KLAMATH
RIVER RENEWAL
CORPORATION

March 22, 2018

DELIVERY VIA ELECTRONIC FILING

David E. Capka, P.E.
Office of Energy Projects
Director, Division of Dam Safety and Inspections (D2SI)
Federal Energy Regulatory Commission
888 First Street, N.E. , Routing Code: PJ-13
Washington, D.C. 20426

RE: FERC No. P-14803, NATDAM-OR00559, CA00323, CA00234, CA00325; Response to October 5, 2017 Directive to Convene an Independent Board of Consultants

Dear Director Capka:

The Klamath River Renewal Corporation ("KRRC") responds to the Federal Energy Regulatory Commission's ("Commission") October 5, 2017 directive ("Directive") to convene an Independent Board of Consultants ("BOC") to review and assess aspects of the proposed dam removal process for the Lower Klamath Project (FERC No. P-14803). Résumés for each proposed BOC member are provided as attachments for your review and approval. This response also addresses the March 15, 2018 "Order Amending License and Deferring Consideration of Transfer Application," and specifically, Item no. 4 in the Appendix, "Additional Information Required for License Transfer Application."

This response to the Directive is solely and exclusively attributable to KRRC. PacifiCorp will coordinate with KRRC and BOC to allow the BOC's work to be performed and completed consistent with the Directive. Except as may otherwise be expressly provided by PacifiCorp, all responses, statements of fact, views, opinions, interpretations, and other communications as may be provided in response to this Directive are solely and exclusively attributable to the KRRC, are based on facts and information that are known to the KRRC, and are not attributable to PacifiCorp or any other party.

The Directive requires that the BOC be fully independent and consist of at least three members with the following experience:

- Civil engineering (with specialized experience in dam construction and removal of both concrete and embankment dams)
- Civil engineering (with specialized experience in hydrology, hydraulics, and stream diversion)
- Geotechnical engineering

In addition, the Commission asked that the BOC include members with experience in the following areas:

- Aquatic and terrestrial biology
- Heavy civil construction cost estimation with experience in dam removal and restoration activities
- Insurance coverage and bonding for large and complex civil construction projects.

The KRRC proposes a six-member BOC to meet the experience requirements summarized above. If approved by the Commission, the resulting BOC would be comprised of four members that fully satisfy the criteria set forth in 18 C.F.R. § 12.31(a) "Independent Consultant." The additional two members proposed are not licensed professional engineers, but they have expertise in the other areas of interest identified by the Commission (i.e., biology and risk management). The KRRC proposes these individuals as full BOC members, but defers to the Commission as to how best to utilize the skills and expertise of these individuals in support of the work to be undertaken by the BOC.

A summary of the experience and qualifications for each proposed BOC member is listed below, and Table 1 summarizes how each proposed BOC member addresses the experience requirements identified in the Directive.

- **Dan Hertel, PE (Engineering Solutions, LLC)**: Mr. Hertel has a 35-year background in the construction of dams, pipelines, tunnels, and other water resource projects. He is an expert in dam construction, heavy-civil construction, and cost estimating. Primary areas of specialization include construction cost estimating, constructability review, construction management, and value engineering. Experience includes oversight of estimating operations including project selection, risk assessment, personnel assignments, constructability analysis, cost estimating, contract review, and bid review. Dan is currently serving on the FERC Board of Consultants for the Anderson Dam Seismic Retrofit Project.

- **James Borg, PE (D&H Concepts, LLC)**: Mr. Borg has more than 43 years of domestic and international experience in water resources and has served as project manager and project engineer on spillway, dam and canal rehabilitation projects; project manager on build-operate-transfer and design-build project developments for construction contractors; and has prepared hydropower development layouts and conducted constructability reviews for the evaluation of project feasibility. James has experience serving as a hydraulic structure expert on an Independent Board of Review for two FERC-licensed hydro projects and an international treaty arbitration assignment.

- **Craig Findlay, PhD, PE, GE (Findlay Engineering, Inc.):** Dr. Findlay's 40 years in the dam safety, water resources and geotechnical engineering profession include a broad variety of consulting and project engineering experience, more than 33 years of which have included involvement with dams and hydroelectric projects. He has served as technical lead or lead geotechnical engineer on hundreds of dam related projects, and serves on ongoing and past Boards of Consultants and Review Panels.

- **Mary Louise Keefe, PhD (R2 Resource Consultants, Inc.):** Dr. Keefe has participated in and/or managed aquatic ecosystem-based projects for the past 27 years. She brings broad experience from working with many different species and habitats located at a variety of water resource projects across the country including California, Alaska, Oregon, Washington, Montana, Mississippi, Pennsylvania, West Virginia and Manitoba Canada. Dr. Keefe has experience with FERC. Earlier in her career, she spent 7.5 years at the Oregon Department of Fish and Wildlife Research Section studying Endangered Species Act listed salmon and steelhead.

- **Ted Chant, PE (Chant Limited):** Mr. Chant has over 40 years of experience performing a full range of management functions in both large and small hydroelectric development and water control/management infrastructure projects in Canada and the United States. Specific experience involves hydroelectric construction risk identification and mitigation, constructability review, cost certainty, execution planning and management (safety, cost, quality and schedule), continuous improvement and value optimization.

- **Robert Muncil, ARM (Cool Insurance Agency, Inc.):** Mr. Muncil is a licensed insurance broker and an Associate in Risk Management, with over 35 years of experience in the hydropower industry dealing with insurance, bonding, claims and evaluating risks. He is a frequent panelist and speaker at national conferences on the hydroelectric power industry and has published several articles about insurance and risk management issues related to the hydropower industry. Mr. Muncil advises his clients through all phases of their projects, from construction to operation, and is supported by over 100 insurance professionals.

Table 1. BOC Experience Matrix

Experience Requirement	Proposed BOC Individuals					
	Dan Hertel, PE	James Borg, PE	Craig Findlay, PhD, PE, GE	Mary Louise Keefe, PhD	Ted Chant, PE	Robert Muncil, ARM
Civil engineering (dam construction)	X	X	X		X	
Civil engineering (hydrology & hydraulics)		X				
Geotechnical engineering			X			
Aquatic and terrestrial biology				X		
Heavy civil construction cost estimator	X				X	
Insurance coverage and bonding (two members)	X				X	X

The Directive anticipates that formal BOC meetings will be attended by "members of the BOC, PacifiCorp, Renewal Corporation, the Renewal Corporation's consultants, and FERC." In connection with these meetings, and generally with respect to communications in response to the Directive, the KRRC would appreciate any guidance that FERC determines to be necessary or appropriate to ensure that these communications are consistent with 18 CFR § 385.2201.

Once we receive approval from FERC, the KRRC will convene the BOC per the requirements outlined in the Directive. We look forward to your response.

Sincerely,

Mark Bransom
Executive Director
Klamath River Renewal Corporation

Enclosures

cc: Douglas Johnson, (D2SI) Portland Regional Engineer
Service List (FERC No. P-14803-000, 001)

ENGINEERING SOLUTIONS

Dan Hertel, P.E.
Cost and Constructability Consultant

Areas of Expertise

- Construction Cost Estimating
- Constructability Review
- Risk Management
- Claims Avoidance
- Project Management
- Board of Consultants
- Value Engineering
- Dam Construction
- RCC Dams
- Earth Fill Dams
- Pipelines
- Water Resources Projects
- Design Build/CMAR

Years of Experience

With Engineering Solutions: 7 Years
With Other Firms: 28 Years

Education

BS Construction Engineering 1982 Montana State University

Registration/Certification

Registered Professional Civil Engineer, Montana

Overview

Mr. Hertel has a 35 year background in the construction of dams, pipelines, tunnels, and other water resource projects. He is an expert in the area of dam construction, heavy-civil construction, and cost estimating. Primary areas of specialization include construction cost estimating, constructability review, construction management, and value engineering. Experience includes oversight of estimating operations including project selection, risk assessment, personnel assignments, constructability analysis, cost estimating, contract review, and bid review.

Operations Manager (1994-2001) and Chief Estimator (1990-1993 and 2001-2010), Barnard Construction Company, Inc.

As a former Operations Manager, Chief Estimator, and Vice President of one of America's premier dam constructors, Mr. Hertel has unique experience and perspective. During Mr. Hertel's 20 years at Barnard Construction, the company constructed numerous projects, including dams and pipelines throughout the United States. During that time, he held direct responsibility and oversight of cost estimating and various construction projects and field operations.

Consultant (2010 – Present) Engineering Solutions, LLC

Representative Projects:

Anderson Dam Seismic Retrofit Project, Santa Clara Valley Water District, San Jose, CA (2017-2018)

FERC Board of Consultants. Project entails over 1 million CY of rockfill excavation and rockfill buttressing, including dewatering, diversion of water, foundation preparation, quarry development, and rockfill. Project also entails outlet works replacement, including two outlet tunnels, intake and outlet components.

Guadalupe Dam Seismic Retrofit Project, Santa Clara Valley Water District, San Jose, CA (2017-2018)

Cost Estimating and Constructability Review. Develop construction cost estimates at the 30%, 60%, 90%, and final design stages. Project consists of dam foundation excavation, blanket and chimney filters and drains, spillway reconstruction, new outlet works tunnel and intake.

Calero Dam Seismic Retrofit Project, Santa Clara Valley Water District, San Jose, CA (2017-2018)

Cost Estimating and Constructability Review. Develop construction cost estimates at the 30%, 60%, 90%, and final design stages. Project consists of dam foundation excavation, blanket and chimney filters and drains, spillway reconstruction, new outlet works tunnel and intake.

Gross Dam RCC Raise, Denver Water, Denver, CO (2017-2021)

Currently serving on the Owner's Representative Team. Role includes development of construction cost estimates, construction schedules, and constructability review for raising an existing concrete gravity dam. Project entails 860,000 CY of Roller Compacted Concrete (RCC), quarry development, materials processing, and

spillway structures. Review of existing studies and team participation in site evaluation and planning.

Atoka Dam and Spillway Rehabilitation, Freese & Nichols, City of Oklahoma City, OK, (2017)
Constructability review, cost analysis review at initial, 60%, 90%, and 100% design development. Evaluation of project access, construction sequencing, control of water, procurement strategies, and other construction approach issues. Review of design drawings, specifications, cost analysis, value engineering, and prequalification or procurement documents. Project includes upgrades to the existing spillway to meet PMF requirements.

Scoggins Dam Raise, Alternatives Analysis, USBR and HDR, Oregon, (2016-2019)
Assist and review of technical data, cost estimates, and construction approach, including embankment dam and RCC dam options. Tasks include review of background materials, participation in review meetings, and follow-up reports.

USACE ATR Review, Isabella Dam, California (2014-2017) (USACE)
Assist with the Agency Technical Review (ATR) of the Isabella DSMP 35% design. Continuing work includes ATR at the 65% and 95% designs. Review of proposed modifications, construction drawings, and overall work approach. Tasks include review of background materials, participation in review panel meetings, and follow-up reports.

Glade Reservoir Site Investigation and Preliminary Design, Fort Collins, CO (2016-2018)
Serving as Technical Advisor for the engineering team. Participation in site investigation, workshop, cost estimates and constructability of dam and pipeline facilities.

USACE ATR Review, The Dalles Dam, Oregon (2015-2018) (USACE)
Assist with the Agency Technical Review (ATR) of the AWS Fish Facility dam penetration. Work includes penetration of the concrete dam, marine work, and large diameter yard piping. Tasks include review of background materials, participation in review discussions, contractor submittals, and follow-up reports. Also site visits during critical component construction.

Dam 7 Modernization Project, Freese & Nichols/Upper Brushy Creek WCID, TX, (2014-2015)
Constructability review, cost analysis review at initial, 60% and 90%, design development. Evaluation of project access, construction sequencing, control of water, procurement strategies, and other construction approach issues. Review of design drawings, specifications, cost analysis, value engineering, and prequalification or procurement documents. Project consisted of replacement of the spillway, realignment of utilities, riprap, and other features.

Wymer Dam and Reservoir Cost-Risk Update Workshop, USBR, Washington (2014)
Participation in a panel of experts in further evaluating the feasibility of a USBR designed 450-foot high concrete-faced, rockfill dam, including pumping station, inlet and outlet works. Analysis included three reservoir sizes.

Cherry Lake Dam VE and DSMS Workshops, USACE, Denver, CO (2016)
Participation in a five-day value engineering workshop to evaluate numerous alternatives associated with dam safety and reservoir expansion. Considerations included cost, constructability, schedule, and other criteria. Additionally participated in a subsequent 3 day DSMS workshop, cost evaluation, and construction considerations.

Chimney Hollow Dam, Northern Colorado Water Conservancy District, Denver, CO (2015-2019)
Development of construction cost estimates and constructability review for a new rockfill embankment dam. Engineering Solutions produced parallel cost estimates for two alternatives – Concrete Faced Rockfill Dam, and Earth Core Rockfill Dam. Analysis included quarry development, site use, and materials processing. Review of previous studies and team participation in site evaluation and planning.

Gross Dam Enlargement Study, Denver Water, Denver, CO (2013-2014)
Development of construction cost estimate, construction schedule, and constructability review for raising an existing concrete gravity dam. Project entails 860,000 CY of Roller Compacted Concrete (RCC), quarry development, materials processing, and spillway structures. Review of existing studies and team participation in site evaluation and planning.

USACE SAR-Independent External Peer Review, Folsom Dam, California (2012-2015) (USACE)
Participation in SAR/IEPR panel at 65% and 95% design, including review of all related documents. Evaluation included review of proposed spillway and approach channel modifications. Project includes significant concrete hydraulic structures and related excavation and anchoring.

USACE Risk Management Center (RMC) Hydraulic Structures Workshop, Lakewood, CO (2014, 2016)
Participated in preparation and presentations as an instructor in a one-week workshop pertaining to the hydrology, design, modeling, and construction of hydraulic features including spillways and outlet works.

Constructability ATR, QCC Review, Bluestone Dam, WV, (2013, 2016) (USACE)
Participation in a Constructability Review ATR team, as well as QCC Review team member for the Dam Safety Modification Study. Spillway and drainage modifications, Phase 5.

Review of Technical Approach and Cost Estimates, USACE, Argonaut Dam, CA (2015)
Review of technical memorandum and cost estimates associated with alternatives analysis including RCC, Mass Concrete, and Structural Concrete solutions. Argonaut Dam is a 100 year old Ambursen type arch dam in need of stability measures.

Red Lake Dam Rehabilitation, New Mexico (BIA) (2014)
Construction Cost Estimate and Constructability Review for an Alternatives Analysis for dam safety improvements, including Outlet Works Improvements, Embankment Reconstruction, and Filter Trench.

Equalizer Dam Value Engineering Study, Idaho (BIA)(2014)
Participated in a 3-day value engineering workshop regarding new spillway, outlet works, and dike modifications. This VE workshop resulted in proposed significant savings and risk reduction.

Battle Creek Hydroelectric Diversion, VE Workshop and Cost and Schedule Analysis Alaska (2014-2015)
Currently working on final design. Participated in a 2-day value engineering workshop regarding a two mile diversion canal to be constructed in a remote location. This VE workshop resulted in recommendations that would have significant cost, risk, and operations savings. Follow on work includes cost estimates, constructability analysis, and construction sequencing associated with the new design.

Clear Lake RCC Dam Board of Consultants, CO (2015)
Participation on the Board of Consultants for an RCC replacement dam, including water diversion, dewatering, foundation preparation, RCC aggregate production, RCC facing systems, reinforced concrete training walls and outlet works replacement.

Dam Safety Modification Study (DSMS) QCC Review, Herbert Hoover Dike, FL, (2014, 2015) (USACE)
Participation in Quality Control and Consistency Review team for USACE Risk Management Center. DSMS includes seepage cutoff and control, levee safety improvements, outlet control modifications. QCC reviews in 2014 and 2015.

Anderson Dam Seismic Retrofit Project, Santa Clara Valley Water District, San Jose, CA (2012, 2013)
Development of construction cost estimate and constructability review for rehabilitation of an existing rockfill dam. Project entails over 1 million CY of rockfill excavation and rockfill buttressing, including dewatering, diversion of water, foundation preparation, quarry development, and rockfill. Project also entails outlet works replacement, including two outlet tunnels, intake and outlet components.

Clear Lake Dam Replacement Project, Xcel Energy, CO (2013)
Participation in design workshops and development for an RCC replacement dam, including water diversion, dewatering, foundation preparation, RCC aggregate production, RCC facing systems, reinforced concrete training walls and outlet works replacement, constructability review and cost analysis.

Wohlford Dam Replacement (RCC), CA (2013-2015)
Cost estimating, constructability review, and overall team support for design of a new RCC replacement dam at the site of an existing embankment dam. Project includes diversion of water, dewatering, foundation preparation, RCC aggregate production, RCC facing systems, outlet works construction.

Fort Peck Dam RCC Emergency Spillway, MT (2012) (USACE)
Development of construction cost estimate and constructability review for RCC spillway apron and training walls. Project included dewatering, excavation, cutoff

walls, rock anchors, significant RCC apron and training walls to accommodate 265,000 CFS flows.

USACE DSMS QCC, Risk Assessment, and Constructability Reviews, Addicks and Barker Dams, Texas. Participation in 4 review panels (2011 and 2012) (USACE)
Review for US Army Corps of Engineers Risk Management Center. Review of DMSM (Dam Safety Modification Study) reports, participation in risk management review meetings, development and review of reports. Area of concentration included cost estimates, and constructability review

Tempe Town Lake Dam, City of Tempe, Tempe, AZ (2011, 2012, 2013)
Development of construction cost estimate and constructability review for a new gated spillway and stilling basin. Project entails an 880 ft wide gated spillway, including evaluation of large hinged crest gates and Obermeyer crest gates, reinforced concrete spillway elements, RCC dam foundation, cutoff wall construction, and associated earthwork.

Education

BS Construction Engineering
Montana State University 1982

Professional Societies/Affiliates

U.S. Society on Dams (USSD), ICOLD, ASDSO, ASCE
Former President and Board Member USSD
Former Water Committee – Design-Build Institute of America
Industry Advisory Board – Montana State University
Industry Advisory Board – Montana Tech

Publications

Presenter and panel member 2011 and 2007 International RCC conference, Atlanta, GA.
Technical papers authored and co-authored include: *What the Heck is in My Spec?, ASDSO 2014; Guidelines for Responsible Construction Cost Estimating for Engineers and Owners,* U.S. Society on Dams, 2011*; Accurate and Reliable Construction Cost Estimates,* U.S. Society on Dams, 2009; *Alternative Project Delivery Methods for Dam Construction and Rehabilitation,* U.S. Society on Dams, 2008; *Estimating Costs and Escalation in Today's Market,* U.S. Society on Dams, 2007.

