Earth Consultants International

# Eldon Gath, PG, CEG

**Senior Consultant, President**
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Mr. Gath has 30 years of experience in the identification, investigation, and remediation of geologic hazards involving land use planning, environmental assessments, field exploration and analysis, and presentation of findings. Mr. Gath has particular experience with the evaluation of active faults for construction site planning, the development of seismic safety programs and policies, and the determination of remediation and design alternatives for geologically sound site development. His experience with fault evaluation studies includes investigations on the San Andreas, San Jacinto, Pelican Hill, Peralta Hills, Whittier, Sierra Madre, Springville, Elsinore, Cucamonga, Newport-Inglewood, Malibu Coastal, Palos Verdes, and Santa Monica faults. Mr. Gath has published slip rate studies for the Whittier fault, displacement and recurrence intervals for the Whittier Extension fault, and magnitude, displacement, and slip history of the Springville fault.

Eldon Gath's experience in the translation of geologic and seismic hazards into municipal policy and mitigation spans public agencies, private developers, and research. He was the Principal-in-Charge for the Safety Elements of Los Angeles County, Santa Monica, Burbank, Garden Grove, Rolling Hills, Rolling Hills Estates, Calimesa, Yucca Valley, Chino Hills, Riverside County, and Culver City. He was the Principal-level geologic consultant to the City of Brea for their future city expansion planning. All of these projects involved intense interaction with public and technical review groups, planning commissions, and city councils or county supervisory boards.

Mr. Gath's international experience includes several field projects in Turkey, Mexico, and Panama, plus participation on projects in Japan, Pakistan, Indonesia, Afghanistan, and Honduras. In particular, his projects in Panama on the Pedro Miguel, Miraflores, Gatún, Limón, Azota, and other faults have led to a complete redefinition of the seismotectonic understanding of Panama. He has played a prominent team role in the quantitative determination of the seismic hazard for the Panama Canal Expansion Project, and is the lead geologist for the Program Management Team of the Canal Expansion Program's Locks Design-Build contract.

His experience with geologic investigations and hazard assessments of oil fields includes the Whittier, West Coyote, Olinda, Signal Hill, Mineral Springs, and Puente Hills oil fields. Mr. Gath was invited by the Division of Oil and Gas to be their participant in a DOG, RWQCB, and DHS-sponsored, 1993 workshop on *"Geoenvironmental Issues in the Redevelopment of Abandoned Oil Fields."*

He has represented both private and public parties in the preparation or review of dozens of Environmental Impact Reports for projects covering new freeways, harbor expansions, landfills, large housing developments, water infrastructure, and large commercial/industrial/recreational facilities. For nearly ten years, he was an invited engineering geology member of the Los Angeles County Department of Public Works' *Land Development Technical Advisory Committee,* a policy advisory forum and liaison group between the public and private sectors in planning, permitting, and grading activities within the County.

Mr. Gath has served as a consultant and expert in several large litigation cases. He has served as an expert for defendants in earthquake damage, landslides, and environmental impacts, including

La Conchita Ranch, Laguna Summit, Kerr McGee, Thrifty Oil, City of Yorba Linda, and Chevron. Several of these projects involved claims in excess of $100M. In addition, he has worked on dozens of other consulting assignments that were conducted under attorney-client privilege confidentiality.

He is also heavily involved in professional practice organizations, including the Association of Engineering Geologists (National President-1997, as well as a Southern California Section Chair-1990), the Earthquake Engineering Research Institute (Technology Transfer and Professional Ethics committees), and was the AEG liaison to The National Earthquake Hazard Reduction Program (NEHRP) Coalition. He has given over one hundred presentations before professional and public groups, and has published extensively on a wide range of subjects.

**EDUCATION**

Ph.D. pending in Environmental Health, Science, and Policy, University of California at Irvine, 1998-Present
[Research *Tectonic geomorphology and seismic hazards of Orange County*]
Post-graduate study in Geomorphology, University of California at Riverside, 1993-1996
[Research *Tectonic geomorphology of the southeastern Los Angeles basin*]
Post-graduate study in Engineering Geology, California State at Los Angeles, 1982-1990
[Research *Tectonic geomorphology and neotectonics of the Whittier fault in southern California* ]
B.S. in Geology, University of Minnesota, Institute of Technology, 1978

**PROFESSIONAL CERTIFICATIONS**

Professional Geologist: California, PG 4140, (1986)
Engineering Geologist: California, EG 1292, (1986)

**PROFESSIONAL HISTORY**

President, Earth Consultants International, Tustin, California: 1997-Present
Principal Geologist, Leighton and Associates, Inc., Irvine, California: 1988-1996
Director of Geology, Leighton and Associates, Inc.,
Los Angeles County Office, Diamond Bar, California: 1986-1993
Staff/Senior/Project Geologist, Leighton and Associates, Inc.,
Orange County Office, Irvine, California: 1984-1986
Staff Geologist, Pacific Soils Engineering, Irvine, California: 1980-1984
Field Technician, Irvine Soils Engineering, Irvine, California: 1979-1980
Senior Laboratory Technician, Soil Testing Laboratory,
University of Minnesota, St. Paul, Minnesota: 1977-1979

**PROFESSIONAL AFFILIATIONS**

Association of Engineering Geologists (AEG)
President: 1996-1997
Vice President: 1995-1996
Treasurer: 1993-1995
Southern California Section Chair: 1990-1992

Earthquake Engineering Research Institute (EERI)
Technology Transfer Committee: 1991-1993
Liquefaction Subcommittee Co-chair: 1992-1993
South Coast Geological Society (SCGS)
President: 1987
Geological Society of America (GSA)
International Association of Engineering Geologists (IAEG)
American Geophysical Union (AGU)
Seismological Society of America (SSA)
American Association of Petroleum Geologists (AAPG)
Inland Geological Society (IGS)
San Diego Association of Geologists (SDAG)
Los Angeles Basin Geological Society (LABGS)
Coast Geological Society (CGS)

**COMMITTEE MEMBERSHIPS**

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| National Research Council of the National Academy of Sciences, Committee to Develop a Long-Term Research Agenda for the Network for Earthquake Engineering Simulation (NEES) | 2002 |
| President of the Association of Engineering Geologists | 1996-1997 |
| Board of Directors of Association of Engineering Geologists | 1990, 1991, 1993-1998 |
| Land Development Technical Advisory Committee of the Los Angeles County Department of Public Works | 1991-1999 |
| Technology Transfer Committee of the Earthquake Engineering Research Institute | 1992-1995 |
| Professional Ethics Committee of the Earthquake Engineering Research Institute | 1996-1999 |
| Liaison for Association of Engineering Geologists to Earthquake Engineering Research Institute | 1992-1999 |
| Association of Engineering Geologists representative to The NEHRP Coalition | 1992-1999 |
| Geology Working Group of the Southern California Earthquake Center | 1992-Present |
| Assistant Chairman of Association of Engineering Geologists Annual Meeting | 1992 |
| Field Trip Chairman of South Coast Geological Society | 1984, 1985, 1987 |

**PROJECT EXPERIENCE**

**Project Manager for the preparation of a new Hazard Mitigation Plan [Public Safety Element] for the County of Riverside, California [1999-2001].** The project involved an extensive collection, digitization, and analysis of geologic and cultural data for the entire County of Riverside, an area of over 7,000 square miles (35,000 $km^2$). The data were all compiled into a MapInfo and ArcInfo GIS database for use in hazard abatement planning by the Department of County Planning. All supporting metadata plus discussions as to the data sources, reliability, adequacy, and recommended programs for either current usage or future enhancement were compiled into a large Technical Report entitled *Natural Hazard Mapping, Analysis, and Mitigation*. The main focus of the project was to develop a map-based hazard management and mitigation plan for the County of Riverside to implement over the next twenty years. The final preparation of the Element has involved close coordination and meetings with the County Planning staff, including testimony before the County Planning Commission, and presentations to a select technical review board.

