineation of recharge areas. Local protection options may include town or county ordinance and landowner agreements. Local solutions can be enhanced by collaboration with related programs including watershed planning, wellhead protection and nutrient

trading. Mapping, modeling and monitoring tools can guide design of local solutions. Focus has shifted to municipal water supplies, as opposed to domestic water supplies. Non-municipal residential areas "are more on their own" in preventing problems.

During breaks and at lunchtime, attendees visited with Eric Plantenberg (student at UW-Milwaukee School of Freshwater Sciences) to discuss his poster presentation "Evaluating the Success of Restoration Efforts at Three Lake Michigan Beaches".



After we returned from a delicious buffet lunch, Carolyn Streiff of the WG&NHS gave a presentation “Electrical Resistivity Imaging and the Passive Seismic Method: Estimating Depth-to-Bedrock and inferring Subsurface Variations Across Wisconsin”. Geophysical data collection can supplement, and build confidence in, hydrogeological data sets for local and region groundwater studies. The Wisconsin Geological and Natural History Survey utilizes the Horizontal-to-Vertical Ratio (HVSR) passive seismic and Electrical Resistivity Imaging (ERI) methods to infer subsurface sediment and bedrock character and identify possible hydrogeologically significant units.

The HVSR and ERI acquisition methods rely on physical differences between the bedrock and overlying sediment. The ERI method is used to create a profile of electrical resistivity with depth. Because bedrock is commonly more resistive than the overlying sediment, the ERI method can easily image the sediment/bedrock contact for most surveys. Subsurface structure variation within units can also be inferred from impedance contrasts. For example, if a sediment layer's water content increases, a decrease in resistivity will be seen in the ERI profile. In contrast, gravel deposits will usually be seen as higher resistivity anomalies.

The HVSR is a fast (about a 5-minute setup), inexpensive way to collect depth-to-bedrock point data estimates. Low frequency passive seismic "noise" is measured for ~10-18 minutes at individual data point locations. This waveform information is used to determine the resonant frequency of the overlying sediment, which is related to sediment thickness with the use of an empirical equation. This sediment thickness can then be turned into a depth-to-bedrock estimate. If other changes in the subsurface units have large enough impedance contrasts, an estimated depth to these contacts can also be determined. For example, the depth to the contact between clay and sand can be estimated in some locations. The technique cannot see through hardpan, however. The WG&NHS unit is manufactured by Tremino and is available for loan. Carolyn gave examples of recent studies at the Little Plover River, Long Lake near Plainfield, WI, New Rome, WI, and the Central Sands area.

ERI provides depth-to-bedrock profiles and lateral variation information in karst regions and other areas with hydrogeologically significant sediments. HVSR supplements groundwater study data by constraining sediment thicknesses. These methods are fast (about a 40-minute setup), inexpensive, and reliable, which makes them excellent tools to provide more concentrated subsurface information across Wisconsin. Carolyn gave examples of recent studies at Bown Quarry near Gays Mills and the Kettle Moraine Fish Hatchery in Sheboygan County.

Then Reinhard Klaus of Sigmund Lindner (who also had a vendor booth at the conference) spoke about “Glass Bead Filter Media: Higher Efficiency and Reduced O & M costs”. The declining quality of natural sand and gravel filter pack media for water supply wells became a challenge for the well industry in the past years worldwide. Inadequate values for crushing strength, abrasive resistivity, roundness, gradation and chemical resistivity lead to insufficient hydraulics, increased well clogging and scaling, higher electrical energy demand, reduced lifetime, and increased Operations & Maintenance costs. Deeper wells also suffer from bridging and jamming of gravel during installation which results in incomplete annular filling, improper bedding and sudden subsidence as a means of severe well damage.

High performance wells, like ASR, mine dewatering and in-situ leaching wells with huge water volumes transported created further needs to raise the standards for filter pack media.

Otherwise they are impaired by irreversible clogging, due to disintegration and compaction of gravel packs which means significantly reduced well performance and lifetime.

In late 2007 high quality soda lime glass beads were first used as an alternative for gravel in the filter pack of a 400 ft. well in Germany with severe scaling problems. This scale was caused by iron and manganese encrustation. Extensive comparative field and laboratory studies with several universities and discussions whether glass beads are a better choice also fostered the fundamental analysis and understanding of the role of filter packs and the influence of media properties on well performance. Bench tests proved how underrated features like sphericity and gradation so far were for well development capacity and efficiency.

Experience with app.180 wells in Europe and the USA, among them two 1.500 m deep mine dewatering wells in Colorado, with glass bead filter packs show properly packed isotropic annular fillings, higher specific well capacity, reduced pumping costs and significantly extended operation cycles between rehabilitation intervals.

A case study at the Cave Creek ASR well In Phoenix was outlined.

Then Wayne Hutchinson of Antea Group presented “3-D Visualization for Conceptual Site Model Clarification”. Hydrogeology is an innately three-dimensional proposition. To fully understand, and predict, the flow of ground water or the migration path of a contaminant requires an understanding of the interaction and interrelationship between various geologic units, surface water, recharge areas, conduits and source areas. 3D visualization can evaluate the relationships between several datasets simultaneously.