Employment History

2010 to Present – Engineering Solutions, LLC, Bozeman, MT
Consulting Engineer
1990 – 2010 – Barnard Construction Company, Bozeman, MT
Vice President, Operations Manager, Chief Estimator
1984 – 1990 – Wilder Construction, Anchorage, AK
Project Manager, Superintendent, Estimator

Contact Information

PO Box 11983, Bozeman, MT 59719, (406) 579-6261, dhertel@q.com

James E. Borg
D&H Consultants, LLC
2548 Nuttall Ct.
Holland, MI 49424
Phone: (608) 469-6118
Email: james.borg@dandhconcepts.com

Areas of expertise

Hydropower project planning and design
Hydraulic engineering
Dam safety and regulatory compliance
International financing

Education

MS, Civil Engineering, Montana State University
BS, Civil Engineering, Bradley University

Registration

Licensed Professional Engineer – Illinois, Michigan, Montana and Wisconsin

Memberships

American Society of Civil Engineers
US Society of Dams
Association of State Dam Safety Officials

Publications

"Restoring Lake Delton – How to Beat a Royal Flush," Association of State Dam Safety Officials, September 2009 (J.E. James, B. Ripp and J.L. Rutledge).
"Rehabilitation of Devil's Gate Dam," Association of State Dam Safety Officials Instruction to Speakers, September 1995 (J.E. James).
"Hydraulic Models," Section 3 in Davis' Handbook of Applied Hydraulics, 4th edition, McGraw-Hill, 1993.
"Hydraulic Transients," Section 22 in Davis' Handbook of Applied Hydraulics, 4th edition, McGraw-Hill, 1993.
"Fuseplugs: Structures Designed to Fail," Association of State Dam Safety Officials, September 1992 (J.E. James, J.C. Jones and W.J. Marold).
"Determining Inflow Design Floods for a System of Dams," Hydro-Review Vol. XI, 1992 (J.E. James and N. Pansic).
"Moose River Air Chamber Design and Performance," Waterpower '89 proceedings of the International Conference on Hydropower, ASCE, August 1989 (J.E. James and E.H. Steward III, co-authors).

Awards

Daily Reporter newspaper and Wisconsin Builder magazine, 2009 Engineer of the Year

Languages

English and Spanish

Past employment

MWH
Mead & Hunt
Ecoluz S.A., Ecuador
HCJB World Radio
Harza Engineering Company

Experience Summary

James has more than 43 years of domestic and international experience in water resources and has served as project manager and project engineer on spillway, dam and canal rehabilitation projects; project manager on build-operate-transfer and design-build project developments for construction contractors, and has prepared hydropower development layouts and conducted constructability reviews for the evaluation of project feasibility.

James is a Federal Energy Regulatory Commission (FERC)-approved Independent Consultant for dam inspection assignments; and has served as lead hydraulic engineer on major hydroelectric water supply, flood control, irrigation and dam decommissioning and removal projects. James also has experience serving as hydraulic structure expert on Independent Board of Review for two FERC-licensed hydro projects and an international treaty arbitration assignment.

James' experience includes developing an international small hydro project and serving as director of a hydropower company, working with developers and contractors for the preparation of design-build, engineer-procure-construct (EPC) and design-build-operate-transfer (DBOT) bids for major water resources projects. His projects have included high pressure buried and free standing pipelines, water conveyance tunnels, and long potable water supply aqueducts with and without booster pumping stations and large diameter penstocks buried beneath future debris retention reservoirs.

DAM DECOMMISSIONING AND REMOVALS

Condit Dam hydroelectric project decommissioning

PacifiCorp
White Salmon, Washington

James was responsible for the quality assurance and quality control (QA/QC) for plans and technical specifications preparation for removing the 125-foot-high concrete gravity dam and appurtenant facilities of PacifiCorp's Condit Hydroelectric Project on Washington's White Salmon River. The assignment also includes the development of a Quality Control and Inspection Program (QCIP) for the removal in accordance with Federal Energy Regulatory Commission (FERC) guidelines.

Dam retirement study

Consumers Energy
Cadillac, Michigan

James served as project manager for the retirement study of 11 hydroelectric projects in the Midwest United States. The study involved identifying the costs and environmental studies for the decommissioning, partial and complete dam removal and river and reservoir restoration.

Gold Ray Dam removal

Hamilton Construction Co.
Springfield, Oregon

James served as design project manager for the preparation of the design-build (DB) bid of the removal of the Gold Ray Dam on the Savage River in Oregon. The design included the development of the staged approach for the removal of the existing powerhouse and Ambursen Dam.

DAM SAFETY

Gatun Spillway final design panel of experts

Panama Canal Authority
Panama City, Panama

James served as the hydraulics structures expert on the panel of experts for the hydraulic design of the new Gatun Spillway in Panama. Assignment included review of alternative spillway concepts, periodic design reports, participation in PRB meetings in Panama City, and review of physical hydraulic model studies performed at the INA hydraulic laboratory in Buenos Aires, Argentina.

Eau Pleine project independent board of review

Wisconsin Valley Improvement Company
Wausau, Wisconsin

James serves as the hydraulic structures expert for the Independent Board of Review for the evaluation of emergency spillway conceptual developments to increase the project's discharge capacity to safely pass the 166,000 cubic feet per second (cfs) probable maximum flood event. The assignment included the evaluation of five potential emergency spillway alternative locations, resulting in the recommendation to further investigate a roller compacted or conventional concrete embankment overlay adjacent to the project's gated spillway and an excavated emergency channel around the end of the project's northern embankment dam.

Kings Dam hydroelectric project independent board of review

Tomahawk Power and Pulp Company
Concord, California

James served as the hydraulic structures expert for the Independent Board of Review for the spillway modifications proposed to increase its discharge capacity to safely pass the project's the 24,000 cubic feet per second (cfs) probable maximum flood event. The assignment included the evaluation of downstream scour

potential and review of proposed scour protection alternatives to prevent undermining of the spillway and powerhouse pile-supported structures and adjacent embankment dams.

Hydroelectric project condition assessment
Ecoluz, S.A.
Papallacta, Ecuador
James performed a condition assessment of Ecoluz's hydroelectric facilities to determine measures which would be needed to meet spillway capacity and concrete dam stability requirements. The hydroelectric facilities included two concrete gravity dams with removeable flashboards, two powerhouses with 2.2-MW and 6-MW capacity. The condition assessment also included the preliminary design and cost estimate to determine the feasibility of constructing an additional concrete dam to provide additional storage to improve dry season generation.

Belding hydroelectric project
Renewable World Energies, LLC
Neshkoro, Wisconsin
James developed the Belding hydroelectric project discharge rating curves for the ungated and gated spillway structures. The rating curves successfully demonstrated to the FERC that no additional spillway capacity would be required to pass the project's Inflow Design Flood.

Au Train hydroelectric project
Renewable World Energies, LLC
Neshkoro, Wisconsin
James served as the Federal Energy Regulatory Commission (FERC)-approved Independent Consultant responsible for the inspection and preparation of the Fifth Five-Year Part 12 Inspection Report addressing the stability of 1,160 feet of earth-fill dams; 4,500 feet of sand-fill levee; a 100-foot-long concrete gravity ungated spillway; a concrete power intake structure; a 2,516-foot-long riveted steel penstock; and a two-unit, 1.6 megawatt (MW) powerhouse; and the review of the project Inflow Design Flood (IDF), spillway discharge capacity and project hazard classification. The assignment included the audit of Renewable World Energies' Owner's Dam Safety Program (ODSP).

Dam hazard classification, a discussion of regulations and risks session moderator
HydroVision
Sacramento, California
James served as the Session 2B moderator for the discussion of the regulations and risks associated with US and international dam hazard classifications. The session panel included Constantine (Gus) Tjoumas (CEATI), William (Bill) Allerton (FERC Dam Safety), David Bowles (RAC Engineers and Economists), Ellen Faulkner (Ayres Associates) and Scott Klabunde (North American Hydro).

Risk informed decision making basics workshop
Federal Energy Regulatory Commission
Madison, Wisconsin
James has participated in the FERC's risk informed decision making (RIDM) basics workshop. The three day workshop included the review of potential failure modes, risk analysis, explanation of event trees, probabilistic flood hazard and seismic hazard analyses, dam break analysis, and life and economic loss consequences related to dam failure, risk assessment, and guidelines for preparing for a FERC pilot risk analysis.

Alexander hydroelectric project
Wisconsin Public Service Company
Merrill, Wisconsin
James served as the Federal Energy Regulatory Commission (FERC)-approved Independent Consultant responsible for the preparation of the project's Supporting Technical Information Document, participation on the Potential Failure Mode Analysis (PFMA) meetings and providing inspection services for the preparation of the

project's Ninth (2007) Consultant's Safety Inspection Report (CSIR). The project inspection involved the survey of movement monuments, underwater diving inspection of the project's embankment dam, non-overflow retaining walls, powerhouse and spillway structure. The inspection also included an "up-close" inspection of the spillway gates and a bathymetric survey of the spillway exit channel. The CSIR included recommendations for remedial measures required to comply with the FERC's dam safety guidelines.

Three Rivers (Fairbanks Morse) hydroelectric project
Grande Point Power Corporation
Three Rivers, Michigan
James served as the Federal Energy Regulatory Commission (FERC)-approved Independent Consultant responsible for participation on the Potential Failure Mode Analysis (PFMA) meetings and providing inspection services for the preparation of the project's 2007 Consultant's Safety Inspection Report. The project inspection involved the inspection of the project's embankment dams, non-overflow retaining walls, powerhouse and spillway structure.

Federal Energy Regulatory Commission (FERC) Part 12 assistance
Tacoma Public Utilities, Light Division
Tacoma, Washington
James served as the project manager, responsible for providing consulting engineering assistance in preparing responses to FERC Part 12 dam safety-related questions for five major hydroelectric projects.

Escanaba River hydroelectric project
Mead Paper Corporation
Escanaba, Michigan
James served as the Federal Energy Regulatory Commission (FERC)-approved Independent Consultant responsible for the inspection and preparation of the Initial Five-Year Part 12 Inspection Report addressing the stability of 1,500 feet of earth-fill dams; a 16,000 cubic feet per second (cfs) capacity, three-gate controlled ogee spillway structure; a 9,000 cfs capacity flashboard controlled overflow spillway structure; a two-unit, 2.5 megawatts (MW) powerhouse; and the review of the project Inflow Design Flood (IDF), spillway discharge capacity and project hazard classification.

Boney Falls dam
Mead Paper Corporation
Escanaba, Michigan
James served as the Federal Energy Regulatory Commission (FERC)-approved Independent Consultant responsible for the inspection and preparation of the Fourth Five-Year Part 12 Report addressing the stability of 3,600 feet of earth-fill dams; a 28,200 cubic feet per second (cfs) capacity, six-gate controlled ogee spillway structure; a 5,200 cfs capacity free overflow spillway structure; a three-unit, 4.4 megawatts (MW) powerhouse; and the review of the project Inflow Design Flood (IDF) and spillway discharge capacity.

Wissota hydroelectric project
Northern States Power Company
Eau Claire, Wisconsin
James served as the Federal Energy Regulatory Commission (FERC)-approved Independent Consultant responsible for the inspection and preparation of the Third Five-Year Part 12 Report addressing the stability of 3,000 feet of earth-fill dams, 165 feet of 66-foot-high concrete gravity dams, a 272,000 cubic feet per second (cfs) capacity 13-gate Stauwerke spillway structure and a six-unit 36 megawatts (MW) powerhouse. James was also responsible for the review of the project Inflow Design Flood (IDF) and spillway discharge capacity.

Wynoochee dam project
Tacoma Public Utilities

Tacoma, Washington
James served as lead hydraulic engineer for the field inspection of the 175-foot-high concrete gravity/earth embankment dam, 52,500 cubic feet per second (cfs) capacity gated spillway structure and 9,000 cfs capacity low-level outlet works. Ongoing work included development of outlet works venting requirements and automatic instrumentation monitoring procedures.

HYDROPOWER DEVELOPMENTS

Hydraulic structure expert - international arbitration
Confidential Client
International location
James is providing hydraulic structure expert consulting in support of a client's position on an international treaty arbitration. The assignment involved the reconfiguration of two hydroelectric project layouts under construction to comply with the treaty's negotiated requirements.

Santa Cruz River hydroelectric projects
Electroingenergía
Patagonia, Argentina
James is providing QA/QC review of the design of the diversion and hydraulic structures associated with the EPC development of the 1,200 MW Dr. Nestor Kirchner and the 600 MW Gobernador Jorge Capernic hydroelectric projects in Argentina.

Greenfield hydroelectric projects
Confidential Client
Eastern Europe
James directed the due diligence for optimizing and finalizing five partially constructed hydroelectric complexes having a total of seven separate hydroelectric facilities with installed capacities ranging from 10 MW to 40.5 MW. The phased assignment included review of existing information, site visits to assess their condition, optimization studies leading to recommendations for the final development for their completion, and the preparation of construction and development costs estimates.

J. M. Stuart hydro project
Hull and Associates
Dayton, Ohio
James served as design project manager for the preparation of the engineer-procure-build (EPC) bid for adding a 3.6-MW hydro facility at the terminus of the fossil fuel plant's cooling water return system. The design efforts included the hydraulic studies to configuration the conversion and stage construction without taking the fossil fuel plant out of operation during construction, preliminary design and layout of the civil works, preparation of drawings, solicitation of bids from the equipment supplier, and estimates of annual energy production.

Juniper Ridge hydroelectric engineer-procure-construct (EPC) power project
Mountain Cascade Inc.
Livermore, California
James served as design project manager for the preparation of the engineer-procure-build (EPC) bid of the Central Oregon Irrigation District's conversion of the open channel conveyance system to a closed conduit system and the addition of a 5-MW hydropower plant. The design included the preliminary design and layout of the civil works, preparation of drawings, solicitation of a bid from the equipment supplier, and estimates of annual energy production.

Due diligence of Red River Lock & Dam Nos. 3 through 5 hydroelectric projects
Confidential Client
Louisiana
James directed the due diligence for three run-of-river hydroelectric developments totaling 98 MW located at US Army Corps of Engineers navigation dams within the J. Bennett Johnson Waterway in Louisiana. The due diligence included review of the status of FERC licensing and agency approval processes, current and projected electricity market conditions, potential average annual firm generation, and estimate of project development and O&M costs and schedule, and preliminary economic analysis showing levelized cost of energy, internal rate of return on investment, and development cash flow.

Review of potential small hydropower developments
Confidential Client
United States
James provided QA/QC review of the evaluation of 11 potential small hydro developments. These hydro projects have been permitted by a private developer and are under various stages of the FERC licensing process. The assignment included the initial screening, on behalf of the client, of the feasibility and completeness of the technical work performed by the developer. The study culminated with the recommendations for further investigations of several of the projects which have higher potential for further development.

Hydrologic and energy evaluation of potential hydro projects
Confidential Client
Albania
James provided QA/QC review of hydrologic studies and energy estimates for eleven hydropower projects in Albania. The studies included evaluation of system layouts, flow data, head losses, and average annual energy estimates and firm capacity for each of the projects. Alternative turbine and generator units were also evaluated for some of the projects and corresponding energy generations were estimated.

Black River Falls minimum flow unit
Municipality of Black River Falls
Black River Falls, Wisconsin
James served as project manager for a feasibility study to assess the technical and economic viability of adding a 400 kW minimum flow unit at the project's spillway to increase generation. The feasibility study included performing annual generation estimates for the low-head generating unit, estimating construction cost and soliciting water-to-wire electromechanical equipment budgetary quotations from suppliers.

Hydro development feasibility study, Mississippi Lock and Dam Nos. 24 and 25
Klingner & Associates, P.C.
Quincy, Illinois
Mead & Hunt conducted a feasibility study to assess the technical and economic viability of constructing hydroelectric generating facilities at two sites located on the Mississippi River. The generating facilities would utilize the Mississippi River flows and head created by the navigation locks and dams that are operated by the United States Army Corps of Engineers (USACE). The potential for hydropower development was evaluated based on site attributes, flow characteristics and available head. James was responsible for quality assurance and quality control review for the feasibility study to determine the viability for development of each of the three sites. The analyses showed a favorable outlook for hydropower development using new technologies that provide improved efficiencies for low-head installations. James served as lead hydraulic engineer during the preparation of the Preliminary Application Document for the development of the projects.

Marseilles hydroelectric project rehabilitation
North American Hydro
Marseilles, Illinois
James served as project manager for the fast-track design of the rehabilitation of the Marseilles hydroelectric project on the Illinois River. The assignment included hydraulic and generation studies and project improvements design culminating in the design report, technical specifications, design drawings and quality control and inspection plan for project rehabilitation. Major rehabilitation work included installing turbine/generator units and electromechanical equipment, fabricating two new dewatering bulkheads, installing a new trash rack system, constructing two new sections of retaining walls along the power canal, raising the canal walls to provide adequate freeboard and providing miscellaneous powerhouse improvements for structure stability.

Upper Pacolet hydroelectric project feasibility study and final design
Lockhart Power Company
South Carolina
James served as the project manager for this study to evaluate the feasibility of installing a generating unit at an existing dam site. The generating unit would use flows from the Pacolet River diverted through the abandoned mill water intake structure. This structure is on the right abutment of the existing masonry-concrete gravity dam. The generating unit would be located in a powerhouse immediately downstream of the intake structure and would return flows to the pool approximately 0.6 miles downstream created by the Lower Pacolet hydroelectric project.

Hydro development licensing support for Mississippi River Lock & Dam Nos. 20, 21 and 22
Klingner and Associates, P.C.
Quincy, Illinois
James provided preliminary design guidance and quality assurance and quality control for the pre-engineering studies in support of the licensing for the construction of hydroelectric generating facilities at three sites on the Mississippi River. The pre-engineering studies include performing large-scale physical hydraulic model studies and associated numerical modeling to simulate the effects of adding hydropower facilities on navigation, sediment and ice flow patterns and fish passage. The assignment also includes coordinating the project development with the manufacturers of newer low-head generating equipment.

Hydro development feasibility study for Mississippi Lock and Dam Nos. 20, 21 and 22
Klingner and Associates, P.C.
Quincy, Illinois
Mead & Hunt conducted a feasibility study to assess the technical and economic viability of constructing hydroelectric generating facilities at three sites on the Mississippi River. The generating facilities would utilize the Mississippi River flows and head created by the navigation locks and dams operated by the United States Army Corps of Engineers (USACE). The potential for hydropower development was evaluated based on site attributes, flow characteristics and available head. As project manager, James was responsible for directing the feasibility study to determine the viability for developing each of the three sites. The analyses showed a favorable outlook for hydropower development using new technologies that provide improved efficiencies for low-head installations. James served as lead hydraulic engineer during the preparation of the preliminary application document for the projects.