**Principal Geologist and Project Manager for a fault hazard investigation of the northern San Jacinto fault within the Lytle Creek drainage in Rialto to locate the active traces of the fault, and quantify probable displacement magnitudes for bridge structure design [1995].** The purpose of

the study was to quantify the fault rupture hazard of the northern segment of the San Jacinto fault where several new freeway bridge structures are proposed for the I-210 extension in San Bernardino County (Foothill Freeway). The project was two-phased, an air photo and geomorphic analysis to locate evidence for probable active traces of the San Jacinto fault in the area of Lytle Creek, followed by a subsurface trenching investigation across the major bridge locations to screen the area for secondary faults. The project required that the trench excavations be backfilled in conformance with Caltrans design specifications, and the final trenching and compaction report was reviewed by Caltrans.

**Principal Geologist and Project Manager for a geological and geotechnical review and design-level analysis of Phase 2B of ALARKO's Alkent Istanbul 2000, an upscale residential development project in Istanbul, Turkey [2001].** The Alkent Istanbul 2000 project is a master planned residential development and community east of Istanbul, Turkey. Developed by the ALARKO Group, it consists of large single-family homes, plus recreational, commercial, and educational facilities to support a contained and secure community environment. Over 800 homes have already been constructed. ECI was initially retained to provide ALARKO with a second opinion on landslide stability issues for their upcoming Phase 2B development of nearly 100 additional home (villa) sites. Shallow slope failures and landslides extensively impacted the site. The slides were initiated from a perched water condition that had developed within a weathered regolith that was capping a hard shale unit. Following the initial consultation, ECI was requested to complete a design-level geotechnical analysis to develop the construction stabilization requirements and detailed implementation drawings. Because of difficulties in relying on good fill compaction, the stabilization measures relied on pile support for all villas, slopes, and retaining walls. Construction design details were also developed for site dewatering subdrains.

**Principal Geologist and Project Manager for a fault hazard investigation of San Bernardino Valley College to locate the active traces of the San Jacinto fault for campus redevelopment planning [1995-2007].** The San Bernardino Valley College campus in San Bernardino was constructed gradually from the early 1930's to the early 1970's upon an elevated pressure ridge (the Bunker Hill Dike) formed along the San Jacinto fault. As part of an overall campus redevelopment planning, this study was undertaken to quantify the fault rupture hazard through the SBVC. In addition to the threat posed by surface rupture, other secondary seismic impacts were addressed, including liquefaction, shaking amplification, and ground deformation due to folding. The project involved the excavation of eight trenches within the campus area to expose the traces of the San Jacinto fault, completion of ten boreholes to depths of 50-100 feet coupled with nearly 100 cone penetrometer tests, and shear wave velocity profiling of the borings. The trenches revealed that the surface trace of the fault passes through four of the school's buildings. Eight other buildings were determined to be at risk due to secondary ground fracturing or their location across an active surface fold caused by shallow blind thrust faulting.

**Principal Investigator to identify and quantify active seismic sources in the Eastern Los Angeles Basin using tectonic geomorphic mapping [2003-2006].** The study was funded by the U.S. Geological Survey under the National Earthquake Hazard Reduction Program to compile geomorphic indicators of active tectonics in the area of the eastern Puente Hills, Chino Hills, and northern Santa Ana Mountains. By identifying and mapping fluvial terraces in the Puente Hills and Santa Ana Mountains, uplift rates were calculated for both topographic features. OSL age dating, combined with soil stratigraphy and radiocarbon, provided age control. The study results were compiled into a Technical Report submitted to the U.S. Geological Survey and included into the Southern California Earthquake Center's Community Fault Model.

**Principal in Charge for the preparation of a FEMA-funded education and outreach pamphlet on Unreinforced Masonry Building Hazard Mitigation for Local Building Officials [2007-2008].** Under contract to the Applied Technology Council (ATC), and with funding from FEMA, Earth Consultants International prepared an illustrated pamphlet detailing the hazards of Unreinforced Masonry Buildings (URM), steps to take for a community vulnerability assessment, and a range of mitigation alternatives to improve community economic stability and public safety. Entitled *"Unreinforced Masonry Buildings: Don't Play the Odds - Protect Your Community from Earthquake Catastrophes - A Guide for Officials and Others Concerned About Earthquake Safety",* the 12-page booklet is well illustrated with numerous photos, drawings, and tables. Now in final editorial review by ATC and FEMA, the booklet is due to be released nationally in early 2009.

**Project Manager for the preparation of a new Hazard Mitigation Plan [Seismic and Safety Element] for the County of Los Angeles [1988-1992].** The project necessitated the collection, collation, and analysis of geologic and cultural data for the entire County of Los Angeles, an area of over 4,000 square miles. The data was transcribed onto eight separate 1:100,000-scale overlay sheets for use in hazard abatement analysis by the Department of Regional Planning. All supporting technical data and discussions as to the data sources, reliability, adequacy, and recommended programs for either current usage or future enhancement were compiled into a 430 page Technical Report *"Hazard Reduction in Los Angeles County"*. In addition to the extensive data collection effort, the main focus of the project was to develop the Goals, Policies, and Programs for Los Angeles County to implement as part of their Five Year Seismic Hazards Reduction Program. The final preparation of the Element involved close coordination and meetings with the County Planning staff, including testimony before the County Planning Commission, several local public hearings, presentations to civic groups, and County Board of Supervisors' presentations prior to final adoption. The project was awarded the 1991 Distinguished Service Award by the National Association of Counties.

**Principal Geologist and technical reviewer of the Hazard Mitigation Plans [Safety Elements] for the cities of Rolling Hills and Rolling Hills Estates [1992].** The Rolling Hills and Rolling Hills Estates Safety Elements focused on landslide management and prevention programs. As part of this management plan, development standards, geological investigations, and water-related issues were identified as requiring the most attention within the city. Following the mapping compilation of all known landslides within the two cities, the landslide susceptibility map was combined with relevant mitigation alternatives and presented to city council. The Safety Elements that were prepared were both adopted into the respective city's General Plan.

**Principal Geologist and technical reviewer of the Hazard Mitigation Technical Report to the Safety Elements for the cities of Burbank, and Culver City [1992].** The Burbank and Culver City Safety Elements were oriented towards mitigating the impacts of earthquakes and ground failure, through pre-development site investigations and post-earthquake emergency response planning. Both cities are traversed by active faults, the Verdugo and Newport-Inglewood faults respectively. Both cities have large areas potentially susceptible to earthquake-induced liquefaction and slope failures. Burbank and Culver both must deal with the potential for flooding and inundation. Numerous mitigation strategies were suggested for each city to use in developing their hazard reduction plans. The Planning Departments of each city used the technical information collected to prepare their own Safety Elements.