Three examples were presented, two in bedrock and one in unconsolidated sediments, where 3D visualization was instrumental in enhancing the understanding of each site’s hydrogeological conditions and clarifying the site conceptual model. The first was a 1963 gasoline pipeline leak where limestone fractures in the Prairie du Chein dolomite controlled the flow. The second was a propane cavern excavated to hold 337 cubic feet at 300 ft below the surface of the earth. The third was the area which housed the old Standard Oil tanks in Superior, WI, from around 1880 to 2000.

Next David Swimm of the DNR spoke on “Using Laser Induced Fluorescence (LIF) Surveys to Define Non Aqueous Phase Liquid (NAPL) Micro-Traps". LIF surveys are increasingly being used at clean-up sites to define subsurface NAPL distributions. The NAPL that is present is often the most potent source of ongoing groundwater contamination. LIF surveys are one of several types of information regarding NAPL sources that should be integrated together to form a better understanding of the nature of the NAPL accumulations, including details of its geologic context (i.e., micro-traps). From this, better constraints on remedial options can often be determined. For example, integrated LIF survey results can provide details concerning the nature of the “venting container” for sites considering soil vapor extraction (SVE)

or can detail where meaningful accumulations of NAPL exist for sites considering hydraulic extraction. The focus of this presentation was to provide the rational for undertaking LIF surveys and how best to gain value from them.

Regarding value, the presentation provided details on LIF survey interpretation, including establishing appropriate instrument response interpretation biases and calibration relative to the NAPL and the soils within which it is contained. A survey submitted without interpretation is of little use to DNR. The presentation also showed how detailed stratigraphic correlations using the ancillary conductivity tool can be accomplished. The resolution is far and above that capable from conventional soil borehole sampling. Examples from petroleum storage tank and MGP sites were provided to illustrate the interpretation process and show how micro-traps can be resolved. One conclusion from the examples was that remedial wells should often be horizontal to best access the advantageous NAPL saturations.

Next Bob Smail of DNR presented “Building and Irrigated Lands Coverage for Wisconsin”. The Water-Use Section (WUS) came about due to the Great Lakes Compact. The WUS requires detailed reports of water withdrawals and has been getting 98% report completion. DNR staff integrated multiple datasets including reported water withdrawal data, land ownership records

from DOA, remote sensing data from USDA, and National Weather Service data (utilizing GIS) to compile a statewide irrigated lands coverage for Wisconsin. This dataset was then used to estimate the annual volume of irrigation water applied per crop type in Wisconsin. For example, golf courses and cranberry flooding each only used 1% of total withdrawals. This presentation highlighted the process used to build the dataset as well as results of ongoing analysis showing where different crops are grown in Wisconsin (using USDA satellite maps) and how much water is typically applied per crop type. Corn, soybeans, and potatoes show up well. In addition, this presentation showed how water irrigation rates vary due to weather based changes in crop water demand. It was found that irrigation totals are very drought dependent. Growers can use results from this analysis to compare their own irrigation rates to other statewide and local averages. In addition, this dataset will be useful for planning and modeling where fine grain knowledge of existing irrigation and prediction of future irrigation are important. Efficient irrigation rates can be benchmarked for conservation planning. Crop rotations can be tracked. The DNR can even use precipitation data with the irrigation data minus ET to get recharge values at a field level. Plans are in the works to tie such info to geology to determine aquifer stress. This analysis has been updated from past efforts using ARC GIS and is expected to improve as water use data and remote sensing resolution improves.

Finally it was time for our Keynote Speaker. Lee Trotta introduced Alain Gachet, President of Radar Technologies International based in France. Alain remotely gave an interesting electronic presentation called “WATEX, a new remote sensing technology applied in Africa and Middle-east to discover deep aquifers”. Dr. Alain Gachet founded RTI in 1996 after spending years leading discovery efforts for multinational oil and gas companies. An experienced geologist and geophysicist, Dr. Gachet began experimenting with Geo-Scanner technology in 1999 while exploring structures linked to the genesis of gold and other base metals in the Republic of Congo. There, he utilized the technology to penetrate the rainforest canopy and reveal geological features beneath the ground's surface. Radar images are affected by roughness, but this effect can be measured. Exploration deeper than 50 meters requires geophysics data too. He shifted his exploration investigation from metals to deep water since the Darfur crisis in 2004 thanks to his invention of the WATEX Process (WATer EXploration), to bring freshwater to the refugee. He pursued his groundwater exploration in international projects all over war torn areas thanks to USAID and the United Nations in Africa : Chad, Sudan, Angola, Ethiopia, Somalia, Kenya and in the Middle-East : Iraq ad Jordan. The project in Ethiopia was done in cooperation with the USGS.

He was awarded in 2015 by the French Government the title “*of Chevalier de la Legion d’Honneur* “for his humanitarian achievements and published a book relating his expeditions in Africa under the title “*Alain Gachet, l’Homme qui fait jaillir l’eau du desert*”.

Thank you to all who attended the Annual Conference! Please continue to support the WGWA and its sponsors in bringing quality groundwater education to Wisconsin.