Conceptual development study for Lockhart hydro canal minimum flow unit
Lockhart Power Company
Lockhart, South Carolina
James served as project manager for a conceptual development study to assess the technical and economic viability of constructing an 850 to 1,000 kW minimum-flow unit at an abandoned pump house on the existing Lockhart hydro canal. The study involved reviewing the project scheme to identify "fatal flaws" that may impact the assumed economic feasibility of the project and identifying cost-saving solutions. The conceptual layout included a low-velocity intake, buried high-density polyethylene (HDPE) penstock and thrust constraints and flood-proof powerhouse arrangement. We also solicited electromechanical equipment budgetary quotations from suppliers.

The initial evaluation resulted in the developing a conceptual layout in sufficient detail to solicit budgetary quotes from local contractors for the project construction.

Juniper Ridge hydroelectric project
David Evans and Associates, Inc.
Bend, Oregon
James served as project manager for a pre-feasibility study to assess the technical and economic viability of adding a five megawatts (MW) unit in the Central Oregon Irrigation District canal system during its conversion from an open channel conveyance system to a closed pipeline conveyance system. The pre-feasibility study included a wye branch encased in a thrust block and a low-profile powerhouse arrangement with two 2.5 Francis turbine-generators. Mead & Hunt also solicited water-to-wire electromechanical equipment budgetary quotations from suppliers. The pre-feasibility study was sufficiently detailed to allow the owner to pursue funding for the project development.

Mahoning Creek hydroelectric project
Advanced Hydro Solutions, LLC
Fairlawn, Ohio
James served as project manager for a prefeasibility study and conceptual project layout of a 4.4 megawatts (MW) hydroelectric development at the existing United States Army Corps of Engineers (USACE) Mahoning Dam. The study involved the review of the project scheme to identify "fatal flaws" that may impact the assumed economic feasibility of the project, identifying innovative cost savings solutions and evaluating measures to meet project dissolved oxygen objectives.

Red Rock hydroelectric project
CRD Hydroelectric, LLC
Iowa
James served as lead hydraulic engineer for the preliminary feasibility evaluation for the site. The assignment involved the layout of a three-unit development totaling 36 megawatts (MW) at an existing United States Army Corps of Engineers (USACE) flood control structure.

Ecoluz S.A.
HCJB World Radio
Ecuador
James was the executive director for the new hydro generating company with two plants having combined capacity of 8 megawatts (MW) with $1.4 million in gross revenues. His management responsibilities included power sales marketing and contract negotiations with electric utilities and large consumers, permitting and regulatory compliance, management of local and foreign equipment procurement and design contracts, international shipping and import coordination and construction management. James coordinated defense of water rights issues and assisted in establishing an Ecuadorian-registered hydroelectric group subsidiary for mission's hydro facilities totaling 8.1 MW. He also coordinated studies for the transfer of 28 subcontracted employees into the organization.

Loreto hydroelectric project
HCJB World Radio
Ecuador
James served as the project manager in Ecuador for the $3.2 million development of a 2.1 megawatts (MW) hydroelectric project for a non-profit Christian organization. His management responsibilities during the 3-year assignment included project planning, international project financing, power sales marketing, power sales contract negotiations with electric utilities and large consumers, permitting and regulatory compliance, management of local and foreign equipment procurement and design contracts, international shipping and import coordination and construction management. He also coordinated defense of water rights issues and assisted in establishing an Ecuadorian-registered hydroelectric group subsidiary for mission's hydro facilities totaling 8.1 MW.

Marañon hydroelectric project
Confidential client
Peru
James served as project engineer for a developer's 75 megawatts (MW) Greenfield hydroelectric project. His responsibilities included project layout optimization, preliminary designs, construction material quantity takeoffs and preliminary construction cost estimates and schedules.

Miguillas Valley hydroelectric project
Confidential client
Bolivia
James served as project engineer for the contractor's engineer-procure-construct (EPC) bid for the Greenfield 160 megawatts (MW) hydroelectric project development. His responsibilities included project layout optimization, preliminary designs, construction material quantity takeoffs and assistance during bid preparation

Rio Bermejo
Confidential client
Argentina and Bolivia
James served as project manager for the due diligence review of three Greenfield multipurpose project engineer-procure-construct (EPC) developments in Argentina and Bolivia with estimated combined construction costs of $520 million.

Santa Ana River penstock/flowline relocation
Southern California Edison
Rosemead, California
James served as project engineer for the successful design-build (DB) bid preparation. He prepared basic design criteria, technical layout and project component costs for the relocation of 10,000 feet of a four-foot-diameter, 90 cubic feet per second (cfs) capacity penstock buried within the river channel upstream of Seven Oaks Flood and Debris Control Project. He led the effort that brought the award of the contract for both phases of relocation of the project, although the client had originally requested proposals for only the first phase of work.

Small hydro design
Long Lake Energy Corporation
Various Locations
James was the lead hydraulic engineer for the design of seven small hydroelectric projects in Upstate New York for Long Lake Energy Corporation. Projects ranged in size from the 12.2 megawatts (MW) Moose River Project to the 700 kW Christine Falls Project. He also conducted power conduit and tailrace transient studies for seven projects ranging from the 14 MW Tembagapura Project in Indonesia to the 170 MW Cerron Grande Project in El Salvador.

Sault Ste. Marie hydro plant condition assessment
Edison Sault Electric Company
Michigan
James was project manager and lead hydraulic engineer for the condition assessment of the 106-year-old hydroelectric plant. The assessment included an underwater inspection to determine the deterioration of the timber- and masonry-lined power canal and powerhouse tailrace channels. The assessment also involved visual inspection of the nearly 1,250-foot-long masonry powerhouse structure and evaluation of the plant's electromechanical equipment. The objective of the assessment was to develop a rehabilitation program with cost estimates to extend the useful plan life an additional 50 years.

Sault Ste. Marie hydroelectric canal rehabilitation project

Edison Sault Electric Company
Sault Ste. Marie, Michigan
James served as project manager for this hydroelectric rehabilitation project. General deterioration had occurred to the timber and masonry lining of the nearly two-mile-long, 35,000 cubic feet per second (cfs) capacity power canal during its 100 years of service. The project involved field investigations to determine the extent of the damage to the power canal lining, an alternative evaluation study to develop rehabilitation measures and a multi-year rehabilitation program, preparation of contract documents and technical assistance during construction.

Rocky Mountain pumped-storage project
Oglethorpe Power Corporation
Rome, Georgia
James served as lead hydraulic engineer for three lower reservoir spillways, an upper reservoir over-pumping fuse plug controlled spillway, three lower reservoir outlet works and transients studies for the design of the 2,700-foot-long power tunnel and three-unit powerhouse. His responsibilities included coordination of hydraulic model studies of the 1:40-scale upper reservoir power tunnel intake at St. Anthony Falls Hydraulic Laboratory in Minnesota.

Grizzly powerhouse project
Pacific Gas and Electric Company (PG&E)
San Francisco, California
James served as lead hydraulic engineer for the review of hydraulic transient studies of the 713-foot-high, 22 megawatts (MW) hydroelectric project. The project features a 12,482-foot-long, 12-foot-diameter tunnel; 4,278 feet of eight-foot-diameter steel penstock; and a 190-foot-high, 20-foot-diameter surge tank.

Macal/Mollejon hydroelectric project
Dominion Energy, Inc.
Belize
James served as the lead hydraulic and rehabilitation engineer for the design and supervision of on-site emergency repairs to switchyard erosion protection damaged by project flood of record and restoration of operation of a 25 megawatts (MW) powerhouse. The assignment included 3.5 weeks of site assistance during construction of temporary repairs and home office design of permanent erosion protection measures. James identified emergency repairs that allowed the project to come on line in six weeks.

Gregory County pumped-storage project
United States Army Corps of Engineers (USACE) – Omaha District
Omaha, Nebraska
James served as lead hydraulic engineer for the design of the 1,200 megawatts (MW) pumped-storage project. The project consisted of a 10,500-foot-long power conduit, a surface powerhouse and a 1,400,000-cubic-foot compressed-air, multi-port surge chamber. James's responsibilities included hydraulic transient studies for the design of the surge chamber and power conduit.

Seminoe pumped-storage project
US Bureau of Reclamation
Denver, Colorado
James served as lead hydraulic engineer for the design of the 570 megawatts (MW) pumped-storage project. The project features included a 3,500-foot-long power conduit, underground powerhouse, downstream surge tank and 2,800-foot-long tailrace tunnel.

HYDRAULIC STRUCTURES

Au Train spillway capacity expansion alternatives study
North American Hydro
Au Train, Michigan
James directed the due diligence studies to identify cost-effective spillway expansion alternatives to double the project's discharge capacity to safely pass the probable maximum flood. Among the alternatives were conversion of the overflow spillway to a gated structure and downstream channel improvements, and construction of an additional flashboard-controlled spillway in one of the project embankments to work in concert with the overflow spillway improved to meet stability requirements.

Spillway reconstruction feasibility study and design
Black River Falls Municipal Utilities
Black River Falls, Wisconsin
Mead & Hunt performed a feasibility study to evaluate alternatives for the rehabilitation, replacement, or removal of the 100-year-old gated spillway at the Black River Falls Hydroelectric Project. The feasibility study recommended reconstructing the gated spillway in its existing location. The final spillway configuration consisted of maintaining the original sill elevation and replacing the original eight-gated spillway with six, 27-foot-wide by 14.5-foot-wide steel tainted gates. The new spillway would be capable of passing the 500-year flood discharge of 81,000 cubic feet per second (cfs) while maintaining the project's low hazard classification. The assignment included the subsequent design and preparation of bid documents for the spillway replacement project. James directed the hydraulic design of the project and provided quality assurance and quality control review for the project.

Weed Dam emergency spillway evaluation
Gresham Municipal Utilities
Gresham, Wisconsin
James provided quality assurance and quality control for the evaluation of the project's 1,500-foot-long and 140-foot-wide, grassed-lined emergency spillway. The evaluation includes a hydraulic analysis to identify potential velocities through the emergency spillway during the flood event with the reservoir surcharged to the top of the dam. The evaluation includes estimating the scour potential of the erodible crest control section, as well as throughout the channel located along the downstream toe of the adjacent embankment. Supporting site surveys and geotechnical investigations are being performed to identify areas where shallow rock could potentially limit the channel's flow capacity and control the depth of erosion.

Jackson Bluff hydroelectric project auxiliary spillway
City of Tallahassee
Tallahassee, Florida
James was the lead hydraulic engineer for the alternative auxiliary spillway evaluation and design phases to increase the spillway discharge capacity and safely pass the project's Inflow Design Flood (IDF). The selected auxiliary spillway layout involved armoring the sand embankment dam with an 825-foot-wide ungated concrete overflow chute terminating a United States Bureau of Reclamation (USBR) Type-III stilling basin to operate with the gated spillway and increase the project's discharge capacity by 69,900 cubic feet per second.

Flambeau hydroelectric project spillway capacity review
Dairyland Power Cooperative
Ladysmith, Wisconsin
James performed the spillway gate hoist mechanism evaluation and identified the owner's means of sufficiently opening the spillway radial gates to safely pass the project's Probable Maximum Flood (PMF) discharge of 91,400

cubic feet per second (cfs). The evaluation results prevented the needless and costly recalculation of the project's PMF.

Hatfield hydroelectric project crest gate spillway
North American Hydro
Wisconsin
James was the lead hydraulic engineer for the replacement design of the existing 160-foot-long timber-trip and 258-foot-long stoplog overflow spillway sections with nine 41.75-foot-long crest gates. The assignment included re-evaluating the gated spillway's operation to increase its discharge capacity and work with the new crest gate spillway to successfully lower the Inflow Design Flood (IDF) reservoir level and satisfy spillway stability requirements.

15 de Septiembre hydroelectric project
Comisión Ejecutiva Hidroeléctrica del Río Lempa (CEL)
El Salvador
James served as the project manager responsible for the diagnostic evaluation of the cause of damage to 900,000 cubic feet per second (cfs) capacity spillway stilling basin and the design and preparation of contract documents for concrete repair and the installation of an aeration device. He provided resident engineer services during construction. Aeration device design developed in 1:27-scale sectional hydraulic model at St. Anthony Falls Hydraulic Laboratory in Minnesota.

Prickett dam emergency spillway options study
Upper Peninsula Power Company
Wisconsin
James served as project manager for this emergency spillway options study for the upgrade of the project's fuse plug spillway to comply with Federal Emergency Regulatory Commission (FERC) dam safety guidelines. Studies involved developing fuse plug emergency spillway alternatives to comply with FERC guidelines. Project included hydraulic engineering, preliminary civil and geotechnical engineering, cost estimating and site inspection.

Prickett hydroelectric project
Upper Peninsula Power Company
Michigan
Project manager and lead hydraulic engineer for the study of spillway capacity improvements to safely pass the project Probable Maximum Flood (PMF). Studies included performing staged fuse plug failure analyses to identify the project Inflow Design Flood (IDF), revising the project PMF and identifying spillway gate and gate hoist improvements required to safely pass the reduced PMF peak outflow through the project.

Willow Dam Road, Tomahawk River bridge and approaches
Wisconsin Valley Improvement Company
Little Rice, Wisconsin
James provided quality assurance and quality control (QA/QC) for hydraulic spillway analyses for the design of a new bridge crossing the Willow Dam. The dam is a FERC-regulated high-hazard structure creating the Willow Flowage, a 6,300 acre reservoir at the confluence of three tributaries of the Wisconsin River. Project included bridge and roadway design, dam modifications design, analysis of flood hydraulics of the dam and spillway, geotechnical analyses of the dam and retaining walls and dikes, handicapped trail design compliant with the standards of the Americans with Disabilities Act (ADA) and fence, gate.

Tallahassee-Jackson Bluff hydroelectric project
City of Tallahassee
Tallahassee, Florida
James served as project manager and lead hydraulic engineer for the feasibility study for identifying spillway discharge capacity improvements. Studies involved developing fuse plug emergency spillway alternatives to

comply with FERC guidelines. Project included hydraulic engineering, civil and geotechnical engineering, cost estimating and site inspection.

Milyang multipurpose dam inspection
Hyundai Engineering & Construction Co., Ltd.
Korea
James served as project engineer for review of the design of project spillway aerators and stilling basin. This assignment resulted in identifying minor revisions to aerator design that improved performance without increasing project construction costs.

Potreillos project
Energía Mendoza
Argentina
James served as the lead hydraulic engineer for the hydraulic evaluation of contractor's build-operate-transfer (BOT) bid for a 300-foot-high dam and 100 megawatts (MW) powerhouse. The evaluation resulted in the hydraulic redesign of diversion tunnel, outlet works and spillway and powerhouse arrangement to reduce costs, improve operation and increase safety in accordance with the client's request.

Big Dalton dam rehabilitation
Los Angeles County Flood Control District
County of Los Angeles, California
James served as lead hydraulic engineer for the development of seismic strengthening alternatives for the 160-foot-high concrete multiple arch-buttress dam and spillway expansion alternatives to increase the project discharge capacity from 5,000 cubic feet per second (cfs) to safely pass the project Probable Maximum Flood (PMF) of 8,100 cfs.

Coamo dam rehabilitation project
Puerto Rico Electric Power Authority
Puerto Rico
James served as project manager for the raising of 6.2 miles of 50-foot-high earth-fill embankment and the removal of bridge piers on the 66-foot-high, 575-foot-long Ambursen dam ogee spillway structure to increase project discharge capacity. The project also involved the reconstruction of the spillway abutment embankment retaining structures and rehabilitation of a federal highway bridge immediately downstream of the project.

Devil's Gate dam rehabilitation project
County of Los Angeles, Department of Public Works
County of Los Angeles, California
James served as project manager responsible for feasibility study, final design and preparation of plans and specifications for an roller compacted concrete (RCC) buttress to improve stability during seismic and Probable Maximum Flood (PMF) conditions for the 130-foot-high concrete gravity-arch dam and spillway expansion alternative to increase the 16,000 cubic feet per second (cfs) existing spillway capacity to pass the PMF inflow of 42,000 cfs.

In-the-wet construction concept design new gated dam at lock and dam 2 on the Monongahela River
United States Army Corps of Engineers (USACE), Pittsburgh District
Pittsburg, Pennsylvania
James served as lead hydraulic engineer for the development of an in-the-wet construction concept design for replacement of an existing dam featuring a state-of-the-art floating concrete dam.

Norway spillway rehabilitation project
Northern Indiana Public Service Company
Merillville, Indiana
James served as project engineer responsible for preparing plans and specifications for the rehabilitation of 38,100 cubic feet per second (cfs) capacity gated spillway crest and stilling basin. Rehabilitation included use of unique dentated sill to dissipate energy and limit scour to acceptable levels.

Oakdale spillway rehabilitation project
Northern Indiana Public Service Company
Merillville, Indiana
As project engineer, James performed condition evaluation and identified rehabilitation and stability improvement alternatives for 34,100 cubic feet per second (cfs) capacity hollow crest gated spillway and baffled stilling basin slab.

Englewood dam flood control project
Miami Conservancy District
Dayton, Ohio
James served as lead hydraulic engineer for the spillway expansion studies of the 122-foot-high dam flood control project. He supervised alternatives for evaluation phase for the rehabilitation of a 60-year-old spillway to increase discharge capacity to safely pass the Probable Maximum Flood (PMF) project design flood. The alternatives included a fuse plug, an uncontrolled crest and radial gated headworks with capacity of up to 100,000 cubic feet per second (cfs).

Cabin Creek spillway project
Public Service Company of Colorado
Golden, Colorado
As lead hydraulic engineer, James supervised alternatives for evaluation phase and developed hydraulic design of the 145-foot-wide spillway placed within the lower reservoir embankment dam to increase project spillway capacity to 11,055 cubic feet per second (cfs) to safely pass the site-specific Probable Maximum Flood (PMF) design flood.

Brule spillway rehabilitation project
Wisconsin Electric Power Company
Milwaukee, Wisconsin
James served as the lead hydraulic engineer responsible for developing the hydraulic design for a rehabilitated radial gate service spillway and new multi-staged fuse plug controlled side channel auxiliary spillway to increase project discharge capacity to 62,000 cubic feet per second (cfs).

