2008 ANNUAL MEETING ABSTRACTS

Alphabetical According to Lead Author ~ TS=Technical Session ~ See Page 4 for Technical Session Names

FACTORS INFLUENCING THE STABILITY OF CUT SLOPES SUBJECT TO DIFFERENTIAL WEATHERING

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The geology of Ohio is characterized by sub-horizontal, inter-layered competent (siltstones, sandstones, limestones) and incompetent (shales, claystones, mudstones) rock units. Cut slopes in this type of stratigraphy are subject to differential weathering leading to undercutting of competent layers by incompetent layers that, in turn, results in the occurrence of rockfalls. The existing rock slope stability analysis techniques, including the Hoek and Bray's procedures based on orientation of discontinuities and the rock mass rating (RMR) systems based on rating of various geological and geotechnical parameters (unconfined compressive strength, joint spacing, joint orientation, ground water conditions), have limited application to the undercutting-induced slope failures. In order to investigate the factors affecting the stability of cut slopes subject to differential weathering, 36 cut slopes in Ohio were selected and categorized into six groups based on stratigraphy. The geological and geotechnical parameters that influence the rate of undercutting and frequency of rockfalls were investigated for each site. Data about the fate of generated rockfalls (landing on the slope face or falling in the catchment ditch) were also collected. Data analysis shows that the factors that influence the rate of undercutting and the frequency of rockfalls include bedding thickness, joint spacing, rock type, relative positions of the competent rock units on the cut slopes, and slake durability of the incompetent rock units. Slope geometry, joint spacing, bedding thickness, and lithologic composition of the competent rock units were also found to influence the fate of rockfalls. The relationships between these factors, as well as the applicability of rock mass strength, are currently being considered for designing cut slopes in inter-layered sequences of competent and incompetent rock units that dominate the geology in Ohio.

SPATIAL AND TEMPORAL CHARACTERISTICS OF PALEOEARTHQUAKES IN EAST CENTRAL ARKANSAS

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Earthquake-induced liquefaction features, including very large sand blows and sand dikes, formed 5,000-7,000 years ago near Marianna, Arkansas. The prehistoric liquefaction features have been found using satellite imagery, aerial photographs, and field and river reconnaissance and studied in detail with ground-penetrating radar and trenching and logging techniques. The liquefaction features occur over a 900 sq km area centered on Marianna, Arkansas, about 75 km from the southern terminus of the New Madrid seismic zone and Memphis, Tennessee. Many of these features occur at the ground surface and others are buried by Late Holocene deposits. The sand blows are similar in size to New Madrid sand blows, yet predate paleoearthquakes attributed to the New Madrid seismic zone. Therefore, the causative earthquakes are likely to be as large as New Madrid earthquakes but centered near Marianna and outside the New Madrid seismic zone. Several fault zones are currently under consideration as the source of the prehistoric earthquakes, including the eastern Reelfoot Rift margin. If the rift margin were confirmed to be the source of Middle Holocene earthquakes near Marianna, seismicity would appear to vary in space and time within the Reelfoot Rift system. This would have important hazard implications for currently inactive faults and possibly other aulacogens embedded in intraplate regions. As demonstrated in the Marianna area, paleoseismology can provide valuable input to seismic risk assessment, especially in areas where the historic record is short or incomplete.

APPLIED PALEOSEISMOLOGICAL BENEFITS FOR THE RESIDENTIAL EARTHQUAKE INSURANCE IN CALIFORNIA

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The reduction of uncertainty in the estimation probability of the occurrence of a damaging earthquake in a developed area of California may result in the savings or the increase in premiums for those individuals who purchase residential earthquake insurance. The establishment of a reoccurrence intervals for select damaging earthquakes based upon an a priori approach or a moment balanced approach where paleoseismological data is not available has now been completed for the State of California in the publication: *The Uniform California Earthquake Rupture Forecast, Version 2 (UCERF 2.0)* [USGS Open File Report 2007-1437]. The research behind the development of the UCERF 2.0 was partially funded by the California Earthquake Authority (CEA). This presentation was instigated by a conversation between Dr. Glenn Biasi of the Nevada Seismological Laboratory and the presenter during a trip to view faulting along the Southern San Andreas Fault on February 3, 2008. The insight in how the CEA, the largest residential earthquake insurance provider in the United States, uses paleoseismological information is intended to help paleoseismologists and engineering geologists understand how important trench logging and dating of earthquake related features are to the CEA and by extension to residential earthquake insurance industry in California.

COMPARISON AND CONTRAST BETWEEN THE MOMENT MAGNITUDE 7.9 SICHUAN PROVINCE, CHINA AND MOMENT MAGNITUDE 7.8 SOUTHERN SAN ANDRES FAULT, CALIFORNIA EARTHQUAKE SCENARIO

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On May 12, 2008, Southwestern China was struck by a moment magnitude 7.9 earthquake whose epicenter was located approximately 75 kilometers (~47 miles) west northwest of the city of Chengdu in the province of Sichuan. The earthquake was felt over a large part of Asia including most of China, and as far away as Bangkok, Thailand and Hanoi Vietnam. At the time of the earthquake, the largest earthquake exercise in the history of the United States was being planned. The exercise scenario is based on a moment magnitude 7.8 earthquake on the Southern Segment of the San Andres fault. The scenario earthquake was similar in size to the Sichuan Province earthquake but not in fault style or in the overall area of anticipated destruction. This presentation is a general overview of what is known about the Sichuan earthquake and to the modeled Southern San Andreas fault scenario.

USE OF P-, SV- AND SH-WAVES TO CHARACTERIZE THINLY-MANTLED KARST AND IDENTIFY SOLUTION-ENLARGED FRACTURES, BOURBONNAIS, ILLINOIS

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Seismic refraction tomographic images (velocity tomograms) at the Perry Farm Park, Bourbonnais, IL, show lateral velocity and overburden thickness variations across thinly mantled karst (Silurian dolostone with about 5 m of overburden). Both P- and S-wave tomograms indicate low-velocity zones lying between high-velocity "knobs." These low velocity zones have the appearance of "fracture-like" structures in the subcropping bedrock surface. Independent electrical surveys (2D resistivity and GPR) also image these low-velocity zones and the "knobs."

Observed S-wave velocity anisotropy is the result of structural anisotropy, most likely caused by near-vertical fractures/faults in the karstic subsurface. The low-velocity zones represent either sediments filling bedrock depressions, or thick zones of highly weathered bedrock along faults and joints. For these zones the estimated Poisson's ratios (Vp/Vs) ranges from 1.5 to 2. A Vp/Vs ratio of 2 is typical of saturated sediments, and at Perry Farm is associated with fracture-like low-velocity zones saddling bedrock highs.

The low-velocity zones and bedrock "knobs" are probably associated with different facies in the dolomite bedrock and/or fracture zones. These zones may be water-saturated or partially saturated, and probably play an important role in the hydrogeology of the area. The near-vertical fractures very likely act as ground water recharge, discharge, and transmission features at the Perry Farm Park site. Borings and piezometers are needed to confirm this hypothesis.

TUNNEL CONSTRUCTABILITY, ENGINEERING GEOLOGY, AND GEOTECHNICAL ISSUES – SCOP, CLEAN WATER COALITION REACH 3 TUNNEL, LAS VEGAS, NEVADA

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The Reach 3 tunnel is a 1 mile section of an 18 mile long project to discharge highly treated effluent from Las Vegas to Lake Mead. This project is known as the System Conveyance and Operation Program (SCOP) of the Clean Water Coalition that is composed of the City of Las Vegas, City of Henderson, Clark County, and City of Henderson. SCOP will divert tertiary treated effluent, originating from three waste water reclamation facilities, that currently flows down Las Vegas Wash into the Las Vegas Bay of Lake Mead. SCOP includes 1.5 miles of buried gravity pipeline, 4.6 miles if buried pressurized pipeline including a pump station, force main, and a 0.4 mile wash crossing, 8.3 miles of steel lined tunnels through the River Mountains, a power generation station, and 2.8 to 3.9 miles of multiple diffuser pipelines into Lake Mead. The Reach 3 tunnel of the SCOP and associated shafts will encounter Quaternary alluvial deposits, Tertiary Muddy Creek and Horse Springs Formations, and several faults and/or shear zones. Bedrock, consisting of claystones, siltstones, sandstones, conglomerates with varying amounts of gypsum and some limestone, generally strikes northwest and dips southwest with two intersecting joint sets. Constructability of the Reach 3 Tunnel excavation is predicated on bedrock orientation, rock discontinuities, and fault/shear zone orientation to the tunnel alignment, bedrock quality, and groundwater inflow. This presentation discusses the results of the geologic mapping, geophysical and geotechnical testing, and presents conclusions regarding tunnel stability during construction.

SUPERGLUE FOR AN UNSTABLE ROCK SLOPE

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Rockfall mitigation schemes for transportation projects typically include design elements that dramatically alter the visual appearance of rock slopes. For example, slope profile reconfiguration and installation of rockfall netting and control barriers are commonly used to reduce rockfall hazards. Projects for which preservation of existing aesthetic qualities of the rock slope is a high priority, design elements that severely impact the rock slope's appearance are less desirable than elements that are hidden or have a limited surface expression. The use of polyurethane resin (PUR) grout in lieu of traditional rock bolts and rock anchors may be a practical solution to reduce the rockfall hazard potential while preserving slope aesthetics. The method of injecting PUR grout into the rock mass for the purpose of bonding individual blocks into a bigger, more stable, continuous mass is called "rock gluing." Rock gluing has been used in the tunneling and mining industries primarily to control water seeping into underground spaces and stabilize the crown. Rock gluing is relatively new as an above ground technique but has been used successfully in transportation projects to improve the structural integrity and slope stability of rock masses. A comparison of two design concepts for mitigating potential rock slope failure modes within a 240-ft long, 35-ft tall rock slope on the George Washington Memorial Parkway in Arlington County, Virginia shows that incorporating rock gluing into the mitigation design in lieu of traditional patterned rock anchors provides an effective way to reduce rockfall hazards while preserving slope aesthetics.

"YOU WANT ME TO TAKE *WHAT* COURSE?" – A FORMER STUDENT'S TRIBUTE TO DR. TERRY R. WEST

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At the end of my freshman year at Purdue University (a long, long, time ago), a structural geology professor urged me to choose the engineering geology curriculum under Professor West. The engineering geology program was broader in scope than all the other programs, yet more rigorous and would prepare me well for whatever specialization I chose later. That recommendation was a testament to what Professor West had achieved at Purdue University and it was the beginning of my career in engineering geology.

In the years following my education, I would increasingly realize the influence that Professor West has had on my professional career. I have assembled a slideshow from four projects that highlight aspects of engineering geology that I, and students before and after me, have learned from Terry West: a tailings dam remediation project at a trona mine in southern Wyoming; design of a well field in the Atacama desert of northern Chile for one of the world's largest copper mines; design, construction, and inspection of a cut-off wall 17,000 feet long and 91 feet deep in central Indiana; design of a groundwater drain system 5 miles long, and encircling a solid waste facility located within a surface mine. These projects represent part of Terry West's legacy as a teacher and mentor. Truly, his teaching and mentorship has had, and continues to have, a ripple effect on the world around us.

TOWARDS A MODEL FOR THE PERMANENT ERADICATION OF MINE RELATED ASBESTOS POLLUTION IN SOUTH AFRICA

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Naturally occurring asbestos minerals (NOAMs) are endemic in many regions of South Africa. This is due to the abundance of serpentine that occurs in the Archaean basement rocks of South Africa. In addition, NOAMS are widely developed in our Proterozoic sequences such as the Transvaal Supergroup. These rock sequences are developed in extensive swathes through the northeastern regions of SA as well as the northern Cape Province. NOAMS are even present within the boundaries of the Cradle of Humankind north of Johannesburg.

The need for a solution of the post mining NOAM pollution problem in South Africa vies in importance with that of AIDS. Asbestosis and related forms of illness are arguably among the most pernicious chronic diseases known to man.

The eradication of asbestos pollution is, unlike the AIDS virus, technically feasible given present knowledge and capabilities. The major ingredients that have been missing so far have been political will, commitment and money. The paper reviews current rehabilitation practices in South Africa and shows that these are unsustainable over the long term.

The paper provides suggestions as to the path that needs to be taken if a sustainable solution is to be found.

The scientific and engineering professions, the SA Government and to the world at large are challenged to address this scourge through broad, comprehensive actions not contemplated to date.

The future health of thousands of South Africans and many international visitors to our country depends on finding a sustainable solution.

PRACTICAL APPLICATIONS OF GIS/GPS MAPPING TECHNIQUES TO ENVIRONMENTAL AND ENGINEERING GEOLOGY PROJECTS

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Over the past two decades, I have developed and applied simple and commonsense computer mapping techniques to various environmental and engineering geology projects. The use of a laptop computer, GIS software, and a handheld GPS unit can better enable a field geologist to daily document such features as: excavation extent, construction progress, soil and groundwater testing results, landslide locations, and geologic mapping results. The skilled field geologist with this readily available

technology can rapidly and accurately incorporate pre-existing geologic or hydrogeologic data with current data and field observations. Mapping results can be plotted in the field (or in the hotel room) and electronically transmitted to managers and clients.

In this presentation I will show specific examples and computer mapping techniques from a variety of projects. The purpose of this presentation is to share current computer mapping techniques and to demonstrate that in addition to a technical background in geology and engineering, writing ability, and basic computer skills, geologists of today need to develop and integrate GIS/GPS mapping skills as a routine part of their job.

COLORADO ROCKFALL SIMULATION PROGRAM VERSION 5.0

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Poster Session: The Colorado Rockfall Simulation Program (CRSP) was developed to estimate the velocity, energy, and bounce heights of rockfall, which in turn forms a basis for selection of designs for mitigation. A new version of CRSP has been written based on a combination of Particle Flow Code and the Discrete Element Method for dynamic model simulation. This approach provides a more accurate approximation to the equations of motion for rock and slope interaction than employed by previous CRSP versions.

The purpose of this research is to calibrate the program with respect to rock velocity, energy, bounce height, and rollout. Program calibration is based on the results from previously completed rock rolling experiments and new data collected from mapping of natural slopes. Rock rolling experiments have been documented using high-speed cameras to estimate rock velocity and kinetic energy. Natural slopes with rockfall distributed on the slope were mapped to obtain information on rock run out. A cross-section was constructed for each slope, and material type, slope roughness, and boulder size and location were documented. Where present, rockfall scar marks on trees were used as a source of bounce height information.

Calibration experiments compare the experimental and observational measurements to CRSP output, which results in adjustments of the 'soil hardness' coefficients. Preliminary results have found that the program accurately estimates the velocity and kinetic energy of rocks rolling on slope material varying from soft clay to hard rock. Program calibration is currently being conducted on runout distance and bounce height.

THE LOSS OF LIVES AND PROPERTY: A LOOK AT THE IMPACTS OF WESTERN NORTH CAROLINA LANDSLIDES FROM 1916 TO PRESENT

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Throughout the 20th century and into the 21st century, periodic storms and hurricanes have caused flooding and triggered landslides across the mountainous region of western North Carolina (N.C.). To date the N.C. Geological Survey's landslide hazard mapping team has mapped or compiled information on greater than 3,000 slope movements produced from these storms and other events. Early and mid-July 1916 storms impacted several western N.C. counties, producing the first, well-documented slope movements that resulted in the loss of lives and severe damage to infrastructure across the region. A third tropical storm on August 13, 1916 caused the catastrophic failure of the Lake Toxaway dam in Transylvania County. The first of two storms in August 1940 triggered over 2,000 landslides in Watauga County, damaging numerous structures and roads, and causing fourteen fatalities. More recently, in September 2004, intense rainfall from the remnants of Hurricanes Frances and Ivan triggered at least 400 landslides that caused five deaths, destroyed 27 homes, and disrupted transportation corridors throughout western North Carolina. Since 1990 at least 45 structures, mainly homes, have been destroyed or condemned as a result of landslide damage.

Landslides have damaged several critical facilities resulting in lengthy repair delays and expensive corrective action. Direct costs alone exceeded $10 million from a 1997 rockslide along Interstate 40, periodically closing one direction of traffic. The Jackson County Airport has been plagued by slope movements since construction, which have degraded the integrity of the runway. Several roads throughout the mountains, including the Blue Ridge Parkway, are continually repaired due to failures in road cuts and embankments. In one instance in Haywood County, homes are literally being torn apart by a large, slow-moving weathered-rock slide.

This talk will focus on a pictorial history of some of these cases where landslides have impacted infrastructure and lives in western N.C.

INVESTIGATION OF THE SOURCE OF PLACER GOLD IN TOFTY DISTRICT, ALASKA

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Poster Session: The source of the placer gold in the Tofty district is not definitive. The nuggets have leached rings where Mercury and Silver have been removed. The leached rings around the gold nuggets are from the fluvial and groundwater leaching the nuggets. The objective of this research is to investigate if the leaching is pre- or post-depositional. If pre-depositional, the cross section of the nuggets would show the banded leaching because the transport mechanism in placer deposits hammers the nuggets flat, then folds and or breaks the nugget into finer pieces. This action would leave the gold with heterogeneous markings of leaching; thus the nugget will not be evenly zoned. If the nugget was leached after deposition by the ground water then the ring should be relatively uniform and homogenous in reference to the surface of the nugget. The leaching and the depositional direction indicate the gold is from a plutonic source most likely Elephant mountain and the veins of the Eureka district. The progression of leaching and the increased rounding of the fluvial gravels along with the depositional direction, indicates the gold has come from the direction of Eureka area and contains some inclusions of other mesothermal sources along the mafic veins.

PRESENTING THE BIG PICTURE – EVALUATING CONTAMINANT PLUME GEOMETRY USING LIDAR, GIS AND 3-D VISUALIZATION

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We performed detailed analysis of a complex soil and groundwater contaminant plume using LIDAR to develop accurate surface elevations, 3-D visualization software to characterize the subsurface geology and the plume, and GIS to map it on site diagrams. Both soil and groundwater are contaminated. The groundwater contaminant plume resulted from long-term releases of various inorganic and organic chemicals from multiple sources including underground and aboveground storage tanks. Soil contaminants include VOCs and heavy metals resulting from urban filling and past site operations.

LIDAR was used for developing accurate surface elevations. We used 3-D Environmental Visualization System (EVS) software to (1) define areas that require treatment/remediation, (2) characterize important geologic features that influence contaminant distribution and migration, (3) identify data gaps, and (4) map and depict contaminant trends over time. Output results were mapped in GIS. Animations were created to depict plume changes over time and to provide evidence that contamination is contained within the site. The EVS animations provided a means to summarize and evaluate a large data set collected over many years and were also useful in presenting recommendations for site closure. EVS also proved to be a useful tool for presenting the level of confidence of data sets to regulatory agencies.

ACCURACY OF SUPERVISED AND UNSUPERVISED LAND USE CLASSIFICATION TECHNIQUES WHEN COMPARED TO FIELD VERIFIED LAND USE TYPES

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The classification of land use types via remote sensing of the physical environment is a common utilization of satellite imagery. Land use classifications are widely used by Geologists and Engineers as the foundation for advanced raster based GIS applications such as site selection, hydrological assessments and hazard assessments.

The accuracy of land use classifications is, therefore, vital to the success of later projects. Supervised and unsupervised land use classification techniques are most commonly employed to classify remotely sensed data. Supervised classification can be accomplished via parallelepiped, minimum distance, or maximum likelihood algorithms. This study compares and contrasts the classification accuracies between the unsupervised classification and three variations of supervised classification techniques. Field and computer based protocols are employed in an effort to assess the accuracy of each type of classification for a study area in central Mississippi.

MASSIVE DEBRIS FLOW EVENT ON PACIFIC NORTHWEST VOLCANOES, NOVEMBER, 2006: MORE TO COME AS THE CLIMATE CHANGES

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During the second week of November, 2006 a warm, wet airmass called the "Pineapple Express" hit the Pacific Northwest and dumped over 50 cm of rain onto the volcanoes in 36 hours before there was snow cover. It mobilized the abundant sediment on the slopes of the volcanoes and created many devastating debris flows. The amount of sediment available on the slopes has increased in recent years as glaciers have retreated, exposing the inside of lateral moraines. Mt. Hood was the most devastated with 7 of the 11 major drainages producing significant debris flows. Eliot Creek and the White River produced extensive debris flows that measured well over 2 million cubic meters each and closed major highways in the region for weeks. A large delta formed in the Columbia River at Hood River resulting from the debris flows. At Mt. Rainier the SW drainages were hit hard. Kautz Creek rerouted. The Nisqually River enlarged in size and almost undercut the Longmire Headquarters buildings. The Sunshine Campground disappeared. At Mt. St. Helens Lava Canyon was inundated and the roads to the area remain closed even today. Milk Creek had a major debris flow on Mt. Jefferson. On Mt. Adams many debris flows were generated in the drainages of Salt Creek, Adams Creek and the Big Muddy. The largest event was the debris flow that collapsed the moraine at Crofton Ridge. As the climate continues to change, we will see more large debris flows as these air masses arrive before snow cover can shield their impact on the volcanoes.

LANDSLIDES IN LOUISIANA

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Louisiana is located at the southern end of the Mississippi River Basin in the central United States. The region is very flat, with the highest elevation in the state being 210 m above sea level. Even though the area has little relief, I have mapped over 400 landslides. Obviously, the region is not prone to spectacular types of mass movement like rockfalls and debris avalanches, but slumps, earthflows and slump-earthflows dominate the processes with a few translational slides also being found. Four different geomorphic regions have been delineated, each with its own set of mechanical factors that control the stability of slopes. The Tertiary Uplands Province is formed on the interfluves between the major river drainages, and slumps dominate this region. Movement generally occurs after heavy rainfall as the sediments slump along clay interbeds in the sediments, especially at road cuts and where stream headward erosion has cut into the slopes. The largest landslide complex in the state is at Duty and is over 100 km^2 in size. In the Flood Plains Province, most of the failures are slumps and slump-earthflows in the meander bend cutbanks. Some major slides have also occurred in the human-made levees along the rivers. Where embankments have been constructed by the highway construction with sediments containing high smectite clay concentration, slumps and earthflows generally occur within ten years after construction. The Loess Province is mainly along the Mississippi River, and slumps and earthflows dominate the steep slopes. In the Subaqueous Offshore Province, mudslides are common on the Mississippi delta-front lobes in the Gulf of Mexico.

DEEPWATER SITE CHARACTERIZATION: TOOLS, TECHNOLOGY, AND EXCITING GEOLOGY

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This presentation gives an overview of modern deepwater site characterization in support of ongoing petroleum drilling and development in water depths up to about 10,000 ft. Geophysical survey data provides the overview of seafloor and subsurface conditions, including seafloor morphology, geologic features, structural and stratigraphic relationships, and geophysical (acoustic reflection) attributes. The three types of geophysical survey data most commonly used for basic mapping and characterization include low-resolution 3-D exploration seismic (3DX) data, high-resolution 2-D multi-channel seismic data, and very-high-resolution multi-beam echo sounder, side-scan sonar, and sub-bottom profiler data collected using an Autonomous Underwater Vehicle (AUV). Various types of gravity and piston corers, rotary drilling rigs, and in situ testing tools are used to collect soil samples or otherwise provide quantitative characterization of seafloor and foundation-zone soil conditions and details of stratigraphy at specific sites. Networked seismic workstations and visualization technology are used to facilitate efficient, accurate, and comprehensive integration and analysis of the geophysical survey and soil data. This integration provides "calibration" of the geophysical survey data and results in robust site characterization. Results of the site characterization are in turn used as a basis for geohazard risk assessment and for siting and foundation design of production facilities. Examples of various complex deepwater geologic conditions (including faults, submarine slides, and gas hydrates) that can cause engineering difficulties will also be illustrated.

ROCK SLOPE STABILITY OF THE VALDEZ MARINE TERMINAL IN VALDEZ, ALASKA

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To evaluate the stability of rock slopes of the VMT during potential earthquake conditions, a detailed field fracture survey of the rock slopes were conducted in July and August 2006. During the fracture survey more than 300 discontinuity data were measured on those relatively critical slopes including the Ballast Water Treatment Plant, the Power House and Vapor Recovery Plant, the West Manifold Building, the West Tank Farm Slope, and the less critical slopes including the Power House Road Slope, the Tea Shelter Slope, and the rock quarries located on the southern portion of the VMT site. Using these fracture data and existing rock cut information available at the time of this investigation, an analysis of rock slope stability was conducted using kinematic and factor of safety methods. Because of the uncertainty of the information, the probability of failure method was also employed to evaluate the stability of the VMT slopes in this study. A concern for rock slope stability was recognized when a combination of increased pore pressure and earthquake effects occur which decreases the sliding resistance of the rock mass. Remediation measures to reduce the risk of the existing slopes were recommended. The report has been prepared to determine the safety of the rock slopes under different conditions including seismic shaking. It is not intended to be the basis of a design document, but instead its intent is to point out any concerns for the long term stability of rock slopes on the VMT facility.

FIELD-SCALE MEASUREMENT OF WATER-TABLE PROFILES IN A DRAINED SLOPE

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In 2003, Crenshaw and Santi developed a method for calculating average water-table heights between horizontal drains in a slope. The method relies on drain flow rates, slope geometry, and soil hydraulic conductivity. The corrugated shape of water-table profiles between drains (characterized by low levels at drain locations and higher levels at the midpoint between drains) and the departure of the water table from the drain near its uphill end were verified using laboratory-scale physical and computer modeling. In 2007, a study was conducted seeking to confirm these findings using field-scale modeling. The test site consists of a 2H:1V, 30 x 12 ft (9.1 x 3.7 m) concrete slope representing low-permeability bedrock. Five perforated pipes embedded in the concrete are used to simulate base-flow recharge. The concrete was covered with a lean clay and two wick drains were installed at a spacing of 8 ft (2.4 m). Fifty standpipe piezometers were installed to measure water-table profiles between and along drains. Measurements were taken during recharge and drawdown events. The test was repeated with a clayey sand. Test results generally confirm

the findings of Crenshaw and Santi, with some localized variations in water-table profiles. The variations are most likely due to factors such as heterogeneous soil properties, the development of preferential pathways, boundary effects, etc. Field-testing also yielded additional information about the behavior of drained slopes that may be useful for future slope-stability projects.