**Principal Geologist and Project Manager for the revision and updating of the Santa Monica**

**Hazard Mitigation Plan (Safety Element) [1994-1995].** The project involved a very close working relationship with several city departments, including engineering, planning, emergency services, and fire, to incorporate the current efforts of the City into the action programs of the new Safety Element. The study also resulted in the relocation and reclassification of the Santa Monica fault as an active seismic hazard. However, because of our association with the Southern California Earthquake Center, the City Council and planning staff were fully apprised of this new earthquake threat, two weeks before the SCEC press release on the Santa Monica fault was issued. During the Safety Element review period, the M6.7 Northridge earthquake occurred, causing extensive structural damage in the city. At city request, we served as information sources for displaced citizens at a public information meeting immediately after the earthquake, and provided guidance and recommendations to city emergency response officials.

**Principal Geologist and Consultant to the City of Brea for their Vision Building project in planning a 7,000-acre expansion to the City [1993-1994].** The Sphere of Influence expansion area includes the active Whittier fault, several hundred landslides and oil wells, thousands of cubic yards of non-engineered earth fill, and large zones of active crude oil seepage (*brea*). The purpose of the project was to involve the citizens of Brea, the property owners, potential land developers, oil field representatives, and a selected team of consultants (Core Team) in an intimate design process to master plan the future of Brea, involving field trips, weekend design charettes, and weekly meetings.

**Project Investigator to develop the geologic evaluation criteria for 56 alternative alignment segments of a proposed 32-mile freeway project [Foothill Transportation Corridor] in Orange County, California [1984].** The project necessitated a review of existing geologic data, a field reconnaissance of all 170 miles of the alternative alignments, GIS computation of all collected data, and preparation of a geologic evaluation matrix for incorporation into the complete EIR document. Project was presented to the Orange County Board of Supervisors, the preferred alignment was selected, and detailed site investigations and initial construction is proceeding.

**Instructor at the Red Cross Emergency Manager Training Academy [2001 & 2005].** Participated as the leader of several training modules in the Red Cross and Emergency Management Agency's annual Disaster Management Training Academy. In 2001, we prepared materials and conducted a daylong workshop on ***Natural Hazard Mitigation and Management Before the Disaster—an Assessment of the Available Options***. In 2005, we again participated as trainers, conducting workshops on 1) ***What Do We Have To Fear? A quantitative analysis of three earthquake scenarios on Orange County,*** 2) ***Natural Hazard Identification, Impact Analysis, and Risk Assessment for Disaster Mitigation Planning,*** and 3) ***The Effect of Geology on the Southern California Landscape.*** All of the training workshops were attended by emergency management responders, including police, fire department, city officials, and non-governmental organizations. The project included preparation of workshop manuals, handouts and lecture materials, making presentations and facilitating workshop discussions, and serving as a technical resource to workshop participants.

**Convener and Organizer of an Education and Outreach Workshop for the California State Legislature on Earthquake Hazards of California [1995].** In support of a Public and Government Awareness program, the Education and Outreach Program of the Southern California Earthquake Center retained us to organize, advertise, and conduct a state of the knowledge earthquake hazards seminar specifically directed at the members, and staff, of the California State Legislature. ***Bringing earthquake risk to the California State Legislature: an earthquake hazards seminar that***

***involves the decision and policy makers of the State of California*** was the result of that effort. The seminar brought together the leading researchers and practitioners on active faults across the entire state of California for a full day of technical presentations, culminated by a far reaching panel discussion session that dealt with future-oriented issues like earthquake prediction, earthquake probabilities, damage and loss estimates, legislative priorities, and certainty and uncertainty. The project solicited speakers and panel members, advertised the program to the legislative staff, met with legislative staff to increase awareness, prepared several presentations on various active faults, prepared and sent out several meeting announcement mailers, organized the various talks and discussion sessions, prepared and printed an expanded abstract program, moderated the program, sent out follow up news briefs and press releases, and prepared a summary report for the Southern California Earthquake Center.

**Field Geologist for the 10,000-acre Ahmanson Ranch in Ventura County, California for the purpose of site characterization prior to ultimate land use decision making [1983].** The project resulted in a series of maps presenting geologic hazards and conditions for planning evaluation. Follow up subsurface studies were instrumental in documenting that a portion of the site would be suitable for a Class II landfill, and that extensive slope stability problems would economically prohibit a desired low density development of the southern half of the ranch.

**Principal Investigator for a detailed geologic study of the Whittier fault in Los Angeles and Orange Counties to determine slip rates and recurrence intervals for large earthquakes [1992].** The study was funded by the U.S. Geological Survey under the National Earthquake Hazard Reduction Program. Thirty miles of the fault between the Santa Ana River and the San Gabriel River were mapped using air photos to identify tectonic geomorphic features indicative of the most recently active traces of the fault. A detailed three-dimensional paleoseismic trenching study was completed which allowed calculation of the fault's slip rate and slip history. The study results were compiled into a Technical Report submitted to the U.S. Geological Survey. Based on the results of this research, the California Division of Mines and Geology created an Alquist-Priolo zone map for the La Habra quadrangle.

**Principal Investigator to determine the activity and fault kinematics of the northern extension zone of the Whittier fault, in the epicentral region of the 1987 Whittier Narrows earthquake [1994].** This research project involved three dimensional trench excavations and detailed paleoseismic logging to define both lateral and vertical slip on the northwest trending Alhambra Wash fault. The fault lies within the step-over zone where the Whittier fault transitions into the Elysian Park-Monterey Park anticlinorium set of faults. The study began with a detailed aerial photographic reconnaissance to map the potential fault features, and to select optimal trenching sites. The fault was excavated in three dimensions to directly measure the lateral and vertical slip components. Preliminary results indicate recurrent displacements of fault-crossing late Pleistocene stream channels as older units are displaced increasingly larger amounts. The fault is dominantly right lateral with a down to the east component. The study was funded by the Southern California Earthquake Center as part of its mission to quantify and model the seismic risk within the Los Angeles basin.

**Principal Geologist and Project Manager for development of the seismic design parameters for San Bernardino Valley College [2001].** San Bernardino Valley College lies directly on the active San Jacinto fault. As part of the campus-wide redevelopment planning study, ECI was contracted to update the prior seismic design values to account for new code changes that were effective since 1997. In particular, the DSA was concerned about near-fault effects due to a large San

Jacinto fault earthquake. ECI evaluated several fault rupture scenarios for both the San Jacinto and San Andreas faults and produced a design-level report that included probabilistic and deterministic analysis of peak ground accelerations, response spectra, time histories, site and sediment amplification factors, displacement pulse velocities, and permanent deformation analysis. The resultant report was approved by DSA and CGS.

**Principal Geologist and Project Manager for a third-party review and subsurface investigation of a potential landslide hazard under the new business building at Crafton Hills College in Yucaipa, California [2001].** ECI was retained by the Crafton Hills College administration to review geologic reports and data they had received indicating the presence of a landslide under the site of their newly proposed business building. After reviewing all of the materials, and visiting the site, a testing protocol investigation was developed and recommended to the administration. This testing program consisted of two trench excavations that were positioned in key locations to confirm or refute the existence of the proposed landslide. Based on the exposures in the trenches, and a review by the prior consultants and city geologists, everyone agreed that no landslide existed at the site. ECI's documentation report removing the landslide from the map was approved by DSA.

**Principal Geologist for a geologic hazard investigation of Crafton Hills College in Yucaipa, CA, for campus redevelopment planning [2004-2005].** San Bernardino Community College District retained Earth Consultants International to review the geologic constraints and hazards to their proposed campus-wide redevelopment planning project. ECI geologists reviewed and compiled all available geotechnical reports and published geologic materials relevant to the campus area, geologically mapped the entire campus property, and produced a geologic constraints map for use in the initial planning period. The analysis determined that landslides were not a significant planning constraint, but that mud and debris flows were a hazard that needed to be considered in land use planning. Additionally, two splays of the active Crafton Hills fault zone trended into the campus, and could adversely affect several potential building site areas. A supplemental trenching study was authorized to quantify the fault constraint. This investigation is underway.