Cushman spillway expansion project
Tacoma Department of Public Utilities
Tacoma, Washington
As project engineer, James developed hydraulic design of 40,000 cubic feet per second (cfs) replacement orifice spillway for the 50-year-old Cushman project to increase discharge capacity to safely pass the Probable Maximum Flood (PMF) project design flood. His responsibilities included coordination of mechanical, structural, geotechnical and hydraulic disciplines to produce construction drawings and specifications.

Beni Haroun hydroelectric project
Agence Nationale des Barrages
Algeria
James served as the lead hydraulic engineer responsible for the coordination of hydraulic model studies of the 1:100-scale comprehensive model at Northwest Hydraulic Consultants laboratory in Vancouver, Canada. The project features included a 400,000 cubic feet per second (cfs) capacity spillway; two diversion tunnels with a combined capacity of 60,000 cfs; and a 25,000 cfs capacity, low-level outlet works.

Kalabagh dam
Water and Power Development Authority (WAPDA)
Pakistan
James was the hydraulic design engineer for the 265-foot-high dam. The project features included orifice and overflow chute spillways with stilling basins having a combined design discharge of 2,100,000 cubic feet per second (cfs). James's responsibilities included coordination of studies at the Irrigation Research Institute involving 1:40-scale comprehensive, 1:40-scale sectional spillway and 1:60-scale sectional spillway models.

La Paula and Porvenir tailings dams
El Teniente Division of CODELCO
Chile
James served as lead hydraulic engineer for the final design of four copper tailings dam spillways and decanting tower intakes. The spillway capacities varied from 900 cubic feet per second (cfs) for the La Paula spillway to 300 cfs for the Porvenir spillway.

Nam Mun and Lam Sae dams
Royal Irrigation Department
Thailand
James served as lead hydraulic engineer for both irrigation dam projects. The Nam Mun project features included a 35,500 cubic feet per second (cfs) capacity spillway and 33 cfs capacity irrigation outlet works. The Lam Sae project features included a 71,000 cfs capacity spillway and 66 cfs capacity irrigation outlet works.

Pehuenche hydroelectric project
La Empresa Nacional de Electricidad, S.A.
Chile
James served as lead hydraulic engineer for the design of the 216,000 cubic feet per second (cfs) capacity spillway, 72,000 cfs capacity diversion tunnel and 10,800 cfs capacity mid-level outlet works of the 295-foot-high rock-fill dam on the Melado River. His responsibilities included project layout studies in Santiago, Chile and coordination of 1:60-scale comprehensive model studies at Georgia Tech University in Atlanta, Georgia.

Guri hydroelectric project
CVG Electrificación del Caroní, C.A. (EDELCA)
Venezuela
As hydraulic engineer, James prepared hydraulic designs of seven intermediate and final construction stages for the spillway with 1,258,000 cubic feet per second (cfs) capacity. He supervised preparation of hydraulic design, specifications and 40 detailed construction drawings for a 164-foot by 328-foot, 1:50-scale comprehensive hydraulic model of the project. He supervised construction of a hydraulic laboratory with 72 cfs capacity. He prepared detailed test programs and supervised investigation staff of three engineers and five technicians during the hydraulic model studies. He performed hydraulic studies to locate and size aeration ramps to provide cavitation protection for the spillway, including preparation and supervision of the field test programs for two aeration ramp designs.

Summer Falls project
South Columbia Basin Irrigation District
Pasco, Washington
James served as lead hydraulic engineer for the design of a 2,000 cubic feet per second (cfs) capacity spillway, power intake canal and headworks and a 2,000-foot-long power conduit for the 94 megawatts (MW) project.

Santee Cooper hydroelectric and navigation project
South Carolina Public Service Authority
Moncks Corner, South Carolina
James served as the project manager and project engineer responsible for conceptual designs for floating bulkhead and dumped-rock emergency closure scheme of a 200-foot-wide trapezoidal channel conveying 40,000

cubic feet per second (cfs). His responsibilities also included coordination of 1:25-scale hydraulic model studies of the floating bulkhead closure at Chicago Bridge and Iron Laboratory, Illinois and 1:40-scale hydraulic model study of dumped-rock closure at Georgia Tech Research Institute, Georgia.

MISCELLANEOUS ASSIGNMENTS

Village of Lake Delton STH A reconstruction
Wisconsin Department of Transportation
Lake Delton, Wisconsin
James was Mead & Hunt's project manager for the alternative embankment layout evaluation and final design for the reconstruction of STH A embankment to refill Lake Delton. The fast-track project involved preparing final design, plans and specifications for an emergency cofferdam and a 30-foot-high, 400-foot-long sand embankment reconstruction featuring a soil-bentonite slurry cutoff wall. The engineering was completed within 10 weeks, allowing for project completion before the end of 2008.

Dell Creek Dam modifications
MSA Professional Services
Lake Delton, Wisconsin
James was the project manager for designing and preparing plans and specifications to modify the Dell Creek Dam. Modifications were done to meet stability criteria, increase spillway capacity, incorporate improvements to 200 feet of 15-foot-high embankment dam and restore upstream rip rap protection. Spillway capacity improvements included reshaping the 50-foot-long overflow spillway crest to increase flow, improving the sluiceway entrance with an upstream bellmouth entrance and constructing a side channel spillway in the dam's abutment. Spillway modifications will double the project's discharge capacity.

Lake Delton emergency diversion
Wisconsin Department of Transportation
Lake Delton, Wisconsin
James was the project manager for designing and preparing of plans and specifications to evacuate an emergency channel and diversion dike and redirect flow from the Lake Delton breach area to the Dell Creek Dam sluiceway. The work included supervising field contractor' during the channel excavation and diversion dike closure during Dell Creek flows. The project was executed in less than 10 days, which allowed access to the breach area during the geotechnical investigations required for the STH A embankment design.

North Coast superaqueduct project
Ingenieros Civiles Asociados
Puerto Rico
James served as the project manager for preparation of layout and design of 100-million-gallons-per-day (MGD) water treatment plant and 50-mile-long potable water supply aqueduct in sufficient detail to support client's preparation of $350-million bid for the build-operate-transfer (BOT) project. The effort included preparation of 150 project layout drawings in a 12-week period.

Rio Colorado aqueduct
Incosat, S.A.
Argentina
James served as project manager, lead hydraulic engineer and contractor's engineer for the preparation of a design-build (turnkey) bid for a 250-mile-long, 76 cubic feet per second (cfs) aqueduct.

Dayton Dam
Clausen Miller
Dayton, Illinois
James served as project manager for the inspection of the Dayton Dam after a 1996 washout. He was responsible for determining the cause of the failure for lawyers representing the insurance agency.

Prairie du Sac fish passage
Alliant
Sauk Prairie, Wisconsin
As lead hydraulic engineer, James applied his Holyoke fish passage system experience to the development of fish conveyance alternatives for the project. Studies involved the evaluation of fish attraction and guidance structures, mechanical lifts, fish ladders, natural fish ways, conveyance raceways, modified step-pools, pumped locking systems and fish counting holding areas.

Pettibone Park fishery enhancement – Pool 8, Upper Mississippi River National Wildlife and Fish Refuge
Wisconsin
James provided quality assurance and quality control for this project. This fishery enhancement project was designed to rectify documented winter fish kills within a popular 22 acre pond within Pettibone Park, on an island within Pool 8 of the Upper Mississippi River National Wildlife and Fish Refuge. This project involved the design of pumped water systems and their structures and electrical controls for habitat enhancement within an intensive, recreational environment.

LaGrande flow continuation valve
Tacoma Public Utilities, Light Division
Tacoma, Washington
James served as project manager and lead hydraulic engineer for the conceptual layout of the LaGrande flow continuation valve. The assignment was performed in response to a Federal Energy Regulatory Commission (FERC) directive to provide minimum river flow continuation during unit load rejections.

Tongue River dam
Montana Maierle/CSSA
Billings, Montana
James was the project manager for the condition evaluation study of the 4,000 cubic feet per second (cfs) low-level outlet works and development of rehabilitation alternatives for the 70-foot-high earth-fill dam.

Lower Occoquan raw water conduit
Fairfax County Water Authority
Fairfax County, Virginia
James served as lead hydraulic engineer for rehabilitation alternatives study. The feasibility study involved identifying construction joint repair/lining replacement alternatives for a 1,600-foot-long, 40-MGD capacity, multi-barreled concrete-box water supply conduit.

Hydraulic research station
Bureau of Design for Hydroelectric and Irrigation Projects
Government of Madhya Pradesh, India (USAID)
As special consultant, James performed a capabilities evaluation of a state-owned hydraulic laboratory facility. This assignment in Bhopal, India, resulted in a report summarizing the condition of the hydraulic laboratory and recommending equipment purchases, staff training and infrastructure improvements required to meet current and projected laboratory work load.

Al Wehdah dam
Jordan Valley Authority
Jordan
James served as the hydraulic engineer for the design of the 3,100-foot-long, 28,250 cubic feet per second (cfs) capacity construction diversion tunnel.

Lake Huron station hydraulic transient study
Detroit Board of Water Commissioners
Detroit, Michigan

James served as the lead hydraulic engineer for the hydraulic transients and surge protection studies. He conducted transient studies for 90 miles of six- to ten-foot-diameter reinforced concrete transmission mains and identified surge protection devices for future capacity increase from 280 to 620 cubic feet per second (cfs). The surge protection device alternatives included elevated and ground-level one-way surge tanks.

Gotvand Diversion, Irrigation and Drainage Project
Ministry of Water and Power
Iran
As hydraulic engineer, James prepared hydraulic designs for the diversion closure scheme of the 72-foot-high dam with a spillway capacity of 288,000 cubic feet per second (cfs) and canal diversion intake capacity of 330 cfs.

Rio Sanate Irrigation Project
Instituto Nacional de Recursos Hidráulicos
Dominican Republic
As hydraulic engineer, James prepared specifications for self-operating radial spillway, diversion closure bulkheads and irrigation canal regulating radial and slide gates for canals with up to 280 cubic feet per second (cfs) of capacity.

Sandy River Conduit Relocation Project
Emery and Sons Construction Co.
Portland, Oregon
James served as design project manager for the preparation of the design-build (DB) bid of the relocation of the City of Portland's exposed water supply pipeline over the Sandy River to an underground aqueduct. The design included the preliminary layout of the civil works and preparation of management approach, technical approach, staging plans, preliminary plans, and supporting calculations sections of the bid document.

Restoration of the Fox River Navigation System
Lunda Construction Co.
Little Chute, Wisconsin
James served as design project manager for the preparation of the design-build (DB) bid of the restoration of the Fox River Navigation System Authority's Appleton Lock No. 1 of the Fox River Navigation System. The design included the preliminary layout of the civil works and preparation of Project Approach, and Drawings and Specifications sections of the bid document.

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FINDLAY ENGINEERING INC.
GEOTECHNICAL AND WATER RESOURCES ENGINEERING

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Education

- B.S., Civil Engineering, 1976, University of New Hampshire
- M.S., Civil Engineering, 1981, University of New Hampshire
- Ph.D., Engineering, 1991, University of New Hampshire

Professional Licensing/Registration

- Professional Civil Engineer: Alabama, California, Georgia, Idaho, Maine, Maryland, Montana, New Hampshire, New York, South Carolina, Oregon, Vermont, Washington, Wyoming.
- Professional Geotechnical Engineer: California
- Current NCEES Record.

Professional Affiliations

- Member, American Society of Civil Engineers
- Life Member, US Society for Dams (USSD)
- Member, Association of Dams Safety Officials (ASDSO)
- Affiliate Member Advisory Committee, Association of State Dam Safety Officials (ASDSO)
- Co-Editor, ASDSO Journal of Dam Safety
- Current Member, ASCE Task Committee on Guidelines for Instrumentation and Measurements for Monitoring Dam Performance.
- Past Member, Subcommittee on Guidelines, Interagency Committee on Dam Safety (ICODS).

Employment History

1998 to Present:	Independent Consultant and Principal, Findlay Engineering, Inc.
1991 to 1998:	Director of Geotechnical Engineering, Duke Engineering & Services, Inc. (formerly Northrop, Devine & Tarbell, Inc.)
1990 to 1991:	Manager of Geotechnical, Civil and Solid Waste Engineering, ABB- Environmental Services (during completion of Ph.D. Dissertation)
1988 to 1991:	Principal Engineer, Findlay Geotechnical Consulting, Inc. (geotechnical engineering consultant during Ph.D. research)
1981 to 1988:	Senior Geotechnical Engineer, E. C. Jordan Company and Jordan Gorrill Associates, Inc.
1977 to 1981:	Assistant Roadway Foundation Engineer, New Hampshire Department of Transportation

Summary of Experience

Dr. Findlay's 40 years in the dam safety, water resources and geotechnical engineering profession includes a broad variety of consulting and project engineering experience, more than 33 years of which have included involvement with dams and hydroelectric projects. He has served as technical lead or lead geotechnical engineer on hundreds of dam related projects, and serves on ongoing and past Boards of Consultants and Review Panels. Dr. Findlay has worked on several hydroelectric greenfield design and remediation projects which have given him broad experience with water resources projects including earth dam and embankment design and instrumentation; powerhouse, spillway and headworks foundations; stability, liquefaction and deformation analysis; seepage and piping assessments; finite element analysis of stresses in embankments, gravity dams, arch dams and radial gates; finite element analysis of earthquake response of embankments, gravity dams, and arch dams; unlined canal design; water retaining structure remediations; cement-bentonite cutoffs and slurry walls; grouting; anchor design; and dam safety inspections. Dr. Findlay has been an Independent Consultant on over 250 FERC Part 12 and other dam inspections, and/or a Potential Failure Modes Analysis Facilitator for clients including AER-NY Gen, LLC, Alabama Power, Algonquin Power, AEP, Avista Corporation, Brookfield Renewable Power, California Department of Water Resources, Central Nebraska PPID, Central Vermont Public Service, City of Danville Virginia, Duke Power, Eagle Creek, Entergy, EGE Fortuna, SA (Panama), Eugene Power & Electric Board, Florida Power & Light, Georgia Power, Green Mountain Power, Henwood Energy Services, Inc., Idaho Power Company, Louisiana Hydroelectric, Manitoba Hydro, NAE Mass, Nebraska Public Power District, Niagara Mohawk, Northern Lights, Inc., PacifiCorp, Pacific Gas & Electric, PowerSouth, Reliant Energy, South Carolina Electric & Gas, Southern California Edison, Synergics Energy Services, Vista Irrigation District and WE Energies. He has also conducted numerous dam structural stability analyses for gravity, slab and buttress, embankment and/or arch dams for many of the above clients. Craig has presented and published several technical papers on seismic analysis of dams, dam seepage, dam remediation, dam stability, grouting, reservoir erosion and in situ soil property measurement for technical societies including USCOLD, ASDSO, ASCE, ICOG, the Canadian Geotechnical Society, American Society of Testing and Materials (ASTM) and the Transportation Research Board. These papers are listed at the end of this resume.

SAMPLING OF RELEVANT PROJECT EXPERIENCE

Cabin Creek Pumped Storage Board of Consultants - Dr. Findlay is a current member of the Cabin Creek Board of Consultants along with Larry Nuss and Dan Hertel for raising of the upper reservoir of the Cabin Creek Pumped Storage Project which is located near Georgetown Colorado in the Rocky Mountains. The project is owned and operated by Xcel Energy and regulated by the Federal Energy Regulatory Commission.. Construction is to be completed in 2019.

Chilhowee Dam Board of Consultants - Dr. Findlay is a member of the Chilhowee Dam Board of Consultants along with John France and Alex Grenoble for the North Embankment Project, working with Brookfield Renewable Energy Group with regard to diagnosis and potential treatment of a seepage/piping issue at one of the dam's embankments. The project is regulated by the Federal Energy Regulatory Commission. The Board was formed in 2015 as a result of several cloudy seepage incidents over several years. The embankment is a thin sloping core rockfill that was originally constructed by Alcoa. The project included an instrumented controlled deep drawdown to identify the elevation of the seepage defect, found to be at the interface of the embankment and a non-overflow concrete section. A forensic excavation and reconstruction of the defected area, including extensive use of secant piles to allow a box excavation below reservoir level to bedrock. The embankment has been reconstructed and the seepage eliminated. A final Board meeting is planned in 2018 to conclude the work after a year of post-remediation operation.

Prairie Du Sac Board of Consultants – Dr. Findlay is currently a member of the Board of Consultants with Larry Von Thune and John Northrop convened for Wisconsin Power & Light's Prairie du Sac Dam. The dam is a slab-and-buttress structure founded on deep alluvial soils, and is regulated by the Federal Energy Regulatory Commission. The dam is a timber pile supported slab and buttress structure. Degradation of the gravel foundation on the downstream side has lowered the tailwater level significantly, leaving the tops of some of the piles exposed to air, and deterioration. The work has involved advice and review of a request for proposals to retain a design and construction team for remediation. Dr. Findlay is currently serving on the Board during design and the upcoming construction work. The design involves an innovated and complex underpinning using micropiles to support grade beams that will support the buttresses and piers. Construction is to begin in 2018, and to conclude about 2022, at which time the Board's work will be completed.

Logan Martin Board of Consultants - Dr. Findlay is a member of the Logan Martin Dam Board of Consultants for the Deep Foundation Grouting Project, working with Alabama Power Company with regard to ongoing treatment of karstic foundation seepage issues and the related ongoing grouting program. The project is regulated by the Federal Energy Regulatory Commission. Since 1968, the project has been a proving ground for state of the art grouting methodology and an on-site grout plant. Dr. Findlay joined the board of two other members in 2013 (Dr. Brian Greene and Dr. Donald A. Bruce), and was previously a FERC Independent Consultant for the project. The BOC work has included oversight on a unique columnar grouting program to mitigate embankment collapse potential in 2015 (paper reviewing the project presented at the 2015 ASDSO Conference paper for which Dr. Findlay is the lead author. Dr. Findlay also made a presentation regarding the project at the 2017 ASCE Grouting, Deep Mixing & Diaphragm Walls Conference in Honolulu, HI. Ongoing work includes investigation and treatment of other areas of the dam which will include BOC participation. Work is ongoing for the foreseeable future.

