Letter From the President,

Robert Jacob

Greetings everyone! I hope you are able to take time out of your busy day to look at the first NSGS electronic newsletter. I would like to thank our newsletter editor, Emily Hinz, for her hard work in making the electronic newsletter a reality.

There are several Near Surface Geophysics events on the horizon. SAGEEP (Symposium on Application of Geophysics to Environmental and Engineering Problems) will be held March 29th to April 2, 2009 in Fort Worth, Texas. The NSGS of SEG will have a meeting at SAGEEP on Sunday March 29th. The spring AGU (American Geophysical Union) will be held May 24-27, 2007 in Toronto, Canada and as usual will have multiple Near Surface Geophysics technical sessions. We are looking forward to good participation at these events.

The SEG 2009 abstract submission deadline is April 8th, however, the submission system is currently open. Jan van der Kruk is the Technical Chairman this year for the Near Surface Geophysics part of the SEG annual meeting. He is looking forward to organizing high quality sessions. We are all looking forward to a Post-Convention workshop organized by Rick Miller and John Bradford on Near Surface Seismic and GPR. The NSGS is looking forward to offering travel grants of $500 to support students attending the SEG annual meeting.

The NSGS appreciates those members whom agreed to be reviewers for the submitted abstracts. If you are interested in reviewing abstracts please email Jan (j.van.der.kruk@fz-juelich.de).

For more information about NSG Section membership, please contact me at rob.jacob@bucknell.edu. Remember, you can join, renew, or update your profile on the SEG website at any time. Go to http://seg.org/ and click on "My SEG".

Please do not hesitate to contact any of us if you have suggestions about the NSG section or would like to submit an interesting article on Near Surface Geophysics for the NS Views newsletter.

Best Wishes and I look forward to seeing you at upcoming meetings.

Cheers,

Rob Jacob, President,

Near Surface Geophysics Section

NSG Business Meeting at SAGEEP

4-6 P.M.

March 29, 2009

The NSGS will conduct a business meeting open to all of our members during SAGEEP.

Room: Live Oak II

Location: The Worthington, A Renaissance Hotel

200 Main Street

Fort Worth, TX

Time: 4-6 P.M.

Date: Sunday, March 29

SEG 2009

Call for Abstracts

The 2009 SEG annual meeting will be in Houston, TX from October 25 - 30. Expanded abstracts are due April 8th, 2009.

We had a large number of abstracts from the near surface community last year, and we hope that everyone will consider submitting material for this year's conference.

More information can be found at the SEG Annual Meeting website.

WORKSHOP

The joint seismology and GPR workshop is designed to bring the best of the past decade, state-of-the-practice applications of today, and visions for the next decade together providing practitioners and researchers with a unique opportunity to interact and share experiences.

Technologies used in the application of near surface seismology and ground penetrating radar (GPR) have seen significant advances over the last several years. Both methods have benefited from new processing tools, increased computer speeds, and an expanded variety of applications. Many shallow seismic projects now incorporate analysis results from different parts of the seismic wavefield allowing greater redundancy and confidence in interpretations without increased acquisition costs. More information is being extracted from GPR data by utilizing the wide range of analysis techniques developed for seismic data in concert with new tools specific to electromagnetic wave analysis.

It is fitting that these two geophysical techniques share the stage for a workshop that focuses on the highlights of an ever-increasing number of near surface studies taking advantage of the wide range of processing and analysis approaches applicable to both.

Organizers:

Rick Miller; John Bradford; Greg Baker; Klaus Holliger; Alan Levander

What's In Your Levee?

Mara Johnson, Argus Technologies (a Tremaine Company), mjohnson@tremaine.us, www.argustec.com

Louise Pellerin, Green Engineering, Inc, pellerin@ak.net, www.greeninc.us

California's Sacramento-San Joaquin Delta levees were originally built 150 years ago (by hand) to protect farmland. They were constructed by individual preferences with local fill materials such as peat blocks, without standardized engineering specifications. Today, these levees not only protect farmland, but also protect vital infrastructure including water aqueducts, highways, railways, bridges and deep water ship channels, electric utilities, oil/hazardous liquid pipelines, and historic and active communities.