PLANFORM CHANGES ATTRIBUTABLE TO RIPARIAN MINING – AMITE RIVER, SOUTHEAST LOUISIANA AND SOUTHWEST MISSISSIPPI

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The purpose of this study was to document and to understand the effects of riparian sand and gravel mining on this major Gulf Coastal Plain stream. Mining has been conducted since the early 1970s on a 48-kilometer reach centered at Grangeville, LA, and has been considered to be the cause of significant changes in the geomorphic regime as well as loss of aquatic habitat along the mined reach. Currently, ground studies and aerial reconnaissance indicated that accelerated erosion is also occurring on Amite River tributaries along the mined reach as well as upstream of the mined reach along the main stem in Louisiana and Mississippi. The field evidence for accelerated erosion included inclined bank vegetation, fallen vegetation in the channel, incised point bars and divided flow. The channel downstream of the mined reach appears stable. Our examination of historical, rectified panchromatic aerial photography showed that, between 1953 and 1998, stream length upstream and along the mined reach had respectively, decreased by as much as approximately 28 and 29 percent. During this same period, the stream length downstream of the mined reach increased by approximately 2 to 8 percent. The field and planform data are similar to that seen on streams, which have been shortened or channelized. We consider that the channel widening and shortening occurred during high stage events during which flood waters entered the mined areas and cut off the meanders. Overall, these processes have resulted in significant land loss along and upstream of the mined reach, adverse conditions at bridge, pipeline and power crossings, habitat loss as well as degradation of scenic and recreational attributes on the river.

SENSOR TECHNOLOGY APPLICATIONS AND RANGES

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Multiple sensor technologies are available for use as in-situ tools for petroleum hydrocarbon and solvent investigations. Available tools include direct sensing technologies (MIP, ECD) and indirect fluorescence-based optical logging tools (ROST, UVOST, FFD, TARGOST).

Advantages of using in-situ tools over conventional drilling and sampling techniques include:

- Fast, Real Time Data
- No Soil Cuttings
- Multiple Screening Techniques with Single Boring
- Basic Contaminant Type Information

These tools are used with direct push equipment, such as Geoprobe® or cone penetrometer (CPT), and can be deployed in many different types of locations. Each tool provides real-time data with plots of relative contaminant concentrations with depth. The effectiveness of each tool is dependent on selecting the most appropriate tool based on the contaminant types and concentration ranges expected.

This talk aims to provide a comparison of the applicable ranges of these tools based on successful applications as well as lessons learned. Case studies will be presented to show the application of each tool at specific sites, focusing on the high points of their usefulness and noting where they fell short.

LIQUEFACTION IN NORTH LOUISIANA AND SOUTH ARKANSAS AND POSSIBLE EARTHQUAKE SOURCES

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Earthquake sand blow fields in the northern Gulf Coastal Plain are near the Grand Gulf nuclear power facility, and critical infrastructure for and the eastern U.S. Damage to pipelines and major bridges could extend the impacts of a regional earthquake to much of the country. Understanding these sand blows is important to both central U.S. and global intraplate seismic hazard assessment

We identified five fields of sand blows (each >500 km2 in area) on the Coastal Plain of Arkansas and northeast Louisiana using vintage aerial photographs, ground conductivity surveying, push-coring, and trenching. In all these fields, sand blows were vented from Holocene alluvial deposits during at least three earthquakes in the last 7000 years that show no clear relationship to the timing of New Madrid seismic zone (NMSZ) events. Trenching in Louisiana is ongoing.

The NMSZ produces large earthquakes because it occupies the Reelfoot rift. However Arkansas/Louisiana Gulf Coast sand blow fields overlie a greater crustal discontinuity, the Alabama-Oklahoma transform fault margin of the North American craton that strikes southeast beneath Ouachita thrust sheets and Mesozoic/Cenozoic sediments. Ouachita thrust sheets conformed to this craton margin, later reactivated during initial Triassic rifting of the Gulf of Mexico. Rift grabens faults show post-Triassic reactivation with flower structure geometries and up-dip changes in sense of separation, suggesting a strong strike-slip component. Some reactivated faults cut Cenozoic section. Indeed, surface exposures of the Saline River fault zone (SRFZ) in Arkansas show displacement and deformation of Eocene through Holocene sediments where shallow faults in Triassic grabens should reach the surface. Thus, the SRFZ is a strong candidate for the source of earthquakes that produced sand blows in this region.

A RIVER CALLS ITS BLUFF – MONITORING A SLIDE AREA IN INTERIOR ALASKA

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The Copper River Lowland (CRL) in Interior Alaska contained a 2,000 mi^2 proglacial lake during glacial maximum periods, which covered the lowland in glaciolacustrine diamicton deposits. These deposits typically are frozen, with permafrost ranging from 100-ft to 200-ft thick and with temperatures in the range of 29.3ºF to 31.3ºF. The major rivers in the area have cut down through the deposits, exposing walls as high as 500 ft. The Richardson Highway, one of two major north-south thoroughfares in Alaska, transverses the CRL. The highway approaches the Copper River in the vicinity of Glennallen, Alaska, where the river is actively moving to the west and eroding a 300-ft high bluff. The active erosion at the toe of the bluff is compounded by the thawing of ice-rich soils at the surface, which forms gullies along the bluff face. The highway was realigned in 1965 to avoid the bluff face. Headward thermal erosion of the gullies, which induces sliding, has since obliterated portions of the pre-1965 alignment, and is rapidly approaching the current highway. Alaska DOT&PF personnel have monitored the slide area with a vertical inclinometer since 2003. Measurements from one location indicate that the zone from 10 ft to 25 ft below the surface has the highest rate of movement of 1.5 in./yr, with the rate of movement decreasing with depth. Recent measurements indicate that the failure surface at 57 ft is propagating downwards. This presentation details the soils investigations and monitoring of the slide area, and describes the design alternatives.

THE USE OF GIS TO TEST THE EFFICACY OF A MODEL FOR PREDICTING DEBRIS FLOW RUNOUT

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Prochaska (2007) developed a model based on basin topography to predict the runout of debris flows. This method requires calculating the vertical midpoint of the source basin, estimating the point of onset of deposition on the debris fan, and then calculating the declination of a line between the two. An empirical relation allows

calculation of the angle of reach of the flow's runout, which may be plotted to identify the map location of the extent of runout. Although this model gave favorable results on a limited number of test basins, it lacked testing on a larger scale. The goal of this research is to apply Prochaska's method to a larger number of basins of varied geology to confirm the model's effectiveness. Included in this test set are plutonic/metamorphic basins in Wyoming, Idaho, and Montana and sedimentary basins in southern California. In addition, the project will also use ArcHydro and 3-D Analyst to demonstrate an efficient and accurate way to perform the analysis. On the basis of this analysis, slight modifications and limitations to Prochaska's method are identified.

U.S. 101 LANDSLIDE – INVESTIGATION, DESIGN, AND REMEDIATION

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During the 2005-2006 rainy winter season, a large landslide occurred beneath State Route 101 south of Aberdeen, WA. The active landslide encompassed approximately 250 feet along S.R. 101 and extended 400 feet in length upslope and downslope from the highway. Reduced traffic flow and continual maintenance of the road was required. This and other high profile landslides along Washington's byways generated enough publicity to warrant a site visit from the governor of Washington.

Together with Washington State Department of Transportation's (WSDOT), Kleinfelder completed geologic mapping of the area, advanced a series of geotechnical borings and instrumented the slide with piezometers, inclinometers, and survey markers. We established that the active slide was progressive in nature and part of a larger, ancient landslide with a head scarp approximately 300 feet further upslope than the currently active headscarp. Movement of the active portion of the slide was correlated to high rainfall periods. Small scale landslide movement had also been observed by WSDOT during the winter of 2004/2005.

We presented five stabilization options to WSDOT. Because of cost and environmental concerns, WSDOT opted to install a series of horizontal drains at the toe of the slide. The drains effectively reduced the groundwater elevations within the slide mass and stopped movement. Based on current information from WSDOT, the drains are still functioning and no major distress has occurred to the section of roadway since their installation.

WHY SUBSIDENCE HAS BEEN MISUNDERSTOOD ALONG THE LOUISIANA COAST

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To be successful, engineering design of storm surge protection and coastal wetlands restoration for south Louisiana requires geological insights and accurate predictions of subsidence over the next 100 years. Because geologic and geodetic measurements have yielded different results, confusion has resulted among users and policymakers. To clear up the confusion, a comparison was conducted to evaluate each method's measurement characteristics, focusing on differences in strategies to infer subsidence, precision, accuracy, and the amount of time that is averaged to compute rates. Geologic methods that track the position of peat or fossiliferous strata through time cannot generally resolve subsidence at a spatial resolution of less than a meter and a temporal resolution of less than 50 years. Geologic subsidence rates of coastal Louisiana for the late 20th century are based on unrealistic linear extrapolations of data points hundreds and thousands of years old. In contrast, geodetic methods (e.g., leveling, GNSS, and InSAR) employ highly precise technologies that can measure mm to cm vertical change that occurs over intervals as short as a month. Geodetic methods not only provide the most detailed and reliable measurements of 20th century subsidence, they also provide the only reliable means to obtain detailed kinematics data regarding the specific processes causing subsidence. The "controversy" regarding measurements of 20th century subsidence has no basis and stems from: 1) misperceptions about the inherent measurement uncertainties and resultant spatial/temporal resolution provided by measurement systems, and 2) the underreporting of errors associated with geologic measurements.

INVESTIGATION OF A PALEO MEGA-LANDSLIDE IN THE UPPER GÖKSU RIVER VALLEY, TURKEY

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In 2005 and 2006, geomorphology of the upper Göksu River Valley was studied as a part of the Göksu Archaeological Project. This section of the river valley is scheduled to be flooded by the construction of a hydroelectric dam at the mouth of the Çoğla Canyon. The archaeological and geological investigations were made to determine the impact of the dam on historic and archaeological sites within the valley. During the investigation, strong evidence was uncovered for the existence of a lake which reached the 310 meter contour. Analysis of sediments exposed in the upper Göksu indicate the presence of both fluvial and lacustrian environments within the valley. South of the Çoğla Canyon, there are very poorly sorted deposits that are characteristic of outburst flood deposits, indicating a large-scale failure of a landslide dam. Further investigation using GIS and remote sensing applications indicated the presence of a large landslide sequence (approximately 1.5 km wide with a 6 km long run out) off of the edge of the mountain Mahras Dağ that appears to have dammed the Göksu River at Çoğla Canyon. Geomorphic and kinematic investigations indicate that the slide underwent a series of movements, including a slump-block slide with long run out, and a secondary block slide that opened the present-day Çoğla Canyon. Both failures appear to have initiated along a clay-shale layer. This study has implications that relate directly to the present day dam project as well as the complex geologic and occupational history of the region.

LANDSLIDE SUSCEPTIBILITY MAP FOR SHALLOW LANDSLIDES FOR THE WEST HILLS OF PORTLAND, OREGON USING GIS AND LIDAR

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The West Hills of Portland, Oregon, USA (45° 33' N, 122° 45' W) are prone to landslides on the steep slopes covered in loess (ML soils) overlying basalt. The relatively simple geology, the propensity for landslides, the accurate LiDAR base map and the landslide database make the West Hills an ideal place to produce a landslide susceptibility map for shallow (25 ft. or 7.6 m. >) landslide using the approach of study by Harp et al. (2006). The landslide database was used to correlate the susceptibility map with the actual area of the landslides to ascertain the accuracy of the output susceptibility maps. The output maps were calculated using an algorithm based on the Infinite Slope Model modified by Harp et al. (2006) using Portland Hills Silt soil- strength data. The soil values used for the shear strength of the loess were 28º and 32º for the friction angle phi (phi = 27.8 $\pm$ 3.8º, with a range of 18 – 32°), cohesions of 270 and 320 psf (cohesion = 270 $\pm$ 250 psf, with a range of 0-698 psf) and landslide thickness of 4 and 7 ft (t= 4 $\pm$ 3 ft., based of the scarp height of 5 $\pm$ 4 ft.). The model was especially sensitive to changes in thickness, and to a lesser extent phi and cohesion.

GEOLOGIC HAZARDS IN THE NEW ORLEANS AREA AND THE CANAL LEVEE FAILURES

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Hurricane Katrina tested the levee system protecting New Orleans and resulted in numerous levee failures, which caused massive flooding to the city. Geologic and engineering data were gathered from the different levee failures during focused studies by U.S. Army Corps of Engineer geologists and engineers. These data identify a spatially complex geomorphic landscape, shaped by the Holocene rise in sea level and the development of short lived distributary channel networks and associated delta systems. The foundation for the flood control system beneath the New Orleans area consists of relic distributary channels that supplied sediment to form the St. Bernard and Modern Mississippi River delta lobes and different, vertically stacked, shallow water, paludal, and terrestrial Holocene depositional environments (i.e., bay-sound, prodelta, intradelta, lacustrine, barrier beach, interdistributary, marsh, swamp, point bar, and natural levee). The geologic setting, historic subsidence, and

man's activities are responsible for creating the unique landscape that was impacted by Hurricane Katrina. Geologic, engineering, and physical evidence gathered from the canal levee failures is examined to understand the various factors and hazards responsible for the levee failures that caused much of the flooding in the city.

INTEGRAL TO OUR FUTURE: ENCOURAGING STUDENT PARTICIPATION IN AEG

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Many undergraduate and graduate students in geology/earth science programs are unaware of the field of environmental and engineering geology. Most students don't have the benefit of an AEG student chapter, and many students have never met a geologist except for their professors. Therefore, students are often exposed to a very academic focus on geology, with little, if any, exposure to the more applied aspects of geology, oblivious to many of the career choices in the field.

Without learning about the career opportunities in geology early in their education, students, in the end, may feel their degrees have little meaning for their futures and a "now what?" attitude. Therefore, encouraging student participation in AEG through attendance at section and annual meetings, and reaching out to them through the Visiting Professionals Program and mentoring opportunities will provide them with knowledge of environmental and engineering geology and of how AEG can support their educational and professional careers.

In order to recruit good students to environmental and engineering geology undergraduate and graduate programs, to train future colleagues, AEG must continue to reach out to students through its student chapters, and support the creation of new chapters. However, it is also vitally important to reach students in schools without student chapters in other ways, such as contacting the student presidents of geology clubs to encourage student attendance at AEG section and annual meetings, and going to the students by way of the AEG Visiting Professionals Program.

LONG-TERM SUBSIDENCE AND COMPACTION RATES: A NEW MODEL FOR THE MICHOUD AREA, SOUTH LOUISIANA

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Recent geodetic studies challenge the widely held position that modern subsidence in south Louisiana is primarily a function of shallow sediment compaction. Testing such studies involved constructing a structural cross section of the Michoud area in East New Orleans, Louisiana using well logs, chronostratigraphic data, and fault picks, so as to evaluate differential motion along specific faults through time. Employing ages and corrected depths for three key subsurface horizons, long-term (Middle Miocene to Present) time-averaged subsidence rates were calculated: rates range from -0.140 to -0.177 m/kyrs (-0.140 to -0.177 mm/yr). Long-term subsidence rates are incompatible with those derived geodetically for the Michoud area (-14.2 to -23.0 mm/yr), as rates are two orders of magnitude in difference. However, considering the scale of resolution of respective techniques, caution is advised when comparing respective subsidence rates. Nevertheless, the new subsurface, structural model for the Michoud area suggests reactivation of local faults is a transient phenomenon that is likely related to rapid Quaternary sediment loading. Mean long-term compaction rates for strata residing above the Middle Miocene *Bigenerina Humblei* horizon were calculated: rates range from -0.0704 to -0.0914 m/kyrs (-0.0704 to -0.0914 mm/yr), which are two orders of magnitude less than geodetically derived, pre-Holocene strata compaction rates (-4.6 mm/yr). The findings of this research, particularly the discrepancy between mean long-term compaction rates derived in this study and pre-Holocene compaction rates derived geodetically, raises questions into the interpretations and/or accuracy of the geodetic data for the Michoud area, and therefore, the subsidence rates determined from such data.

STUDIES OF THE ENGINEERING PROPERTIES OF PILLARS IN KV-5, TOMB OF RAMSES II, VALLEY OF THE KINGS, EGYPT

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This project sought to investigate the level of understanding of underground structural engineering that the Pharonic Egyptian tomb builders possessed. Pillars in the Tomb of Ramses II, KV-5, have experienced degradation and failure in a seemingly unpredictable pattern, making it an ideal test of their knowledge. A range of factors of safety were calculated with established methods for room-and-pillar style underground openings using existing geologic and engineering data for KV-5. The range of factors of safety was the result of using the upper and lower limits of compressive strengths found within the tomb rocks. Some proxy values and properties of the rocks in the tomb were used based on similar materials due to a lack of samples and specific measurements from the tomb. Factors of safety range from 0.43 to 3.34. Calculated factors of safety using solely rock material properties do not correlate well with reported pillar damage. These results seem to indicate that other factors contribute to the reported damage in the pillars. Vertical tension fractures from valley erosion predate tomb construction and isolate the load on individual pillars. No significant movement has ever been reported along these fractures since tomb construction. Due to the fractures, some pillars carry a smaller load than others. The pillars carrying a smaller load should have less reported damage. This conclusion appears to be true. These conclusions may help conservators find better ways of preserving tombs within the Theban Necropolis.

THE USE OF REGIONAL STRATIGRAPHY AND BOREHOLE SONIC LOGS FOR SITE RESPONSE

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Producing a credible estimate of bedrock earthquake ground motion amplified by a deep soil column (site response) has become an important part of a license application for a new nuclear power plant. The determination of a site-specific shear wave velocity profile is a site characteristic component of that calculation. P-S suspension logging, crosshole seismic methods and spectral analysis of surface waves (SASW) have been used to obtain site-specific data for several combined license applications (COLAs) to the U.S. Nuclear Regulatory Commission. In general, it is impractical from a cost and schedule perspective to drill and log boreholes from the ground surface to hard rock with shear wave velocities of 9,200 feet per second at sites with thick coastal plain deposits. Publications on deep groundwater investigations, oil and gas exploration studies, and regional stratigraphy are used to develop a site stratigraphic column that extends below the depth of site characterization boreholes. State agencies and well log libraries are an inexpensive source of sonic logs that have been drilled for some of those investigations at varying distances from a potential power plant site. A simple conversion calculation is used to convert sonic log values to shear wave velocities. This has been a cost effective method for extending our knowledge of the site soil profile to depths below our deepest site borings. This method has saved clients time and money and provides our geotechnical engineers and seismologists with the data needed to calculate soil amplification factors and ground motion response spectra.

ANALYSIS OF GROUNDWATER TEMPERATURE PROFILES IN CHAUTAUQUA COUNTY, NEW YORK

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The goal of this project at its onset was to determine temperature profiles for several monitoring wells throughout Chautauqua County to determine baseline temperature profiles several areas in the county. These profiles would allow for comparison with future projects in determining the extent of mean annual temperature change in the area. Initial data showed that for wells at higher elevations on the Alleghany Plateau, mean annual temperatures ranged from 9.4°C to 9.8°C (48.9°F to 49.7°F), with range being attributed to microclimates, and wells on the Lake Erie Lowland having a mean annual temperature of 11.4°C (52.6°F).

After the initial data collection, analysis showed a temperature anomaly at a well field located within the town of Clymer, NY. These wells, which are located around a pumping station and adjacent to a stream, showed significant warming trends throughout the winter months that is attributed to induced flow from the nearby stream caused by the pumping station. Further study is needed to determine the extent of vertical and horizontal flow, but data indicates complex flow in the area which incorporates stream flow, regional flow, and mixing of temperature zones from vertical flow.

SHALLOW STRATIGRAPHIC FRAMEWORK AND EVOLUTION OF THE NORTHERN CHANDELEUR ISLANDS, LOUISIANA

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The northern Chandeleur Islands have been described as a transgressive barrier system that follows a recognizable evolutionary sequence of shoreface retreat. Recent observations suggest a modification to this pattern due to a prevailing wave climate oblique to the island chain, and a non-uniform distribution of subsurface features. A dense network of seismic profiles and sediment cores collected around the Chandeleur Islands reveal a near-surface stratigraphy of massive to laminated sands and silts associated with the St. Bernard delta complex, overlain by a transgressive barrier-sand sheet that comprises the islands. The southern half of the island chain is underlain by relict distributary deposits that trend west to east, perpendicular to the strike of the islands. These channels are filled with silty-sands, and incise muddy interdistributay/prodelta deposits that are the dominant stratigraphy. Comparison of sediment grain size in the various lithologies suggests that a significant distributary network is necessary to account for the amount of sand found in the barrier system. The erosion of the distributary channels to the south, coupled with a prevailing southeast wave approach, promote a net island migration northward rather than rapid retreat through rollover. This northward movement is punctuated by storm impacts that erode the subaerial portion of the islands and remove sand from the system. Historical shoreline maps indicate that over the past century the amount of sand made available through erosion of the distributary network does not maintain island configuration, and eventually erosion by storm impact will prevail, likely reducing the islands to ephemeral barriers and submerged shoals.

GROUNDWATER RESOURCE SUSTAINABILITY IN THE VICTORVILLE AREA: RESULTS FROM THE ORO GRANDE WASH RECHARGE PILOT STUDY

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Alto Deep Well (ADW-1) was drilled by the Mojave Water Agency as a part of the Oro Grande Recharge Augmentation Study following up on a pilot recharge project. The area was chosen as it was about 1.8 kilometers north of the California Aqueduct, near extraction wells owned by the Baldy Mesa Water District and Victor Valley Water District with the water table at a depth of about 150 m. In addition, this area was recommended by the USGS as a likely location based on location within Oro Grande Wash and the subsurface geology. Prior to the test, a cone penetrometer survey and a resistivity survey were conducted from the aqueduct to the recharge site in Oro Grande Wash. Three months following the recharge of water (about 50 Hectare-m) a second resistivity survey was conducted and showed that water had migrated 76 m north of the percolation pond and was perched on a fine grained layer of sediment at a depth of 60 m. The 60 m depth correlates well with the caliche cemented top of the Shoemaker Gravel. This area is directly down slope from the exposed porous and coarsely granular deposits that form the Inface Bluffs in Cajon Valley. Several formations of the "Victorville Fan" compose the stratigraphic sequence which fines northward away from the San Gabriel Mountain Front that was the source of these sediments. The depth to basement based on gravity models of the area was expected to be about 800 meters and it was anticipated that the granular nature of the Inface deposits would continue northward towards the river. On the contrary, drilling encountered granitic rock at a depth of 550 meters and only a few thin aquifer quality layers, each about 12 m thick interspersed in a predominantly clay-rich sedimentary rock formation section.

EFFECTS OF GEOLOGICAL FAULTS ON LEVEE FAILURES IN SOUTH LOUISIANA

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During Hurricane Katrina in 2005, a number of breaches occurred in hurricane levees and floodwalls in southeastern Louisiana at locations where the structures were built across deep-seated geological faults. Fault related breaches along the 17th Street Canal, the London Avenue Canal, and the Inner Harbor Navigation Canal in the New Orleans area caused flooding in densely populated urban areas resulting in catastrophic loss of life and property.

Studies during the past decade indicate that ancient deep-seated regional faults, long believed to be dormant, have exhibited surface movement during the past 50 years. Some of these faults extend down 25,000 feet and have been active for 100 million years or more. Fault planes and fault plane zones are deep cracks that result in poor foundation conditions where they reach the surface. The active faults are part of a linked tectonic system that underlies the region. Primarily natural geological processes drive fault movement within this system. The system is an expression of a massive "continental margin gravity slump" extending from the latitude of New Orleans to the deep Gulf of Mexico. Earthquakes and modification of landforms help identify active faults.

Fault hazards were not recognized at the time of levee design and construction, but are now known to pose a significant natural hazard. The fault hazards are not insurmountable obstacles to restoration and maintenance of a sustainable coastal zone in Louisiana, but must be a primary consideration in planning and design of the program.

MODELS TO PREDICT SEDIMENT YIELDS FOR SOUTHERN CALIFORNIA WATERSHEDS

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Poster Session: Debris retention basins in southern California protect communities and infrastructure from hazards of flooding and debris flow. Empirical models that predict sediment yield oftentimes determine the size of debris retention basins. These models were developed using Los Angeles County records of the amount of material removed from debris retention basins, associated rainfall amounts, watershed characteristics, and wildfire extent and history. New sediment yield data for watersheds located in Ventura, Los Angeles and San Bernardino Counties supplement existing data and were used to generate new empirical models that predict sediment yield for watersheds in Southern California. Two models were developed using multiple linear regression, one for watersheds located throughout the Transverse Ranges of Southern California, and one specific to Ventura County watersheds. These models were compared to previously developed models using a test dataset by comparing sediment yields predicted using each model to the recorded amount. The Ventura County specific model under-predicted sediment yields. The model developed using information from Ventura, Los Angeles and San Bernardino Counties best predicted sediment yields for Southern California watersheds as determined from the validation dataset. This model predicts sediment yield as a function of the peak 1-hour rainfall, watershed area burned by the most recent fire, time since the most recent fire, average watershed slope and relief ratio.

QUANTITATIVE DETERMINATION OF THE PEDRO MIGUEL FAULT'S SLIP DISPLACEMENT AND SLIP KINEMATICS FOR DESIGN OF THE PANAMA CANAL EXPANSION PROJECT'S BORINQUEN DAM

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As part of the seismic hazard investigation component for the Panama Canal Expansion Project's design studies, we completed detailed paleoseismic investigations of the Pedro Miguel fault. The fault not only poses a shaking hazard to the Panama Canal, it also crosses through the proposed footprint of Borinquen Dam, a critical part of the expansion program. Borinquen Dam is composed of four discrete dam segments, totaling nearly 5 km in length. It will contain the new 6.7 km long approach channel to the new Pacific Lock, preserving the Gatún Lake water elevation at 10.6 meters above the current Miraflores Lake. Our studies of the fault involved over 55 geologically logged trenches, including three locations where we excavated the fault in 3-D to determine earthquake recurrence, displacement magnitudes and fault slip kinematics. The Pedro Miguel fault poses a significant hazard to the project. We were able to determine that it has had three surface-rupturing earthquakes in the last 1500 years, with the last event almost certainly occurring on May 2, 1621 AD. These three events all had 2-3 meters of right-slip displacement, with 8.1 meters cumulative. The fault exploits weak, low-angle, west-dipping bedding planes of the La Boca Formation to rupture through to the surface as a series of north-stepping, en-echelon, west-dipping fault petals that roll over near the surface to almost horizontal. The challenge for the dam's design will be to correctly understand the specific geology of the fault-crossing location to be able to predict the fault rupture kinematics, and then to use deformation modeling to understand how that rupture will transfer into the dam's earthen structure.