Vermilion Dam Board of Consultants – Dr. Findlay has consulted with Southern California Edison (SCE) on Vermilion dam since 2002 as the Board of Consultants regarding the safety of this dam, which is located in the Sierra Mountains of California, about 60 miles northeast of Fresno California. Although the dam is regulated by the Federal Energy Regulatory Commission, this board is not driven by a regulatory agency but exists at the discretion of the owner in view of the history of seepage at the dam. Also, in his capacity on the project, he has conducted seismic stability post-earthquake analysis and finite element seepage analysis on the dam. Part of his work includes conducting annual inspections of this 165 foot high 4,268 foot long zoned embankment dam. The dam is founded on thick glacial moraine and outwash soils requiring an extensive drainage system which requires continual maintenance and supplementation. Currently, Dr. Findlay is advising SCE with regard to newly proposed drainage improvements downstream of the maximum section of the dam as well as assessments of the service spillway chute and the resistance to head cutting of an emergency spillway cut in soil. Prior to being on the Board, Dr. Findlay conducted three Part 12 Inspections on the dam, dating back to 1994. Involvement has included assisting SCE in developing responses to new seepage areas and improvements in surveillance and monitoring of the dam and downstream

seepage areas. Work is ongoing.

Army Corps of Engineers, Independent External Peer Review Panel – During 2011, Dr. Findlay served on the independent external peer review panel responsible for reviewing the Dam Safety Modification Study for Rough River Dam, Kentucky for the USACE Planning Center of Expertise as a subcontractor to Noblis. He was one of nine panel multi-discipline members, and he provided geotechnical and dam safety technical expertise for this project.

Army Corps of Engineers, Independent External Peer Review Panel - During 2010, Dr. Findlay was selected to participate in the independent external peer review panel to review the East Branch Dam, Elk County Pennsylvania Dam Safety Modification Study for the USACE Flood Risk Management Planning Center of Expertise as a subcontractor to Battelle. He was one of three panel members of a multidiscipline team for this work and he provided geotechnical and dam safety technical expertise for this project..

Powell Lake Dam Review Board – In 2013, Dr. Findlay assisted Brookfield Renewable Energy Group on an advisory board with respect to seismic analysis and rehabilitation of their Powell Lake Dam in Powell River, British Columbia, about 70 miles northwest of the city of Vancouver. The dam retains a reservoir with storage estimated to be 45.36 square miles.

Hawks Nest Post-Tension Anchorage Review Board – From 2012 through 2014, Dr. Findlay assisted Brookfield Renewable Power as a technical advisor with regard to a grouting and post-tension anchorage project completed in 2014. Work included advising on revised grouting methods to resolve problems water proofing anchor holes and other technical issues as they arose in the field. Hawks Nest Dam is located on the New River, in West Virginia.

Flint River Karst – In 2014-2016, Dr Findlay was retained by Georgia Power to participate in consultation with regard to seepage issues related to the karst foundation of this dam, located in southern Georgia. This work was triggered by the development of a sinkhole on the upstream slope of the dam in 2014. The work has included participation in a special potential failure modes assessment with the Part 12 Independent for the project, the owner, and the FERC, with potential rehabilitation consultation pending. In 2016, Dr. Findlay was selected to perform the Part 12 Inspection for the project.

Klamath River – In 2009 and again in 2014, Dr. Findlay conducted the FERC Five-Year Part 12D Independent Consultant Inspection of PacifiCorp Energy's Klamath River Project, including J. C. Boyle Dam in Oregon and Copco 1 Dam and Iron Gate Dam in California. Iron Gate is a 173 foot high zoned embankment with a side channel spillway; J.C. Boyle is a 68 foot high concrete gravity and embankment dam with a Tainter Gate Spillway, and Copco 1 Dam is a 115 foot high thick concrete arch topped with a Tainter gate spillway.

Part 12 Inspection of Fairfield Pumped Storage Development- In 2015-2016, Dr. Findlay completed the Part 12 Inspection and PFMA review for South Carolina Electric & Gas's Parr Shoals Project, which includes the Fairfield Pumped Storage Development and the Parr Shoals Development, the latter of which forms the lower reservoir for the pumped storage project. In 2014, is separate work prior to the Part 12 Inspection, Dr. Findlay performed a third party independent review of the extensive instrumentation of the Fairfield Development.

Risk Assessment for Lundy Lake and Florence Lake Projects - In early 2016, Dr. Findlay participated in a special risk assessment workshop at the request of Southern California Edison for these two dams. Dr. Findlay has participated in Past Part 12 Inspections of the two dams, as well as various geotechnical issued related to the dams over his involvement with the projects since about 1995. The risk workshop included participation of the FERC and the California DSOD.

Risk assessment of Vermilion and Shaver Lake Dams – In the fall of 2014, Dr. Findlay participated in a special risk assessment workshop at the request of Southern California Edison for these two dams. Dr. Findlay has participated in Past Part 12 Inspections of the two dams, as well as various geotechnical issued related to the dams over his involvement with the projects since about 1995. The risk workshop included participation of the FERC and the California DSOD.

Fairfield Pumped Storage Special Independent Review of Surveillance and Monitoring – in 2014, Dr. Findlay was retained by South Carolina Electric & Gas (SCE&G) to conduct an independent review of seepage and monitoring of Dams A, B, C and D of Fairfield Dam, part of the Fairfield Pumped Storage Development, Parr Hydroelectric Project. This work included a review of project data provided by the Licensee and a site visit. In addition to walking the Dam A through D embankments and downstream areas, the site visit included observations on the sides of the intake and walking under the above ground portions of the penstocks for the project downstream of the intake. Observations at Dike 215 and Berm 99, which are saddle dikes on the Fairfield Reservoir (Lake Monticello), were also made. The independent review led to recommendations regarding

relief well and seepage weir monitoring, treatment and monitoring of a boil area, and enhanced monitoring of the adjoining areas of a large intake structure that had experienced some erosion and undermining issues on the downstream side.

Silver Lake assessment of conduit and potential for head cutting of auxiliary spillway- In 2014, Dr. Findlay conducted a Part 12 Inspection of the Silver Lake Project, including assessment of the potential for head cutting of an unlined emergency spillway and inspection and rehabilitation of an eighty year old segmented concrete conduit through a an embankment.

Mathis Dam Slab and Buttress Analysis – Dr. Findlay conducted a linear elastic finite element analysis of this Ambursen-style slab and buttress dam using the computer program SAP-2000, licensed to FEI by Computers and Structures, Inc. The model included the left abutment, an unconstructed powerhouse incorporated into the bottom of the left abutment and half of the spillway section. The analysis considered normal, PMF and seismic loading cases. The dam is located in a moderate seismic area and a response spectra approach proved adequate as evaluated by the computed stress levels in the structure. A separate finite element model was constructed to model the corbels under seismic loading. The dam was found to be adequate except under PMF loading, where the downstream ogee slabs were found to need to be structurally connected to the buttresses to mitigate the potential for uplift during significant spill.

Vermilion Auxiliary Spillway – Dr. Findlay analyzed the potential for headcutting of an unlined emergency spillway for Southern California Edison's Vermillion Dam, located in the Sierra Mountains of California, about 90 miles from Fresno. The analysis included assessment of geologic conditions by subsurface investigation and documentation from original design. HEC-RAS was used to estimate flow velocities through the channel at various spill levels up to PMF. A tractive force analysis was made to estimate the stability of the channel and the ability of an underlying glacial till deposit to limit headcutting should the spillway ever experience a spill.

Wallace Dam –Dr. Findlay conducted the 2014 Part 12 Inspection and PFMA review for the Wallace Dam Pumped Storage Project for Georgia Power Company.

Spokane River- In 2014, Dr. Findlay Conducted the Part 12 Inspection of the Spokane River Project, located in Washington and Idaho, for Avista Corporation, the owner and operator. The project includes several gravity dams and an arch section comprising three developments.

Lewis River Project, Washington – Dr. Findlay conducted the 2012 Part 12 Inspection of the Lewis River Project, located on the Lewis River in the Cascade Mountains south western Washington State. The project includes the 412 foot high Swift No. 1 embankment dam, 323 foot high Yale embankment dam and the 314 foot high Merwin gravity arch dam. The work included advising on implications of a new PMF and revised site specific seismicity in this subduction zone affected region.

2012-2013 EWEB Part 12 Inspections, Oregon – Dr. Findlay conducted the 2012 Part 12 Inspection of Eugene Water and Electric Board's Leaburg-Walterville Project with nine miles of canal and the Carmen Smith Project, including the 235 foot high Smith embankment dam. The projects are located east of Eugene Oregon. Dr Findlay is continuing to assist EWEB in an advisory role with regard to seismic hazard assessments for the projects and structural analyses.

2014 Summary of Work – FERC Part 12 Inspection included projects for PacifiCorp (Klamath River and Pioneer Projects in Oregon, California and Utah), Brookfield Renewable Power (Louisiana Hydro Project, Stewarts Bridge, Upper Raquette River and Carry Falls Projects in Louisiana and New York State), Green Mountain Power (Silver Lake Project in Vermont), City of Danville Virginia (Pinnacles Project), WE Energies (White Rapids and Chalk Hill Projects), and Algonquin Power (SquaPan Project). Other Inspections for Southern California Edison (Vermilion Dam, California). South Carolina Electric and Gas (Fairfield Project in South Carolina). Seismic and Structural Stability Analyses for: Georgia Power (Mathis Dam FEM Response Spectrum – slab and buttress dam). Boards of Consultants/Advisory Boards for Alabama Power, Southern California Edison, and Brookfield Renewable Energy. Participated in two Risk Assessment Workshops for Southern California Edison.

2013 Summary of Work – FERC Part 12 Inspection included projects for PacifiCorp, Duke Energy, Alabama Power, Georgia Power, Power South, Brookfield Renewable Power, AEP, WE Energies, and Nebraska Public Power District. Other Inspections for Southern California Edison. Seismic and Structural Stability Analyses for: PacifiCorp (seismic/deformation – embankment; gravity analysis, intake section), Georgia Power (FEM Response Spectrum – slab and buttress dam; gravity analysis, gravity arch dam). Boards of Consultants/Advisory Boards for Alabama Power, Southern California Edison, and Brookfield Renewable Energy.

2008-2010 Noxon Rapids Hydroelectric Development embankment Seepage Issue – Noxon Rapids dam is located near Noxon, Montana. It is a 260 foot high concrete gravity spillway and intake with two flanking earthfill embankments constructed in 1960. The size of the reservoir formed by the dam is 7,940 acres, and is approximately 38 miles in length and 1.3 miles wide at the maximum width. Total storage is of the order of 400,000 acre-feet, including approximately 75,000 acre-feet of useable storage. The left or southwest embankment and reservoir overlie a lacustrian clayey silt layer underlain by a clean, pervious gravel (referred to as Noxon Gravel) and bedrock. Upon first filling in 1960, sink holes through the lacustrian clayey silt developed upstream of the dam which allowed full reservoir head to enter the Noxon Gravel and caused the phreatic surface under the left embankment and downstream river bank to rise substantially. The Noxon Gravel did not meet reverse filter criteria for the lacustrian layer. The result of the pressurization of the Noxon Gravel was serious slope movements and seepage downstream of the southwest embankment. In response, from 1960 through 1969, Avista conducted extensive clay blanketing of the reservoir bottom to seal the leakage into the Noxon Gravel. This blanketing proved to be successful and the slope movement and seepage were eliminated. In 2008, a non-turbid seep was suddenly discovered approximately 100 yards downstream of the left embankment, in the area of the 1960s seepage and stability problems. Avista retained Dr. R Craig Findlay in the assessment of the new seepage outbreak. The history of seepage and slope stability problems at the location of a suddenly appearing seep raised concerns with regard to the possibility of the past problems redeveloping. The approach taken to understand and address this problem was to compile the history of the area, conduct field investigations, and develop good geologic sections to understand the subsurface conditions. Field exploration at the seepage location identified an old buried conduit across an old buried access road. The conduit was hydraulically connected to a sand deposit downstream of the dam that seasonally surcharged with snow melt water. The work was the subject of an ASDSO annual conference paper presented in 2011.

Cross Channel Analysis of Ambursen-Type Slab and Buttress Dam, Mathis Project, Georgia Power Company – In 2013-2014, Dr. Findlay is conducting a 3D finite element stress analysis of the slab and buttress spillway section of Mathis Dam, located on the Tallulah River at River Mile 354, in Rabun County, about 8 miles southwest of Clayton, Georgia. The dam is a concrete slab-and-buttress structure (Ambursen-type structure, but not constructed by Ambursen) 730 feet long and about 115 feet high. Response spectra were developed for the analysis in the three orthogonal directions. Nine bays of the spillway, an abandoned powerhouse section (three bays), and the left abutment (nine bays) of the dam were modeled using the program SAP2000, and seismic loading was applied in the cross channel, channel parallel and vertical directions. Currently, the model is being refined by Dr. Findlay to take a closer look at the corbels and a transition buttress, to include time history analysis.

Upper and Middle Dam Remedial Measures, Androscoggin River Drainage, Brookfield Renewable Power (formerly FPL Energy-Maine Hydro LLC) – From 2005 and ongoing through 2015, Dr. Findlay has participated as a geotechnical consultant and member of the advisory/review board for replacement of the spillways and remediation of the embankments for Upper and Middle Dams located in the Western Mountains of Maine. The Upper Dam portion of the project is currently under construction. The dams are owned and operated by FPL Energy and regulated by the FERC. The rehabilitation work is under review of the Federal Energy Regulatory Commission (FERC). Currently, Dr Findlay is a member of the review board advising Brookfield with regard to design and construction of the replacement of the spillways and remediation of the embankments of both of the dams. A joint venture of a contractor and consultant prepared the design for the work, and Dr. Findlay has participated in numerous review meetings as well as facilitated a special construction Potential Failure Modes Analyses for the work. The embankments were constructed in the early 1900's and in recent years were identified to have seepage, artesian pressure and slope stability problems that the FERC had directed the owner to remediate. The FERC had also directed the owner to assess if the embankments had any seismic stability/liquefaction issues. In 2006, Dr. Findlay planned an extensive geotechnical investigations conducted by Findlay Engineering, Inc. to assess subsurface conditions for planning the remediations. Engineering evaluation included assessment of existing slope stability, seismic and liquefaction stability, and design analyses of several potential remedial approaches. The subsurface investigations determined that sections of the embankments are founded on pervious alluvial soils underlain by relatively impervious, dense glacial till. The pervious alluvial soils were assessed to be responsible for the artesian conditions identified at the toe of the embankments in at least one locations. To remediate the embankments, a 500 foot long sheet pile cutoff wall was installed at one embankment, and a downstream filter berm is planned at the other. The sheet pile approach was used where the alluvial layer was at a low elevation, to avoid the need to have a

prolonged drawdown of the storage reservoir retained by the embankment or expensive dewatering measures which would otherwise been needed for other remediation approaches which would have required excavation of the downstream toe or slope. At other locations where the alluvial soils are at a higher elevation and would only be a problem with regard to embankment stability during extreme flood scenarios, a filter berm has been proposed for the future remediation currently under design. At present (2015), the sheet pile cutoff has been installed, and the rehabilitation of the spillway is under construction.

Henshaw Dam Part 12 and Seismic Analysis – Dr. Findlay was the Part 12 Independent Consultant for the 2011 Inspection of Henshaw Dam, owned by the Vista Irrigation District, northeast of San Diego, California. The dam is a hydraulic fill embankment that was buttressed in the 1980s to improve seismic stability. The dam straddles a brachiated splay of the Elsinore Fault. At the request of the FERC, Dr. Findlay conducted an updated deformation analysis, which was done using scaled time histories selected based on matching with response spectra for the project region. The analysis used the Newmark Sliding Block method, as implemented using the GeoSlope International suite of finite element and limit equilibrium programs (SIGMA/W, QUAKE/W and SLOPE/W). The dam is located in a zone of high seismicity, and the analysis work also had to consider the potential of fault offset across the dam as well as evaluation of the adequacy of filter compatibility of the zoned embankment materials using modern (USACOE) criteria.

Borel Canal Deformation Analysis – Borel Canal is a power canal that takes water from an outlet through the USACE Lake Isabella Auxiliary Dam, located east of Bakersfield, California, on the Kern River. The canal is owned and operated by Southern California Edison to convey water to the Borel Powerhouse. In the early to mid-2000's, the USACE recognized that the Kern Valley Fault, which runs through the right abutment of the Isabella Auxiliary dam and a section of the Borel Canal, was potentially active and capable of being the source of a significant earthquake (M7). This resulted in an assessment of significantly increased seismicity for the dam and the side hill cut-and-fill canal. The canal has many side hill embankment sections that needed to be re-assessed for seismic deformation at the request of the FERC in 2011. SCE retained Dr. Findlay in 2011 to conduct deformation analyses at five cross sections along the canal route. This was done using scaled time histories selected based on matching with response spectra for the project region. The analysis used the Newmark Sliding Block method, as implemented using the GeoSlope International suite of finite element and limit equilibrium programs (SIGMA/W, QUAKE/W and SLOPE/W). Work also included consultation with regard to potential offset of the canal within one of its tunnel sections.

Swinging Bridge Dam Part 12 Inspection - Dr. Findlay was the Part 12 Independent Consultant for the 2009 Part 12 Inspection of Swinging Bridge Dam, which underwent a high profile rehabilitation for development of a large sinkhole just upstream of the crest in 2005. Dr. Findlay participated in the post-remediation PFMA and prepared the PFMA Report. The PFMA was conducted concurrent with the final Board of Consultants Meeting for the rehabilitation.

Saluda Dam Part 12 Inspection - Dr. Findlay assisted on the first (2010) Part 12 Inspection of Saluda Dam following its high profile seismic rehabilitation. Dr. Findlay was responsible for geotechnical and instrumentation review of the project. The dam is a semi-hydraulic fill structure located in Columbia, SC, and underwent construction of a downstream secondary dam in the mid 2000's as part of a seismic rehabilitation.

Annual Inspections (2001 through 2006) and Seismic Stability Assessment, Fortuna Dam, EGE Fortuna SA – Dr. Findlay has conducted several annual inspections and analysis reviews of Fortuna Dam, as mandated by the government of Panama (the next scheduled for February, 2005). The project is located near David Panama, adjacent to the Costa Rican border which is a relatively active seismic area. The project was completed in 1994 and includes a 341 foot high concrete face rockfill dam, over 10 kilometers of tunnels and an underground powerhouse. The project has a total generation capacity of 300 MW, and provides about 40 percent of the generation capacity of the country. The project included slope stability, post-earthquake slope stability and seismic deformation analyses that were conducted by Dr. Findlay, using simplified approaches as a first cut. Stability of the dam was found to be adequate.

Soil Founded Ambursen Dam Stability and Seepage FEM Analysis, Sugar River Dam 1, Sugar River, Newport, NH – In 1999, Dr Findlay conducted a gravity analysis of a concrete Ambursen structure founded on alluvial soil. The analysis included finite element flow net analysis (using SEEP/W) to assess uplift on the base of the structure, HECRAS analysis to develop a tailwater curve (calibrated from flood observations), and a finite element stress analysis of the stability of the face slab under flood and seismic loading. The latter analysis was conducted by Dr. Findlay using the finite element program SAP2000NL. The gravity analyses of several intermediary flood cases were conducted to find out the

critical loading condition for the dam. An intermediate flood case (significantly less than the PMF) was found to be the critical loading case, and the dam was found to be adequately stable for all loading cases.