In part because of their construction history, but also because of the threatening combination of land subsidence and sea level rise, Delta levees are considered a brittle skeleton of protection (Figure 1). Hidden hazards also threaten levee integrity. There are abandoned objects embedded in successive levee raising events, such as abandoned sluiceways, drainage pipes and cables, concrete loading docks, fuel tanks, and storage drums. In addition natural forces contribute to levee instability – large voids from burrowing beavers, water seepage through voids and permeable strata including backfilled sloughs, and inadequately consolidated zones arising from differential settlement of weak peat foundations. Levee failure results in local destructive flooding of island interiors levees are meant to protect. On a state-wide scale, levee failure(s) have the potential to disrupt of Delta freshwater pumping for the Central Valley Project, which predominantly provides irrigation water to the San Joaquin Valley, and the State Water Project (California Aqueduct) that supplies urban water to 22 million Southern Californians. This scenario could result from an uncontrolled incursion of saline waters from the Pacific Ocean and/or toxic releases of oil and other hazardous materials from damaged Delta infrastructure.

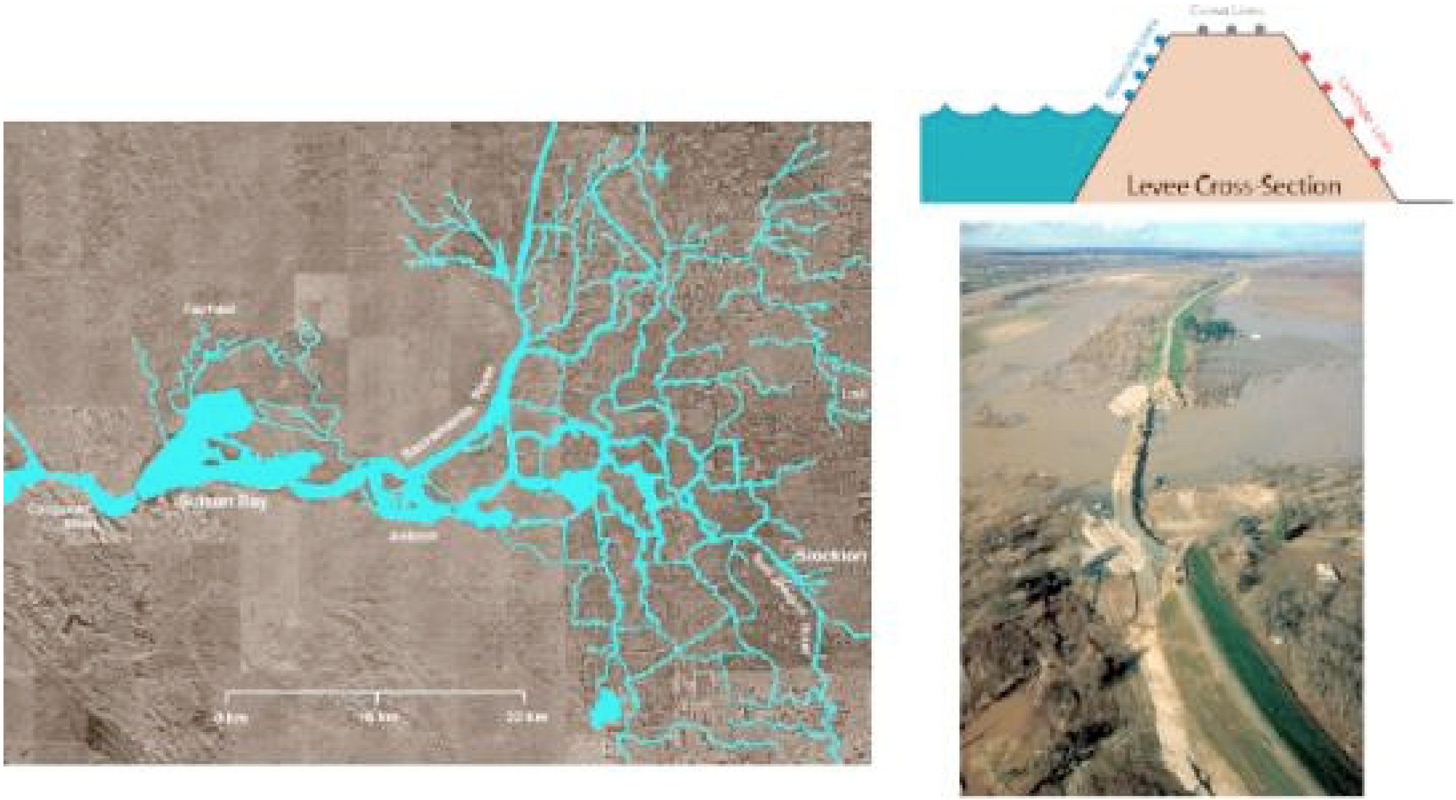

Figure 1. A map showing the extent of the Sacramento-San Joaquin Delta system, a schematic of a levee (land below water level), and a photo of a failed levee.