**Principal Geologist for stormwater erosion damage assessment, repair, and mitigation planning at Rio Hondo College, Los Angeles County, California [1999].** The storms of late 1998 and early 1999 caused extensive flooding, erosion and damage at Rio Hondo College on the western tip of the Puente Hills. ECI was retained by the college maintenance department to assist in damage assessment, and to develop repair options for three of the most critical locations on the northern perimeter road. French drains, deflection walls, freeboard extensions, detention basins, and drainage rerouting solutions were all discussed with college officials, and the most cost effective solutions were selected for implementation. A campus-wide stormwater management plan was requested and a proposal was developed, but it was never implemented.

**Principal Geologist for a detailed fault hazard assessment of the 700-acre West Coyote Hills oil field into a master planned residential community for Chevron Land and Development [1994-1997].** The site is a young anticlinal uplift in the eastern Los Angeles Basin, immediately south of the Whittier fault. Due to the extensional tectonics of the uplifting fold, numerous secondary faults were created. The occurrence of a minor ground rupture along one of these small faults in 1968 prompted the State to include that fault in an Alquist-Priolo Special Studies Zone. For future development planning, other secondary faults within the development area were investigated as to their structural style, recency of activity, and risk to the development. A tectonic model of the area was developed to better characterize the pattern of faulting, and to enhance future risk predictive capabilities.

**Program Manager for the site characterization and construction of 200+ permanent Global Positioning Satellite (GPS) receiver monuments for JPL [1998-2004].** As the construction contractor to the Southern California Integrated GPS Network (SCIGN), 200 permanent GPS receiver stations were sited, geologically characterized for stability, and constructed using the Wyatt-type braced monument. The entire program spanned ten southern California counties, received three scope increases, took three years, and involved a budget of over $4 million. Intensive scheduling and coordination was required between SCIGN's site selection review group, the geological site review team of Earth Consultants Int., the construction contractor Gradient Engineering, and the drilling contractor APEX. Depending upon the site conditions, either a hollow stem auger or an air percussion rotary drill rig was used.

**Project Geologist for fault hazard investigations within the Santa Fe Energy Olinda oil field in Brea [1994-1999].** The purpose of the studies were to comply with the provisions of the Alquist-Priolo Act by locating the Whittier fault and providing minimum setback limits to future development. The studies were phased as the development planning progressed, and ultimately involved logging over 50 trenches and road cut exposures within the 220-acre site. The fault locations were used by the site planner to adjust the final design grades in such a way as to minimize the impact of the fault and fault setback zones.

**Principal Geologist for fault hazard investigations at the proposed Rancho San Andreas development project, Highlands Area, San Bernardino, California [2002].** ECI was retained by the Highland Hills Development Company to take over the fault hazards and constraints investigation for a 700 acre development project in the San Bernardino Mountain southern foothills. The site is bisected by the northern and southern strands of the San Andreas fault. Prior geological investigations of the faults were considered inadequate for development planning by the regulatory reviewer. ECI exhumed selected portions of the prior trenches to QA/QC the previous work, and ultimately completed excavation and geological logging of 23 new trenches and over 2600 linear feet of new trench when the prior fault locations could not be confirmed. Appropriate fault setbacks were proposed, a new development plan was created by the site planner, and our report was approved by the regulator.

**Project Manager/Director for the development of Fullerton Road through the Puente Hills of Los Angeles County [1990-1991].** Detailed subsurface investigations were undertaken, several proposed alignments were reviewed, and remedial grading quantities calculated for each alignment. Massive landslides and generally weak bedrock materials were common along the entire project, and two active segments of the Whittier fault crossed the alignment corridor. The project involved the excavation of over 12-million cubic yards of material to achieve final road grades. Close planning and interface was a requirement of the County of Los Angeles Department of Public Works. Meetings were held with the District Supervisor, Pete Schabarum, to keep him apprised of the project's progress.

**Principal Geologist for an earthquake risk assessment of the AKSA Fabrication Facility in Yalova, Turkey [2000].** The AKSA petrochemical plastic fabrication facility sits on the Yalova Delta in the Marmara Sea. It suffered considerable damage in the August, 1999 earthquake, including delta front slippage, amplified ground shaking, secondary fault rupture, lateral spreading, and liquefaction. Earth Consultants International was retained to provide a seismic hazard assessment to AKSA for the potential impacts of future earthquakes in the Marmara Sea region. Using a combination of trenching, borings, and cone penetrometer (CPT) probes, we were able to

geologically characterize the deltaic area into relative hazard zones for ground failure. The project was completed in partnership with geotechnical engineers from Istanbul Technical University.

**Principal Geologist for a 450-acre hillside development project within the Puente Hills for Shea Homes [1988-1993].** The project took over five years in the conceptual planning and design stages before final construction began in 1988. Extensive meetings and interaction with the County of Los Angeles was required due to the construction of two miles of Fullerton Road and one mile of Pathfinder Road, both under the review of the Department of Public Works. Numerous large landslides were investigated and analyzed for design buttresses, a 170-foot deep fill was placed into an offsite canyon and monitored for secondary consolidation, and debris flow basins were sized and constructed within three drainages entering the site. The site was a former Shell oil field, necessitating the consideration of contaminated soils and the reabandonment of 12 oil wells. An interstate aviation fuel pipeline was relocated due to the grading, and the relocation plan was reviewed for geotechnical impacts. During canyon cleanout operations for Fullerton Road, both the north and south traces of the Whittier fault were exposed, and charcoal samples from the faulted alluvial sediments were sent for radiocarbon dating to provide valuable technical data on the slip history of the fault.

**Principal Geologist for the planning and redevelopment of the Signal Hill oil field into a master planned residential community, within the Newport-Inglewood fault zone.** The project commenced with a thorough data review of the site, followed by subsurface trenching to locate the active strands of the Newport-Inglewood fault system as required by the Alquist-Priolo Act. The Cherry Hill fault and Northeast Flank faults were located and provisional structural setbacks were developed. Extensive geotechnical issues were encountered, including hydrocarbon contaminated soils, thick oil field fills, existing production infrastructure, and adjacent development. Detailed design investigations, and construction mapping, observation, and testing services were provided throughout the phasing of the development.

**Project Geologist and Manager for a fault hazard reassessment of the Sierra Madre fault through the proposed La Viná development of Southwest Diversified in the San Gabriel Mountains north of Altadena.** The project involved the excavation of 15 trenches across the mapped trace of the Sierra Madre fault. Dr's. Thomas Rockwell, Kerry Sieh, and Charlie Ruben of the Southern California Earthquake Center were retained to review the trench exposures and conclusions of the investigation. Based upon sedimentary unit relationships and relative rates of soil development exposed in the trench excavations, the fault was determined to be inactive for at least the last 12-15,000 years and, therefore, does not pose physical development constraints. The study findings were successfully presented before the Los Angeles County Planning Commission and the Board of Supervisors.

**Project Geologist for a detailed fault investigation of the western end of the Las Posas Hills in Camarillo into a master planned residential community for the Spanish Hills Development Company.** The development site has been elevated above the Ventura Basin by the active Springville fault, which has also created numerous smaller secondary faults trending through the proposed development. Utilizing two 30-foot deep trench excavations, the study successfully located the Springville fault, and characterized the frequency and magnitude of activity. Based upon over 30 additional trenches, all but three of the secondary faults were determined to be inactive by use of fault zone mechanics. Development setback zones were provided for the active faults, and, by working closely with the site planners and engineers, a safe and viable land development plan was obtained.