EVALUATION OF LONG-TERM SLOPE STABILITY IN THE BLUDE RIDGE MOUNTAINS, NC

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Poster Session: Few studies exist that measure absolute ages of colluvial hollow infill, so that timing of hollow evacuation and infilling rates can be determined. We present results from two hollows in the Coweeta Hydrologic Lab in the Blue Ridge Mountains of North Carolina, *Pit 13* and *Hollow Trench*. At each location we obtained soil samples from multiple depths and analyzed radiocarbon ages from macroscopic charcoal pieces and two chemical fractions of fine (< 58 μm) material. The fine material was isolated by wet sieving and rapidly drying the fine-grained fraction. Based on the radiocarbon results, we interpret that both hollows experience a complex history of accumulation. At *Pit 13* there is overall stratigraphic consistency with the exception of an older fines sample at 70 cm BLS. All three of the sampling methods are consistent at the saprolite-soil contact (140 cm BLS). These ages constrain an aggradation rate of ~0.024 cm/yr for the last 5000 years if the outlier at 70 cm BLS is excluded. *Hollow Trench* results are also stratigraphically consistent, with the exception of a young charcoal result from 40 cm BLS. Two charcoal samples from the saprolite-soil contact are late Pleistocene in age. We hypothesize that they were temporarily stored and/or slowly transported across the low gradient hilltop above the hollow for ~15,000 years before they were deposited. Hollow Trench colluvium filled at an average rate of ~0.021 cm/yr between ~9,000 and 4000 years BP. For the past ~4,000 years, the average rate of accumulation slowed to ~0.009 cm/yr.

EVALUATING SEISMIC SOURCES IN THE CENTRAL AND EASTERN U.S. FOR INPUT TO PROBABILISTIC SEISMIC HAZARD ANALYSIS IN SITING OF NEW NUCLEAR POWER PLANTS

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The U.S. Nuclear Regulatory Commission is currently evaluating several new reactor applications, primarily in the central and eastern United States (CEUS). Probabilistic seismic hazard analysis (PSHA) provides a tool to estimate seismic hazard for the CEUS because it is capable of incorporating uncertainties. A popular practice for new Combined Operating License applications (COLA) is to use one of the recommended PSHA seismic source models as a starting point and update those sources where new paleoseismic evidence have emerged since the models were published. In the mid 1980s, the EPRI-SOG (Electric Power Research Institute - Seismicity Owners Group) developed a generic seismic source model with uncertainties to support site-specific PSHA anywhere in the CEUS. In 1989, the Nuclear Regulatory Commission (NRC) issued a safety evaluation letter indicating that the EPRI-SOG data was acceptable, but that it was recommended to be updated every 10 years. The issue is that the 1989 underlying generic seismic source model for the CEUS is more than 18 years old. An updated generic CEUS seismic hazard model is proposed by EPRI for completion in 2009 and will benefit several industry participants. This paper presents some background on the current seismic source model (1989, EPRI-SOG) of the CEUS, the project plan for the new source model and a case history at two sites; a deep soil site near the New Madrid Seismic Zone and a hard rock site near the Eastern Tennessee Seismic Zone.

POST-HURRICANE KATRINA EVALUATION OF THE ROLE OF DREDGED MATERIALS IN THE NEW ORLEANS LEVEE SYSTEM

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As part of the Interagency Performance Evaluation Task Force (IPET) work, an assessment of the post-Hurricane Katrina levee performance was conducted by the US Army Engineer Research and Development Center. General Design Memorandums, soils reports, and borehole data from the U.S. Army Engineer District New Orleans were collected and analyzed to identify trends and understand the cause and effects of the water levels and wave heights on the New Orleans levee system. Review of the soil and dredging reports indicated that the earthen levees and capped levees were constructed from dredged material placed by hydraulic fill and mechanical methods. GIS maps delineating the types of dredged materials were created for the 3 major levee systems including New Orleans East, Plaquemines, and St. Bernard polders where significant breaching occurred. Although soil properties contributed to erosion and scouring of the levee system, the storm surge and wave action from the hurricane were the major contributors for levee breaching. Specific areas where long expanses of levee experienced numerous breaches and scouring included the levee sections along the Mississippi River-Gulf Outlet (MR-GO) on the northeast side of St. Bernard Parish and New Orleans East back levee. These levees were constructed from hydraulic fill that were predominately sand- and silt-size materials. In conclusion, the data indicated that the combination of hydraulic dredged materials used for levee construction and high surge and wave action lead to breaches by erosion.

STORM SURGE AND WAVE ENERGY REDUCTION FOR THE INNER HARBOR NAVIGATION CANAL

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The U.S. Army Corps of Engineers (USACE) and the State of Louisiana Coastal Protection and Restoration Authority (CPRA) recently announced the award of the Inner Harbor Navigation Canal Surge Reduction Project. The structure(s) is expected to be located at the confluence of the Gulf Intracoastal Waterway and the Mississippi River Gulf Outlet, generally between Paris Road and the shore of Lake Borgne from New Orleans East to St. Bernard Parish. This project is the largest element in the overall 100-year level of protection for the greater New Orleans area and the largest civil works design-build contract in Army Corps history. The completed Greater New Orleans Hurricane and Storm Damage Risk Reduction System will consist of a combination of floodwalls, levees, gates, pump stations and closure structures.

A sensitivity analysis was performed using numerical models to evaluate a range of structure configurations for synthetic storms of varying intensities and trajectories. Numerical models were used to simulate a range of 2009 interim alignments as well as 2011 final alignments. The interim alignment will reduce risk in 2009 and the final alignment will provide 100-year level of protection in 2011. The modeling methodologies used for this study are in accordance with the unified technical approach developed as part of the Joint Coastal Surge (JCS) Analysis Study with the US Army Corps of Engineers (USACE) and the Federal Emergency Management Agency (FEMA). The circulation model ADCIRC was used to simulate storm surge and was coupled with the nearshore wave generation and transformation model STWAVE. The coupled model results were used to assess the performance of various structure alignments.

THE INFLUENCE OF MARSH RESTORATION AND DEGRADATION ON HURRICANE-GENERATED STORM SURGE AND WAVE ENERGY IN SOUTHEAST LOUISIANA

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The coastal areas of the Barataria and Terrebonne basins are undergoing the greatest land loss in Louisiana. Although these areas are south of New Orleans, the coastal wetlands provide a natural buffer against storm surge and waves. This study evaluated the effects of marsh restoration and degradation in the Barataria and Terrebonne basins on hurricane generated waves and surge. The marsh alternatives included a predicted wetland definition 50 years into the future with no increased action (NIA) taken and a restored/improved marsh condition predicted by USGS and the State of Louisiana. Figure 1 shows the bathymetry differences for the future marsh conditions with no increased action minus the existing conditions. (Hot colors indicate land loss.)

A sensitivity analysis was performed using numerical models to assess the impact of bathymetric and frictional resistance changes on peak surge elevations and waves for storms of varying intensities and trajectories. The circulation model ADCIRC was used to simulate storm surge and was coupled with the nearshore wave generation and transformation model STWAVE. The coupled model results indicate that the wetlands provide some level of protection as a natural buffer and line of defense for Southeast Louisiana and the efficacy is reduced with degradation. The study results could be used to quantify the benefits of marsh restoration in the Barataria and Terrebonne basins.

Figure 1: Bathymetry differences (ft NAVD88 2004.65) for future marsh conditions with no increased action minus existing conditions. Orange areas indicate degradation.

A NEW GUIDANCE DOCUMENT FOR MITIGATING IMPACTS FROM ACID-PRODUCING ROCK FORMATIONS IN TENNESSEE ROAD CONSTRUCTION PROJECTS

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When portions of the Chattanooga shale and other pyrite-bearing or sulfide-bearing rock formations are exposed in Tennessee Department of Transportation (TDOT) road projects, there is a potential for runoff to become polluted with sulfuric acid and metals (mostly iron) when the pyrite/sulfide rock weathers. As a part of surface water pollution management, TDOT recently updated its 18-year-old standard operating procedure (SOP) for dealing with this important issue to create a new guidance document. In the process, a team of geologists and GIS experts developed a GIS database of information that TDOT could use to quickly identify projects that might need to follow the new guideline to avoid impacts. This information includes zones of geologic formations known to contain pyrite and formations containing acidic pH-neutralizing rocks such as carbonates. The GIS database was also configured to not only receive the wealth of analytical data that TDOT has assembled over the past decade on pyrite-related road projects but to allow addition of new information in the future. The project team geochemists further compiled the latest research on pyritic rock characterization and testing and compared it to protocols found in TDOT's existing SOP.

The new guideline document, building on years of TDOT's actual experience, was also based on mining industry experience in mitigating pyrite-derived impacts. It was recognized that despite the implementation of up-to-date Best Management Practices (BMPs), some residual acidic/metal runoff may occur. For these situations, the guideline provides passive treatment system (a.k.a. constructed wetland) BMPs, again based on mining industry derived experience. TDOT's new guidelines are the most comprehensive construction related acidic rock drainage BMPs of any state DOT.

THE EFFECT OF SITE CHARACTERIZATION ON ROADWAY AND STRUCTURE DESIGN, PROPOSED TURNPIKE MON-FAYETTE EXPRESSWAY, DESIGN SECTION 53C, PITTSBURGH, PENNSYLVANIA

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The proposed Mon-Fayette Expressway from S.R. 0051 to S.R. 376 will provide a direct connection from the existing Mon-Fayette Expressway (S.R. 0043) to Monroeville and the City of Pittsburgh. For design purposes, the entire project is divided into 13 sections, 53A through 53L. This paper refers to Section 53C which is located in the City of Duquesne in Allegheny County, Pennsylvania and extends from Homesville Road to the Monongahela River. This location is situated in the McKeesport and Braddock USGS Quadrangle Maps. The proposed alignment passes near the City of Duquesne in a series of cuts and fills and approaches the Monongahela River as a viaduct. An interchange is provided in the section to provide access to the Mon-Fayette Expressway from Commonwealth Avenue. A connector road with Commonwealth Avenue extending to the Duquesne Works (Business Park) and a relocated S.R. 837 bridge are included in this project.

A literature search, field reconnaissance, and pre-final stage subsurface drilling investigation were performed. Several findings triggered stability questions with respect to the roadway and structure designs. These include subsurface abandoned coal mines, surface strip mining with spoil and refuse materials, past mine fires, thick slag deposits, metal objects within slag, acid mine drainage and weak mudrocks.

The roadway design was modified to include the needed geotechnical treatments. Where underground mining was confirmed, undercutting up to 50 feet to the top of the mine was proposed to collapse the mine void and avoid any future sinkholes. Over-excavation of unsuitable materials such as spoil, refuse or mudrocks under roadway grade was proposed to avoid any future settlements. Coal seam treatments in cut slopes were proposed to avoid exposing coal seams and potentially reduce any acid mine drainage effect. Rock toes with side hill benching were proposed at embankments with stability concerns to obtain an acceptable factor of safety.

The thick slag deposits (40 to 80 feet) and the metal objects within the slag influenced the structures foundation design. Mudrocks with low friction angles below the slag deposits were also encountered. Deep foundations are proposed to pass the slag layers and even the mudrocks below the slag.

By utilizing the subsurface information obtained from the drilling program and the available literature of the project site, a better judgment with respect to the roadway and structure design were made.

RECONNAISSANCE ENGINEERING GEOLOGY OF THE LAPRAK LANDSLIDE, GORKHA DISTRICT, WESTERN NEPAL

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Heavy rain during the 1999 monsoon triggered a landslide that killed one person, destroyed ten homes, and took twelve hectares of land out of cultivation in the village of Laprak in the northern portion of the Gorkha District, western Nepal (28°13'4.8"N , 84°48'12.7"E). Inhabited by 3500 people, Laprak lies on steep slopes at 2100 m elevation along the Raizo Khola valley three days by foot (46 km) from the district headquarters in Gorkha. The landslide is about 1500 m long and up to 650 m wide, with 30 cm wide cracks in several locations and springs during the wet season. Slopes measured using a 30 m ASTER DEM average about 30° and in some places exceed 45°, with steeper slopes measured locally in the field. The geologic setting consists of more than 10 m of clayey soil (including older landslide debris) underlain by fractured gneiss and quartzite, with foliation dipping 20° to 30° in a direction nearly perpendicular to the long axis of the landslide. The 24-hour rainfall on July 3, 1999 that triggered the landslide was 342 mm. Another 14 homes and 11 hectares of land were destroyed by recurrent movement during the 2002, 2006, and 2007 monsoons. Laprak is located only 350 m from the trace of the Main Central Thrust, a seismically active fault that extends the length of the Himalaya and constitutes a

major tectonic boundary, bringing the High Himalayan Crystalline Sequence to the surface. Precipitation, toe erosion by the Raizo Khola, and seismicity must therefore be considered as possible future triggers.

RAPID PROTOTYPING OF COMPUTER MODELS TO VISUALIZE DISCONTINUOUS ROCK MASSES

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Digital geologic models of discontinuous rocks can comprise a variety of data types including rock type, discrete discontinuities, brecciated or highly fractured zones, and irregular 3-D surfaces such as original and designed topography, faults, and lithologic contacts. Data formats available on a given project can also be variable, including 3-D point clouds, regularly gridded digital elevation models (DEMs), triangulated irregular networks (TINs), borehole logs, discontinuity orientations measured on the surface or in the subsurface, and 3-D descriptions of the shapes of traces or planes. Using examples from recent rock slope projects along I- 90 near Snoqualmie Pass, Washington, this presentation shows how modern general-purpose mathematics software (in this case *Mathematica*) can be used to rapidly create customized 3-D computer models in support of discontinuous rock mass characterization. Capabilities such as pattern matching, object-oriented programmability, and access to graphics primitives allow information to be extracted from a variety of data file formats and used to create geologic objects— for example, inclined discs representing individual joints— that can be combined with others to create 3-D geometric models that can be manipulated in real time by end-users with no specific modeling experience. Standard graphics objects such as surface plots can also be tailored to optimally convey geologic information such as the morphology of a landslide scar that may be related to subsurface discontinuities. Advantages of general-purpose software over specialized geological modeling software can include lower cost and greater flexibility, albeit at the price of steeper learning curves for beginning modelers.

A TRIBUTE TO TERRY R. WEST

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This presentation focuses on the author's 35 years association with Prof. Terry R. West to highlight the role and contributions of one of the greatest modern time educator, professional, and a remarkable human being who has left an indelible mark in the field of engineering geology. It is my personal tribute to my teacher, mentor, and friend who has touched the life and career of dozens of engineering geology professionals not only in the United States but in many countries all across the world. Many of whom have distinguished themselves as practioners and educators in the fields of engineering and environmental geology and have been recognized for their outstanding achievements.

Following a brief review of the educational and professional record of Prof. Terry R. West, the presentation highlights his unusually long presence—almost half a century—at Purdue University and the role he played in teaching and research in engineering and environmental geology. He deserves the credit for building the program from the grounds up to a level that has led to its recognition nationally and internationally as one of the topmost degree programs in engineering geology.

Prof. West has supervised graduate research of 80 students—20 receiving their Ph.D. degrees and 60 M.S. This is a rare record, and affirms his commitment to advancing knowledge in the fields of engineering and environmental geology. He has published numerous papers and presented his research findings at many national and international conferences. A bibliography of Prof. West's major publications and a list of his service to various professional organizations are also included in the presentation.

HISTORY OF MANUFACTURED GAS IN ARKANSAS; REMEDIAL IMPLICATIONS

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Vast differences; an agricultural economy and non-plentiful coal, destined Arkansas to remain underdeveloped in terms of manufactured gas, throughout the history of that industry. There may prove to be no more than 15 FMPGs in the State; located mostly along the Mississippi River, at major rail centers, and more in the southern part of the State than in its north. Eureka Springs, the late 19th century resort community, readily accessible only by railway at the time of the establishment of its oil-gas plant, in 1886, saw is gasworks go defunct by the turn of the 19th century, never to be replaced.

Local coals were known to be adaptable for gas manufacture, but of insufficient "caking" quality, along with the minimal rail system, and a lack of iron ore, never fostered the development of either non-recovery or recovery-type coke ovens.

The author has yet to locate his first Arkansas producer gas plant; likely explained by the undeveloped economy catering largely to fundamental timber, hardwood, canning and poultry industries that were labor intensive. Steam was utilized widely, due to the low-cost of labor and the abundance of hard-wood fuel. Likewise, the main beneficiaries of the many short-line railroads were the petroleum companies of Texas, Oklahoma and Louisiana, who built their bulk plants in nearly every small town that was served by rail. The abundance of this cheap oil further promoted D.C. electric lighting plants, which further retarded the development of the manufactured gas industry. Eventually (1928), natural gas pipelines began to enter Arkansas, first from Oklahoma, and later, from Texas and Louisiana, and manufactured gas was doomed to one of the lowest State profiles of development. Likely the largest number of "coal-tar" sites will prove to be those of the charcoal and of the creosote wood-treatment industries, again favoring sites along the Mississippi River. Many small towns are believed to have had "gasoline" (distilled petroleum light-spirits) and acetylene gas plants, which generally did not produce toxic residuals and wastes.

HISTORY OF MANUFACTURED GAS IN MISSISSIPPI; REMEDIAL IMPLICATIONS

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Given its typically fine-grained geology and sub-tropical Pleistocene and Quaternary soils, Mississippi presents some unusual remedial considerations for remediation of former manufactured gas plants (FMGPs) and other coal-tar sites. The overall number of FMGPs is less than the dominant tar sites, those of wood-preservation. Earliest gas manufacturing may be 1840 (Natchez), or more certainly 1857 (Jackson) and wood resin ("rosin") and fatwood dominated the industry (One 300 lb. barrel, @ $1.50, yielded 9,000 cf wood gas & several gal. tar) until the completion of post-war reconstruction, about 1876, when steamboat and rail supplies of coal had become affordable. Most gas works were constructed with absentee northern gas money, largely from Ohio River cities capable of supplying river transport for gasworks machinery, installed by local contractors, and $25-30,000 could put a plant in place. Plants remained relatively small until the national holding-company craze of the 1920s, when carbureted water gas became common in the State and plant costs rose to the range of $100-200,000.

The greater number of Mississippi tar sites are those of the creosote wood-preservation facilities (from ca. 1878), charcoal kilns, and WWII-era wood-tar/cellulose acetate plants (Two tons of wood yielded 0.5 ton of charcoal and 10 gal. wood tar). Preservation facilities typically are plagued with unlined, spent-creosote pits.

Given the plentiful supply of surface and groundwater, contact condensation was common and most sites are likely to contain considerable adjacent waterway PAH contamination of fluvial sediment, in addition to the toxics of the usual gasworks dump, on or adjacent to the plant. Late Neogene sedimentary units generally have widespread aquifer sequences, such as those of the Catahoula and the undifferentiated Pascagoula-Hattiesburg Formations, and site geomorphic features may leave their more hydraulically-conductive members and beds open to PAH DNAPL infiltration and transport. Riverside FMGPs exhibit the usual gasworks contamination of adjacent bodies of surface water.

HISTORY OF MANUFACTURED GAS IN LOUISIANA; REMEDIAL IMPLICATIONS

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Louisiana's manufactured gas history is both varied and complicated. Gas was produced at New Orleans as early (1822) as it was in our larger, industrialized cities; the author's count of its own coal-tar sites currently 20, and the number should prove to be considerably larger.

The lessons of Hurricane Katrina have enhanced our understanding of the geologic complexities of the soft, youthful, unconsolidated and geomorphically discontinuous soils of the State's Mississippi River sites. The earliest human remains were discovered (1822) at a depth of 5.5 m bgs in excavation of the gasholder pit of the Locust St. gasworks. New Orleans' gas company changed hands six times (1907-1917) and the constraints of gas distribution technology makes site characterization a demanding task. Among the out-of-State owners were Stone & Webster(Baton Rouge, Lake Charles) and EBASCO (New Orleans). Town gas plants appear to have been limited to New Orleans (1890 population of 290,000), Shreveport (12,000), Baton Rouge, Lake Charles and Lafayette, as well as Jennings (4,500 in 1920s). Considering the general lack of industry in the pre natural-gas era, the potential for producer gas plants. Outside of New Orleans, is small.

Louisiana natural gas was first discovered in developable quantities at Sterlington in 1924 and eventually led to termination of most manufactured gas plants by the early 1930s; 1928 for New Orleans.

Elsewhere in Louisiana, the proximity of wood needing humid-climate preservation brought forth (1895 with a surge at 1900-1910) creosote pressure wood-preservation plants (32 now known; five SUPERFUND NLP), most of which chose direct discharge options for managing their spent impregnation solutions. As in other southern States, once established, with rail connections, other wood preservers tended to put up plants in the same areas.

Of all U.S. physiographic provinces the geologic terranes of this State are most unfriendly to the current RP trend toward risk-avoidance of comprehensive characterization and realistic remedial action.

12TH ANNUAL REPORT ON THE PROFESSION – 2007 STATUS

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2007 brought continued attention to urban infrastructure, a rush into construction-program management and the design-build concept. Engineering geologists will have to struggle to see that our talents are preserved and employed in site characterization, the one activity that cannot be neglected if public health and safety, environmental protection, and liability consciousness are to be recognized in engineered construction.

Economic belt tightening was continued; brought by long-term commoditization of professional services, beginning in the 1980s. Acquisitions continued; acquired firms served to introduce the master firm to a regional market, with subsequent lay-offs of acquired staff who were not equity owners. We took full notice of the "mega-consultants;" firms so large (20,000 + employees) that their geologic endeavors are totally lost to external view, even in the societies.

Nuclear power continued its return in the developed world and national regulators were girding for explosive growth in license applications, such as not seen since the 1970s.

Underground construction remained vast and diffuse, but employment entry requires insider contact, if only to fill retirements of senior technical personnel. Access for University faculty slipped again, as bid-shopping restricted their project involvement, across the profession, with general abandonment of the peer review and quality control roles in which they used to serve. Students are therefore shorted and the role of the professional societies must be expanded toward more effective technology transfer to the classroom. Our technical literature made great bounds in 2007, with historic texts and journal runs alike receiving unprecedented availability on the worldwide web. In summary, the profession is changing at an accelerated pace and keeping informed is now both easier but more demanding of the individual practitioner.

GASWORKS SITE & WASTE CHARACTERIZATION; APPLYING SOME "RULES" OF PROFESSOR

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Former manufactured gas plants (FMGPs) and related tar-generating and tar-utilizing facilities represent the fundamentally most-dangerous of uncontrolled hazardous waste sites. Given the environmentally indestructible nature of these residuals and wastes (mainly PAHs), and their unusual physical properties and characteristics when discharged to the geologic environment, many unfortunate remedial choices are being made with respect to false economies and false presumptive risk assumptions.
Professor West has brought to his teaching a philosophy of seeking field-geologic truths and examining and weighing their implications against the nature of the industrial process creating the toxics and then evaluating real evidence as to what constitutes the needs of remedial action.
The single most-important conclusion that this author derives from "West-Think" in the FMGP context is that assumptions generally are the antithesis of competent geologic work product.
Key site truths are:

- Site manufacturing process; what was manufactured, how it was made, and what its were the toxic residuals and wastes
- Site conceptual geologic model: define the geologic units to be reasonably expected; plan the exploration effort accordingly
- Two basic perpendicular geotechnical profiles; one parallel to expected groundwater flow vector
- Possible geomorphic features; use them to predict contaminant transport paths and likely discharge points
- Establish key elements of geological information requirements; explain them by multiple working hypotheses, and employ daily evaluation of exploration findings.

FMGPs that are not characterized by truth-over-assumption represent unacceptable forms of risk to the public and to the environment.

IMPROVING THE PERFORMANCE OF CUT SLOPES IN SOFT ROCKS: A NEW APPROACH

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Soft rocks, including shale, mudstone, and siltstone, are frequently inter-bedded with hard layers of sandstone or limestone of varying thicknesses. Such strata are found extensively throughout the world and present unique challenges in projects that require cutting in rocks. Soft rocks are prone to weathering and they deteriorate quickly when cut and exposed to climatic changes. The designer is often faced with the dilemma of protecting the freshly cut slopes on the one hand and keeping the cost and environmental impact of the project within limits on the other hand. On the Islamabad-Murree-Dual carriageway project in Pakistan, which passes through the hills composed of alternating beds of shale and sandstone of Miocene age, a new approach was tried to solve this problem. This new approach involved the construction of retaining walls (breast walls) at the toes of the cut slopes. The space behind the wall served as a catch pit for the debris generated from weathering of rock slope (basically shales). As the space behind the wall was filled up, the slope debris acted as a protective layer over the underlying shale strata. The accumulated debris also provided a favorable medium for the growth of vegetation. This paper presents the case history of the project and the lessons learned from it, including how this technique could be applied successfully elsewhere.

CORPS OF ENGINEERS' SEISMIC HAZARD ANALYSIS

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The Corps of Engineers (CoE) has established procedures for Seismic Hazard Analysis (SHA) of its projects. The emphasis of this talk will be on the Central U.S. (CUS) and, in particular, on the region around the New Madrid seismic zone. A few other issues for SHA as a whole will be noted.

The CoE uses both Probabilistic SHA and Deterministic SHA in the design or review of its projects. The CoE is currently reviewing and updating its procedures with a forthcoming Engineering Circular, the Selection of Design Earthquakes. The CoE's procedures for SHA and the seismic sources used in the CUS will be cited.

There are several issues concerning CUS Seismic Sources that are not well utilized or appreciated by owners and the general engineering community. Some of those issues are: what are the accepted CUS seismic sources; what CUS sources should be used for a site-specific analysis or a time-history evaluation; what is the minimum level of CUS background seismicity and how close should a floating earthquake be placed in a site-specific analysis?

IDENTIFYING BANK COLLAPSE AND FLOODPLAIN SEDIMENT IMPACT FROM THE MAY 2007 FLOOD EVENTS ON TWO NORTHWEST MISSOURI RIVERS USING TEMPORAL AERIAL IMAGERY DATASETS

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Anomalous spring storms delivered over 7 inches of precipitation to northwest Missouri from May 4 to 7, 2007 leading to one of the most significant flooding events across the region in more than a decade. The One Hundred Two and Nodaway Rivers in northwest Missouri crested more than 7 feet over flood stage inundating adjacent floodplain areas; inducing channel bank collapse and causing numerous instances of overbank sedimentation. Digital processing including temporal change detection and principal components analysis of aerial imagery obtained as part of the 2005 to 2007 USDA National Agricultural Inventory Program (NAIP) was used to identify and map areas of potential flood impact. Follow-up field investigations verifying collapse and deposit locations were conducted starting in late 2007 and continued through mid-spring 2008. Indications of short term impact on the channel edge and floodplain environments associated with this near-extreme flood event as interpreted from processing of aerial images and field verification activities will be presented.