Argus Technologies (a Tremaine Company) has completed 25 electromagnetic induction surveys on over 300 miles of Delta levees, producing over 1000 miles of data represented by 10s of millions of data points. Over 6000 anomalies have been located and classified using specific objective criteria, and hundreds have been remediated with excavation (see Table 1). Excavation results enable us to challenge assumptions, refine models and continually improve interpretations of the data. As a result, the material producing the anomaly is usually predicted, the location is pinpointed (using GPS-tagged data), the orientation is determined (fully penetrating levee versus waterside, center, or landside), and the depth is estimated. When the client knows what type of hazard exists and where to excavate, the problem can be more efficiently remediated and risk reduced.

Significant progress has also been achieved in software development and in data preparation techniques for advanced modeling. The state of knowledge gained from experience and extensive ground truth is the foundation of a valuable risk analysis toolbox for locating buried hazards in levees. The Buried Hazard Toolbox system can be used to characterize the entire levee system, or tailored to three-dimensional imaging of specific problem areas.

Instrumentation

Argus Technologies has developed the EM^3 to perform mobile, non-invasive underground surveys as shown in Figure 2. This technology is an innovative adaptation of Geonics' conventional hand-held electromagnetic instrumentation. Such instruments have been used successfully in near-surface geophysics and soil studies for decades. The advancements to this base technology include: **1)** mobilizing the instrument on wheels; **2)** combining three receiver-transmitter separations of 1, 2, and 3.67 m for a view of subsurface conditions at successive depths; **3)** increasing data acquisition rates, **4)** simultaneously tagging incoming data with real time kinematic (RTK) GPS X, Y, and Z coordinates with centimeter-level accuracy; and **5)** developing data collection and processing software. The result is an instrument that records bulk measurements to an effective depth of 6 meters (about 20 feet), as it is towed behind an ATV traveling at 5-10 miles per hour.

Figure 2. The EM3 on-site for levee surveys.

The Buried Hazard Toolbox for Levees

Rapid Scoping Tool

Analysis during rapid scoping focuses on high-contrast anomalies, with qualitative interpretation. Using ArcGIS, data are plotted in plan view on topographic maps or aerial photographs using a relative scale that encompasses the entire range of values in a given data set. The data are inspected to locate anomalies that can be explained by known or previously mapped features such as active electric lines and pipes. Those that cannot be explained by known or previously mapped features are noted and classified by anomaly signature to predict possible materials. Figures 3 and 4 provide examples.

Figure 3. Rapid scoping with low apparent conductivity (blue) at the sites of levee repairs, and high apparent conductivity in areas of finer texture and/or higher moisture content.