**Principal Geologist for a geological constraints investigation for Nuevo (Torch) Energy's Stearns Lease [Unocal] oil field in Brea, California for the purpose of site characterization prior to land use planning.** This 700-acre oil field was being reviewed for residential land development opportunities. As one piece of the planning process, the project resulted in a series of maps presenting geologic hazards and conditions for planning evaluation. Follow up subsurface studies were instrumental in documenting that the active traces of the Whittier fault were confined to the extreme northeastern corner of the property, and that the mapped faults through the central portions of the field were inactive under Alquist-Priolo Act residential design criteria. The site has been extensively modified by oil production activities. Uncompacted fills were mapped, unstable or oversteepened slopes were identified, naturally occurring oil seeps were mapped, and mitigation measures were identified for the conditions.

**Principal Geologist for a geological constraints investigation for Murdock Development's Yorba Linda properties for the purpose of site characterization prior to land use planning.** This 1000-acre series of properties were being reviewed for residential land development opportunities. The Planning Center recognized the early importance of a geological constraints map for this property due to the ruggedness of the landscape, and due to the presence of an Alquist-Priolo Earthquake Fault Zone (Whittier fault) through the property. Using only historical aerial photographs, published and unpublished geological maps, geotechnical consulting reports for adjacent properties, and onsite geological field mapping, the project produced a map that presented the geologic hazards and conditions for planning consideration. The properties evaluated contain approximately thirty landslides, high unstable and oversteepened slopes, oil production activities, uncompacted fills, the active Whittier fault, and active utility easements (high-voltage transmission lines, trunk natural gas lines, Diemer main water line, and oil transportation lines). Follow up analytical studies resulted in a ballpark remedial quantity (yardage) estimate to apply towards planning alternatives analysis.

**Project Manager for a 4-parcel, 2,300-acre residential development in the south Corona area for Devere Anderson Enterprises.** The project lies within the active Elsinore fault zone, and has severe development planning constraints due to faulting and massive landsliding. Extensive trenching studies were completed to locate the active traces of the fault, resulting in structural setbacks from six fault segments, and a determination that six other faults could be considered as inactive and pose no significant design constraints. The project is in the conceptual design stage, with design being based upon a geologic constraints and opportunities map prepared following the geotechnical investigation.

**Project Geologist for a seismic risk evaluation of the New Madrid fault at a Department of Energy-regulated uranium ore processing facility in Metropolis, Illinois.** The investigation's probabilistic risk assessment, created smoothed site response spectra for differing risk levels, and assessed the probable structural performance of the facilities under the modeled seismic loading. Subsequent phases of the project involved the detailed structural retrofit of the facilities.

**Project Geologist of the geotechnical investigation for design of new wharf and pile structures for Berths 88-96 at Pier A, Port of Long Beach.** The project used 12 land and 7 offshore borings to correlate subsurface sediment strata for dredge borrow quantities, subsidence prediction, and liquefaction analysis. Probabilistic seismic design parameters were developed for dike and pile design based on the new slip rates for the Palos Verdes Hills fault.

**Project Geologist and Manager for a feasibility investigation to review mitigation options for active crude oil seeps (tar) and methane generation within the Santa Fe Energy Olinda oil field in Brea.** The purpose of the study was to provide the land developer with preliminary remediation and/or planning alternatives for development within a site heavily impacted by naturally occurring surface oil seeps. The project focused on mapping the limits of the naturally occurring tar deposits, and identifying the structural geologic conditions within which the oil seeps are occurring. The volume of methane being produced was investigated with three gas collection boreholes. Several preliminary mitigation measures were outlined.

**Project Manager for a 350-acre hillside residential development in the Puente Hills for The Lusk Company.** The project had been in the tentative tract design stage for six years, with numerous plan revisions developed to finally achieve a viable development concept. A detailed subsurface investigation involving nearly 50 borings and 100 trenches was completed, followed by comprehensive geotechnical analysis of the 20 onsite landslides and proposed cut slope stability, and summarized into a cost benefit analysis of the various development alternatives. The design modifications have necessitated regular working meetings between the consultant team, and several meetings with the County of Los Angeles Planning Commission. Major design efforts and innovative geotechnical remedial solutions were required to preserve historical oak trees at several localities on the site.

**Project Geologist for a 700-acre residential development project by Hon Development in the Laguna Niguel area of southern Orange County.** This large hillside parcel was investigated for both active faults and large landslide constraints. Three very large perimeter landslides were studied to determine their impact upon the proposed upslope development, and the impact of the future development on the landslide stability. Of particular concern was the reactivation of one of the landslides due to the presence of nearly 100 existing homes constructed on the landslide without prior recognition or stabilization of the slide. To isolate the proposed development from the slide and to increase the in situ stability of the residual slide mass, a 190-foot deep by 1,000-foot long shear key was constructed, an elaborate subdrainage system was designed, and several land use plans were reviewed. The project was mass graded into smaller tracts, involving over two years of earthwork and the moving and compacting of nearly 20 million cubic yards of earth fill.

**Project Geologist for a geotechnical investigation and planning study to rehabilitate and develop a shale slag quarry in the Chino Hills.** The site was a former burnt (expanded) shale facility where the bedrock shales were quarried, baked, and processed as lightweight aggregate materials. After approximately 15 years of operation, the facility was closed and the site abandoned. As part of the redevelopment study, the site was explored using borehole and trench excavations, field geologic mapping of bedrock outcrops and mine waste and debris, and depths to ground water mapped as part of a feasibility study for onsite sewage disposal. Based upon the investigation, a land use plan was developed, and recommendations for the remediation of the developable portions of the site were presented.

**Principal Geologic Consultant for a technical review of the Toland Canyon Landfill near Santa Paula, in Ventura County.** The purpose of the study was to complete a third-party technical review of the geologic issues at the Toland Canyon Landfill in Ventura County. The review focused on the issue of active faulting, seismic design, and groundwater monitoring and slope stability. The initial review stimulated the RWQCB to require the landfill operator to undertake extensive new investigations designed to address the age of faulting across the landfill footprint. The new trenching results were reviewed and discussed in the field with all interested parties, which led to

additional focused investigations to address newly uncovered faulting issues. The review was instrumental in stimulating these new studies by generating enhanced regulatory appreciation of the issues, and also led to the development of different, more appropriate, design measures to mitigate the site's geologic conditions for safe landfill operation.

**Field Geologist for the feasibility and design investigations of a proposed Class 2 landfill in the Verdugo Mountains of Los Angeles County.** The project involved detailed field mapping of bedrock units, structural features, joint patterns, and ground water seeps. The study included packer permeability testing of boreholes, fault trenching and activity characterization, water sampling and laboratory testing, rock evaluation for cover material, seismicity assessment from the Verdugo and La Tuna Canyon faults, and design and quantification of clay liner material needs. The site was feasible from a geologic perspective, however, access limitations, site hydrology, and neighborhood opposition combined to terminate the siting study.