THE WOODSON DEBRIS FLOW COMPLEX PART 1: DESCRIPTION OF THE EVENT

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As northwest Oregon was recovering from wind damage, flooding, and landslides that occurred during a significant storm event December 2–3, 2007, a secondary catastrophic event was in the making above the small town of Woodson in Columbia County. Over the course of the week following the storm, water backed up behind a historic railroad embankment with a plugged drainage structure. On December 11, 2007, the embankment failed catastrophically, and an estimated 40,000 cubic yards of fill material, water, and debris mobilized as a debris flow that traveled over 1.5 miles down Eilertsen Creek and ultimately inundated Woodson and US Highway 30. Fortunately, the impending disaster was recognized with enough time to evacuate homes and close down the highway and although significant damage occurred to the homes, there were no injuries. This presentation will outline the events leading up to the failure as well as key decisions, actions, and inactions along the way.

THE WOODSON DEBRIS FLOW COMPLEX PART 2: REFLECTIONS ON THE EVENT

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This presentation will focus on the importance of four key issues identified in the aftermath of the Woodson Debris Flow Complex: inherently high landslide hazard, the legacy of historical land-use practices, the importance of communication, and the need for landslide hazard maps in Oregon.

It has been increasingly recognized that the geology in the Woodson area is especially prone to landslides and debris flows. Steep, confined canyons have been cut into large landslide features. Catastrophic failures on the margins of these deep-seated landslides can generate debris flows when the material enters steep, confined canyons.

On top of the high inherent landslide hazard, a historic logging railroad employed large cuts and fills to maintain its grade. At the site of Eilertsen Creek embankment, 35,000 cubic yards of material was used to bury a trestle that was approximately 80 feet high. A majority of the material had the consistency of beach sand and the embankment was drained primarily with a large puncheon culvert. It is important to recognize that these practices are not permitted today for obvious reasons.

Effective communication was critical to achieving the outcome of preventing injuries or worse. In emergency situations, communication needs to be clear, concise, deliberate, and in certain circumstances brutally honest. It is important to identify who needs to know information, to make sure they get that information in a timely manner, and to verify that they understand the information once they have it. Dealing with the media comes with its own challenges and opportunities, but the same general principles apply.

Debris flow hazard maps can help effectively communicate to government planners, land managers, and most importantly the public where the potential for debris flows exists. In Oregon's political climate, the maps need to be officially recognized in order to give government planners the leverage they need to enforce use of the maps. Ideally, areas identified by the maps would require site-specific review by a geo-professional prior to development or other land-use activities. Owners of land identified with potential debris flow hazard could be systematically notified using such maps. The need for debris flow hazard maps was identified by the Oregon legislature ten years ago, and although interim maps have been produced, they have not been utilized. Efforts are underway to improve the existing maps and to develop support for official recognition and use of the maps.

GEOLOGIC CARBON SEQUESTRATION

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Geologic carbon sequestration can be defined as the placement of CO2 into an underground repository in such a way that it will remain permanently stored. While alternative sequestration methods exist, geologic carbon sequestration is the most viable option for large scale CO2 storage for centuries to come. If injected deeply at carefully selected sites, there is a high probability of storing upwards of 99% of CO2 injected underground for over a millennia.

Three distinct phases exist in any geological carbon sequestration process. First, CO2 is captured at the source and compressed for ease of transport. The CO2 is then transported to the storage site via pipeline. Once it arrives, injection wells are used to insert the CO2 into the designated geologic unit for storage. If this storage phase is to be successful on an industrial scale, several conditions must be satisfied. The potential geologic host (reservoir unit) needs to have high porosity, permeability, injectivity, and potential capacity. An effective cap rock (seal), such as shale, must overlie the injected CO2 reservoir to keep the CO2 trapped underground. In order to remain in a supercritical state and occupy a smaller storage volume, the CO2 must be injected to depths of at least 800-1,000 meters below ground surface. Additionally, a combination of different CO2 trapping mechanisms are necessary if efficient long-term storage is to be attained.

Five major types of subsurface geologic formations are being explored for their CO2 storage potential: oil and natural gas reservoirs, deep saline formations, unmineable coal seams, basalt formations, and organic rich shales. Methods that can be coupled with enhanced resource recovery efforts, such as enhanced oil recovery in depleted oil fields, are desirable to the electricity industry because the recovered resources offset some of the additional costs associated with the geologic carbon sequestration process. However, in the long term, it is probable that the majority of CO2 storage will occur in saline reservoirs, as these formations are broadly distributed and have large storage potential.

While geologic carbon sequestration has the potential to trap CO_2 safely underground for millions of years, site hazards do exist. Careful site characterization both prior to site selection and after CO_2 injection commences is an important part of identifying these geologic site hazards and subsequently mitigating and/or avoiding them.

TRANSPORT OF FISH BIODIESEL, BIODIESEL BLENDS AND CONVENTIONAL DIESEL FUEL IN SATURATED POROUS MEDIA

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Poster Session: The objective of this research was to investigate the fate and transport of pure fish biodiesel (B100), B20 biodiesel blend and high-sulfur diesel fuel (conventional diesel) in saturated porous media using lab-scale batch experiments for biodegradation rates. We have used the different biodegradation rates obtained for each fuel type in developing numerical models on a hypothetical aquifer. MODFLOW was used as the simulator to compare the transport of the constituents of the contaminants and their fate in hypothetical saturated, homogeneous porous media with two different hydraulic conductivities. For each scenario of hydraulic conductivity, a continuous point source of contamination was used with a constant concentration of 2000 mg/L at the source. The rate constants for the microbial reactions were obtained by investigating respiration rate (CO_2 production) of naturally occurring microorganisms in diesel and fish biodiesel contaminated soils as a function of time for different contaminant types and temperatures (6°C and 20°C). Soil data was obtained using ASTM standards. The chemical breakdown of each of the contaminant was determined by using Gas Chromatography / Mass Spectrometry analysis. From the results it was evident that increasing degradation rates were associated with increasing temperature. At high temperature the Fish Biodiesel degradation rate constant was twice that of conventional diesel fuels, yet at lower temperature the rates were very similar amongst the different fuel types. From our simulation, we were able to obtain the relative biodegradation rates of each fuel type for the two different temperatures in comparison to no biodegradation under similar conditions.

CONSTRAINING THE HISTORY OF LARGE (MAGNITUDE-7) EARTHQUAKES ON THE NEPHI SEGMENT OF THE WASATCH FAULT, UTAH

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The Wasatch fault, which runs right through the heavily populated Wasatch Front urban corridor, appears to be divided into eleven segments. Although there have been no large historic earthquakes on the Wasatch fault, geologic studies indicate that each segment is capable of producing earthquakes of about magnitude-7. The area along the Nephi segment of the Wasatch fault is undergoing rapid urbanization, so an understanding of the earthquake history of the Nephi segment is crucial. Studies conducted in the 1980's and 1990's, however, could only constrain the timing of the two most recent earthquakes on the Nephi segment to <1.0±.4 ka and ≈3.9±0.5ka. We excavated a trench across the northern part of the Nephi segment of the Wasatch fault in order to better-constrain the history of earthquakes on the segment. The trench exposed evidence of two large prehistoric earthquakes. The most recent of these quakes produced three meters of v vertical displacement of the ground surface. The trench also exposed organic-rich soil layers that were offset by the earthquakes. We are in the process of determining the ages of these soil layers, which will allow us to constrain the ages of the two earthquakes. This work was conducted largely by two Summer Field geology classes, helping students develop field skills and providing them with practical experience.

HYDRODYNAMICS OF BARATARIA BAY, LOUISIANA

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Barataria Bay is an interdistributary bay formed between the Lafourche and Plaquemines headlands on the Mississippi River Delta. The bay is fronted by a barrier island complex with four principal inlets. Modern discharge curves and tidal prism-cross sectional area relationships for the inlets were developed using ADCP and single beam surveys undertaken in 2006 and 2007. Tidal wave propagation, phase lag and attenuation in the bay were analyzed using tide and stream gage data and velocity time series.

During the past century, backbarrier wetlands have undergone rapid conversion to open water due to subsidence, frontal erosion, hurricane scour, and anthropogenic causes. Wetland loss increases bay area and decreases the frictional resistance of the estuary, thereby reducing tidal wave attenuation. The ensuing enlarging tidal prism has led to large increases in inlet cross sectional area, sand sequestration on ebb-tidal deltas, and a deterioration in the barrier island complex. The greater connectivity with the Gulf of Mexico has further increased tidal range in the bay. A positive feedback has been established, in which wetland loss increases bay area and reduces frictional attenuation of the tidal wave, leading to a larger volume of water discharging through the inlets. Ultimately, this process is forcing barrier disintegration causing further increases bay tidal range.

APPLYING HURRICANE-RELATED PHYSICS OF AIR-SEA-LAND INTERACTION TO COASTAL GEOLOGIC HAZARD INVESTIGATION

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Hurricanes affect coastal geologic hazard investigations in many ways ranging from beach erosion to seabed scouring. In order to study these morphodynamics, the physics of air-sea-land interaction must first be understood. This paper will present the following aspects induced by hurricanes: parameterization of wind-wave interaction; estimation of maximum sustained wind speed and significant wave height; relationship between significant wave height and dominant wave period; and parameterization of storm surge and seabed scour. The data used for this research and development are based on four Category 5 hurricanes including Ivan in 2004, and Katrina, Rita, and Wilma in 2005. Case studies will be presented. For example, according to measurements made by the Naval Research Lab (NRL) during Ivan, the large surface waves and strong near-bottom currents caused significant bottom scour on the outer shelf (in the northeastern Gulf of Mexico) at water depths as deep as 90 m. This is explained physically by the shoaling depth induced by a hurricane, which is approximately 0.2 L_p (where L_p (=1.56 T_p^2) is the dominant wave length and T_p the dominant wave period). When Ivan was near National Data Buoy Center buoy 42040 adjacent to NRL current meters, T_p = 16.67 sec. Therefore the shoaling depth was 87 m which is in excellent agreement with the measurements. Furthermore, this value can also be explained by the physics that the shoaling depth equals approximately (1013 – P_{min}) (where P_{min} is the minimum sea level pressure associated with the hurricane near the area of measurement). During Ivan in the Gulf of Mexico, P_{min} = 928 mb, therefore the initiation of scouring depth is approximately (1013 – 928) = 85 m which is also in good agreement with the measured value of 90 m. Observations by NRL also indicate that extensive bottom scour along the outer continently shelf under Hurricane Ivan resulted in the displacement of more than 100 million cubic meters of sediment from a 35 x 15 km region directly under the storm's path. Since the forces induced by Ivan were sufficient to resuspend and transport sediment over a region at least 80 km wide, or equal to twice Ivan's radius of maximum wind, we will used Ivan's destructive potential by integrated kinetic energy method to compare with impacts done by other hurricanes on the northern Gulf coast and shelf regions.

FEASIBILITY STUDY FOR ASSESSMENT OF WEATHERING DEGREE ON STONE MONUMENT OF GRANITE BY APPLYING REFLECTANCE SPECTROSCOPY

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Poster Session: Stone monuments have been exposed and weathered on the field with exposure of rain and wind during hundreds or thousands years. Many researchers have been tried to assess deterioration degree of the monument for conservative purpose using various assessment techniques. Investigation using naked eyes by geologists is a basic method among conventional methods. Its investigator dependent approach and qualitative result have many limits as an assessment methodology. Another conventional and popular method for weathering degree assessment is chemical analysis using X- ray diffraction (XRD) and X-ray fluorescence (XRF). Those methods are precise and produce quantitative results but rock specimen is necessary for analysis so damage can be caused to the monuments during sampling process. Reflectance spectroscopy can measure and analyze reflected and transmitted electromagnetic energy on the surface of rock to identify rock forming minerals using their diagnostic spectral absorption features so it can be used as an improved nondestructive method. We tested feasibility of this method for granite stone monument.

Granite is composed quartz, feldspars and micas. Feldspars are changed to clay minerals such as kaolinite and illite after weathering process. Biotite of mica can produce iron oxides which induce color changes on surface of rocks. The experiment was conducted using field spectrometer and the range of measurement is form 350μm to 2500μm wavelength. Spectral reflectance of weathering products at each measuring point is processed to remove background effects and to extract quantitative absorption depths which indicate distribution degree of weathering products. We could make deterioration map on the surface of the monument by interpolating absorption depth values of each point with consideration of spatial distribution. Finally working process of this method is designed using whole experimental processes.

MAPPING OF RELATIVE WEATHERING DEGREE ON GAMEUNSAJI THREE STORIED STONE PAGODA USING REFLECTANCE SPECTROSCOPY

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Poster Session: Two Gameunsaji three storied stone pagoda was built in A.D. 682 of Unified Silla period and they were registered for a national treasure. The pagodas are composed of tuff blocks. Main rock forming minerals of tuff were identified as quartz and plagioclase, and small amount of biotite and amphibole in previous studies. Reflectance spectroscopy measures and analyzes reflected and transmitted electromagnetic energy on the surface of object to identify its constituents. The procedure during measurement is nondestructive so this method can be applied to stone monuments without damage. Rock weathering decomposes and changes original minerals to weathering products. Usually plagioclase is changed to clay minerals such as kaolinite and illite. Fe extracted from biotite is changed to iron oxides and these can be investigated as reddish stains which damage esthetic value of stone monuments. It has been studied that Kaolinite and illite have diagnostic absorption feature in the vicinity of 2.2μm and iron oxides have diagnostic absorption features from 0.9μm to 1.0μm. The absorption features can be converted to quantitative absorption depths by removing background effects from raw spectral reflectance curves. The measurements were conducted on the first foundation blocks of the east pagoda with a consideration of block composition. The absorption depths of representative weathering products, iron oxides and clay minerals which mean relative distribution degrees were mapped on the drawing of the pagoda. The relative distribution of weathering products showed that NW and NE face of the foundation stones were more severely weathered than SE and SW face. Also differences of weathering degree among each stone block could be discriminated in the map.

ROCKFALL HAZARD MITIGATION IN HAWAI'I

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The geology of Hawai'i is conducive to generating rockfalls. A combination of layered depositional volcanic sequences with alternating degrees of induration promotes differential erosion and subsequent rockfalls. Heavy precipitation and earthquakes can also trigger rockfall events. Coastal roadways are most adversely affected because the volcanic sequences dip toward the ocean and resultant dip slope cuts are inherently less stable. Successful rockfall hazard mitigation investigation, design and construction projects in Hawai'i are predicated on a careful understanding of the geology. This includes the succession of changing igneous geochemistry and lithology in evolving volcanic landscapes, development of residual soils often covered in ash, clinker, scoria and other ejecta between flows, and the local geomorphology defined by flow events. Many public roadways follow historic trails hugging rugged terrain, and the roadways are commonly narrow and have little or no shoulders. These conditions, as well as limited sight distance, require consideration of repairs and mitigation measures that differ from those that could be used on modern roadways on the mainland. Other limitations, such as protection of ancestral burial and cultural sites, aesthetic impacts, and other stakeholder concerns, must be incorporated in the mitigation design. Ease of maintenance is also a concern and frequently drives design. Recent case histories address control of falling rock, slope repair, and removal of falling rock hazards in culturally sensitive areas.

USING REMOTE SENSING AS AN AID IN ENVIRONMENTAL LITIGATION

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The availability of numerous remote sensing platforms has led to increasing use of data from these in a wide variety of litigious situations. Depending upon the system(s) used, the information may provide critical information that might otherwise not be introduced in court. A number of new high spatial resolution and high spectral resolution instruments and platforms have become available These systems range from "no cost" Google Earth imagery, available for essentially the entire earth, sun-synchronous satellite imagery (such as LANDSAT), available at a nominal cost, to high resolution, more costly, site specific, multiple channel imagery derived from airborne systems such as the Airborne Visible Infrared Imaging Spectrometer (AVIRIS), the Thermal Imaging Multispectrometer System (TIMS), and the Advanced Spaceborne Thermal Emission Reflection and Radiometer (ASTER). Examples are given showing how these have been successfully used to provide information that was pivotal in a number of cases and investigations . Specific examples include: (1) a determination of the source of detritus in a case involving sediment trespass by the Alabama DOT, (2) identification of illegally disposed of fly ash on a power company's property, (3) discharge of excessively high temperature water by a major utility company into an adjacent river, and (4) using thermal imagery at a military arsenal where sites of warm water discharge were used as a proxy for the potential discharge of ground water contaminated by chemical waste explosive, flame thrower wastes, tear gas residues, etc.

BEDROCK STRUCTURAL CONTROL OVER SLOPE STABILITY, EVOLUTION AND DRAINAGE SYSTEMS IN TORTOLA, BVI

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The geology of Tortola is characterized by steeply inclined volcanic strata that are cut by steeply to moderately inclined joint sets. In general slopes are steep with very poor soil cover over only partially weathered rock. Slope drainages or ghuts tend to be linear with steep gradients and filled with colluvial deposits indicating debris flow activity. The ghuts tend to parallel joint set intersections suggesting their origin as debris flows formed in joint wedges. Several slope areas showed disperse colluvial deposits from debris avalanches. All of these slopes were parallel to moderately, outward inclined joint sets and showed evidence of periodic reactivation. The occurrence of colluvium and the distribution pattern of joint sets and their intersections were used to develop a slope vulnerability map for the island.

EARTHQUAKE & LANDSLIDE HAZARD MAPPING FOR COMMUNITY EMPOWERMENT

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The Island of Java is one of many volcanic arc islands in the country of Indonesia. Java was formed by the interaction of the Asian continental plate and the Indian-Australian oceanic plates. Indonesia is frequently struck by earthquakes and landslides. In order to reduce socio-economic losses due to these hazards, an effort to provide appropriate earthquake and landslide hazard maps is urgently required.

It is apparent that most of the existing seismic and landslide hazard maps were produced by placing emphasis on technical aspects. The maps have had limited value in empowering the public and non-technical decision makers. To make maps that are useful to the public and non-technical decision makers, both engineering geologic and psycho-social mapping were carried out in the Bantul District, Yogyakarta Province, Indonesia, as a pilot study to determine if the information presented in the maps would be useful for a non-technical consumer. During the project, both seismic and engineering geological investigations and analysis identified the most susceptible area for ground motion in response to earthquake was in the fluvial sediments along the Opak-Oya River, a densely populated portion of the study area. The study results indicated that the most susceptible zone for landslides and rock falls/slides was situated in colluvial deposits at the foot of andesitic breccias mountains which are also densely populated.

The psycho-social mapping indicated that more than 80% of 300 survey respondents living in the most susceptible earthquake and landslide area along the Opak-Oya River had very limited knowledge on geological disaster phenomena and still traumatized by the May 2006 Yogyakarta earthquake and landslide disasters. This has presented a real challenge on how to introduce and implement earthquake and landslide hazard map products as a tool to improve pubic and non-technical decision maker awareness, preparedness and mitigation activities with respect to earthquakes and landslides. An innovative approach that combines engineering geology and psycho-social approach was accordingly developed. Our presentation is focused on the benefits and difficulties during the implementation of such approach are discussed to recommend most appropriate hazard mapping procedure that may aid in community awareness and empowerment.

MICROGRAVITY: A REVITALIZED METHOD FOR GEOTECHNICAL INVESTIGATIONS IN KARST GEOLOGY

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The complex nature of karst geology poses challenges for the adequate characterization of subsurface conditions. Highly variable top-of-rock, cavities, soil raveling, and paleosinkholes are examples of karst features that represent hazards for most geotechnical projects. These features have a high-degree of spatial variability, necessitating a comprehensive site characterization that incorporates geophysical surveys in the early phases of an investigation.

Microgravity is a relatively old and well-understood geophysical method that is highly effective in karst investigations. The microgravity method provides a precise measurement of the acceleration of gravity, which is directly related to subsurface mass. When microgravity measurements are acquired along a profile line or survey grid, lateral variations in subsurface density can be mapped and related to possible karst features.

Microgravity is often overlooked as a characterization tool because of the perception that it is a time-consuming and costly option. However, recent advances in microgravimeters allow surveys to be conducted at a cost and production rate that is comparable to most other surface geophysical surveys. Microgravity has been successfully applied to a variety of existing and proposed structures in karst terrain including new nuclear power plants, leaky dams, factories and roadways. The results of a microgravity survey guide borings into anomalous conditions and compliment the results of other surface geophysical measurements.

ROCK MASS DEFECTS AND BEDROCK PERMEABILITY, CLEARWATER DAM, PIEDMONT, MISSOURI

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The significant imprint of geologic time and an active geologic history are evident in the Upper Cambrian dolomites underlying the Clearwater Dam site in Southeast, Missouri. Exploratory and production drilling, pressure testing and high mobility grouting being completed as part of a Major Rehabilitation Project reveal subsurface conditions consistent with multiple episodes of marine transgression and regression; uplift; rifting; and sub-aerial exposure. Situated on the southwest flank of the St. Francois Mountains within the Ozark Uplift; the Dam site and underlying Potosi Formation bedrock have been subjected to a series of geologic conditions that influence the current dam rehabilitation project being undertaken by the United States Army Corps of Engineers, Little Rock District. Although depositional and post-depositional sedimentary processes set the stage for subsequent bedrock permeability development; likely the most influential portions of geologic history have been repeated uplift and sub-aerial exposure that resulted in development of fracture systems and secondary porosity features which increase permeability of the bedrock mass. Well developed high angle and bedding plane fracture systems result in classifying the bedrock as Poor to Fair Quality based on RQD. The fracture systems interconnect with secondary porosity features that include well developed pits and vugs as well as interconnected vug systems and cavities to create a bedrock mass whose bulk permeability ranges from about 20 to 200 Lugeon units. Some direct correlations can be drawn between core Recovery and RQD and permeability values but inverse relationships between these measures are also evident.

2-D AND 3-D CHLORIDE PLUME VISUALIZATION EFFORTS AT A FORMER WELL-FIELD IN SOUTHWEST FLORIDA

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A groundwater assessment was required at a former oil field situated in Florida ("the Study Area"), near commercial citrus groves. This Study Area contained a known chloride plume that resulted from historical oil field operations and the associated storage tank battery. High chloride water (brine) is a common component of oil and gas production. In this case the resultant brine water was managed at a tank battery located on the site. The objectives of this assessment included identification of chloride distribution and migration rates for remediation planning.

Surface geophysical methods were performed to assist in the estimate of lateral and vertical distribution of known chloride-impacted groundwater. Geophysical techniques including frequency- domain (Geonics EM34) and time-domain (Geonics EM47) electromagnetic surveys that were successful in visualizing the distribution of high-chloride groundwater. Electromagnetic data were modeled and used to create 2-D and 3-D subsurface visualization of the chloride plume that helped guide placement of monitoring wells. Project personnel are now in the process of developing a groundwater flow and transport model for the site to assess the feasibility of natural attenuation (dilution/dispersion) to meet ground water protection standards, or to design an alternate remediation strategy that is protective of the adjacent citrus groves

ENGINEERING GEOLOGY OF THE WHEELER GULCH TUNNEL, PARACHUTE, COLORADO

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The recently completed Wheeler Gulch tunnel is located about 10 miles north of Parachute, Colorado. The tunnel was constructed by Kiewit Western Company for Williams Production RMT to provide access for natural gas drilling in the Piceance Basin. Tunnel design efforts by Shannon & Wilson consisted of a literature review, outcrop mapping, drilling and logging of select borings, and preparation of a baseline geotechnical report and design documents. Shannon & Wilson also provided on-site services during tunneling. The tunnel measures 3,204-feet-long, 24 feet wide and 20.5 feet high, slopes at about 12 percent, and, except at the lower portal, has a flat roof. The tunnel extends through the Mahogany zone oil shale, a marlstone containing kerogen, of the Parachute Creek Member of the Eocene Green River Formation. Substantial information was available regarding geological conditions of the oil-rich shale zones due to previous federal government and industry investigations and mine development; however, little information was available regarding geological conditions of materials that occur in between these zones. Because the tunnel was inclined at 12 percent, with an overall increase in elevation of about 375 feet, several zones of weaker bedrock were encountered. Except near the portals, the shale was primarily medium to high strength with tight bedding (varves) and few joints. Bedding separations in the roof generally occurred where thin sandstone and tuff beds were exposed. The occurrence of nacholite in the upper section of the tunnel also reduced overall rock strength. Four general ground support systems were designed based on the tunnel Rock Mass Rating (RMR). These systems ranged from 8-foot-long, resin grouted dowels on a 6-by-6 foot pattern (Type 1

ground, RMR greater than 60) to steel sets and shotcrete (Type 4 ground, RMR less than 30). The entire tunnel was excavated with an Alpine Tunnel Miner ATM-105 roadheader. Tunnel excavation began in July, 2006 with installation of steel sets at the lower portal. Hole-through at the upper portal occurred on March 8, 2007.

NATURAL GAS AND COAL SYNTHESIS FROM LIMESTONE AND CARBON DIOXIDE

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I suggest that inorganic pathways exist for producing coal, natural gas and oil from dolomite(CaMgCO3), calcium carbonate(CaCO3) (limestone), calcium carbonate rich sandstones and mudstones, carbon dioxide and carbon monoxide. The carbon in the calcium carbonate is changed to methane and other natural gases by heat, pressure and by reducing hydrogen sulphide gas and water. Active fault zones are a source of hydrogen sulphide gas, carbon dioxide gas and water. Under reducing conditions water poor regions will produce coal. With more water, natural gases are produced. With abundant water, oil is produced.

Natural gas is found within, below and above limestone or calcium rich sandstone layers. These layers are the source of methane. They are not the traps for natural gas. In a reducing environment, limestone is changed to methane.

CaCO3(limestone)+4H2S(hydrogen sulphide)+2Fe(iron) =Ca (OH)2(hydrated lime)+CH4(methane)+H20(water)+2FeS2(Pyrite)

Also, in the presence of water and hydrogen sulphide, a reducing and hydrating environment, methane, lime and sulphur tri-oxide are produced.

CaCO3+H20+H2S = CH4 +Ca (OH) 2+SO3 (sulphur tri-oxide)

Coal and methane may form by carbon dioxide or carbon monoxide bubbling out of volcanic vents in the presence of hydrogen sulphide (black smokers) No limestone is necessary.

H2S will react with salt-water brines to produce HCl (hydrochloric acid).

H2S+2NaCl (salt) = 2HCl+Na2S

Hydrochloric acid reacts with calcium carbonate to produce carbon dioxide.