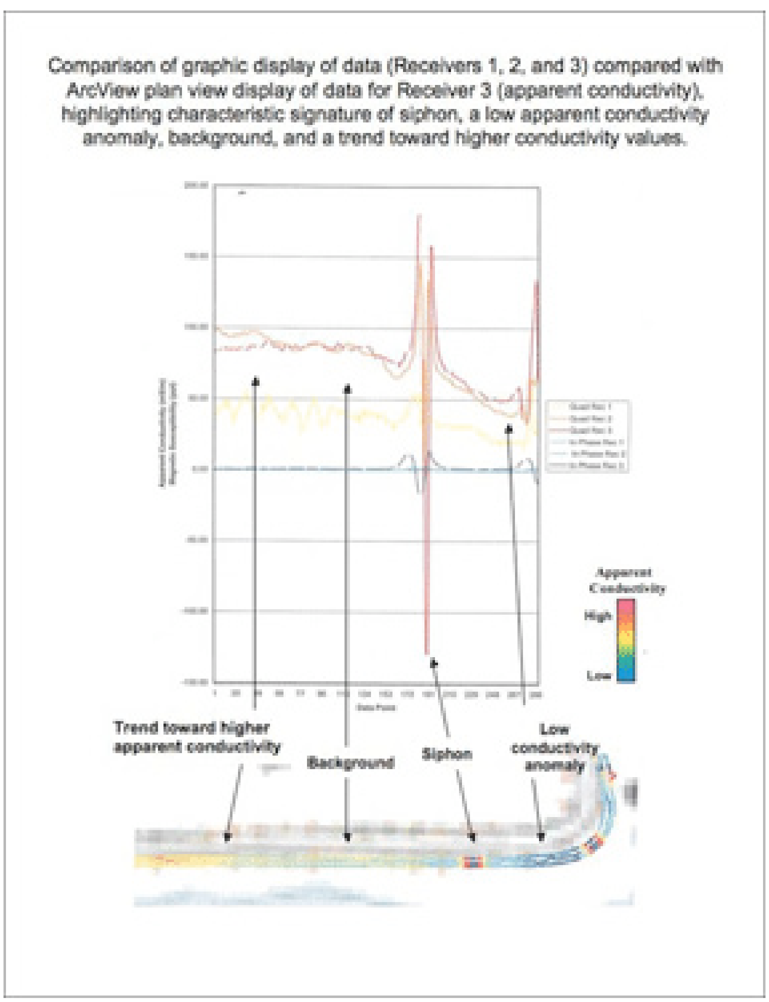

Figure 4. Representative anomaly classification.

Rapid Scoping analysis is most appropriate for landscape-level and for high-contrast targets, where the geophysical response is a gradually varying low conductivity response or an abrupt change in conductivity within a relatively wide range of values, respectively. Anomalies excavated were found to be buried relict pipes and cables, rodent dens, concrete blocks and pads, saturated areas, storage tanks, gross lateral changes in embankment materials, all of which are sources of uncertainty for internal erosion. The complete list can be found in Table 1, while Figures 5 and 6 depicts specific examples.

Table 1. List of identified and remediated anomalies

Backhoe Excavations of 200 Anomalies Found and Remediated
84 Forgotten pipes, diameters one-half to 14 inches
43 Pockets of loose sand or peat
15 Buried cables of various sizes and materials
8 Concrete slabs, walls and/or rubble
8 Metallic debris (auto tire, rebar, trash pits)
6 Rodent (beaver) burrows and dens
3 Electrical conduit
8 Buried fuel tanks, 55 gallon drums, and/or stilling

wells
3 Tree logs and/or roots

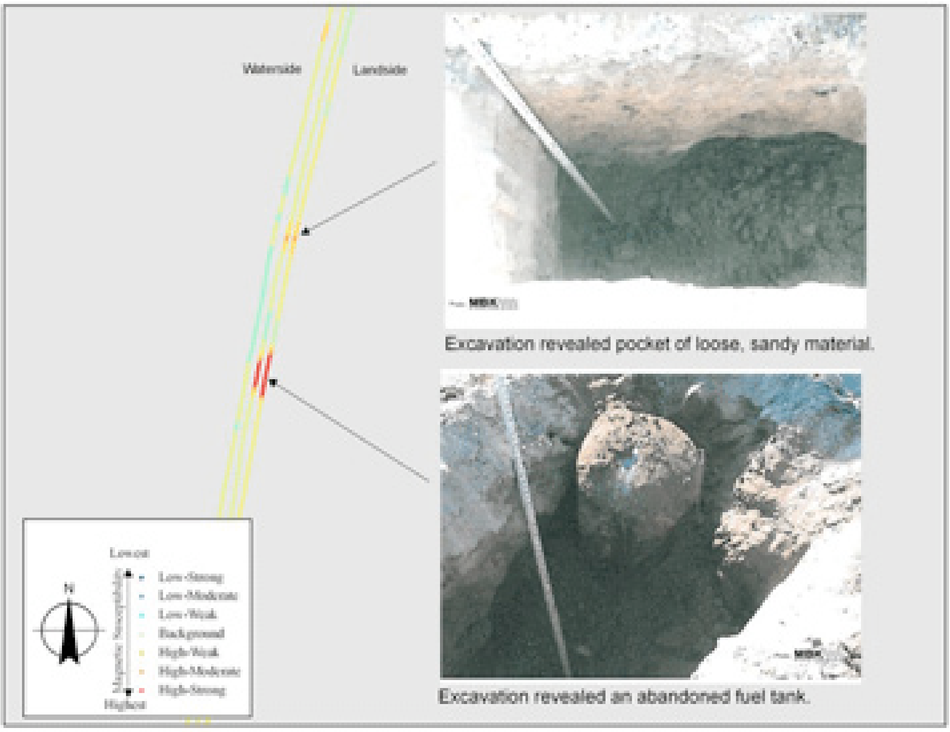

Figure 5. Based on the relative intensity of the anomaly, excavations are efficiently identified to the appropriate side of the levee.