**Project Manager for the preparation of the geology, environmental, and geotechnical engineering sections of an EIR/EIS for the Ports of Long Beach and Los Angeles 2020 Plan.** The proposed 2020 Plan would result in the expansion of the two port facilities by approximately 1,500 additional acres of new dredged landfill area. The project was particularly sensitive due to the potential presence of toxic materials within the harbor bottom sediments that were to provide the majority of the landfill materials. The EIR/EIS evaluated the conditions, the impacts, and the alternatives both avoidable and unavoidable. Four different expansion alternative concepts were evaluated, including the no project alternative. The findings of the EIR/EIS were instrumental in focusing the awareness of harbor officials onto the issue of seismic risk from an active fault [Palos Verdes Hills fault] causing surface rupture or deformation of the new landfill area, and onto the new issue of a "blind" fault underlying the entire harbor area [Torrance-Wilmington fault].

**Principal Geologist for the geologic, soils, and hydrologic portions of an EIR/EIS on the Firestone Boy Scout Reservation in Los Angeles County, California.** Proposed land uses evaluated included two golf courses, a resort hotel complex, a perimeter cluster of medium rise condominiums, and a sprawling equestrian complex. Several large landslides were determined to be present on the margins of the project, alternative land uses and mitigation alternatives were discussed. The primary consideration for analysis was the preservation of the Tonner Canyon drainage and habitat. This ecological preserve was an important wildlife area. Specific mitigation measures developed that would accommodate the ecology, while simultaneously resulting in adequate levels of slope stability.

**Project Manager for the geotechnical portion of the EIR for the proposed Ascot Sports Complex in eastern Los Angeles.** The facility included several mixed-sport fields, an indoor complex, and an extensive amount of earthwork to achieve design grades. Abandoned oil wells and slope stability were the two dominant geotechnical impacts to the project. Although the geological conditions of the site were favorable for the proposed project, political and financial interests combined to relocate the project to an alternative site.

**Project Manager for the geotechnical portion of the EIR for the proposed Powder Canyon Golf Course facility and private residential community in the La Habra Heights portion of the Puente Hills, Los Angeles County.** The project involved moving over 10 million cubic yards of earth to achieve design grades. The dominant geotechnical impacts to the project were landslide mitigation and risk to offsite properties, deep fill subsidence, and the activity of faults throughout the project. Design alternatives were developed to avoid two very large (>1M $m^3$) landslides, but still achieve

the desired golf course, clubhouse, meeting facilities, and residential housing.

**Project Geologist and Manager for a planning study of 200 acres in preparing the Malibu Civic Center Specific Plan.** The project area contained severe constraints from the Malibu Coastal fault, shallow ground water, earthquake induced liquefaction, and wastewater disposal. To evaluate the impact of the fault, 80 cone penetrometer (CPT) and 5 continuous core borings were emplaced, and stratigraphic units correlated between the borings. The project involved presentation and discussion of findings at three public workshops and several General Plan Task Force meetings. The project also comprised technical consultants for Planning, Civil, Biology, Traffic, and Economics all working towards a comprehensive, mixed-use development plan for a "downtown" Malibu; a plan that incorporated site constraints and public input into a viable town center. The study was able to document that the mapped fault was an older structure, and posed no impacts to the proposed land plan. These findings were presented to the California Division of Mines and Geology for their use in defining Alquist-Priolo Special Study Zones for the Malibu Coast fault.

**Project Manager for the geotechnical investigation and land planning constraints of the 800-acre La Conchita Ranch in the coastal area of northern Ventura County.** The La Conchita Ranch was impacted by severe landsliding problems involving an elevated 500-foot high coastal bluff, with occupied residences at the toe of the slide. The ranch was further affected by large-scale landsliding in the higher reaches of the property, the active Red Mountain fault, extensive erosion and mud flow problems, and severe drainage incision resulting in near-vertical 300-foot high channel walls. The scope of the study was phased to investigate those geologic issues posing the highest risk (both public safety and economic) to the planning process. Remedial recommendations were developed for arroyo side-slope stability, access road alignments, debris flow protection, fault setbacks, landslide dewatering, and landuse planning.

**Principal Geologist and Project Manager for a fault investigation of the Malibu Coast Fault across Winter Mesa, Malibu.** The Malibu Coast fault on Winter Mesa was investigated to confirm the active nature of the fault and to develop residential development setbacks away from the fault. Three deep trenches were excavated across previously mapped traces of the fault zone. Unlike prior studies, we were able to definitively show that the faults previously interpreted to be active, were actually inactive under State development laws. The principal fault was investigated in greater detail and it was determined that the last event (dated using the optically stimulated luminescence technique) was a 14,000 year old liquefaction event, not surface fault rupture. After extensive review, the City of Malibu geologists agreed with this determination. A petition was made to the California Geological Survey to remove the Alquist-Priolo Earthquake Fault Zone from this fault zone.

**Principal Geologist and Project Manager for the geologic assessment of land planning constraints for the 1100 acre Whittier oil field in the westernmost Puente Hills of Los Angeles County.** The Whittier oil field includes several land development planning constraints, including the active Whittier fault, a 160-acre landslide, 350 oil wells and associated sumps, infrastructure, and non-engineered cuts and fills. The project involved a general background and air photo review, geologic mapping, and numerous team planning meetings to best incorporate the site's existing geotechnical constraints into the future use options. During the course of the planning efforts Chevron was actively engaged in well abandonment and limited environmental assessment. Data and geologic exposures created by these activities were included in the land planning analysis.

**Expert Geologic Consultant on a landslide litigation case in the Savage Canyon portion of the**

**Whittier oil field in eastern Los Angeles County.** During the course of construction excavation for expansion of the City of Whittier's Savage Canyon landfill, adverse geologic conditions resulted in the failure of the canyon slope. The landslide grew to include one oil well and enlargement endangered several other wells, plus pipelines and access roads. In an emergency mode to attempt to predict the maximum growth dimensions of the landslide, six borings were excavated around the perimeter, the region was geologically mapped, cross sections were prepared and analyzed, and a map was prepared to guide oil field personnel in their response options. The resultant litigation was ultimately settled in the oil company's favor.

**Project Manager and Principal Geologist for the Geologic Constraints Investigation, Planning, and Environmental Impact Report for a new 35,000-acre resort community in Kern County.** As part of the master planning team, Earth Consultants International undertook and completed a phased assessment of the geological and geotechnical constraints to the planning of this large resort and residential project. In Phase 1, ECI used existing materials, aerial photographs, and on-site field mapping to delineate the major geological issues: active faulting, liquefaction susceptibility, slope and landslide instability, and flooding. In Phase 2, ECI used a series of trenches to locate and delimit the active fault avoidance zones in bedrock, and cone penetrometer (CPT) and continuously cored borings to locate and constrain the fault through deep saturated sediments. ECI also participated in the planning process and in the preparation of the environmental documentation for the project EIR.

**Project Manager and Principal Geologist of the Active Fault Constraints Investigation phase of the Planning and Environmental Impact Report for the 17,000-acre "Centennial" project, a new master planned residential community proposed in northern Los Angeles County, 1999-2002 & 2006.** As a consultant to the project's principal geotechnical consultant, Earth Consultants International was tasked with identifying, characterizing, and constraining the active fault hazards within this master planned community immediately adjacent to the San Andreas fault, and near to the Garlock fault. In Phase 1, all previously mapped and newly interpreted faults were compiled into a GIS database. All of these faults were evaluated for mapping accuracy, sense and magnitude of offsets, and their impact on overlying sediments so as to constrain their age. In Phase 2, those faults that could not be demonstrated to be inactive or to not exist, and which were in potential development areas, were trenched and quantitatively evaluated as to age of activity, width of the fault zone, and their impact to the development planning. Fault hazard management zones were recommended, and structural setbacks were established. During subsequent, more detailed geotechnical studies, ECI has been called to provide on-call field review and interpretation of fault features as they are revealed in the field investigation exposures.