1) 3CO2(carbon dioxide) + H2S = 3CO(carbon monoxide) +H2O+SO2 (sulphur dioxide)
2) SO2 +CaCO3 = CaSO4+CO

Sulphur dioxide converts limestone to gypsum or anhydrite.

3) H2S + 3CO = 3C (coal/lignite) +H2O+SO2

Carbon dioxide and water with hydrogen sulphide will produce methane gas.

4) 2C + H2S + 3 H2O =2 CH4 + SO3

The accepted origin for coal and gas is through forests and plankton being buried under heat and pressure. Tree fern fossils or pterodactyl fossils and dinosaur bones in coal do not mean that these fossils created the coal. The fossils were preserved in non – oxidizing, reducing conditions. Plankton in oil means that these reducing conditions preserved these organisms. The plankton did not create the oil. Coal is therefore a chemical sedimentary deposit as is chert (SiO_2) and dolomite ($CaMgCO_3$). Oil and gas are inorganic by-products of reducing environments and conditions. With further reduction and in the presence of iron, coal and seashells, are changed to pyrite. Gastropod shells are often seen under reducing conditions, perfectly preserved and made of pyrite. The Petrified Forest, which represent tree trunks turned to stone, under siliceous conditions, does not mean that living trees when buried, are always preserved in carbon form. The fossils outlines are preserved, but they are altered to the chemistry that surrounds them.

IN-SITU EROSION TESTING AND CHARACTERIZATION OF EARTHEN LEVEE ERODIBILITY

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Selected earthen levee reaches were assessed for erosion damage due to Katrina's overtopping storm surge. Some levee reaches were undamaged, some were slightly eroded, and others were completely breached. Pre- and post-overtopping event levee elevation profiles were compared, and inferential observations from soil boring logs were combined with in-situ Jet Index test results to characterize the erodibility of the predominately fine-grained cohesive soils.

REGIONAL GEOLOGY OF THE BIG BEND, TRANS-PECOS AREA, TEXAS

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In April 2008 the AEG Texas Section boarded the Sunset Limited AMTRAK train headed west for a creative spin on the usual geology field trip. The trip was organized jointly by the AEG Texas Section and the Houston Geological Society (HGS). For the 60 attendees, the geology portion of the trip began just west of San Antonio as the sun rose. From the observation car of the train, participants were able to view and discuss the geology of the Edwards Plateau region and eventually the Trans-Pecos area as the train approached Big Bend National Park, the final destination of the three-day expedition.

The geology of the Big Bend area is very diverse, and can be divided generally into three geologic realms: the Marathon Uplift composed of folded and faulted Paleozoic rock; Tertiary igneous extrusions and intrusions comprising an igneous plateau near Alpine, TX; and large grabens that dominate the mountain and intermountain areas that characterize Big Bend National Park and surrounding areas. This presentation will describe the geology of the Big Bend vicinity, part of the Trans-Pecos region of Texas, as observed throughout the AEG Texas Section/HGS geology field trip. Particular focus will be given to the limestone formations throughout Big Bend National Park, including the lithology, depositional environment, and structure of the upper Buda Formation, and the Ernst and San Vicente members of the Boquillas Formation.

PROPOSAL FOR PROFESSIONAL SUPPORT DURING COMMUNITY DISASTERS

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Regional natural disasters such as wildfires, earthquakes, landslides, tornados, and hurricanes create horrific and catastrophic loss situations. I know first hand as my family and I lost our home to the October 22, 2007, wildfires in San Diego County. While the media portrays these situations as tragic only, there is more to it. My own experience taught me to seek the positive opportunities in the ashes of destruction. I am proposing one such community support opportunity to the Profession for consideration.

In the case of wildfire, the immediate condition of property is a simple burn-ash site. Hazardous materials in abundance where there used to be a home. This is similar to the lessons of 9/11 with a prestigious work address becoming a respiratory hazard source. Similarly destructive events create potentially toxic sites where there used to be a safe environment. And there is the problem; when people return to their destroyed property, they do not think of the potential hazards or risks to themselves and their family members as they sift through the remains. This act of owners sifting through the leftovers is important for psychological reasons (closure) but really risky for health reasons. The exposure scenario is amplified by well-intended church groups and the Red Cross handing out sieves and inadequate paper masks to survivors encouraging them to sift and search the debris. This acute exposure of hazardous materials to the families in shock is too great to ignore.

Cities have good emergency response plans and a few health inspectors try to educate the survivors, but more is needed. I am asking the Sections within the AEG to consider the following:

- Have a plan to coordinate with local disaster relief efforts with the intent to lessen the acute exposures of survivors sifting through their remains
- Provide PPE where and when needed
- Provide brief on-site training and a 1-page "Health and Safety Plan"
- Provide contact information for related assistance (e.g., waste management, rebuilding green)

Liability mitigations will be considered in addition to Good Samaritan Law and Executive Orders suspending environmental regulations in a Disaster Zone.

GEOLOGIC HAZARDS AND ADVERSE CONSTRUCTION CONDITIONS IN THE ST. GEORGE – HURRICANE METROPOLITAN AREA, WASHINGTON COUNTY, UTAH

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Poster Session: Southwestern Utah's mild climate and beautiful scenery combine to make the St. George area one of the nation's fastest growing regions. As land well suited for development becomes increasingly scarce, urbanization has moved into less favorable areas where geologic hazards and adverse construction conditions are of concern. The Utah Geological Survey (UGS) has prepared a GIS-based map folio containing 14 1:24,000-scale geologic-hazard and adverse-construction-condition maps for the St. George - Hurricane metropolitan area (366 square miles). Each map has an accompanying text document that provides information on the nature of the hazard or adverse condition in the study area. The maps are an aid for general planning to indicate where site-specific studies are required. A GIS search application permits the maps to be queried by geologic hazard or adverse condition type, and location and produces a map and report on the hazards or adverse conditions of interest.

Geologic-hazard maps in the folio include surface faulting, liquefaction, flooding, landslides, and rock fall. Adverse-construction-condition maps include expansive soil and bedrock, collapsible soil, gypsiferous soil and bedrock, shallow bedrock, caliche, wind-blown sand, breccia pipes and paleokarst, shallow ground water, and piping- and erosion-susceptible soils. There is also a text document describing the earthquake ground-shaking hazard in the study area; however, data are insufficient to prepare a map.

The UGS will make the maps and search application available to Washington County and municipalities in the study area, and will assist them in preparing master plans and ordinances addressing geologic hazards and adverse construction conditions.

INITIAL ASSESSMENT OF THE PALEOSEISMOLOGY OF THE OPAK FAULT SYSTEM, CENTRAL JAVA, INDONESIA

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The Opak fault (Central Java, Indonesia) seismic hazard potential has only recently been after recognized after the moment magnitude 6.3 Yogyakarta earthquake of May 27, 2006. The earthquake resulted in extensive damage in Yogyakarta Special Province and the southern part of Central Java Province, Java, Indonesia resulting in over 5,700 fatalities and over 37,000 injuries. Prior to our research, attributes such as the location, frequency (reoccurrence interval) and magnitude of paleoearthquakes on the Opak fault system were not well understood. A 1:25,000 scale seismic hazard map of the area damaged by the Yogyakarta earthquake conducted along the Opak fault system was completed in 2006 as a seismic hazard mapping activity used to support the recovery and reconstruction projects.

Current applied research related to seismic hazard assessment and community hazard preparedness in Southern Yogyakarta Special Province is divided into two main activities: A) geological and seismological investigations of the Opak Fault System, and B) psycho-sociological to investigate current levels of community trauma and resilience. Information from both activities will be critical in developing an appropriate community development program for (seismic) hazard preparedness. Our presentation will provide preliminary results of on-going paleoseismologic investigations along the Opak fault system conducted by Gadjah Mada University.

HISTORICAL SHORELINE CHANGES AND BARRIER ISLAND LAND LOSS ALONG LOUISIANA'S GULF SHORELINE: 1800's – 2005

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The Louisiana Coastal Zone is losing land at rates of up to 100 km^2/yr, resulting in drastic changes to shoreline position, geometry, and configuration. In order to: 1) establish a baseline dataset for future restoration efforts, 2) define the character and patterns of historical shoreline change, and 3) quantify the rates of linear shoreline retreat, a comprehensive shoreline change analysis of the entire Louisiana Gulf shoreline was undertaken. This study documents historical rate and range of Louisiana Gulf shoreline change for the period from 1855 to 2005 and provides a comprehensive quantification of shoreline evolution trends along Louisiana's Gulf shoreline. Using historical maps, satellite imagery, and aerial photography, patterns and rates of shoreline change were documented for 4 time periods: 1855-2005 (historical term), 1920's-2005 (long term), 1996-2005 (short term), and 2004-2005 (near term). The high-water line was used as the official shoreline and was interpreted and determined on the aerial photography and satellite imagery according to the location of the wet and dry-beach contact or the high-water debris line. Measurements of shoreline movement and change were taken along transects perpendicular to an offshore baseline spaced at 50 meter intervals alongshore. The shoreline was divided into 80 reaches based on the geomorphology, coastal evolution trends, existence of man-made structures, and/or a combination of these factors. The average historical rate of shoreline change is -2.7 m/yr. The average long-term rate of shoreline change is -4.2 m/yr. During the last decade, shoreline change rates have accelerated to -8.2 m/yr. The impacts of Hurricanes Katrina and Rita in 2005 accelerated the near-term rate of erosion to -57.8 m/yr. The highest rates of erosion due to the 2005 storm impacts were found along the Mississippi River delta barrier islands of Isle Derniers, Timbaliers, and Chandeleur Islands with some sectors undergoing over 182 meters of landward retreat. Beach nourishment, dune construction, and backbarrier marsh creation projects were the only areas where shoreline retreat was not detected in this study.

AN EXAMPLE OF THE EFFECT OF SITE CHARACTERIZATION ON ENGINEERING JUDGMENT AND DESIGN EWING PARK BRIDGE, ELLWOOD CITY, PENNSYLVANIA

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Ewing Park Bridge was built in 1919 over Connoquenessing Creek. Due to the deterioration of the structure, a 15 ton weight restriction was placed on the bridge. The Pennsylvania Department of Transportation (PennDOT) decided to completely replace the bridge including the substructures. A.G.E.S., Inc. was contracted to complete a study to identify geotechnical factors contributing to the existing structure distress, and to develop foundation recommendations for the new structure.

Site reconnaissance revealed indications of slope instability including scarps, bent trees and out of place bedrock. Both abutment areas were observed to be covered with slag fill material from a nearby steel facility. Subsurface drilling indicated the presence of thick slag and cinder fill at both abutments with rock overlying soil strata. Metal obstructions were encountered at the proposed Abutment 2 location below the top of rock. These observations and research into mechanisms of Pleistocene landslides in the Pittsburgh area indicated Quaternary slope movements at the abutment locations. The metal was assumed to be a prior attempt to stabilize a large detached block of rock.

Based on the site reconnaissance and subsurface information, the bridge design was modified. Deep foundations with predrilled shafts were recommended for Abutment 1 and a geogrid reinforced slope was designed to improve stability. The relocation of Abutment 2 up station to the north was recommended to avoid the potential slide area.

SEISMIC HAZARD MICROZONATION OF CHAK HAMA VALLEY, TEHSIL HATTIAN, DISTRICT MUZAFFARABAD, PAKISTAN: A CASE STUDY

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The destructive Kashmir earthquake of October 2005 resulted in a large-scale destruction of infrastructure in the area. Post earthquake rehabilitation and reconstruction of major cities and townships in the earthquake stricken areas are on top of the priority list of policy makers, the urban development planners, and NGOs, all assisting in the reconstruction and rehabilitation activities. The Chak Hama valley covering approximately 130 km^2 area, situated on the right bank of the Jehlum River, has a specific tectonic-setting as two important structural features, Main Boundary Thrust (MBT) and the Panjal Thrust (PT), pass through almost middle of the valley. The valley was severely affected by the devastating earth quake of October 2005 as the tectonic feature representing the source of the earthquake traverses just at a distance of about 14 km. Owing to the critical location of the valley area with respect to these major tectonic features, a cautious land use planning approach was warranted to minimize seismic hazard in case of future earthquake events.

Considering the above-stated tectonic setting, seismic hazard microzonation of the valley was conducted in accordance with the site specific physical and seismic conditions as well as the sensitivity of the proposed buildings for education and health care. This paper gives an overview of the techniques adopted, major finding of the studies conducted, and recommendations for planning the reconstruction activities. Aga khan Development Network, the agency responsible for reconstruction activities, successfully organized all construction actions in accordance with the proposed recommendations.

ARE WE DAMAGING OUR CREDIBILITY? – DETANGLING GEOLOGIC ISSUES FROM THE EVOLUTION DEBATE

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Geologists are different. Our view of the world is different. Our view of the way the world works is different. Visualizing things in three dimensions – no, four – is second nature to us. Our failure to recognize our own peculiarities hinders our ability to explain geology to non-geologists. When we use geomorphology or outcrop patterns to interpret the location of a fault, they think that we have x-ray vision. When we design a subsurface sampling program based on environments of deposition they prefer a program laid out on a grid by a chemical engineer. Our failure to communicate has left people unprepared to face natural disasters and unwilling to take steps to counteract climate change. Arguably the widest communication gap between geoscientists and many non-scientists revolves around the evolution vs. creationism debate. For decades we have been arguing, justifiably, that evolution is one of the best-documented scientific phenomena in the universe, and we fight tirelessly to defeat proposals to teach "intelligent design" in public-school science classes. Perhaps non-geologists—including public policy makers—would assign us greater credibility if we could somehow separate the evolution debate from the rest of geology. I would propose that all of us take advantage of every opportunity to talk to school and community groups about exciting aspects of the Earth and how it works. But if you must take your fossil collection for show and tell, take along some spectacular landslide or erosion videos as well.

PLATE PILE SLOPE STABILIZATION, A 5-YEAR RETROSPECT

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Plate pile slope stabilization, a patented technique and product, has been in use in California since its inception 5 years ago. This stabilization technique utilizes steel mini-pile with an attached steel plate to provide added slope reinforcement and a significant increase in the Factor of Safety against sliding. This cost-effective, environmentally friendly "green" solution to slope stabilization has been successfully applied to numerous geologic and geotechnical conditions to stabilize both existing and potential unstable slopes. An overview of the various case histories where plate piles have been implemented will be highlighted as well as upcoming projects. In addition, a user-friendly software application has been developed for use by consulting engineers and geologists and will be discussed.

SOIL ENGINEERING PROPERTIES CONTROLLING INITIATION OF DEBRIS FLOWS NEAR CHARLOTTE CREEK, COAST RANGE, OREGON

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Between February, 1996 and January, 1997 four intense rainfall events occurred in Western Oregon. Following these events, nearly ten thousand landslides were mapped in Western Oregon by numerous federal, state and local organizations. In 2007, we began a photogrammetric and field-based evaluation of 28 landslides (triggered during the 1996/1997 storms) located in a tributary basin to Charlotte Creek in the Elliott State Forest in west-central Oregon. All of the landslides initiated in soils derived from the Tyee Formation, a Tertiary age sandstone unit with interbeded siltstones. Among the 28 initiation sites investigated, our preliminary analysis reveals that 19 landslides mobilized as debris flows (*flows*), four partially mobilized (*partial flows*) and five did not mobilize as debris flows (*slides*). In March 2008, nearly 90% of the *flow* initiation sites contained springs, 25% of the *partial flow* sites contained springs, and 20% of the *slide* sites contained springs suggesting that springs may play an important role in debris-flow mobilization. In-situ porosity measurements of soil in headscarps reveal two distinct failure regimes with the majority of the *slide* sites being denser than the *flow* sites prior to failure. Porosities of the *partial flow* sites straddled the border between the two regimes. Grain-size distribution analyses for all initiation sites are ongoing.

A REVIEW OF THREE PROPOSED RESERVOIR SITES AND THE IMPORTANCE OF GEOLOGICAL ASSESSMENT PRECEDING RESERVOIR CONSTRUCTION

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Man-made surface water impoundments are common throughout the southeastern United States. While many factors must be considered when identifying a suitable reservoir location, a proper geologic assessment is often overlooked. The importance of a geologic assessment can be identified by reviewing three previous assessments of potential reservoir sites located in the Gulf Coastal Plain of Mississippi. Many site conditions were researched to establish common considerations of reservoir configuration, hydrology, water quality, and source materials for dam construction. Geologic assessments performed at each site identified conditions of concern that are important to construction of a reservoir. Geological concerns included high permeability sands identified in proposed reservoirs' dam abutments and basins, possible faulting located beneath a proposed dam site, geologic materials of concern underlying proposed dam sites, and karst conditions within a proposed reservoir's basin and in the vicinity of the proposed dam location. While some identified conditions of concern may be relatively easily remediated, others may be significant enough to suggest that the location is not feasible for a reservoir. In each case, the geologic assessments identified settings that, if not addressed, may have led to loss of water from the reservoir and/or complete failure of the dam.

GEOLOGICALLY APPROPRIATE FAILURE MODES OF A HIGH EXCAVATED SLOPE IN FRANCISCAN COMPLEXITY, CALIFORNIA

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A high excavated rock slope in Franciscan Complex bedrock exhibited instability, with extensive ground cracks, and near-vertical and overturned scarps. Geological exploration revealed sandstone and shale sequences, with ubiquitous fracturing and shears. An initial interpretation suggested a deep-seated, complex slope failure some 200 ft deep, with no clearly-developed toe and vulnerability to deep-seated ground movement during a major earthquake with associated potential impacts to nearby facilities. Additional exploration and analysis was commissioned to refine the preliminary findings and discriminate those areas that might be impacted as a result of seismically-induced slope instability.

The slope instability is within a chaotic shear zone squeezed between two massive blocks of coherent sandstone. The exposed bedrock is a complexity of shales, siltstones, sandstones and sheared rock, with a pervasively sheared fabric that is generally inclined in the same direction as the slope, but steeper. Analysis of the discontinuity fabric indicated that large masses of the slope had failed, and would continue to fail as slumps, topples and wedges, extending to relatively shallow depths. Such failures are geologically appropriate and expected for the complex rock mass and are consistent with the observed distress at the slope.

Kinematic and limit equilibrium slope stability analyses under static and pseudo-static conditions were performed on the basis of the revised geological model which suggested that deep-seated static or seismic instability was unlikely. The evaluation revealed that deformations observed at the slope were shallow in depth and did not pose a risk to nearby facilities under static conditions or seismic loading due to major earthquakes.

GEOLOGICAL ENGINEERS AND ELEPHANTS – ENDANGERED SPECIES?

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In John Godfrey Saxe's (1816-1887) poem version of an Indian legend, six blind men encounter an elephant for the first time. Each man interprets the creature differently depending on the site of their investigation. One man feels the trunk and declares it a snake. Another man embraces a leg and thinks that it is a tree. Geological Engineers are elephants. And much as the six blind men misunderstood the overall nature of the elephant, many engineering geologists, geologists, and geotechnical engineers misunderstand (and underestimate) the broad range of technical background and skills of Geological Engineers. For example: a Geotechnical Engineer recognizes the soil mechanics background of the typical Geological Engineer but may not be much impressed and conclude that the Geological Engineer is not much an of a Geotechnical Engineer. Similarly, a Geologist may be unimpressed with the geological skills of the Geological Engineer. (Faced with such judgments, Geological Engineers have to have thick skins, just like a pachyderm!). Generally, it often takes another Geological Engineer to appreciate the multi-disciplinary background of another Geological Engineer. The far-ranging, multi-disciplinary technical background of many Geological Engineers is excellent for two-way translations of the languages and concepts of geology and engineering, to the benefit of many geoengineering projects. But because of the increasingly focused and narrow nature of geoengineering education and professional training, it is increasingly rare to find multi-disciplinarians. So, like the elephant, is the Geological Engineer becoming an endangered species? How, where and to whom should Geological Engineers trumpet our talents to ensure our preservation?

CONCEPTUAL DESIGN FOR THE PERMANENT SEQUESTRATION OF CARBON DIOXIDE IN MAFIC VOLCANIC ROCKS

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The alternatives for the reduction of this greenhouse gas in the atmosphere have become a source of scientific discussions and political debates. One alternative is to reduce fossil fuel consumption another is to sequester CO_2 in the subsurface. For several decades the petroleum industry has re-injected CO_2 into oil wells in order to enhance oil recovery. Injecting CO_2 into sedimentary rocks is one alternative for sequestration however, the potential for leakage of the gas back to the surface is a concern. In more recent years, concepts have been developed for the injection of CO_2 into mafic volcanic rocks resulting in the reaction of the CO_2 with the calcium from calcic-plagioclase feldspar and with iron and magnesium from the mafic silicate minerals to form calcium, iron, and magnesium carbonates.

Carbon dioxide contents of flue gases from stationary power generating plants range from 12-15% of the total emissions. With secondary porosities of mafic volcanic rock generally 20% or less, the injected gas stream must be limited to CO_2. Under current technologies, separation of gases is accomplished cryogenically and thus is an energy intensive and costly process. An alternative solution is to pump the entire flue gas stream at elevated temperatures into open cavities (stopes) in the volcanic rocks and to allow the injected gases sufficient time to react with the fractured rock.

At temperatures of 155 ^{0}C, carbonate alteration of 80% of the exposed surface of the mafic volcanic rock will occur within less than one hour and the carbon dioxide will be permanently stored as carbonate minerals.

LANDSLIDE RISK ASSESSMENT NEAR THE ENTRANCE TO DENALI NATIONAL PARK AND PRESERVE, ALASKA

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Denali National Park which is located in central Alaska hosts over 400,000 visitors per year. The park is accessed via the George Parks Highway and the Alaska Railroad. The park contains the highest peaks of the Alaska Range including Mt. McKinley The Alaska Range is currently experiencing rapid uplift of approximately one centimeter per year. There is also significant horizontal movement along the Denali Fault, a strike-slip fault with right lateral offset of at least 300 miles. The Hines Creek strand of the fault system strikes nearly east-west at the park entrance. East of the park entrance the fault strikes southeast and west of the entrance it strikes southwest thus the park entrance is at a large oroclinal bend in the regional structure.

On October 19, 1947, a magnitude 7.0 earthquake with an epicenter approximately 30 miles to the northeast, triggered major landslides in the area resulting in severe damage to the Alaska Railroad. This event predated the construction of the highway and the tourist facilities by 26 years. The landslides include slope and toe failures in the Moody Clay and other glacial lake sediments; toe and base failures in highly sheared metamorphic rocks; planar slides in the more competent schist units; and wedge failures at the contacts of basaltic dikes with the steeply dipping foliation of the schist units. Investigations by Wahrhaftig and Black (1958a, 1958b) provide evidence for large rotation slides predating the 1947 event. Removal of the toes and bases of these larger failures by the down-cutting Nenana River has resulted in continued movement on these and on additional pre-1947 failures not identified prior to the current investigation.

IMPACTS OF SURFACE MINING AND VALLEY FILLS ON STORM RUNOFF IN CENTRAL APPALACHIA

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The central Appalachian physiographic region is a highly dissected plateau with high, tree-covered hills and deep, narrow valleys or "hollows." Large watersheds often feed streams with narrow valleys and small flood plains. In such rugged terrain people live close to the streams and are sometimes affected by floods during heavy rainfall events. Surface mining, including construction of excess spoil fills, alters the topography, drainage patterns, vegetation, and soil cover in and around the valleys. These alterations can impact storm-runoff discharges through the hollows. Concern has been expressed that surface mining above – and valley fill construction within – inhabited hollows increases the potential for flooding, and consequent loss of life and severe property damage. A number of studies have been conducted in response to this concern, including several recently commissioned field-monitoring and modeling projects under the Mountaintop Mining/Valley Fill Environmental Impact Statement (EIS) released in 2005. All together, their findings indicate that the relationship between surface mining and storm runoff intensity is complex and dependent on several site-specific factors. Several studies indicated a connection between mining activity and increases in peak discharge. Significantly, actual storm-runoff events in 2002 and 2005 demonstrate a "window of vulnerability" during the excess spoil fill construction process in which severe, uncontrolled erosion over the face of an unreclaimed fill can cause or augment dangerous debris flows and floods through a local community.

THE ROLE OF HURRICANES IN LONG-TERM MORPHOLOGIC EVOLUTION OF THE CHANDELEUR ISLANDS, LOUISIANA

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Bathymetric analyses (1880-2006) for the Chandeleur Islands reveal long-term trends of barrier extension and retreat and recently, barrier disintegration, shoreface erosion (vertically 1-2 m), and mixed erosion and accretion on the backbarrier platform (0-4 m). Volume calculations indicate ~150 x 10^6 m^3 of sediment has been deposited downdrift (northward) and seaward of the northern terminal spit during the past 125 years, whereas the southern end of the barrier arc has undergone long-term erosion. Bathymetric and shoreline analyses suggest that the islands are impacted primarily during major hurricanes, resulting in shoreline retreat in some sectors and shoal development and in-place drowning in others.

Katrina removed >90% of sand comprising the barriers, exposing backbarrier marshes to wave attack. During the following year, >50% of the length of the northern Chandeleurs shoreline continued to erode (>200 m landward retreat). However, during year two of recovery, marsh islands served as nucleation sites for sand accumulation along the northern arc. Early stages of recovery were marked by sand and shell recurved spit formation at hurricane-cut tidal passes. This was followed by onshore bar migration and welding, a process that resulted in the closure of some inlets. Contrastingly, southern segments of the chain, where marsh islands were absent, underwent transgressive submergence. These southern shoals persisted for 2 years after the storm impact, but have recently began to emerge as narrow, ephemeral barrier islands. Long-term reduction in island area is driven by pulses of rapid land-loss triggered by storm events. The islands do not fully recover from storm impacts because sand is transported to the flanks of the arc removing it from the littoral system. These downdrift sand reservoirs may provide a quasi-renewable resource for nourishing the updrift barrier system.