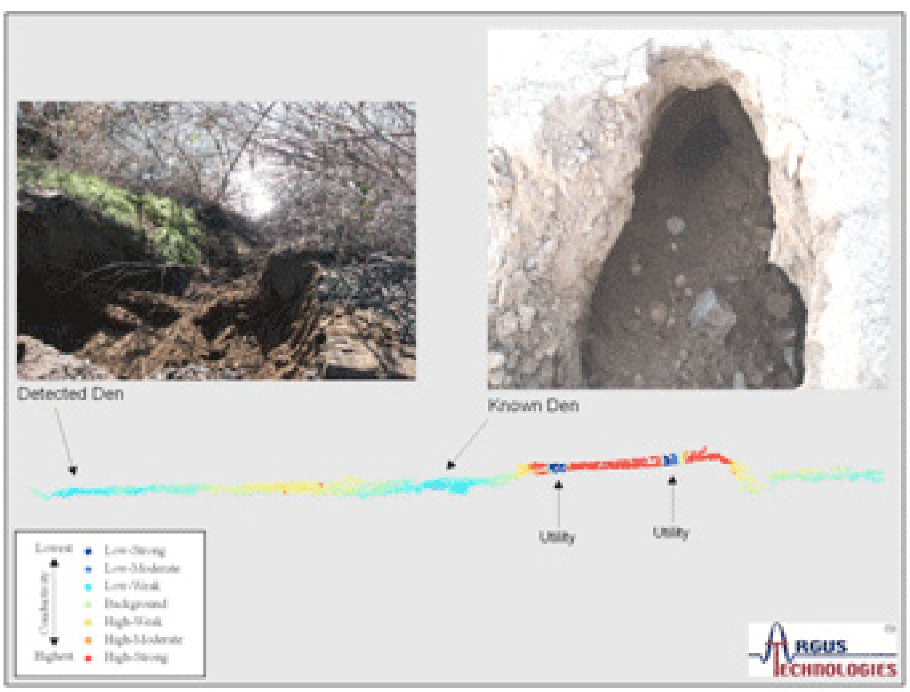

Figure 6. A comprehensive characterization analysis resolved zones of low apparent conductivity that are associated with beaver dens.

Quantitative Analysis

Quadrature and in-phase data, collected at 1-, 2-, and 3.6-meter coil separations, are inverted to locally one-dimensional (1-D) earth models. The horizontal layers vary in conductivity and thickness. Borehole data can be used to constrain the inversion. Geonics EM-34 data can be included in the data set for greater depths of investigation. Data are inverted using the Aarhus Geophysics Workbench (2008). The software, originally designed for airborne electromagnetic data, was customized for the EM^3. The 1-D Laterally Constrained Inversion (LCI) by Auken et al. (2005) is a modification of the mutually constrained inversion of Auken et al. (2001). The LCI method is employed such that locally 1-D models are constrained from sounding to sounding, so that the resulting model varies smoothly over distances prescribed by the user. The 1-D inverse models are used to construct two-dimensional (2-D) conductivity cross sections, and conductivity interval plan view maps at different depths within the section that give a three-dimensional (3-D) view.

A 3-D representation is used to identify various building materials and changes in moisture content within the levee. Results along an area of interest on the Grand Island levee are presented in Figure 7. Data are visualized in a point image format where an average 1-D model is presented as a column, or circle in plan view; the point image is only defined in the points on the map where the underlying geophysical model is defined. The points show the values of the theme as colors at the locations as defined by the theme. In this case the theme is a mean conductivity for layer of one meter starting at z=0, the top of the crown. Other themes might include the depth to a conductor or resistor thereby mapping subsurface topography. Moving from the upper left to the lower right we move down through the levee from 0 to 11 meters below the top of the crown.

The EM^3 is relatively insensitive to resistive values; hence the difference between 4 and 6 mS/m (green to blue) is insignificant. Several features are noted: the top of the crown is relativity homogeneous with conductivity of ~6-8 mS/m (green). With depth >5m below the top of the crown the waterside becomes more resistive with values of 3-5 mS/m (blue-green) and the land side is more conductive (yellow) with values of 10-20 mS/m. The variation in conductivity indicates a change in building material and moisture content. Mapping conductivity values to specific materials requires correlation with borehole data, but we interpret the increased conductivity with depth and from water to land side as an increase in moisture. The NE area, and to a lesser extent the SE, become more conductive reaching values of 50-60 mS/m. The conductive areas correspond to observed seepage on the landside.