**Third Party Geologic Reviewer for the Hayward fault investigation in support of the expansion of the UC Berkeley Coliseum Stadium, 2006.** Under contract to the University of California Berkeley's legal division, ECI was retained to conduct a third party field review of the trenches excavated by Geomatrix during their Hayward fault investigation in support of the UC Berkeley's expansion of their Coliseum stadium. The Hayward fault crosses through the existing stadium. This study was looking for any secondary faults that may transect the proposed athletic office expansion.

**Expert Geologic Consultant for a $120M litigation case involving property devaluation based on geotechnical mitigation costs in oil field redevelopment, 2002-2003.** The project involved litigation between the original property owner and a long term leasing oil company in the northern Los Angeles area. The property owner required a cash settlement from the oil company for

environmental cleanup, rather than allowing the oil company to undertake the work themselves. The property owner's environmental consultant developed a remediation plan that was presented to the oil company for payment. The oil company considered the costs to be excessive, and using ECI to evaluate the geological and geotechnical constraints at the site, determined that the conditions at the site were so severe that the property was virtually undevelopable. In trial, it was presented that the excessive environmental remediation costs were intended as an offset to the geotechnical remediation costs in order to lower the development costs. The case settled during the trial for approximately 20% of the original claim.

**Expert Geologic Consultant for a $1.5M litigation case involving property damage from slope instability initiated by improperly maintained municipal storm drainage in Yorba Linda, 1997-2005.** This case involved a dispute as to the responsible party for a landslide that failed in the rear yard of three homes in Yorba Linda. Earth Consultants International was retained by the property owners to assist in understanding the cause of failure and in determining stabilization and repair alternatives. The work done was used by the litigation experts to prove a case of design inadequacy and maintenance negligence against the City, following a judge-trial, leading to a cash settlement for the plaintiffs.

**Expert Geologic Consultant for La Conchita Ranch in the litigation case over the catastrophic landslide failure in 1995.** During the El Nino storms of 1995, a portion of the 400-foot high bluff above the town of La Conchita failed catastrophically, crushing and destroying over a dozen homes. ECI was retained by the La Conchita Ranch above the failure to serve as an expert witness and geologic consultant in their defense of a lawsuit filed by the homeowners. The plaintiffs had asserted that the Ranch's avocado orchard contributed to the failure. Using the isotopic geochemistry of the ground water, a temporal correlation chart of precipitation and previous landslide failures, geologic structure maps, and soil stratigraphy to refute the arguments, the defense prevailed in court.

**Peer Review Panel Member providing technical review and binding arbitration mediation between the Ocean Trails Golf Course's and the City of Rancho Palos Verdes' geotechnical consultants, 2004-2007.** A technical Peer Review Panel was established to provide binding mediation and direction between the geotechnical consultants to the Ocean Trails Golf Course and the geotechnical reviewers for the City of Rancho Palos Verdes. Several years of dispute existed over the three-dimensional subsurface geometry of several bentonitic clay layers, and the resultant stability analysis. Despite over 40 geologically logged borings, the two sides were unable to reach consensus on the stratigraphic correlations. After extensive review, the Peer Review Panel recommended the drilling of four additional borings targeted towards specific points of contention. All four borings were also refit with inclinometers and grouted-in-place multi-level piezometers. The borings were successful in resolving the geological model to all parties, and new stability analysis based on that model is underway.

**Project Manager for a coseismic deformation analysis of the Coyote Pass Blind Thrust Fault for design of the Northeast Interceptor Sewer tunnel [NEIS], 1999.** Earth Consultants International was retained by the City of Los Angeles to assist in the design of the NEIS tunnel through the area of the Coyote Pass Escarpment, an area of active surface folding associated with a blind thrust fault. Using core data obtained by the City geologists for the geotechnical investigation, supplemented with two additional borings, we were able to geographically constrain the passive and active hinges of the fold where the NEIS tunnel would experience deformation strains and tilts in the next earthquake. Using paleoseismic and geomorphic data collected on another study (LA

MTA Red Line tunnels), we were able to quantify these coseismically generated strains, extrapolated to the next earthquake. Based on this analysis, the City's tunnel design engineers were able to design strengthening measures appropriate to resisting the earthquake-generated deformations.

**Project Manager for the faulting and folding hazard assessment of four new Police Facilities in the City of Los Angeles, 2003-2004.** The City of Los Angeles retained Earth Consultants International to undertake a detailed fault hazard assessment of the proposed new Emergency Operations Center, Metro Jail, a relocated Rampart police station, and an enlarged Hollenbeck station. All four facilities were within the possible zone of deformation above the Coyote Pass Escarpment, created by an active blind thrust fault. Using a trench excavation at Rampart, existing geotechnical borings at the Metro Jail, existing geotechnical and six new borings at the EOC, and 20 new borings at Hollenbeck, we were able to conclude that the Rampart, EOC, and Metro Jail sites were north of the active deformation zone, but that the Hollenbeck facility was impacted not only by fold growth and tilting, but also by a transfer fault through the facility that segmented the fold hinge. Using the borehole data we were able to develop a model of fold growth and surface deformation and tilting over the past several thousand years, predict the location and magnitude of future coseismic deformation, and extrapolate the probable surface location, but not displacements, for the tear fault.

**Project Manager for a paleoseismic fault investigation of the Gatún and Limón faults to develop a seismic hazard model for the Autoridad del Canal de Panamá (ACP, formerly Panama Canal Authority), Panamá [2005].** The Autoridad del Canal de Panamá is undergoing an extensive planning program to expand the capacity of the existing Canal. As part of this program, considerable concern was raised by ACP's geologists about the validity of the existing seismic hazard models being used for seismic risk assessments and design. Earth Consultants International was retained by the ACP to undertake a paleoseismic investigation of two high-risk faults: Gatún and Limón. After detailed imagery mapping and geomorphic field reconnaissance, it was concluded that the fault's impacts on the landscape clearly indicated that they were active faults. Then, using 2-D and 3-D trenching techniques, ECI geologists were able to determine an average geologic slip rate of 8 mm/yr for the Gatún and 5 mm/yr for the Limón faults, while recurrence intervals were radiocarbon dated at 150 years for the Gatún and 500 years for the Limón. After presentation to the ACP management and the ACP's Geotechnical Advisory Board, including a field trip to view the youthful tectonic geomorphology of the Limón fault, the geologically determined recurrence intervals and slip rates were incorporated into the ACP's new seismic hazard model.

**Project Manager for a regional tectonic geomorphic reconnaissance of the Western Gatún, Pedro Miguel, Miraflores, Azota, Caballo, and several other faults within the Panama Canal watershed area, for the Autoridad del Canal de Panamá (ACP), Panamá [2006].** Building on the findings of ECI's prior studies of the Gatún and Limón faults, ECI was again retained to review a large area centered on Gatún Lake for indications of other active faults that would impact the seismic hazard model. Using stereo aerial photographs, a 10-m digital elevation model, helicopter reconnaissance, and extensive field verification and geomorphic mapping, ECI identified that the Azota, Pedro Miguel, and Miraflores faults were active and should be incorporated into the seismic hazard model. The results were presented to the ACP's management.