REGIONAL COASTAL EVOLUTION IN RESPONSE TO RAPID RELATIVE SEA-LEVEL RISE AND INTERIOR WETLAND LOSS, SOUTH-CENTRAL LOUISIANA

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Rates of relative sea level rise, which are locally in excess of 1 cm/yr, are forcing barrier shoreface retreat along the periphery of the Mississippi River delta plain. Additionally, conversion of interior wetlands to open water has increased bay tidal prism, resulting in degradation of barriers by means of inlet widening, formation of new inlets, and sediment sequestration in ebb tidal deltas. Single-beam bathymetric surveys along a 165 km stretch of south-central Louisiana barrier coast, from Raccoon Point in Terrebonne Parish to Sandy Point in Plaquemines Parish, were conducted in 2006. These data, combined with historical bathymetry from three time periods (dating to the 1880's) provide a series of digital elevation models (DEMs) that show the 3-dimensional morphological evolution of this area. The DEMs for each time period were employed to conduct a seafloor change analysis and calculate sediment volumetric changes, identifying long-term sediment erosion and accretion trends. The dominant trends during the 125 year period include: 1) erosion of ~ 9 x 10^8 m^3 from the shoreface, forcing shoreface retreat, 2) deposition in coastal bights and at ebb tidal deltas, and 3) an increase in collective tidal inlet cross-sectional area from ~41,400 m^2 to ~139,500 m^2. The rate of increased tidal inlet cross-sectional area is directly proportional to the rate of interior wetland loss. The dramatic coastal evolution documented in this study: 1) identifies long-term erosional trends in a degrading, abandoned delta complex, 2) stresses the linked relationship between coastal evolution and interior wetland loss, and 3) emphasizes the importance of implementing a system-wide approach to sediment management in the Mississippi River delta plain.

THREE-DIMENSIONAL GEOLOGIC MODELING OF DEWEY-BURDOCK IN SITU URANIUM PROJECT IN FALL RIVER COUNTY, SOUTH DAKOTA

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Powertech Uranium Corporation has proposed to conduct in situ mining within a uranium-enriched ore deposit on the proposed permit area known as the Dewey-Burdock project. The project is located on the southwest flank of the Black Hills, approximately 12 to 15 miles north-northwest of Edgemont, South Dakota.

A comprehensive understanding of the geology is required for permitting, conceptual geohydrologic model, mine design, ore reserve calculations, and public relations visualization. A three-dimensional (3D) geologic model for the proposed permit area was built in Mining Visualization Systems (MVS), a 3D visualization software package by C Tech Development Corporation. Model data consists of approximately 4,000 historical Tennessee Valley Authority (TVA) exploration holes and interpreted ore grade maps, augmented with data from the current exploration process.

The model targets the consolidated sedimentary rocks of Jurassic and Cretaceous age that comprise and bound the Inyan Kara group which hosts the Uranium ore. A general 3D stratigraphic model was built to create isopach and structure contour maps and constraining surfaces for an ore interpolation grid. Detailed lithologic submodels were built along the ore body to identify ore-bearing sand units, confining aquitards, and to generate cross sections. Interpolated ore bodies were generated to facilitate well field design and reserve calculations. An ESRI geodatabase contains the model data and products for distribution via an ArcServer-based Web site and ArcExplorer.

A 3D grid was generated from the results of the geohydrologic model containing material attributes for numerical groundwater modeling. Results from the numerical modeling were then input into MVS for visualization of groundwater flow paths.

TIDALLY INFLUENCED NEW ORLEANS CANAL NETWORK BENEFITS FROM ACCURATE WATER LEVEL, CONDUCTIVITY, AND TEMPERATURE DATA

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Since Hurricane Katrina pounded the Gulf Coast in August 2005, New Orleans city canals have been fortified with control gates, pumping stations, and a district-wide water level monitoring network rooted in the continuous readings from In-Situ® Inc. Level TROLL® 500 and Aqua TROLL® 200 sensors. These devices improve management of water levels throughout the Southern Louisiana Hurricane Protection System. Continuous water level monitoring helps synchronize pumping and assures that all elements of the water level control system are within proper ranges.

Level TROLL 500 sensors monitor and record water level and temperature, and offer the multiple communication options required for a real-time monitoring network.

Aqua TROLL 200 sensors monitor and record water level, temperature, conductivity, and salinity data. The sensors automatically and continuously correct depth and level parameters for changes in water density due to salinity fluctuations. This dramatically improves the accuracy of depth and level measurements in waters where tides and rainfall continuously affect local salinity.

Instruments are deployed at sites along each of three canals—New Orleans Canal, London Avenue Canal, and the 17th Street Canal—where the major breech occurred that flooded the city during Hurricane Katrina. Level TROLL 500s also maintain surveillance at monitoring stations around Lake Pontchartrain, along the Gulf Intracoastal Waterway, and at ground water monitoring sites throughout the district. This paper will give an overview of the monitoring network and how Level TROLL and Aqua TROLL instruments are integrated into the Hurricane Protection System.

MUNICIPAL LANDSLIDE STUDY USING AIRBORNE LIDAR AND GEOLOGICAL MODEL, PEACE RIVER, ALBERTA

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The Peace River Lowlands of Alberta and British Columbia is one of the most historically active mass movement areas in western Canada. Landslides have resulted in significant damage to property and infrastructure over the last 50 years in the Town of Peace River, in northwestern Alberta. In this study area, the Peace River has incised through approximately 180 m of Quaternary sediments and 30 m into the underlying bedrock. Failures of varying types have occurred in both the Quaternary sediments and the underlying shale bedrock.

As part of a multi-year landslide hazard study, currently being undertaken, airborne Light Detection and Ranging (LiDAR) data was flown over the municipality in May 2007. The ability to be able to remove surface vegetation and apply various sun angles is utilized to recognize subtle geomorphic features and highlight these on the digital terrain model. The data are used to map landslides in and around the municipality and make observations as to their style and dimensions in various geological media. This information is to be coupled with a bedrock surface model generated from multiple data sources, and an interpretation of the overlying quaternary sediments to develop a better understanding of the pattern and distribution of the various styles of movement.

USGS SEISMIC HAZARD MODELS FOR THE CENTRAL AND EASTERN UNITED STATES

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In the central and eastern United States (CEUS) causal relationships between earthquakes and seismogenic structures are poorly understood by earth scientists. The USGS uses only four specific fault sources in its seismic hazard model for the CEUS (Frankel and others, 1996 and 2002; Petersen and others, 2008): New Madrid, Charleston, Meers, and Cheraw, with model parameters estimated primarily from paleoseismic data. In the USGS analysis mid-to-high-frequency seismic hazard at most CEUS sites is controlled by gridded and smoothed historical seismicity (Frankel, 1995). By emphasizing the earthquake catalog, we can avoid making judgments about the seismogenic potential of tectonic features that are, at best, only weakly associated with past earthquakes.

The USGS gridded-seismicity method (an alternative to traditional areal source zones) is based on the expectation that future hazardous earthquakes will occur near historical small and moderate-size events. We model seismicity-based sources using traditional truncated-exponential (Gutenberg-Richter) frequency-magnitude distributions: $N_m = 10^{a-bm}$, where N_m represents the rate of earthquakes with magnitude m, the a value specifies the overall rate of seismic activity, and the b value specifies the relative rates of large and small earthquakes. Regional b values and local a values are estimated from statistical analysis of a declustered earthquake catalog. For each grid cell (0.1° latitude × 0.1° longitude) three model rates for earthquakes with $m_b \geq 3$, 4, and 5 are computed using a method that accounts for variable catalog completeness levels. These three rates are weighted and averaged along with a regional background rate, and spatially smoothed. Each grid cell becomes an individual seismic source in the hazard computation. Hazard from each source is computed over a frequency-magnitude distribution that is pinned at the average cell rate and truncated at m_{max}, the magnitude of the largest expected earthquake given the seismic and tectonic setting. USGS m_{max} choices are based on seismicity data from global CEUS tectonic analogs – again, avoiding judgments based on inadequate CEUS datasets.

Hazard curves are computed for a CEUS firm-rock site condition using a suite of published ground-motion-prediction relations, and hazard maps are constructed for selected risk levels and structural periods. Engineering-design maps derived from the hazard maps are used in recent updates of the International Building Code, and the hazard maps are also used in applications like emergency planning and land-use planning.

References:

Documentation for the 1966, 2002, and 2008 updates of the USGS National Seismic Hazard Maps can be found at http://earthquake.usgs.gov/research/hazmaps/

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SANDY CREVASSE SPLAY DEPOSITS FROM THE LEVEE AND FLOODWALL FAILURE ON THE LONDON AVENUE CANAL IN NEW ORLEANS DURING HURRICANE KATRINA AND THE ROLE OF SAND IN THE FAILURE

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During Hurricane Katrina on August 29, 2005 a 235 foot section of the levee and floodwall on the east side of the London Avenue Canal in New Orleans failed catastrophically. The failure resulted in a sandy crevasse splay deposit that filled streets and houses in the neighborhood near the breach. The source of the sand was the 4,000 – 5,000 year old Pine Island beach sands which were exposed in the bottom of the canal at this location. Steel sheet piles supporting the floodwall were driven only into the upper ~8 feet of the ~40- foot-thick sand body. The deposit consisted mostly of reworked beach sands containing whole and broken shells, as well as debris from throughout the neighborhood, including several automobiles. Deposition was controlled by the location of streets and homes in the neighborhood. The deposit had a maximum thickness of 6 feet and a volume of about 932,000 ft^3. (The deposit has been subsequently removed). The canal bottom was scoured up to 20 feet below the original bottom adjacent to the failure, but volume balance relations suggest that much of the canal bottom along the length of the canal was also scoured. Increase in hydrostatic head due to storm surge entering the canal from Lake Pontchartrain resulted in underseepage through the permeable sand and below the sheet piles. The relatively thin organic clays of the swamp/marsh deposits overlying the sand was not sufficient to counter the hydraulic head and resulted in the levee and floodwall failure, and subsequent scour, flooding, and deposition of the splay deposit.

APPLICATION OF SURFACE GEOPHYSICS FOR PROVIDING A DETAILED GEOTECHNICAL ASSESSMENT OF A LARGE RESORT DEVELOPMENT SITE IN ANGUILLA, BWI

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N.S. Nettles & Associates (NSN) has completed extensive geophysical investigations that have guided engineering practices for a proposed large resort community in Anguilla, BWI. The project site is characterized by extensive karst features that were of concern as potential hazards to the geotechnical engineer for structural stability issues and proper design criteria. NSN utilized diverse technologies including Multi-Electrode Electrical Resistivity (MER), Continuous Resistivity Profiling (CRP), and Multi-Channel Analysis of Surface Waves (MASW) to map the site. Resistivity techniques allowed for differentiation of geologic units and the identification of karst features and sub-surface anomalies. MASW transects were performed to determine sub-surface density variability. Drilling included 41 Standard Penetration Test (SPT) borings, 71 Cone Penetration Tests (CPT), and 12 rock cores to ground-truth the geophysical data and determine engineering properties of rock units. Additionally, NSN mapped a stagnant salt pond with MER and CRP to determine sediment thickness over rock and to determine the competency of the underlying limestone. This provided volume calculations for dredging, the first phase in the transformation of the hypersaline pond to a functional marine habitat. NSN further designed specifications for 12 horizontal flushing channels connecting the salt pond to the adjacent bay. Two Surface Water Modeling System (SMS) hydrodynamic models were implemented to predict both regional and site-specific hydrologic processes related to construction of the flushing channels. Results have provided the geologic framework for a successful construction strategy, and have shown the invaluable nature of utilizing geophysics as a first-order technique for rapid and cost-effective geotechnical investigations.

COLORADO'S ANTON ESCARPMENT – IS IT A PALEOSEISMIC FEATURE?

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Poster Session: We recently completed a multi-year field investigation of the Anton Escarpment on Colorado's eastern plains to determine if this linear, 135-km-long, 24-m-high feature is seismogenic in origin. We dug 600 meters of trenches augmented by drillhole cores and a seismic refraction survey. Sediment samples were dated using luminescence and radiocarbon techniques. We used a high-resolution stratigraphic framework to evaluate the nature of geomorphic evolution on and adjacent to the escarpment.

We found no evidence of faulting. The trenches exposed a succession of predominantly eolian units overlying gravels of the Miocene Ogallala Formation. The upper escarpment contains late Pleistocene loess and sheet sand (30-16 ka) and dune sand (>110-35 ka). The flanking low area contains alternating loess and sand layers with strong calcic paleosols (Pliocene-middle Pleistocene?). These are overlain by a zone of polygonal sand wedges and other periglacial features (26-18.5 ka), sheet sand and playa deposits (19.5-12.5 ka), and loess with humic paleosols (10-6 ka).

The younger (post-26 ka) units form discontinuous sediment bodies that overlie gullied, bowl-like, or flat-bottomed erosion surfaces with up to 20 m of paleotopography. The older units appear to be continuous beneath the escarpment face. We interpret that the Anton escarpment is not a late Quaternary paleoseismic feature, but instead was created by paleowinds. It marks a linear interface between an extensive, late Pleistocene plateau of thick loess and sand deposits dominated by eolian aggradation and a contemporaneous, topographically low plain dominated by wind erosion and partial infill since at least the early Pleistocene.

PROBABILITY OF TRIGGERING RUNOFF IN SMALL WATERSHEDS USING SUPPORT VECTOR MACHINES

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Poster Session: Runoff is one of the most complex hydrological phenomena to comprehend due to the tremendous spatial variability of catchment characteristics and precipitation patterns. However, the determination of runoff is critical for flood protection works, effective water storage and release, and protection of land. The quantity of runoff depends on parameters such as rainfall intensity, duration, initial soil moisture, land use, and catchment geomorphology or relief. One common approach to estimate runoff is to develop physical models validated with measured data that relate the variables (input – output relationship) in the system. Conversely, this extraction of knowledge from the data requires large datasets, sophisticated modeling techniques as well as human intuition and experience. Additionally, the exact conditions that trigger runoff are difficult to predict because of their dependency on a combination of rainfall intensity, antecedent soil moisture conditions, and physical soil properties. Currently, pattern-learning algorithms based on artificial intelligence have shown promise in developing non-parametric models involving complex processes using few input parameters due to their ability to learn and recognize trends in the data. In this study, we explore the applicability of a sparse pattern-learning algorithm called Support Vector Machines (SVM) for modeling runoff from small watersheds. Results show that these methods can be an effective alternative to physical models for identifying runoff generation characteristics. Once identified, characteristics that trigger runoff from catchments, such as rainfall intensity and antecedent soil moisture, may be successfully used for large scale monitoring of watersheds using remote methods such as satellite sensors.

HOW TO ORGANIZE AND RUN A GEOLOGY FIELD TRIP: WITH A 4-DAY BIG BEND GEOLOGY TRIP AS A CASE STUDY

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Running a geology field trip may seem like an easy task and one that many may have undertaken in the past. However, organizing a successful geology field trip necessitates a large amount of time and energy. Above all, the participants' safety and satisfaction are of utmost importance. For a multiple-day field trip, many tasks are involved in the planning of the trip, including transportation, accommodations, and meals. In addition, a key to a successful geology trip is a good guidebook and great field trip stops.

The Association of Environmental & Engineering Geologists, Texas Section jointly with the Houston Geological Society organized and ran a geology field trip for 60 people to Big Bend National Park in West Texas from April 23-26, 2008. Big Bend National Park is near the Mexican border adjacent to the Rio Grande River, and approximately 300 miles from El Paso, 250 miles from Midland, and 460 miles from Austin. The logistics for organizing a field trip where there are few hotels, one restaurant and minimal transportation options is, at best, challenging and at worst, a mistake.

A field trip committee which included members of both organizations was formed, and approximately nine months prior to the field trip date, field trip planning commenced. Planning included determining a theme, drafting an agenda for the field trip, determining costs, selecting field trip leaders, and assigning other organizational tasks. If a geology field trip is planned appropriately, then once the field trip is underway, most, if not all of the work is already completed. But be prepared for the unexpected, and have a contingency plan. Finally, solicit feedback from participants in order to better plan any future field trips.

LIQUEFACTION SUSCEPTIBILITY AND PROBABILISTIC LIQUEFACTION POTENTIAL HAZARD MAPPING, ST. LOUIS, MISSOURI AND ILLINOIS

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This research builds on and expands recently-completed liquefaction susceptibility mapping of five quadrangles including downtown St. Louis area (Pearce and Baldwin, 2004). This research completed construction of seven (7) new liquefaction susceptibility maps and, with the inclusion of our five existing susceptibility maps, and construction of twelve (12) new probabilistic liquefaction potential maps. In total, the study encompasses twelve U.S.G.S. 7.5-minute quadrangles that include St. Louis, East St. Louis and the surrounding metropolitan area. Much of these areas are underlain by saturated granular Holocene fluvial deposits of the Mississippi, Missouri, and Meramec Rivers (Harrison, 1997), as well as artificial fill material that is susceptible to earthquake-induced liquefaction. Coupled with the 1811-1812 earthquakes, St. Louis also has experienced multiple historical earthquakes from more local seismic sources (e.g. within 80 to 110 km) some with earthquake magnitudes estimated up to M5, and MMI between V-VI; most recently the April, 2008 ~M5.2 earthquake in the Wabash Valley Seismic Zone. The potential for liquefaction depends not only on the susceptibility of a deposit to liquefy, but also depends on the estimated ground motions to exceed a specified threshold required to initiate liquefaction. Probabilistic liquefaction hazard potential maps are based on liquefaction susceptibility maps, and directly incorporate numerically modeled earthquake ground motion data (PGA) for different probabilities of occurrence (return intervals). Thus, this effort directly results in hazard maps for the probabilistic liquefaction potential hazard within the greater metropolitan St. Louis area.

We employ detailed surficial geologic mapping in conjunction with a quantitative geotechnical analysis (Simplified Procedure) to evaluate and classify the relative susceptibility to liquefaction of the Quaternary deposits. From the mapping we differentiate four primary geologic units: Artificial fill, Holocene alluvium, Pleistocene glacio-fluvial alluvium, and Pleistocene loess and other non-alluvial deposits. Not surprisingly, the results of the susceptibility analysis show that Holocene alluvial units are the most susceptible to liquefaction; however the liquefaction susceptibility of the Holocene alluvial sub-units is more uniform than originally expected. Liquefaction triggering thresholds for mapped deposits were estimated based on the Simplified Procedure analysis. The PGA values from the National Seismic Hazard Mapping Program served as the basis for the probabilistic evaluation of liquefaction potential. This research evaluated two earthquake ground motion scenarios: the 2% probability of exceedance in 50 years (~2500 yr return period), and 10% probability of exceedance in 50 years (~500 yr return period). The results of the analyses show that while much of the surficial deposits are susceptible to liquefaction, the PGA values for the 10% in 50 years probability appear to be deficient to trigger liquefaction, whereas stronger (i.e. more conservative) ground acceleration values for the 2% in 50 years probability have sufficient magnitudes to trigger liquefaction within much of the study area. Additionally, the result of the 2% probability in 50 year analysis indicates: (1) liquefaction trigger thresholds are exceeded within much of the study area, however the liquefaction potential decreases northerly across the region with PGA; and, (2) the hazard is predominantly controlled by the magnitude of co-seismic strong ground motion and, to a lesser degree, variability of surficial deposits.

The results of this study provide data needed to effectively evaluate and manage liquefaction hazards in the St. Louis area, and thus will contribute to the USGS and FEMA loss reduction efforts in the greater central United States. Quantitative evaluation of the possible amounts and locations of permanent ground surface deformation from the potentially liquefaction-triggering ground motions (e.g., differential settlement, lateral spread), as well as incorporation of next generation attenuation models and soil ground motion amplification is a necessary future research path that will add value and refine the understanding of the overall seismic hazard of the greater metropolitan region.

FOUNDATION GEOLOGY OF THE GRAND CANYON SKYWALK

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The Skywalk at the west rim of Grand Canyon is a steel cantilevered box beam that extends seventy feet beyond the canyon rim located on the Hualapai Reservation, Arizona. A glass floor and glass sides allow visitors to view the canyon's depth of 4000 feet, the Colorado River and the surrounding canyon cliffs without obstruction. The horseshoe-shaped beam is positioned on four piers composed of sets of twenty two 2.5 inch steel micropiles drilled and grouted 40 feet into the Mississippian Redwall Limestone and incorporated in massive concrete caps. The piers near the cliff at the canyon's edge also have three 40 foot steel tiebacks drilled and grouted at 30 degrees below the horizontal. A rockbolt scheme was devised to further stabilize a wedge of rock near the southeast pier because of intersecting joints that produced a wedge failure about 35 feet below the cliff top in the past.

The site investigation included surface mapping, core drilling and testing, helicopter inspection of the canyon walls and close inspection of the cliff face using a man cage suspended from a crane at the surface. Rock structure at the initial proposed location was considered unsuitable because of the open condition and unfavorable orientation of joints in the Redwall. Karst features in the Redwall are present hundreds of feet below the site but are considered to be inactive and pose no hazard to the foundation and structure. Wind loading on the beam was addressed by proposing to incorporate a seismic monitoring installation near the front piers. Three component 4 Hz seismometers are to be embedded in two 9 foot deep borings in rock with capacity for continuous recording. The installation is also capable of recording any activity on active faults within fifty miles of the site as well as teleseismic activity.

THE NORTHERN BOULEVARD CROSSING: CONNECTING TWO SETS OF TUNNELS IN QUEENS, NEW YORK

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The East Side Access Project will bring the Long Island Railroad (LIRR) into a new terminus located in Manhattan beneath Grand Central Terminal. The project consists of two sets of tunnels connecting the borough of Queens to Manhattan and a second set between Queens and the existing LIRR mainline. The two sets of tunnels are liked by the Northern Boulevard Crossing (NBX).

The NBX is a 123-foot long, oval shaped (37 feet high by 56 feet wide) single tube excavation crossing beneath an existing subway tunnel, Northern Boulevard, and an elevated subway constructed on pile-supported piers. The NBX will be excavated in predominately cohesionless glacial soils located below the water table with weak to strong metamorphic bedrock present in or just below the bottom of excavation. To date, launch shafts for the running tunnels have been constructed, using slurry walls bordering the future location of the NBX crossing.

The NBX design included in the Contract Documents consists of:

- Ground pre-treatment utilizing horizontal compensation grout holes below the existing subway tunnel
- Pre-support of the excavation with a horizontal four- to eight-foot thick frozen ground arch "socketed" into the bedrock. The ground freezing piping system would extend inwards from one or both of the existing headings.
- Ground excavation within the frozen arch utilizing sequential excavation techniques with shotcrete and lattice girder support.
- Provisions for the Contractor to finalize the design based on his preferred means and methods.

This presentation summarizes the development of the design criteria and the Contractor's submitted design modifications and provides an update on the construction undertaken through August 2008.

A NEW PIPELINE THROUGH SCHENKEL CAVE

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Schenkel Cave is a naturally formed 1,400-foot long cave located in northeastern Frankfort, Kentucky. Taking advantage openings at both ends of the cave, a ductile iron pipeline was placed inside the cave in the late 1950s to convey wastewater flows from the plateaus above Frankfort down-gradient to a treatment plant. The cave is located through the upper members of the Lexington Limestone, which contain solution features associated with karst topography.

The existing 14-inch pipeline is a hydraulic bottleneck in the sanitary sewer system; as a result, sanitary sewer overflows (SSOs) occur periodically upstream of the cave. To address this issue the Frankfort Sewer Department employed a team led by Quest Engineers to investigate options to eliminate the SSO. The team was to evaluate several options including increasing the pipe size within the cave and installation of new and larger pipe in a bypass of the cave constructed using trenchless methods.

A field investigation performed by Hatch Mott MacDonald and Thelen Associates staff logged and characterized the conditions in the cave and portal rockmass, the 40-year-old sewer pipe, and existing ground support. In addition, mapping of the surrounding areas identified zones of side caves and sinkholes that would have to be crossed by any new construction.

This presentation summarizes the methods used for the cave investigation, our findings and the options proposed to address the project needs, and an update on the construction work performed to date.

INITIATION ZONE CHARACTERIZATION OF MASSIVE DEBRIS FLOWS GENERATED ON MOUNT HOOD, OR, NOVEMBER 2006

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In November, 2006, a storm generated a minimum of 34 centimeters of precipitation in six days, triggering major debris flows in many of the drainages on Mount Hood, Oregon. This composite volcano is located in the Cascade Range 125 kilometers east of Portland. The mountain has a long history of debris flow and lahar activity. To date, management response to high magnitude meteorological events has been limited by a lack of distinction between debris flow prone drainages and drainages with little to no response. Documentation of the November 2006 event is critical for the design of future hazard management plans. Recognition of common factors linked to debris flows at Mount Hood will be applicable to identification of hazard prone areas on other volcanoes in similar climactic and tectonic settings.

An initial reconnaissance survey was conducted on the primary drainages around the mountain. This assessment determined that the November storm triggered debris flows on all sides of the volcano. Of the eleven primary drainages surveyed, seven experienced powerful debris flows; these include the White River, Salmon River, Clark Creek, Newton Creek, Eliot Creek, Ladd Creek and Sandy River basins. Five of these flows caused major damage to bridges and roadways. Highway 35, a key access route on Mount Hood, was closed in two places. Further investigation and analysis revealed two separate mechanisms for flow initiation. Debris flows in the Eliot Creek, Sandy River, and Ladd Creek basins appear to have been caused either by landslides. Flows in the White River, Salmon River, Newton Creek, and Clark Creek basins appear to have initiated through coalescence of multiple small debris flows into a major channel. Estimates for initial landslide volumes range from 2,200 cubic meters to 120,000 cubic meters. Unconsolidated regolith was sampled in the initiation areas for subsequent particle size analysis and bulk density determinations. Average bulk density measurements for landslide induced debris flows ranges from 1.36 – 1.76 g/cm^3. Physical characterization of source area materials will be used to assess factors controlling debris flow initiation. Preliminary findings indicate that drainages with abundance of non-vegetated, unconsolidated sediment and over steepened slopes may be more susceptible to debris flow processes. This project seeks to answer the question of why some drainage systems spawned debris flows, while others experienced only flooding. The primary outcome of the project will be a debris flow hazard map derived from the November 2006 storm event.

THE CONTINUED MARGINALIZATION OF ENVIRONMENTAL AND ENGINEERING GEOLOGY

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Marginalize: to relegate to an unimportant or powerless position within a society or group. As environmental and engineering geologists we should be at the fore front of industry practice. We should be pioneering new techniques for field investigations and site characterizations. We should be considered valuable to our employers. Instead, we have perpetuated the practice of marginalizing ourselves. The marginalization begins with the increasing disparity between the experienced and knowledgeable in our field and those that are just entering it. We marginalize our practice by the continued allowance of the lowest price investigations with the rationalization that safety factors applied during design will compensate or change orders during construction are an accepted norm. We marginalize our practice by allowing the use of tools to replace us, not assist us. We marginalize our practice by not using knowledge and skills that should be applied to investigations. We marginalize our practice by misapplying tools, by lack of comprehension about investigation means and methods, by relying on subcontractors who have a more limited skill set that we do, by not comprehending the purpose of our work, and most importantly, we marginalize our practice by not being aware how far we have fallen.