Mammoth Pool Dam Fragility Analysis - Southern California Edison Company has embarked on a risk assessment program of their portfolio of dams. In support of that effort, in 2008 and 2009, Dr. Findlay conducted a detailed seismic stability "fragility" analysis of the 400 foot high Mammoth Pool zoned embankment dam located on the upper San Joaquin River watershed, about 50 miles northeast of Fresno California. A fragility analysis is an analysis that focuses on a potential failure mode(s) of the dam, and investigates the resulting factor of safety under various return periods of loading, in this case seismic loading. Review of the available project data and boring logs indicated that liquefaction was not anticipated to be an issue at the dam, leaving the potential seismic deformation as the key question to be investigated. For seismic loading, return periods of 1000, 2500, 5000 and 10,000 years were considered. Seismic time histories (horizontal and vertical) were selected and scaling factors developed by a seismologist retained by Edison. This resulted in 24 sets of time histories for each return period, and four different distance/magnitude models. As a result, on the order of almost 100 analysis runs were required. Due to the very high number of time histories that were considered, an approach to analysis that streamlines the data handling problems was critical. Because of their seamless integration, the GeoStudio (GeoSlope Inc, Alberta Canada) suite of computer programs (SEEPW, SIGMAW, QUAKEW, and SLOPEW was used. These programs conduct seepage and initial stress finite element analysis, an equivalent linear finite element response analysis (similar to QUAD4M), and a double integrated Newmark analysis. The work was completed in 2009.

Saddlebag Dam Fragility Analysis - Southern California Edison Company has embarked on a risk assessment program of their portfolio of dams. In support of that effort, in 2010-2011, Dr. Findlay conducted a detailed seismic stability "fragility" analysis of Saddlebag Dam, a 45-foot-high, timber-faced, dumped rock fill dam, with a length of 600 feet, located on Vining Creek, near Tioga Pass in the Sierra Nevada Mountains. SCE posed two questions for Dr. Findlay to answer. The first was to determine to what degree the dam could be damaged under seismic loading by events with probabilities of recurrence of 1,000; 2,500; 5,000; and 10,000 years. The second question was to assess how much overtopping the dam could withstand since the spillway was found to be insufficient to pass a PMF event without overtopping. With regard to the first question, the analysis considered the failure mode of seismic deformation of the rockfill, since the dam itself would not be susceptible to liquefaction due to its relatively free draining character. The analysis was conducted using the GeoStudio suite of programs (Sigma/W, Quake/W and Slope/W) to conduct a Newmark sliding block deformation analysis using the results of finite element analyses to determine initial stresses within the dam and response of the dam to seismic loading. It was found that the dam is not expected to lose its water retaining integrity for earthquake hazard defined by the time histories considered up to a probability of recurrence of 10,000 years. At the 10,000 year seismic hazard, damage to the downstream slope is likely to exhibit some surficial sloughing to a depth of a foot or less, but no deep penetrating instability was indicated. On the upstream slope, the analyses indicated that no deformation would occur below the level of the reservoir surface. It appears that the effects of reservoir confinement mitigate deformation on the upstream slope below the reservoir surface. Above the reservoir surface, some surficial deformation is possible on the upstream slope, which could damage or bulge the timber facing, and repairs may be necessary following a significant earthquake; however, the reservoir should be retained following an earthquake, since little damage would be anticipated below the reservoir surface level. With regard to the overtopping question, the dam rockfill was considered with respect to its ability to sustain a "flow-through" type failure. This involves overtopping of the dam, with the discharging water flowing into the riprap of the downstream slope. "Flow Through" analysis is described in an article by Thomas M. Leps which is included as a chapter in a text "Embankment-Dam Engineering" edited by Hirchfeld and Poulos (1973). Dr. Findlay used the Leps method to assess the ability to withstand overtopping, and concluded that Saddlebag Dam will likely not tolerate significant overtopping without downcutting and breach due to the relatively fine character of the rockfill that was used to construct the dam, based on field observations. Therefore, it is a recommendation of this report that such overtopping not be considered as a viable addition to the discharge capacity to pass the inflow design flood (assumed to be the Probable Maximum Flood). The spillway for the dam was subsequently enlarged and improved.

Cross Channel Analysis of Ambursen-Type Slab and Buttress Dam, Aziscohos Project, FPL Energy Maine Hydro LLC – In 2004, Dr. Findlay conducted a 3D finite element stress analysis of the internally arched buttress dam section of Aziscohos Dam, located on Magallowag River near Wilson Mills, Maine. Response spectra were developed for the analysis in the three orthogonal directions. Five bays of the dam were modeled (the deepest bays) using the program SAP2000NL, and

seismic loading was applied in the cross channel, channel parallel and vertical directions. Seismic loading at normal full reservoir level, both with and without ice loading, was considered. The dam was found to be structurally adequate.

Diversion Dam Seismic Issues, Beaver River, Niagara Mohawk Power Corporation – From 1997 through 2002, Dr. Findlay was a consultant to Erie Boulevard Hydroelectric, LP (now Brookfield and formerly Niagara Mohawk Power Corporation) regarding seismic stability analysis of the need for and design of the approach for remediation of Diversion Dam. The dam is an 80-foot high hydraulic fill structure, which is part of the Beaver River Project, located in New York State. Work included a major field investigation program using energy calibrated standard penetration testing on both the upstream (barge) and downstream slopes of the dam. The field investigation was conducted in the summer of 1998 to assess the relative density of a construction cofferdam observed on the upstream side of the dam in old 1924 construction photographs. The borings were also conducted using carefully controlled methods, in accordance with the published recommendations of Seed and others. The drilling procedure including prevention of the development of unbalanced hydrostatic head on the sample zone during drilling rod removal. The controlled drilling methods facilitated measurement of standard penetration test blow count values which were improved over those from previous field investigations made at the site. Because of the sensitivity of the field work, Dr. Findlay spent a significant amount of time in the field overseeing the drilling procedures and energy calibration of the SPT test equipment. The field work is the subject of a paper that Dr. Findlay co-authored and presented at the 1999 USCOLD Annual Lecture in Atlanta. Following the field work, an extensive seismic stability analysis was carried out by Dr. Findlay on the existing dam and later on the designed remediation cross section. Seismic analysis included liquefaction analysis, post-earthquake, and deformation analysis components of three separate cross sections of the dam. For the liquefaction analysis, seepage analysis (SEEP/W), static finite element analysis (SIGMA/W), dynamic response finite element (QUAD4M), and liquefaction triggering analyses (spreadsheet based) were conducted. Post-earthquake residual strengths and strengths reduced by seismically induced pore pressures were assessed and post-earthquake slope stability analyses were conducted. Finally, QUAD4M acceleration time histories for selected potential sliding blocks were double integrated (Newmark-type deformation analysis method) to determine potential movement of the dam during seismic shaking. The analyses of existing conditions indicated a need to improve seismic stability. Dr. Findlay was involved in developing a remedial approach, which consisted of a foundation drainage system and downstream seismic berm. The work was conducted under review of the FERC and their consultant's A. J. Hendron and I.M. Idriss. Rehabilitation of the dam included construction of a downstream stability berm and toe drainage system, and was completed in the fall of 2002. This project is the subject of papers co-authored and presented by Dr. Findlay at the 2003 USSD and Waterpower Conferences. A paper summarizing the work was also published in the summer 2004 issue of the ASDSO Journal of Dam Safety.

Post-Earthquake Analysis, West Embankment, Sinclair Dam, Georgia Power Company– *Between* 2005 through 2007, Dr. Findlay conducted a detailed seismic analysis of the 90 foot high West Embankment of Sinclair Dam, a high hazard structure. The reservoir is the source of cooling water for a large coal fired power plant, and is located on the Oconee River, near Milledgeville, Georgia. Dr. Findlay assisted in addressing follow-on questions and analyses as directed by the FERC. The dam has lower upstream core sections consisting of semi-hydraulic fill, and exhibited in old construction photographs (circa 1920s) and as determined by low SPT "N" values measured in test borings. The FERC has requested several dam owners in the southeast to re-evaluate the seismic stability of their semi-hydraulic fill dams, based on potentially loose conditions that could exist and the proximity of some of the dams to the 1886 Charleston, S.C. earthquake epicenter. Georgia Power retained Dr. Findlay to conduct the seismic assessment. The work included assessing liquefaction potential based on SPT "N"-values, assessment of post-earthquake residual strength, and post-earthquake and seismic deformation analysis. The post-earthquake analysis was conducted using the program UTEXAS4, which required extensive review and assessment of drained and undrained triaxial test data to develop strength parameters for the two-step Wong and Duncan type undrained strength approach incorporated into the program. The analysis indicated adequate seismic stability. Deformation was estimated using the Makdisi-Seed approach, and indicated that seismic deformation under the maximum credible earthquake would be tolerable, although upstream sloughing could occur that would not breach the crest. The analyses have been accepted by the FERC in 2007, and no rehabilitation of the West Embankment has been required.

Abbott Brook Dike Seismic Stability Assessment and Rehabilitation, Skelton Project, Florida Power & Light – Dr Findlay conducted an assessment of post-earthquake stability and deformation analysis for this 700 foot long, 40 foot high hydraulic fill dam located in Northern Maine. This work also included conducting carefully controlled standard penetration testing (SPT) of

the embankment and foundation materials. The analysis was based on SPT blow counts and the methods of Seed and Idriss, recently updated as summarized by Youd and Idriss. It was determined that the downstream lower core of the structure potentially susceptible to liquefaction, and the downstream slope had minimum computed factors of safety less than would be desirable, under the maximum credible earthquake loading event. As an additional complicating factor, the foundation soils for the dam (glacial till interlayered with sand) contained artesian pressure in excess of the ground surface at the toe of the dam. As a result, a special potential failure modes analysis of the situation was conducted with the FERC, and rehabilitation, consisting of toe drainage and a stability berm to improve the post-earthquake stability of the dam as well as mitigating the potential of heave at the toe of the embankment was determined to be necessary. Dr. Findlay designed the rehabilitation, and retained a subconsultant to maintain a field presence during critical phases of construction. The rehabilitation was successfully completed in 2010 and is the subject of a paper presented at the ASDSO Annual Conference in 2011.

Review of Embankment Instrumentation, Relief Wells, and Seismic Stability, Skelton Project, Florida Power & Light – Dr. Findlay is provided assistance to Florida Power & Light (FPL Energy Maine Hydro LLC) regarding the instrumentation and monitoring of a relief well system for its 75 foot high Skelton Embankment on the Saco River in Southern Maine. The dam is founded above a confined sand deposit which has experienced increasing artesian pressure since construction in the 1940's. Initial work included re-assessment of stability with regard to heave at the toe as well as general slope stability. Work has included a historic review of construction and maintenance records, review of historic monitoring data, slope stability analysis, post-earthquake analysis and planning and observing a program of video inspection and redevelopment of the existing system of 15 relief wells. Rehabilitation has included re-screening structurally deficient well screens, and design and installation of two new 80 foot deep, 12-inch diameter permanent pumped relief wells. A network of 50-year old metal standpipe piezometers was replaced with vibrating wire piezometers (in part, to prevent winter freezing/artesian water level problems) that are monitored from centralized locations. The rehabilitation and improvements have decreased confined foundation pressures well within acceptable levels. At the request of the FERC, FPL was asked to review the seismic stability of the project. Dr. Findlay conducted that assessment, including liquefaction triggering, post-earthquake, and deformation analyses of the embankment dam. He also analyzed the post-earthquake stability of the gravity structures, including the post-earthquake adequacy of the spillway piers if damaged by the MCE event. The work at this dam has been summarized in papers presented at the 2002 and 2006 ASDSO Annual Conventions.

Chittenden Dam Detailed Slope, Gravity and Seismic Stability Analyses – Central Vermont Public Service - In 2006, Dr. Findlay updated stability analyses on selected interpretive cross sections of Chittenden Dam. The dam is located in central Vermont, about eight miles northwest of the city of Rutland at the head of East Creek. The analyses included consideration of the west (main) embankment cross section, an east embankment cross section, and a concrete spillway section founded over a portion of the embankment dam. The cases of normal full pool loading, flood loading, normal plus seismic, and rapid drawdown were analyzed. The embankment slope stability analyses were conducted using the program SLOPE/W, licensed by FEI from GEOSLOPE International, Calgary Alberta, Canada. The analysis was completed using the Spencer Method. Analyses of the concrete gravity ogee spillway were made using the two-dimensional gravity analysis method, and the normal, PMF and post-earthquake loading cases were considered. The tailwater elevation at the spillway is an important consideration with regard to assessing uplift under the concrete gravity spillway. No previous analysis of the PMF tailwater elevation has been made for the project. For this analysis, a simple HECRAS model of the spillway discharge using the inline spillway feature of HECRAS. Three cross sections upstream of the spillway were developed to model the reservoir and three cross sections downstream of the dam were developed to model tailwater conditions. The upstream boundary condition of the model was a constant head elevation of the reservoir, and the downstream boundary condition (900 feet downstream of the spillway) was critical flow depth. The steady state model used downstream cross sections developed from interpretation of USGS topographic mapping, and the available near-dam project topography. The analyses found the structures were adequately stable under all considered loading conditions.

Slope and Seismic Stability Analyses, Lake Robinson Dam, Lake Robinson Nuclear Station, Progress Energy - Dr Findlay conducted slope and seismic stability assessments of the embankment dam retaining Lake Robinson, which is adjacent to Robinson Nuclear Plant near Hartsville, S.C. The earth dam about 4,300 feet long and up to 50 feet in height. The dam and power plant are owned and operated by Progress Energy of Raleigh, NC. The analyses were prepared as required by the Nuclear Regulatory Commission (NRC) for inclusion in the plant's Facility Description and Safety Report on file with the NRC. The potential for foundation

liquefaction needed to be assessed and embankment deformation was to be assessed using a Newmark approach. The original analysis details could not be found, and the analysis was required to be redone. Dr. Findlay reviewed available subsurface investigation information, soil profiles, geology reports and construction specifications to develop properties for use in the analyses and to characterize the appropriate seismicity of the project locations. The slope and seismic stability analysis was conducted using the Programs SEEP/W and SLOPE/W, which were developed by GeoSlope International, of Calgary, Alberta, Canada. Since phreatic surface conditions at the embankments are not known by the analyst, a finite element seepage analysis using SEEP/W was conducted to define the steady state phreatic surface through the embankment, based on assumed hydraulic conductivity values. The results of the seepage analysis were then imported into the slope stability analysis program (SLOPE/W), and slope stability analyses, using the Spencer Method were conducted. The analyses found the embankment had adequate stability under all considered loading cases, that foundation liquefaction was not anticipated under the regional seismicity (as indicated by standard penetration test results), and that embankment deformation would be minimal under the operating basis earthquake.

Silver Lake and Sugar Hill Dams, Central Vermont Public Service – In 2006, Dr. Findlay served as an owner's representative for review of a field investigation and stability assessment for the two dams which are owned and operated by Central Vermont Public Service. The analyses and field work were conducted by another consultant retained by the owner. The field investigation encountered relatively loose, saturated soils under the upstream slope of one of the dams, triggering a more detailed assessment of liquefaction and potential seismic deformation under a maximum credible seismic event. Dr. Findlay reviewed and commented on the analyses performed by the other consultant and participated in discussions between the owner and the Federal Energy Regulatory Commission as a technical expert.

Seepage and Slope Stability Analysis of Vermilion Dam, Southern California Edison – Vermilion Dam is a 165 foot high, 4,234 foot long zoned embankment dam located at about elevation 7,650 feet in the Sierra Nevada Mountains of California. The dam is founded on a complex soil foundation of glacial moraine and interbedded alluvial materials. Seepage is controlled by numerous drainage systems, some of which were originally designed under the review of Dr. Karl Terzaghi. One of the key monitoring piezometers for a section of Vermilion Dam had elevated readings that were above the phreatic surface assumed in previous slope stability analyses, bringing the minimum computed factor of safety for slope stability into question. The previous analyses used a phreatic surface model consisting of a single phreatic surface. However, the piezometers at the dam are nested in sets of three piezometers each at various depths. Threshold values for each of the piezometers had not been established, and using phreatic surface assumptions of the previous slope stability analyses would not properly account for the flownet-like distribution of phreatic conditions actually indicated by the piezometer readings. Because the foundation layer was relatively thick, it was postulated that the single phreatic surface assumption of the previous analyses was overly conservative with regard to slope stability compared to the flownet-like conditions that actually exist. Dr. Findlay used the program SEEP/W to model the seepage through and within the foundation below the dam, calibrated using the piezometer readings. The resulting seepage model was then imported into the slope stability program SLOPE/W, and slope stability analysis was conducted. The dam was found to be adequately stable even with the elevated piezometer water level observed. An additional important aspect of the finite element seepage analysis and associated slope stability analyses conducted by Dr. Findlay was that they allowed a rational approach to developing threshold piezometer readings for the several sets of nested piezometers at the dam, satisfying requirements for the Performance Monitoring Plan for the dam.

Post-Earthquake Analysis, Lundy Lake and Vermilion Dams, Southern California Edison – In 1999 and 2004, respectively, Dr. Findlay conducted post-earthquake analyses of these two dams for Southern California Edison. The analysis approach included the assumption of liquefaction of suspected relatively looser zones of the embankment cross sections, assessment of appropriate post-earthquake residual strength values, and post-earthquake slope stability analysis using the program SLOPEW. The embankments were found to be adequately stable with regarding the loading under the maximum credible earthquake.

Post-Earthquake Analysis, Gulf Island Dam, Florida Power & Light – Dr. Findlay conducted post-earthquake analyses of this dam for FPL Energy Maine Hydro, LCC at their Gulf Island Project located on the Androscoggin River, in Lewiston, Maine. The analysis approach included the assumption of liquefaction of suspected relatively looser zones of the embankment cross sections, assessment of appropriate post-earthquake residual strength values, and post-earthquake slope stability analysis using the program SLOPE/W. The embankment was found to be adequately stable with regarding the loading under the maximum credible earthquake.

Supplemental Seismic and Flood Analyses of Tioga Lake Dams, Southern California - In 2004, Dr. Findlay conducted slope stability analysis of the timber crib rockfill dam and small concrete arch dam at Tioga Lake, located in Tioga Pass, California. The slope stability analysis was conducted using the program SLOPE/W and the arch analysis was conducted using SAP2000 NL, using a response spectrum approach. Both dams were found to be adequately stable to resist the maximum credible earthquake loading case.