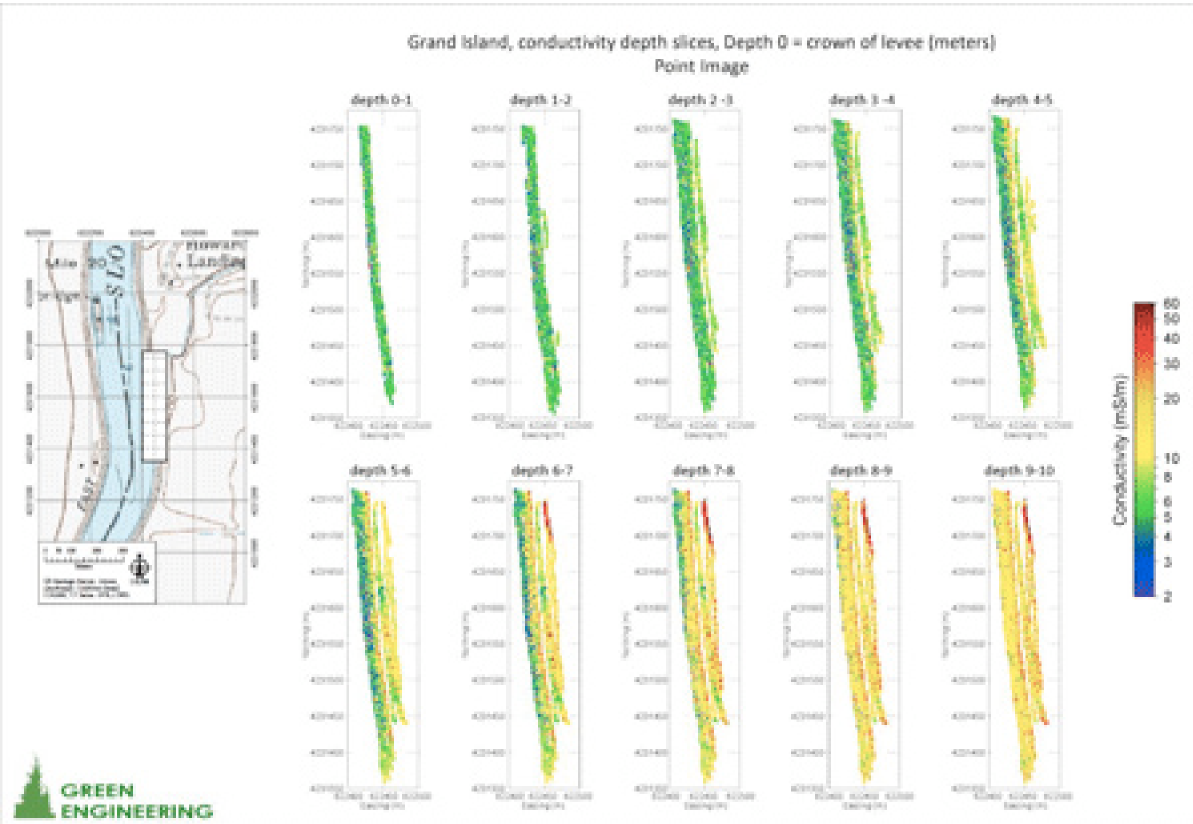

Figure 7. Inverse models of a section of the Grand Island levee at 1 m depth slices. The location map is shown to the left. The model is presented as point images at an average sounding site.

Acknowledgements

This work, supported by the Federal Emergency Management Agency, is a unique cooperative effort among members of the individual Reclamation Districts and their District Engineers, the California Department of Water Resources, Argus Technologies, and Green Engineering. It exemplifies a proactive approach to seek out and remove hazards to improve levee integrity reduce the risk of levee failure.

References

Aarhus Geophysics, 2009, http://www.aarhusgeo.com/

Auken E., Christiansen A.V., Jacobsen B.H., Foged N., and Sørensen K.I., 2005, Piecewise 1D Laterally Constrained Inversion of Resistivity Data: Geophysical Prospecting, **53**, 497-506.

Auken, E., Pellerin, L., and Sørensen, K., 2001, Mutually Constrained Inversion (MCI) of Electrical and Electromagnetic Data: Annual Meeting of the Society of Exploration Geophysics, San Antonio, TX, USA