**Principal Consultant for several Seismic Hazard Model Development Workshops for the Autoridad del Canal de Panamá (ACP), Panamá [2006 & 2007].** Following the results of ECI's

previous studies on active faults of central Panama, ECI geologists Rockwell and Gath were retained by ACP to participate as source experts for a workshop to finalize the input parameters for the evolving seismic hazard model of Panama. The workshops, led by ACP, also included seismologists from the University of Panama, geologists and seismologists from URS Consultants, and William Lettis Associates, plus the members of the Seismic Advisory Board, Structural Advisory Board, Geotechnical Advisory Board, and Paleoseismic Review Board. Through the several meetings, we made multiple presentations, led several field trips to the fault investigation sites for the various Board members, and actively participated in the development of the seismic hazard parameters, weighting factors and logic tree formulation.

**Project Manager for a paleoseismic investigation of the Pedro Miguel fault to quantify input to the seismic hazard model for the Autoridad del Canal de Panamá (ACP), Panamá [2007].** The recent findings by ECI that the Pedro Miguel fault had a tectonic geomorphic signature indicative of an active fault led the ACP to contract with ECI for an emergency investigation designed to generate quantitative data on the fault's past seismic history. The prior geomorphic study had identified a prospective trenching site in the Cocoli area immediately west of the Miraflores Lock that was viewed as a good chance to prove the fault was active, and to develop a slip rate for the fault. ECI excavated 14 trenches across and parallel to the fault to measure laterally displaced (offset) channel deposits to calculate a slip rate for the fault, and to find sufficient datable alluvial sediments to determine a recurrence interval for the fault. Based on the study, ECI confirmed that the Pedro Miguel fault is indeed highly active, with an average 5 mm/yr geological slip rate and a recurrence interval of 500-1000 years for M7-level surface-rupturing earthquakes. The results were presented to the ACP's management and their new Seismic Advisory Board, including a field trip to visit a trench excavation showing recurrent fault offsets of alluvial and colluvial units.

**Project Manager for a detailed paleoseismic investigation of the Pedro Miguel fault to determine event chronology and the timing of the last earthquake, for the Autoridad del Canal de Panamá (ACP), Panamá [2007].** Findings by ECI's last investigation were that the Pedro Miguel fault was active, and that it was a leading candidate for generating the 1621 AD earthquake, that was highly destructive within Panama City. At the request of the Chief Administrative Officer of the ACP, ECI was retained to conduct a supplemental study of the Pedro Miguel fault, specifically designed to develop a detailed understanding of the magnitude and timing of the Pedro Miguel fault's earthquake history. We completed three 3-D and paleoseismic recurrence interval studies of the fault within the Cocoli area. The study confirmed the presence of a large earthquake within the timeframe of the 1621 event, and determined an average recurrence interval of 500 years for such events. As a consequence of all prior findings by ECI, but particularly because of this study, the seismic design loads for the structural building code of Panamá will need to be significantly revised.

**Project Manager for an investigation of the Miraflores fault to quantify input to the seismic hazard model for the Autoridad del Canal de Panamá (ACP), Panamá [2007].** A 2006 finding by ECI that alluvial gravels were sheared and in fault contact with the Miraflores fault in a new exposure along the Centennario Bridge Road triggered an investigation of the fault to determine its level of activity. Using trenches excavated across the fault, ECI was able to determine that the fault was had experienced repeated late Holocene earthquakes, estimated a slip rate of 5 ± 3 mm/yr based on the age of the displaced gravels, and recommended that it should be included into the seismic hazard model.

**Project Manager for an investigation of the surface rupture risks posed by the Pedro Miguel and**

**Miraflores faults to the existing Pedro Miguel and Miraflores Locks, for the Autoridad del Canal de Panamá (ACP), Panamá [2008].** Findings by ECI that the Pedro Miguel and Miraflores faults were both active triggered ACP to retain ECI for additional studies of both faults to make a determination as to whether they pose a surface rupture risk to the existing Pedro Miguel and Miraflores Locks, and their associated infrastructure. Using historical maps, eighty years of historical geological data and boring logs, detailed geological field mapping, backhoe trenches, and geophysical transects of the Miraflores Lake (by Technos Inc.), ECI geologists drilled several borings within Miraflores Lake to correlate lake stratigraphy within the fault zones identified by Technos. Trenching and geologic mapping along both sides of the Lake allowed ECI to determine that both faults lie outside the lock footprints, but that their approach causeways are potentially at risk of fault-rupture damage.

**Project Manager for a detailed kinematic investigation of the Pedro Miguel and Miraflores faults within the footprint of the proposed Borinquen Dam portion of the Canal Expansion Project, for the Autoridad del Canal de Panamá (ACP), Panamá [2008].** As part of the new Panama Canal Expansion Project, the 5 km long Borinquen Dam is proposed to separate the new third lock from the existing Pedro Miguel and Miraflores Locks. Findings by ECI that the Pedro Miguel and Miraflores faults were both active triggered ACP to retain ECI for additional studies of both faults to prepare detailed maps and fault kinematic measurements for design of the Borinquen Dam to resist future fault rupture failure. Using extensive subsurface trenching excavations and previous geophysical transects by Technos Inc., ECI was able to present a 3-D spatial and kinematic model of faulting within the dam footprint for use by the dam's designers.

**Project Manager to locate abandoned underground mine workings beneath a proposed surface haul road and ore crusher facility for General Moly's Mt. Hope mine in Eureka, Nevada [2009].** In conjunction with Technos Geophysical Services, ECI was retained as program manager to attempt to locate undocumented and abandoned underground mine workings under the Mt. Hope Molybdium mine's proposed mile-long primary haul road. Combining detailed geologic field mapping and borehole correlation with Micro-gravity, Resistivity, and Ground Penetrating Radar (GPR), the team identified numerous anomalies that were likely to be air-filled mine workings. Following good initial results, the project was expanded to include an additional area proposed for a large crusher mill.

**Geologic Expert for a landslide-related litigation case involving twelve large apartment buildings in Laguna Niguel California [2009].** In conjunction with Diaz Yourman Associates for geotechnical engineering, ECI was retained by GMA Insurance Adjusters to provide engineering geologic expertise on a $65M litigation case alleging that nearly the entire apartment complex was underlain by a large and active landslide due to observed damages in some of the structures. ECI and DYA evaluated the existing geotechnical and geologic data, made several field visits, generated cross sections and maps from the data, participated in several meetings, and completed a final report that refuted the landslide interpretation in favor of long duration slow consolidation of thick fills, complicated by progressive shrink-swell of expansive soils. The case is still underway.

**Project Manager for the Seismic Hazard Assessment of large manufacturing facilities in Japan and Taiwan [2010].** ECI was retained by a large US company to assess the seismic hazard and vulnerability of their manufacturing facilities in Asia. The project consisted of a desktop research and compilation of published materials, supplemented with unpublished materials by Japanese and Taiwanese colleagues. Separate repots were prepared for each of the facilities in Shizuoka

and Saki City Japan, and Tainan and Taichung Taiwan, detailing the faults, slip rates, recurrence, and probabilities, within 100 km of the plant sites. The Shizuoka facility was then selected to complete a PSHA analysis and Spectral Matching at three different probabilities for three different earthquakes.

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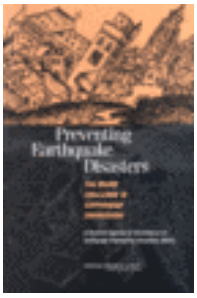


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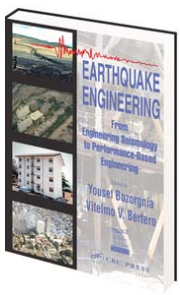


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