FERC Part 12 Dam Safety Inspection and Slope Stability Analysis, Oswegatchie Project, Orion Power – Dr. Findlay conducted the 2000 Part 12 inspection of the Oswegatchie Project on the Oswegatchie River in upstate New York. The project includes four developments, including concrete gravity dams and earthen and concrete saddle dikes and sections. Follow up work conducted in 2002 included slope stability analysis of a previously unanalyzed embankment structure. The program SLOPE/W was used. The analysis considered the normal, pseudostatic and flood cases.

Penstock Replacement Geotechnical Issues and Slope Stability Analyses, Schaghticoke Project, Hoosic River, New York, Niagara Mohawk Power Corporation – Dr. Findlay was retained by Orion Power – NY (and formerly Niagara Mohawk Power Company) to serve as their liaison and peer reviewer of the geotechnical aspects for the design and replacement of the aging 1,100 foot long penstock. The penstock ruptured during the spring of 1998 under full hydrostatic load. The penstock traverses a pipe bridge across the Hoosic River, and steep slopes which have had historic slope stability problems. To complicate geotechnical issues, a confined zone of artesian pressure was identified by Niagara Mohawk under the penstock alignment, which is being considered in the review of slope stability. Work conducted by FEI includes independent laboratory testing and review of significant subsurface investigations by both the designer and Niagara Mohawk, independent detailed slope stability analysis conducted with SLOPE/W, participating in weekly design review meetings, and detailed review and comment on the design criteria, drawings and specifications. The work was summarized in a paper presented by Dr. Findlay at the 2000 ASDSO conference in Providence, Rhode Island and published in the conference proceedings.

Big Creek Dam 4, Dam 5 and Dam 6 Abutment Rock Slope Stability Analyses, Big Creek, California, Southern California Edison Co. - The Federal Energy Regulatory Commission was concerned with the abutment slope stability of these 50 and 75 foot high concrete arch dams supported by exfoliated granite abutments. To address this issue, FEI completed a detailed analysis of the stability of the granite abutments of Big Creek Dams 4 and 5. The developments are part of Southern California Edison's historic Big Creek Project located in the Sierra Nevada Mountains of California. Dr. Findlay first mapped the bedrock features of both abutments, involving access by technical climbing. The mapping identified the critical blocks of the exfoliating granite for analysis, as well as the strikes and dips of the joints defining the blocks. Joint roughness was estimated by measuring the asperities of an exposed surface of the potential sliding plane of the most critical block. The analyses were made using the sliding block approach as outlined by Hoek and Bray as well as by using a spreadsheet coding of the two plane wedge (with tension crack) approach, also outlined by Hoek and Bray. The analyses found the abutments to be stable under normal gravity and seismic loading (0.15g) and PMF flooding, except on the left abutment of Dam 4. At that abutment, a large block was found to be marginally unstable if the tension crack was surcharged with water (such as might occur under PMF overtopping during an extreme flood). A recommendation is that the vertical and near vertical joints defining the left abutment block of dam 4 be dry pack grouted to mitigate surcharging with water. The project was the subject of a paper presented at the 2000 ASDSO Annual Conference and in a recent ASDSO (winter 2000-2001) news letter article.

Dam Safety Inspection, Murphy Dam Project, Connecticut River, New Hampshire Department of Environmental Services - Water Resources Council – In 1998, Dr. Findlay was the Project Manager, Lead Dam Inspector, and Lead Geotechnical Engineer for a detailed review of the condition of this 100 foot high zoned earthfill dam in northern New Hampshire. The project consists of a review of project seismicity since two Magnitude 5 earthquakes have occurred within about 10 kilometers of the dam within the past 35 years. In addition, work included installation of monitoring piezometers, assessment of liquefaction potential, a review and update of the structural stability of the dam and spillway, review and update of the PMF, a dam break analysis and preparation of inundation mapping for preparation of an Emergency Action Plan, and preparation of a list and cost estimate of capital improvements anticipated to be necessary to maintain the facility into the future.

Buzzard's Roost Project, Dam Safety Inspection, Saluda River, South Carolina, Duke Power Company – In 1993, Dr. Findlay participated in the FERC Part 12 on-site inspection and prepared the summary report for Duke Power Company's Buzzards Roost Project. The project is located on the Saluda River, near Chappels,

South Carolina. The project consists of a 2,400-foot-long, 80-foot-high earth embankment, a 200-foot-long fuse plug, and an 80-foot-high gated spillway/ogee, and integrated intake and 15 MW powerhouse. As a follow up to the 5-year inspection, Dr. Findlay provided a peer review of a liquefaction analysis conducted by Duke Power as ordered by the FERC. The analysis is on the 80-foot earth embankment which is founded on alluvial sands.

Lake Blackshear Dam, Dam Breach Repair, Flint River, Georgia, Crisp County Power Commission - During July 1994, Tropical Storm Alberto released torrential rains which caused overtopping of the 3,400-foot-long north embankment of Lake Blackshear Dam, causing a breach about 650 feet in length. Dr. Findlay was retained by the Crisp County Power Commission to provide geotechnical engineering services to investigate subsurface conditions, design a repair of the breached section, and assess the integrity of the intact portion of the northern embankment. The subsurface investigation program consisting of 15 borings. Because the dam is founded on alluvial sands which are loose at some locations, liquefaction analysis was conducted using the approach developed by Seed, et al. A 2-dimensional transient finite element seepage model was used to assess the cause of boils observed during the flood at locations of the dam that remained intact. As a result of the investigation, a cutoff wall consisting of a cement-bentonite slurry was constructed using slurry trench methods along the axis of the entire northern embankment. The cutoff was determined to be necessary to remediate potential seepage damage to the intact portions of the dam and to mitigate the potential for future piping through the alluvial sands below the breached section. The project included close coordination with the Federal Energy Regulatory Commission and the Federal Emergency Management Agency. The geotechnical aspects of the project were the subject of papers presented by Dr. Findlay at Waterpower '95 in San Francisco in July 1995, the Association of State Dam Safety Officials Annual Convention in Atlanta in September 1995, and the Maine Section of ASCE in March 1996.

Graham Lake Dam, Graham Lake Dam Remedial Measures Project, Union River, Maine, Bangor Hydro-Electric Company – In 1992, Dr. Findlay was the lead geotechnical engineer for the Graham Lake Dam Remedial Measures Project, undertaken to improve dam stability and spillway capacity. Stability analysis and liquefaction analysis indicated the dam had deficient downstream slope stability, and the upstream slope was susceptible to liquefaction. This project consisted of building a new flood control structure just downstream of an existing semi-hydraulic fill dam in Ellsworth, Maine for Bangor Hydro-Electric Company. One aspect of involvement included design of a deep well dewatering system to intercept seepage through the existing dam which served as the upstream cofferdam for the work. This design included three-dimensional groundwater flow modeling using the USGS program MODFLOW to assess the effectiveness and number of wells needed to accomplish dewatering. After installation of the wells, pumping tests were conducted and the results incorporated into the model to verify expected performance. In addition to the dewatering aspects of the project, the existing dam was founded on soft clay, making excavation for the new flood control structure a potentially risky situation. Dr. Findlay developed an innovative excavation stabilization system which consisted of a cellular-constructed granular stabilization berm which was significantly reduced costs over an originally proposed tie-back wall system. The project was completed in the spring of 1994, and was the subject of technical papers presented by Dr. Findlay at the 1993 ASCE Specialty Conference on Dam Rehabilitation in Raleigh, North Carolina, and the 1994 Association of State Dam Safety Officials (ASDSO) Annual Convention in Boston, Massachusetts, and the 1996 ASDSO Annual Convention in Seattle, Washington.

Pontook Hydroelectric Project, New Hydroelectric Development, Androscoggin River, New Hampshire, Combustion Engineering – In the early 1980s, Dr. Findlay was the lead geotechnical engineer for development of a new hydroelectric project under contract to Combustion Engineering. The project included geotechnical investigation, design, and construction consultation for a new 11.4 MW hydroelectric facility on the Androscoggin River in mountainous northern New Hampshire. Included was design and construction of a 6,000-foot unlined canal in glacial till to transport water to a new powerhouse. The canal construction involved full cut sections up to 70 feet in depth, as well as hill side embankment sections up to 30 feet in height. Excavation for the canal and the powerhouse involved deep well depressurization of artesian layers within the till to mitigate excavation instability. Unlined canal design included assessment of ability of the glacial till to self-armor to limit channel erosion. A 700-foot-long timber crib dam with a shear key to increase sliding stability was constructed across the Androscoggin River, downstream of the canal intake, to raise river levels sufficiently for power production. The project was selected by the Consulting Engineers of Maine to receive the "Award for Engineering Excellence" in January of 1988 and was the subject of a technical paper authored by Dr. Findlay for the 1988 Second International Conference on Case Histories in Geotechnical Engineering, sponsored by the University

of Missouri Rolla, St. Louis, Missouri.

Baldwin Hydroelectric Project, New Hydroelectric Development, Connecticut River, New Hampshire, Baldwin Hydro Corporation – in 1991, Dr. Findlay was the Project manager and lead geotechnical engineer in the development and design of a 4.4 MW hydroelectric facility on the Connecticut River in Pittsburg, New Hampshire. The project includes construction of a 170-foot-wide concrete gravity dam, canal headworks, a 4,600-foot-long unlined canal requiring excavation up to 50 feet deep, a penstock intake, and 450-foot-long penstock, a powerhouse and tailrace. It was determined that construction of the powerhouse would require deep dewatering using drilled gravel packed wells to depressurize a confined aquifer to allow excavation up to 50 feet in depth. The project has not yet been constructed.

Hydro-Kennebec Project, Increased Headpond Level, Kennebec River, Maine, Scott Paper Company – In 1987, Dr. Findlay was the lead geotechnical engineer for assessment of several miles of shoreline which were to be impacted by raising the normal water elevation of the existing dam at Scott Paper Company's (now Kimberly Clark) Winslow, Maine paper making facility. This increase in dam height resulted in a substantial increase in the impoundment elevation, affecting the shoreline at several industrial and residential areas. Assessment was made in two phases; a preliminary phase to evaluate the impact at individual locations based on observation, and a follow-up phase which included subsurface investigation and additional assessment at critically impacted areas. The assessment resulted in delineation of areas and recommended methods for slope stabilization. Work included development of contract plans and specifications for implementation of the recommendations. Involvement included consultation and monitoring services through construction.

Keowee Hydroelectric Project, Finite Element Seepage Analysis, Keowee River, South Carolina, Duke Power Company – In 1994, Dr. Findlay developed a finite element model and preliminary input parameters for seepage analysis of an 80-foot-high intake dike for the Keowee Hydroelectric Project/Oconee Nuclear Project in Oconee County, South Carolina. The dike is for the intake of the nuclear project, and is also a water retaining structure for Duke's Keowee Hydroelectric Project. Work included setting up and debugging the model so that Duke Power could use the model for a parametric study of the effect of varying hydraulic conductivity on seepage. The program SEEP/W (Geoslope International) was used to develop the model.

Drawdown Effects on Bank Stability – In 1993, a confidential client was interested in determining how the nominal 2-foot-daily drawdown at one of their reservoirs might safely be interpreted to mitigate reservoir bank stability. For example, if a one-foot rise followed by a three-foot draft in 24 hours could be interpreted as a "net" 2-foot-daily drawdown, some optimization of reservoir operation could be realized, provided such operation did not exacerbate bank erosion. Reservoir fluctuations can impact bank stability if the groundwater does not immediately equilibrate with reservoir level changes. In other words, the greater the lag time of groundwater response, the greater impact on slope stability of the reservoir banks. As a result, the study planned and conducted by Dr. Findlay included field samples and testing, laboratory testing, and groundwater modeling of the response of the water table in the reservoir banks to various reservoir fluctuation scenarios at three selected critical sites. Field work included in situ permeability testing. The USGS groundwater flow model MODFLOW was used to assess groundwater response to fluctuations. The resulting groundwater information was then used to analyze impacts on slope stability. Slope stability analysis was completed using the program STABRD (developed at the University of California at Berkeley) to compute the effects of the groundwater lag on slope stability. Preliminary results of the study indicate the "net" interpretation will have no significant impact on bank stability up to incremental level changes of 4 feet.

Brassua Hydroelectric Project, Expert Witness for Piping Failure, Rockwood, Maine - Dr. Findlay was retained in 1990 as an expert witness for the contractor during post-construction litigation of a piping failure which developed during construction. The piping developed underneath an existing concrete gravity dam founded on glacial till. Dr. Findlay thoroughly reviewed the project design and construction documentation and provided a deposition during the discovery period. The litigating parties decided to attempt mediation to settle the case. Dr. Findlay made a technical presentation for a mediation hearing on the mechanics of piping and a review of the chronology of events leading to the piping failure.

Technical Publications and Presentations

Bruce, D.A.; Greene, B.H.; Findlay, R.C.; Williams, B.E.; Williams, J.H.; and Mickwee, R.L. (2017), "**Long-Term Grouting of a Karst Foundation at Logan Martin Dam, Alabama**"; Paper presented at the 2017 International Conference on Grouting, Sponsered by ASCE, in Honolulu, HI.

Findlay, R.C.; Greene, B.H.; Bruce, D.A.; Williams, B.E.; Williams, J.H.; and Mickwee, R.L. (2015), "**Unique Use of Grout Column Support of Karst Features below Logan Martin Dam, AL**"; Paper presented at the 2015 ASDSO Annual Convention, New Orleans, LA.

Findlay, R.C., and Jensen, Mary C, (2011), **"Noxon Rapids Dam Sudden Seepage and Erratic Piezometer Behavior"**, a paper presented at the 2011 ASDSO Annual Convention, Washington, DC, September.

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Findlay, R.C., (1993), "**Piping Security of Glacial Till-Structure Interfaces**," Proceedings of Waterpower '93, ASCE Convention, Nashville, Tennessee.

Jones, A.N., and Findlay, R.C., (1993), "**Graham Lake Dam Remedial Measures Project**," published in Geotechnical Practice in Dam Rehabilitation, ASCE Geotechnical Special Publication No. 35, Raleigh, North Carolina.

Findlay, R.C., and Benoit, J., (1993), "**Some Factors Affecting In Situ Measurement Using the Cambridge Self-Boring Pressuremeter**," ASTM Geotechnical Testing Journal, Vol.16, No.2, June, Philadelphia, Pennsylvania.

Findlay, R.C., (1991), "**Use of the 9-Arm Self-Boring Pressuremeter to Measure In Situ Horizontal Stress, Stress Anisotrophy, and Stress Strain Behavior in Soft Clay**," Submitted in partial fulfillment of the degree of Doctor of Philosophy, University of New Hampshire, Durham, New Hampshire.

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Findlay, R.C., (1988), "**Hydrostatic Pressure at a Soil-Structure Interface**," Proceedings of the Second International Conference on Case Histories in Geotechnical Engineering, sponsored by the University of Missouri Rolla, St. Louis, Missouri.

Wardwell, R.E., Findlay, R.C., and Muzzy, M.W., (1988), "**Seepage Effects on Sedimentation of Fly Ash Slurry**," published in Hydraulic Fill Structures, ASCE Geotechnical Special Publication No. 21, Colorado State University, Fort Collins, Colorado.

MaryLouise Keefe, Ph.D.

Senior Fisheries Scientist

EDUCATION

- Ph.D. (Doctor of Philosophy in Biological Sciences) University of Rhode Island, 1990
- Graduate Courses (Biological Oceanography) University of South Florida, 1984
- B.A. (Biology) Smith College, 1983

- Years of Experience - 27
- Primary Work Location -Vancouver, Washington

PROFESSIONAL AFFILIATION AND TRAINING

- American Fisheries Society (AFS)
- Sigma Xi
- President Equal Opportunity Section AFS 1997-2000
- Vice President Oregon AFS 1996
- Senior Project Management Fundamentals
- Contract Pricing and Negotiation

BIO

Dr. Keefe has participated in and/or managed aquatic ecosystem based and collaborative since projects for the past 27 years. She most recently has been a Project Manager for R2's on-call contract with Metropolitan overseeing successful completion of four task orders in the past two years. During this same period she has been managing a large scale Fish and Aquatics Research Program on the Susitna River for Alaska Energy Authority. This program included studies on fish distribution and abundance, fish escapement, fish behavior and habitat use, river productivity and food web studies, aquatic habitat mapping and characterization, and fish barriers. MaryLouise brings broad experience from working with many different species and habitats located at a variety of water resource projects across the country including: California's Bay Delta System, the North Fork Feather, American, Santa Ana, Mukelumne and Sacramento river basins, Alaska's Susitna River, throughout the Columbia River basin in Oregon, the Nelson River in Manitoba Canada, Lewis, Baker, and Coeur D'Alene Rivers in WA, the Noxon and Clark Fork rivers in Montana, the River in Mississippi and the Ohio River in Pennsylvania and West Virginia. Earlier in her career, Dr. Keefe spent 7.5 years at Oregon Department of Fish and Wildlife Research Section studying ESA listed salmon and steelhead. MaryLouise served as a technical expert for recovery planning in the Lower Snake River basin assessing limiting factors and prioritizing recovery actions for listed spring Chinook salmon and Summer Steelhead. Dr. Keefe has published nine articles in peer reviewed fisheries journals.

KEY SKILLS

Fish and Aquatic Science: Dr. Keefe has worked with freshwater and anadromous fishes in the West since 1991. She has experience designing and implementing fish migration and natural production studies using a variety of collection, enumeration and mark-recapture techniques. She has experience leading water quality monitoring, salmon escapement monitoring, fish barrier assessment, fish habitat assessment and carrying capacity, and limiting factors analysis. MaryLouise worked in three relatively untouched AK river systems for the past ten years. There she led collaborative teams, from multiple agencies, universities and consulting firms in documenting fish distribution and abundance, habitat use, aquatic habitat, water quality, and river productivity as well as oversaw fish migration studies. Previously, she spent more than seven years as a Project Leader monitoring the natural production and outmigration of ESA listed spring Chinook salmon and summer steelhead smolts. These studies were among the first to combine the use of rotary screw trap and pit-tagging to evaluate migratory patterns of wild salmon and survival of tagged fish through mainstem dams. Dr. Keefe's field experience includes marking/tagging technologies includes acoustic and radio telemetry, Passive Integrative Transponder (PIT) tag technologies, as well as non-invasive marking techniques such as pan-jet marking, dye immersion, and elastomer tagging.

Dr. Keefe has a strong background in study design, biostatistics and data analysis.