It is in our best interest that we begin to stop the downward spiral that we have entered into. The question is; how do we do that?

ISIS: INTEGRATED SEISMIC IMAGING SYSTEM FOR EXPLORATION AHEAD OF TUNNELING

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Tunnel construction gains increasing importance for growing infrastructures. Optimization of the work flow during tunnel construction by minimizing risks in safety and costs can be significantly supported by detailed prediction of the geologic environment along the tunnel alignment. Especially in deep tunnelling or complex

geological situations the resolution of geological structures achieved with standard exploration techniques from the earth surface is insufficient. To improve the resolution, an integrated seismic imaging system (ISIS) has been developed at the GFZ Potsdam, Germany. In distinction to other seismic prediction systems, ISIS is non-intrusive and can be used in mixed geologic environments as well as in hard rock. Two impulse hammers are used as seismic sources, positioned on either tunnel wall opposite to each other. The receivers are four 3-component geophones, two on either side of the tunnel in an angle of 130°, installed on 2m long rock bolts. The system uses surface waves restricted to the vicinity of the tunnel wall which dominate the wave field excited by the seismic sources as was shown by finite-difference modelling and field observations at the Gotthard Base Tunnel construction site. In February 2007 a survey was performed at the Hydro Electric Power Plant Glendoe/Scotland in cooperation with Herrenknecht AG, Germany. The geological interpretation of the seismic data is in good agreement with the independently performed geological mapping by Herrenknecht geologists. Additionally, a TBM-driving data set was used for more detailed interpretation. The correlation of TBM-driving parameters, seismic data and geological mapping is the ground work for an integrated interpretation of seismic prediction in tunnelling.

CHARACTERIZATION OF THE CARMEL KNOLL AND DEVILS PUNCH BOWL LANDSLIDES OF COASTAL OREGON

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Poster Session: The Carmel Knoll and Devils Punch Bowl landslides, located on the central coast of Oregon, are being characterized to determine the driving mechanisms, age and the initial cause(s) and trigger(s) of failure for the slides. These results can be useful for future mitigation studies on the many similar landslides affecting highways and development along the coast.

To identify mechanisms responsible for landslide formation and reactivation, several methods are being utilized. Drilling has been completed and geologic logs and borehole samples obtained will be used to help characterize the shear zone location and material properties. Piezometers, water content sensors, and extensometers were installed in the borings. An engineering geologic map will be created to determine the boundaries of the slides. Continuous monitoring of both slides includes information from rain gages, piezometers, water content sensors and extensometers. Laboratory shear strengths of shear zone materials will be determined for each slide, both peak strength and residual strength. Also, pore pressures along shear zones will be monitored before and during movement. Slope-stability analyses will be conducted to back calculate the shear strength of the slides and for evaluating reactivation mechanisms. Finally the pre-failure topography will be re-constructed and failure analyses will be conducted to determine likely conditions and driving mechanisms during initial failure.

CHILLED GAS PIPELINE CONSTRUCTION IN ALASKA

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Poster Session: This poster will be for Will Robinson's and Seth Miller's senior design project. The objective for the project was to provide a well researched, comprehensive report detailing and explaining the concerns, up-to-date techniques and practices, and sample methodology for the reconnaissance of geologic and geotechnical data critical for buried, chilled gas pipeline construction in the demanding environment of Alaska. The project was then broke up into four individual phases as follow:

- Phase I: Geotechnical Concerns
- Phase II: Remote Sensing Techniques
- Phase III: Field Survey Methods
- Phase IV: Suggested Methodology with Example Corridor

The first section aptly characterizes and details relevant and probable geologic and geotechnical concerns that will be faced early in the construction of a natural gas pipeline in the northern permafrost environment of Alaska. Concerns detailed in this section include: frost heave, slope stability, and thermokarst, to name a few.

The second section provides an overview of current and promising remote sensing techniques, such as air photography, satellite imagery, terrain classification methods, and topographic and published map analysis, accompanied with a summary of their usefulness, limitations and application to this project.

The third section provides a review of the reconnaissance field survey methods being practiced in northern permafrost regions for both linear developments (pipelines) and camp site developments. Therein, we thoroughly detail the operation of each method, provide data examples, and assess the accuracy and resolution of each method. We also indicate the appropriate conditions for each method and each method's potential to identify engineering construction concerns and/or problems. Additionally, we provide an analysis of advantages and limitations associated with each method.

In the fourth section we developed and provided a general survey methodology and specification for a pipeline corridor reconnaissance. We demonstrated the developed methodology using a 50-mile long, 2-mile wide proposed natural gas pipeline corridor between Tok and the Canadian border.

RUPTURE POTENTIAL OF THE LEFT ABUTMENT FAULT, SAN VICENTE DAM, SAN DIEGO COUNTY, CALIFORNIA

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During original construction of San Vicente Dam in the 1940s, a fault was identified in the left abutment of the proposed dam as a 6 inch-wide gouge zone in early Cretaceous Santiago Peak metamorphosed volcanic rock. The fault was briefly studied by J. Buwalda of Caltech and deemed not a concern, as the fault had little geomorphic expression. However, as part of the geologic investigations to raise San Vicente Dam, we have conducted new, detailed studies of this fault to assess its rupture potential and possible hazard to the dam. The fault is NW-striking, and horizontal striae are preserved in the gouge on slikensided surfaces. Because this fault aligns with other strike slip faults in southern California, it was considered plausible that the fault may accommodate minor localized slip related to the current stress regime along the Pacific - North American plate boundary.

We conducted extensive field mapping, trenching, and thin section analysis of the Left Abutment fault. The fault juxtaposes two domains of metamorphic volcanic rocks, and mapping of the fault into a granitic pluton shows 9.5 feet of left-lateral separation of the pluton contact. This sense of slip is opposite of that expected from the current stress regime. To assess whether the fault has been active since emplacement of the pluton, we cleared off the soil cover into the pluton and determined: 1) there is no significant offset of the granite itself, and 2) the fault dies into the pluton. Analysis of thin sections across shear surfaces indicates that most or all "gouge" is pedogenic clay and confirms the absence of young shearing and grain-size reduction.

Our observations from the fieldwork and thin section analysis indicate that the Left Abutment fault is not active and does not pose a concern for raising the level of San Vicente Dam. Our trenching and mapping show that the observed displacement on the fault resulted from minor crustal adjustments related to the emplacement of a Cretaceous pluton, its subsequent uplift and consequent stream incision, and is therefore not a rooted seismogenic fault.

PALEOSEISMIC ASSESSMENT OF THE VILARIÇA SEGMENT OF THE MANTEIGAS-BRAGANÇA FAULT IN NORTHEASTERN PORTUGAL FOR THE PROPOSED SABOR RIVER DAM

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We studied the late Quaternary activity of the Manteigas-Bragança fault as part of the seismic hazard characterization for the proposed Sabor Dam in NE Portugal. This fault, which is a major, 250 km-long, NNE-striking, sinistral strike-slip structure, has no historical seismicity for large earthquakes, although it may have generated moderate (M5+) earthquakes in 1751 and 1858. Evidence of continued left horizontal displacement is shown by the presence of Cenozoic pull-apart basins as well as late Quaternary stream deflections. To investigate its recent slip history, a number of trenches were excavated at three sites along the Vilariça segment, north and south of the Douro River. At one site, the Vale Meão winery, the occurrence of at least two and probably three events in the past 14.5 ka was determined, suggesting an average return period of about 5-7 ka. All three events appear to have occurred as a cluster in the interval between 14.5-11 ka, suggesting a return period of less than 2 ka between events within the cluster. In the same area, a small offset rill suggests 2-2.5 m of slip in the most recent event and about 6.1 m after incision below a ~16 ka alluvial fill event along the Douro River. At another site along the Vilariça River alluvial plain, northeast of the Vale Meão site, several trenches were excavated in late Pleistocene and Holocene alluvium, and exposed the fault displacing channel deposits dated to between 18 and 23 ka. In a succession of closely-spaced parallel cuts and trenches, the channel riser was traced into and across the fault to resolve ~6.5 m of displacement after 18 ka and ~9 m of slip after ~23 ka. These observations yield a slip rate of 0.3-0.5 mm/yr, which is consistent with earlier estimates. Combining the information on timing at Vale Meão winery and displacement at Vilariça argues for earthquakes in the M7+ range, with co-seismic displacements of 2-3 m. This demonstrates that there are potential seismic sources in Portugal that are not associated with the 1755 Lisbon earthquake or the Tagus Valley, and although rare, large events on the Vilariça fault could be quite destructive for the region and for proposed and existing dams.

LEVEE FAILURES ALONG THE INNER HARBOR NAVIGATION CHANNEL IN NEW ORLEANS

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The failure of the New Orleans regional flood protection systems, and the resultant catastrophic flooding of much of New Orleans during Hurricane Katrina, represents the most costly failure of an engineered system in U.S. history. This presentation will be an overview of the principal events that unfolded in the central portion of the New Orleans metropolitan region during Hurricane Katrina, addressing the levee failures and breaches that occurred along the east-west trending section of the shared Gulf Intercoastal Waterway/Mississippi River Gulf Outlet channel, and along the Inner Harbor Navigation Channel, which led to additional admission of floodwaters into the New Orleans East protected basin and into the St. Bernard Parish and Lower Ninth Ward protected basin. The emphasis in this presentation will be on the forensic investigations undertaken by the team funded by the National Science Foundation and the lessons learned with regard to the design, implementation, operation, and maintenance of major flood protection systems of this scale. Significant lessons learned in the central portion of New Orleans included: (1) the need for regional-scale flood protection systems to perform as systems, with the various disparate components meshing well together in a mutually complimentary manner, (2) the importance of considering all potential failure modes in the engineering design and evaluation of these complex systems, and also in forensic investigations of failures, and (3) the problems inherent in the construction of major regional systems over extended periods of multiple decades. These are important lessons, as they are applicable to other regional flood protection systems in other areas of the United States, and throughout much of the world.

PROFESSOR ARTHUR B. CLEAVES OF WASHINGTON UNIVERSITY (TERRY'S ORIGINAL ENGINEERING GEOLOGY MENTOR)

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GEOLOGIC CONDITIONS UNDERLYING THE 2005 17TH STREET CANAL LEVEE FAILURE IN NEW ORLEANS

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A careful program of subsurface sampling and CPT soundings was employed to characterize the geologic conditions beneath the failed portion of the 17th Street Canal levee in New Orleans, LA where a 150 m long section of the levee and floodwall translated up to ~16 m when flood waters rose to 1 to 2 m of the wall's crest on August 29, 2005, during Hurricane Katrina. The subsurface conditions are characterized by discrete layers of fill placed upon the historic cypress swamp, which is underlain by a deeper, prehistoric cypress swamp. These swamp deposits were consolidated beneath the levee, and in the area of the 2005 failure, the swamp materials infilled a natural depression believed to be an old slough, which dipped below the sheetpile tips for a distance of about 50 m, which corresponds to where the breach appears to have initiated. Detailed examination of the recovered soils suggest that recent hurricanes periodically inundated the swamps with saline and/or brackish water, which cause a mass die-off of swamp vegetation and flocculation of suspended clays, due to the sudden increase in salinity. These conditions promote deposition of discontinuous clay seams beneath layers of organics, which are then covered by fresh water swamp deposits. This sequence is repeated, like a series of tree rings, throughout the swamp deposits. The cypress swamp deposits lying beneath the levee also exhibit high hydraulic conductivity. These materials contain corky wood, and recovered samples often exhibited densities less than water. Nine of the post-Katrina borings recovered intact samples of a basal rupture surface comprised of organic silty clay exhibited near zero residual shear strength after shearing 8 to 10 cm.

APPLYING 21ST CENTURY TECHNOLOGY TO DEVELOP SURVIVABLE FLOOOD PROTECTION SYSTEMS IN THE MISSISSIPI DELTA REGION

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A great debate has erupted since Hurricane Katrina, which basically revolves around the question "Can we build levees that won't fail?" Should we, as a society, allow or encourage urban development of lands that are either: 1) below sea level; or, 2) barely above sea level? Public opinion polls show that most people feel that whoever chooses to live in "high risk areas" should pay greater insurance premiums for the privilege of living in such places. For engineers designing flood protection systems, the core value should be survivability. Above all else, flood barriers, such as levees, should be constructed to withstand short short-term overtopping, without suffering catastrophic failure. Earthen levees represent old technology; they are not reliable when founded upon compressible organic soils, soft/weak soils, or highly pervious soils. Levees are also susceptible to erosion by overtopping, by edified flow, and by undercutting overtopping, flow. Once flood waters overtop an embankment they quickly scour the land side toe of the embankment, and scour deep holes that develop on either side of the hydraulic jump.

Over the past quarter century, geogrid soil reinforcement has been increasingly employed as facing elements for mechanically mechanically-stabilized embankments comprised of weak or erodible soils. These soil reinforcing materials do not corrode and plants and trees can take root in them, so they are more "environmentally friendly." Geotextiles and geomembranes allow construction of embankments slopes at any desired inclination by employing "false layers," of geotextiles, between primary reinforcement layers of mechanically stabilized embankments (MSE). These false layers restrict slope raveling and erosion. In areas exposed to storm surge some thought might be given to equipping levees to be more efficient energy dissipation systems; and not just simple barriers. Though more complicated, they might not have to be as high as conventional levees and would not be nearly as heavy. The weight of conventional earthen levees with flat side slopes (necessary to achieve acceptable bearing capacity) has been a vexing problem in areas underlain by highly compressible organic rich soils. Soil reinforcement could be applied to engender greater shear strength, allowing much steeper cross sections, which weigh much less. Segmental levee systems could be crafted into

"green" systems, which would employ swamp troughs between the embankments. As the cypress trees mature, their impact on storm surge dissipation would increase, helping to offset freeboard losses caused by regional settlement. Examples of these conceptual energy dissipation and barrier systems will be presented.

DEVELOPMENT OF THE NEW ORLEANS FLOOD PROTECTION SYSTEM PRIOR TO HURRICANE KATRINA

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The system of flood protection surrounding New Orleans and its adjoining parishes prior to Hurricane Katrina evolved over a period of 280 years. The earliest drainage works sought to elevate the river's natural levees and excavate drainage canals leading towards Bayou St. John, the only natural break across the Metairie-Gentilly distributary ridge. An extensive zone of Cypress Swamps occupied the levee flank depression between the ridge and Lake Pontchartrain. 58 km of drainage canals were excavated across the natural levee backslope and through the swamp depressions bordering the lake between 1833-78. These canals sought to drain the lower portions of the city, which suffered periodic outbreaks of yellow fever, which killed more than 100,000 people during the 19th Century. The city has not suffered flooding from the Mississippi River since 1895, most damaging floods having emanated from hurricane surge off of Lake Pontchartrain. Since 1559, 177 hurricanes have struck the Louisiana coastline. A system of pump stations was constructed between 1895-1927, which pump water into the river, the lake, and adjacent bayous. The cypress swamps were replaced by the Lakeview and Gentilly residential districts, built after 1945. This old swamp zone has settled as much as 3+ m since 1895. After the 1927 the Army Corps of Engineers assumed a leadership role in providing flood control infrastructure, supervising the Mississippi River & Tributaries Project in 1931-72. In 1955 the Corps role was expanded to include the City of New Orleans, which included maintaining capacity and freeboard of the old drainage canals. After as series of lawsuits between 1961-1977, the Corps was forced to employ concrete flood walls along the subsiding drainage canals. These walls were constructed in the 1990s, though some transition elements remained incomplete when Hurricane Katrina struck in August 2005.

CONCEPTS FOR REPLUMBING THE MISSISSIPPI RIVER TO CURTAIL COASTAL LAND LOSS IN LOUISIANA

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The Mississippi River drains approximately 41% of the continental United States, discharging about 580 km km3 of water each year (420 billion gpd). Almost 50% of this water emanates from the Ohio River, from 1/6th of the watershed area. The Missouri River encompasses 43% of total watershed area, but only contributes 12% of the discharge. Prior to 1700, the average sediment discharge was about 440 million tons/year, mostly from the Missouri River watershed. This figure has decreased about 50% since 1950, because of dams constructed on Missouri and Arkansas Rivers. This loss somewhat compensated by 5 to 10 fold increase in sediment load carried down the Ohio River, because of row farming and deforestation. Between 1932-1990 an average of 35 square miles of land was being lost to the sea each year in the Mississippi Delta, with an average loss of 44 square miles/year of wetlands. Coastal land loss has been accelerating since 1950. During Hurricane Katrina, 115 square miles of land area was lost. Since 1950, the average sediment load of the Mississippi River has been reduced to about ~215 million tons per year, but most of this is lost out the jetties. At present we are losing about 50X more land mass than we are saving.

The physical situation is very difficult because the Mississippi River within a deeply-incised channel, that extends below sea level from a position near Greenville, MS, 450 miles upstream of the river's mouth. This creates a difficult design problem because most of the sediment laden water lies below sea level except during brief periods of flood flow, when most of the sediment is deposited. Significant floods only occur about 5 to 10 times per century. We will have to become much more opportunistic about how we manage the Mississippi River if we hope to effectively divert its unpredictable flood flows. One idea is to divert the flow of the river during high flows using precast concrete "tunnel taps," between 1 and 2 miles long. These precast concrete liners could be jacked through the overbank sediments, beneath the river river's levees, similar to those used for I-90 in the Boston Big Dig. These distributor alignments would need to be flexible, to accommodate an uneven distribution of sediment. Flexibility will be key aspect of such a system. The Atchafalaya River Basin is the prime candidate to accept such diversions because its gradient is three times steeper than that of the lower Mississippi and its path to the gulf is much shorter (225 kilometers to the Gulf of Mexico from the Red River entrance versus 480 kilometers for the Mississippi). Under natural conditions, the Mississippi River would probably have switched its course to the Gulf of Mexico via the Atchafalaya distributary between 1965 and 1975, if not for the levees. The Atchafalaya now drains about 30% of the combined flows of the Mississippi and Red rivers to the Gulf of Mexico.

GIS OUTREACH AND EDUCATION IN POST-KATRINA MISSISSIPPI

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Poster Session: Geographic Information Systems volunteers quickly rallied to assist rescue operations in the wake of Hurricane Katrina, but GIS efforts were complicated by widespread reliance on paper maps and non-spatial databases. In addition, few local rescue and government personnel were proficient in GIS or even aware of its capabilities.

The need for transition to digital maps and databases was apparent, but most of rural Mississippi's rural counties and municipalities are very poor. Grants from the National Oceanic and Atmospheric Administration (NOAA) were therefore obtained for an outreach and education project to provide on-site GIS training and follow-up assistance to state and local government personnel and emergency providers at no cost to the agencies or individuals.

Original workshops as well as all eight training courses in the Environmental Systems Research Institute's (ESRI) Authorized Training Program are taught by the three Mississippi State University faculty and staff comprising the project team. All training is taken directly to client sites, utilizing the project's 28 laptops configured with the latest version of ESRI software or the 12 desktop computers, server and satellite internet dish with which the project has refurbished the mobile computer lab on the Mississippi State University Extension Service bus.

Over a thousand participants from approximately half of Mississippi's 82 counties have attended the GIS workshops since the project's inception in June 2006. Based on participant costs of travel to an ESRI site for the workshop, registration fees, lodging and per diem, the State has realized savings of over a million dollars.

ASSESSING THE FEASIBILITY OF MARINE TUNNEL AND OCEAN OUTFALL OPTIONS IN THE LOS ANGELES AREA VIA INTEGRATED SITE CHARACTERIZATION STUDIES

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As a part of their major wastewater facilities planning and engineering efforts, the "Clearwater Program", a proposed tunnel and ocean outfall is under feasibility consideration by the Sanitation Districts of Los Angeles County (Districts'). The tunnel and ocean outfall is intended to convey treated wastewater from the Districts' Joint Water Pollution Control Plant (JWPCP) in Carson, California. The tunnel may be up to 20 foot diameter and may extend up to 19 miles from the JWPCP to the offshore continental shelf in water depths of up to about 285 feet. Outfall designs include options for up to 14,000 foot of diffuser pipe.

Complex geologic and geotechnical conditions significantly impact routing options. Thick sequences of loose, potentially liquefiable, Holocene sediments cover the seafloor in the vicinity of various outfall options. Early Pleistocene and Tertiary age formations underlying these surficial sediments are generally soil like to very weak with highly variable percentages and thicknesses of stronger rock layers, and will pose challenges for selection of optimal tunneling equipment and pipe materials. The various options all include crossing of the Palos Verdes fault zone, an active fault that varies from strike slip to thrust trending northwestward across the project area. Steeply dipping bedding will be encountered as the tunnel passes through a complex anticlinorium. The sporadic presence of naturally occurring oil and gas seeps within the Miocene age formations will also complicate tunneling and muck disposal options.

The various tunnel options are being evaluated in a phased approach by a combination of exhaustive literature research, onshore and offshore geotechnical explorations including boreholes, vibracores, and Cone Penetrometer Tests, extensive laboratory testing of recovered samples, and multi-system high resolution geophysical surveys in the onshore and offshore project areas. Engineering studies have focused on the fault zones, seismic engineering properties of the formational materials, and characterization of the weak rock.

THE DECEMBER 20, 2007 M=6.8 EARTHQUAKE, GISBORNE, NEW ZEALAND

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At 8:55pm local time on December 20, 2007 a magnitude 6.8 earthquake released on the Kermadec Trench 50km east of the coastal town of Gisborne, on the North Island of New Zealand, at a depth of 40km. The earthquake caused approximately NZ$34M damage, collapsing three buildings, damaging approximately 50 more, and resulting in over 3200 claims to the Earthquake Commission, a national hazard insurance coverage program. Most damage was related to brick facades, collapse of parapets and chimneys, shaking of structure contents, and stream bank failure. Regional earthquakes result from the subduction collision between the Australian Plate on the west, which contains New Zealand's North Island and the Pacific Plate on the east, which contains most of the South Island. The region experiences an earthquake of this magnitude approximately every 10 years with the last significant event of M=6.3 in 1993, located 15km inland. Two earthquakes in 1947 caused tsunamis up to 10m, and even though the 2007 event was too deep to cause a tsunami, several thousand people fled to higher ground. An M=7.8 event in 1931 caused widespread regional damage, including total destruction by fire of the town of Napier, 150km to the southwest of Gisborne. The outcome of this earthquake shows that, in spite of a high level of awareness of the seismic activity and efforts towards retrofitting older buildings, a larger or shallower earthquake could have caused significant damage to older structures.

INVESTIGATION OF A ROTATIONAL LANDSLIDE AFFECTING TWO ADJACENT PROPERTIES

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A medium-size rotational landslide, occurring along the boundary between two adjacent properties, designated as properties A and B, took out portions of each property. The owner of property A blamed the owner of property B for causing the landslide that ultimately led to a law suit by the owner of property A (Plaintiff) against the owner of property B (Defendant). The chief consultant for the Plaintiff attributed the landslide to a buried drain pipe on the Defendant's property that, in the consultant's opinion, discharged water on the slope face, causing erosion of the slope face and promoting piping of the soil in the trench containing the pipe. Other consultants hired by the Plaintiff considered dumping of grass clippings along the slope crest and storm-water runoff from adjoining areas as the probable causes of the landslide. In all, the law suit produced about two dozen legal documents.

The slope affected by the landslide was 40-ft high and had an angle of 55^{o}. The soil stratigraphy at the failure site consisted of a 35-40 ft thick layer of sandy silt underlain by a 40-50 ft thick layer of glacial till (silty clay) that was further underlain by shale bedrock with inter-layers of siltstone. The failure was located entirely within the sandy silt layer, with the base of the failure grazing the underlying clay layer. Laboratory tests performed on the sandy silt indicated the following values for various engineering properties: natural water content = 14.3%, liquid limit = 19.2, plasticity index = 2.3, bulk density = 123.3 lb/ft^3, cohesion = 892 lb/ft^2, and friction angle = 30^{o}. Stability analyses, performed by three different methods (Taylor's charts, method of slices, and STABL software), showed factor of safety values close to 2 for the natural state and 1 or less for the saturated state. The results of stability analysis, along with other field observations, indicated that the landslide occurred, most likely, as a result of pore pressure buildup during spring, but it did not occur due to erosion caused by the drain pipe, the weight of grass clippings, or storm-water runoff.

A NUMERICAL MODEL FOR SIMULATION OF A LARGE HOLOCENE DEBRIS FLOW, LOST RIVER RANGE, IDAHO

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An investigation was carried out to simulate a large Holocene-age debris flow in Idaho. As described by Shaller (1991), the debris flow was initiated as a large-scale landslide in Tertiary basaltic rock in middle Holocene time. The landslide originated at a ridge-line location, and the resulting debris flow entered and was channeled through an existing watershed. The deposit has a surface area of approximately 3.1 km^2 and a volume of approximately 100,000,000 m^3. A two-dimensional flow routing model (FLO-2D) was utilized to simulate the debris flow. The objective of the study was to use the model to predict the runout distance and spatial distribution of the debris based on the pre- and post-flow topography. The model was also queried regarding the varied surface textures preserved on the deposit.

Digital topographic data was used to create the model grid, which consists of approximately 60,000 10 m x 10 m square grids. Inputs to the model included the water and volumetric sediment concentration, yield stress, dynamic viscosity, surface roughness, floodplain storage and change in floodplain depth. Parameters such as average hydraulic conductivity, average capillary suction head, initial and final saturation, initial abstraction, and soil porosity were assumed to be zero, thus providing a conservative estimate of the extent of the debris flow. The model simulations were carried out using the full dynamic wave option. A sensitivity analysis was carried out by varying key input parameters (yield stress, viscosity, and bottom roughness) to assess the uncertainty of the model predictions. A comparison of these results with the actual deposit showed that the model was able to realistically reproduce the existing field conditions.

EVALUATION OF SIMPLE CLAIMS FOR A LANDSLIDE IN COMPLEX MELANGE

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In February 2000 a high excavated slope failed at a long-established residential area of Millbrae, California. The slide was largely within Franciscan Complex melange. Litigation proceedings followed shortly afterward during which several simple allegations were made, two being: 1) a water-supply reservoir, some 1500 feet from the landslide, had leaked groundwater through the intervening low broad ridge; and 2) the ridge was an "embankment" and thus it was expected that there would be leakage from the reservoir to the "downslope face", which in this case partly included the failed slope.

Geological and geotechnical investigations revealed Franciscan Complex melange within the ridge, consisting of a chaotic mixture of clayey, highly sheared matrix with blocks composed of sandstone, shale, greenstone and other lithologies. Hydrogeological observations and analyses concluded that the permeability of the melange ranged between 2.1x10-8 to 1.4x10-7 centimeters per second. Detailed hydrogeological analyses showed the alleged contribution to the landslide of groundwater leaking from the reservoir through the ridge is invalid. Furthermore: there was no technical justification for modeling the topography and geological composition of the natural ridge between the lake and the landslide as a dam "embankment" (an engineered structure).

Following additional investigations and analyses, it was apparent that other factors had contributed to the landslide. These included long-term degradation of the melange exposed in the excavated slope, aggravated by lack of slope maintenance and the effects of poorly controlled surface drainage.

LITHOLOGY AND SEDIMENTOLOGY OF AN INNER SHELF SHOAL OFF CHOCTAWHATCHEE BAY, FLORIDA, USA

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Poster Session: Though tectonically stable, the northeast Gulf of Mexico (GOM) is a storm dominated coast, exposed to both tropical cyclones and cold front storms. The effect of these storms on the geomorphology and stratigraphic structure of the sediments on the inner shelf/nearshore region is not well understood. This study focuses on a northeast-southwest trending shoal on the inner shelf off the western Florida Panhandle, USA, in order to assess the stratigraphic and sedimentological evolution at a finer scale. This region is of particular interest given the increase in tourism and coastal development in the past decade, as well as the increase in landfall of tropical storms in recent years. In addition, the shoal and nearshore regions have been designated as potential borrow sites of high quality sands for beach re-nourishment. In this study, sub-bottom (seismic) profiles and 277 vibracores, their stratigraphic logs and granulometry were analyzed. Preliminary results indicate that the shoal and nearshore region are characterized by a regionally transgressive sand sheet, the Mississippi-Alabama-Florida (MAFLA) sheet sand; this is a medium-to-fine grained sand deposit, underlain and sometimes interbedded by clay and organic material. The nature of this material does not conform to published data, indicating that previous concepts of material reworked offshore during storm events, may not be valid for this region. Radiocarbon dating of the organic material and geophysical interpretations are being conducted in order to more accurately describe the geological and physical forcing mechanisms affecting this region.

HISTORIC ENGINEERING SURVEY DATA FROM DRAINAGE DISTRICTS WITHIN THE MISSISSIPPI EMBAYMENT REGION: AN OVERLOOKED RESOURCE FOR EARTHQUAKE-HAZARDS STUDIES?

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The rich, agricultural land of westernmost Kentucky and Tennessee, northeast Arkansas, and southeast Missouri (aka 'Swampeast Missouri') owes its productivity to numerous, privately-developed drainage districts established in the early 20th century. Before then, that land was mostly forested, often saturated, and generally disagreeable to farm or inhabit. For example, in 1905, local community leaders in southeast Missouri initiated the world's largest drainage project: The Little River Drainage District (LRDD). A public entity, the LRDD eventually engineered and installed a system of over 300 miles of levees and over 950 miles of ditches that drained over 1.2 million acres. (Many of the engineers who were completing the Panama Canal found their way to work on the LRDD.) The engineering database left behind by these 'topographic pioneers of the Mississippi Embayment' offers an interesting resource for present-day earthquake-hazards researchers: detailed elevation data of most of the land-surface over the New Madrid fault zone measured on 500-foot spacings and to a one-tenth-foot vertical accuracy. Since installation, the maintenance records of the various drainage districts also may offer insight into local and regional uplift, downwarp, and tilting – possibly due to tectonic forces at depth. The drainage districts of the mid- and lower-Mississippi River valley may be considered a "poor-man's laser system" – that has been in place for almost 100 years.

INTERFACE OF GEOLOGY AND SEISMOLOGY IN REVIEW OF APPLICATIONS FOR POTENTIAL NEW NUCLEAR POWER REACTORS AT THE U.S. NUCLEAR REGULATORY COMMISSION

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Consideration of geologic framework is fundamental for selecting sites for nuclear power facilities and designing and constructing the facilities to ensure safe operation in light of potential geologic and seismic hazards. NRC requirements in Title 10, Part 52, of the Code of Federal Regulations (10 CFR Part 52) specify geologic and seismic characteristics that must be described by an applicant and included in application materials for a proposed new reactor site. 10 CFR Part 100.23 defines geologic and seismic siting factors that must be considered for design of safety-related facilities and discussed in the application. To implement these regulatory requirements, an applicant must analyze geologic features at site region (320-km [200 mi] radius of the site), site vicinity (40-km [25 mi] radius), site area (8-km [5 mi] radius), and site location (1-km [0.6 mi] radius) scales and present results of the analyses in a Safety Analysis Report (SAR) which is an important part of the application materials prepared for the proposed site.

NRC geologists and seismologists familiar with site characterization methods and geologic features of the site region, vicinity, area, and location are actively reviewing materials related to basic geologic and seismic information and surface faulting presented in SARs for several proposed sites. They are assessing presence of tectonic and non-tectonic surface deformation, seismogenic structures, and seismic source zones and conducting site visits to determine whether conclusions presented in the SARs about age of faulting at the sites accurately reflect geologic field evidence. Review of SARs and related activities performed by NRC geologists and seismologists enable assessment of the sites in relation to potential geologic and seismic hazards and ensure that protection of public health and safety is the highest priority during all reviews.

TRIBUTE FOR TERRY WEST, TEACHER, MENTOR AND COLLEAGUE

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Terry accepted me as a 'conditional' graduate student in engineering geology and remote sensing, an unlikely combination of disciplines. At the time the Laboratory for Applications in Remote Sensing at Purdue University was experimenting in the use of digital image processing of airborne multispectral imagery. A student was wanted to investigate the use of thermal infrared imagery for transportation purposes and the influence of terrain upon radiance. That research has led me into investigations into failure of an industrial chemical waste landfill for which I (and others) were recognized with the Autometric award by the American Society of Photogrammetry and Remote Sensing. Lately I also used this same research to investigate the use of remote sensing to locate carbon dioxide gas leaking beneath a soybean field, a method which has application for deep geologic sequestration.

What I learned from Dr. West was the importance of joining professional organizations to learn from colleagues and to support them with your time and energy. I also learned about writing proposals, papers and graciously accepting comments from peer-reviewers, and professional conduct mostly by his example.

It has been my pleasure to see Terry at meetings and talk with him as a colleague over the years since I graduated. His advice has continued to guide my career in many ways not described here including encouragement to work toward a Ph.D. degree. It is my hope that my conduct and career will be a tribute to his teaching.

CONTROVERSY REGARDING ACTIVE FAULTING ON THE LA NACION FAULT, SAN DIEGO, CALIFORNIA

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The La Nacion Fault Zone (LNFZ) consists of a series of parallel to subparallel normal faults that extend approximately 20 miles from the United States/Mexico border northward to the area south of Mission Valley. Historically, geotechnical studies of the LNFZ have provided data indicating both pre- and post-Holocene ages for fault movement, thus resulting in various conclusions and recommendations regarding the activity level of the fault.

For example, in 1973, Artim and Pickney reported that Holocene alluvium was offset in two localities up to approximately 1 meter. In contrast, radiocarbon age dates of unfaulted alluvium overlying the La Nacion fault vary from approximately 7,000 years old (Hart, 1974) to at least 14,000 years old (Gayman, 1979). More recently, geotechnical studies for new developments have both recommended and not recommended fault setbacks from mapped traces of the fault. Further complicating the classification of the LNFZ, geomorphic features that are commonly associated with active faulting have not been observed.

Recent fault exploration has resulted in providing new evidence supporting the conclusion of active faulting along portions of the LNFZ. The study included excavation of two exploration trenches across the fault trace. We observed elongation and shearing of a secondary carbonate bleb along with shearing of colluvium within the main fault contact. In addition, we observed several very linear contacts between the colluvium and the fault that indicate offset, along with a colluvial filled fissure extending approximately 2 feet below the base of the colluvial contact.

COMPARING THE ACADEMIC SCHOLARSHIP PROGRAMS OF THE AEG FOUNDATION TO ALL GEOSCIENCE SCHOLARSHIP GRANTORS AND A PEER GROUP. HOW ARE WE DOING*?*

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The AEG Foundation annually offers seven fixed-value academic scholarships with a total value of $11,500, a mean value of $1,642, and range in value from $1,000 to $2,500. How does this portfolio compare to the similar scholarships offered by other non-profit geoscience membership organizations and their related foundations?

Internet searches found 66 geoscience entities that offer academic scholarships. Of these, only 38 both 1) grant fixed value scholarships in programs similar to that of the AEG Foundation and 2) publish enough data to permit statistical comparisons. These 38 organizations grant 183 scholarships in a composite year, with a total value of $247,400.

A subset peer group of 12 grantors was defined based on similarity to the AEG Foundation in 1) applicant qualification criteria, 2) program administration, and 3) scholarship usage restrictions. The peer group grants 54 fixed academic scholarships annually with a total value of $86,400. The table summarizes the results.

COMPOSITE ANNUAL GEOSCIENCE ORGANIZATION FIXED VALUE ACADEMIC SCHOLARSHIP PROGRAM OUTPUT

GROUP	SIZE, #	NUMBER OF SCHOLARSHIPS	RANGE OF VALUE, $	MEAN VALUE, $
ALL	38	183	200 - 5,000	1341
PEER	12	54	500 - 5000	1600
AEG Foundation	1	7	1000 - 2500	1642

Compared to the output of all grantors and the peer group, AEG Foundation scholarships occupy the mid-range of scholarship value and are higher in average value.

DETERMINING LANDSLIDE SUSCEPTIBILITY ALONG NATURAL GAS PIPELINES IN NORTHWEST OREGON

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The study area runs along three natural gas transmission pipelines passing through ancient landslides, steep terrains, and weak bedrock geology with rainfall reaching 508 cm/year. The natural gas pipelines cross 300 km of mostly Cenozoic basalts and marine sediments of the Oregon Coast Range with 269 landslides (148 field checked) mapped in a 1.6 km width corridor. 59 geologic units were mapped from ten compiled geologic maps.

The key discovery found in this study within the Oregon Coast Range is that 83% of all landslides originated at geological contacts which creates a new focus for determining landslide susceptibility. Landslides on lithologic contacts according to occurrence (O_k) and length coverage (C_k), area density within geologic units (G_k), and slope (θ) can be compiled into one function, T_i which determines TIN triangle values for landslide susceptibility. The developed model was tested in the neighboring area of Astoria, Oregon with 77% landslides located on the predetermined higher ranked TIN triangles.

Each pipeline has their own individual parameters for T_i which includes the following functions: landslide area density for each geologic unit (G_i), lithologic units with percentage of landslides occurring on their contacts (O_k), lithologic contacts with the length percent running through landslide material (C_k), and minimum slope angle (θ). Pipeline corridors susceptible to landslides are segments with basalts capping older and weaker marine sediments. Mean slope of failure for all three pipelines is 17° (mode, 11°; minimum, 5°).

PALEOSEISMOLOGY AND LONG-TERM DEFORMATION IN THE CENTRAL UNITED STATES: IMPLICATIONS FOR EARTHQUAKE SOURCES

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Paleoseismology is illuminating spatial and temporal patterns of earthquake activity and enhancing our understanding of long-term fault behaviour. The paleoseismic record indicates that the New Madrid seismic zone, attributed to the Reelfoot Rift, produced earthquake sequences, similar to the destructive 1811-1812 event, in 1450 A.D., 900 A.D., and 2350 B.C., as well as large earthquakes in 1.7 ka, 5.5 ka, and 11 ka. The eastern rift margin appears to have produced very large earthquakes during the Late Wisconsin-Early Holocene in western Tennessee and during the Middle Holocene in east-central Arkansas, and the western rift margin experienced multiple episodes of faulting and ground shaking during the Wisconsin and Holocene in southeastern Missouri. In contrast, the northern portion of the rift in southern Illinois and adjacent Kentucky generated large earthquakes prior to 55-128 ka but apparently has not done so since. A paleoseismic record developed for the Wabash Valley of Illinois and Indiana shows that large earthquakes occurred there during the Late Wisconsin, Middle Holocene, and Late Holocene. The Grayville Graben and the Commerce Geophysical Lineament have been proposed as sources of those paleoearthquakes. Furthermore, faults outside the Reelfoot Rift and Wabash Valley, such as the Meers fault in Oklahoma, have produced multiple large earthquakes during the Holocene. Recent paleoseismic findings suggest that seismicity migrates along the Reelfoot Rift and perhaps other geologic structures on time scales of several thousands to tens of thousands of years and that there may be faults capable of large earthquakes that have not yet been recognized.

SOIL AND ROCK FORMATION INDEX AND ENGINEERING PROPERTY CHARACTERIZATION FOR TUNNEL AND OCEAN OUTFALL FEASIBILITY STUDIES, PALOS VERDES PENINSULA AND SAN PEDRO BAY, LOS ANGELES COUNTY, CALIFORNIA

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This study is part of a feasibility-level investigation of prospective routes for the design of a critically-needed new tunnel and ocean outfall that will serve about 5.3 million people in Los Angeles County. The tunnel may be up to 20 feet in diameter and may be up to 19 miles long, between elevations of -60 and -350 feet MSL. It will supplement two existing smaller-diameter tunnels built in 1937 and 1958. About 25% percent of the 112-square-mile project area is located onshore encompassing the eastern Palos Verdes Peninsula and adjacent Port of Los Angeles. The remaining area is offshore over the San Pedro and Palos Verdes Shelves.

Existing geotechnical data were compiled and index and geotechnical engineering property tests were conducted in order to characterize Quaternary deposits and Tertiary-age rock formations underlying the project area. The Middle Pleistocene through Middle Miocene-age geologic units (Timms Point Silt, Malaga Mudstone, and Monterey Formation) present in the project area are generally composed of poorly-indurated (soil-like to extremely weak), siltstone, claystone, and mudstone possessing many of the engineering characteristics of a very hard soil, and frequently include diatomaceous materials. Strong rock layers and lenses up to several feet thick are infrequently present, and comprise dolomitic and siliceous siltstone and other types of strong rock, including cherty and porcelaneceous rocks, and possibly

volcanic rocks interstratified within the Monterey Formation. A summary is provided of onshore and offshore geotechnical exploration, including borings, CPTs, vibracores, offshore seismic reflection surveys and downhole suspension logs, and laboratory testing of these materials.

THE MECHANICAL ADVANTAGES OF SHRINK WRAPPING WEAK ROCK CORE

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The main objectives in collecting samples of rock core during drilling for laboratory testing include preserving the in-situ moisture condition and delivering the sample to a lab in relatively undisturbed condition. But collecting core samples in weak and variable rock in suitable condition for laboratory testing is both delicate and problematic. The common practice for sealing and protecting samples includes wrapping them in kitchen cellophane (SaranWrap™) or sealing them in sample bags, then wrapping them with packaging bubble wrap. Though bubble wrap provides excellent protection during transport and cellophane and plastic bags can adequately retain moisture, the samples still lack proper confinement and are subject to slaking and disintegration due to stress relaxation and disturbance during transport - a problem encountered particularly with weak rock. Furthermore, the cellophane wrap is typically cumbersome, and frustratingly awkward to handle in windy and wet drilling conditions.

Heat shrinkable wrap is not only easy to handle, but provides sufficient confinement for particularly weak rock samples to keep from falling apart during transport and handling. The wrap is of heavier gage than kitchen cellophane but partially melts and shrinks tightly against the core when heated with a heat gun. Loss of moisture due to heat shrinking is minimal. The sealing and wrapping equipment is a very minor investment (a few hundred dollars), the process requires little more field effort than the existing methods, and allows sampling and characterization of rock that would otherwise be nearly impossible to test.

Two projects in the East San Francisco Bay hills allowed development of the method. During the projects, sample wrapping progressed from kitchen cellophane and bubble wrapping to heat shrink wrapping collected rock core. Both project sites are located within the Cretaceous Panoche Formation, part of the Great Valley Sequence. The Panoche heterogeneous mix of extensively faulted, folded, sheared and jointed claystone, siltstone, and sandstone, often of submarine landslide origin. With such variable rock types and strengths, it is especially important to appropriately characterize the rock mass in its entirety. As weak rock is difficult to sample and test, it is common to select robust specimens of rock core for testing, which bias results in unconservative strength characterizations.

Compared to previous test data generated from earlier projects at the site, at each site, it was clear that the overall strength of the rock mass was somewhat less than originally evaluated, based on the stronger core specimens tested for prior projects. The heat shrink wrapped weak rock core samples withstood preparation, transport and testing allowing appropriate characterization of the weak rock masses.

ASSESSMENT AND COMMUNICATION OF SEISMIC HAZARD AND RISK IN THE CENTRAL UNITED STATES

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In the central Unite States, large earthquakes (M7.0-8.0), similar in magnitude to the 1811-1812 New Madrid events, have been found to occur several times in the past few thousand years. Moderate earthquakes, such as M5.2 southern Illinois earthquake of April 18, 2008, also occurred throughout the region. Consequently, the communities in the central United States are facing certain seismic hazard and risk. How to translate the scientific information into seismic hazard and risk is a challenge in the central United States, however. It is too often heard: “I am just a scientist and this is what it is.” It is also too often heard that “the selection of an appropriate seismic hazard or risk for policy consideration is not really a technical question, but rather a societal one.” Clearly, there is a gap in understanding of scientific results and seismic hazard and risk between the scientists who produce them and the policy-makers and the general public who use them. It is a daunting task for scientists to try to convey scientific information to the policy-makers and the general public. But it is essential for scientists to make very effort to convey scientific information clearly, accurately, and understandably. Otherwise, the scientific facts would not be considered, and could even cause difficulties in formulating public policies. These are evidenced by the difficulties in formulating seismic mitigation policies by the communities in the central United States.

A HALF CENTURY OF TEACHING UNIVERSITY LEVEL GEOLOGY AND THE RELATED PROFESSIONAL EXPERIENCE

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Following undergraduate degrees in geology and geological engineering at Washington University, St. Louis, I entered the graduate program in Geology as a teaching assistant. During the next two years I taught geology labs in Physical Geology, Historical Geology, Optical Mineralogy and Petrography. This is when I decided that college teaching was my goal. I also took my first course in Soil Mechanics which led me toward engineering geology. My mentors were Dr. Arthur Cleaves from Geology and Professor Henry Reitz from Civil Engineering. I subsequently worked for Henry Reitz as a geologist/engineer in his St. Louis firm, while pursuing my MA degree in geology with a civil engineering minor.

Purdue University admitted me into their engineering geology Ph.D. program in 1961 as a full-time instructor. This required me to teach two courses per semester and after five years I received the Ph.D. degree, preceded by an MSCE degree two years earlier. After the PhD degree I was promoted to Assistant Professor in Civil Engineering. In 1967 the engineering geology group was transferred from CE to the Science School as a nucleus for the Geosciences Department. Meteorology was added to form the new department. From 1967 until the present, I have served as a faculty member in the now Department of Earth and Atmospheric Sciences. Over the intervening years I have directed research for 80 graduate students, 18 PhDs and 62 MS degrees. My textbook, “Geology Applied to Engineering”, was published in 1996 by Prentice-Hall Book Company.

Concurrent to this, I served as an active consultant in engineering geology authoring over 300 consulting reports. Regarding professional activities, I have served as Chair of the Steering Committee for the Highway Geology Symposium, President of the Indiana Academy of Science, Chair of the Engineering Geology Division of the Geological Society of America and recently as President of the Association of Environmental and Engineering Geologists (AEG). In 2001 I was awarded the Sagamore of the Wabash award by Indiana Governor, Frank O’Bannon, commemorating 40 years of teaching geology at Purdue University.

My professional life has been full and very rewarding. I wish to thank my wife Shirley, and my two children, Jill and Matthew, for their understanding and support over this half century career. I also have enjoyed considerable travel throughout the United States and the world in conjunction with various topics in engineering geology and geotechnics.

DESIGN CRITERIA FOR ROCK-CUT SLOPES IN OHIO

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Twenty-four sites were selected to collect relevant data for developing design criteria for rock-cut slopes for various geologic and hydrologic conditions in Ohio. Geometric parameters of the slopes (angle, height, length), including benches (height, width, back-slope angle), were measured at each site. Geometries of catchment ditches (width, depth, ditch angle) and retaining structures (height, width) were also recorded to evaluate their effectiveness using the Colorado Rockfall Simulation Program (CRSP) and the Rockfall Catchment Area Design Guide. Information regarding the as-built cut-slope design as well as the current cut-slope condition was used to evaluate the performance of the as-built design. Stratigraphic profiles, including bedding thicknesses of the competent and the incompetent rock units, were established for each site. The number, orientation, and condition of discontinuities for both the competent and the incompetent rock units were determined by performing the detailed line survey method. For sites showing the presence of undercutting, the maximum depth of undercutting was measured with respect to the edge of the overlying competent layer. Fifteen of the 24 sites were drilled to prepare geologic logs and determine Rock Quality Designation (RQD). For the remaining sites this information was obtained from the Ohio Department of Transportation records. Unconfined compressive strength and 2nd-cycle slake durability index values were determined for a number of samples from each site. The stability of cut slopes was analyzed using the Rock Pack software and the data collected in the field and laboratory. The results of the study, along with the observations of field performance of each slope, were used to determine the optimum angles for different rock units comprising the slopes and to develop the related design criteria. Unconfined compressive strength, slake durability, and RQD are the important properties considered in the design criteria.

A TRIBUTE TO PROFESSOR TERRY WEST: 47 YEARS OF TEACHING SERVICE AT PURDUE UNIVERSITY

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How does one prepare to survive for more than 30 years in the profession of geology? Since graduating from Purdue in 1974, I have experienced several changes in the workplace in the demand for geologists in the disciplines of oil & gas, environmental consulting and engineering geology. I credit Dr. West as a mentor in the preparation of my successful career as a professional geologist. Dr. West was my graduate advisor for 2-½ years at Purdue. He was very involved in my education, including course selection and arranging for research and teaching assistantships. He emphasized practicality in course content, generality in course selection and development of problem solving skills in research. He told me recently that my research paper on the engineering geology of Boone County, Indiana is still useful. He took an active interest in my personal and professional skill development. While Dr. West's student, I joined AEG and presented two professional papers that I co-authored with him. Looking back, it was this skill set that prepared me to survive the changing and sometimes volatile workplace in geology during the past 30 years.

I had the great pleasure of visiting with Dr. West last summer for the first time in 33 years. I was the host for his technical presentation at our Dallas Chapter Meeting of AEG. He still had a full dose of enthusiasm and professionalism that was applied to his first love of educating geologists and engineers. He is a great mentor. Thank you, Dr. West.

MENTORING AND APPRENTICESHIP PROGRAMS NEED TO BE REVITALIZED IN THE ENGINEERING GEOLOGY PROFESSION

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The concept of mentoring has existed since the time of the early Greeks when Mentor in Homer's Odyssey was appointed to guide the development of Telemachus (hence the development of the term mentoring). The idea that a young person would learn the skills of a trade from a more experienced individual is the underlying concept of apprenticeship. Although traditionally apprenticeships have been thought to apply more commonly to the skilled trades, the idea is equally important in all professions including engineering geology. Most academicians recognize that they have been successful in educating an individual if they are able to provide the graduate with the skills to learn – not just to fill them with facts. Most undergraduate academic programs do not provide students with the opportunity to practice the skills learned in the classroom. One of the reasons for thesis-based graduate programs is to provide the student with the opportunity to do relatively independent but supervised work. Graduate programs are essentially mentoring or apprenticeship opportunities. Currently upon entering the practicing world of engineering geology, the new graduate does not have many opportunities to receive the mentoring (or become the apprentice) of the experienced professional (the master). This loss of opportunities has become increasingly pronounced in the past two decades. There are many reasons for this including the lack of employer resources of time and money. This decline in mentoring or apprentice opportunities creates increased errors, lower quality, and incomplete work. If the profession of engineering geology is to maintain quality and improve, this decline in mentoring and apprenticeship programs has to be reversed.

AN INNOVATIVE COURSE IN ENGINEERING GEOLOGY: A TRIBUTE TO TERRY R. WEST

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Dr. West offered a "new" course "Consulting Case Histories in Engineering Geology" in May 2002. This course is one of many excellent courses I have taken. However, it differs from other courses in that it covers diverse subjects, offers the most interesting filed trips, and challenges students in report writing. This course is very special because it combines Dr. West's forty plus years experience in engineering geology teaching and consulting practice.

This course suits students well with different background in geology, geotechnical engineering and environmental engineering. It covers diverse subjects, such as dams, landfill, building foundations, karst topography, site selection and characterization, superfund, rockfall, water supply and groundwater contamination.

This course offers interesting and exciting field trips. The field trips in 2002 include Mississinewa Dam in Peru, Indiana, Westside Landfill in Indianapolis, and Prophet town State Park in Lafayette, Indiana.

This course provides student with an enjoyable and rewarding learning experience. I still remember the details of subjects covered, field trips and course project even after six years.

This course reflects Dr. West's dedication to engineering geology teaching, gifted teaching skill, and many years' consulting practice. Through this course he has inspired many students like me to excel in engineering geology practice.

APPLICATIONS OF SAR INTERFEROMETRIC POINT TARGET ANALYSIS (IPTA) FOR DETECTING DISPLACEMENT ON LAND SURFACE TARGETS

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Interferometric Synthetic Aperture Radar (InSAR) has been used for mapping land surface deformation by many researchers during the past two decades. However, the application of InSAR is limited due to temporal and spatial de-correlation, as well as other unwanted interferences such as cloud in the atmosphere. IPTA, which bases on persistent point-target scatterers, offers the possibility to estimate the progressive deformation of the ground surface at millimeter accuracy over an extended period of time. The IPTA software package has been developed by GAMMA Remote Sensing Research and Consulting AG in Switzerland. IPTA is a collection of tools to exploit the temporal and spatial characteristics of interferometric signatures collected from persistent point-target scatterers. There are several sources of SAR data applicable for this study, including ERS-1/2, ENVISAT, RADARSAT, PALSAR, JERS and ALOS. The RADARSAT, ENVISAT, and ERS-1/2 SAR systems all use a radar wavelength of 56 mm (2.2 inch) corresponding to a frequency of 5.3 GHz, which is within the C-band radio spectrum. The JERS and ALOS SAR used a wavelength of 235 mm (9.25 inch) corresponding to a frequency of 1.3 GHz, which lies within the L-band radio spectrum. This study involved collection and analysis

of SAR data from different sources and application of the IPTA techniques to detect possible movement of the Trans-Alaska Pipeline (TAP) during certain period of time.

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