Fish and Aquatic Science

(*continued*)

Most recently for Metropolitan she led a team in re-creating and expanding the Delta Smelt data base to support revisions and updates to the Delta Smelt population model. Other recent fisheries examples include: application of GRTS approach to fish distribution and abundance, development of a Fish-Use Habitat Index, fish and aquatic habitat inventories, and resident fish telemetry in the Susitna River, Rainbow Trout telemetry project in the Lake Iliamna watershed.

Dr. Keefe also has conducted desk top analyses and technical white papers regarding potential fish impacts. She recently co-authored a white paper on resiliency of stream systems to large scale environmental perturbations using the recovery of the Toutle River post Mt. St. Helen's as a case study. MaryLouise has co-authored fish research, monitoring and evaluation plans including plans for the USACE, PacifiCorp, and Eugene Water & Electric Board. She served as a technical advisor to the Portland District in support of the R, M &E Program implementation. Dr. Keefe has conducted literature reviews to identify potential impacts associated with fish diseases for salmon in California on the Oroville Hydroelectric Project and for American Eels on the Roanoke Rapids and Gaston Project.

Dr. Keefe has experience with oversight and management of water quality projects. Most recently, she directed staff in the conduct of four water quality monitoring projects: Ringold Hatchery Design, Walterville Chevron Modifications, and for two studies of the Hyporheic Zone water quality in the Koktuli and Susitna rivers, Alaska. She was Senior Advisor for the Yazoo Water Quality Monitoring Study that spanned four Mississippi river basins. MaryLouise has led the development of FERC and NEPA water quality documents. For the Pebble Project, she managed the team responsible for conducting QA/QC on an existing database, writing up the water quality environmental baseline documents, and providing senior technical support on water quality issues. For the Boundary Project, MaryLouise led the development of the water quality preliminary and revised study plans. At PGE's Willamette Falls Project, Dr. Keefe was the technical editor for the APEA and 401 Certification Application. She worked closely with aquatics staff in identifying relevant issues and appropriate data analysis and presentation. In addition, she supervised a field crew in collection of water quality data, a gas supersaturation study, and development of a water quality monitoring plan for license implementation. Dr. Keefe also assisted PacifiCorp with their 401 Certification Application for their North Umpqua Project assessing the impacts of water quality issues from a fish population perspective. As project manager or aquatics lead for numerous multidisciplinary projects, MaryLouise has overseen development of water quality assessment and impact sections, and has guided technical staff in issue identification, selection of analytical methods, and data presentation for: Condit Dam, Port Townsend EA, Utah Lakes EIS, Hagg Lake EIS, Elliot State Forest EIS, Kellogg Creek Watershed Assessment, and upper Nehalem River Watershed Assessment.

Habitat

Dr. Keefe possesses knowledge of riverine and estuarine habitats gained from past experience throughout the U.S. Her project experience includes: fish habitat assessments and estimates of carrying capacity, limiting factors analysis, natural production studies, documenting fish-habitat association, water quality monitoring, salmon escapement monitoring, habitat restoration projects, She has led a dozen project teams in both remote and field habitat mapping and characterization covering well over 700 miles of fish habitat throughout the Columbia River Basin, in Utah and Alaska. She has lead mulitdisciplinary teams is assessing potential for habitat impact to threatened and endangered plants, amphibians, and terrestrial vertebrates. These assessments have covered habitats in their natural state as well as those affected by impoundments, forest practices and urbanization. As part of several habitat assessments MaryLouise and the R2 developed new habitat protocols (e.g., to quantify salmon spawning habitat) or adapted existing protocols to better meet study objectives and/or address specific habitat conditions (e.g., mapping habitats in large navigable rivers). Dr. Keefe has managed project teams in the collection of data for and the development of physical habitat models in the Tualatin River, the Provo River, the Koktuli River, and Upper Talarik Creek and has managed fish habitat restoration projects in Fanno Creek and the McKenzie River.

Fish Passage Projects

Dr. Keefe has been evaluating fish passage at dams and natural barriers since 1991. Most recently she has participated in several fish passage feasibility studies: for Alaska Energy Authority's proposed Susitna dam, for two proposed Manitoba Hydropower projects on the Nelson River, an upstream passage feasibility study at Leaburg Dam, and she assisted with an independent review of passage alternatives at Opal Springs and Carmen Smith dams. MaryLouise has worked effectively on collaborative teams with engineers and stakeholders to tailor passage goals and objectives to meet specific project needs and has helped to ensure that decisions were compatible with each the ecology of the river system as well as biological goals for managed systems. She has conducted fish-passage projects during license implementation for PacifiCorp including detailed studies on the behavior of fish in the Merwin Dam tailrace, entrainment of fish at Yale dam, passage at the Fish Creek bypass facility, and technical support on passage implementation issues at Condit and Soda Springs dams. Other relevant fisheries studies include downstream passage studies conducted at the Baker River and Leaburg-Walterville hydroelectric projects. Dr. Keefe has used both standard and advanced tagging technologies to evaluate fish passage through the facilities. At Baker she oversaw four concurrent field studies assessing downstream passage through the reservoir and attraction to the floating surface collector. At Leaburg-Walterville she assisted EWEB with the study design and plan development for five separate, FERC- and agency-approved passage studies. She worked with staff at R2 to implement of three of these passage studies at Leaburg and Walterville facilities. She is also currently overseeing a fish passage barrier study on the Susitna River in Alaska.

Hydropower

Dr. Keefe has varied experience in hydropower licensing/relicensing projects that include Project Management, study plan development, preparation of FERC documents and exhibits, and implementation of water quality and fisheries studies for utility clients as well as working as an independent contractor for FERC. For the past four years she has been managing the Fish and Aquatics Baseline Studies Program for the Susitna-Watana Hydroelectric Project. Her responsibilities have included oversight of the Preliminary and Revised Study Plans, implementation, analysis and completion of the Initial Study Reports and Study Implementation Reports for 13 separate studies. She has managed hydro-related studies for multiple clients including Puget Sound Energy, PacifiCorp, Portland General Electric, Eugene Water & Electric Board, and California Department of Water Resources. Dr. Keefe has developed and implemented 30 fish and aquatics study plans and has coordinated study plans with technical working groups, agency staff and stakeholders. Study plans have ranged from literature reviews to multi-disciplinary field surveys and include: Leaburg Walterville fish monitoring and evaluation plan, Willamette Falls water quality monitoring plan, Willamette Hatchery Mitigation Program Research, Monitoring and Evaluation and 3-year Monitoring and Evaluation plans. She has also prepared FERC technical memoranda, exhibits, 401 Certification applications as well as NEPA and ESA documents.

Impact, Mitigation, and ESA Studies

Dr. Keefe has conducted and written impact studies, NEPA reports, EAs, EISs, and BAs for a variety of projects including: hydroelectric and flood control dams, water supply projects, and fish hatchery facilities. Recent project experience includes: Participation on the Fish Technical Team for Pebble Project, aquatics lead for the Tualatin Basin Water Supply Draft EIS, the Project Manager of the Port Townsend Water Supply EA, and the Aquatics Technical lead for the Central Utah Water Conservancy District's Utah Lakes Water Supply Project. For the Tualatin EIS, Dr. Keefe also had a lead role for ESA consultation and agency negotiations to obtain a State of Oregon fish passage waiver. She oversaw preparation for multiple Biological Assessments including the following projects: Tualatin Basin Water Supply Draft EIS, EWEB's Leaburg-Walterville Project, Port Townsend Water Supply EA, Coeur D'Alene Tribal Hatchery EA, Santa Ana EA, and Mukelumne EA. She has led multi-disciplinary teams is assessing impacts to aquatic and terrestrial species that are listed under ESA or are of special concern in the state of Washington, Idaho, Oregon and California.

TED CHANT, P. Eng.

PROFILE

- 40+ years of experience over a full range of management functions in both large and small hydro-electric development and water control/management infrastructure in Canada and the United States
- Innovative subject matter expert in the fields of hydro-electric construction risk identification and mitigation, constructability review, cost certainty, execution planning and management (safety, cost, quality and schedule), continuous improvement and value optimization
- Background includes working with public, para-public and private sector project owners under a variety of contracting and project delivery models.

EDUCATION

1977 **Bachelor of Applied Science – Civil**
Queen's University

PROFESSIONAL AFFILIATIONS AND OTHER TRAINING

- Association of Professional Engineers of Ontario
- Association of Professional Engineers and Geoscientists of the Province of Manitoba
- Association of Professional Engineers of Yukon
- Association of Professional Engineers, Geologists and Geophysicists of Alberta (APEBGA)
- Professional Engineers and Geoscientists of BC (APEGBC)
- Canadian Construction Association Gold Seal Certificate – Project Manager
- Numerous management, finance, law, leadership and construction safety training courses

LANGUAGES

- **English and French**

PROFESSIONAL EXPERIENCE

January 1999 – Present **CHANT LIMITED**
PRESIDENT and CEO

- Functional responsibility for overall direction and control of privately held, Ontario based Construction Services Provider. Primary line responsibilities include business development, cost estimating, quality assurance and contract execution oversight (safety, cost, schedule and quality).

- Acts as *Project Manager* for all Chant Limited's major construction related undertakings including:

Active Projects:

- Talbot Dam Kirkfield Bundle Project, Gamebridge, ON
  - Overall Project Manager for the Advisory and Construction Services Phases of a major Trent Severn Waterway (lock, dam and canal) asset rehabilitation and replacement project. ($35 million – 12% complete).

- Mersey River Redevelopment Project, Nova Scotia Power
  - Chant Project Manager advising Nova Scotia Power (under an Early Contractor Involvement model) on the redevelopment of 6 cascading generating stations (total 45 MW) in Nova Scotia. Tasks include constructability review, pre-construction planning, integration of common elements, tendering strategy development and cost confidence process development/oversight.

- Gordon Butte Pump Storage Project, Absaroka Energy, Montana
  - Chant Project Manager providing cost confidence and execution planning support services as a member of the Owners Team for this 400 MW pump storage project.

Completed Projects:

- Site C GSS Contract. BC Hydro, British Columbia
  - Chant Limited was engaged by Bechtel Canada to provide an independent cost estimate of all Direct construction costs in support of Bechtel's tendering process for the work. This 1,100 MW project requires the batching and placement of almost 900,000 y^3 of concrete. Specifically, responsible for means and methods selection, schedule, aggregates and batch plant equipment selection and costing, penstock erection sequencing and ensuring overall quality of costing effort. ($800 million).

- Keeyask Generating Station, Manitoba
  - Chant Limited was contracted by Manitoba Hydro to provide a complete independent AACE Class 2 contractor style construction cost estimate for this 700 MW new generating station on the Churchill River. Specifically, provided input on proposed risk transfer methodologies and contract language. Lead constructability of the work assessments, means and methods selection, schedule development, lead earthworks estimator and retained overall responsibility for the quality of costing effort. ($1.4 billion)

- Dorena Lake Dam Hydroelectric Project, Oregon
  - As Project Manager provided oversight to the delivery of construction management services for the completion phase (ownership change) of this 7.5 MW new hydro/existing USACE dam project. ($25 million)

- Box Canyon Hydroelectric Power Project, British Columbia
  - As Project Manager lead the provision of front-end engineering and development services during the initial stages of the project. Chant Limited also provided construction management services during the execution phase. ($38 million).

- Mayo-Dawson Transmission Line, Yukon
  - Project Sponsor for the full design, construction, commissioning and start-up of a 223 km 69kV transmission line. ($30 million).

- Brilliant Expansion Project, Castlegar, British Columbia
  - Chant Internal Project Manager and Supervisory Board Member for the Design-Build Consortium that delivered this single unit 120 MW expansion of an existing hydroelectric station on the Kootenay River. ($150 million).

- Shikwamkwa Replacement Dam Project, Ontario
  - Project Manager for the placement of 1,000,000 m^3 of zoned embankment and the installation of 20,000 m^2 of plastic concrete foundation cutoff wall. Scope of work included the decommissioning and partial removal of an existing dam (similar size) embankment. ($100 million).

- High Falls Redevelopment Project, Ontario
  - As Project Manager provided the Owner's design oversight, project and construction management services through to commissioning complete for this new 45 MW hydroelectric generating facility. Scope of work included the decommissioning of an existing powerhouse, wood stave penstocks and intake structure. ($75 million).

1996 – 1998 **VICE PRESIDENT - ARMBRO CONSTRUCTION LIMITED**
Design-Build Projects

1977 – 1996 **PETER KIEWIT & SONS CO. LTD.**
(Including subsidiaries or sponsored joint ventures)

1993 – 1996 **AREA MANAGER/DISTRICT MANAGER AND VICE-PRESIDENT**
Ontario District

1991 – 1992 ***JAMES BAY AREA SUPERINTENDENT***
Montreal District

1987 – 1991 **ENGINEER-ESTIMATOR**
Toronto Regional Office

1986 – 1987 **PROJECT MANAGER**
Forty Mile Coulee Project, Alberta

1985 – 1985 **PROJECT MANAGER**
Nipawin Hydroelectric Project, Nipawin, Saskatchewan

1982 – 1985	**GENERAL EARTHWORKS SUPERINTENDENT** *Nipawin Hydroelectric Project*
1980 – 1982	**EXCAVATION AND EMBANKMENT SUPERINTENDENT** *LG-4 Main Dam Project, James Bay, Quebec*
1977 - 1980	**FOREMAN** *Duncan Dykes and LG-4 Main Dam Projects, James Bay, Quebec*

About Chant Limited:

Chant Limited ("Chant"), an Ontario based corporation, began operations in 1999 and over the last 18 years has successfully delivered a wide range of projects and technical services assignments to major utility and independent power producers in Canada and the United States. Responsibilities have varied from producing third party construction, operations and maintenance cost estimates as part of an owner's cost confidence process, providing detailed constructability reviews, acting as owner representative (project manager, construction manager and safety monitor) to at-risk construction management or general contracting for hydroelectric power generation/energy transmission related infrastructure projects.

Chant's core competencies offer clients financial and technical audits for project financing and feasibility, technical reviews of existing facilities, pre-construction concept design development, design management, constructability reviews, value engineering inputs, risk identification/mitigation strategy development and comprehensive cost assessments/audits for both capital and maintenance oriented undertakings.

RESUME OF
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Education and Designations:

Bachelor of Arts, Political Science, State University of New York, Plattsburgh 1980
Congressional Intern, Washington DC 1979
Associate in Risk Management, Boston MA 1988
Licensed Insurance Broker

Employment:

1981-1982 Hartford Insurance Company, New Orleans LA - Commercial Insurance Underwriter
1982-1984 Crum & Forster Insurance Co, Boston MA - Commercial Insurance Underwriter
1984-1989 Caddell & Byers Insurance Agency, Burlington MA – Commercial Insurance Broker
1989-1993 William Gallagher Associates, Boston MA – Commercial Insurance Broker
1993-1997 Austin & Co, Albany NY – Commercial Insurance Broker
1997-Present Cool Insuring Agency, Inc., Albany NY - Commercial Insurance Broker

Areas of Expertise:

Cool Insuring Agency is a large, independent broker based in Albany NY. Presently, I am the broker for over 130 hydroelectric power projects throughout the US. I am a frequent panelist and speaker at national conferences on the hydroelectric power industry, and I have published several articles in trade magazines about the insurance and risk management issues associated with hydropower energy production. In conjunction with my company's Risk Management Department, I have advised my power production clients through all phases of their projects, from construction to operation. I am supported in my efforts by a staff of over 100 insurance professionals.

Insurance Placements and Claim Handling:

Due to the age of many of my clients' hydro projects which are in operation today, I have been intimately involved with both the risk assessment/insurance placement as well as the handling of claims when projects fail. Similarly, as projects undergo rehabilitation or upgrades I have worked closely with the project owners and contractors to address all insurance and risk management matters from pre-construction on. This includes placement of construction risk

coverage (Property, Liability, Delay in Start Up, Environmental Impairment Liability, etc) and eventually placement of all operations coverage.

Examples of my Hydro Clients' Claims:

- Dam Failure during construction
- Multiple machinery failures and resulting loss of income
- Fires which destroyed powerhouses and equipment
- Personal injury to the public
- Catastrophic Flood damage

Work with River Systems:

Along with insuring individual hydroelectric power projects, my clients also include legal entities which either manage river systems, or have several projects on one river system. Services which I provide to these entities include; placement of all insurance coverages including General Liability, Property coverages, Flood Coverage, Directors and Officers Liability, Environmental Impairment Liability, etc. Furthermore, we provide OSHA-related consultation, and on-going risk assessment to address all concerns of these clients.

Hudson River-Black River Regulating District
The mission of the Hudson River-Black River Regulating District is to construct, maintain, and operate reservoirs in the upper Hudson River and Black River watershed, including the Sacandaga, Indian, Black, Moose, and Beaver Rivers for the purpose of regulating the flow of streams or rivers, when required by public welfare, including public health and safety. The Regulating District owns and operates the Conklingville Dam on the Sacandaga River and the Indian Lake Dam on the Indian River. The water releases from these dams are interdependent and control about 40 percent of the waters in the Hudson River Area's 8,300-square mile basin. Completed in 1930, the Conklingville Dam created the 42-square mile Great Sacandaga Lake, which is the largest reservoir in the State, with a 125 mile shoreline and capacity of 37.73 billion cubic feet.

Wisconsin Valley Improvement Company
Wisconsin Valley Improvement Company's mission is to operate the Wisconsin River Reservoir System to maintain a uniform flow and a reasonable balance among the benefits the water resource provides. The total drainage area is 12,000 square miles and is comprised of 21 reservoirs and 25 hydroelectric projects (independently owned). The WVIC is tasked with providing "as uniform a flow as practicable" in the river for papermaking, power generation and public safety. To that end, the WVIC must work collaboratively with industry, lakeshore property owners, the tourist industry, pioneer agriculture, the northern forest and aquatic wildlife concerns.

Gravity Renewables – New York State Canal System

This client has in its portfolio 2 projects which are an integral part of the New York State Canal system. The projects are the 8-MW Seneca Falls and 2-MW Waterloo plants, located in New York's Finger Lakes region. The plants which were completed in 1917 and 1916, respectively, to utilize the increased water volume and elevation required to operate the newly-completed Seneca-Cayuga branch of the Barge Canal.

Renewable World Energies - Flambeau River

This client owns and operates 5 hydroelectric projects on the Flambeau River in Wisconsin. They are responsible for coordinating flow between sites and I provide insurance and advice associated with public safety etc.

Community Involvement:

Board of Directors, Addictions Care Center of Albany, 2006 to Present
Coach, Basketball and Soccer 1995 to 2007
Volunteer, Songwriting with Soldiers 2011 to Present